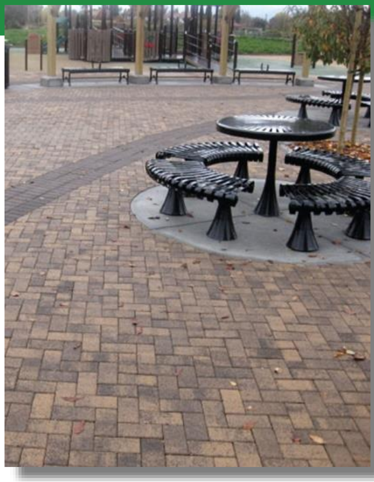
C.3 Stormwater Handbook



Guidance for Implementing Stormwater Requirements for New Development and Redevelopment Projects

Santa Clara Valley
Urban Runoff
Pollution Prevention Program

June 2024

Campbell • Cupertino • Los Altos • Los Altos Hills • Los Gatos • Milpitas • Monte Sereno • Mountain View • Palo Alto
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C.3 Stormwater Handbook

June 2024

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Credits

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A list of Program Management Committee members is provided on the following page.

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Management Committee

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Glossary of Terms

Base Course A layer of constructed material (typically aggregate base), located above the subbase course and/or subgrade course and below the surface layer of pavement, that supports the surface layer and distributes load.

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 was updated in 2023 and is available for download at

https://www.clearcreeksolutions.info/bahm-download-page.

Bay Area Municipal Stormwater Collaborative (BAMSC) The Bay Area Municipal Stormwater Collaborative (BAMSC) is an informal association of 103 stormwater management agencies in the San Francisco Bay Area. BAMSC was organized in 2021 by the Board of Directors for BASMAA to continue the information sharing and permittee advocacy functions of BASMAA in an informal manner after BASMAA's dissolution. BAMSC continues BASMAA's mission to encourage information sharing and cooperation, and to develop products and programs that are more cost-effectively completed regionally than locally. BAMSC products, along with past BASMAA documents, are available on www.basmaa.org .

Bay Area Stormwater Management Agencies Association (BASMAA) A consortium of nine San Francisco Bay Area municipal stormwater programs collaborating on stormwater management in the region from 1990-2021. www.basmaa.org

Bay-Friendly Landscaping (ReScape) A holistic approach to landscaping that works in harmony with the natural conditions of the San Francisco Bay Watershed. Bay-Friendly (ReScape) practices foster soil health and protect water resources while reducing waste and preventing pollution. More can be found on the ReScape website at: https://rescapeca.org/

Beneficial Use The uses of waters of the State protected against degradation, such as domestic, municipal, agricultural and industrial supply; power generation; recreation; aesthetic enjoyment; navigation and preservation of fish and wildlife, and other aquatic resources or preserves.

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 A type of biotreatment measure designed to detain stormwater runoff, filter stormwater runoff through biotreatment soil media and plant roots, and infiltrate stormwater runoff to underlying soils as allowed by site conditions.

Bioretention A type of biotreatment measure designed to detain stormwater runoff, filter stormwater runoff through biotreatment soil media and plant roots, and either infiltrate stormwater runoff to underlying soils, as allowed by site conditions, or release treated stormwater runoff to the storm drain system, or both. 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 LID treatment measure designed to detain stormwater runoff, filter stormwater runoff through biotreatment soil media and plant roots, and release the treated stormwater runoff to the storm drain system. As required by Provision C.3.c.i(2)(vi), biotreatment systems must 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 must use biotreatment soil as specified in the MRP (Appendix C of this Handbook).

Biotreatment Soil Media A specified soil mix required for use in biotreatment, bioretention, and bioinfiltration measures for compliance with LID treatment measure design standards. Also known as BSM or biotreatment soil mix. (See Appendix C for current specification.)

Buffer Strip or Zone Strip of erosion-resistant vegetation over which stormwater runoff sheet flow is directed, which may be used as pretreatment upstream of a treatment measure.

C.3 Provision of the Municipal Regional Stormwater NPDES Permit (MRP) that requires each Permittee 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 subject to stormwater control requirements as defined by Provision C.3.b.ii of the MRP. This includes public and private projects that create and/or replace quantities of impervious surface that exceed specific thresholds defined in the MRP.

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) A statewide organization that publishes the California Stormwater Best Management Practices Handbooks, available at www.cabmphandbooks.com. Successor to the Storm Water Quality Task Force (SWQTF).

Caltrans The California Department of Transportation, publisher of the Caltrans Standard Specifications Manual.

Class 2 Permeable Material Class 2 Permeable Material (Class 2 Perm) is a Caltrans specification for a mix of rock and fines that is placed around underdrains, provides storage in biotreatment measures, and does not require filter fabric, unlike open-graded aggregate

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 (NPDES), which regulates surface water discharges from municipal storm drains, publicly-owned treatment works and industrial discharges.

Cistern A storage facility for rainwater and/or stormwater for subsequent use. Cisterns can be located above or below ground. Water stored this way can be used to supplement or replace potable water used for irrigation, toilet flushing, or other uses.

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 that a municipal agency 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. Types of conduits and conveyance systems include open channels, covered channels and pipes. Culverts are covered channels or large diameter pipes that allow water to flow under a road, railroad, trail, or similar obstruction.

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

Design Storm A hypothetical storm defined by rainfall intensities and durations for which a stormwater control facility is designed.

Detached Single-Family Home Project The building of one single new house or the addition and/or replacement of impervious surface associated with one single existing house, which is not part of a larger plan of development.

Detention The temporary storage of stormwater runoff in ponds, vaults, or depressed areas to allow treatment by sedimentation and/or infiltration, or from which discharge of runoff is released at controlled flow rates. See **Infiltration** and **Retention**.

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

Direct Discharge 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 deep infiltration trenches, designed to bypass surface soils and transmit runoff directly to groundwater. See also **Infiltration Device**.

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

Discharger Any responsible party or site owner or operator within the MRP Permittees' jurisdiction whose site discharges stormwater runoff, or a non-stormwater discharge.

Dispersion The practice of routing stormwater runoff from impervious areas, such as rooftops, walkways, and patios, onto the surface of adjacent pervious areas. Stormwater runoff is dispersed via splash block, dispersion trench, or sheet flow and soaks into the ground as it moves slowly across the surface of the pervious area.

Drainage Management Area A designated area of the site that is either self-treating, self-retaining, or drains to a stormwater treatment measure, with its boundaries based on grade breaks, barriers, and/or type of surface.

Drawdown Time The time required for a stormwater detention basin or infiltration facility to drain and return to the maximum storage capacity. For detention basins, drawdown time is a function of storage volume and outlet orifice size. For infiltration facilities, drawdown time is a function of storage volume and infiltration rate.

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

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

Erosion The diminishing or wearing away of land due to wind or water. Often the eroded debris (silt or sediment) becomes a pollutant via stormwater runoff. Erosion occurs naturally, but can be intensified by land disturbing and grading activities such as farming, land development, road building, or timber harvesting.

Evapotranspiration The loss of water to the atmosphere by the combined processes of evaporation (from soil and plant surfaces) and transpiration (from plant tissues).

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 allow water to pass through while keeping sediment out.

Floor Area Ratio Floor Area Ratio is defined as the ratio of the total floor area on all floors of all buildings at a project site (except structures, floors, or floor areas dedicated to parking) to the total project site area.

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

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

Flow Duration Control An approach to mitigating development-caused hydromodification which involves running 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 also **Hydromodification Management**.

Flow-Through Planter A LID biotreatment measure designed to treat stormwater by intercepting runoff from a roof or other impervious surface and slowly draining it through biotreatment soil media into an underdrain.

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

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

Gross Density Gross density is defined as the total number of residential units divided by the acreage of the entire site area, including land occupied by public rights-of-way, recreational, civic, commercial and other non-residential uses

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

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

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

High-Flow Bypass In stormwater treatment measures, a pipe, outlet, or other structure designed to convey flood flows (i.e., flows that exceed the water quality design flow) directly to the storm drain system without entering the treatment measure.

Hydrodynamic Separator Mechanical stormwater treatment systems designed as flow-through structures that use centrifugal force to remove sediment, trash, and oil and grease. Acceptable for use as a pretreatment measure.

Hydrograph Runoff flow rate plotted as a function of time.

Hydrologic Source Control Site design techniques that minimize and/or slow the rate of stormwater runoff from the site.

Hydromodification The modification of the runoff hydrograph from a project site that is caused by land development, resulting in increased peak flows, volumes, and flow durations. The effects of hydromodification include, but are not limited to, increased bed and bank erosion in the receiving stream, loss of habitat, increased sediment transport and deposition, and increased flooding.

Hydromodification Management A set of techniques focused on retaining, detaining, or infiltrating runoff (e.g., see **Flow Duration Control**) to meet pre-project conditions. Hydromodification management helps prevent erosion problems caused by increased stream flows and sediment transport downstream of a watershed.

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

Impervious A term applied to surfaces – roads, sidewalks, rooftops, and parking lots – that prevent or inhibit rainfall from infiltrating into native soils.

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; gravel areas not built as pervious pavement systems, and any other continuous watertight pavement or covering. Landscaped soil and pervious pavement systems, including pavers with pervious openings and seams, underlain with pervious soil or pervious storage material, such as an aggregate layer sufficient to hold at least the C.3.d volume of rainfall runoff are not impervious surfaces as long as infiltration into native soil can occur. 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 are considered impervious surfaces for purposes of runoff modeling for meeting the hydromodification management standard.

Indirect Infiltration Infiltration via facilities such as landscaped areas and bioretention areas that are expressly designed to hold and treat runoff and allow it to percolate into surface soils. Runoff may reach groundwater indirectly following filtration by surface soils.

Infiltration The use of the filtration, adsorption, and biological decomposition properties of soils to remove pollutants prior to the intentional routing of stormwater runoff to subsurface storage for potential groundwater recharge.

Infiltration Devices Infiltration facilities that are 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). For the purposes of this document, these are also referred to as direct infiltration methods.

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). For the purposes of this document, these are also referred to as indirect infiltration methods, which allow stormwater runoff to percolate into surface soils. The infiltrated water may either percolate down into subsurface soils, or it may be drained into subsurface pipes.

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 surface and/or subsurface soils.

Inlet An entrance into a ditch, storm drain, or waterway.

Integrated Pest Management (IPM) An approach to weed and pest control that aims to avoid/reduce the use of chemicals (i.e. pesticides and herbicides). Instead, IPM 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, thus avoiding the use of chemical pesticides.

Interceptor Trees A site design measure that consists of a tree in the landscape near an impervious surface. <u>Interceptor trees are no longer permitted as a method of compliance with MRP 3.0 C.3 requirements.</u>

Joint Treatment Facility A stormwater treatment facility built to treat the combined runoff from two or more Regulated Projects located adjacent to each other.

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 one or more of the following types of stormwater treatment measures: infiltration, evapotranspiration, rainwater harvesting and use, and biotreatment.

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

Maximum Extent Practicable (MEP) A standard for implementation of stormwater management actions to reduce pollutants in stormwater. Clean Water Act (CWA) 402(p)(3)(B)(iii) requires that municipal stormwater permits "shall require controls to reduce the discharge of pollutants to the maximum extent practicable, including management practices, control techniques and system, design and engineering methods, and such other provisions as the Administrator or the State determines appropriate for the control of such pollutants." Also see State Board Order WQ 2000-11.

Media Filter A stormwater treatment measure that allows runoff to flow through a filter bed or cartridges filled with an absorptive media designed to remove pollutants.

Municipal Regional Stormwater Permit (MRP) The Phase I municipal stormwater NPDES permit under which discharges are permitted from municipal separate storm sewer systems throughout Santa Clara Valley and other NPDES Phase I jurisdictions within the San Francisco Bay Region.#The current permit ("MRP 3.0", Order No. R2-2022-0018) was adopted on May 22, 2022 and amended on October 11, 2023.

New Development Land disturbing activities, construction or installation of a building or structure, creation of impervious surfaces, and/or land subdivision on a previously undeveloped site.

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 are prohibited.

Notice of Intent (NOI) A formal notice that must be sent to State Water Resources Control Board by an owner/developer to obtain coverage under the State Construction General Permit (or other General 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 General Permit.

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

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

Operation and Maintenance (O&M) Refers to requirements in the MRP to inspect stormwater treatment and hydromodification management measures and implement preventative and corrective maintenance in perpetuity. See Chapter 8.

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

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

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

Percolation The movement of water through pores in soil or permeable rock.

Permeability A property of soil that enables water or air to move through it, usually expressed in units of 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.

Pervious Pavement For the purposes of this document, pervious pavement is defined as (but not limited to) any of the following types of properly designed paving or pavement systems: permeable interlocking concrete pavement (PICP), pervious or permeable concrete pavers, pervious grid pavements containing either gravel or turf, pervious concrete, porous asphalt, turf block, grasscrete, and bricks and stones set on an aggregate base with aggregate in the joint spaces. Pervious paving or pavement systems are designed to store and infiltrate rainfall at a rate equal to immediately surrounding unpaved, landscaped areas, or store and infiltrate the rainfall runoff volume described in Provision C.3.d of the MRP.

Pervious Surface A natural, landscaped, or permeable hardscape (e.g., turf block, brick, natural stone, cobbles, gravel) surface that allows surface runoff to infiltrate into underlying soils.

Perviousness The ability of a surface to allow penetration by stormwater and infiltration into 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 beneficial use of the receiving water.

Post-Construction Stormwater Control See **Stormwater Control Measure**.

Priority Development Area A Priority Development Area is an existing or planned infill development area formally designated by the Association of Bay Area Government's Metropolitan Transportation Commission's FOCUS regional planning program.

Provision C.3 A section of the MRP requiring each Permittee to control the flow of stormwater and stormwater pollutants from new and redevelopment sites over which it has jurisdiction.

Rainwater Harvesting The capturing and storing of stormwater runoff for later use for irrigation or non-potable indoor use.

Rational Method A method of calculating runoff flows based on rainfall intensity, a runoff coefficient, and the drainage area.

Redevelopment Land-disturbing activity that results in the creation, addition, or replacement of exterior impervious surface area on a site on which some past development has occurred.

Regional Project A private or public stormwater treatment or hydromodification control facility that collects runoff from a large area or from multiple development projects and discharges into the same watershed that the C.3 Regulated Project does.

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

Replaced Impervious Surfaces Hardscape or roof area installed on an area of a site that was previously impervious, even if the type of impervious surface changes. Also includes the removal and replacement of an asphalt or concrete pavement to base course or lower or repairing the pavement base (including repair of the pavement base).

Retention The storage of stormwater to prevent it from leaving the development site.

Runoff Water originating from rainfall and other sources (e.g., sprinkler irrigation) that does not get absorbed or retained on the land surface and flows into drainage facilities and receiving water bodies.

Santa Clara Valley Urban Runoff Pollution Prevention Program The Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP or Urban Runoff Program) is an association of thirteen cities and towns in Santa Clara Valley, the County of Santa Clara, and Valley Water that share a common NPDES permit to discharge stormwater to South San Francisco Bay. Member agencies (Co-permittees) include Campbell, Cupertino, Los Altos, Los Altos Hills, Los Gatos, Milpitas, Monte Sereno, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale, the County of Santa Clara, and Valley Water.

Sedimentation The process of depositing soil particles, clays, sands, or other sediments.

Sediments Soil, sand and minerals washed from land into water, usually after rain.

Self-Retaining Area An area of a development site designed to retain the first inch of rainfall (by ponding and infiltration and/or evapotranspiration) without producing stormwater runoff, and receive runoff from adjacent impervious areas. Self-Retaining Areas may include graded depressions with landscaping or pervious pavement. "Areas Draining to Self-Retaining Areas" are adjacent impervious or partially pervious areas that drain to Self-Retaining Areas (see also **Dispersion**).

Self-Treating Area An area 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, pervious pavement, and interceptor trees. A Self-Treating Area only treats the rain falling on itself and does not receive stormwater runoff from other areas.

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

Source Control Measures Land use or site planning practices, or structural or nonstructural measures that aim to prevent runoff pollution by reducing the potential for contact with rainfall runoff at the source of pollution. Source control measures minimize the contact between pollutants and urban runoff.

Special Projects Certain types of smart growth, high density and affordable housing development projects that are allowed, under Provision C.3.e.ii of the MRP, to receive LID treatment reductions.

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

Stormwater Pollution Prevention Plan (SWPPP) A plan describing the temporary best management practices used to prevent erosion and control the discharge of sediment and other pollutants during construction of a project.

Stormwater Treatment Measure Any engineered system designed to remove pollutants from stormwater runoff by infiltration, evapotranspiration, settling, filtration, biological degradation, plant uptake, media absorption/adsorption or other physical, biological, or chemical process. This includes landscape-based systems such as bioretention areas as well as proprietary systems. Sometimes called a treatment control, treatment system, or treatment BMP.

Structural Source Control Measure Permanent features that are designed and constructed as part of a project to keep pollutants from coming in contact with stormwater runoff, such as sanitary sewer connections for washing areas.

Subsurface Infiltration System A stormwater treatment measure with underground pipes or vaults that store and infiltrate stormwater. These systems allow infiltration into surrounding soil while preserving the land surface above for parking lots, streets, parks, and playing fields.

Suspended Pavement System Systems that provide additional uncompacted soil volume for tree root growth supporting adjacent pavement areas as well as allowing for "underground" bioretention. The pavement can be suspended by using modular units such as Strata Vault and Silva Cell products, or by constructed suspension systems such as post and beam vaults, that contain uncompacted soil under pavement.

Total Project Cost For the purpose of determining impracticability of hydromodification management measures, total project cost includes the construction (labor) and materials cost of the physical improvements proposed, and does not include land, transactions, financing, permitting, demolition, or off-site mitigation costs.

Transit Hub "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. (A bus stop with no supporting services does not qualify.)

Treatment Any method, technique, or process designed to remove pollutants and/or solids from polluted stormwater runoff, wastewater, or effluent.

Tree Well Filter A stormwater treatment measure that has a tree planted in it. Tree well filters may be constructed as individual units or linked together in a series with or without suspended pavement systems. Tree well filters that contain biotreatment soil media are considered LID treatment measures.

Vector Control Any method to limit or eradicate vectors that carry and transmit disease-causing pathogens (e.g. viruses or parasites). Vectors include mammals, birds, or insects such as mosquitoes. For the purpose of this document, vector control refers to mosquito control.

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

Vegetated Swale Open, shallow channels with vegetation covering side slopes and bottom that collect and slowly convey runoff to downstream discharge points. Vegetated swales are no longer considered stand-alone LID treatment systems in the MRP.

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

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

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

WEF or URQM Method A method for determining the required water quality design volume of treatment measures, described in *Urban Runoff Quality Management* (WEF/ASCE, 1998).

Chapter

1

Introduction and Guide to Using this Handbook

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

1.1 Purpose of this Handbook

This handbook was written to help developers, builders, and project applicants include appropriate post-construction stormwater controls in their projects, to meet local municipal requirements and requirements of the Bay Area Municipal Regional Stormwater Permit (MRP). Municipalities covered by the MRP must require post-construction stormwater controls on development projects as part of their obligations under Provision C.3 of the MRP. This permit is a National Pollutant Discharge Elimination System (NPDES) permit issued by the San Francisco Bay Regional Water Quality Control Board (Regional Water Board), allowing municipal stormwater systems to discharge stormwater to local creeks, San Francisco Bay, and other water bodies if municipalities conduct prescribed actions to control pollutants. In case of conflicting information between this handbook and the MRP, the MRP requirements prevail.

The term "***post-construction stormwater control***" refers to permanent features included in a development 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) site design, source control, and treatment measures as well as hydromodification management measures. LID techniques reduce water quality impacts by preserving and re-creating natural landscape features, minimizing imperviousness, maximizing opportunities for infiltration and evapotranspiration, and using stormwater as a resource.

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

Information on best management practices (BMPs) that protect water quality during construction is available on the Urban Runoff Program's website www.scvurppp.org as well as the California Stormwater Quality Association's website www.casqa.org.

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 Background on the Urban Runoff Program

The Santa Clara Valley Urban Runoff Pollution Prevention Program (Urban Runoff Program) is an association of thirteen cities and towns in Santa Clara Valley, the County of Santa Clara, and the Santa Clara Valley Water District that share a common NPDES permit to discharge stormwater to South San Francisco Bay. Member Agencies (also called Co-permittees) include Campbell, Cupertino, Los Altos, Los Altos Hills, Los Gatos, Milpitas, Monte Sereno, Mountain View, Palo Alto, San Jose, Santa Clara, Saratoga, Sunnyvale, the County of Santa Clara, and Valley Water (formerly the Santa Clara Valley Water District).

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

1.3 How to Use this Handbook

> Some requirements in this Program-wide handbook ***may vary*** from one local jurisdiction to another.

When using this Program-wide handbook, 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 learn how the C.3 requirements – and other planning, zoning and building requirements – will apply to your project. Also, because regulatory requirements may change, be sure to ask the local municipal staff to provide any updates of information or requirements.

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

A synopsis of the handbook's chapters and appendices is provided below:

Chapters

- Chapter 2 explains how development affects stormwater quality and 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 techniques into planning permit and building permit application submittals for your project.
- Chapter 4 presents information on ***site design measures***, including guidance for self-treating and self-retaining areas, which can help reduce the requirements for stormwater treatment measures.
- Chapter 5 provides ***general technical guidance for stormwater treatment measures***, including hydraulic sizing criteria, getting runoff into stormwater treatment measures, infiltration guidelines, underdrains, bypassing high flows, using "treatment trains", mosquito control, and plant selection and maintenance.
- Chapter 6 gives technical guidance for ***specific types of stormwater treatment measures***, including bioretention area, flow-through planter, tree well filter, infiltration trench, subsurface infiltration system, rainwater harvesting and use, media filter, extended detention basin, green roof, and pervious paving.
- Chapter 7 explains the requirements for ***hydromodification management measures***, which keep the flow rates, volumes, and durations of post-project stormwater flows at pre-project levels, in order to minimize development-induced erosion in susceptible creek channels.
- Chapter 8 explains the ***operation and maintenance*** requirements for stormwater treatment measures.
- Chapter 9 describes the MRP's Provision C.3.e., which allows projects to construct or contribute to off-site ***alternative compliance*** projects instead of constructing on-site stormwater treatment measures.

Appendices

- Appendix A presents guidelines for using stormwater controls that promote on-site ***infiltration*** of stormwater, and includes a depth to groundwater map.
- Appendix B provides worksheets for ***hydraulic sizing*** of stormwater treatment measures, including a map of Mean Annual Precipitation and hydraulic sizing curves for treatment measures, as well as examples showing how to use the worksheets and sizing approaches.
- Appendix C provides regional ***Biotreatment Soil Specifications*** for use in stormwater biotreatment measures.
- Appendix D includes a ***list of plants*** appropriate for use in landscape-based treatment measures. It also offers general guidance on plant selection and maintenance.

- Appendix E contains resources for meeting the ***Hydromodification Management*** (HM) requirements, including an applicability flow chart and map, design guidance for flow duration control facilities, a description of the Bay Area Hydrology Model (BAHM) and information on applying the 2% cost criterion for infeasibility.
- 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 SCVURPPP ***Model Source Control Measures List***, for use in determining which source controls measures may need to be incorporated into your project.
- Appendix I includes information on determining the ***Feasibility of Rainwater Harvesting and Use*** and sizing curves for rainwater harvesting and use facilities.
- Appendix J features the ***Special Projects Criteria*** for determining the LID treatment reduction credits for which a smart growth project may be eligible.
- Appendix K features ***Site Design and Source Control Specifications for Small Projects***.

1.4 Precedence

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

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

Chapter

2

Background / Regulatory Requirements

This Chapter summarizes the impacts of development on stormwater quality and quantity and explains the post-construction stormwater control requirements for development projects.

2.1 Stormwater Issues 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 currently 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 natural drainage patterns, introduce pollutants, and increase erosion, degrading natural habitats.

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[1] USEPA, https://www.epa.gov/nps/basic-information-about-nonpoint-source-nps-pollution

[2] San Francisco Bay Regional Water Quality Control Board, Basin Plan, 2004. https://www.waterboards.ca.gov/sanfranciscobay/basin_planning.html

2.1.1 Stormwater Runoff in a Natural Setting

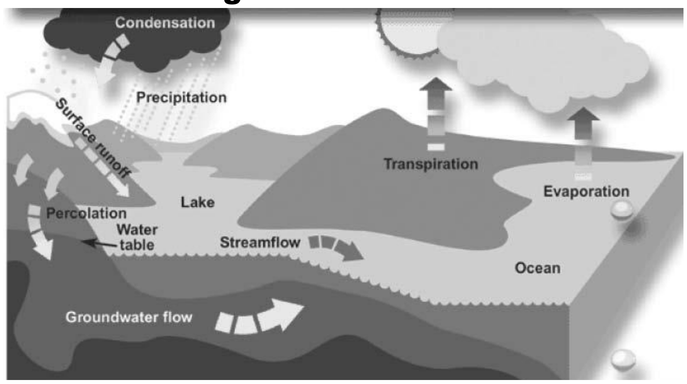

Figure 2-1: The Water Cycle (NGRDC/GDNR, 2005/06)

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 consists of 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 rainfall flows over the surface as runoff. The natural vegetation tends to slow the runoff and maintain a sheet flow condition, allowing suspended particles and sediments to settle. In the natural condition, the hydrologic cycle creates a stable supply of groundwater, and surface waters are naturally cleansed of impurities. Sediment is carried with the flow of stormwater runoff, but in a natural setting, creeks typically find an equilibrium in which sediment inflow to a given reach of stream generally equals sediment outflow from that reach.

2.1.2 Stormwater Runoff in Urban or Urbanizing Areas

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

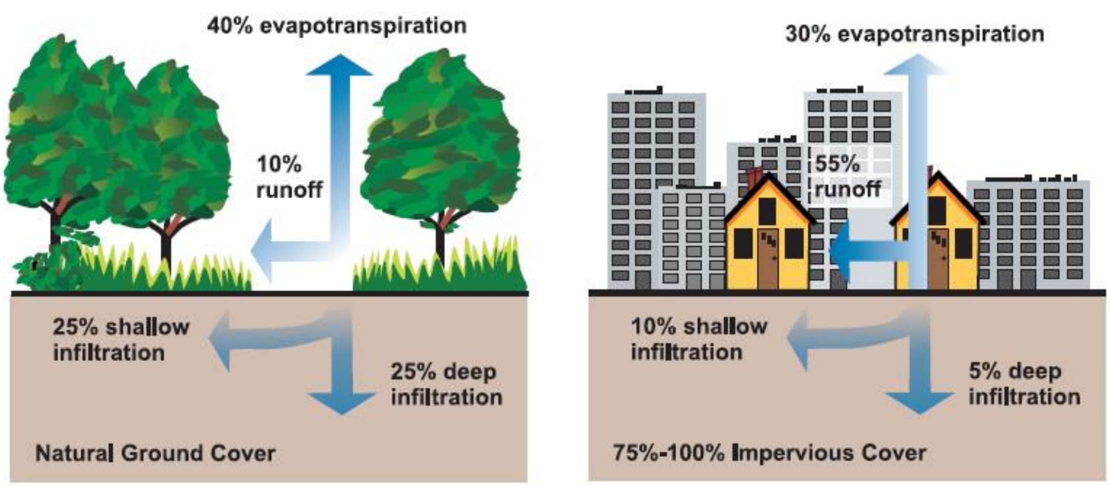

Figure 2-2: Change in volume of stormwater runoff after development. (adapted from USEPA, 2003)

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. This effect is called hydrograph modification or hydromodification. Natural creek channels must suddenly handle much greater volumes of water traveling at much faster rates, greatly increasing the duration of erosive forces on their bed and banks. In response to these changes, creek channels enlarge by eroding and may also become less stable. Figures 2-3 and 2-4 contrast creek channels in the natural condition and creek channels subject to the effects of hydromodification.

2.2 Post-Construction Stormwater Controls

Various permanent control measures have been developed in order to ***reduce the long-term impacts*** of development on stormwater quality and creek channels. These permanent control measures are often called post-construction stormwater controls, low impact development (LID) techniques, or post-construction best management practices (BMPs) to distinguish them from the temporary construction BMPs that are used to control sedimentation, erosion, and pollutants while a project is being constructed. ***LID techniques*** reduce water quality impacts of development by preserving and re-creating natural landscape features, minimizing imperviousness, and 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 Impacted by 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*** that help reduce stormwater pollutants and lessen increases in the peak runoff flow and volume, 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 or construct them with pervious paving;
- Minimize impervious surfaces that are directly connected to the storm drain system by routing runoff to landscaped areas;
- Cluster structures and paved surfaces; and
- Use landscaping as a drainage feature.

2.2.2 Source Control Measures

Source control measures consist of either structural project features or operational “good housekeeping” practices that ***prevent pollutant discharge and runoff*** at the source and keep 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
- Connecting areas used for washing equipment such as floor mats and storage racks to the sanitary sewer. (Note that any sanitary sewer connections must be approved by the local permitting authority.)

Examples of operational source controls include:

- Marking storm drain inlets with a “No Dumping” message;
- Street or parking lot sweeping; and
- Regular inspection and cleaning of storm drain inlets.

2.2.3 Stormwater Treatment Measures

Stormwater treatment measures are engineered systems that are designed to ***remove pollutants from stormwater*** using processes such as filtration, infiltration, and sedimentation. Stormwater treatment measures must be sized to comply with one of the hydraulic design criteria listed in MRP Provision C.3.d, which are described in Section 5.1 of this handbook.

Stormwater treatment measures can be categorized as either ***low impact development (LID) treatment measures*** or non-LID. LID treatment measures are designed to mimic a site’s predevelopment hydrology and provide stormwater treatment close to sources of runoff. The MRP requires the use of LID treatment measures in private development and identifies acceptable LID treatment measures as rainwater harvesting and use, infiltration, evapotranspiration, and biotreatment.

Chapter 6 provides technical guidance specific to treatment measures listed in Table 2-1.

Table 2-1 Stormwater Treatment and Site Design Measures Described in Chapter 6		
	LID	**Non-LID**[3]
Treatment Measures		
Bioretention areas	✓	
Flow-through planters	✓	
Tree well filters	✓ If biotreatment soils are used	✓ If biotreatment soils not used
Infiltration trench	✓	
Subsurface infiltration system	✓	
Rainwater harvesting and use	✓	
Media filter		✓
Extended detention basins		✓
Site Design Measures		
Green roofs	✓	
Pervious pavement	✓	
Grid pavements	✓	

For very limited types of urban infill, high density and affordable housing development, referred to as "Special Projects," use of non-LID tree well filters and media filters may be allowed. (See Section 2.3.3 and Appendix J for more information on Special Projects.)

2.2.4 Hydromodification Management Measures

If a project will be increasing the amount of impervious surface on the site, compared to the pre-project condition, and is located in the drainage area to a creek that is susceptible to erosion, the project may need to implement hydromodification management (HM) measures, either on-site, off-site, or within the creek channel. HM measures include site design, hydrologic source control, and treatment measures that promote infiltration or otherwise ***minimize the change in the peak flow, volume and duration of runoff***, when compared to the pre-project condition. HM measures may also include constructed facilities (such as basins, ponds, or vaults) that manage the flow rates and volumes of stormwater leaving a site (or from several sites that discharge to a regional facility), and under some conditions may also include re-engineering of at-risk channels downstream from the site. In some cases, a single stormwater control measure may be used to meet both the LID treatment and HM requirements for a project. More information on applicability and sizing of HM controls is provided in Chapter 7.

[3] Starting December 1, 2011, non-LID treatment measures are not allowed as stand-alone treatment (unless allowed in Special Projects), but non-LID treatment measures may be included as part of a "treatment train" (see Section 5.6).

2.3 Municipal Stormwater Permit Requirements

The development or redevelopment of a property represents an opportunity to incorporate post-construction controls that can reduce water quality impacts of the development over the life of the project. Since 2003, the Urban Runoff Program's municipal agencies have required new development and redevelopment projects to incorporate post-construction stormwater site design, source control, and treatment measures in their projects. Since 2005, the hydromodification management measures have been required as well, where applicable. Beginning December 1, 2011, new development and redevelopment projects have been required to incorporate LID-based post-construction stormwater control measures.

The Municipal Regional Stormwater Permit (MRP), reissued by the San Francisco Bay Regional Water Quality Control Board in May 2022, includes requirements for incorporating LID-based post-construction stormwater control measures into new development and redevelopment projects. These requirements are included in Provision C.3 of the MRP (Order No. R2-2022-0018, as amended by Order No. R2-2023-0019)[4]. Changes to the C.3 requirements took effect on July 1, 2023.

2.3.1 Do the C.3 Requirements Affect My Project?

Provision C.3.b establishes thresholds of impervious surface created and/or replaced at which new development and redevelopment projects must comply with Provision C.3. Projects that meet or exceed these thresholds are called ***Regulated Projects***. Provision C.3 also states that "all projects, regardless of size should be encouraged to incorporate appropriate source control and site design measures". Thus, municipalities may include standard ***stormwater conditions of approval*** as needed for all projects that receive development permits. These conditions of approval may require site design and source control measures as appropriate.

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

REGULATED PROJECTS

The thresholds for determining whether Provision C.3 applies to a project are based on the amount of impervious surface that is created and/or replaced[5] by a project, as described below. Beginning July 1, 2023, the following types of projects are Regulated Projects.

- Public and private projects that create and/or replace ***5,000 square feet or more*** of impervious surface on a parcel, including portions of the public right of way that are developed or redeveloped as part of the project.

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[4] See https://www.waterboards.ca.gov/sanfranciscobay/water_issues/programs/stormwater/

[5] Replaced impervious area includes hardscape or roof area installed on an area of a site that was previously impervious, even if the type of impervious surface changes. It also includes the removal and replacement of an asphalt or concrete pavement, to base course or lower, or repairing the pavement.

- Large detached single-family home projects that create and/or replace ***10,000 square feet or more*** of impervious surface and are not part of a larger development or redevelopment plan, including portions of the public right of way that are developed or redeveloped as part of the single-family home project.
- New public and private road projects that create and/or replace ***5,000 square feet or more*** of impervious surface. This includes construction of new roads (and associated bike lanes and sidewalks) and widening of existing public and private roads with additional travel lanes.
- Construction of impervious trails that create and/or replace ***5,000 square feet or more*** of impervious surface and are greater than or equal to 10 feet wide or are creek-side (within 50 feet of the top of bank).
- Public works projects in the right-of-way, such as sidewalk gap closures, sidewalk section replacement, and ADA curb ramps, that create and/or replace ***5,000 contiguous square feet*** or more of impervious surface.
- The following pavement maintenance practices associated with parcel-based projects (e.g., renovation of existing public/private parking lots and other pavement projects) if they create and/or replace ***5,000 contiguous square feet*** or more of impervious surface.
    - Removing and replacing an asphalt or concrete pavement to the top of the base course or lower, or repairing the pavement base (including repair of the pavement base in preparation for bituminous surface treatment, such as chip seal);
    - Extending the pavement edge without increasing the size of the road prism, or paving graveled shoulders; and
    - Resurfacing by upgrading from dirt to gravel[6], to a bituminous surface treatment (e.g., chip seal), to asphalt, or to concrete; or upgrading from gravel to a bituminous surface treatment, to asphalt, or to concrete.
- Projects involving **reconstruction of existing streets or roads**[7] that create and/or replace ***1 contiguous[8] acre or more*** of impervious surface and that are public road projects and/or fall under the building and planning authority of a Permittee. These include sidewalks and bicycle lanes that are built or rebuilt as part of the existing streets or roads, and utility trenching projects which are - on average, over the entire length of the project - greater than or equal to 8 feet wide.

Table 2-2 summarizes the requirements for Regulated Project types and thresholds. Table 2-3 summarizes included and excluded pavement maintenance practices.

[6] Gravel is considered an impervious surface unless it is part of a pervious pavement system.

[7] The definition of roads includes roads on levees.

[8] Project areas interrupted by cross streets or intersections are considered contiguous.

Table 2-2
Summary of Regulated Project Types and Thresholds

Project Type/Description	Impervious Surface Threshold Criterion	Impervious Surface Threshold	Notes	Sub-provision
Parcel-Based Requirements				
Detached single-family home not part of a larger plan of development	Cumulative	10,000 SF	1, 2, 3	C.3.b.ii.(6)
Public/private development (e.g. new library on previously undeveloped site)	Cumulative	5,000 SF	1, 3	C.3.b.ii.(1), (2)
Public/private redevelopment project (e.g. renovated hospital)	Cumulative	5,000 SF	1, 3	C.3.b.ii.(3)
Renovation of existing public/private parking lots and other pavement (see applicable activities in Table 2-3)	Cumulative	5,000 SF	1, 3	C.3.b.ii.(1)
Roads, Sidewalks, and Trails				
New roads, including sidewalks and bicycle lanes	Contiguous	5,000 SF	1	C.3.b.ii.(4)
Adding traffic lanes to an existing road	Contiguous	5,000 SF	1	C.3.b.ii.(4)
New impervious trail projects ≥ 10 feet wide or ≤ 50 feet from creek bank	Contiguous	5,000 SF	1, 4	C.3.b.ii.(4)
Public works projects such as sidewalk gap closures, sidewalk replacement, and ADA curb ramps not associated with a parcel-based project	Contiguous	5,000 SF	1	C.3.b.ii.(3)
Road Maintenance Projects				
Reconstruction of existing roads, including sidewalks and bicycle lanes (see applicable activities in Table 2-3)	Contiguous	1 acre	1	C.3.b.ii.(5)
Utility trenching projects ≥ 8 feet wide (on average over the length of the project)	Contiguous	1 acre	1	C.3.b.ii.(5)

Notes:

1) Projects that fall under the planning and building authority of the Permittee.

2) Includes addition of an ADU within a lot.

3) "Project" includes any improvements in the public right of way associated with the project..

4) Sidewalks, bicycle lanes, and trails may be excluded if runoff is directed to a vegetated area.

Table 2-3 Applicability of Pavement Maintenance Activities	
Specific Activities	**Included or Exempt**
Upgrade from dirt to gravel (exempt if built to spec for pervious pavement)	Included
Upgrade from dirt/gravel to asphalt or concrete pavement (exempt if built to spec for pervious pavement)	Included
Removing/replacing asphalt or concrete to top of base course or lower	Included
Repair of pavement base (i.e. base failure repair)	Included
Extending roadway edge (e.g., lane widening or safety improvement)	Included
Paving gravel or dirt roadway shoulder	Included
Interior Remodels	Exempt
Repair of roof or exterior wall surface	Exempt
Pothole and square cut patching	Exempt
Overlay gravel on existing gravel	Exempt
Overlay asphalt or concrete on existing asphalt or concrete (no increase in area)	Exempt
Applying chip seal or cape seal to existing asphalt or concrete pavement (no increase in area)	Exempt
Upgrade from chip seal or cape seal to asphalt or concrete (no increase in area)	Exempt
Shoulder grading	Exempt
Reshaping/regrading drainage	Exempt
Crack sealing	Exempt
Pavement preservation that does not expand road prism	Exempt
Vegetation maintenance	Exempt

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, for larger sites, in acres. The area of building roofs includes not only the footprint of the main building or structure, but also garages, roof overhangs, and other accessory structures. Non-building related impervious surfaces include asphalt, concrete, and gravel. Pervious pavement underlain with pervious soil and pervious storage material, such as a gravel layer sufficient to hold at least the Provision C.3.d volume of rainfall runoff, is not considered an impervious surface.

The municipalities use a "C.3 Data Form" to help project applicants perform these calculations and determine whether or which C.3 provisions apply to their projects. ***Contact your local jurisdiction*** to obtain its C.3 Data Form or equivalent. More discussion of the contents of the C.3 Data Form is provided in Chapter 3.

EXCLUSIONS FOR PENDING PROJECTS

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

- Any Regulated Project that has been approved with stormwater treatment measures in compliance with Provision C.3.d (numeric sizing criteria) under a previous municipal stormwater permit is exempt from the requirements of Provision C.3.c (LID requirements) in the current MRP and may proceed with the approved treatment measures.
- Any Regulated Project that was approved with <u>no</u> Provision C.3 stormwater treatment measures under a previous municipal stormwater permit and has not begun construction by the July 1, 2023, is required to fully comply with the current requirements of Provisions C.3.c and C.3.d, unless:

    1. The project was previously approved with a vesting tentative map that confers a vested right to proceed with development in substantial compliance with the ordinance, policies, and standards in effect at the time the vesting tentative map was approved or conditionally approved, as allowed by State law; or
    2. The local agency has no legal authority to require changes to previously granted approvals for the project, e.g., the project has been granted a building permit.

    An exemption from the LID requirements of Provision C.3.c. may be granted to this type of Regulated Project as long as stormwater treatment with media filters is provided that complies with the hydraulic sizing requirements of Provision C.3.d.
- Any pending Regulated Project that has not yet been approved as of June 30, 2023, and for which a Permittee has no legal authority to require new requirements under Government Code sections 66474.2 or 65589.5., subd. (o), is subject to the Provision C.3 requirements in the permit ("MRP 2.0") just preceding the current permit ("MRP 3.0"). These requirements are provided in Attachment I of MRP 3.0.

EXCLUSIONS FOR SPECIFIC TYPES OF PROJECTS

Provision C.3.c of the municipal stormwater permit excludes specific types of projects from Provision C.3 requirements, even if they meet the threshold requirements described above. The list of excluded project types is shown in Table 2-4.

Table 2-4 Projects Excluded from Provision C.3 Requirements	
Road and trail projects	• Sidewalks built as part of new streets or roads and built to direct stormwater runoff to adjacent vegetated areas; • Bicycle lanes built as part of new streets or roads, but that are not hydraulically connected to the new streets or roads and that direct stormwater runoff to adjacent vegetated areas; • Impervious trails that direct stormwater runoff to adjacent vegetated areas, or other non-erodible permeable areas, preferably away from creeks or towards the outboard side of levees, where those areas are at least half as large as the contributing impervious surface area; • Sidewalks, bicycle lanes, or trails constructed as pervious pavement systems; and • Caltrans highway projects and associated facilities[9].
Remodeling, repair or maintenance projects	• Interior remodels; • Routine maintenance or repair, such as roof or exterior wall surface replacement; or • The following pavement maintenance practices: o Pothole and square cut patching; o Overlaying existing asphalt or concrete pavement with asphalt or concrete without expanding the area of coverage; o Shoulder grading; o Reshaping/regrading drainage systems; o Crack sealing; o Pavement preservation activities that do not expand the road prism; o Upgrading from a bituminous surface treatment (e.g., chip seal) with an overlay of asphalt or concrete, without expanding the area of coverage; o Applying a bituminous surface treatment to existing asphalt or concrete pavement, without expanding the area of coverage; and o Vegetation maintenance.

2.3.2 What is Required by Provision C.3?

Except for the excluded projects listed in Table 2-2, Regulated Projects must incorporate the stormwater controls listed below:

- Site design measures;
- Source control measures;

[9] Caltrans has its own statewide stormwater NPDES permit, but when a Caltrans project is located in the right-of-way of a municipality covered by the MRP, the project must comply with C.3 requirements.

- Stormwater treatment measures; and
- Hydromodification management measures, if applicable.

In addition to the thresholds in Section 2.3.1, there are size thresholds for implementing site design measures but not stormwater treatment or hydromodification management measures:

- Small projects that create and/or replace between 2,500 square feet and 5,000 square feet of impervious surface; and
- Detached single-family home projects that create and/or replace between 2,500 square feet and 10,000 square feet of impervious surface.

REDEVELOPMENT PROJECTS

If the project is located on a previously developed site and will ***add or replace impervious surface***, then it is considered a redevelopment project and the following special provisions apply to it:

- ***"50 Percent Rule:"*** Projects that replace or alter less than 50 percent of the existing impervious surface need to treat stormwater runoff only from the portion of the site that is redeveloped. Projects that replace or alter 50 percent or more of the existing impervious surface are required to treat runoff from the entire site. Calculations of the altered portion should include portions of the public right of way that are altered as part of the redevelopment project.
- A project that does not increase the total amount of impervious surface over the pre-project condition is not required to meet hydromodification management (HM) requirements.

Large detached single-family homes and road widening projects are also subject to the 50 percent rule.

SINGLE-FAMILY HOME PROJECTS

Large single-family home projects are regulated when the following conditions are applicable:

- The construction of the detached single-family home is a stand-alone project that is not part of a larger, common plan of development. Typically, a larger common plan of development has shared infrastructure, such as utilities, and contiguous parcels, but the final determination will be made by the jurisdiction approving the project.
- The project replaces and/or creates 10,000 square feet or more of impervious surface.

Site design measures can be utilized effectively to reduce the impervious surfaces that are created and/or replaced or that require treatment.

ROAD RECONSTRUCTION PROJECTS

Road reconstruction projects that create and/or replace 1 contiguous acre or more of impervious surface and that are public road projects and/or fall under the building and planning authority of a permittee (including sidewalks and bicycle lanes that are built or rebuilt as part of the existing streets or roads) are required to comply with Provision C.3, including the "50 percent rule" for stormwater treatment (see above).

Additionally, the following road maintenance practices are also considered Regulated Projects under the Road Reconstruction category, it they trigger the 1 contiguous acre threshold.

- Removing and replacing an asphalt or concrete pavement to the top of the base course or lower, or repairing the pavement base (including repair of the pavement base in preparation for bituminous surface treatment, such as chip seal);
- Extending the pavement edge without increasing the size of the road prism, or paving graveled shoulders; and
- Resurfacing by upgrading from dirt to gravel, to a bituminous surface treatment (e.g., chip seal) to asphalt, or to concrete; or upgrading from gravel to a bituminous surface treatment, to asphalt, or to concrete.

The Road Reconstruction Project category also includes utility trenching projects which are greater than or equal to 8 feet wide, on average, over the entire length of the project and replace 1 contiguous acre or more of impervious surface.

ALTERNATIVE COMPLIANCE

The MRP allows projects to use "alternative compliance," to meet stormwater treatment requirements offsite or through in-lieu fee programs. See Chapter 9 for more information.

HOW DO PROJECTS MEET THE C.3 REQUIREMENTS?

Permit application submittals must include detailed information showing how the Provision C.3 stormwater requirements will be met. Chapter 3 provides step-by-step instructions for incorporating C.3 stormwater submittals into your permit application.

2.3.3 Special Projects

The MRP recognizes that certain urban infill, high density, or affordable housing development projects have inherent environmental benefits; that is, construction of such projects can either reduce existing impervious surfaces or create less "accessory" impervious areas and automobile-related pollutant impacts. There are three categories of qualifying projects, known as "Special Projects", that may receive LID treatment reduction credits. This means that these projects are allowed to use specific types of non-LID treatment measures (tree well filters and media filters) to treat a certain percentage of the site's runoff, <u>if the use of LID treatment is first evaluated and then determined to be infeasible</u>.

Prior to granting any LID Treatment Reduction Credits, the municipal agency must first determine the infeasibility of treating 100% of the amount of runoff specified in Provision C.3.d with LID treatment. Project applicants must provide a detailed description of the technical evaluation demonstrating why it is infeasible to treat runoff with LID, on- or off-site, with their project submittal. If LID is deemed to be feasible, then it must be implemented as the method of treatment for the C.3.d amount of runoff.

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: Affordable Housing Projects

A Regulated Project that meets the criteria for one of the categories may apply the LID treatment reduction credits according to the project's density, floor area ratio, location relative to an existing or planned transit hub or priority development area (PDA), minimized surface parking, and/or rent/mortgage rates of dwelling units. (The project may not apply the credits for more than one of the three categories.) The criteria and LID treatment reduction credits for each category are described in Appendix J.

2.3.4 Site Design Requirements for Small Projects

Certain small projects must meet site design requirements in Provision C.3.i of the MRP. This applies to:

- Projects that create and/or replace between 2,500 and 5,000 square feet of impervious surface; and
- Individual single-family home projects that create and/or replace between 2,500 and 10,000 square feet 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.

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

Chapter

3

Preparing Permit Application Submittals

This Chapter outlines the development review process and gives step-by-step instructions for preparing C.3 stormwater submittals for 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 C.3 requirements apply to your project, your permit application submittal must show how you have incorporated the required post-construction stormwater controls into the design of the project. Section 3.2 gives step-by-step instructions on how to do this, beginning at the earliest phases of project planning. Section 3.3 provides guidance for preparing for construction. Section 3.4 provides ***simple instructions for small sites***.

Project compliance with stormwater requirements must be addressed early in the design process. Preparing the preliminary design of stormwater controls ***simultaneously with the preliminary site plan*** and the landscaping plan will achieve the following benefits:

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

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

Check with the local municipality to determine what stormwater-related submittals are required and at what stages of the municipality's development project review process. Municipalities typically require a preliminary Stormwater Management Plan showing how your project will incorporate post-construction stormwater controls as part of the Planning Permit application. A review of the preliminary Stormwater Management Plan by municipal staff will either result in requests for more information (if incomplete), or conditions of approval which allow staff to grant final discretionary approval of the project. Submittal of a revised Stormwater Management Plan is typically required as part of the Building Permit application.

Some municipalities will require you to obtain a ***third-party review*** of the preliminary or revised Stormwater Management Plan by a qualified engineer or consulting firm. You may need to either pay a development fee to the municipality for this service, or contract directly with a qualified engineer. A list of qualified consultants for design, review and/or certification of stormwater treatment measures and hydromodification flow control facilities is provided on the Urban Runoff Program website and updated every two years by the Program. The list can be found at: https://scvurppp.org/2022/12/20/scvurppp-list-of-qualified-consultants/

The municipality will also require you to prepare and submit separate documents to show how erosion, sediment and other pollutants will be controlled ***during construction***. See Section 3.3 for more information.

3.2 How to Prepare a Stormwater Management Plan

A checklist is provided in this section to help identify the C.3 stormwater-related items that you will need to include with your project-specific Stormwater Management Plan. Contact the planning staff of the 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 instructions in this section to prepare your submittal. Applicants with smaller projects are encouraged to read Section 3.4, "***Simple Instructions for Small Sites***," before using these instructions.

C.3 submittals show how the project will reduce pollutant loading and prevent increases in creek channel erosion during ***long-term project operations***.

3.2.1 The Permit Submittal Checklist

Table 3-1 presents a checklist of items that are typically included in a project's Stormwater Management Plan. Municipal staff may use this checklist or something similar to determine whether your submittal is complete. It is 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, use ***hydromodification management measures*** to control erosion-inducing flows by reducing the peak rate, volume, and duration of runoff.

Table 3-1: Stormwater Management Plan Checklist		
Required?*		
Yes	No	Information on Plan Sheets
❑	❑	Existing natural hydrologic features (low points where ponding may occur, watercourses) and other natural resources (mature trees, areas of undisturbed vegetation)
❑	❑	Soil types and depth to groundwater
❑	❑	Existing and proposed site drainage network and connections to offsite facilities
❑	❑	Drainage Management Area (DMA) boundaries
❑	❑	Amount of existing pervious and impervious areas, for total project site, street frontage area (if applicable) and within each DMA
❑	❑	Amount of proposed new and/or replaced impervious area, including roof, plaza, sidewalk, street, and parking lot areas (for total site, street frontage area if applicable, and within each DMA)
❑	❑	Amount of proposed pervious area, including sensitive natural areas to be preserved and protected from development (for total site and each DMA)
❑	❑	Proposed site design measures to minimize impervious surfaces and promote infiltration**
❑	❑	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
❑	❑	Proposed locations and sizes of stormwater treatment measures and (if applicable) hydromodification management (HM) measures
❑	❑	Stormwater treatment measure and HM measure details
❑	❑	Preliminary planting palette for stormwater treatment/HM measures
		Written Information on Municipal Forms
❑	❑	Soil types and infiltration rate (saturated hydraulic conductivity if available)
❑	❑	Completed C.3 Data Form (obtain from local agency)
❑	❑	Completed Special Projects Worksheet and LID Feasibility Narrative (if applicable)
❑	❑	List of source control measures included in the project
❑	❑	Sizing calculations for treatment and/or HM measures
❑	❑	Preliminary maintenance plan for treatment and/or HM measures and responsible party

* 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.

3.2.2 Project-Specific Stormwater Management Plan

Step-by-step instructions are offered below to help you incorporate post-construction stormwater controls into your project and prepare your Stormwater Management Plan.

Step 1: Collect 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.

- ***Site boundaries*** and ***off-site improvements*** that may be required for the frontage area. The MRP requires that any impervious surfaces created or replaced as part of the project, including areas adjacent to the site in the public right of way, be managed by stormwater control measures. These areas can include sidewalks, roadways, planter strips, cycling facilities, street trees, etc.
- Existing natural features and landscaping (including on-site trees and street trees in the frontage area), especially ***hydrologic features*** including creeks, wetlands, watercourses, seeps, springs, ponds, lakes, areas of 100-year floodplain, and any contiguous natural areas. This information may be obtained by site inspections, a topographic survey of the site, and existing maps such as US Geologic Survey (USGS) quadrangle maps, Federal Emergency Management Agency (FEMA) floodplain maps, and US Fish and Wildlife Service (USFWS) wetland inventory maps.
- Existing site and off-site (frontage area) ***topography***, including the general direction of surface drainage, high and low points on the site, any steep slopes, outcrops, or other significant geologic features. This may be obtained from topographic maps and site inspections.
- Existing site and off-site (frontage area) ***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, project plans for the previous development, and site inspections. Identification of the creek to which the site ultimately drains (i.e., the watershed in which the site is located) will also be required.
- ***Soil types*** and ***depth to groundwater.*** The project soils report, if available, should be used to determine hydrologic soil groups and/or the saturated hydraulic conductivity of site soils. If a soils report is not required for the project, planning-level information may be obtained from the soils map in Appendix B or from the Natural Resource Conservation Service (NRCS) soil survey website[1] to determine the feasibility of onsite infiltration of stormwater. However, the local jurisdiction may require site-specific soils testing prior to project approval.
- ***Existing impervious areas.*** Measuring the area of existing impervious surface is necessary to calculate the amount of impervious surface that will be replaced or the increase in impervious surface that may need to be mitigated with HM controls. The MRP requires that redevelopment projects that replace more than 50 percent of impervious surface treat the stormwater runoff from the entire site, not just the redeveloped area. If 50 percent or less of the existing impervious surface is replaced, and the existing development was not subject to stormwater treatment measures, then only the redeveloped portion must be included in treatment measure design.

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[1] The NRCS Web Soil Survey can be accessed at: http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm.

- ***Zoning and planning*** information, such as setback, tree, street, and open space/landscape requirements.

> ***Constraints*** may include low permeability soils, high groundwater, steep slopes, geotechnical instability, high-density land use, or heavy vehicle traffic. ***Opportunities*** may include existing natural areas, low areas, and landscaped areas.

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 low permeability soils, high groundwater, steep slopes, geotechnical instability, high-intensity land use, heavy vehicular traffic, or safety concerns. ***Opportunities*** might include existing natural upland areas, areas set aside for landscaping, including open space and buffers (which can serve as locations for stormwater treatment measures), and low areas (suitable locations to site stormwater treatment measures to facilitate gravity flow of runoff, but which are not state or federal jurisdictional waters). Preparing a table or brief written summary of constraints and opportunities may prove helpful in selecting and siting stormwater controls.

Step 2: Determine the Applicable Post-Construction Stormwater Requirements

Effective July 1, 2023, stormwater treatment is required for projects that create and/or replace ***5,000 square feet*** or more of impervious surface, single-family home projects that create and/or replace ***10,000 square feet*** or more of impervious surface, and road reconstruction projects that create and/or replace 1 acre or more of impervious surface – with some exceptions listed in Chapter 2.

The ***C.3 Data Form*** provided by the local jurisdiction must be completed as part of the permit application submittal. Excerpts from the Urban Runoff Program's model C.3 Data Form are provided throughout this section to illustrate the process. Figure 3-1 shows how the form is used to calculate the amount of impervious surface that will be created, retained, and/or replaced. Note that the form contains rows for indicating the amount of impervious surface created and/or replaced off-site (i.e., improvements in the frontage area required by the project), as well as the pervious surface off-site under pre- and post-project conditions.

The C.3 Data Form is also used to determine whether treatment and/or HM measures are required, and indicate which site design measures, source control measures, treatment control measures and HM measures will be provided (see Figures 3-2 through 3-7).

2. Project Size

a. Total Site Area: ________ (ft^2)		b. Total Land Area Disturbed During Construction: ________ (ft^2) (including clearing, grading, stockpiling, or excavating)			
Project Totals	**Total Existing (Pre-project) Area (ft^2)**	**Existing Area Retained[1] (ft^2)**	**Existing Area Replaced[2] (ft^2)**	**New Area Created[2] (ft^2)**	**Total Post-Project Area (ft^2)**
Impervious Area (IA)					
c. Total on-site IA					0
d. Total off-site IA[3]					0
e. Total project IA	0	0	0	0	0
f. Total new and replaced IA			0		
Pervious Area (PA)[4]					
g. Total on-site PA					
h. Total off-site PA[3]					
i. Total project PA	0				0
j. Total Project Area (2.e.+2.i.)	0				0
k. Percent Replacement of IA in Redevelopment Projects: (Existing on-site IA Replaced ÷ Existing Total on-site IA) x 100% ______%					

[1] "Retained" means to leave existing IA in place. An IA that receives surface treatment (e.g., pavement resurfacing/slurry seal/grind) only is considered "retained". This category does not apply to off-site areas.
[2] The "new" and "replaced" IA are based on the total project area and not specific locations within the project. Constructed IA on a project that does not exceed the total pre-project IA will be considered "replaced" IA. A project will have "new" IA only if the total post-project IA exceeds the total pre-project IA (total post-project IA – total pre-project IA = New IA).
[3] Off-site areas include sidewalks and other parts of the public right-of-way (e.g., roads, bike lanes, curbs, ramps, park strip) that are being reconstructed as part of the project footprint. Note that gravel is considered an impervious surface.
[4] Include bioretention areas, infiltration areas, green roofs, and pervious pavement in PA calculations.

Figure 3-1: Excerpt from C.3 Data Form (Impervious Surface Calculation)

Impervious areas are those areas covered by a structure or pavement that prevents the land's natural ability to absorb and infiltrate rainfall/stormwater. Impervious surfaces include, but are not limited to, the following:

- Footprints of all buildings and structures, including rooftops, garages, carports, sheds, etc.;
- Driveways, paved patios, parking lots, and decking;
- Streets, sidewalks, and walkways;
- Impervious concrete, asphalt, and gravel; and
- Other continuous watertight pavement or covering.

"New" impervious surface is hardscape or a building roof that is created on an area of the site that was previously pervious. "Replaced" impervious surface is hardscape or roof area installed on an area of the site that was previously impervious, even if the type of impervious surface changes. For example, when a building is constructed in an area that used to be a parking lot, the parking lot impervious surface is replaced by the building roof surface, even though it is a new roof.

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

Figure 3-2 shows how the C.3 Data Form is used to determine whether Provision C.3 requirements apply. As indicated in Item 4.a of the form, projects that meet or exceed the size thresholds for impervious surface must include site design measures (Step 3), pollutant source controls (Step 4), and stormwater treatment measures (Step 6). If your project is below the C.3. thresholds, check with the local jurisdiction to determine whether Steps 3 and 4 will apply to your project. As indicated in Item 4.b of the form, if a project replaces more than 50% of the existing impervious area, C.3 requirements apply to the entire site. For projects that replace 50% or less of the existing impervious area, C.3 requirements apply only to the impervious area created and/or replaced.

4. MRP Provision C.3 Applicability:

a. Is #2.f. equal to **5,000 ft²** or more, or **10,000 ft²** for single family homes?

☐ Yes, C.3. source control, site design and treatment requirements apply

☐ No, C.3. source control and site design requirements may apply – check with local agency

b. For redevelopment projects, is #2.k. equal to 50% or more?

☐ Yes, C.3. requirements (site design and source control, as appropriate, and stormwater treatment) apply to the entire on-site area

☐ No, C.3. requirements only apply to the impervious area created and/or replaced

Figure 3-2: Excerpt from C.3 Data Form (C.3 Applicability)

To determine HM applicability, you will answer the questions on page 2 of the C.3 Data Form, shown in Figure 3-3:

5. Hydromodification Management (HM) Applicability:

a. Does the project create and/or replace one acre or more of impervious surface AND is the total post-project impervious area greater than the pre-project (existing) impervious area?

☐ Yes (continue) ☐ No – exempt from HM, go to page 3

b. Is the project located in an area of HM applicability (green area) on the HM Applicability Map? www.scvurppp.org/hmp-map

☐ Yes, the project must implement HM requirements

☐ No, the project is exempt from HM requirements

Figure 3-3: Excerpt from C.3 Data Form (HM Applicability)

HM measures are required for projects that create and/or replace one acre or more of impervious surface, AND result in an increase in impervious surface, AND are located in susceptible areas identified in the HM Applicability Maps. See Chapter 7 for more information on HM requirements.

Projects that are adjacent to streams and creeks may be required to comply with the Santa Clara Valley Water District's stream stewardship requirements. Check with the local municipality for the applicable requirements.

Step 3: Incorporate Site Design Measures

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

- Development should be set back from ***creeks and riparian habitat*** as required by the local jurisdiction. If your project involves impacts to creeks and riparian habitat, contact municipal staff to determine what coordination with the Regional Water Board and/or other resource agencies is required.

- If the project includes ***wetlands*** subject to Section 404 of the federal Clean Water Act, or habitat for ***special-status species*** protected by federal or State laws, these areas should be indicated, and evidence should be provided to demonstrate compliance with the applicable laws.
- The project will need to comply with any local tree preservation ordinances and other policies protecting ***heritage or significant trees***, including street trees. Mature trees can offer substantial stormwater benefits, and their preservation is recommended, where feasible, even if it is not required by law. (See Section 4.5 for potential treatment credits for existing trees.)
- 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.

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

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

Page 3 of the C.3 Data Form includes a checklist of site design measures (Figure 3-4), where you will indicate which site design measures have been incorporated into your project.

Site Design Measures

- ❑ Minimize land disturbed (e.g., protect trees and soil)
- ❑ Minimize impervious surfaces (e.g., reduction in post-project impervious surface)
- ❑ Minimum-impact street or parking lot design (e.g., parking on top of or under buildings)
- ❑ Cluster structures/ pavement
- ❑ Disconnected downspouts (direct runoff from roofs, sidewalks, patios to landscaped areas)
- ❑ Pervious pavement
- ❑ Green roof
- ❑ Other self-treating[5] area (e.g., landscaped areas)
- ❑ Self-retaining[5] area
- ❑ Rainwater harvesting and use (e.g., rain barrel, cistern for designated use)[6]
- ❑ Preserved open space
- ❑ Protected riparian and wetland areas/buffers
- ❑ Other ____________

Figure 3-4: Excerpt from C.3 Data Form (Site Design Measures)

Options for site design techniques include the following:

- Direct ***runoff to depressed landscaped areas.*** You may be able to design an area within your site to function as a "self-retaining area," in which the amount of stormwater runoff that is required to be treated is infiltrated or retained in depressed landscaped areas. A maximum 2:1 ratio of impervious area to the receiving pervious area is acceptable, where the pervious area can pond up to 3 inches in depth (see Chapter 4). Much higher ratios are possible if the runoff is directed to a bioretention area or other landscape-based treatment measures.

- 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 rain barrels or cisterns can be a practical way to reduce the amount of runoff from the site and store rainwater for use in on-site irrigation. Small-scale rainwater harvest systems (e.g., rain barrels) are considered a "site design" practice and do not need to be hydraulically sized for treatment. Use of larger scale rainwater harvest systems for treatment is described in Step 6 and Chapter 6.
- Use ***drainage as a design element.*** Bioretention areas, depressed landscape areas, tree well filters, vegetated buffers, and flow-through planters can serve as visual amenities and focal points in the landscape design of your site.


Figure 3-5: Stevens Creek Corridor Park in Cupertino includes turf block pavers in parking lot.

- Include alternative, pervious surfaces. ***Green roofs*** can partially or fully replace traditional roofing materials. ***Pervious pavement*** such as pervious concrete or asphalt, interlocking concrete pavers, turf block, permeable pavers, or grid pavement can be used for sidewalks, parking lots, and low-volume residential streets. Green roofs and areas of pervious pavement may be designed to function as self-treating areas (see next bullet).
- Identify ***self-treating areas.*** Some portions of your site may provide "self-treatment" if properly designed and drained. Such areas may include conserved natural spaces, large landscaped areas (such as parks and lawns), green roofs and areas of pervious paving. These areas are considered "self-treating" because infiltration and natural processes that occur in these areas remove pollutants from stormwater. As long as the self-treating areas do ***not receive runoff from impervious areas*** on the site, your drainage design may direct the runoff from self-treating areas directly to the storm drain system or other receiving water.

More information on site design techniques, including self-treating and self-retaining areas is provided in Chapter 4.

Figure 3-6: A turf block fire lane in Mountain View.

Step 4: Incorporate Source Control Measures

Pollutants are generated by many common activities that will occur after construction is completed. Each local jurisdiction has specific pollutant source control requirements for projects that include landscaping, swimming pools, vehicle washing areas, trash/recycling areas, and other sources of pollutants. The SCVURPPP ***Model Source Control Measures List*** is provided in Appendix H for reference (note that local lists may vary.) The list is divided into two parts: Structural Source Controls and Operational Source Controls. The two types of source controls are described as follows:

> Source control measures are permanent structures or operational activities that aim to ***prevent runoff pollution*** by reducing the potential for contact between the pollutant source and the stormwater runoff.

- ***Structural Source Controls -*** Structural source controls are permanent features that are designed and constructed as part of a project to keep pollutants from coming in contact with stormwater runoff, such as sanitary sewer connections for restaurant wash areas.
- ***Operational Source Controls*** – Operational source controls are "good housekeeping" activities that must be conducted routinely during the operations phase of the project – such as cleaning spills with dry methods, parking lot sweeping and maintaining "No Dumping" messages on drain inlets.

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

- ***Review structural source controls*** in the SCVURPPP Model List or the local list and compare this list to your site plan and intended facility uses after construction. 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 project designer was unaware of this requirement, it may not be shown on the project plans.
- ***Incorporate into project drawings*** all applicable structural source controls.
- ***Review the operational source controls*** to determine which are applicable to the proposed uses of the site.

- ***Document applicable source controls*** on the C.3 Data Form and in notes on the site plan or in the Stormwater Management Plan. One way to do this is to prepare and submit a table listing the potential sources of pollutants, the structural source control measures, and any operational source control measures that apply to the project. Table 3-2 is an example Table of Source Controls.

Table 3-2
Example Table of Stormwater Source Controls

Potential Source of Pollutants	Structural Source Controls	Operational Source Controls
Litter, pesticides, motor oil or other on-site pollutants	On-site storm drains shall be clearly marked with the words "No Dumping! Flows to Bay" (or applicable water body) per the municipality's specifications.	All on-site storm drain inlets shall be cleaned at least once a year immediately prior to the rainy season.
Refuse areas	New buildings (such as food service facilities and/or multi-family residential complexes or subdivisions) shall provide a covered or enclosed area for dumpsters and food waste and recycling containers that drains to the sanitary sewer. The area shall be designed to prevent water run-on to the area and runoff from the area.	The refuse area shall be kept clean and free of trash. Bins should be appropriately sized, and their lids should be kept closed.

You will need to indicate which source control measures you have incorporated into your project on page 3 of the C.3 Data Form. This checklist, which is shown in Figure 3-5, is not exhaustive; see Appendix H and check with the local jurisdiction for all the source control measures that will need to be incorporated.

Source Control Measures

- ❑ Wash area/racks, drain to sanitary sewer[7]
- ❑ Covered dumpster area, drain to sanitary sewer[7]
- ❑ Sanitary sewer connection or accessible cleanout for swimming pool/spa/fountain[7]
- ❑ Beneficial landscaping (minimize irrigation, runoff, pesticides and fertilizers; promotes treatment)
- ❑ Outdoor material storage protection
- ❑ Covers, drains for loading docks, maintenance bays, fueling areas
- ❑ Maintenance (pavement sweeping, catch basin cleaning, good housekeeping)
- ❑ Storm drain labeling
- ❑ Other ______________

Figure 3-7: Excerpt from C.3 Data Form (Source Controls)

Step 5: Determine Drainage Management Areas on Site

Review information on the existing and proposed site drainage network and connections to drainage offsite, which was collected in Step 1. Based on site topography, divide the site into Drainage Management Areas (DMA), each of which will drain to its own stormwater treatment area. A rooftop may be considered a DMA on its own, or it may be part of a larger DMA. Selecting appropriate locations for treatment and HM measures involves a number of important factors, including the following:

- ***Design for gravity flow.*** 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 should not be used for new and redevelopment projects as these sites should be implementing, and have every opportunity to implement, the goal of Provision C.3.c. to its full extent by mimicking a site's predevelopment hydrology and treating stormwater runoff close to its source. Pumped systems may be necessary for retrofit projects (particularly in the public right-of-way or those subject to the 50% rule) but should be considered the last resort, as they are more expensive, require more maintenance, are difficult to inspect, can introduce sources of underground standing water that promotes mosquito production, and have greater potential for failure. If pump systems are used in a project design, a dual pump or back-up system should be included to reduce the chance of failure, along with an alarm system to notify the proper owner or operator of a failure. Proper maintenance and inspection methods should also be developed and shared with the responsible party/municipality to help facilitate compliance with Provision C.3.h of the MRP.

- ***Incorporate treatment measures in the landscape design.*** Almost every project includes landscaped areas. Most zoning districts require a certain amount of landscaping or open space, and some require landscaped setbacks or buffers. It may be possible to locate some or all of your project's treatment/HM measures within required landscape areas.
- ***Plan for maintenance access and equipment.*** Stormwater treatment measures will need to be accessible to the largest piece of equipment that will be needed for maintenance. For example, bioretention areas need access for vegetation maintenance. Large extended detention basins need to have a perimeter access road accessible by heavy vehicles for sediment removal and controlling emergent vegetation. Underground treatment measures and media filters require access for periodic cleanout (by vactor truck) and media replacement. All treatment measures should allow access by maintenance workers, inspectors from the local municipality, and staff from the Santa Clara County Vector Control District. If the property will be subdivided, be sure to locate shared treatment measures in a common, accessible area – not on a private lots.

Step 6: Select Treatment and HM Measures

There are many different types of treatment measures, each with particular advantages and disadvantages, and new innovative solutions continue to be developed. ***Chapter 6*** provides technical guidance for specific types of stormwater treatment measures that may be used in the Santa Clara Valley. While other treatment measures may be acceptable, they may add complexity to the review and permitting of your project.

Figure 3-8: This landscaped area in San José also functions as a stormwater treatment area.

Beginning ***December 1, 2011***, stormwater treatment requirements must be met using LID treatment measures, either onsite or offsite at a regional facility. LID treatment measures include infiltration, evapotranspiration, rainwater harvesting and use, and biotreatment (landscape-based treatment measures such as bioretention and flow-through planters). Some landscape-based measures that have been used for stormwater treatment in the past, such as vegetated swales, are not considered LID treatment measures (unless they are designed to function as biotreatment areas). In addition, vault-based systems such as media filters and hydrodynamic separators are not acceptable treatment measures unless they are part of a treatment train. Media filters and proprietary high-rate tree well filters may be allowed for certain types of urban infill, high density or affordable housing projects if the projects qualify for LID treatment reduction credits.

LID treatment reduction credits can be applied to urban infill, high density, or affordable housing projects that meet specific criteria for "Special Projects" included in Appendix J. Contact municipal staff to determine whether your project meets the criteria to be considered a Special Project. If so, you may be able to use certain non-LID treatment measures for treating runoff from portions of your site for which LID treatment is infeasible. The Special Projects Checklist in Appendix J will help you determine the amount of LID treatment reduction credits that can be applied to your project. The checklist will need to be completed and submitted with your application.

Other general factors to consider when selecting stormwater treatment measures are describe below:

- ***Need for hydromodification management.*** If your project needs to meet both treatment and HM requirements, consider whether stormwater control measures can be designed to meet both treatment and HM needs. HM detention requirements are likely to exceed the volume required for water quality treatment and may also need to be coordinated with separate requirements for flood control detention.
- ***Size of the project site.*** Some treatment measures, such as flow-through planters and tree well filters, are especially suited for very small, urban sites. Bioretention areas may be suitable for many urban settings because of their flexibility in fitting into whatever sizes and shapes of pervious areas are available. For larger sites that can be divided into separate drainage areas, a variety of smaller stormwater treatment measures may be dispersed throughout the site.
- ***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 (sandy) soils generally have the lowest runoff potential and the highest infiltration rates. Group D soils (clay loam, sandy clay and clay) have the greatest runoff potential and lowest infiltration rates. Treatment measures that rely primarily on ***infiltration***, such as infiltration trenches*,* may be unsuitable for use in Group D soils as well as some Group C (silty loam) soils. Bioretention areas installed in Group C and D soils typically require underdrains.
- ***Site slope.*** Landscape-based treatment measures need to be carefully selected and designed when used 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 terraces or check dams for projects on sites with some slope constraints.
- ***Maintenance requirements.*** The amount of maintenance that a stormwater treatment measure will require should be considered when selecting treatment measures. You will need to prepare and submit a ***maintenance plan*** for stormwater treatment measures with

the planning and/or building permit application. Chapter 8 provides information regarding the maintenance requirements for various treatment measures.

- ***Potential for mosquito problems.*** The mosquito control guidance provided in Appendix F needs to be implemented for all stormwater treatment measures, with special consideration given to treatment measures that may have standing water for long periods of time. This includes some types of media filters that incorporate a permanent pool of water, and extended detention basins or subsurface infiltration systems (vault type) that may take a long time to drain.
- ***Potential for groundwater contamination.*** If considering an infiltration device, such as an infiltration trench, infiltration basin, or dry well, review the infiltration device guidelines presented in Appendix A to protect groundwater from potential contamination by pollutants in stormwater runoff.

You will indicate which treatment methods and HM methods you have incorporated into the design of your project on page 3 of the C.3 Data Form, as indicated in Figure 3-6 and 3-7:

Treatment Measures

- ❑ None (all impervious surface drains to self-retaining areas)

LID Treatment

- ❑ Bioretention area
- ❑ Flow-through planter
- ❑ Tree Well Filter or Trench with bioretention soils
- ❑ Rainwater harvest/use (e.g., cistern for designated use, sized for C.3.d treatment)
- ❑ Pervious pavement, sized for C.3.d treatment
- ❑ Infiltration trench
- ❑ Infiltration well/dry well
- ❑ Subsurface Infiltration System (e.g., vault or large diameter conduit over drain rock)
- ❑ Other ________________

Non-LID Treatment Methods

- ❑ Proprietary high flow rate tree box filter[8]
- ❑ Proprietary high flow media filter (sand, compost, or proprietary media)[8]
- ❑ Vegetated filter strip[9]
- ❑ Extended detention basin[9]
- ❑ Vegetated swale[9]
- ❑ Other ________________

Figure 3-9: Excerpt from C.3 Data Form (Treatment)

Flow Duration Controls for Hydromodification Management (HM)

❑ Extended Detention basin ❑ Underground tank or vault ❑ Bioretention with outlet control ❑ Other

Figure 3-10: Excerpt from C.3 Data Form (HM Controls)

STEP 7: PRELIMINARY DESIGN OF TREATMENT AND 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. You may be required to complete the sizing worksheets in Appendix B or provide similar documentation of the sizing calculations.

Drawings and details need to be included to illustrate the proposed design and sizing information based on runoff calculations. As indicated in Figure 3-8, you will also need to indicate in the C.3 Data Form which hydraulic sizing criteria were used when designing the treatment measures (using the dropdown menu):

7. Stormwater Treatment Measure (STM) Sizing for Projects with Treatment Requirements

Stormwater Treatment Measure (STM)	Hydraulic Sizing Criteria Used*
Choose from list	Choose from list
Choose from list	Choose from list
Choose from list	Choose from list
Choose from list	Choose from list

*Key: 1a: Volume – WEF Method
1b: Volume – CASQA BMP Handbook Method
2a: Flow – Factored Flood Flow Method
2b: Flow – CASQA BMP Handbook Method
2c: Flow – Uniform Intensity Method
3: Combination Flow and Volume Design Basis

Figure 3-11: Excerpt from C.3 Data Form (Hydraulic Sizing Criteria)

Design of HM measures is described in Chapter 7. If the project is required to include HM measures, these measures should be sized using the most recent version of the ***Bay Area Hydrology Model*** (BAHM 2023), developed by the Urban Runoff Program in cooperation with the Alameda Countywide Clean Water Program, the San Mateo Countywide Water Pollution Prevention Program, and the Contra Costa Clean Water Program. The BAHM has been approved by the Regional Water Board as an acceptable tool for ensuring that HM measure sizing is in compliance with the MRP. The BAHM results should be provided with the planning permit submittal. The BAHM 2023 may be downloaded at:
https://www.clearcreeksolutions.info/downloads

Step 8: Record Additional Stormwater Treatment of Non-Regulated Area

Any non-regulated impervious area that is provided stormwater treatment should be identified in the C.3 Data Form as shown in Figure 3-9.

8. Additional Stormwater Treatment of Non-Regulated Areas - Is the project providing stormwater treatment for non-regulated impervious area that is not included in **Item 2 Project Size**? For example, stormwater treatment of right-of-way areas that are outside the project footprint, or treatment measures that are treating more right-of-way impervious area quantities than required.

☐ Yes, complete the table below
☐ No

Additional Stormwater Treatment of Non-Regulated Areas

Non-Regulated Area Draining to Treatment Measure			Treatment Measures	Hydraulic Sizing Criteria
Impervious Area Treated (ft²)	Pervious Area Treated (ft²)	Total Area Treated (ft²)		
			Flow-through planter concrete lined	Choose from list
			Choose from list	Choose from list
			Choose from list	Choose from list
			Choose from list	Choose from list
			Choose from list	Choose from list
			Choose from list	Choose from list

Figure 3-12: Excerpt from C.3 Data Form (Additional Stormwater Treatment of Non-Regulated Areas)

Step 9: Identify Use of Alternative Certification

As indicated in Figure 3-10, you will need to indicate whether the treatment system sizing and design were reviewed by a qualified third-party professional.

9. Alternative Certification: Was the treatment system sizing and design reviewed by a qualified third-party professional that is not a member of the project team or agency staff?

☐ Yes ☐ No Name of Third-party Reviewer ____________________

Figure 3-13: Excerpt from C.3 Data Form (Alternative Certification)

Step 10: Specify Soils and Consider Planting Palettes for Treatment Measures

A specialized, biotreatment soil mix must be used with landscape-based treatment measures in order to ensure the appropriate infiltration rate for proper filtering of pollutants and the viability of the plants. MRP Provision C.3.c.i(2)(c)(ii) requires biotreatment soils with a minimum infiltration rate of 5 inches per hour, and a biotreatment measure surface area no smaller than what is required to accommodate a 5 inches/hour stormwater runoff surface loading rate. For more information on the appropriate soil mix for your treatment measure, refer to the regional soil specifications for use in stormwater biotreatment measures included in Appendix C.

The selection of appropriate plant materials is an important part of designing an effective landscape-based stormwater treatment measure. Plants need to be hardy, low-maintenance, and tolerant of saturated soils. Natives or drought tolerant plants that can survive long periods with little or no rainfall will ***help reduce irrigation requirements***, although irrigation is typically required for the establishment period. Appendix D provides guidance regarding the selection of plant materials for landscape-based treatment measures.

Step 11: Coordinate Stormwater Management Plan with Other Project Elements

When submitting the C.3 stormwater drawings with the permit submittal, the stormwater site design, source control, treatment and HM measures must be shown on a separate Stormwater Management Plan sheet. Check with the local municipality about its specific requirements for text descriptions that may need to accompany the Stormwater Management Plan sheet. In addition to the Stormwater Management Plan, 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.
- ***Soil Compaction during Construction.*** Compaction for building pads, remedial areas and from construction traffic can severely restrict the infiltration capacity of soils at your site. In the construction staging plan, protect and limit operation in those portions of the site that will accommodate self-treating areas or stormwater treatment measures that rely on infiltration.
- ***Building Drainage.*** Building codes require that drainage from roofs and other impervious areas be directed away from the building. The codes also specify minimum sizes and slopes for roof leaders and drain piping. Any stormwater measure located in close proximity to the building, or that may affect building foundations, must be designed to meet the minimum building code requirements.
- ***Control of Elevations.*** Getting runoff to flow from impervious surfaces to landscaped surfaces may require greater attention to slopes and elevations in grading and landscaping plans. For example:
  - ***Provide Adequate Change in Elevation*** between the pavement and vegetated areas. The landscaped area needs to be low enough so that runoff will flow into it even after the turf or other vegetation has grown up. If adequate slope is not provided, runoff will tend to pond on the edge of the paved surface.
  - ***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 erosion controls, such as cobbles or splash blocks, in the project plans.
  - ***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 (compacted per specifications from the Geotechnical Engineer). Otherwise they may settle more than the surrounding ground, creating depressions that can hold standing water and contribute to nuisances such as mosquito breeding.
- ***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 below the elevation of

habitable structures. 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 high flows directly to the storm drain system. More information on high flow bypasses is provided in Chapter 5. Check with your local jurisdiction regarding the need to prepare a drainage plan, and when it is required to be submitted.

- ***Signage for Traffic and Parking.*** If your project includes depressed landscaped areas next to parking lots, driveways or roadways, it may be necessary to include bollards, striping or signs to guide traffic, especially if curbs are flush with the pavement. Traffic striping may not be practical for some permeable pavements such as crushed aggregate and unit pavers. In these areas, signs and bollards may be needed to help direct traffic.
- ***Existing and Proposed Utilities.*** Vegetated treatment facilities like bioretention areas often end up being the locations for streetlights, backflow preventers, fire hydrants, mailboxes, and utility boxes. These features reduce the bioretention area below the proposed sizing (above and below ground), obstruct flow, and reduce infiltration due to soil compaction for the stability of the utilities. Utilities in these areas should be restricted or prohibited unless they can accommodate the issues listed above.

Step 12: Prepare a Preliminary Maintenance Plan

A stormwater treatment measure maintenance plan describes how stormwater treatment measures will be maintained after construction is completed during the life of the project. The C.3 Data Form you will complete and turn in with your permit submittal requires the property owner's name and the contact information for the party responsible for proper operation and maintenance (see Figure 3-11). ***Check with your local jurisdiction*** regarding when a complete maintenance plan is required for your project.

10. Operation & Maintenance Information

A. Property Owner's Name: __________

B. Responsible Party for Stormwater Treatment/Hydromodification Control O&M:

a. Name: __________

b. Address: __________

c. Phone/E-mail: __________

Figure 3-14: Excerpt from C.3 Data Form (O&M Information)

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 permit submittal, applicants may 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. Maintenance plan templates for various types of stormwater treatment measures are included in Appendix G.

Step 13: Submit Permit Application

Assemble all the items listed in Table 3-1 that municipal staff indicates are required for your project, complete the C.3 Data Form and include them as attachments to the Stormwater Management Plan that you will submit with the permit application.

3.3 Preparing for Construction

Projects that disturb one acre or more of land require coverage under the State's Construction General Permit. To obtain coverage, you must file a Notice of Intent (NOI) and prepare a Stormwater Pollution Prevention Plan (SWPPP). Details on SWPPP development can be found at: www.swrcb.ca.gov/water_issues/programs/stormwater/construction.shtml and the CASQA Construction BMP Handbook Portal (subscription required). The local municipality will not issue a grading permit until it has received a waste discharge identification number (WDID) demonstrating you have coverage under the Construction General Permit. Some municipalities also require a copy of the SWPPP. Information is collected on the C.3 Data Form (see Figure 3-12) to determine whether coverage under this General Permit is needed.

3. State Construction General Permit Applicability:

a. Is #2.b. equal to 43,560 ft^2 (1 acre) or more?

☐ Yes, applicant must obtain coverage under the State Construction General Permit (see https://www.waterboards.ca.gov/water_issues/programs/stormwater/construction.html)

☐ No, applicant does not need coverage under the State Construction General Permit.

Figure 3-15: Excerpt from C.3 Data Form (Construction General Permit Applicability)

If your project will disturb less than one acre of land (including material storage and contractor areas), it does not need Construction General Permit coverage, but you will likely need to prepare an erosion and sediment control plan to comply with local erosion control ordinances. Check with your local jurisdiction to determine the requirements.

3.4 Simple Instructions for Small Sites

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.*** You will need to include in your permit application submittal some of the items that are listed in the Table 3-1 checklist. Not every item in the checklist is required for every project. Consult with municipal staff and refer to web resources to determine submittal requirements.

- ***Maximize the use of site design measures.*** The less impervious surface area on the site, the smaller your stormwater treatment measures will need to be. Chapter 4 lists many strategies for reducing impervious surfaces, and it offers guidance for using self-treating areas (for example, lawns, areas paved with turf block, or green roofs) to further ***reduce the size*** of treatment measures. In some cases, you may be able to reduce the amount of impervious surface below the size threshold for C.3 applicability and eliminate the need for stormwater treatment measures. Note that projects that create and/or replace between 2,500 and 5,000 square feet of impervious surface are required to incorporate one of six site design measures. Single-family home projects that create and/or replace between 2,500 and 10,000 square feet of impervious surface are also required to incorporate one of six site design measures. Guidance on implementing these requirements is included in Appendix K.

- ***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 J). Chapter 6 includes technical guidance for LID treatment measures such as flow-through planters, tree well filters, and green roofs, which are suitable for ***small sites in densely developed areas***. Bioretention areas also lend themselves well to small sites, as they can fit into whatever space may be available on the property.

- ***Consider using the simplified sizing method.*** Chapter 5 includes a simplified sizing method for flow-through planters and bioretention areas. 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 D provides guidance for selecting appropriate plantings for landscape-based stormwater treatment measures. Municipal staff will check to confirm that the plants included in your design meet the criteria in this handbook.

- ***Avoid the use of pumps for moving stormwater.*** Whenever possible, it is best to use gravity and surface flow to convey stormwater to treatment measures. Pumps can malfunction and since they are typically out of sight, operation and maintenance issues may not be noticed. If pumps are necessary, ensure that there is a backup pump and that frequent maintenance checks will be performed to confirm proper operation. To avoid flooding in the event of a power outage, provide backup power to the pumps.

Chapter

4

Site Design Measures

This Chapter explains how low impact development (LID) site design measures help protect water quality and can reduce the size of required stormwater treatment measures.

Site design measures for water quality protection are low impact development (LID) techniques employed in the design of a project site in order to reduce the project's impact on water quality and beneficial uses. Including site design measures in a project 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 open space***, and
- Site design measures that ***reduce impervious surfaces*** in a project.

Preserving sensitive areas and open space includes the following types of sustainable practices:

- Preserving and protecting healthy trees during construction;
- Preserving topsoil by:
  - Not disturbing or grading areas with high-quality topsoil;
  - Stockpiling topsoil during grading and using it during landscape construction;
- Protecting open space areas from equipment compaction, or if this is not possible, uncompacting soils after grading;
- Avoiding compaction of soils in areas of the site that will not have structures;
- Protecting water bodies by avoiding or restricting construction within 100 feet or more from banks (or as required by local ordinances or policies);
- Avoiding lime treatment of soil; and
- Avoiding grading and construction work during the rainy season or when the soil is saturated.

The remainder of this chapter emphasizes site design measures that reduce impervious surfaces, which can reduce the amount of stormwater runoff that will require treatment. This translates into fewer or smaller facilities to meet stormwater treatment requirements than would have been needed without the site design measures. Site design measures are also important in minimizing the size of any required hydromodification management measures for the site. A wide variety of site design measures can be incorporated in your project, including:

- Design ***self-treating*** areas and ***self-retaining*** areas.
- ***Reduce the size of impervious features*** in the project.
- Use cisterns or rain barrels to ***store rainwater*** onsite.

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

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

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

4.1 Using Self-Treating Areas

Some portions of your site may provide "self-treatment" if properly designed and drained. Such areas may include conserved natural spaces, landscaped areas (such as parks and lawns), green roofs, and areas paved with turf block. These areas are considered "self-treating" because ***infiltration and natural processes that occur in these areas prevent stormwater and pollutants from being discharged.*** Areas of pervious pavement – such as pervious concrete, pervious asphalt, or permeable interlocking concrete pavers – and artificial turf may function as self-treating areas if they are designed to store and infiltrate (into native soil) the runoff volume described in Provision C.3.d of the MRP[1]. Technical guidance for green roofs, pervious pavement, and grid pavements is provided in Chapter 6.

As long as the self-treating areas do not receive runoff from other impervious areas on the site, your drainage design may route the runoff from self-treating areas directly to the storm drain system or other receiving water. In this way, the stormwater from the self-treating areas is kept separate from the runoff from paved and roofed areas of the site and does not require treatment.

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

[1] Current C.3 requirements define gravel as an impervious surface unless it is part of a pervious pavement system. Therefore, gravel areas (including decomposed granite surfaces) cannot be used as self-treating areas, although they can be designed to drain to landscaped areas.

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

Figure 4-1 compares the size of the stormwater treatment measure that would be required to treat the runoff from a site, depending on whether or not the runoff from a self-treating area discharges directly to the storm drain system or other receiving water. In the first (upper) sequence, runoff from the self-treating area is directed to the stormwater treatment measure. In the second (lower) sequence, runoff from the self-treating area bypasses the treatment measure and flows directly to the storm drain system or other receiving water, resulting in a smaller volume of stormwater that will require treatment.

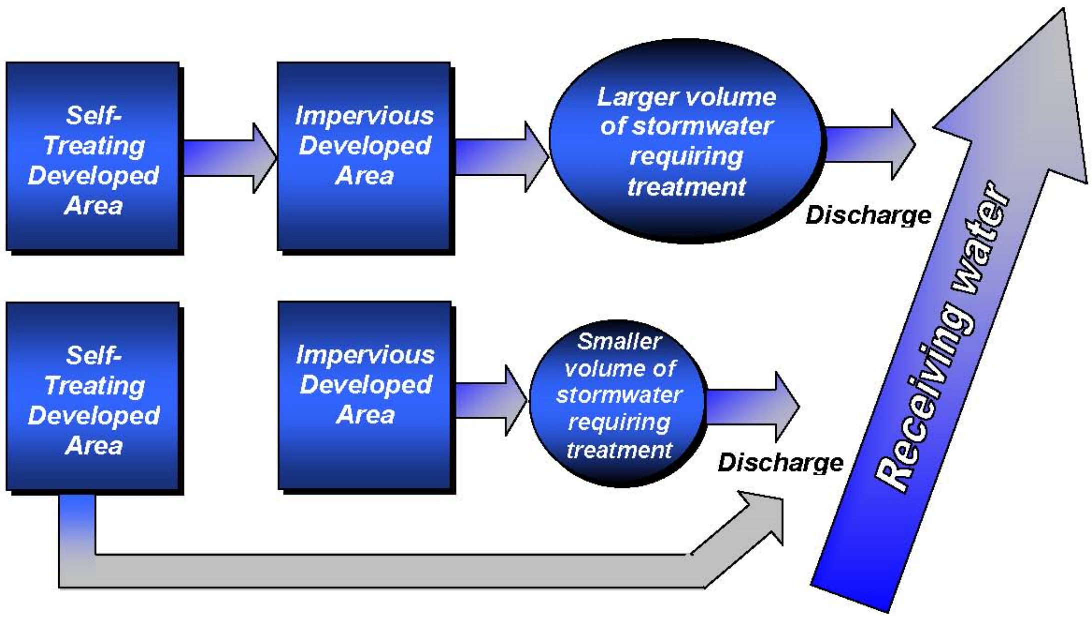
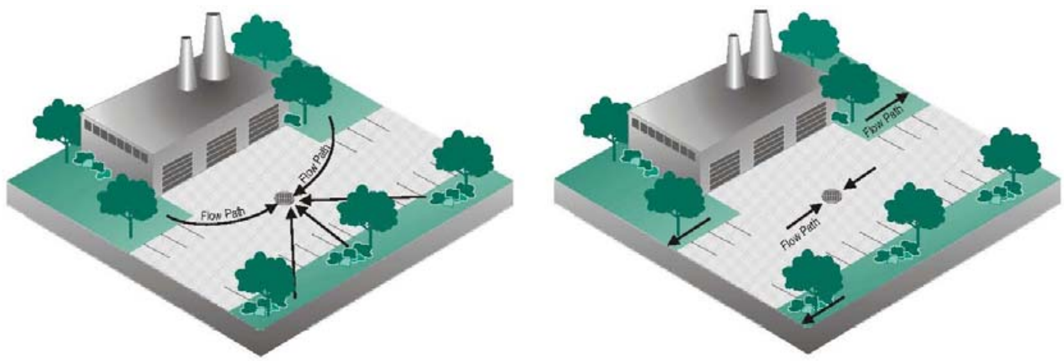


Figure 4-1: Self-Treating Area Usage (Source, BASMAA, 2003)

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



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

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

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

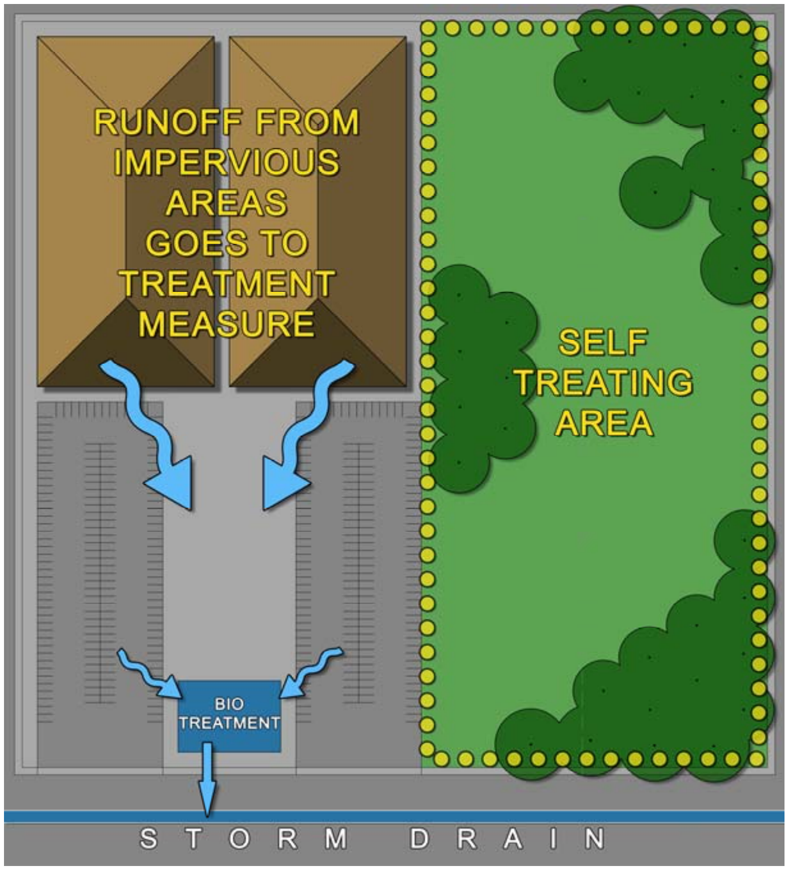


Figure 4-3: Schematic Diagram of a Site with a Self-Treating Area

4.2 Self-Retaining Areas

In “self-retaining areas”, also known as “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. If it is possible to create a self-retaining area on your site, you can design smaller stormwater treatment measures (as illustrated in Figure 4-4). ***Drainage from roofs and paving can be directed to the self-retaining area***, where it can pond and infiltrate 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 (as illustrated in Figure 4-5); or by designing areas of pervious pavement to accept runoff from impervious surfaces[2]. The following design considerations apply to self-retaining areas:

- Landscaped self-retaining areas are designed as concave areas that will retain the first one-inch of rainfall without producing any runoff (although self-retaining areas do not need to be hydraulically sized like a treatment measure, one inch depth roughly corresponds to the C.3.d. volume of runoff).

[2] Current C.3 requirements define gravel as an impervious surface unless it is part of a pervious pavement system. Therefore, gravel areas (including decomposed granite surfaces) cannot be used as self-retaining areas, although they can be designed to drain to landscaped areas.

- 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. The area must allow for infiltration of water and not be lined with impervious materials or constructed over an impervious barrier.
- Artificial turf (e.g., sports fields) 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 artificial turf and the impervious surfaces that contribute runoff. The area must allow for infiltration of water and not be lined with impervious materials or constructed over an impervious barrier.
- 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.
- The self-retaining area must drain completely within 5 days under saturated conditions.
- A ***maximum 2:1 ratio of impervious area to the receiving pervious area*** is acceptable, where the pervious area can pond up to 3 inches in depth (i.e., 1 inch of depth on the pervious area plus 1 inch from each of the 2 units of impervious area). The 2:1 ratio applies to landscaped areas, pervious paving, and artificial turf 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.
- The municipality may require amended soils, vegetation and irrigation in the self-retaining area to maintain soil stability and permeability. However, special biotreatment soils are not required.
- Self-retaining areas should be protected from construction traffic and compaction and should be preserved for the life of the project.

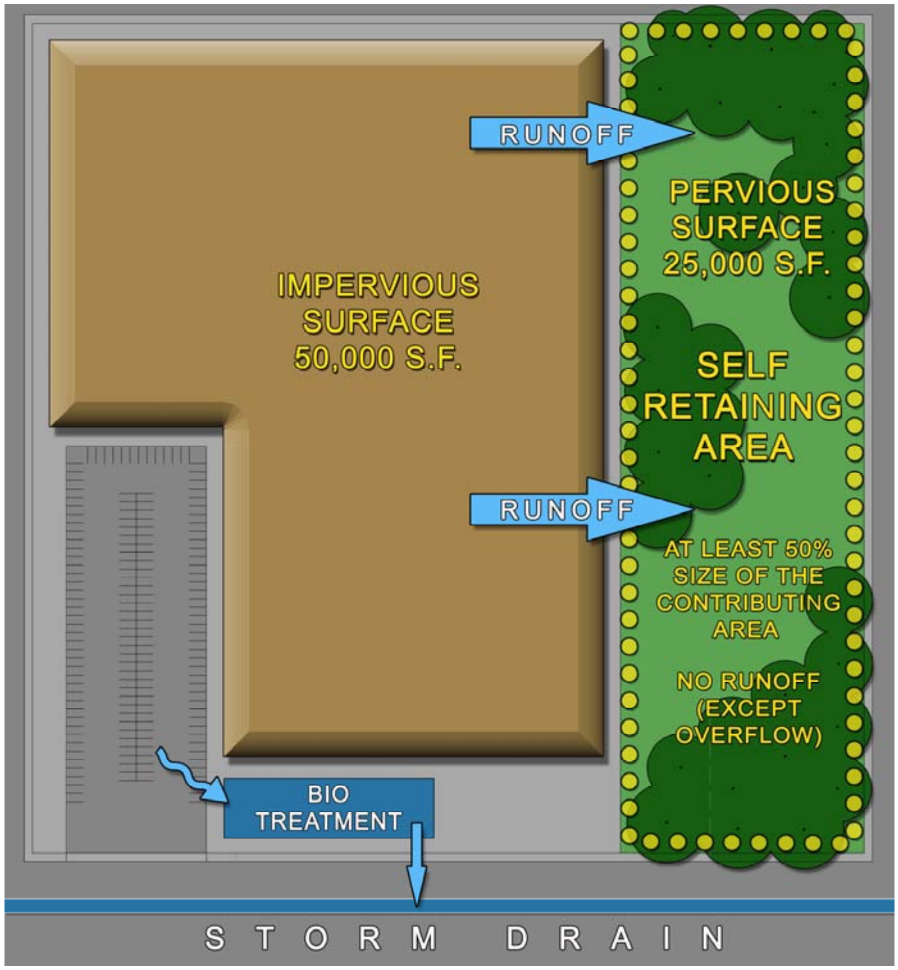


Figure 4-4: Schematic Drainage Plan for Site with a Self-Retaining Area

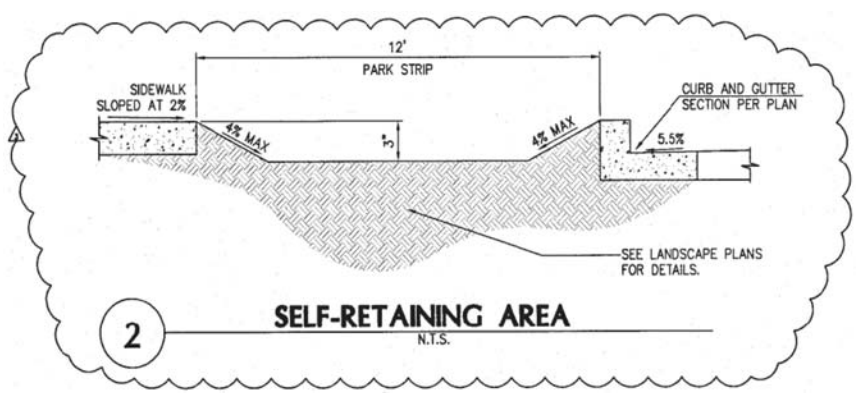


Figure 4-5: Example Self-Retaining Landscaped Area Cross Section

4.3 Reducing the Size of Impervious Areas

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

4.3.1 Convert Impervious to Pervious

Consider replacing planned impervious areas with ***pervious pavement*** – such as pervious concrete, porous asphalt, interlocking concrete pavers, or grid pavements – which is not considered "impervious" if designed to store and infiltrate the rainfall runoff volume described in Provision C.3.d of the MRP. Artificial turf is also considered a pervious area if designed to store and infiltrate the C.3.d amount of runoff. These areas are classified as self-treating areas and ***do not need to be counted as impervious area*** for the purpose of applying the C.3 size thresholds (i.e., determining whether your project is a Regulated Project). Green roofs are another site design measure that can be considered a self-treating area and subtracted from the impervious surface calculation. See Chapter 6 for technical guidance on pervious paving and green roofs.

Figure 4-6: Pervious paving at Mayfield Soccer Field in Palo Alto.

4.3.2 Use Alternative Site Layout Techniques

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

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

4.3.3 Minimize Surface Parking Areas

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

- ***Structured parking*** can be an efficient way to reduce the amount of impervious surface needed for parking. Structured parking can be integrated with usable space in buildings that also house offices, residential units or ground-floor retail, or can be built underground.
- Maximize efficiency of parking utilization with ***shared parking*** that serves different land uses that have different times of peak demand. For example, an office use with demand peaks during the day can share parking with restaurants, where demand is greatest during the evening, and to some extent residential uses, where demand peaks are in the evenings, nights and on weekends.
- 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.
- ***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 users, 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

- 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.

4.4 Rainwater Harvesting and Use

Rainwater harvesting systems are water storage systems that ***collect rainwater from roofs*** and other impervious building surfaces, and store it so it may be used for irrigation and other non-potable uses. Rainwater from a building's gutters and downspouts is conveyed to storage vessels, such as ***rain barrels*** or above- or below-ground ***cisterns***. For rainwater to serve as a useful irrigation supply in the Bay Area, it may need to be stored until dry periods, requiring more storage capacity. As allowed by the local jurisdiction, harvested rainwater may be also used for toilet flushing, industrial processes, car washing, washing machines, and swimming pools (if chlorinated).

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 local requirements. Also review the 2022 California Plumbing Code, effective January 1, 2023, which includes rainwater harvesting regulations (see Chapter 16). Section 6.6 of this Handbook contains more detail on the 2022 Plumbing Code.

Water storage systems should include ***preventive measures for pollutants and mosquito control***. The initial rainfall of any storm often picks up the most pollutants from dust, bird droppings and other particles that accumulate on the roof surface between rain events. ***If rainwater is used for drip irrigation,*** a diverter device may be needed to separate the dirtier, early rainfall (which is likely to contain solids that could clog the drip system) and divert it so that it does not mix with the cleaner runoff that follows. Through a simple valve design, a "roof washer" diverts the first 0.02 inches of rainfall per 24-hour period per square foot of roof area away from the rainwater harvesting storage tanks or cisterns. Water diverted by a roof washer may be routed to a landscaped area large enough to accommodate the volume, or a hydraulically-sized treatment measure. Roof washers should be installed in such a way that they will be easily accessible for regular maintenance. Also, water storage facilities must be equipped with tightly sealed covers and screens at all flow entry points to reduce mosquito-breeding risk.

Although many types of roofing materials may contribute pollutants to harvested water, ***certain roofing materials have particular concerns***. Water harvested from roofs with wood shingles or shakes may be suitable for irrigating ornamental landscaping only, due to the leaching of fire-proofing compounds. In addition, food-producing gardens should not be watered with rainwater from roofs with asphalt composite shingles, tar, lead, or other materials that may adversely affect food for human consumption.

Technical guidance for rainwater harvesting and use is provided in Chapter 6. A rainwater harvesting system is considered a stormwater treatment measure if it is designed to capture and use the full amount of runoff that is required to be treated per Provision C.3.d of the MRP (i.e., the "water quality design volume"). A rainwater harvesting system is considered a site design measure if it is designed to capture and use less than the water quality design volume and overflow into a landscaped area, or if the captured water cannot be used prior to the next rain event.

Figure 4-8: Rainwater is collected and used for flushing toilets at Mills College, Oakland.

Meeting Stormwater Treatment Requirements with Harvesting and Use

If rainwater harvesting systems are used to meet the MRP stormwater treatment requirements, they must be designed to handle back-to-back storms. In the event that the cistern or other water storage unit were full when a storm occurred, any water released from the cistern would need to be treated before discharging to storm drain system. To avoid the redundancy of installing both a rainwater harvesting system and treatment measures for treating overflows from the system, rainwater harvesting systems intended to meet stormwater treatment requirements should ***achieve one of the following three objectives:***

- ***Use the full water quality design volume of runoff for irrigation.*** In order to capture and use the full design volume for irrigation use, the following conditions must be met: (a) there must be sufficient irrigation demand for the design volume on or near the project during the wet season, or (b) it must be feasible to store the amount of the rainwater that is harvested during the wet season (October through April) until it is used for irrigation (primarily May through September, although some irrigation may occur during wet season months).
- ***Use the full water quality design volume of runoff for non-irrigation purposes.*** In order to harvest and use the full design volume for non-irrigation uses, the following conditions must be met: (a) there must be a reliable non-potable demand for the harvested rainwater during the wet season, and (b) the cistern or other water storage unit must be designed with sufficient volume to accommodate consecutive storms without discharging any of the required treatment volume to the storm drain system.
- ***Use the full water quality design volume of runoff from only a portion of the site.*** It may be possible to divide your site into drainage areas and store and use rainwater from only one drainage area, such as a rooftop or portion of a rooftop. As in the first two scenarios, the full design volume would need to be used for either irrigation or non-irrigation purposes, but in this case, it would be the design volume of runoff from one drainage area, which would allow for a smaller cistern.

More information on design of rainwater harvesting systems as stormwater treatment measures is provided in Chapter 6. Procedures for determining the feasibility of meeting stormwater treatment requirements with rainwater harvesting and use, including sizing curves for cisterns, are provided in Appendix I.

4.5 Tree Preservation and Planting

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. Tree canopies shade and cool paved areas.

Despite these many benefits, trees located near impervious surfaces (formerly known as “interceptor trees”) cannot currently be credited toward treatment of those areas. However, trees can be integrated into stormwater control measures (see discussion in Chapter 5).

Figure 4-9: Pruneridge Towers, Campbell (Source: Dave Docktor, City of Palo Alto)

Note: The use of ***interceptor trees*** as a site design measure to reduce the impervious area required to be treated at a development project is ***no longer allowed.***

4.6 Site Design Requirements for Small Projects

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

- Projects that create and/or replace between 2,500 and 5,000 square feet of impervious surface; or
- Individual single family home projects that create and/or replace between 2,500 and 10,000 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; or
- 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 Santa Clara Valley Urban Runoff Program collaborated regionally with 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 K.

To supplement guidance provided in the regional fact sheets, refer to Table K-2 in Appendix K 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

The technical guidance in this Chapter will help you with proper sizing and design concepts for various types of stormwater treatment measures.

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

- Hydraulic sizing criteria;
- Getting runoff into stormwater treatment measures;
- Infiltration guidelines;
- Underdrains;
- Bypassing high flows;
- Using "treatment trains";
- Mosquito control;
- Plant selection and maintenance;
- Integrating trees and stormwater treatment.

5.1 Hydraulic Sizing Criteria

The stormwater treatment measures must be sized to treat stormwater runoff from ***relatively small sized storms*** (storms with frequent recurrence intervals) that comprise the great majority of all storms. The intent is to treat most of the stormwater runoff on an average annual basis while recognizing that it would be infeasible to size stormwater treatment measures to treat runoff from very large storms that occur only every few years. (See Section 5.5 for more information on how stormwater treatment measures that are sized to treat runoff from small, frequent storms can also be designed to handle flows from large, infrequent storms.)

How Much of a Project Site Needs Stormwater Treatment?

The Municipal Regional Stormwater Permit requires that, for all "Regulated Projects"[1], runoff from the project site must be treated. Exceptions to the stormwater treatment requirement for Regulated Projects are pervious areas that are "self-treating" (including areas of pervious pavement with a hydraulically-sized aggregate base layer) as described in Section 4.1, and "self-retaining areas" designed to store and infiltrate runoff from rooftops or paved areas as described in Section 4.2. Other than "self-treating areas" and "self-retaining areas," runoff from ***all areas of a project site*** must receive stormwater treatment.

For redevelopment projects and road reconstruction projects, the ***"50% Rule"*** applies. Projects that alter or replace less than 50 percent of existing impervious surface need to treat stormwater runoff only from the portion of the site that is redeveloped. Projects that alter or replace 50 percent or more of the existing impervious surface are required to treat runoff from the entire site. Calculations of the altered portion should include portions of the public right of way that are altered as part of the redevelopment project.

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. ***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 tree well filters and most proprietary media filters. ***Volume-based treatment measures*** detain stormwater for periods of time and treat primarily through settling and/or infiltration processes. Examples of volume-based stormwater treatment measures include infiltration basins and infiltration trenches. Flow-through planters and bioretention areas can use a sizing method based on a ***combination of flow and volume*** for stormwater treatment. Table 5-1 shows which hydraulic sizing method is appropriate for commonly used stormwater treatment measures.

[1] "Regulated Projects" are projects that create and/or replace 5,000 square feet or more of impervious surface, detached single-family home projects that create and/or replace 10,000 square feet or more of impervious surface, and road reconstruction projects that create and/or replace 1 acre or more of impervious surface.

Table 5-1 Flow and Volume Based Treatment Measure Sizing Criteria		
Type of Treatment Measure	**LID?**	**Hydraulic Sizing Criteria**
Bioretention area	Yes	Flow- or volume-based or combination
Flow-through planter box	Yes	Flow- or volume-based or combination
Tree well filter	Yes[2]	Flow-based
Infiltration trench	Yes	Volume-based
Subsurface infiltration system	Yes	Volume-based
Rainwater harvesting and reuse	Yes	Volume-based
Media filter	No	Flow-based (most)
Extended detention basin	No	Volume-based

Note that this section does not address the sizing of a treatment system that will be used for both volume and flow duration control, as may be required if the project is subject to hydromodification management (HM) requirements.

Volume-Based Sizing Criteria

The Municipal Regional Stormwater Permit specifies two alternative methods for hydraulically sizing volume-based stormwater treatment measures:

- Determine the stormwater quality volume for the area, based on historical rainfall records, using the formula and volume capture coefficients in "Urban Runoff Quality Management (URQM), WEF Manual of Practice No. 23/ASCE Manual and Report on Engineering Practice No. 87 (1998), pages 175-178 (known as the "URQM Approach"); or
- Determine the stormwater quality volume equal to 80% of the annual runoff, in accordance with the methodology in Appendix D of the California Stormwater Best Management Practices Handbook (2003) using local rainfall data (known as the California BMP Handbook Approach").

The URQM approach is based on modeling and regression analysis using long-term rainfall records from six U.S. cities, including San Francisco, but the coefficients are based on average storm event size and do not represent local rainfall patterns. The California BMP Handbook Approach incorporates sizing curves that were developed using continuous simulation modeling based on local rainfall data. For these reasons, SCVURPPP recommends the use of the "California Stormwater BMP Handbook Approach." This approach was adapted for Santa Clara Valley using continuous simulation modeling to generate sizing curves based on rainfall records from four rain gages in Santa Clara County (see Table 5-2) for various soil types

> ***Recommended Volume-Based Sizing Approach***
>
> Volume-based treatment measures should be designed to treat the stormwater quality volume equal to 80% of the annual runoff from the site, using the sizing curves in Appendix B specific to Santa Clara Valley conditions.

[2] A tree well filter is considered LID treatment if biotreatment soil is used as the filter media and the unit is sized based on a 5 in/hr surface loading rate.

and site slopes. These curves are provided in Appendix B.

SCVURPPP has developed a Worksheet for Sizing Volume-Based Treatment Controls, which is included in Appendix B. Completing this worksheet will walk you through the following steps to size your volume-based treatment measure.

1. Determine the treatment measure ***drainage area***. This includes all areas that will contribute runoff to the stormwater treatment measure, including pervious and impervious areas. The drainage areas of the site should be laid out such that any self-treating areas (described in Section 4.1) or impervious surfaces that drain to self-retaining areas (described in Section 4.2) do NOT drain to the treatment measure.
2. Determine the ***percent imperviousness*** of the drainage area for the stormwater treatment measure.
3. Determine the ***mean annual precipitation*** for the project site (MAP_{site}) using the map in Appendix B.
4. Identify the ***reference rain gage*** that is closest to your project site from the list of rain gages in Table 5-2, and the mean annual precipitation for the reference gage (MAP_{gage}).
5. Determine the ***rain gage correction factor*** for the precipitation at your site using the information from Step 3 and Step 4.

   Correction Factor = MAP_{site}/MAP_{gage}
6. Identify the general ***soil type*** for the treatment measure drainage area, using the map in Appendix B or site soils information.
7. Determine the ***average slope*** for the drainage area of the treatment measure.
8. Determine the ***unit basin storage volume*** using the sizing curves provided in Appendix B. The worksheet in Appendix B will help you identify which curve to use for the applicable rain gage, depending on the average slope and soil type. You may need to interpolate between the curves for your site's average slope.
9. Size the stormwater treatment measure using the following equation:

Water quality design volume = Rain gage correction factor X Unit Basin Storage Volume X Drainage area

Table 5-2
Reference Rain Gages

Rain Gage	Mean Annual Precipitation (MAP_{gage})
San Jose Airport	13.9
Palo Alto	13.7
Gilroy	18.2
Morgan Hill	19.5

Appendix B includes examples of sizing volume-based treatment measures using the worksheet. Stormwater treatment measure sizing worksheets (in Excel format) are also available on the Program website at this link: https://scvurppp.org/newdev/

Flow-Based Sizing Criteria

The Municipal Regional Stormwater Permit specifies three alternative methods for hydraulically sizing flow-based stormwater treatment control measures, such as bioretention areas, flow through planters, and media filters. 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	The flow of runoff produced by a rain event equal to at least two times the 85th percentile hourly rainfall intensity, using local rainfall data.	Curves providing the 85th percentile rainfall intensity for the four rain gages in Santa Clara Valley are provided in Appendix B.
0.2 Inch-per-Hour Intensity (Uniform Intensity Approach)	Simplification of the Percentile Rainfall Intensity Method: The flow of runoff resulting from a rain event equal to at least 0.2 inches per hour intensity.	This simplified approach is most commonly used. In the Bay Area, calculating the percentile rainfall intensity has generally resulted in a value of 0.2 in/hr or greater. However, in some areas of the Santa Clara Valley, the percentile rainfall intensity is less than 0.2 in/hr, which may result in a smaller treatment facility.
10% of the 50-year peak flow rate (Factored Flood Flow Approach)	The design flow rate 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 85th percentile hourly rainfall depth and multiplying this value by two. 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.

Because two of the permit allowed methods yield similar results and the third method requires data that may not be readily available, SCVURPPP recommends the use of a ***rainfall intensity of 0.2 inches/hour*** or two times the 85th percentile rainfall intensity at a local rain gage (adjusted based on MAP) to design flow-based treatment systems.

The Sizing for Flow-Based Treatment Controls Worksheet in Appendix B provides the procedures to size the stormwater treatment measure 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 accomplish this, the worksheet uses the following steps:

1. Determine the ***drainage area***, "A," 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 [3]

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

Type of Surface	Runoff Coefficients "C" factor
Roofs	0.90
Concrete	0.90
Stone, brick, or concrete pavers with mortared joints and bedding	0.90
Asphalt	0.90
Stone, brick, or concrete pavers with sand joints and bedding	0.90
Pervious concrete	0.10
Porous 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

The runoff coefficients in Table 5-4 are for use only in stormwater treatment designs based on ***small, frequent storms***. These runoff coefficients are not for sizing conveyance or flood control facilities.

[3] 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.

[4] 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.

Appendix B includes examples of sizing flow-based treatment measures using the worksheet. Stormwater treatment measure sizing worksheets (in Excel format) are also available on the Program website at this link: https://scvurppp.org/newdev/

Simplified Sizing Method

A biotreatment measure (e.g., bioretention area *or* flow-through planter) can be sized by calculating a surface area equal to 4 percent of the contributing impervious area. This is a flow-based sizing method, assuming a runoff inflow of 0.2 inches per hour (equal to the rainfall intensity), with an infiltration rate of 5 inches per hour (0.2 in/hr divided by 5 in/hr = 0.04). This "4 percent method" is conservative as it does not take into consideration the volume of water that is temporarily detained in the surface ponding area; however, it is the recommended method to design bioretention areas, because it maximizes the amount of infiltration that can be achieved at a given location. If there are site constraints or infiltration is not allowed, then the combination flow and volume method may be used.

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 are within the drainage area that will contribute runoff to the treatment measure, the area of these pervious surfaces is multiplied by a factor of 0.1 and added to the area of impervious surface, to obtain the amount of "equivalent impervious surface". To apply the 4 percent method, the worksheet uses the following steps:

1. Based on the topography of the site and configuration of buildings, divide the site into drainage areas, each of which will drain to one LID treatment measure. Implement Steps 2 through 5 for each drainage area.
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 drainage areas for the treatment measures.
3. For each drainage area in which a portion 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 drainage areas, add the product obtained in Step 3 to the area of impervious surface, to obtain the area of "equivalent impervious surface."
5. Multiply the impervious surface (or equivalent impervious surface in applicable drainage areas) by a factor of 0.04. This is the required surface area of the LID treatment measure.

Combination Flow and Volume Design Basis

Some stormwater treatment measures, such as bioretention areas and flow-through planters, include some design elements that provide flow-based treatment and some that provide volume-based treatment. For example, flow-based treatment occurs in a biotreatment area with an underdrain as stormwater filters through the soil and flows out the underdrain. Volume-based treatment is provided when stormwater is stored in the surface ponding area and the pore spaces of the soil media. The ponding area may be sized so that it retains a certain volume of runoff prior to it entering the soil at the required 5 inch per hour surface loading rate.

The "simplified approach" for sizing bioretention areas and flow-through planters, in which the surface area of the treatment measure is designed to be 4 percent of the impervious area that drains to the treatment measure, is a flow-based sizing approach. This approach tends to result in the design of a conservatively large treatment measure because it does not account for any storage provided by the surface ponding area or media pore volume. A volume-based sizing approach for bioretention areas, in which the surface ponding area and depth are sized to contain the entire water quality design volume, is also conservative because it does not take into account the emptying of this ponding area into the soil media during the storm event.

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 criteria is best applied when using a continuous simulation hydrologic model to demonstrate that a treatment system is in compliance with C.3.d. However, when doing sizing calculations by hand, compliance with C.3.d. can be demonstrated by showing how the treatment system design meets both the flow-based and volume-based criteria.

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. Note that the approach assumes that all of the design rainfall becomes runoff, and thus ***it is only appropriate for use where the drainage area to the bioretention area is mostly impervious*** (small amounts of contributing pervious area can be converted to equivalent impervious areas using the factors in Table 5-4).

1. Determine the required treatment volume using the ***recommended volume-based sizing approach*** described earlier in Section 5.1. As part of this method, you will calculate the ***unit basin storage volume*** in inches using the sizing curves provided in Appendix B (adjusted for the mean annual precipitation of the project site) and the ***water quality design volume*** in cubic feet (the unit basin storage volume multiplied by the drainage area to the treatment measure, converted to units of cubic feet). For example, say you determined the adjusted unit basin storage volume to be 0.5 inches, and the drainage area to the bioretention facility is 7,000 square feet. Then the water quality design volume would be 0.5 inches × (1 foot/12 inches) × 7,000 square feet = 292 cubic feet.

2. Assume that a ***rainfall intensity of 0.2 inches/hour*** will be used as the flow based sizing criteria (as recommended by the Urban Runoff Program).

3. Assume that the rain event that generates the required capture volume of runoff determined in Step 1 occurs at a constant intensity of 0.2 inches/hour from the start of the storm (i.e., assume a rectangular hydrograph). Calculate the ***duration of the rain event*** by dividing the unit basin storage volume by the intensity. In other words, determine the amount of time required for the unit basin storage volume to be achieved at a rate of 0.2 inches/hour. For 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.

4. Make a ***preliminary estimate of the surface area*** of the bioretention facility by multiplying the equivalent impervious surface area to be treated by a sizing factor of 0.04. For example, a drainage area of 7,000 square feet × 0.04 = 280 square feet of bioretention treatment area.

5. Assume a bioretention area that is about 25% smaller than the bioretention area calculated in Step 4. 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 3. For example, for a bioretention treatment area of 210 square feet, with an infiltration rate of 5 inches per hour for a duration of 2.5 hours, the volume of treated runoff = 210 square feet × 5 inches/hour × (1 foot/12 inches) × 2.5 hours = 219 cubic feet.
6. 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 5. For example, the amount remaining to be stored comparing Step 1 and Step 5 is 292 cubic feet – 219 cubic feet = 73 cubic feet. If this volume is stored over a surface area of 210 square feet, the average ponding depth would be 73 cubic feet ÷210 square feet = 0.35 feet or 4.2 inches.
7. Check to see if the ***average ponding depth is approximately 6 inches*** *(or up to a maximum of 12 inches if allowed by the municipality)*, which is the recommended ponding depth in a bioretention facility or flow-through planter. If the ponding depth is less than 6 inches, the bioretention design can be optimized with a smaller surface area (i.e., repeat Steps 5 and 6 with a smaller area). If the ponding depth is greater than 6 inches (or the depth allowed by the municipality), a larger surface area will be required. (In the above example, the optimal size of the bioretention area is 190 square feet with a ponding depth of 6 inches.)

Appendix B includes examples of sizing bioretention areas using this combination flow- and volume-based method. Stormwater treatment measure sizing worksheets (in Excel format) are also available on the Program website at this link: https://scvurppp.org/newdev/

5.2 Getting Runoff into Treatment Measures

Stormwater may be routed into stormwater treatment measures using ***sheet flow or curb cuts.*** The following guidance on common curb cut types is taken from the San Mateo County Sustainable Green Streets and Parking Lots Design Guidebook.

Figure 5-1: Cobbles in this stormwater treatment measure in San José help prevent erosion.

A minimum 18-inch width is recommended for curb cuts, to avoid clogging. A minimum 2-inch drop in grade between the impervious surface and the finish grade of the stormwater treatment facility is required; a 4- to 6-inch drop is recommended so that vegetation or mulch build-up does not obstruct flow. To avoid erosion, cobbles or other energy dissipater materials are recommended below the drop for a distance of at least 4 feet. The overflow drain for the treatment measure should not be located directly in line with or next to the curb cut.

Standard Curb Cut: Design Guidance

- Opening should be at least 18 inches wide; for smaller facilities, 12" width may be allowed at more frequent intervals subject to municipal approval.[5]
- Curb cut can have vertical sides or have chamfered sides at 45 degrees (as shown).
- Need to slope the bottom of the concrete curb toward the stormwater facility.
- Allow a drop in elevation of 4 to 6 inches between the paved inlet surface and biotreatment soil elevation.
- Provide cobbles or other energy dissipater to prevent erosion below the drop, for 4 ft.

Figure 5-2: This standard curb cut at parking lot rain garden has 45 degree chamfered sides.

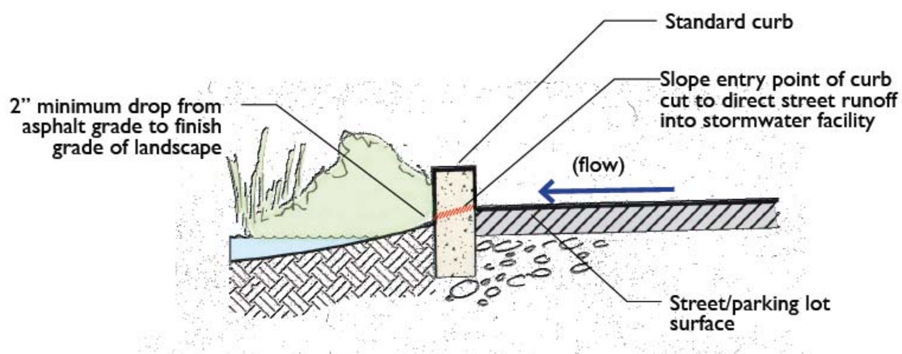


Figure 5-3: Standard curb cut: section view (Source: San Mateo Countywide Water Pollution Prevention Program [SMCWPPP] 2009)

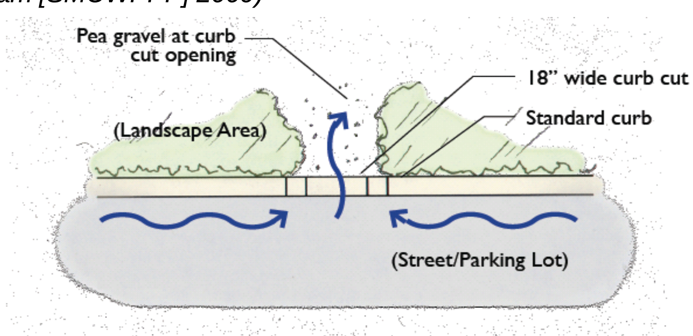


Figure 5-4: Standard curb cut: plan view (Source: SMCWPPP 2009)

[5] For on-grade openings, it is recommended that the designer calculate the required opening width to account for the approach velocity, so that the design flow does not bypass the opening. The opening to the treatment measure should be sized similar to an on-grade storm drain inlet. The flow rate, approach depth and flow cross section dictate the length of the curb opening needed. See Orange County Local Drainage Manual, 1996: http://www.ocflood.com/Documents/pdf/Local_Drainage_Manual_1996.pdf

Standard Curb Cut with Side Wings: Design Guidance

- Opening should be at least 18 inches wide; for smaller facilities, a 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 a 2" drop from the inlet to the splash apron or energy dissipater.
- Provide cobbles or other energy dissipater to prevent erosion below the drop.

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

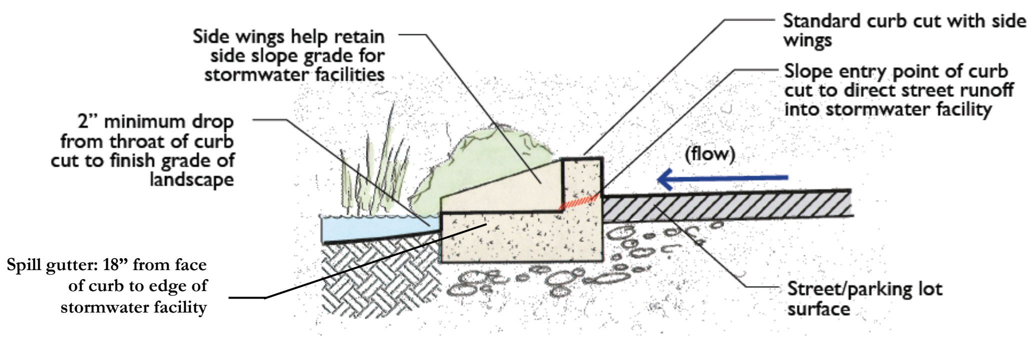


Figure 5-6: Standard curb cut with side wings: cut section view (Source: SMCWPPP 2009)

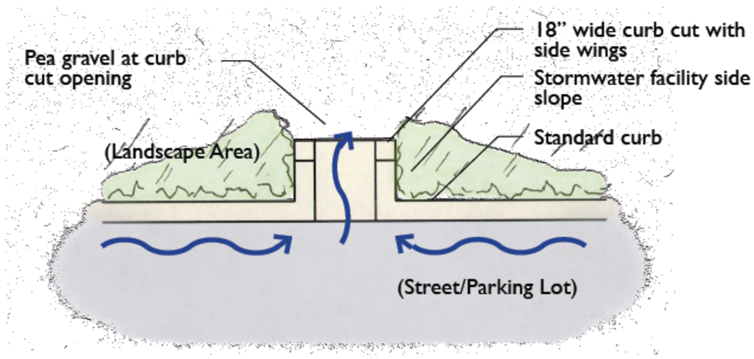


Figure 5-7: Standard curb cut with side wings: plan view (Source: SMCWPPP 2009)

Wheelstop Curbs: Design Guidance

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

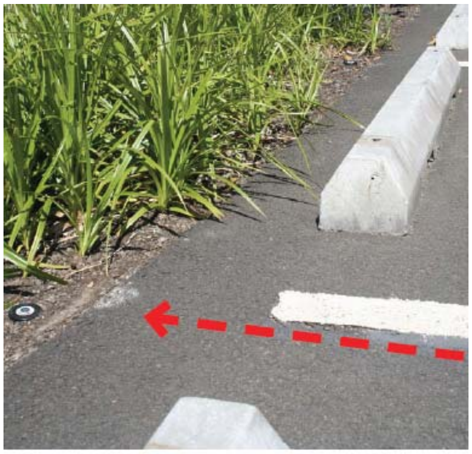


Figure 5-8: Stormwater runoff enters the stormwater facility through the 3-foot space between these wheelstops. The design could be improved by providing more of a drop in grade between the asphalt and landscape area.

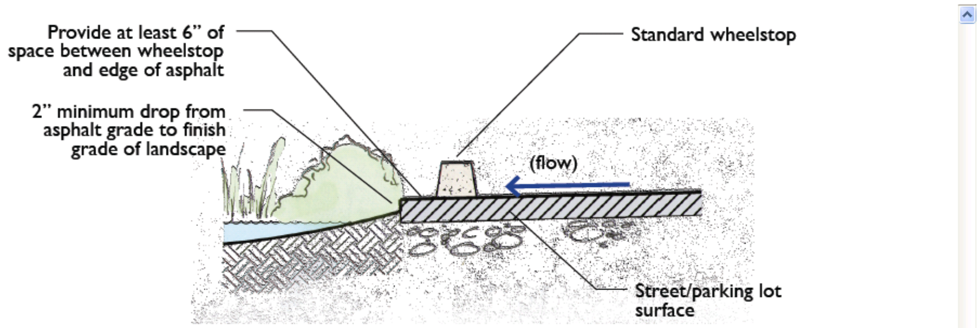


Figure 5-9: Opening between wheelstop curbs: section view (Source: SMCWPPP 2009)

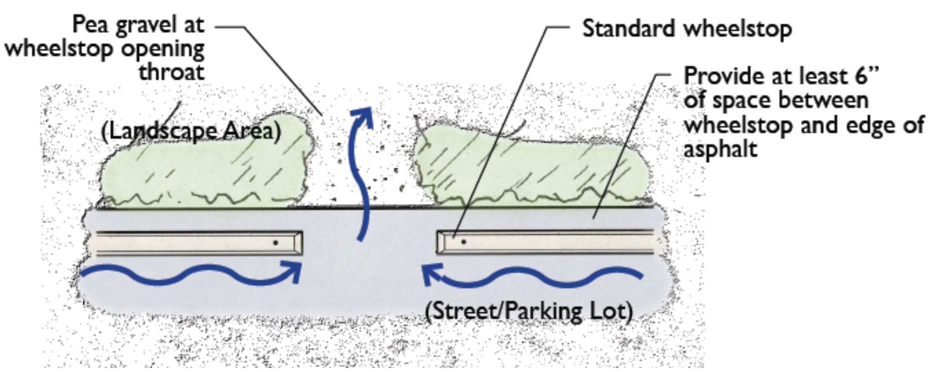


Figure 5-10: Opening between wheelstop curbs: plan view (Source: SMCWPPP 2009)

Grated Curb Cut: Design Guidance

- Grated curb cuts allow stormwater to be conveyed under a pedestrian walkway. The curb cut opening should be at least 18 inches wide; 12" may be allowed for smaller facilities subject to municipal approval. (See footnote under standard curb cut for design of on-grade opening.)
- Grates need to be ADA compliant and have sufficient slip resistance.
- 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 5-11: A grated curb cut allows stormwater to pass under a pedestrian walkway to the stormwater facility.

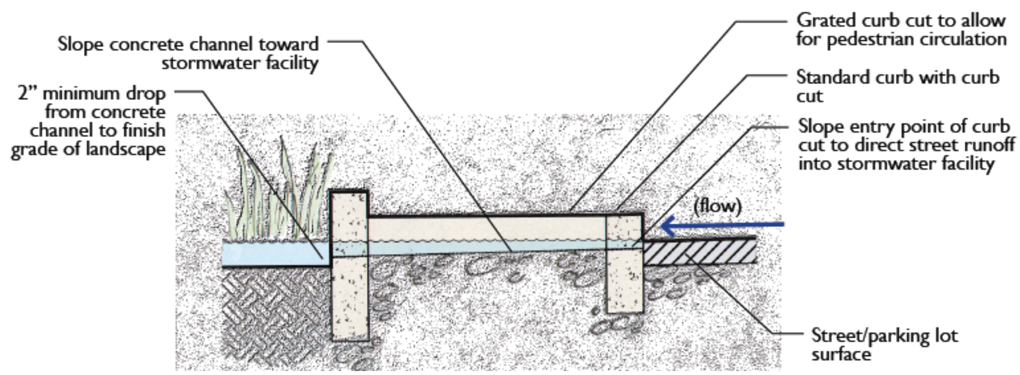


Figure 5-12: Grated curb cut: section view (Source: SMCWPPP 2009)

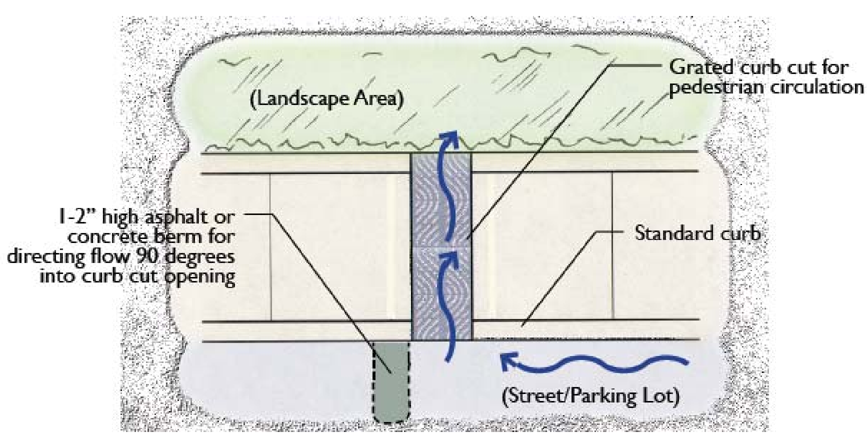


Figure 5-13: Grated curb cut: plan view (Source: SMCWPPP 2009)

5.3 Infiltration Guidelines

Infiltration is a preferred LID treatment measure and a cost-effective method to manage stormwater – if the conditions on the site allow. Site design and treatment measures that accomplish stormwater infiltration can be categorized as follows:

- ***Site design measures*** -- clustering development or otherwise laying out the site to reduce the overall impervious area, routing drainage from building roofs to landscaped areas for infiltration, and using pervious pavement.
- ***Indirect infiltration*** – methods which allow stormwater runoff to percolate ***through surface soils***. Runoff may reach groundwater indirectly, following treatment by surface soils. Bioretention is an example of an indirect infiltration method.
- ***Direct infiltration*** methods*,* which are designed to ***bypass surface soils*** and transmit runoff directly to subsurface soils, which allows infiltration to groundwater. These types of devices must be located and designed to limit the potential for stormwater pollutants to reach groundwater. Infiltration basins and trenches are examples of a direct infiltration method.

The local jurisdiction may require a geotechnical review for your project. When selecting site design and stormwater treatment measures that promote on-site infiltration, be sure to ***follow the geotechnical engineer's recommendations*** based on soil boring data, percolation tests, drainage patterns, and conditions needed for slope stability. The geotechnical engineer's input will be critical to prevent infiltrating water from damaging building foundations, surrounding properties, public improvements, and sloped banks.

Appendix A provides guidelines to help you determine whether your project site is suitable for infiltration measures or devices and regulatory requirements that apply to infiltration devices.

5.4 Underdrains

Where 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 Santa Clara Valley, 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 perforations or slots should be cut along the underside of the pipe, so that water enters the pipe primarily from the bottom and lower sides to allow for more water storage within the system. Slots are considered less open to root intrusion than round perforations. 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.

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 infiltrate 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.

5.5 Bypassing High Flows

Although stormwater treatment measures are sized to remove pollutants from flows resulting from frequent, small storms, projects must also be designed to bypass drainage from large infrequent flows to ***prevent flooding and potential damage*** to the treatment measure. The safe conveyance of high flows through or around the treatment measure 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 stormwater treatment measures do not erode during flows that will be experienced during larger storms. Infiltrating vegetated swales and extended detention basins can be designed to handle higher flows, although they would not be providing much treatment during these flows.

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 high flows larger than the water quality design flow or volume 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.

The second option for stormwater treatment measures designed as low-flow systems is to restrict stormwater flows to the treatment measure and ***bypass excess flows around the facility.*** Bypassing larger flows helps prevent hydraulic overload and resuspension of sediment, and it can protect stormwater treatment measures from erosion. In some designs, the ponding depth in the bioretention facility may prevent the excess runoff from entering the facility, causing it to flow to a separate grate system or downstream inlet.

Flow splitter devices may be used to direct the initial flows of runoff, or "first flush," 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 control measure that is designed to handle high flows. This can be accomplished using a stepped manhole (Figure 5-14) or a proprietary flow splitter (Figure 5-15). The proprietary flow splitter works in the following manner: 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 weir elevation, stormwater begins to flow out the overflow pipe, shown at the upper right of the figure, bypassing the stormwater treatment measure.

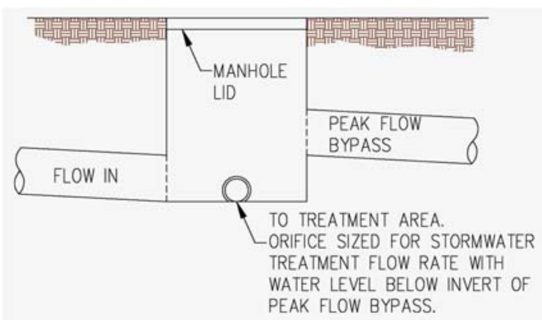


Figure 5-14: Stepped manhole design directs low-flows to treatment measure and diverts high flows to storm drain system. (BKF Engineers)

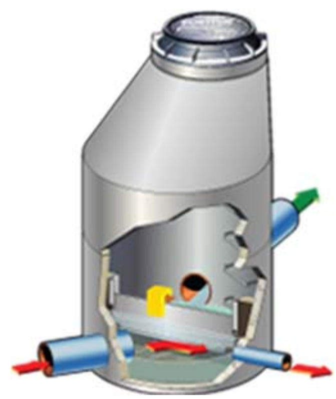


Figure 5-15: StormGate™ flow splitter structure. Source: Contech Construction Products

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

5.6 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.

Figure 5-16: Detention pond at a retirement center in Saratoga

5.7 Mosquito Control

Treatment measure designs and maintenance plans must include the mosquito control ***design and maintenance strategies*** in Appendix F if applicable.

Some types of stormwater treatment measures are designed to detain water, and other treatment measures may have the potential to ***retain standing water*** if they are not properly designed, constructed and maintained. The surface of standing water provides habitat for mosquitoes. Local agencies annually provide information to the Santa Clara County Vector Control District (SCCVCD) on the locations of newly installed stormwater treatment measures, to assist the District with addressing potential vector control issues.

SCCVCD staff has identified a ***five-day maximum*** allowable water retention time, based on actual incubation periods of mosquito species in this area. With the exception of certain stormwater treatment measures designed to hold permanent water (e.g., wet ponds), all treatment measures should drain completely within five days to effectively suppress vector production. *Please note that the design of stormwater treatment measures* ***does not require*** *that water be retained for five days.* Treatment measure designs and maintenance plans must include mosquito control ***design and maintenance strategies*** included in Appendix F.

5.8 Plant Selection and Maintenance

Selecting the appropriate plants and using sustainable, horticulturally sound landscape design and maintenance practices are essential components of a successful landscape-based stormwater treatment measure. Appendix D provides a list of plants that can be used for stormwater treatment and Chapter 6 includes guidance in selecting the best plants for the specific stormwater treatment measures.

Plant Selection Guidance

Plant selection must consider the type of development and location, uses on the site and an appropriate design aesthetic. Ideally, a Landscape Architect will be involved as an active member of the design team ***early in the site design phase*** to review proposed stormwater measures and coordinate development of an integrated solution that responds to all of the various site goals and constraints. In some cases, one professional will design a stormwater control, while another designs the rest of the landscaping. In these situations it is critical for the professionals to work together very early in the process to integrate their designs. Appendix D provides guidance for selecting plants appropriate to the vegetated stormwater treatment measures included in Chapter 6 and the site design measures in Chapter 4.

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 in conserving water as the Model Water Efficient Landscape Ordinance (MWELO) prepared by the Department of Water Resources (DWR). The MWELO automatically went into effect, on January 1, 2010, in municipalities that had not adopted a local Water Efficient Landscape Ordinance (WELO).

The California Water Commission approved the revised MWELO on July 15, 2015. The deadline for local agencies to adopt the MWELO or adopt their own WELO, which must be at least as effective in conserving water, was December 1, 2015. The deadline for local agencies creating a regional ordinance was February 1, 2016.

Most new and rehabilitated landscapes are subject to a WELO. The MWELO applies to the following public and private development projects:

(1) new construction projects with an aggregate landscape area equal to or greater than 500 square feet requiring a building or landscape permit, plan check or design review;

(2) rehabilitated landscape projects with an aggregate landscape area equal to or greater than 2,500 square feet requiring a building or landscape permit, plan check, or design review.

Contact the municipality to ***determine whether your project is subject to the MWELO*** or a comparable local WELO. Water conserving, drought tolerant plants that are suitable for use in stormwater treatment measures are listed in Table D-1 in Appendix D.

Bay Friendly Landscaping (ReScape)

Bay-Friendly landscaping is a whole systems approach to the ***design, construction and maintenance*** of landscapes in order to protect the San Francisco Bay watershed. Project sponsors are encouraged to use landscape professionals who are familiar with and committed to implementing Bay-Friendly landscaping practices from the initial plant selection through the long-term maintenance of the site. Appendix D summarizes Bay-Friendly Landscaping Practices that may be implemented to benefit water quality of the Bay and local creeks, based on the Bay-Friendly Landscaping Guidelines (available at www.rescapeca.org)[6].

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 will be required to use IPM practices, as indicated in each agency's source control measures list. ***Avoiding pesticides and quick release synthetic fertilizers***, covering exposed earth with appropriate mulch material, and nourishing the soil with compost are particularly important when maintaining stormwater treatment measures to protect water quality.

IPM encourages the use of many strategies for preventing and controlling pests. It places a priority on fostering a healthy environment in which plants have the strength to resist diseases and insect infestations, and out-compete weeds. Using IPM requires an understanding of the life cycles of pests and beneficial organisms, as well as regular monitoring of their populations. When pest problems are identified, IPM considers all viable solutions and uses a combination of strategies to control pests, rather than relying on pesticides alone. The least toxic pesticides are used only as a last resort. More information on IPM is included in Appendix D.

[6] The Bay-Friendly Landscaping Coalition is now known as ReScape (www.rescapeca.org).

5.9 Integrating Trees and Stormwater Treatment

As discussed in Chapter 4, trees provide a variety of functions that can benefit water quality. Despite these benefits, trees that are simply planted or maintained near impervious surfaces ("interceptor trees") cannot be credited toward treatment of those areas. However, trees can be integrated into biotreatment systems that are sized and designed to provide stormwater treatment. The types of biotreatment systems that can incorporate trees include bioretention, tree well filters, and bioretention in combination with suspended pavement systems.

In general, trees should only be ***planted in bioretention systems*** when the tree species is appropriate for sandy soils (or where adjacent loamy/clayey soils can be utilized and accessed by tree roots) and sufficient soil volumes and space are provided for the tree to reach mature size without causing problems with surrounding infrastructure, pavement, and buildings. Overhead infrastructure, such as lighting, awnings, and utilities can also reduce space for trees or limit the list of tree species for selection to smaller stature types. The design of the system and tree species selected should also be carefully considered for future irrigation needs (especially with large tree species, as irrigation demand may increase as the tree grows, possibly causing problems in a future drought scenario.) Hybrid systems that are able to use different soil types in different sectors of the landscape can also assist in providing water retaining soils for large trees.

Retrofitting or modifying an existing planting area with a tree into a bioretention area with that tree can be done, but there are many design and construction issues. An arborist or landscape architect should be consulted before attempting that advanced strategy. Similarly, if a stormwater treatment measure is proposed for a location adjacent to an existing tree of value, then the impacts to and protection measures for the tree should be discussed with an arborist. The design of the measure might also have to be modified to protect the tree. Trees that have not previously been inundated with water during the rainy season and become inundated after modification into a bioretention area can experience health impacts. This can occur when pavement surrounds the tree and that pavement is removed as part of the retrofit.

High volumes of leaf drop in a short period of time can create inlet blockages in stormwater treatment measures, so leaf collection or accommodation of degradation of leaves within the stormwater landscape needs to be assessed and/or incorporated into the design before large broadleaf deciduous trees (such as the London Plane or Sycamore) are selected.

Soil volume, soil compaction, structural trimming, and compost, along with appropriate irrigation during the first three years, are important to long-term tree health. Where limited open space is available for planting trees and roots may damage hardscape, consider the use of ***suspended pavement systems***. One type of suspended pavement system is ***structural soil,*** an engineered planting medium that consists of a stone or aggregate skeleton structure for strength, planting soil, and in some cases a hydrogel to adhere the two materials together, which allows urban trees to grow under pavement. The structural soil system creates a load-bearing matrix with voids filled with soil and air, which 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 some stormwater storage capacity. However, structural soils provide minimal (approximately 20%) amounts of soil because the majority of the space is taken up by the rock and void space. In addition, structural soil does not meet the specification for biotreatment soil media, so it cannot be used in a treatment measure.

Modular suspended pavement systems (also known as load-bearing modular grid products) 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. These products provide similar benefits in terms of pavement support and tree health as structural soil. When filled with biotreatment soil, modular products can be used to increase the surface area of a tree well filter and provide more capacity for stormwater treatment. Having these systems set up for a tree ensures the long-term health and growth by providing rootable soil volumes without destroying urban features, such as lifting sidewalks.

Modular products, such as the Silva Cell, are typically composed of a frame (or frames) and a deck. 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. Newer versions can also be modified to different heights without stacking. Cells can be installed laterally as wide as necessary. Void space within the cells may accommodate the surrounding utilities. More information on the use of these systems is provided in Section 6.3. Check with the local jurisdiction to confirm that they accept the use of Silva Cells or other suspended pavement systems as options for stormwater treatment systems in their plan review process.

An additional strategy used to provide trees with adequate soil volumes is related to the ***planting of trees in places where there is an adjacent landscaped area***. If the adjacent area is separated from the tree planting location by impervious surfaces such as sidewalks or parking areas, then suspended pavement systems can be used to provide an uncompacted soil "bridge" or "root channel" between the two landscaped areas allowing roots to grow through and under that pavement to the adjacent landscaped area without heaving of the pavement over time. This strategy can be even more important if the adjacent landscaped area contains a clayey/loamy soil with good water retention compared to the sandy biotreatment soil media used in bioretention areas. With the expectation of recurrent droughts in the future, loamy soils are a good option for retaining water for trees during the dry season, thereby reducing the need for irrigation. For more information on how to integrate trees and bioretention, refer to Section 6.3.

Chapter

6

Technical Guidance for Stormwater Treatment and Site Design Measures

In this Chapter, technical guidance is provided for the stormwater treatment measures allowed by permit requirements as well as selected site design measures.

Table 6-1: Treatment and Site Design Measures Addressed in Chapter 6			
Treatment Measures		**LID?**	**Design Basis**
6.1	Bioretention area	Yes	Flow, Volume, Both
6.2	Flow-through planter	Yes	Flow, Volume, Both
6.3	Tree well filter	Yes[1]	Flow, Volume, Both
6.4	Infiltration trench	Yes	Volume
6.5	Subsurface infiltration system	Yes	Volume
6.6	Rainwater harvesting and use	Yes	Volume
6.7	Media filter	No	Flow[2]
6.8	Extended detention basin	No	Volume
Site Design Measures			
6.9	Green roof	Yes	Volume
6.10	Pervious pavement	Yes	Volume
6.11	Grid pavements	Yes	Volume

[1] A tree well filter meets LID requirements for a biotreatment measure if biotreatment soil is used as the filter media in the unit, and the unit is sized based on a 5 in/hr surface loading rate. A proprietary tree well filter that contains manufactured media with a higher flow rate is not considered LID treatment and may only be used at qualifying Special Projects. See Section 6.3 for more details.

[2]While some non-proprietary media filters are sized using a volume-based approach, this section focuses on proprietary systems that may be used at qualifying Special Projects or as part of a treatment train.

The technical guidance in this chapter is intended to assist you in preparing permit application submittals for your project. The guidance is in the form of fact sheets on specific treatment or site design measures that provide information on advantages and limitations of each measure, design and sizing considerations, construction guidelines, siting considerations and maintenance requirements. Municipalities will require you to prepare more specific drawings taking into consideration project site conditions, materials, plumbing connections, etc., when you submit your application.

Control measures should be located in areas that can be accessible at any given time for the purpose of operation and maintenance and inspections. Ensure requirements needed for access are in place (e.g., easements, permission to access in maintenance agreements).

Table 6-1 presents a list of the treatment and site design measures covered in this chapter. The table also indicates whether the measures meet the definition of low impact development site design or treatment, and whether the measures should be hydraulically sized on a flow or volume basis or both.

This technical guidance was developed based on a review of existing documents on design and maintenance of treatment and site design measures (specific to California), local experience, and best engineering judgment. Fact sheets will be updated as new information is gained through experience with stormwater treatment or site design measure design and installation.

6.1 Bioretention Area

Figure 6-1: Bioretention area in office building parking lot in San José. Source: City of San José.

Best uses

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

Advantages

- Landscape feature of any shape that works with a variety of plants
- Low maintenance
- Reliable once established

Limitations

- Geotechnical conditions must be suitable if runoff is infiltrated
- May require irrigation
- Susceptible to clogging – especially if installed prior to construction site soil stabilization.

Bioretention areas, or "rain gardens," function as soil and plant-based filtration measures that remove pollutants through a variety of physical, biological, and chemical treatment processes. These facilities normally consist of a ponding area, a mulch layer, plants, and biotreatment soil mix, underlain by drain rock and an underdrain (if required). Bioretention areas are designed to distribute stormwater runoff evenly across the surface ponding area. Water stored in the ponding area percolates through the biotreatment soil mix to the drain rock layer and then either infiltrates into native soil or flows out through the underdrain to the storm drain system.

Bioretention areas can be any shape, including linear. Bioretention areas with underdrains should be designed to maximize infiltration to native soils by placing the underdrain near the top of the drain rock layer unless infiltration is not permitted due to site conditions (e.g., high groundwater table, steep slopes, proximity to structures, presence of contaminated soil or groundwater, etc.). Bioretention areas without underdrains are sometimes referred to as "bioinfiltration" measures. All bioretention areas should include an overflow/bypass system to convey runoff volumes that are greater than the water quality design volume.

It is recommended that stormwater control measures be located in places that are easily accessible at any given time for operation and maintenance, as well as inspections. Bioretention areas should not be located on inaccessible private property such as residential backyards.

Design and Sizing Guidelines

DRAINAGE AREA AND SETBACK REQUIREMENTS

- The area draining to the bioretention area is limited by available surface area for the unit, and maintenance considerations. Multiple units can be installed to serve any size area.
- Units should be located in areas that can be accessible at any given time for the purpose of operation and maintenance and inspections. Bioretention units should not be located on inaccessible private property such as residential backyards.

- The drainage area should not contain a significant source of sediment, such as unstabilized and unvegetated areas.
- The bioretention area should be set back from structures at least 10 feet or as required by the structural or geotechnical engineer or local jurisdiction, unless it has a waterproof lining.
- If the bioretention area is designed to infiltrate stormwater to underlying soils and the site includes a septic system leach field, a 100-foot setback is required from the leach field.

TREATMENT MEASURE DIMENSIONS AND SIZING

- It is recommended that the bioretention area be sized to be 4% of the impervious surface area of the project site. The area of tributary impervious surface multiplied by the 0.04 sizing factor will equal the required surface area of the bioretention area. This sizing factor is derived from the flow-based treatment standard (runoff from 0.2 in/hr intensity rainfall) and a desired surface loading rate of 5 in/hr through the biotreatment soil media (BSM). Alternatively, if there are site or infiltration constraints, bioretention sizing may be calculated using a volume-based sizing method or a combination flow- and volume-based sizing method described in Section 5.1 of the C.3 Handbook.
- The surface of the bioretention area should be primarily flat, but elevations may vary as needed to distribute stormwater flows throughout the surface area. Edges may slope up to meet surrounding grade. Side slopes should not exceed 3:1.
- Bioretention areas, including linear treatment measures, should not be constructed on slopes greater than 4%, unless constructed as a series of relatively horizontal bioretention cells. A bioretention facility should be one level (maximum 2% inner cell slope), shallow basin or a series of basins. As runoff enters each basin, it should flood and fill throughout before runoff overflows to the outlet or to the next downstream basin. This will help prevent movement of surface mulch and soil. In a linear bioretention area, check dams should be placed for every 4 to 6 inches of elevation change and so that the top of each dam is at least as high as the toe of the next upstream dam. A similar principle applies to bioretention facilities built as terraced roadway shoulders[1]. The slope within cells should not exceed 2%. Bioretention cells are not recommended if overall slope exceeds 8%.
- Surface ponding depths may vary, with a recommended 6-inch depth, and a maximum 12-inch depth if allowed by the municipality. The depth is measured from the surface of the BSM and not adjusted for the application of mulch. If ponding depths exceed 6 inches, the landscape architect should approve the planting palette for desired depth. The 3-inch mulch layer can be within the 6-inch ponding depth.
- The inlet to the overflow pipe or catch basin should be at least 6 inches above the flat surface of the bioretention planting area and at least 2 inches above the high point of the bioretention area (i.e., the top of planting mounds). Additional freeboard requirements may apply to protect nearby structures from flooding; check with the local jurisdiction.

INLETS TO TREATMENT MEASURE

Flow may enter the treatment measure in the following way(s):

- As overland flow from landscaping;
- As overland flow from pavement;
- Through a curb opening (minimum 18 inches wide, with the number and locations designed so that runoff is dispersed throughout the bioretention area);
- Through a curb drain;
- With drop structure through a stepped manhole;

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[1] Contra Costa Clean Water Program. February 2012. C.3 Stormwater Guidebook, 6th Edition and Stormwater Management Handbook: Implementing Green Infrastructure in Northern Kentucky Communities, 2009. www.epa.gov/smartgrowth/publications.htm)

- Through a pop-up or bubble-up emitter; and/or
- Through roof leader or other conveyance from building roof.
- Where flows enter the bioretention area, allow a change in elevation of 4 to 6 inches between the paved surface and the BSM elevation, so that vegetation or mulch build-up does not obstruct flow.
- Install splash blocks, splash aprons, cobbles or rocks, underlain by geotextile fabric, to dissipate flow energy and velocity and avoid erosion at the point where runoff enters the bioretention area. Place cobbles around splash blocks and aprons to prevent erosion.
- Bioretention areas 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 should be discouraged and only be used on retrofit projects, as a last resort.
- Curb openings should be a minimum of 18 inches wide (or 12 inches if allowed by the municipality), with the number and locations of openings designed so that runoff is dispersed throughout the bioretention area.
- Long bioretention areas should space curb openings to the bioretention area at 10-foot intervals or less. Alternatively, a flow spreading system could be utilized.
- Bubble-up emitters and pipes to bubble-up emitters should have weep holes to avoid standing water after storm events.

See Section 5.2 of the SCVURPPP C.3 Handbook for example inlets and additional guidance.

UNDERDRAIN AND OVERFLOW STRUCTURES

- An underdrain system is generally required for installations in slow-draining native soils. If the water quality design volume will infiltrate into native soils in 72 hours or less, based on local percolation tests, and the local jurisdiction allows, then no underdrain is required.
- The underdrain should consist of a minimum 4-inch diameter perforated HDPE or PVC pipe with cleanouts and connection to a storm drain or discharge point. Solid HDPE or triple-walled HDPE pipe, with smooth inner and outer layers and a corrugated middle layer, are recommended. To help prevent clogging, two rows of perforation may be used.
- The underdrain trench should include a minimum 12-inch thick layer of drain rock, such as Caltrans Standard Section 68-1.025 Class 2 permeable material or equivalent. At least two inches of drain rock should cover the underdrain. The underdrain should be placed with perforations facing downward, at a minimum 0.5% slope to the storm drain or discharge point (unless a flatter slope is allowed by the municipality based on site-specific conditions).
- To avoid clogging, filter fabric should not be used in or around the underdrain or between the BSM and the drain rock. If desired, a 2-inch pea gravel layer may be used between the BSM and the drain rock.
- If there is 5 feet or more separation between the base of the bioretention facility and the groundwater table and infiltration is permitted on site, the underdrain should be installed at least 6 inches above the base of the trench to maximize infiltration into native soils.
- If there is less than 5 feet separation to the groundwater table, or infiltration is not permitted due to site-specific conditions, the facility should be lined with a waterproof fabric and the underdrain should be placed just above the waterproof fabric (see Figure 6-6).
- A cleanout for the underdrain should be provided, consisting of a vertical, rigid, non-perforated, non-corrugated PVC or HDPE pipe, with a minimum diameter of 4 inches and a watertight cap fit, raised above the ponding elevation or flush with the biotreatment soil surface. The connection between the cleanout and underdrain should be a long sweep ell to allow access for cleaning equipment.

- The design should include an overflow or bypass system, with the overflow inlet elevation set to achieve the design ponding depth, to convey the runoff volume that exceeds the water quality design volume.

PLANTING SOIL REQUIREMENTS

- Soil used in the bioretention area should meet the BSM specifications included in Appendix C of this Handbook (BASMAA, 2016). A minimum long term infiltration rate of 5 inches per hour is required (initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time).
- Bioretention areas should have a minimum BSM depth of 18 inches.

VEGETATION

- Plant species selected should be suitable for the location of the bioretention area, biotreatment soils and occasional inundation. A variety of plants, including ground cover, shrubs and small trees, helps maintain a healthy soil environment and pollutant removal capabilities. See planting guidance in Appendix D.
- Plants within the bioretention area need to be spaced closely enough to ensure substantial plant coverage to prevent scour, keep mulch in place and provide pleasing aesthetics. The local jurisdiction may have landscaping guidelines that specify plant spacing.
- Trees may be planted in the bioretention area as allowed by the municipality (see Appendix D for recommended tree species). If larger trees are selected, plant them at the periphery of bioretention area. No trees should be planted within 20 feet of an overflow inlet. BSM depth may need to be increased to accommodate tree root systems. (For more biotreatment options that utilize trees, see Section 6.3)
- Install and maintain a 3-inch layer of composted wood mulch, consistent with the regional Biotreatment Wood Mulch (BWM) specification (see Appendix D of the Handbook), in areas between plantings. Alternatively, biotreatment area sod that provides 100% soil coverage may be used. “Micro-bark”, or “gorilla hair” mulches, as well as chipped wood mulch from recycled pallets and dimensional lumber, are not recommended.
- Rock mulch, such as cobble or gravel, should be used sparingly and only where necessary. Pea-gravel is not recommended due to heat intensity, compaction of BSM, reduction of soil health, and increased maintenance requirements. Cobbles should only be used for erosion protection at inlets. Large boulders should not be placed in the bioretention area.
- The underdrain trench should be offset from the edge of tree planting zone, as needed, to maximize distance between tree roots and the underdrain. The underdrain should be solid pipe for a distance 10 feet upstream and downstream of any tree.
- Drought tolerant plants are preferred and may be required by the local municipality. Provide sufficient irrigation for the initial establishment period as well as long term maintenance of plant life. If an irrigation system is not present, then hand watering should be conducted weekly through plant establishment – typically through the first six months depending on the season and precipitation levels.
- Use integrated pest management (IPM) principles in the landscape design to help avoid the need for synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction regarding local IPM policies.
- Trees and vegetation should not block inflow, create traffic or safety issues, or obstruct utilities.

Construction Requirements

- Bioretention areas are not intended to work as construction-phase BMPs. Protect the area from construction site runoff; divert runoff from unstabilized areas away from completed bioretention areas.
- If the bioretention area will be used for infiltration, 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 bioretention area.
- Minimize compaction of existing soils in the location of bioretention areas; 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 it with the Maintenance Agreement. Refer to Chapter 8 and Appendix G for specific maintenance requirements.

Note that even though not shown in the details below, 3 inches of mulch will need to be added on top of the biotreatment soil media for all bioretention area measures. Cleanout rims may be raised above the ponding elevation or flush with the biotreatment soil surface. The connection between the cleanout and underdrain should be a long sweep ell to allow access for cleaning equipment.

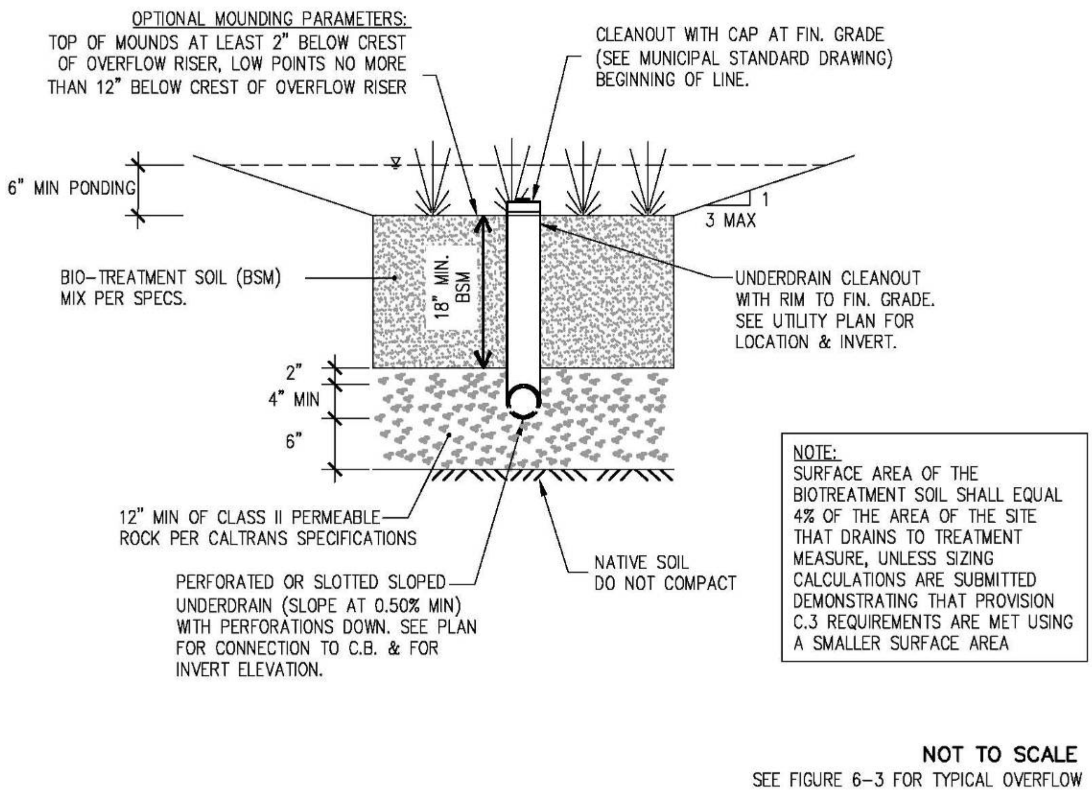

Figure 6-2: Cross Section of a Bioretention Area (with Maximized Infiltration)

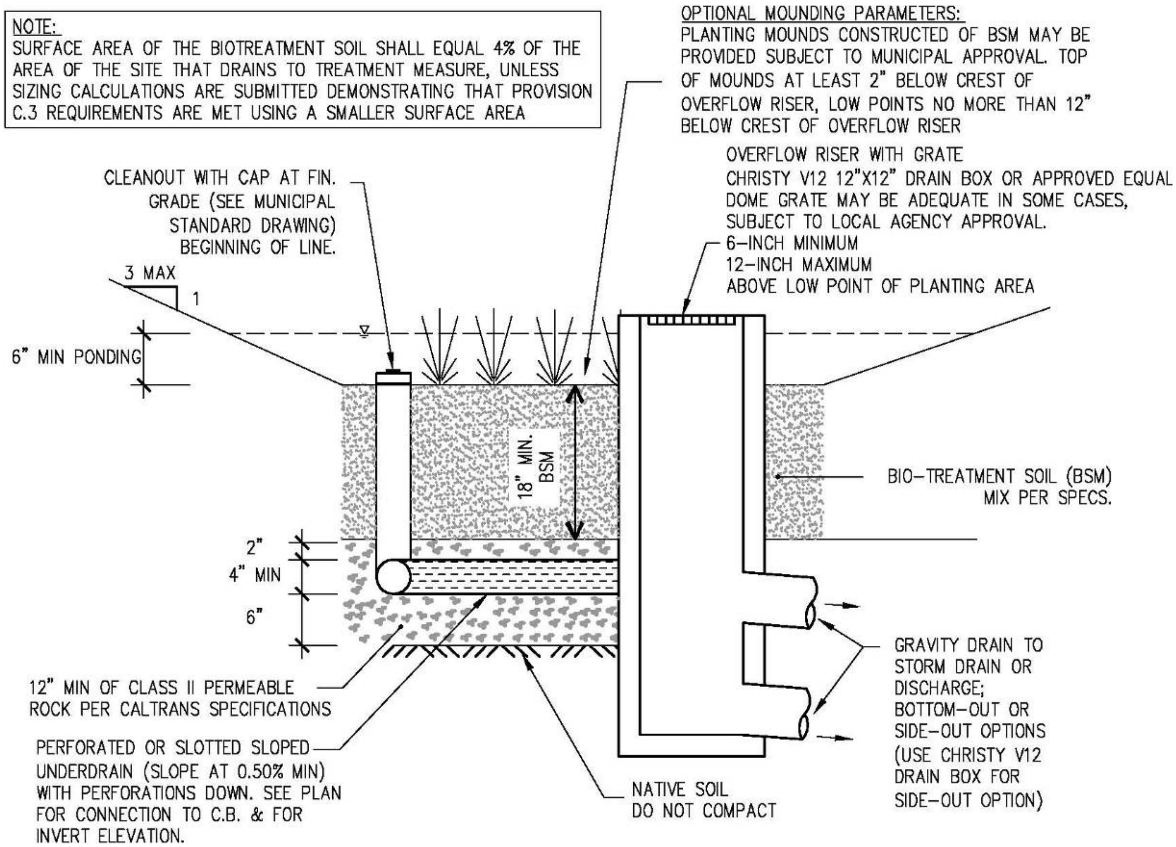

Figure 6-3: Cross Section of a Bioretention Area (Side View)

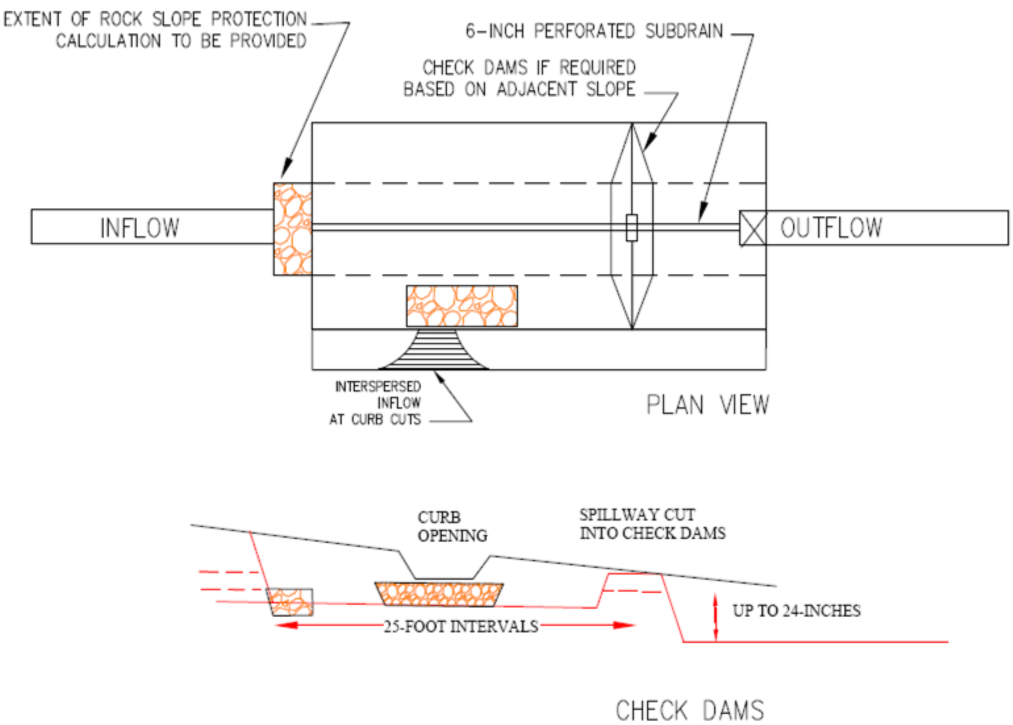

Figure 6-4: Check Dam (plan view and profile) for installing a series of linear treatment measures (bioretention cells) in sloped area

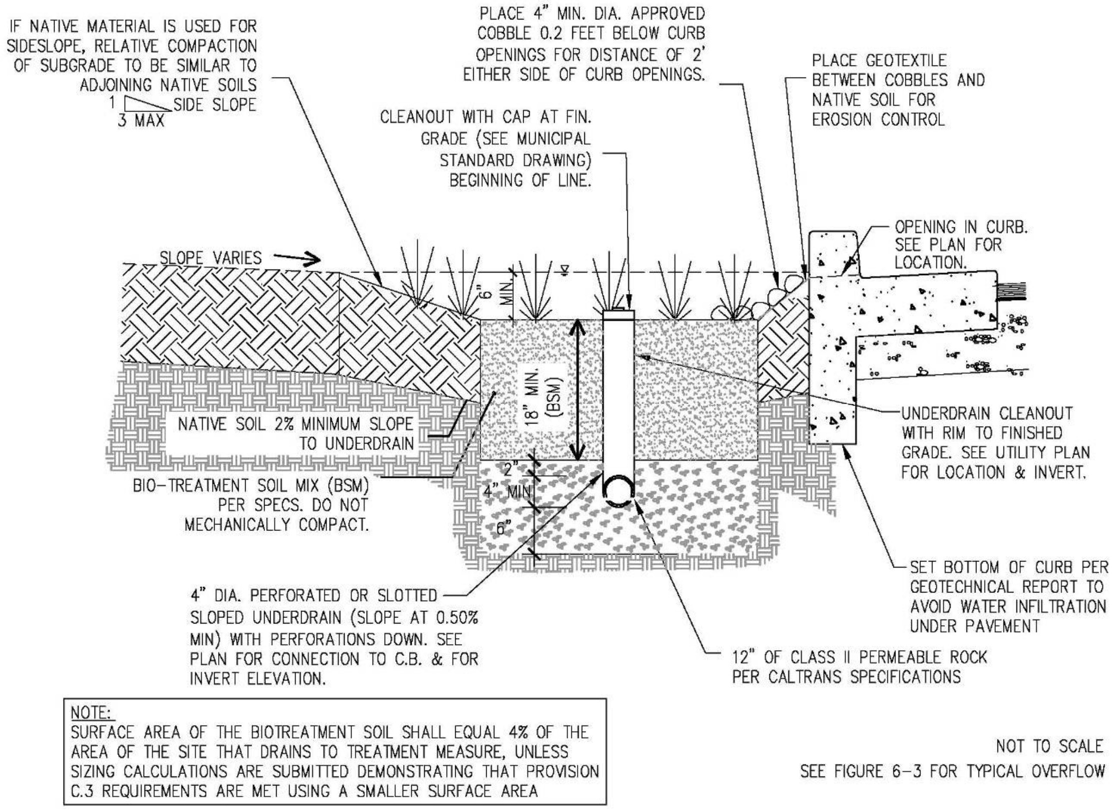

Figure 6-5: Cross Section of a Linear Bioretention Area (with Maximized Infiltration)

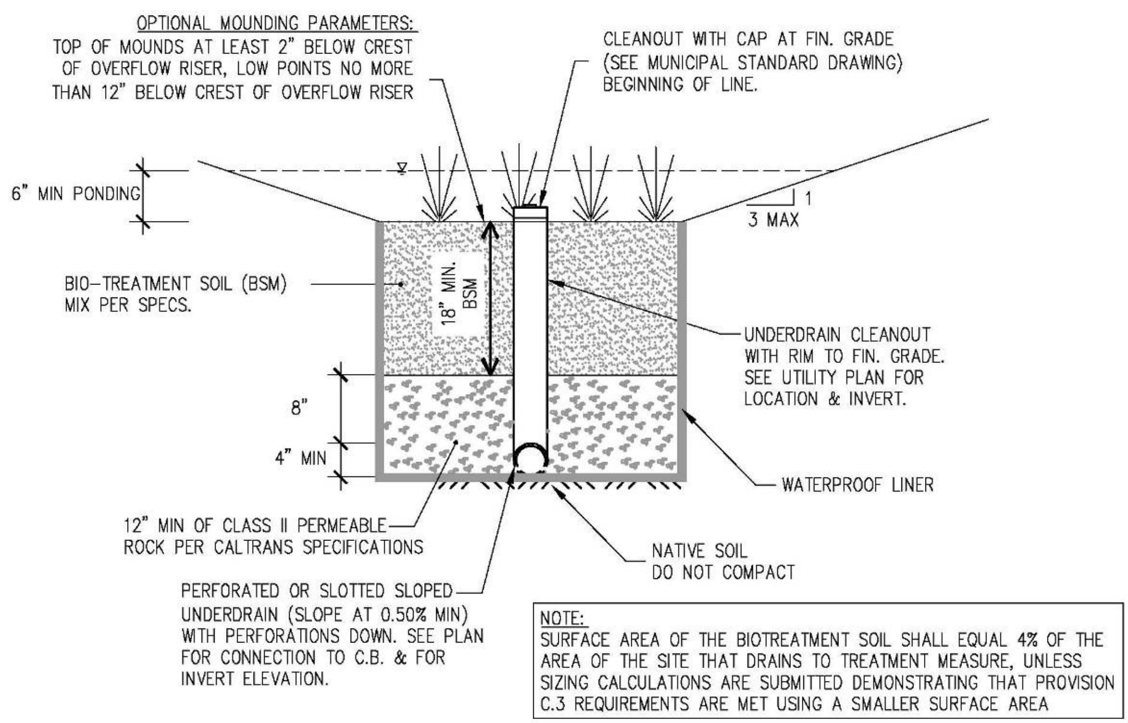

Figure 6-6: Cross Section of Lined Bioretention Area (Infiltration Not Allowed)

6.2 Flow-Through Planter

Figure 6-7: Flow-through planters at Hampton Park residences in San Jose. Photo: EOA, Inc.

Best uses

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

Advantages

- Can be adjacent to structures
- Versatile
- May be any shape
- Relatively low maintenance

Limitations

- May require sufficient head
- Requires careful selection of plants
- Requires level installation

Flow-through planters function similar to bioretention areas but are designed to detain and treat runoff without allowing seepage into the underlying soil. They are a type of biotreatment facility that is completely lined and surrounded with concrete or other structural planter box walls with waterproof membranes. 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 surrounding grade and receive runoff as sheet flow. Pollutants are removed as the runoff passes through the biotreatment soil media (BSM) and is collected in an underlying drain rock layer and perforated underdrain. The underdrain must be directed to a storm drain or other discharge point. An overflow inlet conveys flows that exceed the capacity of the planter.

Design and Sizing Guidelines

TREATMENT MEASURE DIMENSIONS AND SIZING

- It is recommended that flow-through planters be designed with a surface area that is 4% of the impervious area draining to it. This sizing factor is derived from the flow-based treatment standard (runoff from 0.2 in/hr intensity rainfall) and a desired surface loading rate of 5 in/hr. Alternatively, if there are site constraints, planter size may be calculated using a volume-based treatment method or a combination flow- and volume-based treatment method described in Appendix B.
- Flow-through planters can be used adjacent to buildings and within set back areas, if allowed. They can also be used above or below grade and on podiums or roof tops with sufficient structural capacity and waterproofing.
- The surface of the planting bed should be relatively level but may have a slight slope if needed to distribute stormwater flows throughout the surface area. For example, the BSM ca be graded slightly (1%) away from inlet(s) to the rest of the planter area.

- Surface ponding depths may vary, with a recommended 6-inch depth and a maximum 12-inch depth if allowed by the municipality. The depth is measured from the surface of the BSM and not adjusted for the application of mulch. If the design ponding depth exceeds 6 inches, the landscape architect should approve the planting palette for the desired depth. The 3-inch mulch layer can be within the 6-inch ponding depth.
- Waterproofing should be installed as required to protect adjacent building walls.
- Units should be located in areas that can be accessible at any given time for the purpose of operation and maintenance and inspections.

INLETS TO TREATMENT MEASURE

Flows may enter the planter in the following ways:

- As overland flow from landscaping or pavement;
- Through a curb opening (minimum 18 inches with the number and locations designed so that runoff is dispersed throughout the planter area);
- Through a curb drain;
- Through a pop-up or bubble-up emitter with sufficient head;
- Through roof leader or other conveyance from building roof; and/or
- Through a runnel, swale, valley gutter or other conveyance system.
- If the flow-through planter is installed at grade, allow a change in elevation of 4 to 6 inches between the surrounding paved surface and the BSM elevation, so that vegetation or mulch build-up does not obstruct flow.
- If the flow-through planter is installed above grade, sufficient head must be provided for bubble-up emitters to discharge to the planter surface.
- Bubble-up emitters and pipes to bubble-up emitters should have weep holes to avoid standing water after storm events.
- Install splash blocks, cobbles or rocks, underlain by geotextile fabric as needed, to dissipate flow energy and avoid erosion where runoff enters the planter. Place cobbles around splash blocks and aprons to prevent erosion.
- For planters installed at grade with curbs, curb openings should be a minimum of 18 inches wide (or 12” if allowed by the municipality) with the number of openings and locations designed so that runoff is dispersed throughout the bioretention area. Alternatively, a flow spreader system may be utilized.
- For long linear planters, space inlets to the planter at 10-foot intervals or install a flow spreader (see Figures 6-12 and 6-13).
- Flow-through planters 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 should be discouraged and only used on retrofit projects, as a last resort.

See Section 5.2 of the SCVURPPP C.3 Handbook for example inlets and additional guidance.

OVERFLOW STRUCTURE

- The design should include an overflow or bypass system, with the overflow inlet elevation set to achieve the design ponding depth, to convey the runoff volume that exceeds the water quality design volume.
- The inlet elevation of the overflow structure should be at least 6 inches above the low point of the planting area and at least 2 inches above the high point of the planting area (i.e., the

top of planting mounds). Planter box walls should be at least 2 inches higher than overflow elevation and an overflow point away from buildings should be designed. The maximum head requirements should be checked using the maximum flow and planter outlet configuration. Additional freeboard requirements may apply to protect nearby structures from flooding; check with the local jurisdiction.

UNDERDRAINS

- An underdrain system is required for flow-through planters.
- The underdrain should consist of a minimum 4-inch diameter perforated HDPE or PVC pipe with cleanouts and connection to a storm drain or discharge point. Solid HDPE or triple-walled HDPE pipe, with smooth inner and outer layers and a corrugated inner layer, is recommended. To help prevent clogging, two rows of perforation may be used.
- The underdrain trench should include a minimum 12-inch thick layer of drain rock, such as Caltrans Standard Section 68-1.025 permeable material Class 2 or equivalent. The underdrain should be placed near the bottom of the drain rock layer, with perforations facing downward, at a minimum 0.5% slope (unless a flatter slope is allowed by the municipality based on site-specific conditions).
- A cleanout for the underdrain should be provided, consisting of a vertical, rigid, non-perforated, non-corrugated PVC or HDPE pipe, with a minimum diameter of 4 inches and a watertight cap fit, raised or flush with the planter bed surface. If the cleanout is raised above the ponding depth, it can also be used as an observation well. The cleanout should be connected to the underdrain using a long sweep elbow fitting for ease of maintenance.
- To avoid clogging, filter fabric should not be used in or around the underdrain or between the BSM and the drain rock. If desired, a 2-inch pea gravel layer may be used between the BSM and the drain rock.
- To avoid excess hydraulic pressure on subsurface concrete 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.

PLANTING SOIL REQUIREMENTS

- Soils used in the planter should meet the BSM specifications included in Appendix C of this Handbook (BASMAA 2016). A minimum long term infiltration rate of 5 inches per hour is required (initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time).
- Flow-through planters should have a minimum BSM depth of 18 inches.

VEGETATION

- Plant species selected should be suitable for the flow-through planter location, biotreatment soils and occasional inundation. A variety of plants, including ground cover, grasses, and shrubs, helps maintain a healthy soil environment and pollutant removal capabilities. See planting guidance in Appendix D.
- Plants within the planter area need to be spaced closely enough to ensure substantial plant coverage to prevent scour, keep mulch in place and provide pleasing aesthetics. The local jurisdiction may have landscaping guidelines that specify plant spacing.
- Install and maintain a 3-inch layer of composted wood mulch, consistent with the regional Biotreatment Wood Mulch (BWM) specification (see Appendix D of the Handbook), in areas between plantings. Alternatively, biotreatment area sod that provides 100% soil

coverage may be used. "Micro-bark", or "gorilla hair" mulches, as well as chipped wood mulch from recycled pallets and dimensional lumber, are not recommended.

- Rock mulch, such as cobble or gravel, should be used sparingly and only where necessary. Pea-gravel is not recommended due to heat intensity, compaction of BSM, reduction of soil health, and increased maintenance requirements. Cobbles should only be used for erosion protection at inlets. Large boulders should not be placed in the bioretention area.
- Use integrated pest management (IPM) principles in the landscape design, i.e., select native and/or pest resistant plants, to avoid the need for synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction regarding local IPM policies.
- Drought tolerant plants are preferred and may be required by the local municipality. Provide sufficient irrigation for the initial establishment period as well as long term maintenance of plant life. If an irrigation system is not provided, hand watering should be conducted weekly through plant establishment – typically throughout the first six months depending on the season and precipitation levels.
- Vegetation should not block inflow, create safety issues, or obstruct utilities.

SAFE ACCESS MEASURES

- Safety access to flow-through planters located above the first floor of buildings and along building edges should be provided as part of the building and planter design.

Construction Requirements

- At-grade planters are not intended to work as construction-phase BMPs. Protect the area from construction site runoff; divert runoff from unstabilized areas away from completed planter areas.

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 it with the Maintenance Agreement. Refer to Chapter 8 and Appendix G for specific maintenance requirements.

Note that even though not shown in the details below, 3 inches of composted mulch on top of the biotreatment soil media is required for all bioretention area measures.

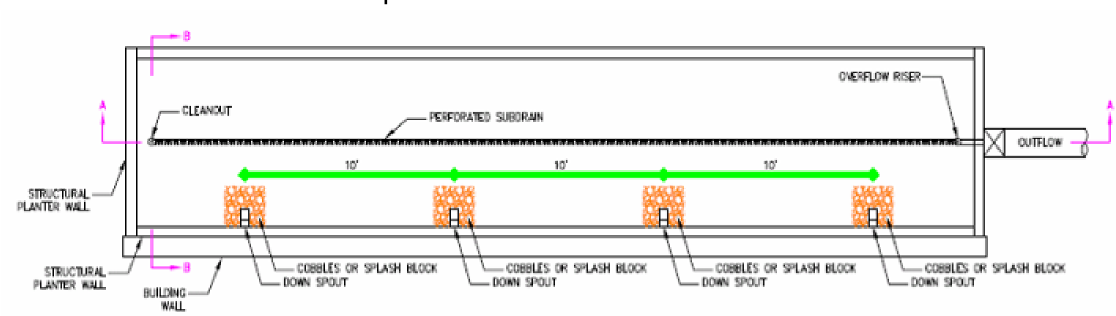

Figure 6-8: Plan view of long, linear planter, with inlets to the planter distributed along its length at 10' intervals.

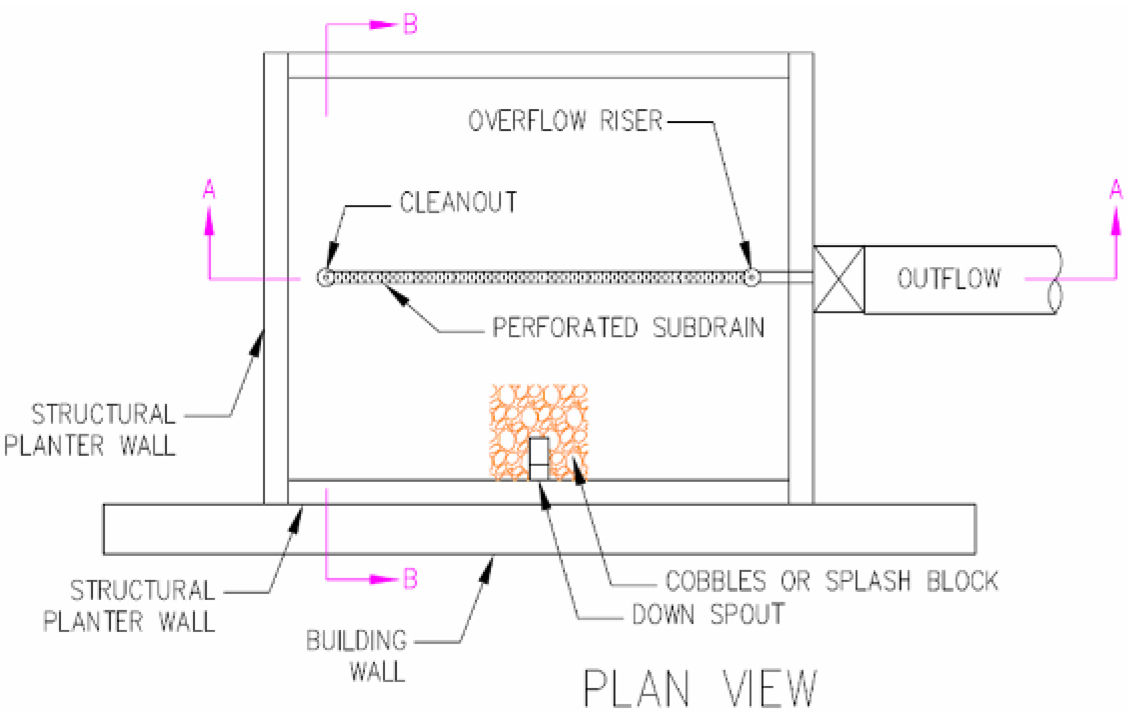

Figure 6-9: Plan view of planter designed to disperse flows adequately with only one inlet to planter

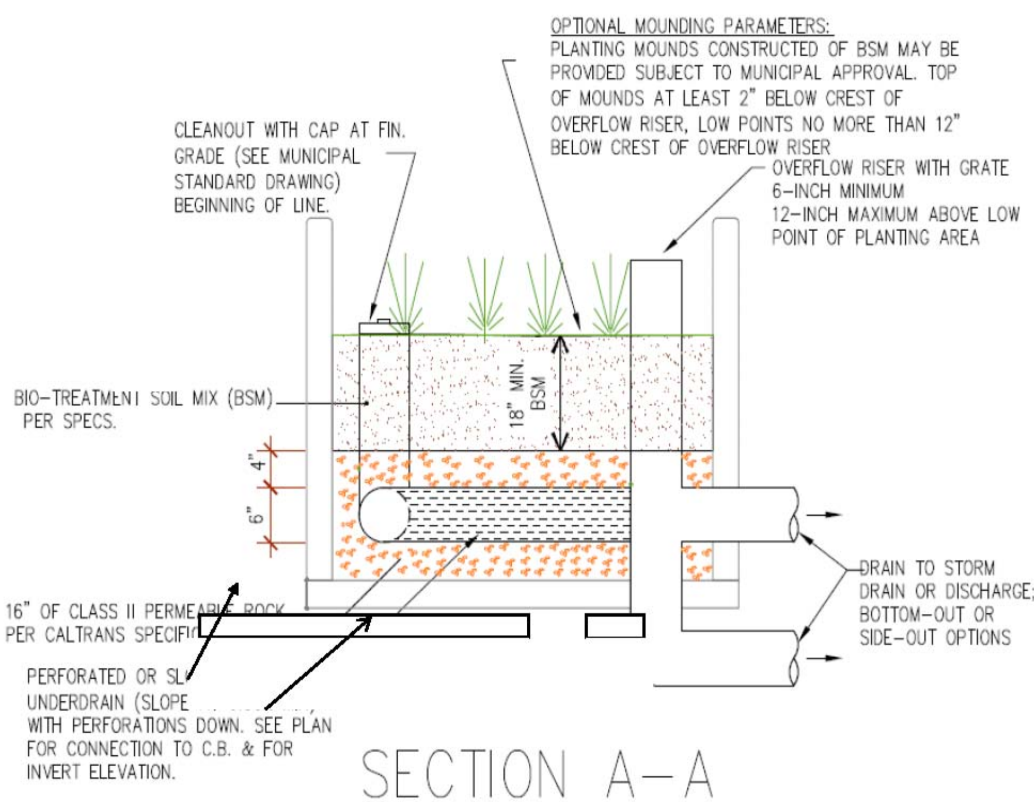

Figure 6-10: Cross section A-A of flow-through planter, shows side view of underdrain

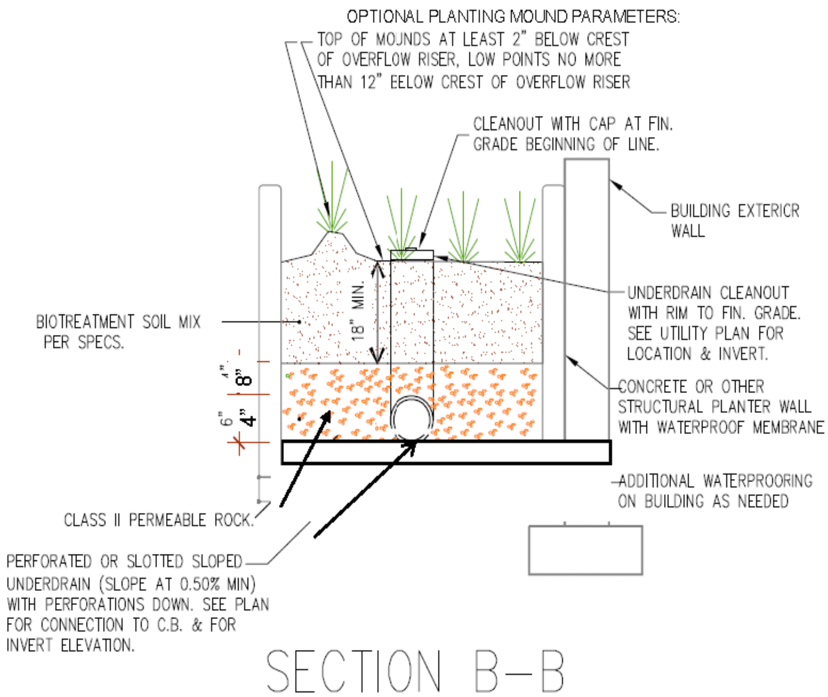

Figure 6-11: Cross section B-B of flow-through planter, shows cross section of underdrain

Figure 6-12: Half-buried, perforated flexible pipe serves as a flow spreader to distribute stormwater evenly throughout a long flow-through planter in Emeryville (Source: GreenGrid/ Weston Solutions).

Figure 6-13: The same planter as shown in Figure 6-12, after vegetation has matured and partially conceals the half-buried pipe from view (Source: San Francisco Estuary Partnership).

6.3 Tree Well Filter

Figure 6-14: Tree well filters in San José. Photo: City of San José.

Best Uses

- Sites with limited space
- Street improvement projects
- Sidewalks, urban plazas
- Special Projects

Advantages

- Aesthetic feature
- Occupies small footprint
- Integrates with landscape plan

Limitations

- Can clog without maintenance
- Higher installation cost
- Systems containing high flow rate media are only allowed for Special Projects

Tree well filters are especially useful in settings where available space is at a premium. They can be installed as open-bottom systems that promote infiltration or in closed-bottom systems where infiltration is undesirable or infeasible, such as sites with tight clay soils, groundwater contamination, or high groundwater levels. Tree well filters are often installed along urban sidewalks as part of an integrated street landscape, but they are highly adaptable and can be used in most development scenarios. The top of the soil and mulch is set low enough that runoff from adjacent pavement can flow into the system. Tree well filters can also be constructed using modular suspended pavement system products such as Silva Cells (see Chapter 4 and Figure 6-18 below). Note that some jurisdictions do not accept the use of Silva Cells or other suspended pavement systems as acceptable treatment measures in their plan review process. Additionally, some proprietary systems are too small for street tree applications and may not be supported by some jurisdictions. Consult local stormwater plan review personnel and municipal arborists or foresters for approval.

The tree well filter's basic design is similar to that of a bioretention area or flow-through planter. It consists of an excavated pit or vault filled with biotreatment soil media (BSM) or other filtration media, planted with a tree and/or other vegetation, and underlain with drain rock and an underdrain. A tree well filter that uses BSM and is designed for a stormwater runoff surface loading rate of 5 inches per hour is considered an LID treatment measure (either an infiltration or biotreatment measure, depending on its design). Suspended pavement systems can provide additional uncompacted soil volume for tree root growth under adjacent pavement areas as well as allowing for "underground" bioretention. If used as part of the stormwater treatment system, the areas under the pavement should follow bioretention design guidelines, i.e., be installed with the required amount of BSM and underdrains as necessary, in addition to satisfying requirements for street tree planting. Consult stormwater plan review personnel and municipal arborists or foresters for appropriate soil volumes for specified trees.

High flow-rate tree well filters containing manufactured media with design loading rates that exceed 5 inches per hour do not qualify as LID treatment measures and will only be allowed for use in Special Projects, as described in Appendix I.

Design and Sizing Guidelines

TREATMENT MEASURE DIMENSIONS AND SIZING

- It is recommended that a tree well filter with BSM be sized to be 4% of the contributing impervious surface area; i.e., the area of impervious surface multiplied by the 0.04 sizing factor will equal the required surface area of the tree well filter. This sizing factor is derived from the flow-based treatment standard (runoff from 0.2 in/hr intensity rainfall) and a required surface loading rate of 5 in/hr. Alternatively, if there are site constraints, tree well filter sizing may be calculated using a volume-based treatment method or a combination flow- and volume-based treatment method described in Appendix B. Larger size systems will allow for a larger tree species.
- The allowable ponding depth for the type of tree selected should be determined by the landscape architect or municipal arborist and should not exceed 6 inches. The 3-inch mulch layer can be within the 6-inch ponding depth.
- Tree well filters cannot be placed in sump condition; therefore, tree well filters should have flow directed along a flow line of curb and gutter or other lateral structure.
- High flow rate tree well filters (non-LID):
  - The system should be reviewed by the manufacturer/local supplier before and during installation. High flow rate tree well filters should be sized based on the TAPE-verified loading rate of the media. The manufacturer should certify the ratio of impervious area to treatment area for the project.
  - The tree species will likely be of small stature due to the constrained box environment and lack of ample rootable soil. Larger boxes will allow for more soil volume and possibly increased tree health. Typically 1-2 trees per unit are used. Small stature trees will not contribute to urban canopy calculations due to their canopy size and anticipated frequency of replacement; therefore, seek to include large sized trees with an approved soil volume for rooting capacity.
  - High flow rate tree well filters are available in pre-cast concrete boxes. The required size of the box is based on the size of the tributary impervious surface and the infiltration rate of the filter media. The product must be certified by the Washington State Technical Assessment Protocol – Ecology (TAPE) program, General Use Level Designation (GULD) for Basic Treatment, and sized based on the certified design operating rate[1].
- Units should be located in areas that can be accessible at any given time for the purpose of operation and maintenance and inspections.

INLETS TO TREATMENT MEASURE

Flow may enter the tree well filter in the following ways:

- As overland flow from landscaping or pavement;
- Through a curb opening (minimum 18 inches);
- Through a curb drain;

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[1] For more information, see: http://www.ecy.wa.gov/programs/wq/stormwater/newtech/technologies.html

- Through a bubble-up manhole or storm drain emitter; and/or
- Through roof leader or other conveyance from building roof.
- Where flows enter the tree well filter, allow a change in elevation of 4 to 6 inches between the paved surface and biotreatment soil media elevation, so that vegetation or mulch build-up does not obstruct flow.
- Install cobbles or rocks as needed to dissipate flow energy where runoff enters the treatment measure.
- Bubble-up emitters and pipes to bubble-up emitters should have weep holes to avoid standing water after storm events.

OVERFLOW STRUCTURE

- Flows in excess of the treatment flow rate should bypass the tree well filter to a downstream inlet structure or other appropriate outfall.
- The inlet elevation of the overflow structure should be set at the allowable ponding depth above the low point of the planting area and at least 2 inches above the high point of the planting area (i.e., the top of planting mounds). Additional freeboard requirements may apply to protect nearby structures from flooding; check with the local jurisdiction.

UNDERDRAINS

- An underdrain system is required for installations in slow-draining native soils. If the water quality design volume will infiltrate into native soils in 72 hours or less, based on local percolation tests, and the local jurisdiction allows, then no underdrain is required.
- If there is 5 feet or more separation between the base of the tree well and the groundwater table and infiltration is permitted on site, the underdrain should be installed at least 6 inches above the base of the trench to allow infiltration into native soils.
- If there is less than 5 feet separation to the groundwater table, or infiltration is not permitted due to site-specific conditions, the facility should be lined with an impermeable fabric and the underdrain should be placed just above the impermeable fabric.
- The underdrain should consist of a minimum 4-inch diameter perforated HDPE or PVC pipe with cleanouts and connection to a storm drain or discharge point. Solid HDPE or triple-walled HDPE pipe, with smooth inner and outer layers and a corrugated inner layer, are recommended. To help prevent clogging, two rows of perforation may be used.
- The underdrain trench should include a minimum 12-inch thick layer of drain rock such as Caltrans Standard Section 68-1.025 permeable material Class 2 or equivalent. The underdrain should be placed at least 2 inches below the top of the drain rock layer, with perforations facing downward, at a minimum 0.5% slope (unless a flatter slope is allowed by the municipality based on site-specific conditions).
- The cleanout for the underdrain should consist of a vertical, rigid, non-perforated, non-corrugated PVC or HDPE pipe, with a minimum diameter of 4 inches and a watertight cap fit, raised 2” above the ponding height, or as required by municipality. The cleanout should be connected to the underdrain using a long sweep elbow fitting for ease of maintenance.
- To avoid clogging, filter fabric should not be used in or around the underdrain or between the biotreatment soil mix and the drain rock. If desired, a 2-inch pea gravel layer may be used between the biotreatment soil mix and the drain rock.
- To avoid excess hydraulic pressure on subsurface concrete 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.

PLANTING SOIL REQUIREMENTS

- Soils used in the tree well filter should meet the BSM specifications included in Appendix C of this Handbook. A minimum long term infiltration rate of 5 inches per hour is required (initial infiltration rate may exceed this to allow for tendency of infiltration rate to reduce over time).
- Tree well filters should have a minimum BSM depth of 18 inches. This depth may need to be increased to accommodate large tree root systems (consult with the local arborist).
- For high flow rate tree well filters (to be used in Special Projects only), follow the media recommendations from the manufacturer.

VEGETATION

- Suitable tree and plant species are identified in the planting guidance in Appendix D.
- Install and maintain a 3-inch layer of composted wood mulch, consistent with the regional Biotreatment Wood Mulch (BWM) specification (see Appendix D of the Handbook), around the tree as appropriate or as recommended by the landscape architect. Rock, cobble, or pea gravel may also be used. “Micro-bark”, or “gorilla hair” mulches, as well as chipped wood mulch from recycled pallets and dimensional lumber, are not recommended.
- Rock mulch, such as cobble or gravel, should be used sparingly and only where necessary. Pea-gravel is not recommended due to heat intensity, compaction of BSM, reduction of soil health, and increased maintenance requirements.
- Drought tolerant trees are preferred and may be required by the local municipality. Provide sufficient irrigation for the initial establishment period as well as long term maintenance. If an irrigation system is not present, then hand or truck watering should be conducted weekly through tree establishment – typically through the first six months depending on the season and precipitation levels. If trees are being planted in BSM and an irrigation system is not present, then even drought tolerant species will require supplemental watering for their lifetime.
- Use integrated pest management (IPM) principles to help avoid the need for synthetic pesticides and quick-release fertilizer. Check with the local jurisdiction regarding local IPM policies.
- Trees should not block inflow, create traffic or safety issues, or obstruct utilities.

Construction Requirements

- When excavating a tree pit, avoid spreading fines of the soils on bottom and side slopes. Loosen soils at the bottom of the excavation prior to constructing the tree well filter.
- Minimize compaction of existing soils in the location of tree wells (except as needed to support tree installation); protect from construction traffic.
- Protect the area from construction site runoff; divert runoff from unstabilized areas away from completed tree wells.

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 it with the Maintenance Agreement. Refer to Chapter 8 and Appendix G for specific maintenance requirements.

Figure 6-15: Tree Filter with Overflow Bypass. Source: University of New Hampshire Environmental Research Group, 2006

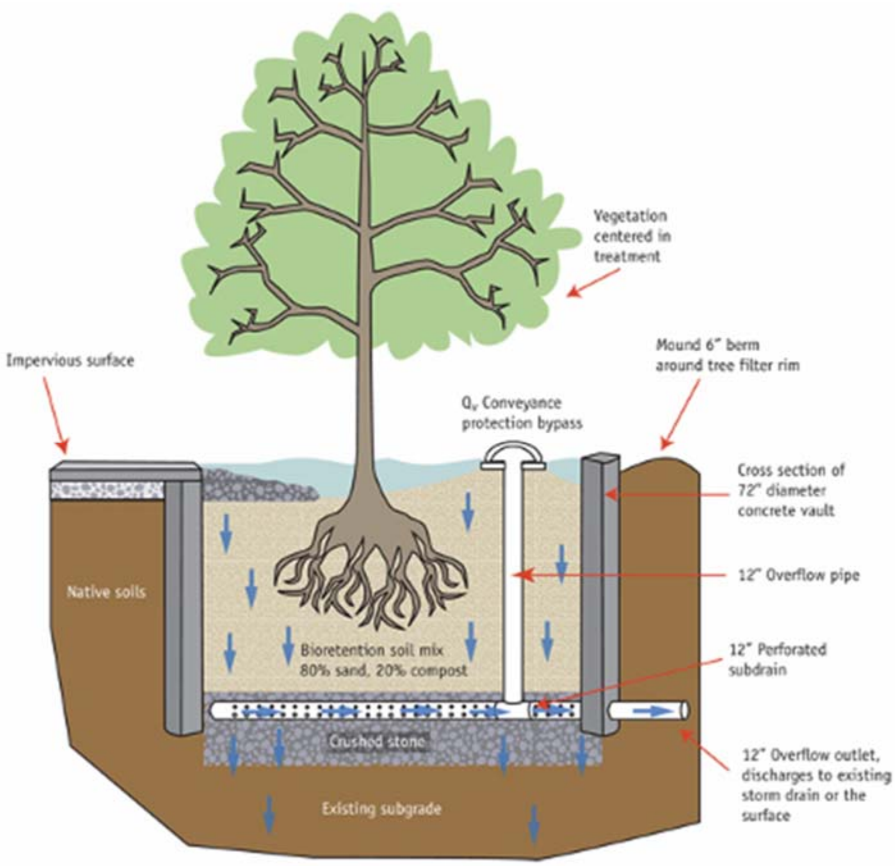

Figure 6-16: Schematic of a non-proprietary tree well filter (note that bioretention soil mix and other components vary from Bay area requirements). Source: UNH Stormwater Center 2007 Annual Report.

Figure 6-17: Proprietary tree well filter at an office building in San José. Photo: City of San José.

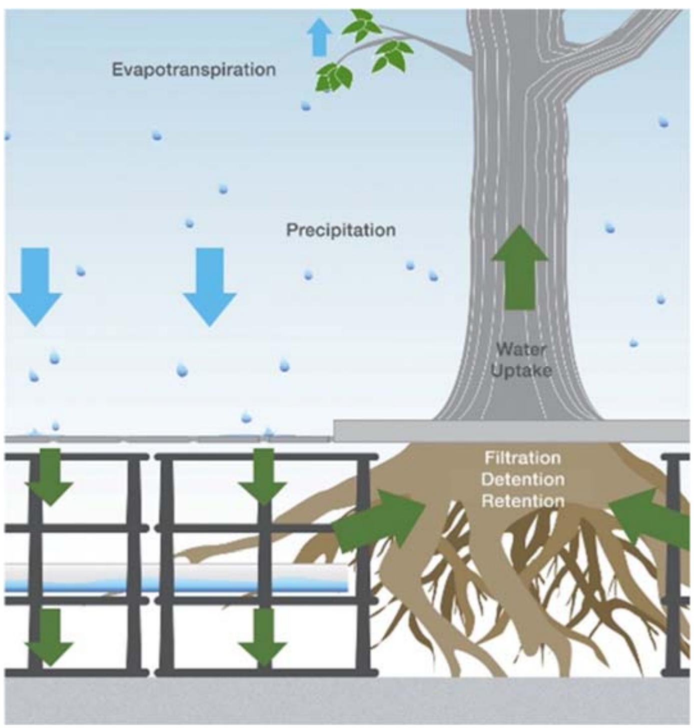

Figure 6-18: Schematic of modular suspended pavement system. Image: Deeproot Inc.

6.4 Infiltration Trench

Figure 6-18: Infiltration trench next to parking structure, Palo Alto. Photo: EOA, Inc.

Best Uses

- Limited space
- Adjacent to paved surfaces
- Landscape buffers

Advantages

- Meets LID requirements
- Achieves treatment via infiltration into existing soils
- No surface outfalls

Limitations

- Susceptible to clogging if not maintained
- Infiltration rate of site soils must exceed 0.5 in/hr (i.e., not suitable for Type C or Type D soils)
- Cannot be used with certain site conditions, e.g., high groundwater table, contaminated soils, proximity to wells or septic systems.
- Not for use on steep slopes or in fill soils
- Not for use at industrial sites

An infiltration trench is a long, excavated trench backfilled with a stone aggregate, and lined with a filter fabric. Infiltration trenches remove suspended solids, particulate pollutants, coliform bacteria, organics, and some soluble forms of metals and nutrients from stormwater runoff by detaining the runoff, storing it in the void spaces of the aggregate, and allowing it to infiltrate into the underlying soil. An underdrain may be provided if the drain is placed above the void space needed to store and infiltrate the water quality design runoff volume. Infiltration trenches are prone to clogging with sediment and require pretreatment using buffer strips or swales as well as regular observation and maintenance to ensure proper functioning.

If an infiltration trench is deeper than it is wide, it will be considered a Class V injection well that is regulated by EPA's Underground Injection Control Program[1]. Care should be taken to design the trench such that its depth does not exceed its largest horizontal dimension. This is usually not an issue with a long, narrow trench. However, note that Santa Clara Valley Water District guidelines for stormwater infiltration devices (Appendix A) will apply when siting any infiltration trenches.

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[1] See EPA Region 9's website: https://www.epa.gov/uic/underground-injection-control-regulations-and-safe-drinking-water-act-provisions

Design and Sizing Guidelines

DRAINAGE AREA AND SETBACK CONSIDERATIONS

- Infiltration trenches work best when the upgradient drainage area slope is less than 5 percent. The downgradient slope should be no greater than 20 percent to minimize slope failure and seepage.
- In-situ/undisturbed soils should have a low silt and clay content and have infiltration rates greater than 0.5 inches per hour. Soil testing near the trench location is highly recommended to confirm infiltration rates.
- A 10-foot separation between the bottom of the trench 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 Santa Clara Valley Water District Infiltration Guidelines (Appendix A) for additional setback and separation requirements.

TREATMENT MEASURE DIMENSIONS AND SIZING

- The infiltration trench should be sized to store and infiltrate the water quality design volume.
- A site-specific trench depth can be calculated based on the soil infiltration rate, aggregate void space, and the trench storage time. The stone aggregate used in the trench is 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. Trench depths are usually between 3 and 8 feet.
- The trench surface may consist of large stone or pea gravel.
- Place permeable filter fabric around the walls and bottom of the trench and 1 foot below the trench surface. The filter fabric should overlap each side of the trench in order to cover the top of the stone aggregate layer. The filter fabric prevents sediment in the runoff and soil particles from the sides of the trench from clogging the aggregate.
- 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 can be 4- to 6-inch diameter perforated PVC pipe, which is anchored vertically to a foot plate at the bottom of the trench.

INLET TO THE TREATMENT MEASURE

- Ideally runoff should enter the trench via sheet flow from the paved surface. Runoff can be captured by depressing the trench surface or by placing a berm on the downgradient side. Underground inlets can also be used, but care must be taken to pretreat inflows to remove sediment to reduce the risk of clogging.
- To prevent clogging of the system with sediment, a vegetated buffer strip at least 5-feet wide, or other means of pretreatment, should be located adjacent to the infiltration trench to capture 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 to prevent erosion. The buffer strip should be graded with a slope between 0.5 and 1.5 percent so that runoff enters the trench as sheet flow.

VEGETATION

- Infiltration trenches should be kept free of vegetation. If vegetation on the surface is desired, a different treatment measure (e.g., a linear bioretention area) should be selected.

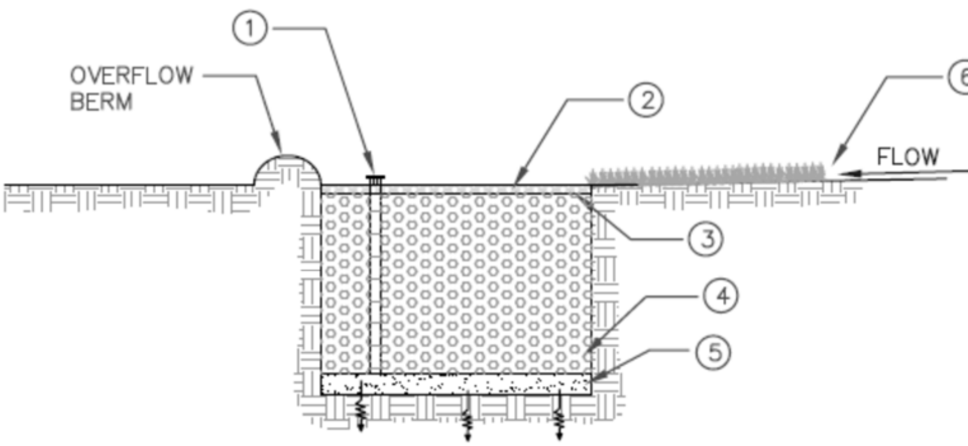
- To avoid accumulation of leaves and other debris that can lead to sediment production and clogging, trees and other large vegetation should be planted away from trenches such that drip lines do not overhang infiltration beds.

Construction Requirements

- The drainage area must be fully developed and stabilized with vegetation before constructing an infiltration trench. High sediment loads from unstabilized areas will quickly clog the infiltration trench. During project construction, runoff from unstabilized areas should be diverted away from the trench into a sedimentation control BMP until vegetation is established.
- 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.
- Minimize compaction of existing soils in the trench area. 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 it with the Maintenance Agreement. Refer to Chapter 8 and Appendix G for specific maintenance requirements.



Notes:
1. Observation well with lockable above-ground cap
2. 2" pea gravel filter layer
3. Provide filter fabric if no pretreatment is provided
4. 3' – 5' deep trench filled with 1.5" – 2.5" diameter clean stone with approximately 35% voids
5. 6" deep sand filter layer (or fabric equivalent)
6. Runoff filters through grass filter strip or vegetated swale
7. Optional flow control device for off-line configurations

Figure 6-19: Infiltration Trench Section. Source: County of Los Angeles, 2010.

6.5 Subsurface Infiltration System

Figure 6-20: Photo of subsurface retention/infiltration system installation under a parking lot. Source: CONTECH Engineered Solutions.

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
- Multi-benefit attributes: groundwater recharge, flood mitigation, pollutant load reduction

Limitations

- Not recommended for poorly infiltrating soils or highly polluted runoff with potential for groundwater contamination
- Requires pretreatment
- Potential for standing water and mosquito production

Subsurface infiltration systems, also known as infiltration galleries, are underground vaults or pipes that store and infiltrate stormwater. 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 parking lots, parks or playing fields. A number of vendors offer prefabricated, modular infiltration galleries in a variety of material types, shapes and sizes. Many 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 the link below and Appendix A). The Santa Clara

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[1] See EPA Region 9's website: https://www.epa.gov/uic/underground-injection-control-regulations-and-safe-drinking-water-act-provisions

Valley Water District guidelines for stormwater infiltration devices (Appendix A) also apply when siting any subsurface infiltration system.

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 Santa Clara Valley Water District Infiltration Guidelines (Appendix A) 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 C.3.d amount of runoff. 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.

TREATMENT MEASURE DIMENSIONS AND SIZING (EXFILTRATION TRENCHES)

- The exfiltration trench should be sized to store and infiltrate the C.3.d amount of runoff. 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.

6.6 Rainwater Harvesting and Use

Figure 6-21: Rainwater is collected and used for flushing toilets at Mills College, Oakland.

Best Uses

- High density residential or office buildings 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

- Higher installation and maintenance costs than other LID treatment measures.
- High toilet flushing or irrigation demand needed to use design volume
- Municipal permitting requirements are not standardized.

Rainwater harvesting is the process of collecting rainwater from impervious surfaces and storing it for later use. Rainwater harvesting systems are designed 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 rain barrels, above-ground or below-ground cisterns, open storage reservoirs (e.g., ponds), and various underground storage devices (tanks, vaults, pipes, and proprietary storage systems). The harvested water is then fed into irrigation systems or non-potable water plumbing systems, either by pumping or by gravity flow. Rooftop runoff is the source of stormwater most often collected in a harvesting/use system, because it often contains lower pollutant loads than at-grade surface runoff, and it provides accessible locations for collection in storage facilities via gravity flow. Rainwater storage systems designed for stormwater management are usually much larger than rain barrel systems (typically 100 gallons or less) used for supplemental landscape irrigation on small sites.

Uses of Harvested Water

Uses of captured water may include irrigation, vehicle washing, and indoor non-potable use such as toilet flushing, heating and cooling, or industrial processing[1]. In the Bay Area, toilet flushing in high density residential or office projects and schools is the use that most commonly generates sufficient demand to use the water quality design volume of runoff. In projects with a very large

[1] Rainwater harvesting for potable use has special requirements and is not covered by this guidance.

landscaped areas, irrigation demand may be sufficient to utilize the required amount of runoff; however, in these types of projects, it is generally more cost-effective to disperse runoff from impervious areas directly onto surrounding landscaping, rather than collecting it in large cisterns for distribution later.

Codes and Standards

The State of California added rainwater harvesting and graywater regulations into the State's Plumbing Code on January 1, 2014, and has since been updated in 2016, 2019, and 2022. Chapter 16 of the Plumbing Code, which contains the rainwater harvesting requirements, allows rainwater to be harvested from rooftops 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 15 of the Code. Some small catchment systems (5,000 gallons or less) being used for non-spray irrigation do not require permits – see Chapter 16 for more details[2].

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."[3] 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*[4] may also be used as a resource.

System Components

Rainwater harvesting systems typically include the following components: (1) methods to divert stormwater runoff to the cistern or other storage facility; (2) an overflow for releasing water when the cistern is full; (3) a distribution system to get the water to where it is intended to be used; and 4) filtration and treatment systems. Treatment is required for indoor uses of harvested rainwater (see Table 6-2).

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 cistern. The initial rainfall of any storm usually picks up pollutants from dust, bird droppings, and debris 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 collection surface away from the cistern (typically to landscaping) to remove accumulated smaller contaminants, such as dust, pollen, and bird and rodent droppings. Roof washers are commonly used to waste the initial water coming off the collection surface before being allowed to fill the cistern. The simplest version is a standpipe connected to the downspout that fills before rainwater can flow into piping leading to the cistern.

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[2] https://epubs.iapmo.org/2022/CPC/ ; click on Chapter 16

[3] https://epubs.iapmo.org/2022/CPC/ ; click on Chapter 2

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

TREATMENT METHODS

Harvested rainwater typically requires filtration prior to any use, and disinfection for indoor non-potable use. As a general reference, the Texas Manual on Rainwater Harvesting (3rd Edition, 2006) identifies two methods of disinfection used in rainwater harvesting systems for indoor use: chlorine and ultraviolet (UV) light. Compared to chlorination, UV light is often preferred because it is safer to use, does not create harmful disinfection by-products, and uses minimal power for operation. However, filtration before the UV light treatment is required because pathogens can be shadowed from the UV light by suspended particles in the water. Disinfection using ozone may also be an option for larger systems. Check with local health officials for acceptable methods of disinfection.

The 2022 California Plumbing Code contains minimum treatment and water quality standards for rainwater, which are summarized in Table 6-2 below.

Table 6-2
Summary of Minimum Treatment and Water Quality Standards for Rainwater

Application	Minimum Treatment	Minimum Water Quality
Subsurface or non-sprinkled surface irrigation (less than 5,000 gallons of storage)	No treatment required if tank is supported directly on grade and height:width ratio < 2:1	N/A
Spray irrigation (less than 360 gallons of storage);	Debris excluder or other approved means; disinfection	N/A
Surface, subsurface, and drip irrigation; car washing	Debris excluder or other approved means; 100 micron filter	N/A
Spray irrigation (360 gallons or more of storage); ornamental fountains and other water features	Debris excluder or other approved means	Turbidity < 10 NTU; Escherichia coli < 100 CFU/100 ml
Toilet flushing, clothes washing, and trap priming; cooling tower make-up water	Debris excluder or other approved means; 100 micron filter	Turbidity < 10 NTU; Escherichia coli < 100 CFU/100 ml
Source: 2022 California Plumbing Code, Table 1603.5, Chapter 16, page 323.		

Design and Sizing Guidelines

HYDRAULIC SIZING

- If a rainwater harvesting system will be designed to fully meet Provision C.3.d stormwater requirements, there must be sufficient demand to use the water quality design volume, i.e., 80 percent of the average annual rainfall runoff, from the collection area. Appendix I provides guidance on how the estimate the required landscaping or toilet flushing demand to meet C.3.d. requirements.
- If the project appears to have sufficient demand for rainwater, size the cistern (or other storage facility) to achieve the appropriate combination of drawdown time and cistern volume indicated in the sizing curves included in Appendix I.

- If a rainwater harvesting system is designed for less than the water quality design volume, the overflow must receive additional treatment, e.g., by infiltration in landscaping or by infiltration/biotreatment in a bioretention area.

DESIGN GUIDELINES FOR ALL SYSTEMS

- Provide separate piping without direct connection to potable water piping. Dedicated piping should be color coded and labeled as harvested rainwater, not for consumption. Fixtures supplied with non-potable rainwater should include signage identifying the water source as non-potable and not for consumption.
- The rainwater harvesting system must not be connected to the potable water system in any way.
- When make-up water is provided to the rainwater harvesting 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.
- Equip rainwater storage facilities covers with tight seals and/or screens, to reduce risk of mosquito production. Follow mosquito control guidance in Appendix F.
- Do not install rainwater storage facilities 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.
- Storage facilities should be provided with access for maintenance, and with a means of draining and cleaning.

DESIGN GUIDELINES FOR INDOOR USE

- Provide filtration and disinfection of harvested rainwater for indoor non-potable use, as required by the California Plumbing Code (Table 6-2) and any municipality-specific requirements.
- Avoid harvesting water for indoor non-potable use from roofs with architectural copper, which may discolor porcelain plumbing fixtures.

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 to a hydraulically-sized treatment measure.
- First flush diverters should be installed in such a way that they will be easily accessible for regular maintenance.
- Do not direct any rainwater from roofs with wood shingles, asphalt shingles, tar, lead, etc. to food-producing gardens due to the leaching of compounds that may adversely affect food for human consumption.

Construction Requirements

- Hire a contractor experienced with the installation of rainwater harvesting systems.
- Do not allow sediment to get into the system during construction, and 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 it with the Maintenance Agreement. See Chapter 8 and Appendix G for guidance on maintenance requirements, and discuss maintenance requirements with your contractor or supplier.

6.7 Media Filter

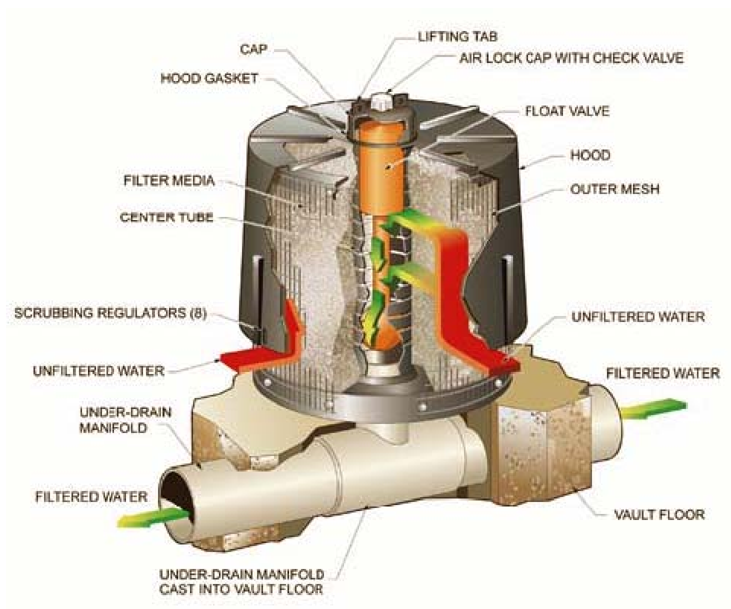

Figure 6-22: Filter Cartridge, Typically Used as Part of Array. Source: CONTECH Engineered Solutions, 2006. (Note: This photo is for general information only and is not an endorsement of this or any other proprietary product.)

Best Uses

- Special Projects
- Limited space
- Underground
- As part of a treatment train (pre-treatment)

Advantages

- Less area required
- Customized media
- Customized sizing

Limitations

- Not considered LID
- High installation and maintenance costs; rely on manufacturer
- Confined space entry may be required
- Media filtration is only allowed at 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 J). Media filters may also be used as part of a treatment train, e.g., as pre-treatment for a subsurface infiltration system. Because Special Projects are typically dense urban infill projects where LID treatment is infeasible due to space constraints, this section focuses on proprietary cartridge filters, which are suitable for limited space and/or underground applications.

Cartridge filters use cartridges of a standard size that can be filled with various types of manufactured media, individually or in combination, including perlite (expanded volcanic ash), zeolite (natural mineral), granular activated carbon, and granular organic media (such as processed leaves). The media are designed to remove certain types of pollutants. The media cartridges are placed in vaults, manholes, or catch basins. In the unit shown in Figure 6-22, the

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

water flows laterally (horizontally) into the cartridge, through the media 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 (i.e., surface loading rate).

Design and Sizing Guidelines

- For Special Projects, the selected media filter product must 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 (see Figure 6-23 for an example).
- 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 6-24 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.
- Units should be located in areas that can be accessible at any given time for the purpose of operation and maintenance and inspections. Media filter access manholes should not be located in parking stalls because they can't be inspected if a car is parked in the spot. Media filters should also not be located in garages as vactor trucks need access for cleaning.

Installation Requirements

- Consult the manufacturer to determine the installation requirements for a specific product.
- For vault-based media filters, base preparation will be required. Typically, the soil subbase will need to be compacted and a minimum 6-inch layer of crushed rock base material provided. See manufacturer's specifications.
- To avoid excess hydraulic pressure on subsurface treatment system structures:
  1. The depth to seasonal high groundwater level should be at least 5 feet from the bottom of the structure.

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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

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

Maintenance Requirements

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

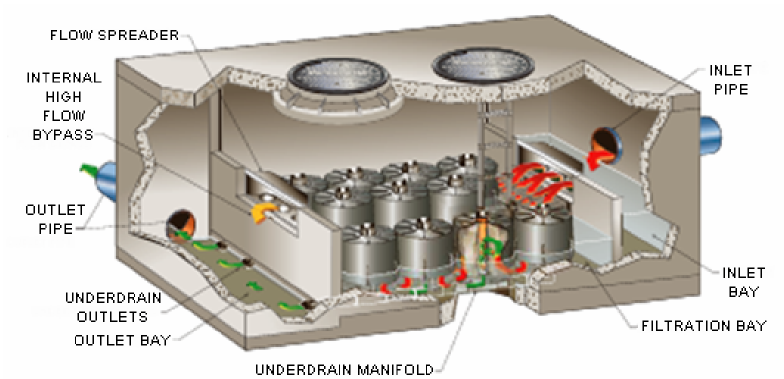


Figure 6-23: Plan View, Filter Array in a Vault. Source: CONTECH, 2006. (Note: This photo is for general information only and is not an endorsement of this or any other proprietary product.)

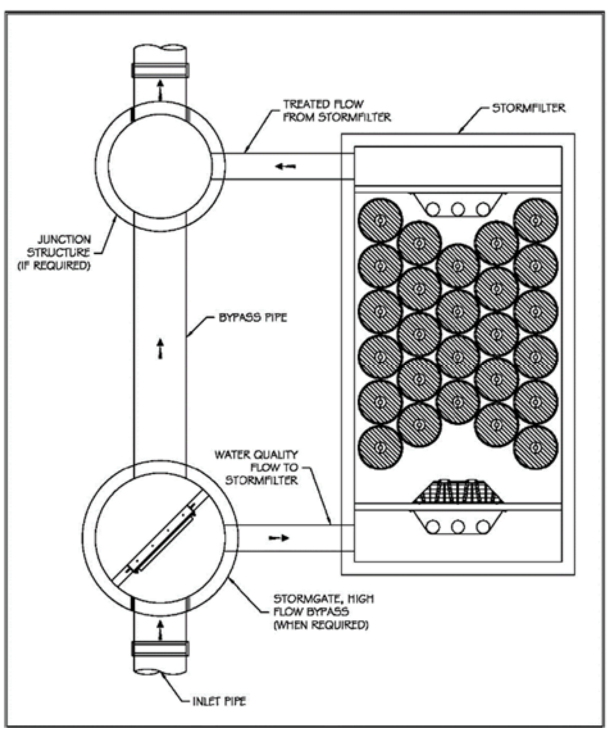


Figure 6-24: Profile View, Filter Array in a Vault with a High Flow Bypass. Source: CONTECH Stormwater Solutions, 2006. (Note: This photo is for general information only and is not an endorsement of this [illegible]y other proprietary product.)

6.8 Extended Detention Basin

Figure 6-25: Extended detention pond. Source: City of Saratoga

Best uses

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

Advantages

- Easy to operate
- Relatively inexpensive to construct
- Treatment of particulates
- Low maintenance

Limitations

- Land requirements
- Not a stand-alone treatment measure after 12/1/11
- Not considered LID treatment measure

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

Starting December 1, 2011, projects are not 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, an extended detention basin could be used as part of a treatment train, in which the basin stores a large volume of water and gradually releases it to an LID treatment measure, such as a bioretention area.

Design and Sizing Guidelines

TREATMENT DIMENSIONS AND SIZING

- Extended detention basins used as part of a treatment train should be sized to capture the required water quality volume with a 48-hour detention time.
- Extended detention basins should have no greater than 3:1 side slopes (2:1 side slopes may be allowed if fenced).
- The optimal basin depth is between 2 and 5 feet.
- A safety bench should be added to the perimeter of the basin wall for maintenance when basin is full.

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

INLETS TO TREATMENT MEASURE

- The inlet pipe should enter the basin at the invert, and have engineered energy dissipation.
- Piping into the extended detention basin should have erosion protection. As a minimum, a forebay with a 6-inch thick layer of Caltrans Section 72, Class 2 rock slope protection should be placed at and below the inlet to the extent necessary for erosion protection.
- Check with municipality regarding trash screen requirements. Trash screen installation may be required upstream of the outlet pipe or as part of the outlet riser.

OUTLETS AND ORIFICES

- If the detention basin is to be used as part of a treatment train, the outlet should be sized with a drawdown time of 48 hours for the design water quality volume.
- If the detention basin is to be used for hydromodification management, see Chapter 7 and Appendix E of the SCVURPPP C.3 Handbook for outlet and orifice sizing guidelines.
- Orifices should each be a minimum diameter of 0.5 inch. Extended detention basins are not practical for small drainage areas because the criteria for the minimum orifice diameter cannot be met.
- Each orifice should be protected from clogging using a welded stainless steel wire mesh screen. The screen should protect the orifice openings from runoff on all exposed sides. For example, see Caltrans standard detail for Water Quality Outlet Riser Type 1.

VEGETATION

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

GROUNDWATER SEPARATION CONSIDERATIONS

- 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.

- If there is at least a 5-foot separation between the bottom of the facility and the seasonal high groundwater level, and geotechnical conditions allow infiltration, the facility may be unlined.

Construction Requirements

- Minimize compaction of existing soils. Protect from construction traffic.
- Protect the area from construction site runoff. Runoff from un-stabilized areas should be diverted away from the detention basin.

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.

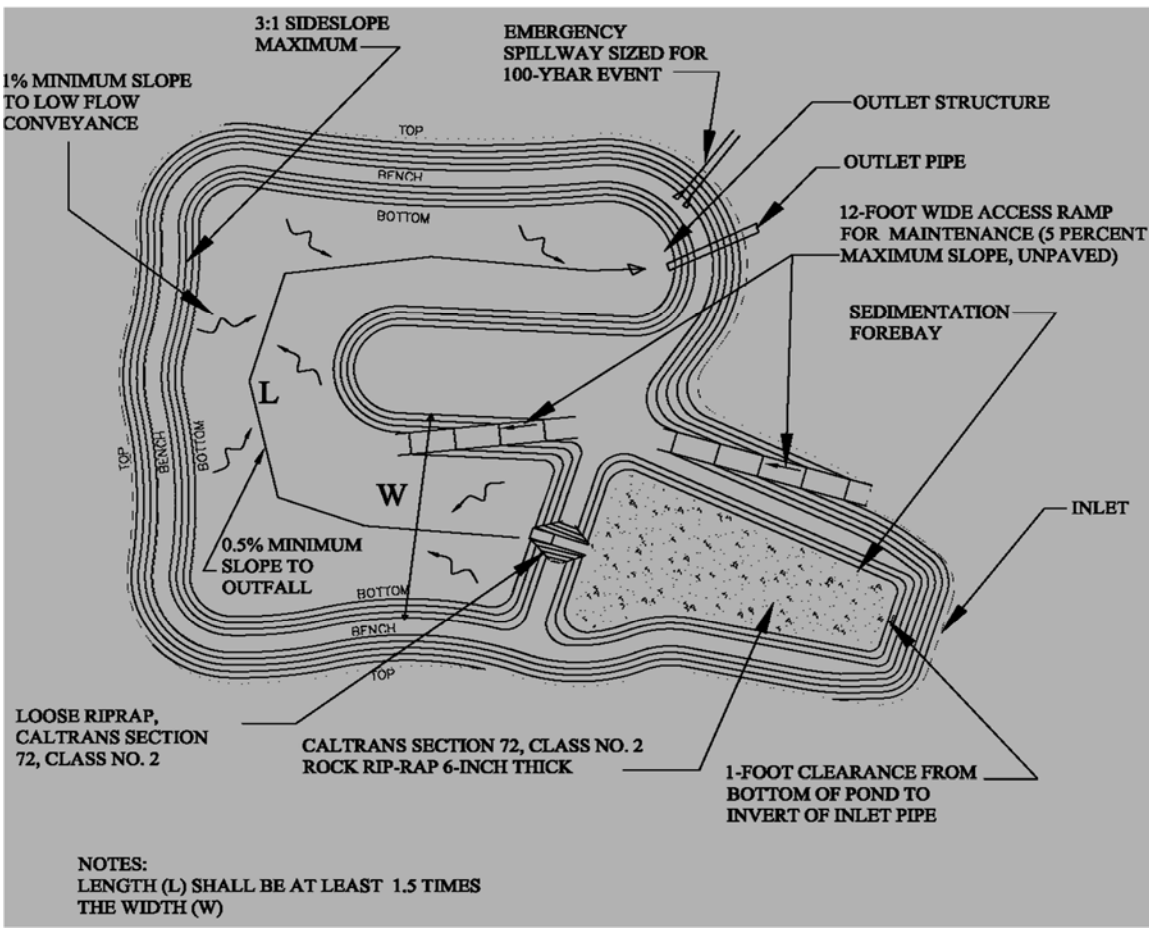


Figure 6-26: Plan View, Typical Extended Detention Basin

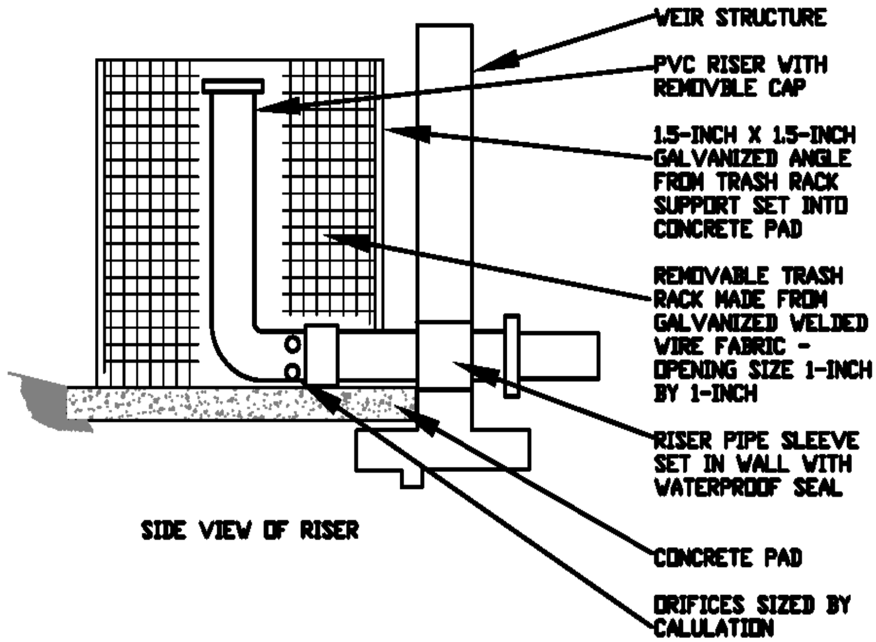


Figure 6-27: Side view of riser, extended detention basin

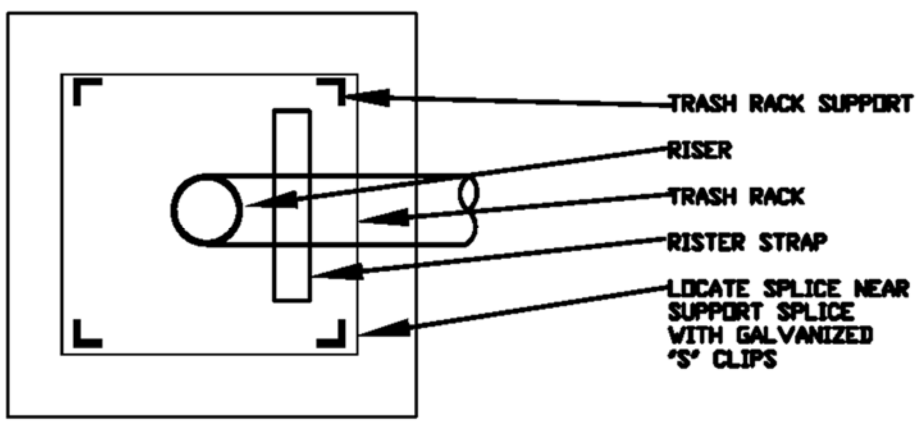


Figure 6-28: Top view of riser, extended detention basin (square design)

6.9 Green Roofs

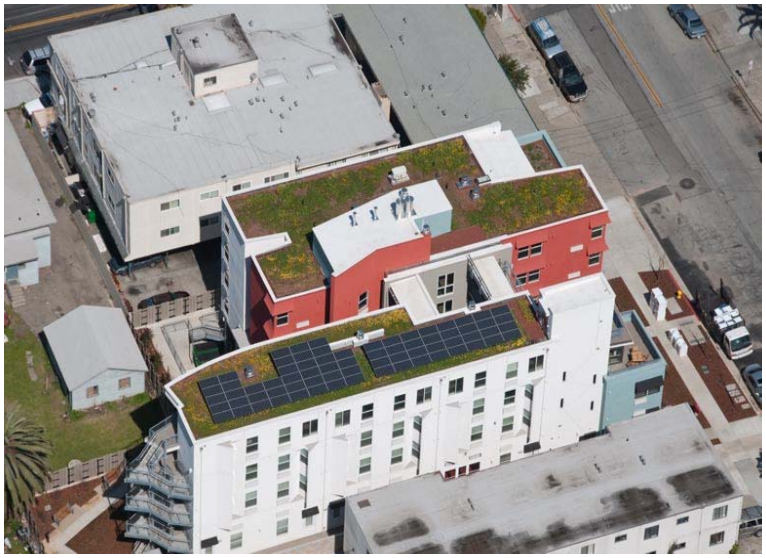


Figure 6-29: Extensive green roof at the Casa Feliz Studios in San José.

Best Uses

- Urban infill sites with limited room for stormwater treatment

Advantages

- Minimizes roof runoff
- Insulates and reduces "heat island" effect
- Earns LEED credits
- Vegetation can provide habitat
- Longer "lifespan" than conventional roofs

Limitations

- Sloped roofs require stepped surfaces
- Non-traditional design
- Higher installation costs

Green roofs are vegetated roof systems that filter, absorb, and retain or detain the rain that falls upon them. Green roof systems are comprised of a layer of planting media planted with vegetation, underlain by other structural components including waterproof membranes, synthetic insulation and geofabrics. A green roof can be either ***extensive***, with 3 to 7 inches of lightweight planting media and low-profile, low-maintenance plants, or ***intensive*** with a thicker (8 to 48 inches) media, more varied plantings, and a more garden-like appearance. Green roofs can provide energy savings, high rates of rainfall retention and decrease the peak flow rate because of the storage that occurs in the media during rain events. Green roofs can also provide habitat for endangered species of butterflies if the right native vegetation is planted.

Design and Sizing Guidelines

- Green roofs may be considered "self-treating areas" or "self-retaining areas" and may drain directly to the storm drain, as allowed by the local municipality, if they meet the following requirements:
  - The green roof system planting media must be sufficiently deep to provide capacity within the pore space of the planting media for the water quality design volume (i.e., 80 percent of the average annual runoff).
  - If the green roof system receives runoff from other areas of the roof, such as mechanical/HVAC equipment areas or impervious walkways, the media must be sufficiently deep to provide capacity for the additional runoff.
  - The planting media must be sufficiently deep to support the long-term health of the vegetation selected for the green roof, as specified by the landscape architect or other knowledgeable professional.
- Extensive green roof systems contain layers of protective materials to convey water away from the roof deck. Starting from the bottom up, typical construction consists of a waterproof membrane, followed by a root barrier, a layer of insulation (optional), a drainage layer, a filter

fabric for fine soils, the engineered growing medium or soil mix, and the plant material (see Figure 6-33).

- The components of intensive green roofs are generally the same as those used in extensive green roofs, with differences in depth and project-specific design application.
- Design and installation should be completed by an established vendor or certified green roof professional.
- Plants should be selected to create a healthy, drought-tolerant roof cover. In general, selected plants should:
  - Be native or adapted species tolerant of extreme climate conditions (e.g., heat, drought, and wind);
  - Be low-growing, with a range of growth forms (e.g., spreading evergreen shrubs, succulents, perennials, or self-seeding annuals);
  - Have shallow root systems without the chance of developing a deep taproot; and
  - Be long-lived or self-propagating, with low maintenance and fertilizer needs.

  See Appendix D for planting guidance.
- Green roofs should drain to landscaping or to bioretention facilities where feasible to do so.
- Irrigation systems are typically required to establish and/or maintain selected plants. In addition, local fire codes may require irrigation systems to prevent a fire hazard or for emergency fire suppression.
- Buildings with green roofs should provide the required facilities (e.g., ladders, guard rails, and anchors) to ensure safe access by maintenance workers in compliance with OSHA regulations.

Maintenance

- Vegetation must be maintained in a healthy state for the life of the project.
- Inspections should be conducted at least semi-annually to confirm adequate irrigation and plant health.
- Fertilize and replenish growing media as specified by landscape designer and as needed for plant health. Avoid the use of pesticides or quick release fertilizers.

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

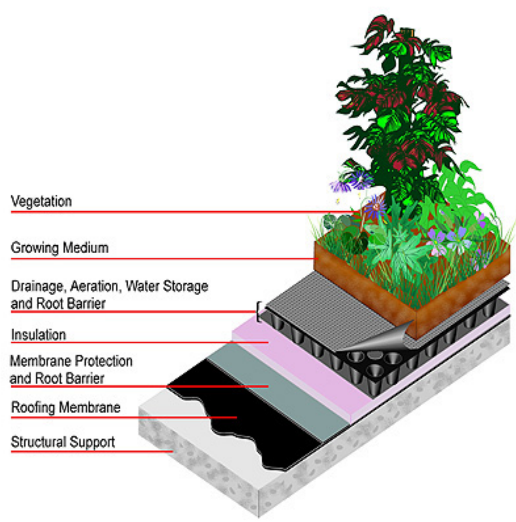


Figure 6-30: Green roof cross-section. Source: American Wick Drain Corp.

Figure 6-31: Intensive Green Roof at Google, Mountain View.

6.10 Pervious Pavement

Figure 6-32: Parking Lot with Pervious Concrete, San José

Figure 6-33 Porous Asphalt Parking Lot, Stanford

BEST USES

- Low-speed residential roads
- Alleys
- Parking lots
- Driveways
- Sidewalks & plazas

ADVANTAGES

- Flow attenuation
- Volume reduction
- Provides treatment via infiltration
- Reduces need for other treatment measures

LIMITATIONS

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

Figure 6-34: Permeable Pavers, Palo Alto

Pervious pavement 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 allows water to infiltrate at a high rate. Pervious pavement is well suited for automobile parking lots, alleys, walking paths and sidewalks, plazas, and driveways. It can also be used for low-speed residential roads receiving occasional truck traffic.

The types of pervious pavement include pervious concrete, porous asphalt, pervious concrete pavers, and permeable interlocking concrete pavement (PICP). Pervious pavers allow infiltration across the entire surface of the paver while permeable pavers utilize the joint space between the pavers for infiltration. Figures 6-35 to 6-37 illustrate pavement cross sections typically under vehicular traffic. These cross sections may include underdrains. Crushed aggregate is sometimes used as pervious pavement as well.

Pervious pavement is not considered an impervious area and can function as a self-treating or self-retaining area when underlain with a depth of aggregate material sufficient to store and infiltrate into native soil the C.3.d volume of runoff. Note that this criterion applies to projects that use pervious pavement to reduce the impervious surface area to below the C.3 regulated projects threshold.

Pervious pavement treatment systems may have underdrains but must include infiltration of the C.3.d volume of runoff into native soil to be considered LID. To accomplish this, the discharge point of the underdrain must be raised above the depth of the C.3.d volume in the aggregate section (see Figure 6-39 for example). When calculating the C.3.d volume, using the methods described in Chapter 5, the surface of the pervious pavement system must be assumed to be impervious in order to correctly include the amount of rainfall falling on the pavement surface.

SCVURPPP gratefully acknowledges the contributions of Mr. David Smith, Technical Director of the Interlocking Concrete Pavement Institute, to this section of the Handbook, including pavement sections, design details, and specifications.

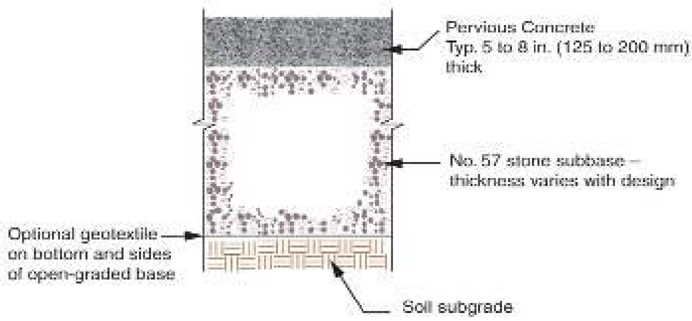


Figure 6-35. Typical Pervious Concrete Pavement
(Source: Interlocking Concrete Pavement Institute)

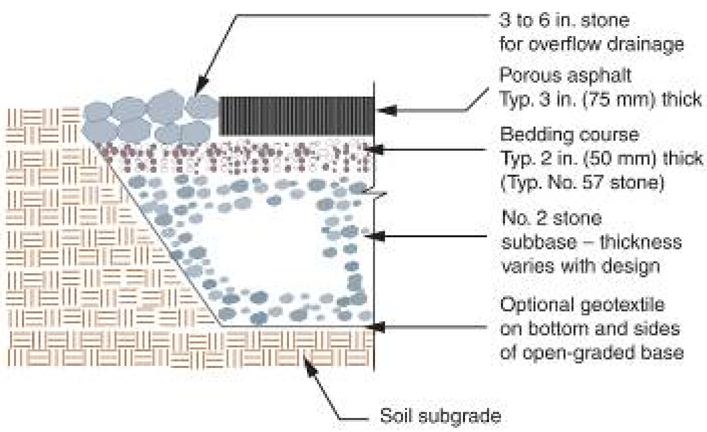


Figure 6-36. Typical Porous Asphalt Pavement
Note: ASTM No. 3 or 4 stone may be substituted for No. 2 stone.
(Source: Interlocking Concrete Pavement Institute)

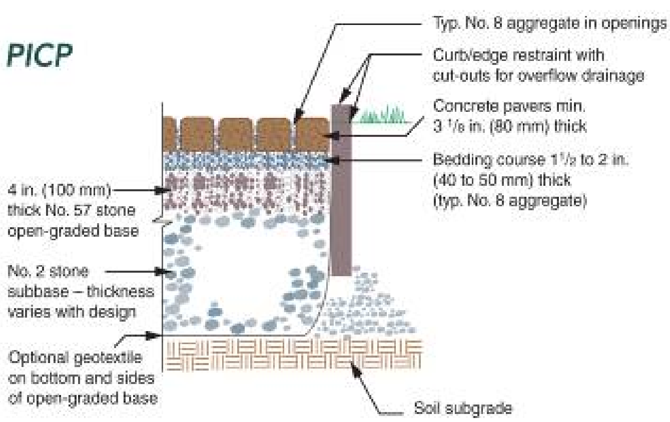


Figure 6-37. Typical Permeable Interlocking Concrete Pavement
Note: ASTM No. 3 or 4 stone may be substituted for No. 2 stone.
Note: ASTM No. 89 or 9 stone may be used in the paver openings.
(Source: Interlocking Concrete Pavement Institute)

Design and Sizing Guidelines

The base thickness design of pervious pavement is determined by the expected traffic loadings on the pavement and hydrologic sizing considerations. The thicker of the two base designs is used for the project. The following design 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 Handbook, or include an underdrain(s) to remove detained flows stored within the aggregate base. The surfacing and bedding materials (where applicable) are not used to store water.
- Depth to seasonal high groundwater from the soil subgrade should be at least 5 feet from the bottom of the subbase of the pervious pavement system, unless a different separation is recommended by the geotechnical engineer.
- Slopes of pervious pavement surface should not exceed 5% or up to 16% with underdrains. 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. Alternatively, pervious pavement systems can be terraced to step down a steep slope, maintaining level bed bottoms separated by earthen berms.

AGGREGATES AND UNDERDRAINS

- 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 has sufficient capacity in its void spaces to store and infiltrate at least the C.3.d amount of runoff, the area of pervious paving is not considered an impervious surface and can function as a self-treating area per Section 4.1 of the C.3 Handbook.
- Pervious pavements may be designed to accept runoff from adjacent areas. If the subbase/base layer has sufficient capacity in its void spaces to store and infiltrate the C.3.d volume of rainfall falling onto the pervious paving <u>and</u> runoff from adjacent areas, the pervious paving is not considered an impervious surface and can function as a self-retaining area per Section 4.2 of the C.3 Handbook.
- If an underdrain is used, position the perforated pipe within the subgrade enveloped on all sides by a least 4 inches of open-graded aggregate and provide non-perforated, upturned elbow pipe for outflows (see Figures 6-38 and 6-39. A cleanout with surface access is recommended at the upturn. To be considered a self-treating area or self-retaining area, the underdrain raised outlet should be positioned above the portion of the base layer that stores and infiltrates the C.3.d volume of rainfall falling onto the pervious paving (and runoff from adjacent areas, if self-retaining).
- Design calculations for the base should describe and quantify the following:
  - o 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;
  - o Fill type if used, installation, and compaction methods plus target densities or deflections;
  - o Lifetime expected vehicular traffic loading in 18,000 lb. equivalent single axle loads or Caltrans Traffic Index;

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

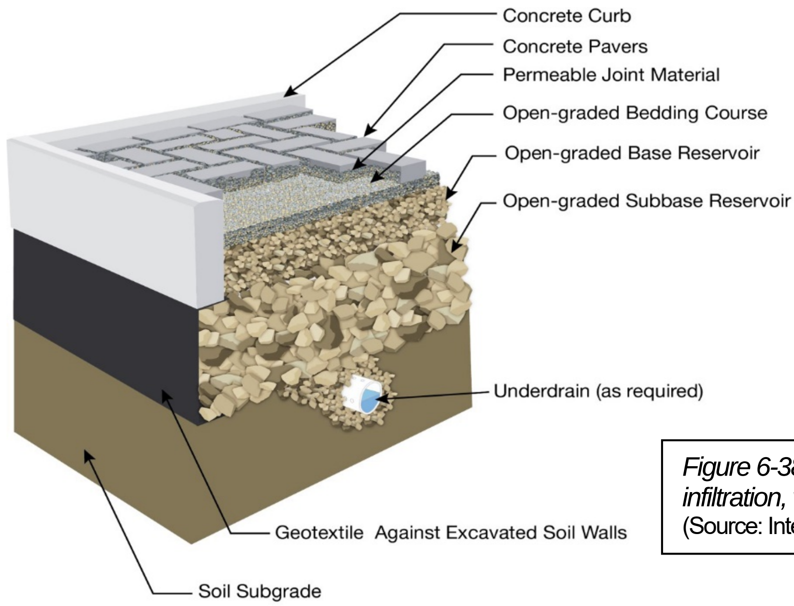
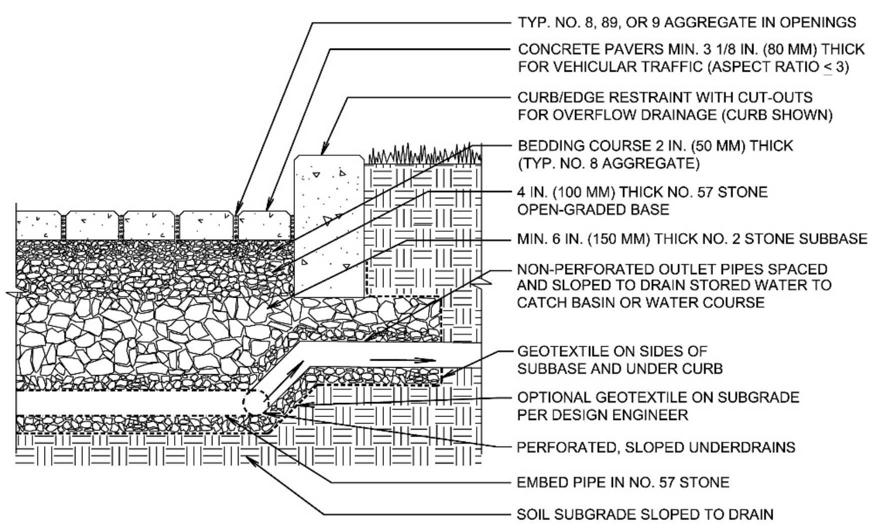


Figure 6-38. PICP designed for partial infiltration, with underdrain.
(Source: Interlocking Concrete Pavement Institute)



NOTES:
1. 2 3/8 IN. (60 MM) THICK PAVERS MAY BE USED IN PEDESTRIAN AND RESIDENTIAL APPLICATIONS.
2. NO. 2 STONE SUBBASE THICKNESS VARIES WITH DESIGN. CONSULT ICPI PERMEABLE INTERLOCKING CONCRETE PAVEMENT MANUAL.
3. NO. 2 STONE MAY BE SUBSTITUTED WITH NO.3 OR NO.4 STONE.

Figure 6-39. Detail of underdrain in aggregate trench with upturned elbow.
(Source: Interlocking Concrete Pavement Institute)

PAVEMENT MATERIALS

- The pavement materials should not crack or suffer excessive rutting under anticipated traffic loads. This is controlled by designing pervious concrete and porous asphalt surfacing materials and layer thicknesses that minimize the horizontal tensile stress at their base. All pervious pavements benefit from using open-graded aggregate base materials with sufficient thicknesses and compaction that spread and minimize applied vertical stresses from vehicles.
- Pervious concrete and porous asphalt materials require narrow aggregate grading to create open voids in their surfaces. Material 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 and have a length to thickness ratio not exceeding 3.

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 pervious concrete pavement should be reviewed by the concrete manufacturer, the National Ready Mixed Concrete Association (NRMCA) (www.nrmca.org), or as directed by the municipality. Consult Portland Cement Association publication, *Hydrologic Design of Pervious Concrete* (2007) available from www.cement.org.
- Design for porous asphalt should be reviewed by the asphalt manufacturer, the National Asphalt Pavement Association (NAPA) (www.porousasphalt.net), or as directed by the municipality. Consult NAPA publication, *Porous Asphalt for Stormwater Management* (2008) for additional information on design, construction, and maintenance.
- Design for PICP should be reviewed by the concrete paver manufacturer, the Interlocking Concrete Pavement Institute (ICPI) (www.icpi.org), or as directed by the municipality. Consult ICPI publication, *Permeable Interlocking Concrete Pavements* 4th Edition (2011) for additional information on design, construction and maintenance.
- Installation of pervious concrete, porous asphalt and PICP should be done by contractors who have constructed 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/pervious/index.html.
- For PICP, it is recommended that only contractors holding a record 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 pervious concrete and porous asphalt pavements should have a minimum surface infiltration rate of 100 in./hr when tested in accordance with ASTM C1701. PICP should have a minimum surface infiltration rate of 100 in./hr when tested in accordance with ASTM C1781. Test results using both methods are comparable.

- Protect excavated area from excessive compaction due to construction traffic and protect the finished pavement from construction traffic.
- Additional design resources can be found on www.dot.ca.gov/hq/oppd/stormwtr/pervious.htm.

Maintenance

- A maintenance plan should be provided. Typical requirements are described in Chapter 8. An essential requirement is periodic surface vacuuming to remove accumulated debris and sediment.

6.11 Reinforced Grid Paving

Figure 6-40: Turf block fire access at the Residence Inn in Los Altos

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

Reinforced grid paving consists of concrete or plastic grids placed over compacted Caltrans Class 2 or Class 2 permeable base or similar materials. It can be used in areas that receive occasional light traffic, such as overflow parking or fire access lanes. Class 2 permeable base should use an underdrain in silt and clay soils. The surfaces of these systems can include a top layer of gravel or be planted with topsoil and grass in their openings and installed over a sand bedding layer that rests over the aggregate base (see Figures 6-41 and 6-42). When planted with turf grass, they also assist in providing a cooler surface than conventional pavement. Some of these systems are also known as turf block or grasscrete. Reinforced grid paving can also be designed with aggregates in the openings.

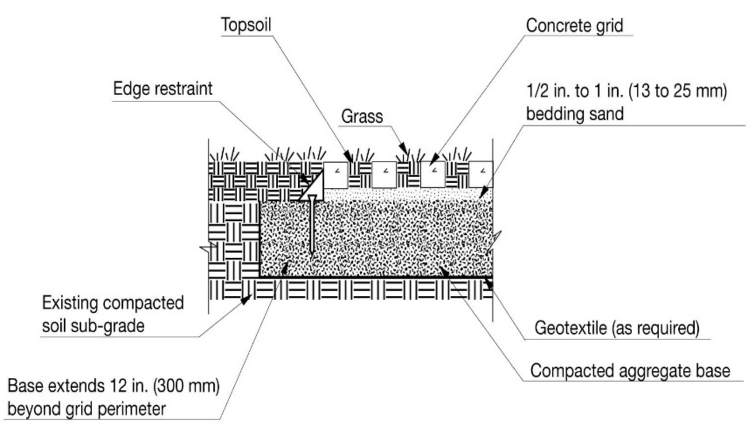


Figure 6-41: Concrete Grid Pavement for Occasional Vehicular Use or for Emergency Access Lanes

SCVURPPP gratefully acknowledges the contributions of Mr. David Smith, Technical Director of the Interlocking Concrete Pavement Institute, to this section of the Handbook, including pavement sections, design details, and specifications.

Figure 6-42: 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.

Reinforced grid paving can be installed over open-graded aggregate bases for additional water storage, infiltration, and outflow via an underdrain in low permeability soils if needed. However, such designs should see limited automobile traffic and no truck traffic other than rarely occurring emergency vehicles. Reinforced grid paving is not considered an impervious area and can function as a “self-treating area” when supported by an aggregate base sufficient to hold the C.3.d volume of runoff. Reinforced grid pavings with dense-graded bases are not generally designed to accept runoff from adjacent areas.

Contrary to most other treatment measures, small areas of reinforced grid paving do not need as much maintenance, so they can be located in remote sections of private property such as backyards. However, if the total grid paving area is 3,000 sq. ft. or more, these areas are considered regulated treatment systems and require an O&M agreement, with municipal inspections at least once every five years. Therefore, these larger systems should only be constructed in front yards, driveways, parking lots and other areas visible from the public right of way so that municipal inspectors can see and verify the existence of the systems.

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 from the soil subgrade should be at least 5 ft. from the bottom of the subbase of the reinforced grid paving system, unless a different separation is recommended by the geotechnical engineer.
- Grading of the soil subgrade below the reinforced grid paving should be relatively flat to promote infiltration across the entire area, or berms should be used. Slopes of reinforced grid pavings 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 amount of runoff, the area of reinforced grid 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 the perforated pipe within the subgrade enveloped on all sides by a least 4 inches of open-graded aggregate and provide non-perforated, upturned elbow pipe for outflows. A cleanout with surface access is recommended at the upturn. To be considered a self-treating area or self-retaining area, the underdrain raised outlet should be positioned above the portion of the base layer that stores and infiltrates the C.3.d amount of rainfall falling onto the reinforced grid paving (and runoff from adjacent areas, if self-retaining).

- 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

REINFORCED GRID PAVING 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.
- Reinforced grid paving 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 reinforced grid paving 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 reinforced grid paving 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 reinforced grid paving 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.

Maintenance

- A maintenance plan should be provided. Maintenance of grassed grid surfaces will require watering and mowing. Maintenance of gravel grid surfaces will require light sweeping and replacement of gravel. Typical maintenance requirements are described in Chapter 8.

Chapter

7

Hydromodification Management Measures

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

7.1 What is Hydromodification?

The change in the timing, peak discharge, and volume of runoff from a site due to land development is known as "hydrograph modification" or "hydromodification". When a site is developed, some of the rainwater can no longer infiltrate into the soils, so it flows offsite at ***faster rates and greater volumes,*** generally in a shorter time period. As a result, erosive levels of flow occur more frequently and for longer periods of time in creeks and channels downstream of the project. Hydromodification 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 watershed (the yellow, or light, line). The axes indicate the volume of water discharged, and the time over which it is discharged.

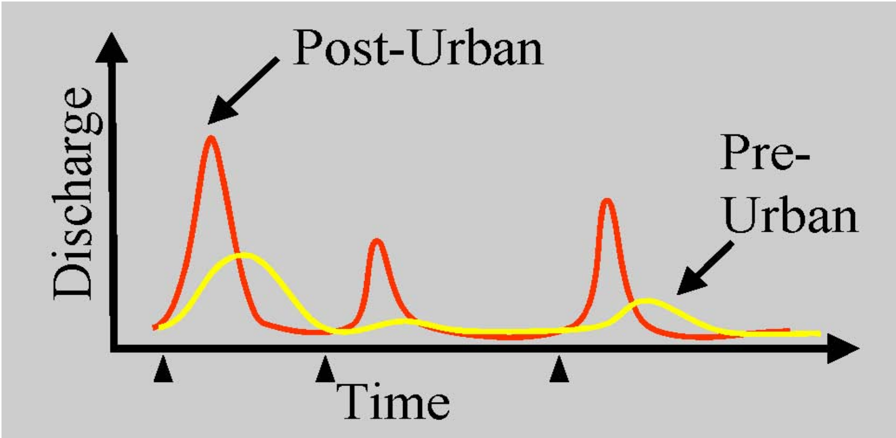


Figure 7-1: Stormwater Peak Discharges in Urban (Red) and Less Developed (Yellow) Watersheds (Source: NEMO-California Partnership, No Date)

Figures 7-2 and 7-3 further illustrate the effect of increasing urbanization on stormwater volumes. Land development increases the impervious area, decreases natural vegetation, changes grading and soil compaction, and creates new drainage facilities. These development activities decrease site infiltration, increase volume, duration, and frequency of flows, and increase connectivity of runoff to creeks. These effects can cause stream channel erosion and impair beneficial uses of the stream channel. 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 flood control detention basin designs.

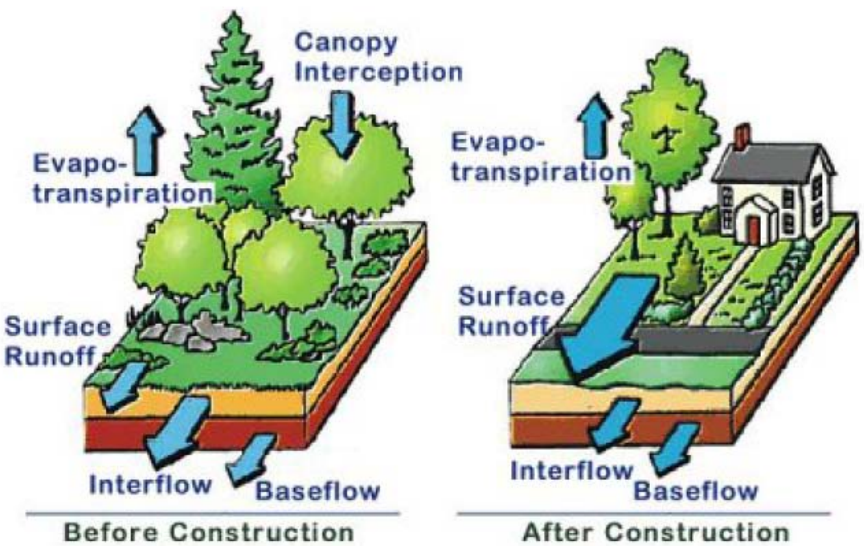


Figure 7-2: Effects of Urbanization on the Local Hydrologic Cycle (Source: 2000 Maryland Stormwater Design Manual)

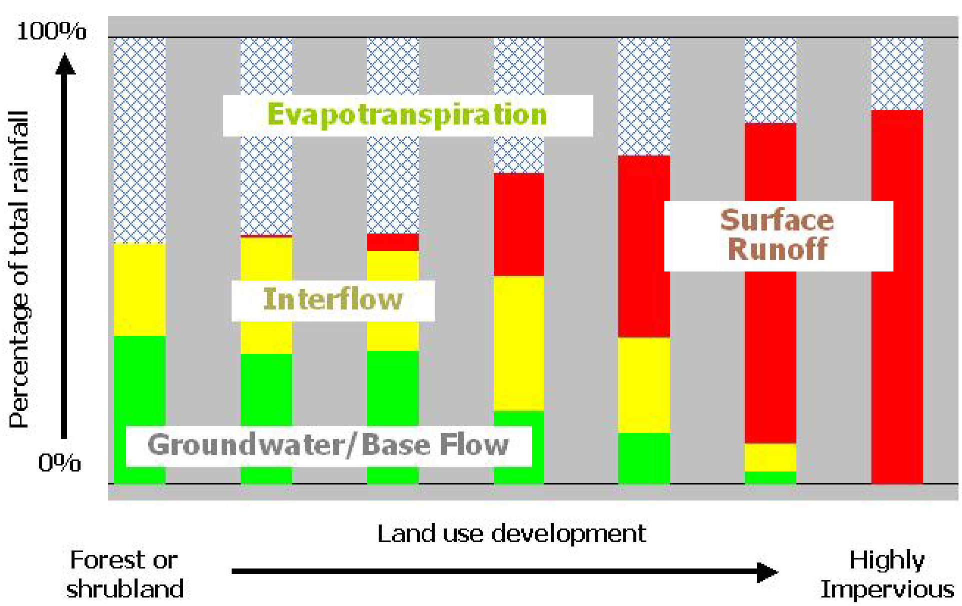


Figure 7-3. Variation in rainfall contribution to different components of the hydrologic cycle for areas with different intensity of urban development. (Chart used by permission of Clear Creek Solutions.)

7.2 Hydromodification Management Requirements

Hydromodification management (HM) techniques focus on ***retaining, or detaining and slowly releasing runoff*** in a way that matches pre-project runoff patterns.

Some projects may be subject to the hydromodification management (HM) requirements in the MRP's Provision C.3.g, which limits increases in runoff peak flow, duration and volume where such increases may cause increased erosion of creek beds and banks, silt pollutant generation, or other impacts to beneficial uses. The Urban Runoff Program developed a Hydromodification Management Plan (HMP) Report in 2005 that delineated areas where such increases will be detrimental to channel health and water quality and described means of managing such situations to maintain the pre-project runoff conditions after development. A recommended management objective and performance criteria were developed based on the watershed assessments and technical analyses described in the HMP. These have now been adopted into the MRP as part of Provision C.3.g. and Attachment F, along with some changes to applicability requirements.

The HM requirements in the MRP and Attachment F can be summarized as follows:

Pre-project runoff conditions are those that exist on-site immediately before development (or redevelopment) activities occur. They are not the same as pre-development conditions (i.e., before any human land use occurred.)

- Increases in runoff peak flow, volume, and duration shall be managed for ***all projects that create and/or replace 1 acre or more of impervious surface***;
- Post-project runoff rates and durations shall not exceed estimated pre-project rates and durations;
- These conditions apply to areas where such increases in runoff flow or volume can cause increased erosion of creek beds and banks (as shown on HM applicability maps).
- HM requirements do not apply to projects that discharge to hardened or tidally influenced portions of channels, where increased discharges present minimal potential for erosion or other impacts to beneficial uses.

The management objective and detailed performance criteria are presented below.

7.2.1 Hydromodification Management Objective and Standard

Stormwater discharges from any development/redevelopment project that creates or replaces one acre or more of impervious surface shall not cause an increase in the erosion potential of the receiving stream over the pre-project (existing) condition, i.e., an Erosion Potential Index[1] of up to 1.0 will be maintained for stream segments downstream of the project discharge point.

[1] The Erosion Potential Index is explained in detail in the HMP Report, Chapter 3, Section 3.3. For most HMP applications, project applicants and Co-permittee staff will not need to compute this index if on-site flow controls are provided.

Increases in runoff flow and volume shall be managed so that post-project runoff shall not exceed pre-project rates and durations, where such increased flow and/or volume is likely to caused increased potential for erosion of creek beds and banks, silt pollution generation, or other adverse impacts on beneficial uses due to increased erosive force.

7.2.2 Performance Criteria

> ***Flow duration*** means the number of times (or hours) that a certain runoff or stream flow rate occurs over a long period of time. A graph of flow rates versus the number of times they occur is called a ***flow duration curve.***

1. Projects shall meet the management objective by providing stormwater controls as needed to maintain the pre-project stream erosion potential. Stormwater controls may include a combination of on–site, off-site and in-stream measures.
2. On-site controls that are designed to provide flow duration control to the pre-project condition are considered to meet the erosion potential management objective and comply with Provision C.3.g of the MRP.
3. Range of Flows to Control: Flow duration controls shall be designed such that the post-project stormwater discharge rates and durations match pre-project discharge rates and durations from ***10 percent of the pre-project 2-year peak flow up to the pre-project 10-year peak flow***.
4. Goodness of Fit Criteria: The post-project flow duration curve shall not deviate above the pre-project flow duration curve by more than 10 percent over more than 10 percent of the length of the curve corresponding to the range of flows to control. (For examples of flow duration curves, see Appendix E.)
5. Allowable Low Flow Rate: Flow control structures may be designed to discharge stormwater at a low flow rate[2] that shall be ***no greater than 10 percent of the pre-project 2-year peak flow***.
6. HM Modeling: On-site and regional HM controls designed using the Bay Area Hydrology Model (BAHM) (see Section 7.5.3) and site-specific input data shall be considered to meet the HM Standard. Alternatively, the project proponent may use a continuous simulation hydrologic computer model to simulate pre-project and post-project runoff and to design HM controls. At a minimum, 30 years of hourly rainfall data representative of the area being modeled should be used in the modeling of HM controls. Retention and detention basins must be considered impervious surfaces for purposes of calculating post-project runoff. Pre- and post-project runoff shall be calculated and compared for the entire project area being developed, without separating or excluding areas considered self-retaining.

Applicable projects shall be required to meet the HM Standard when they are located in areas of HM applicability as shown on the revised Santa Clara HM Map (see Section 7.3). The

[2] The low flow rate, known as "Qcp", is a means of apportioning the critical flow in a stream to individual projects that discharge to that stream, such that cumulative discharges do not exceed the critical flow in the stream. The critical flow, "Qc" is the flow rate that initiates stream bed or bank erosion.

revised HM Map was adopted by the Water Board on November 28, 2011 and incorporated into the MRP through Order No. R2-2011-0083.

7.3 Which Projects Need to Implement HM Controls?

A flow chart for determining whether HM requirements apply to your project is included in Appendix E-1. A Regulated 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***, AND
- The project ***will increase impervious surface*** over pre-project conditions, AND
- The project is ***located in a susceptible area***, as shown on the HM applicability map.

The Santa Clara Valley HM applicability map (revised November 2010) is provided in Appendix E-2. City-specific maps are available at: https://scvurppp.org/hmp-maps/

Contact the local municipality to determine if a more detailed (parcel level) map is available.

Table 7-1 presents a guide to the areas that are identified and shaded on the map with the corresponding HM applicability.

Map Colors	**Table 7-1 HM Applicability**
purple	Catchments draining to exempt channels*: HM controls not required
red	Subwatersheds and catchments greater than or equal to 65% impervious: HM controls encouraged but not required.
green	HM controls required

*Exempt channels include those that are tidally influenced or continuously hardened from the discharge point to the Bay, Sunnyvale East Channel, Sunnyvale West Channel, and underground storm drains discharging directly to the Bay.

The total project area should be used to determine if HM requirements apply. However, if a project site straddles two different applicability zones (e.g., green and red) the separate drainage areas in each applicability zone are used to determine the change in impervious surface and whether full HM requirements apply to that drainage area. For example, say the total area of a project is 25 acres but a 10-acre drainage area is in the green zone and 15 acres is in the red zone according to the HM map. The 10-acre drainage area in the green zone would need to meet full HM requirements. The 15 acres in the red zone would be exempt from HM requirements but encouraged to implement hydrologic source control measures where appropriate and feasible.

The following are guidelines that Co-permittees can use to identify project characteristics that may cause a project to be exempt from HM controls (only one condition is required for exemption). A project is exempt if:

a. The project creates and/or replaces less than 1 acre of impervious surface.

b. The project is located in a purple or red area of the applicability map.

c. The project does not increase the amount of impervious area on the site (compared to the pre-project condition) and does not significantly change the drainage pattern from the site.

d. The project can show via a hydrologic modeling analysis that even though the impervious surface area has increased, actual runoff will be less because permeability of the remaining area will be enhanced by the project and/or there is less directly connected impervious surface.

7.4 Selecting HM Controls

Hydromodification management (HM) measures can be grouped into the following categories:

- ***Site design and hydrologic source control measures***, which are generally distributed throughout a project site. These types of measures minimize hydrological changes caused by development beginning with the point where rainfall initially meets the ground. Examples include minimizing impervious area, disconnecting roof leaders and providing localized detention. ***LID treatment measures also serve as hydrologic source control measures*** because they reduce runoff volumes and peak flows by retaining and detaining runoff.

- ***On-site structural HM measures*** that manage excess runoff from the site after hydrologic source control measures are applied. Stormwater is temporarily detained, and then the runoff is gradually discharged at a rate calculated to avoid adverse effects. Examples of storage facilities include extended detention basins, underground vaults, and oversized storm drain pipes. The discharge is controlled by outlet structures containing weirs and/or orifices designed to allow certain flow rates. Depending on pre-project and post-project conditions, the required detention volume is likely to be greater than the capture volume required for treatment. However, in some cases, HM requirements can be met by increasing the available storage associated with an LID treatment measure and controlling the outflow. LID treatment measures can also be designed to meet HM requirements.

> Structural HM measures must be sized to control the flow and duration of stormwater runoff according to a ***flow duration control*** standard, which results in facility sizes greater than those required for volume-based treatment.

- ***Off-site structural HM measures*** that manage excess runoff from multiple development projects, such as a regional detention facility. Such a facility would require the coordination of multiple projects in close proximity. At the present time, there are no plans for such facilities to be constructed by public agencies.

- ***In-stream or restorative measures*** that modify the receiving stream channel slope and geometry so that the stream can convey the new flow regime without increasing the potential for erosion and aggradation. In-stream measures should be intended to improve long-term channel stability and prevent erosion by reducing the erosive forces imposed on the channel boundary. In-stream measures are only an option where the stream receiving runoff from the project is already impacted by erosive flows and shows evidence of excessive sediment, erosion, deposition, or is a hardened channel. Examples of in-stream measures include biostabilization techniques using roots of live vegetation to stabilize banks and localized structural measures such as rock weirs, grade stabilizers, boulder clusters or deflectors.

In-stream measures, or a combination of in-stream and onsite controls, must be designed to achieve the HM Standard from the point where the project(s) discharge(s) to the stream to the mouth of the stream or to achieve an equivalent degree of flow control mitigation (based on amount of impervious surface mitigated) as part of an in-stream project located in the same watershed. Designing in-stream controls requires a hydrologic and geomorphic evaluation (including a longitudinal profile) of the stream system downstream and upstream of the project. As with all in-stream activities, the project proponent must obtain regulatory permits[3] and coordinate with Valley Water and other local agencies as appropriate.

7.5 Designing Flow Duration Controls

For projects subject to HM requirements, consider HM at every stage of project development and incorporate the step-by-step instructions for C.3 submittals, provided in Chapter 3. In general, the strategy for designing HM measures should:

- ***Start with site design and hydrologic source controls, including LID treatment measures,*** to minimize the amount of runoff to be managed (see Planning Steps 2 & 3 in Chapter 3).
- Where possible, ***maximize infiltration*** to further reduce detention requirements. Note that infiltration may be limited by site constraints such as slope stability concerns, low-permeability soils or groundwater levels.
- Use ***structural HM measures*** to detain the remaining increased runoff from the site and ***control its release*** in a way that meets the flow duration control requirements.

7.5.1 Flow Duration Control Approach

Flow duration control differs from traditional "design storm" approaches used to design detention facilities for flood control or water quality treatment. Instead of a peak flow standard for one or a few discrete events, the flow duration control standard requires management of discharges over the full range of flows, 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

> ***Critical flow,*** or Qc***,*** is the stream flow that initiates stream bed or bank erosion, depending on stream channel characteristics.

[3] In-stream control projects require a Stream Alteration Agreement from CDFW, a CWA section 404 permit from the U.S. Army Corps of Engineers, and a section 401 certification from the Water Board. Early discussions with these agencies on the acceptability of an in-stream modification are necessary to avoid project delays or redesign.

the receiving stream at a level below the critical flow (Qc) that causes sediment movement in the stream bed or bank. The duration of channel flows below Qc may be increased indefinitely without significant contribution to hydromodification impacts.

The flow duration control approach has been determined in technical studies to be the most effective method of protecting streams from erosive impacts of hydromodification[4]. Facilities that are designed to meet the pre-project hydrograph for a single design storm event do not effectively protect the receiving stream from the increased durations of runoff flows from multiple small storm events.

7.5.2 Application of Flow Duration Control to Project Areas

On-site controls designed to provide flow duration control to match the pre-project condition are considered to comply with the HM standards. The flow duration control approach involves:

1) Simulating the runoff from the project site, pre- and post-project, using a hydrologic model with a continuous rainfall record;
2) Generating flow duration curves from the results; and
3) Designing a flow duration control facility such that when the post-project time series of runoff is routed through the facility, the discharge pattern matches the pre-project flow duration curve for the required range of flows.

Typically, the post-project increase in surface runoff volume is routed through a ***flow duration control pond*** or other structure that detains a certain portion of the increased runoff and discharges it through a ***specialized outlet structure*** (see Figure 7-4). The flow duration basin, tank or vault is designed conceptually to incorporate multiple stages that are filled with different frequencies and discharge at different rates. The low-flow stage 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 stages 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 stages 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. (See Appendix E-3 for a detailed discussion of designing flow duration control facilities and generating flow-duration curves.) For some sites, HM standards may also be achieved through the application of LID site design and/or treatment measures, but this should be verified using a continuous simulation hydrologic model (see Section 7.5.3).

[4] For more information on these studies, see the SCVURPPP Hydromodification Management Plan Final Report at https://scvurppp.org/2005/04/21/hydromodification-management-plan-2/

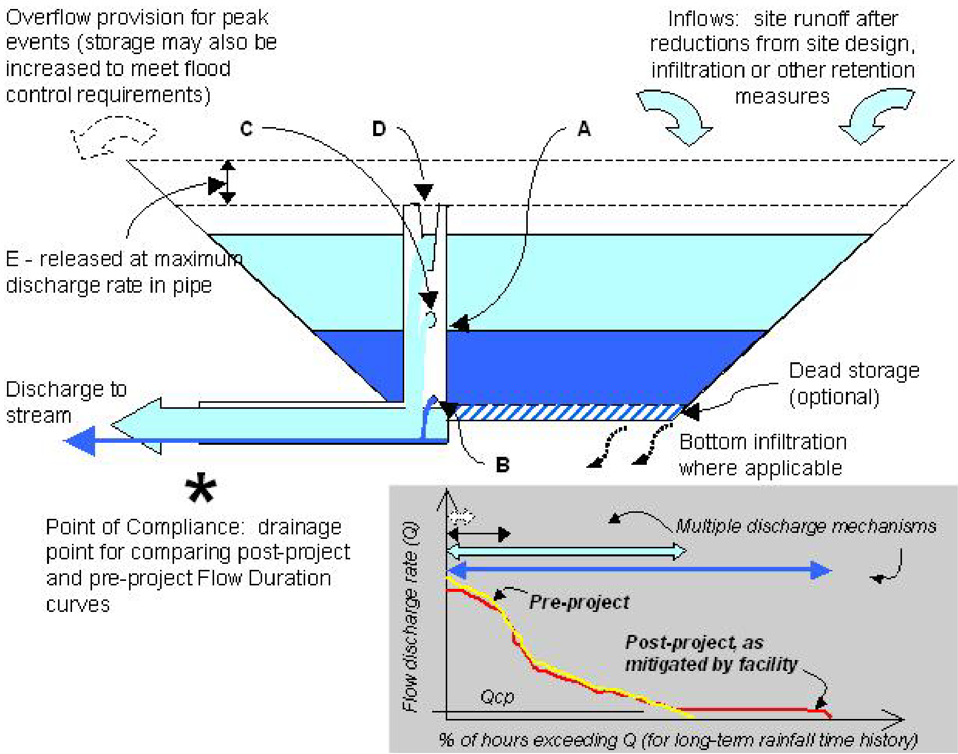


Figure 7-4: Schematic flow duration control pond and flow duration curves matched by varying discharge rates according to detained volume.

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)

7.5.3 Bay Area Hydrology Model (BAHM)

To facilitate the continuous simulation modeling and design of flow duration control measures for project proponents and their engineers, the Urban Runoff Program collaborated with the Alameda, San Mateo, and Contra Costa Countywide stormwater programs to develop the Bay Area Hydrology Model sizing tool. The BAHM is a calibrated, local version of the Western Washington Hydrology Model (WWHM) developed by Clear Creek Solutions for the State of Washington Department of Ecology. The WWHM was specifically developed to help engineers design facilities to meet a Flow Duration Control standard for development projects. The BAHM makes it easy for project proponents to design, and municipal staff to review, flow control facilities in the Bay Area. Flow control facilities designed using the BAHM and site specific input data are considered to meet the management objective and HM standards.

The BAHM and its User Manual were updated in 2023 and are available for downloading at https://www.clearcreeksolutions.info/bahm-download-page. Training videos are also available at this link. The BAHM includes:

- Databases to automatically assign ***rainfall and evaporation data*** for a project location selected within the Valley 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 long-term rainfall records appropriately scaled for the project location.
- A design module for sizing a ***flow duration control 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 the point where runoff leaves the facility or the project area.
- Options to incorporate runoff reductions attributable to ***LID treatment and hydrologic source control measures***.
- Standardized output ***report files*** that can be saved in Word format, and include all information about data inputs, model runs, facility design, and summary of the hydrological statistics showing the compliance of post-project flow duration curves with the Flow Duration standard. Project input and output data can also be saved in Excel and other formats.

A paper describing the development and use of the BAHM is provided in Appendix E-4.

7.5.4 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. Non-exempt projects are required to perform a detailed analysis to compare pre-project and post-project runoff patterns for the project site. The BAHM can be used to do this analysis and to design flow control facilities. If the applicant wishes to use a more detailed or site-specific approach, the following steps must be taken. Flow duration curves illustrating the distribution of flows resulting from a continuous rainfall record will need to be generated 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. These or similar tools will then be used to design flow duration control measures that produce a discharge pattern that matches the pre-development flow duration curve. ***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.***

After a project has gone through the analyses described above, the next step is to incorporate the flow duration control measures into the project design. Meeting 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. These types of facilities may be challenging to incorporate into the project site due to space limitations, soil conditions, depth to groundwater, and other factors. You may need to consider a combination of project design changes and on-site, off-site, and/or in-stream control 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.

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[5]. 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:

1) Increasing the drainage area to the HM facility (e.g. combining flows from two or more drainage management areas);
2) Reducing the depth of the pond (i.e., increase the surface area) to reduce the head on the orifice;
3) Adding a flow throttling device such as an elbow restrictor; and/or
4) Add an infiltration measure downstream of the pond to further mitigate flows from the low-flow orifice.

Appendix D of the BAHM User Manual provides more information on how to size a flow duration facility with a specified minimum orifice size[6]. The Western Washington Manual[5] provides more detail on orifice design.

7.5.5 Maintenance Considerations

HM facilities, like treatment measures, should be designed with maintenance considerations in mind. Design guidance for detention basins is provided in Chapter 6 of the C.3 Handbook. 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[7].

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 of the C.3 Handbook.

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[5] 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

[6] Clear Creek Solutions, December 2023. *Bay Area Hydrology Model User Manual.* Prepared for the Alameda Countywide Clean Water Program, the Contra Costa Clean Water Program, the San Mateo Countywide Water Pollution Prevention Program, and the Santa Clara Valley Urban Runoff Pollution Prevention Program. https://www.clearcreeksolutions.info/bahm-download-page

[7] Caltrans Stormwater Quality Handbooks Supplemental Details Design Guidance, December 2020. Water Quality Outlet Detail: https://dot.ca.gov/-/media/dot-media/programs/design/documents/17_dg-supplementaldetails_ada.pdf

7.6 HM Control Submittals for Review

Determine the potential applicability of the HM requirements to the proposed project, using the guidelines in Section 7.3, the flow chart in Appendix E-1 and the applicability map in Appendix E-2 (or city-specific map), and indicate HM applicability on the C.3 Data Form. Then prepare an HM Control Plan as part of the project's Stormwater Management Plan.

Table 7-2 provides a model checklist of submittal requirements for the HM Control Plan. Information on site design and LID treatment measures should also be included, if they are part of the HM Control Plan and any modeling analyses. Check with the local jurisdiction to determine the specific requirements for your project.

Table 7-2: HM Control Plan Checklist

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

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

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

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

- 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.

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

Any in-stream HM control measures must be coordinated with Valley Water and special permits will be needed.

Figure 7-5: Example of a multi-purpose detention facility for HM control in San Jose.

Chapter

8

Operation and Maintenance

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

8.1 Summary of O&M Requirements

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

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

> O&M requirements apply to stormwater treatment, pervious pavement, AND HM measures, and are the responsibility of the

8.1.1. Responsibility for Maintenance

The responsibility for the maintenance of stormwater treatment and structural HM measures ***belongs to the project applicant and/or property owner*** unless other specific arrangements have been made. Ownership and maintenance responsibility for stormwater treatment measures and HM measures should be considered at the earliest stages of project planning. 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 Santa Clara County Vector Control District staff to inspect the control measures.

8.1.2 Considerations When Selecting Treatment Measures

OPERATION AND MAINTENANCE

When determining which types of treatment measures to incorporate into project plans, be mindful of their maintenance requirements. Maintenance obligations will vary depending on the system design, so review O&M requirements for LID systems and study the operation manual for any manufactured, proprietary system. Note that some jurisdictions may require more frequent maintenance than the minimums outlined in this section. 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.

The party responsible for maintenance will also be required to ***dispose of accumulated residuals properly.*** Residuals such as trash, filter media, weeds, dead vegetation, and fine sediments collected from treatment measures 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 dispose of residuals in the same way they would dispose of any uncontaminated soil. Two landfills in Santa Clara Valley accept sediment (“soil”), contaminated or otherwise:

- Newby Island Sanitary Landfill, 1601 Dixon Landing Road, Milpitas, (408) 432-1234.
- Guadalupe Rubbish Disposal Company, 15999 Guadalupe Mines Road, San Jose, (408) 268-1666.

Alternatively, property owners may choose to contract with the treatment device manufacturer or other service provider 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. With the exception of certain treatment measures designed to hold permanent pools of standing water, treatment measures should drain completely within five days to effectively prevent mosquito production. Guidance on controlling mosquitoes with proper treatment measure design and maintenance is included in Appendix F.

> Treatment measures should ***drain completely within five days*** to prevent mosquito production.

CONSIDER ACCESS

The O&M agreement or other means of maintenance assurance for your project will need to grant permission to local municipal staff, the Santa Clara County Vector Control District, and Water Board staff to access 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 HM measures are ***readily accessible to the inspectors*** and contact municipal staff to determine whether easements will be needed. Stormwater treatment and HM measures must also be accessible to equipment needed to maintain them. Maintenance needs vary by the type of treatment measure that is used. Review the maintenance requirements described in Section 8.2 to identify the accessibility needs for maintenance equipment.

8.1.3 Documentation Required with Permit Application

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

- A conceptual plan of the site, clearly showing the locations of stormwater treatment and HM measures, as well as areas of pervious pavement. The plan should specifically identify all pervious pavements systems that total 3000 $ft.^2$ or more (excluding private-use patios for single-family homes, townhomes, or condominiums).
- Detailed maintenance plan for pervious pavement, stormwater treatment and HM measures, including inspection checklists, as appropriate.

Please note that requirements may vary from one jurisdiction to another. However, most will require the O&M agreement to be signed and notarized before any certificates (temporary or final) of occupancy are issued.

Appendix G includes templates to assist project applicants in preparing their maintenance plans. Guidance on preparing these documents is provided in Section 8.2.

8.1.4 Maintenance Agreement or Other Maintenance Assurance

Where a property owner of a regulated project is responsible for maintenance, they will be required to provide assurance of long-term maintenance. This may be in the form of a maintenance agreement with the municipality, or conditions of approval, or another mechanism to ensure long-term maintenance of stormwater control measures. Contact your local jurisdiction to obtain a copy of its standard maintenance agreement or other mechanism.

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

- The post-construction stormwater control requirements;
- What stormwater controls are present onsite;
- The need for maintenance;
- How necessary maintenance should be performed; and
- For the initial deed transfer, the assistance that the project applicant can provide.

If stormwater control measures will be located in the public right-of-way and ownership will be transferred to the municipality, the property owner has responsibility for maintenance until the treatment measures are accepted by the municipality.

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 must begin to implement the maintenance plan. Inspection reports must be submitted to the municipality if required by the maintenance agreement or other maintenance assurance.

The municipality, Water Board staff, and/or the Santa Clara County Vector Control District will conduct ***operation and maintenance verification inspections*** to make sure that stormwater control measures are being maintained. In the event adequate maintenance is not conducted, the municipality will inform the property owner, and require maintenance to be performed. If necessary (and authorized by local ordinance), the municipality will either take an enforcement action against the responsible party or take steps to restore the stormwater control measures to good working order, in which case the property owner will be responsible for reimbursing the municipality for expenditures.

8.2 Preparing Maintenance Plans

This section provides instructions for preparing the maintenance plan that will typically be required as part of the building or development permit application, if your project is a regulated project and includes 3,000 sq. ft. or more of pervious pavement, stormwater treatment measures, and/or HM measures.

The maintenance plan must be sufficiently detailed to demonstrate to the municipality that stormwater control 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 Assessor's Parcel Number and directions to the site.
- Identification of the number, type and location of all stormwater control 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.")
- A self-inspection checklist, specific to the stormwater control measure(s) included in your project, which indicates the items that will be reviewed during regular maintenance inspections. The checklist should include maintenance indicator 'triggers' to determine when maintenance activities must be performed. You may be required to submit completed inspection forms as part of an annual report to the municipality or make the forms available during an inspection by the municipality or other agency. Check with your local jurisdiction for requirements.

Maintenance plan templates to help you prepare your maintenance plan are provided in Appendix G. When using a template, please insert project-specific information where you find prompts such as the following: [[== insert name of property owner/responsible party ==]]. Each template includes sample inspection checklists. Common maintenance concerns for frequently used stormwater control measures are presented in the following sections.

8.2.1 Bioretention Areas

The primary maintenance requirement for bioretention areas is the regular inspection and repair or replacement of the treatment measure's components. Because these systems remove pollutants by filtering runoff through biotreatment soil, routine maintenance is needed to ensure the flow is unobstructed, erosion is prevented, and the soils and plants are biologically active. Generally, the level of effort is similar to the routine, periodic maintenance of any landscaped area. It is recommended that certain maintenance tasks be conducted quarterly, annually before the rainy season, and annually after the rainy season and/or after large storm events.

- Depending on the system needs, conduct quarterly inspections as follows:
  - Inspect the bioretention surface area, inlets and outlets for obstructions and trash; clear any obstructions and remove weeds and trash.
  - Inspect bioretention areas for standing water. Presence of algae growth in ponded water is a good indicator of problems. In general, if standing water does not drain within 2-3 days, there may be a problem with the system. First check the cleanout riser (if there is one) and clean out any material in underdrains. Other causes of standing water can include clogged outlets, faulty irrigation systems, and/or improperly specified or installed biotreatment soil media, mulch, or plant materials. If needed, replace problematic materials with approved biotreatment soil media, mulch, new plants and/or other components as needed. Compaction of native soil can also be a cause of standing water; in which case the whole system may need to be reconstructed. If mosquito larvae are observed, contact the County Vector Control District at (408) 918-4770 or (800) 675-1155.

- Before and after the rainy season, an evaluation of the whole treatment system should be conducted, including the following activities:
  - Ensure that the vegetation is healthy and dense enough to provide filtering and protect soils from erosion. Prune and weed the bioretention area and remove trash. Remove and/or replace any dead plants. Do not use pesticides or other chemical applications to treat diseased plants, control weeds or remove unwanted growth.
  - Use compost and other natural soil amendments and fertilizers. Do not use synthetic fertilizers, especially if the system uses an underdrain.
  - Inspect the energy dissipator at the inlet to ensure it is functioning adequately, and that there is no scour of the surface mulch. Remove any accumulation of sediment.
  - 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. Use the cleanout riser to clear underdrains of obstructions or clogging material.
  - Maintain the irrigation system and ensure that plants are receiving the correct amount of water (if applicable). Repair or replace any improperly functioning equipment.
  - Inspect and, if needed, replace wood or rock mulch. It is recommended that 3" of composted arbor mulch be applied once a year. Mulch should also be replaced when erosion is evident. The entire area may need mulch replacement every two to three years, although spot mulching may be sufficient for random void areas. Rock mulch can be raked up or manually collected and redistributed after maintenance is performed.

- Annually at the end of the rainy season, and/or after large storm events, inspect the system for:
  - o Erosion of biotreatment soil, loss of mulch, standing water, structural failure, clogged overflows, weeds, trash and dead plants. If using rock mulch, check for 3" of coverage.

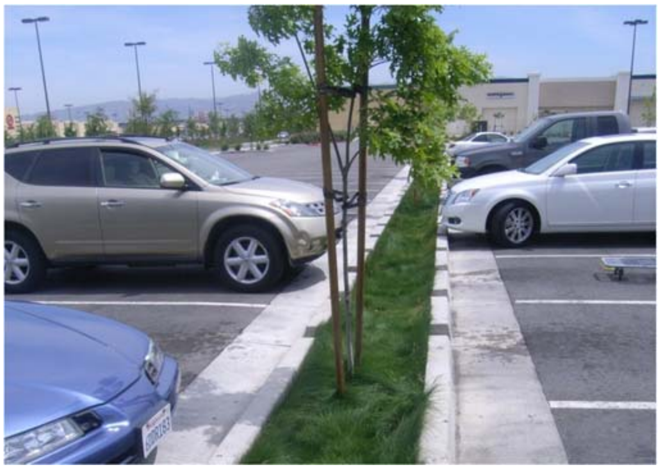

Figure 8-1: Bioretention area at a shopping center in San Jose.

8.2.2 Flow-Through Planters

Flow-through planters function similar to bioretention areas. 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. It is recommended that certain maintenance tasks be conducted quarterly, annually before the rainy season, and annually after the rainy season and/or after large storm events.

- Depending on the system needs, conduct quarterly inspections as follows:
  - o Inspect the planter surface area, inlets and outlets for obstructions and trash; clear any obstructions and remove trash.
  - o Inspect planter for standing water. Presence of algae growth in ponded water is a good indicator of problems. In general, if standing water does not drain within 1 day, there may be a problem with the system. First check the cleanout riser (if there is one) and clean out any material in underdrains. Other causes of standing water can include clogged outlets, faulty irrigation systems, and/or improperly specified or installed biotreatment soil media, mulch, or plant materials. If needed, replace problematic materials with approved biotreatment soil media, mulch, new plants and/or other components as needed. If mosquito larvae are observed, contact the County Vector Control District at (408) 918-4770 or (800) 675-1155.
  - o Check for eroded or settled biotreatment soil media. Level soil with rake and remove/replant vegetation as necessary.
- Before and after the rainy season, conduct a complete evaluation of the system, including the following activities:

  - Ensure that vegetation is healthy and dense enough to provide filtering and protect soils from erosion. Prune and weed as necessary. Replace dead plants. Remove excessive growth of plants that are too close together to allow water flow and/or causing other issues. Do not use pesticides or other chemical applications to treat diseased plants, control weeds or remove unwanted growth.
  - Remove trash and sediment.
  - Use compost and other natural soil amendments and fertilizers. Do not use synthetic fertilizers, especially if the system uses an underdrain.
  - 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. Use the cleanout riser to clear underdrains of obstructions or clogging material.
  - Inspect the energy dissipator at the inlet to ensure it is functioning adequately, and that there is no scour of the surface mulch. Remove any accumulation of sediment.
  - Inspect and, if needed, replace wood or rock mulch. It is recommended that 3" of composted arbor mulch be applied once a year. Spot mulching may be sufficient for random void areas. Rock mulch can be raked up or manually collected and redistributed after maintenance is performed.
- Annually at the end of the rainy season and/or after large storm events, inspect the system for:
  - Erosion of biotreatment soil media, loss of mulch, standing water, clogged overflows, weeds, trash and dead plants.
  - Structural integrity of walls, flow spreaders, energy dissipators, curb cuts, outlets and flow splitters.

Figure 8-2: Flow-through planter in the City of Emeryville

8.2.3 Tree Well Filters

The following maintenance requirements are typical of both proprietary and non-proprietary tree well filters:

- Conduct a biannual (twice yearly) evaluation of the health of trees and any ground cover. Remove and replace any dead or dying vegetation.
- 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.
- Do not use pesticides or other chemical applications to control weeds or unwanted growth.
- Use compost and other natural soil amendments and fertilizers instead of synthetic fertilizers, especially if the system uses an underdrain.
- Before the wet season begins, check that the media is at the appropriate depth. Replenish mulch as needed. Remove any accumulations of sediment, litter, and debris.
- Inspect tree well filter after storms to ensure that it has not clogged and is draining per design specifications. Till or replace the media 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.

For proprietary tree well filters, follow the manufacturer's requirements for maintenance. Some manufacturers require a maintenance agreement, under which the manufacturer conducts the maintenance.

Figure 8-3: Pervious asphalt directs water to an enlarged tree well filled with engineered 'structural soil', San José.

8.2.4 Infiltration Trenches

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

- Conduct a thorough inspection annually, including inspection of the observation well to confirm that there is no standing water in the trench. If inspection indicates that the trench is partially or completely clogged, it should be restored to its design condition.
- Inspect the trench after large storm events and remove any accumulated debris or material. Repair any erosion at inflow or overflow structures.
- Check the observation well 2 to 3 days after storms to confirm drainage. The trench should completely dewater within 5 days.
- Mow and trim vegetation around the trench as needed to maintain a neat and orderly appearance. Routinely remove trash, grass clippings and other debris along the trench perimeter and dispose of these materials properly.

Figure 8-4: Infiltration Trench at former Agilent site, Palo Alto

- Trees or other large vegetation should be prevented from growing adjacent to the trench to prevent damage to the trench.
- Do not use pesticides or other chemical applications to control weeds or unwanted growth of vegetation near the trench.

8.2.5 Detention Basins

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

- Conduct semi-annual inspection as follows:
  - Evaluate the health of the vegetation and remove and replace any dead or dying plants.
  - Remove any trash and debris.
  - Inspect the outlet, embankments, dikes, berms, and side slopes for structural integrity and signs of erosion or rodent burrows. Fill in any holes detected in the side slopes.
  - 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. Ensure that engineered energy dissipation is functioning adequately by checking for evidence of local scour around the inlet.

  - Inspect for standing water and correct any problems that prevent the extended detention basin from draining as designed.
  - Confirm that any fences around the facility are secure.
  - If you observe mosquito larvae, contact the Santa Clara County Vector Control District at (408) 918-4770 or (800) 675-1155.
- Maintenance activities at the bottom of the basin shall NOT be performed with heavy equipment, which would compact the soil and limit infiltration.
- Harvest vegetation annually, during the summer.
- Trim vegetation at beginning and end of the wet season and inspect monthly to prevent establishment of woody vegetation and for aesthetic and mosquito control reasons.
- Do not use pesticides or other chemical applications to control weeds or unwanted growth in the basin.
- Remove sediment from the forebay as needed.
- Remove accumulated sediment within the basin area and regrade about every 10 years or when the accumulated sediment volume exceeds 10 percent of the basin volume.

Figure 8-5: Detention pond at a retirement center in Saratoga

8.2.6 Pervious Pavement

Types of pervious pavement include pervious concrete, porous asphalt, and permeable interlocking concrete pavement (PICP), concrete grid pavers, and plastic reinforcement grid pavers. All pervious pavement can become clogged with sediment over time if routine maintenance is not performed. Sources of sediment include vehicles and eroding soil, leaves and mulch from adjacent landscaped areas. Regular surface cleaning will help maintain a high surface infiltration rate and keep out vegetation.

<u>Routine maintenance (two to four times annually)</u>:

- Prevent soil from washing or blowing onto the pavement. Do not store sand, soil, mulch or other landscaping materials on pervious pavement surfaces.
- Conduct preventative surface cleaning, using commercially available regenerative air or vacuum sweepers, to remove sediment and debris.

<u>Inspection (two to four times annually)</u>:

- Check for sediment and debris accumulation on pervious pavement.
- Check for standing water on the pavement surface within 30 minutes after a storm event if possible. Standing water indicates that restorative cleaning may be required.
- Inspect pervious pavement for any signs of pavement failure.
- Inspect underdrain outlets and cleanouts annually, preferably before the wet season. Remove accumulated trash/debris.

As needed maintenance:

- Remove weeds from permeable pavement as needed. Do not use pesticides or other chemical applications to control weeds or unwanted growth near pavement or between pavers. Vegetation in grid pavements (such as turf block) should be mowed as needed.
- Repair any surface deformations or broken pavers. Replace missing joint filler in PICP.
- If routine cleaning does not maintain infiltration rates, then restorative surface cleaning with a vacuum sweeper and/or reconstruction of part of the pervious surface may be required. Adjust the vacuum sweeper suction to a level that does not remove portions of the pervious pavement base layer or joint filler.
- Power washing with simultaneous vacuuming also can be used to restore surface infiltration to highly clogged areas of pervious concrete, porous asphalt or PICP, but is not recommended for grid pavements.
- Replenish aggregate in PICP joints or grids as needed after restorative surface cleaning.

Fig, 8-6 Porous asphalt, pervious concrete and pervious interlocking concrete pavers at Stanford University demonstration project.

8.2.7 Rainwater Harvesting Systems

- Conduct annual inspections of all components, including pumps, valves, tanks, and backflow prevention systems, and verify operation.
- Inspect and clean filters and screens every three months and replace when necessary.
- Inspect and verify that disinfection, filters, and other water quality treatment devices are operational, in accordance with manufacturer's recommendations or local jurisdiction requirements.
- If rainwater is provided for indoor use, conduct annual water quality testing per the requirements of the local jurisdiction.
- Inspect and clear debris from rainwater gutters, roof surfaces, downspouts, roof washers, and first-flush devices every six months, or as needed, to prevent clogging. Remove tree branches and vegetation overhanging roof surfaces to reduce amount of debris.
- Maintenance requirements specific to cisterns:

  - Flush cisterns annually to remove sediment. Flushed water should drain to landscaping or to the sanitary sewer.
  - For buried structures, vacuum removal of sediment is required.
- Maintenance requirements specific to rain barrels:
  - Regularly inspect the gutters and gutter guards, downspouts, spigots, and rain barrels, and clean or replace parts as needed.
  - Inspect screens and seals prior to the wet season to make sure debris is not collecting on the surface and that there are not holes allowing mosquitoes to enter the rain barrel. Inspect screens more frequently if there are trees that drop debris on the roof.
  - Clean the inside of the rain barrel once a year (preferably at the end of the dry season when the rain barrel has been fully drained) to prevent buildup of debris. If debris cannot be removed by rinsing, use vinegar or another non-toxic cleaner. Use a large scrub brush on a long stick and avoid actually entering the rain barrel. Drain washwater to landscaping.

8.2.8 Media Filters

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

- During the wet season, inspect periodically for standing water, sediment, trash and debris, and to identify potential problems.
- Remove any accumulated trash and debris in the unit 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 and per manufacturer's specifications.
- Replace the media per manufacturer's instructions or as indicated by the condition of the unit.

Chapter

9

Alternative Compliance

This chapter provides information on using Alternative Compliance options where LID treatment is required and cannot be accommodated onsite.

9.1 What Is Alternative Compliance?

Provision C.3.e of the Municipal Regional Stormwater Permit (MRP) allows new development or redevelopment projects to use one of two options for "alternative compliance" instead of providing full onsite treatment of the Provision C.3.d amount of stormwater runoff with low-impact development (LID) treatment measures. ***Projects that choose alternative compliance must still provide LID treatment in full, but some or all of the treatment may be provided offsite.*** There are no special eligibility criteria for using alternative compliance, nor is there a requirement to determine that LID is impracticable or infeasible in order to use alternative compliance; any project may use alternative compliance to meet these requirements. The MRP offers two options for using alternative compliance: 1) offsite treatment; or 2) payment of in-lieu fees to a Regional[1] or Offsite[2] Project. Specific requirements, including deadlines for constructing offsite alternative compliance projects, are described below.

9.2 Categories of Alternative Compliance

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

9.2.1 Option 1: LID Treatment at an Offsite Location

Projects may use offsite LID treatment measures, or a combination of onsite and offsite LID treatment measures, to achieve treatment of the required amount of stormwater runoff. For example, a project could treat half of the required runoff on-site and treat the remaining half at

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[1] **Regional Project** – A regional or municipal stormwater treatment facility that captures runoff from a drainage area larger than the parcel on which it is located and discharges into the same watershed as the Regulated Project.

[2] **Offsite Project** – A stormwater treatment facility that discharges into the same watershed as the Regulated Project and is located at a different public or private parcel or property (e.g., right-of-way) from the Regulated Project

an adjoining site or at a joint treatment facility[3]. Alternatively, a project could treat the entire amount of its C.3.d volume at a separate site within the watershed. The MRP requires that any offsite facilities provide equivalent pollutant removal benefits, i.e., offsite pollutant loads in runoff to the LID treatment measures are comparable to onsite loads, and achieve a net environmental benefit.

An offsite alternative compliance project must provide offsite 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, plus a net benefit (e.g., treatment of additional runoff or pollutant load). Examples of acceptable alternative compliance projects include the installation of LID treatment measures in a nearby parking lot, street right of way, or other development where LID treatment measures are not previously installed. The offsite LID treatment measures must remain and be maintained for the life of the project that uses them for alternative compliance.

9.2.2 Option 2: Payment of In-Lieu Fees

Projects may treat all or a portion of the required amount of stormwater runoff by paying in-lieu fees to a program that builds and operates a regional or municipal LID treatment facility, if such a program and/or facility exists.

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 or Offsite Project <u>and</u> a proportional share of the operation and maintenance costs of the project. The Regional or Offsite Project must achieve a net environmental benefit, through a net increase in impervious surface treated, and/or a net reduction in flow and/or pollutant load. Check with the municipality that has jurisdiction for your project to determine whether a Regional or Offsite Project is available as an alternative compliance option.

9.3 Offsite or Regional Project Completion Deadlines

Construction of an Offsite or Regional LID treatment project must be completed within three years after the end of the construction of the project seeking alternative compliance. This can be extended to five years only with prior Regional Water Board Executive Officer approval. In order for the Executive Officer to grant the extension to five years, the applicant must have demonstrated good-faith efforts to implement the Offsite or Regional Project by applying for the necessary permits and having the necessary funds encumbered for project completion.

9.4 Alternative Compliance Provision Effective Dates

All projects seeking alternative compliance should comply with the requirements in the Municipal Regional Permit reissued on July 1, 2022.

[3] A joint treatment facility treats the stormwater runoff from more than one development project.

References

Allen, V., Connerton, A., and Carlson, C., 2011. Introduction to Infiltration Best Management Practices. Contech Construction Products Professional Development Series.

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

American Rainwater Catchment Systems Association and American Society of Plumbing Engineers, 2009. Rainwater Catchment Design and Installation Standards.

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. Prepared by Tom Richman and Associates.

BASMAA, 2003. Using Site Design Techniques to Meet Development Standards for Stormwater Quality: A Companion Document to Start at the Source. Prepared by Camp Dresser & McKee, Inc.

BASMAA, 2011. Harvest and Use, Infiltration and Evapotranspiration Feasbility/Infeasibility Criteria Report. Prepared by Geosyntec Consultants.

BASMAA, 2012. Stormwater Control for Small Projects Fact Sheets: Rain Gardens; Landscape Designs for Stormwater Management; Pervious Pavement; and Rain Barrels and Cisterns.

Bicknell, J., Beyerlein, D., and Feng, A., 2006. The Bay Area Hydrology Model – A Tool for Analyzing Hydromodification Effects of Development Projects and Sizing Solutions. Presented at the 2006 CASQA Annual Conference, September 26, 2006.

California Plumbing Code, 2013. California Code of Regulations, Title 24, Part 5. Adopted by California Building Standards Commission based on the 2012 Uniform Plumbing Code, Effective January 1, 2014. Chapter 17, Nonpotable Rainwater Catchment Systems and Appendix K, Potable Rainwater Catchment Systems.

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.

Caltrans Treatment BMP Design Guidance and Details. Available at: http://www.dot.ca.gov/hq/oppd/storm1/caltrans_20090729.html

City and County of San Francisco, 2008. Memorandum of Understanding Between San Francisco Public Utilities Commission, San Francisco Department of Building Inspection, and San Francisco Department of Public Health for Permitting Requirements for Rainwater Harvesting Systems located in the City and County of San Francisco.

City of Berkeley, 2010. Guidelines for Rainwater Harvesting.

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: Stormwater Quality Solutions for the City of Emeryville.

City of Portland, Oregon, 2004. Stormwater Management Manual. https://www.portlandoregon.gov/bes/64040

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

CONTECH Stormwater Solutions, affiliated with CONTECH Construction Products, Inc., 2006. http://www.contech-cpi.com/stormwater/products/14.

Contra Costa Clean Water Program, 2012. Stormwater C.3 Guidebook: Stormwater Quality Requirements for Development Applications. 6th ed.

County of Los Angeles Department of Public Works, 2010. Stormwater Best Management Practice Design and Maintenance Manual for Publicly Maintained Storm Drain Systems. http://dpw.lacounty.gov/DES/design_manuals/StormwaterBMPDesignandMaintenance.pdf

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

Hade, James D., and Smith, David R., 1988. "Permeability of Concrete Block Pavements". From Proceedings of the Second International Conference on Concrete Block Paving, Rome Italy, pp. 217-223.

Interlocking Concrete Pavement Institute, 2011. Permeable Interlocking Concrete Pavements - Design, Specifications, Construction, Maintenance (4th Ed.)

Lindeburg, M.R., 2003. Civil Engineering Reference Manual for the PE Exam (9th edition). Appendix 20.A - "Rational Method Runoff C-Coefficients", p. A-45.

Low Impact Development Center, 2010. Low Impact Development Manual for Southern California: Technical Guidance and Site Planning Strategies. Prepared for the Southern

California Stormwater Monitoring Coalition in cooperation with the State Water Resources Control Board.

Maryland Department of Environment, 2009. Maryland Stormwater Design Manual, Volumes I and II. Effective October 2000, revised May 2009.

Metzger, M.E., 2004. Managing Mosquitoes in Stormwater Treatment Devices. University of California Division of Agriculture and Natural Resources (ANR) Publication 8125.

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. http://foresternetwork.com/weekly/stormwater-weekly/the-dark-side-of-stormwater-runoff-management-disease-vectors-associated-with-structural-bmps/

Melbourne Water (Melbourne Australia), 2006. Water Sensitive Urban Design. http://wsud.melbournewater.com.au/

Minnesota Pollution Control Agency (State of Minnesota), 2016. Minnesota Stormwater Manual. http://stormwater.pca.state.mn.us/index.php/Main_Page

Montana State University Extension, 2006. Rainwater Harvesting Systems for Montana. http://msuextension.org/publications/agandnaturalresources/mt199707ag.pdf

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.

Rescape California, 2016. Bay-Friendly Landscaping Principles. http://rescapeca.org/about-us/principles/

San Francisco Public Utilities Commission (SFPUC), 2016. Stormwater Management Requirements and Design Guidelines. www.sfwater.org/smr

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, May 22, 2022. Order No. R2-2022-0018, NPDES Permit No. CAS612008, Municipal Regional Stormwater Permit, Adopted May 22, 2022 and amended October 11, 2023.

Santa Clara Valley Urban Runoff Pollution Prevention Program (SCVURPPP), 2007. Developments Protecting Water Quality: A Guidebook of Site Design Examples.

Texas Water Development Board, 2005. Texas Rainwater Harvesting Manual, 3rd edition. http://www.twdb.texas.gov/publications/brochures/conservation/doc/RainwaterHarvestingManual_3rdedition.pdf

University of New Hampshire Environmental Research Group, 2012. Tree Box Filter Fact Sheet, Page 22, https://www.unh.edu/unhsc/sites/unh.edu.unhsc/files/docs/UNHSC.2012Report.10.10.12.pdf
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

US EPA, 2008. Managing Wet Weather with Green Infrastructure. Municipal Handbook. Rainwater Harvesting Policies. Prepared by the Low Impact Development Center. EPA-833-F-08-101. https://www.epa.gov/green-infrastructure/green-infrastructure-municipal-handbook

US EPA, No Date. Stormwater Frequently Asked Questions. https://www.epa.gov/npdes

US EPA, No Date. Underground Injection Control Program, Class V Well Information. https://www.epa.gov/uic/underground-injection-control-regulations-and-safe-drinking-water-act-provisions

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

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.