Stormwater Control Measure Design Requirements

F.1 Infiltration (Detention) Basin Design

- Subsurface infiltration basins that include vaults, chambers or proprietary devices designed to capture and infiltrate runoff are considered Class V wells.
- Registered professional civil engineers shall design infiltration basins using sufficient technical knowledge of the vertical and lateral movement of infiltrated runoff through soil and the interaction with groundwater established through a geotechnical investigation.
- Shall not be installed on slopes greater than 15%.
- Size the basin to capture and infiltrate the design volume.
- The basin shall be designed to drain the above ground volume within 72 hours.
- Basin side slopes shall be 3H:1V or flatter.
- The slope of the floor of the basin shall not exceed 5%.
- Inlet energy dissipation structure shall be used where inflow velocities may cause erosion of the filter media.
- Runoff from storm flows will be detained and released at pre-developed rates for the following storms:
  - 2-yr, 24-hr post-project peak flow (discharge) rate ≤ 2-year, 24-hr pre-developed peak flow;
  - 5-yr, 24-hr post-project peak flow rate = 5-yr, 24-hr pre-developed peak flow rate
  - 10-yr, 24-hr post-project peak flow rate = 10-yr, 24-hr pre-developed peak flow rate
  - 25-yr, 24-hr post-project peak flow rate = 25-yr, 24-hr pre-developed peak flow rate
  - 50-yr, 24-hr post-project peak flow rate = 50-yr, 24-hr pre-developed peak flow rate
  - 100-yr, 24-hr post-project peak flow rate = 100-yr, 24-hr pre-developed peak flow rate

F.2 Infiltration Trench Design (from C.3 Stormwater Handbook)

- Subsurface infiltration trenches that include vaults, chambers or proprietary devices designed to capture and infiltrate runoff are considered Class V wells.
- If trench is deeper than it is wide, then it is considered a Class V injection well.
- Pretreatment shall occur upstream of the infiltration trench through a vegetated buffer strip or
other system. If a vegetated buffer strip is used, the strip must be at least 5-feet wide.

- Upgradient slope shall not be greater than 5%.
- Down gradient slope shall not be greater than 15%.
- In-situ/undisturbed soils shall have infiltration rates greater than 0.5 in/hr.
- 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.
- Runoff shall enter trench via sheet flow.

**F.3 Dry Well and Class V Injection Well Design**

- Shall be designed by a Professional Engineer
- Provide adequate treatment of stormwater runoff upstream of wells
- Meet requirements set forth by the U.S. EPA and the Safe Drinking Water Act for Class V injection wells. This requires registration of the facility using the online form at [https://www.epa.gov/uic/forms/underground-injection-well-registration-pacific-southwest-region-9](https://www.epa.gov/uic/forms/underground-injection-well-registration-pacific-southwest-region-9). See [https://www.epa.gov/uic/federal-requirements-class-v-wells](https://www.epa.gov/uic/federal-requirements-class-v-wells) for additional information.
- Methodology to evaluate outflow from each specific configuration needs to be submitted to the City for approval.
- Dry wells that are not deeper than they are wide are not considered Class V injection wells and are not required to meet EPA requirements. Components considered to be subsurface fluid distribution systems are included

**F.4 Pervious Pavement Design**

Pervious pavement includes, but is not limited to, the following types: Pervious pavement detention, open-celled block pavers, open-jointed block pavers, porous concrete and porous asphalt, porous turf pavement, porous gravel pavement, and open-celled plastic grids.

- Registered professional civil engineers shall design pervious pavement.
- Follow pavement manufacturer’s design and installation recommendations.
- Sub-base layers shall be capable of bearing an appropriate load without deforming.
• Appropriate gradations of aggregate material must be used to minimize the migration of particles from one layer to the next. If this cannot be achieved, a woven geotextile shall be used under the bedding layer above the base course to minimize migration. A woven geotextile fabric layer such as SI Corporation Geotex 117F or equal can be used.

• Filter fabrics may be placed on the bottom and sides of the sub-base layer. To allow infiltration and minimize clogging, the filter fabric shall be woven geotextile fabric layer such as SI Corporation Geotex 117F or an approved equivalent.

• Pervious pavement shall not be used in areas where there is outdoor storage or use of chemicals or materials within the drainage area that could threaten groundwater quality if a spill were to occur.

• Where infiltration of stormwater may result in slope failure, foundation settlement, pavement failure or a negative impact to existing underground infrastructure, an impermeable barrier is required and the configuration is considered to be a detention facility, not pervious pavement.

• Edge restraints are required around the perimeter and shall be installed on compacted subgrade or base material, not on the bedding.

• A concrete perimeter wall shall be installed to confine the edges of block installations. The perimeter wall shall be 6 inches thick and to extend 6 inches deeper than the base course, bedding layer, and block depth combined.

• Contact the City of Salinas prior to the use of synthetic turf.

F.5 Bioretention Basin, Biofiltration Basin and Stormwater Planter Design

For projects where treatment upstream from direct infiltration is needed, or treatment, but not runoff reduction is required, biofiltration SCMs can be used to fulfill water quality treatment requirements. Biofiltration SCMs include, but are not limited to, the following treatment systems: biofiltration basins, cisterns, green roofs, landscape detention, and vegetated filter strips and swales.

Note that bioretention basins provide water quality treatment without the underdrain used in biofiltration basins. Biofiltration basins and stormwater planters include underdrains and can contain an impermeable barrier at the base of the systems. Stormwater planters are used in areas where infiltration is infeasible. Biofiltration basins can be used both when infiltration is feasible.
and when infiltration is infeasible. The location of the underdrain in the biofiltration facility changes depending on the amount of infiltration that is feasible.

The following two conditions preclude the use of biofiltration SCMs:

1. High groundwater table within 5 feet of the bottom of the biofiltration SCM (unless enclosed within an impermeable liner or a concrete box with an underdrain or the City Engineer has approved the specific application based on there not being a significant risk to ground water quality).

2. On sites prone to runoff with high sediment loads (unless an additional sedimentation basin is installed upstream of the biofiltration/bioretention basin).

**SCM Design Requirements:**
- Shall be designed by a Professional Engineer
- Shall be designed to have a stormwater surface loading rate not exceeding 5 in/hr at the peak flow rate based on the SCM surface area.
- Shall be designed to retain runoff from the 85th percentile rainfall event on-site. This is effectively equivalent to the County’s current retention standard of the 25-year, 1-hour storm.
- If the design infiltration rate is less than 0.3 inch/hr, an underdrain system consisting of a perforated pipe in a gravel layer shall be included in the design. The slotted PVC underdrain pipe shall be located at a height to provide the minimum storage necessary.
- Shall have 3:1 maximum side slope on all biofiltration/bioretention basins.
- Overflow must have a grate to prevent trash from entering the storm drain system.
- Biofiltration/bioretention basins must have adequate access for maintenance.
- When infiltration is not feasible, one inch of dead storage shall be provided beneath the underdrain.
- Where required, orifice sizing shall be in accordance with the following recommended sizing procedures.

Establish the size of the orifice opening using the following equation:

\[
Q = C_o A (2gh_d)^{1/2}
\]
Stormwater Development Standards for New and Redevelopment Projects

Appendix F – SCM Design Requirements

Where:

\[ Q = \text{design flow rate (cfs)} \]
\[ C_d = \text{orifice coefficient} = 0.618 \text{ (dimensionless)} \]
\[ A = \text{orifice area (sq ft)} \]
\[ g = \text{gravitational constant (32.2 ft/sec}^2) \]
\[ h_d = \text{height of water above mid-point of orifice (feet)} \]

- If an underdrain system is required, it shall consist of a minimum 4-inch diameter perforated pipe surrounded by 12 inches of drain rock (or functionally equivalent configuration).
- Biofiltration systems shall include an engineered soil mix consisting of a well-mixed combination of 60-70% clean sand and 30-40% certified compost (see Appendix D) installed to a minimum depth of 24 inches topped with 3 inches of non-floatable mulch beneath the temporary ponding area.
- Sod shall not be used in the design of biofiltration basins as it typically contains a high percentage of clay that inhibits infiltration.
- The drain rock sub-base shall consist of clean coarse aggregate (3/4” drain rock and/or ¾” Class II permeable aggregate) or alternative storage configuration. Recycled wash water shall not be used to wash the aggregate because it typically has a high pH. The aggregate shall be rinsed with potable water prior to installation and construction of the biofiltration system.
- Erosion control/energy dissipation features shall be provided where runoff enters biofiltration systems (e.g., cobbles or riprap beneath a curb cut opening or a splash block beneath a roof drain downspout).
- Weirs or grade control structures shall be included in the design to divert excess runoff from large events away from (or out of) the facility and towards the conventional storm drain system. The controls can be configured to provide for detention of runoff from less frequent rainfall events above the design volume based on more frequent storms.

Construction Inspection Requirements:
- The Engineer of Record shall provide construction observations. The Contractor shall coordinate the biofiltration basin/planter construction and inspection schedule with the Engineer to ensure the Engineer is able to perform the required inspections. The following inspections are anticipated:
- **Basin Excavation** – Measure excavation area and elevation and observe subgrade condition structures;
- **Structures** - Measure structure elevations and observe all structures and pipes and appurtenances related to the LID systems;
- **Bioretention Soil Mix/Finished Grade** – Measure basin area and slopes and observe BSM condition and placement;
- **Final Inspection** - Observe condition of completed basin/planter, including finished grades, mulch, irrigation, and plants.

- Bioretention basins/planters may be rough graded and used as temporary sedimentation basins during construction. The bottom of the temporary sedimentation basins must be at least six (6) inches above the bottom of the final bioretention basin soil layer to allow from final excavation as described below or rough grade to full depth with fiber roll around the basin.

- Final basin excavation and placement of drain rock and bioretention soil mix shall occur **after** construction of surrounding embankments, pavements and curbs and **after** stabilization of the surrounding landscape area, and not more than two (2) weeks prior to mulching and landscaping the basins.
  - Final basin excavation must be to a depth of at least six (6) inches into undisturbed native soil, to ensure fine-grained sediments deposited during the course of construction are removed from the basin footprint.
  - If construction site runoff enters the basin after final excavation (i.e. due to storm or irrigation runoff), and prior to placement of BSM, the City may require removal of an additional two (2) inches of undisturbed native soil.

- The Contractor is responsible for basin maintenance during construction until project acceptance by the City. This includes removal of all sediments which are deposited in the basins.
  - Immediately prior to acceptance by the City, Contractor must remove all trash, debris, and accumulated sediment.

- The **Operation & Maintenance (O&M) Plan** shall be prepared and submitted as part of the Maintenance Declaration to be recorded prior to final inspection by the City. The O&M Plan shall outline the operation and maintenance requirements of the LID features after acceptance by the City.
**Example Bioretention Construction Inspection Checklist:**

- **Layout (to be confirmed prior to beginning excavation)**
  - Square footage of the facility meets or exceeds minimum shown in Stormwater Control Plan
  - Site grading and grade breaks are consistent with the boundaries of the tributary Drainage Management Area(s) (DMAs) shown in the Stormwater Control Plan
  - Inlet elevation of the facility is low enough to receive drainage from the entire tributary DMA
  - Locations and elevations of overland flow or piping, including roof leaders, from impervious areas to the facility have been laid out and any conflicts resolved
  - Rim elevation of the facility is laid out to be level all the way around, or elevations are consistent with a detailed cross-section showing location and height of interior cims
  - Locations for vaults, utility boxes, and light standards have been identified so that they will not conflict with the facility
  - Location for signage is identified
  - Facility is protected as needed from construction-phase runoff and sediment

- **Excavation (to be confirmed prior to backfilling or pipe installation)**
  - Excavation conducted with materials and techniques to minimize compaction of soils within the facility area
  - Excavation is to accurate area and depth
  - Slopes or side walls protect from sloughing of native soils into the facility
  - Vertical moisture barrier, if specified, has been added to protect adjacent pavement or structures.
  - Native soils at bottom of excavation are ripped or loosened to promote infiltration

- **Overflow or Surface Connection to Storm Drainage**
  (to be confirmed prior to backfilling with any materials)
  - Overflow is at specified elevation
  - No knockouts or side inlets are in overflow riser
  - Overflow location selected to minimize surface flow velocity (near, but offset from, inlet recommended)
  - Grating excludes mulch and litter (beehive or atrium-style grates with ¼" openings recommended)
  - Overflow is connected to storm drain via appropriately sized piping

- **Underground connection to storm drain/outlet orifice**
  (to be confirmed prior to backfilling with any materials)
  - Perforated pipe underdrain (PVC SDR 35 or approved equivalent) is installed with holes facing down
  - Perforated pipe is connected to storm drain at specified elevation (typ. bottom of soil elevation)
  - Cleanouts are in accessible locations and connected via sweep bends
  - Monitoring well, if required, is installed.
  - Structures (arches or large diameter pipes) for additional surface storage are installed as shown in plans and specifications and have the specified volume
Drain Rock/Subdrain (to be confirmed prior to installation of soil mix)
- Rock is installed as specified. Class 2 permeable, Caltrans specification 68-2.02[F](3) recommended, or 4"-6" depth of pea gravel is installed at the top of the crushed rock layer to prevent migration of fines into gravel layer.
- Rock is smoothed to a level top elevation. Depth and top elevation are as shown in plans.
- Slopes or side walls protect from sloughing of native soils into the facility.
- No filter fabric is placed between the subdrain and soil mix layers.

Soil Mix
- Soil mix is as specified.
- Mix installed in lifts not exceeding 12".
- Mix is not compacted during installation but may be thoroughly wetted to encourage consolidation.
- Mix is smoothed to a level top elevation. Depth of mix (24” min.) and top elevation are as shown in plans, accounting for depth of mulch to follow and required reservoir depth.

Irrigation
- Irrigation system is installed so it can be controlled separately from other landscaped areas.
  - Smart irrigation controllers and drip emitters are recommended.
- Spray heads, if any, are positioned to avoid direct spray into outlet structures.

Planting
- Plants are installed consistent with approved planting plan.
- Any trees and large shrubs are staked securely.
- No fertilizer is added; compost tea may be used.
- No native soil or clayey material are imported into the facility with plantings.
- 1”-2” mulch may be applied following planting; mulch selected to avoid floating.
- Final elevation of soil mix maintained following planting.
- Curb openings are free of obstructions.

Final Engineering Inspection
- Drainage Management Area(s) are free of construction sediment and landscaped areas are stabilized.
- Inlets are installed to ensure entry of runoff from adjoining pavement, have sufficient reveal (drop from the adjoining pavement to the top of the mulch or soil mix, and are not blocked.
- Rock or other energy dissipation at piped or surface inlets is adequate.
- Inflows from roof leaders and pipes are connected and operable.
- Temporary flow diversions are removed.
- Overflow outlets are configured to allow the facility to flood and fill to near rim before overflow.
- Plantings are healthy and becoming established.
- Irrigation is operable.
- Facility drains rapidly; no surface ponding is evident.
- Any accumulated construction debris, trash, or sediment is removed from facility.
- Permanent signage is installed and is visible to site users and maintenance personnel.
F.6 Rain Barrels, Cisterns, and Rainwater Harvesting System Design

Cisterns are used to collect and store stormwater runoff from impervious surfaces such as roofs, paved terraces and patios.

- Cisterns are required to have a filter system at entrance of tank and be adequately covered to prevent mosquito breeding
- Tanks shall be sized based on area of impervious surface
- Tanks shall be sized to drain in 48 to 72 hours over a landscaped area equal to at least 25% of the impervious tributary area.
- Outflow from the tanks shall be distributed relatively uniformly over the receiving pervious area over the drawdown period.
- Tanks shall be placed on level pads.
- Tanks located within 10 feet of the structure need to be restrained to prevent damage in the event of an earthquake.
- Rainwater may be collected from roof areas that drain to downspouts that have minimal leaf drop from overhanging tree branches
- All non-potable irrigation/industrial water lines (pressure/non-pressure) shall be identified by continuous lettering on 3” minimum width yellow tape with 1” black lettering bearing the wording “Non-Potable Water” permanently affixed at 5’ intervals atop all piping. Identification tape shall extend to all valve boxes and/or vaults, exposing piping, hydrants, and quick couplers.
- Maintain clear access to rain barrel outlets and cleaning access points
- For further information: https://cityofpacificgrove.org/living/community-economic-development/planning/stormwater/lid-techniques/design-guidelines/rainwater
Figure 1: Rainwater capture and reuse system schematic with an above ground storage tank.

NOTE: IN THIS CONFIGURATION, WATER WILL POOL IN THE U-SHAPED FILL PIPE AND WILL BACKUP IN THE DOWNSPOUT TO A HEIGHT EQUAL TO THE HEIGHT OF WATER IN THE TANK. INSTALL WATER TIGHT SEALS TO PREVENT LEAKS.
F.7 **Green Roof Design**

- Green roofs shall be constructed on flat or pitched roof structures with a maximum slope of 40% (or 5 in 12 pitch).
- Shall be constructed with 4 to 8 inches of growth media (or soil).
- Shall be planted with hardy, drought-tolerant species to minimize additional irrigation, maintenance, cost and weight.
- A building’s structure must be able to support at least an additional 10-25 pounds per square foot of saturated weight, depending on the growth media and vegetation used.
- For further information: https://www.epa.gov/sites/production/files/documents/GreenRoofsSemiAridAridWest.pdf

![Figure 2: Green roof Construction Detail Schematic](image)
Vegetated Swale Design

- Vegetated swale shall detain stormwater for a least 9 minutes for treatment.
- Maximum swale tributary area is 10 acres.
- Longitudinal slopes are to be between 0.5% and 2.5%.
- Longitudinal slopes between 2.5% and 5% may be allowed if check dams are installed to reduce runoff velocity to 2.0 feet per second or less.
- If swale bottom slope is less than 1%, install underdrain system to prevent standing water.
- Swale side slopes in the treatment area shall not be steeper than 4H:1V (25%). Side slopes of the freeboard area above the treatment zone are 2.5H:1V (40%) or less. The swale’s slope end to end must be at least 0.5%.
- Do not apply in areas with adjacent slopes of 5% or greater or in areas with highly erodible soils.
- If a swale is to be designed to both convey and treat the Water Quality Flow (WQF) rate and to convey the flows produced by larger storm flows, the swale shall be designed to safely convey flows produced by the 5-, 20- and 100-year rainfall events.
- The maximum bottom width of treatment area of swale shall be 6 feet minimum not exceed 10 feet. The minimum bottom width shall not be less than two feet. The swale shall be no more than ½ foot deep. The freeboard area has at least one foot of vertical height.
- To size the bottom width, use the Manning’s equation at the WQF with a roughness coefficient (n) value of 0.25 for grass and 0.40 for mixed vegetation and rocks.
- Improved pollutant removal efficiency occurs with a minimum 10-minute hydraulic residence time at the WQF. Swales shall be configured so that 90 % of the tributary runoff will have a residence time of at least 9 minutes.
- The swale must not hold standing water for more than 72 hours to prevent vector problems.
- To provide proper drainage, a minimum 4-inch diameter perforated PVC underdrain pipe shall be provided where underlying soils have infiltration rates less than 0.5 in/hr.
- Design vegetation height of 4 - 6 inches is required.
- Design with flow height one inch below design grass height for WQF.
- All swales shall have an energy dissipater at the entrance to reduce velocities and spread flow across the treatment area. The minimum length of the energy dissipater shall be four feet.
Figure 3: Typical Design and Structure of a Vegetated Swale (from Clean Water Services)
F.9 Vegetated Filter Strip Design

Limitations on Use of Vegetated Filter Strips:

- Drainage area is limited due to the sizing requirements for a filter strip.
- Cannot be applied in areas with highly erodible soils.
- Typically requires supplemental irrigation.
- A uniformly graded thick vegetative cover is required to function properly.
- May not be applicable adjacent to industrial sites or locations where spills may occur.
- Avoid siting in areas of high traffic, both by automobiles and people.
- Place only in areas with gently sloping surfaces where vegetation is hearty and shallow sheet flow occurs.
- Vegetated filter strips are impractical in highly urban areas with little pervious ground.

Design Requirements:

- Slopes shall not be greater than 4% (2% to 4% is preferred).
- Sheet flow must be maintained across filter strips.
- Channelized flow across filter strips shall not be permitted.
- Sod shall not be used in the design of filter strips.
- If seeds are used to plant the vegetated filter strip, they shall be protected with mulch for a minimum of 75 days.
- The top of the vegetated filter strip shall be installed 2 – 5 inches lower than the impervious surface that is being drained.
Sizing Vegetated Filter Strips:
The hydraulic load shall not exceed 0.05 cfs/linear foot of the vegetated filter strip during based off runoff generated as a result of a rainfall intensity of 0.2 in/hr.

The minimum length of a vegetated filter strip (normal to flow) shall be determined using the following equation:

\[ LG = \frac{WQF}{0.05} \]

Where:
- \( LG \) = minimum design length (feet)
- \( WQF \) = water quality flow (cfs)

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

\[ WG = 0.2LL \text{ or } 8 \text{ feet (whichever is greater)} \]

Where:
- \( WG \) = width of the filter strip
- \( LL \) = the length of the flow path over the upstream impervious drainage area (feet)

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

\[ WG = 0.15\left(\frac{A_t}{L_t}\right) \text{ or } 8 \text{ feet (whichever is greater)} \]

Where:
- \( A_t \) = the drainage area (square feet)
- \( L_t \) = the length of the drainage area (normal to flow) adjacent to the filter strip (feet)

(See Figure next page)
Figure 4: General Design Guidelines for a Typical Vegetated Filter Strip
(Modified from UDFCD 1999)
F.10 Technical Criteria for Non-LID Treatment Facilities
Non-LID Treatment Facilities may be either tree-box-type high-flowrate biofilters or vault-based high-flowrate media filters.

General:

- Design inflow rate is that generated by a continuous rainfall intensity of 0.2 inches per hour.
- Landscape and non-impervious surfaces should be made self-treating or self-retaining and not drain to treatment facilities, if feasible.
- Use the runoff factors in the table below:

<table>
<thead>
<tr>
<th>Surface Type</th>
<th>Runoff Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roofs and paving</td>
<td>1.0</td>
</tr>
<tr>
<td>Landscaped areas</td>
<td>0.1</td>
</tr>
<tr>
<td>Bricks or solid pavers on sand base</td>
<td>0.5</td>
</tr>
<tr>
<td>Porous concrete or asphalt</td>
<td>0.0</td>
</tr>
<tr>
<td>Turfblock or gravel—total section min. 6&quot;</td>
<td>0.0</td>
</tr>
</tbody>
</table>

- The applicant’s Stormwater Control Plan (SWCP) must include, as an attachment, a letter from the manufacturer stating the manufacturer has review the SWCP, the proposed device meeting these technical criteria, and the manufacturer will provide a warranty for two years following activation of the facility.

High-Flowrate Tree-Box-Type Biofilters

- Precast concrete construction
- Inlet design to capture flows at least up to the maximum design surface loading rate to bypass high flows
- Minimum media depth of 1.8 feet
- Media and facility configuration support a healthy tree or other vegetation

Vault-Based High-Flowrate Media Filters

- Replaceable cartridge filters
- Maximum design filter surface loading rate (to cartridge filters) of 1 gpm/ft$^2$
- Storage volume detains runoff and allows settling of coarse solids prior to filtration
- Flow through the cartridge filters is controlled by an orifice or other device so that the design surface loading rate is not exceeded
Alternatively, applicants may specify treatment systems that have received a General Use Level Designation (GULD) for Basic Treatment from the Washington State Dept. of Ecology based on independently verified field testing following the Technical Assessment Protocol – Ecology (TAPE). Treatment systems must be sized to treat the water quality flow rate at the design operating rate for which they receive the TAPE GULD certification for Basic Treatment.

Media filters and high-flowrate tree filters currently holding this certification can be found at the following link: