

INF-3: Bioretention with no Underdrain

Bioretention stormwater treatment facilities are landscaped shallow depressions that capture and filter stormwater runoff. These facilities function as a soil and plant-based filtration device that removes pollutants through a variety of physical, biological, and chemical treatment processes. The facilities normally consist of a ponding area, mulch layer, planting soils, and plants. As stormwater passes down through the planting soil, pollutants are filtered, adsorbed, and biodegraded by the soil and plants. For areas with low permeability native soils or steep slopes, bioretention areas can be designed with an underdrain system that routes the treated runoff to the storm drain system rather than depending entirely on infiltration.



Feasibility Screening Considerations

- Bioretention with no underdrains shall pass infiltration infeasibility screening criteria to be considered for use.

Opportunity Criteria

- Land use may include commercial, residential, mixed use, institutional, and subdivisions. Bioretention may also be applied in parking lot islands, cul-de-sacs, traffic circles, road shoulders, and road medians.
- Drainage area is ≤ 5 acres, preferably ≤ 1 acre.
- Area available for infiltration.
- Soils are adequate for infiltration or can be amended to improve infiltration capacity. Site slope is less than 15 percent.

OC-Specific Design Criteria and Considerations

- Placement of BMPs should observe geotechnical recommendations with respect to geological hazards (e.g. landslides, liquefaction zones, erosion, etc.) and set-backs (e.g., foundations, utilities, roadways, etc.)
- Depth to mounded seasonally high groundwater shall not be less than 5 feet.
- If sheet flow is conveyed to the treatment area over stabilized grassed areas, the site must be graded in such a way that minimizes erosive conditions; sheet flow velocities should not exceed 1 foot per second.
- Ponding depth should not exceed 18 inches; fencing may be required if ponding depth exceeds 6 inches to mitigate the risk of drowning.
- Planting/storage media shall be based on the recommendations contained in MISC-1: Planting/Storage Media
- The minimum amended soil depth is 1.5 feet (3 feet is preferred).
- The maximum drawdown time of the planting soil is 48 hours.

- Infiltration pathways may need to be restricted due to the close proximity of roads, foundations, or other infrastructure. A geomembrane liner, or other equivalent water proofing, may be placed along the vertical walls to reduce lateral flows. This liner should have a minimum thickness of 30 mils.
- Plant materials should be tolerant of summer drought, ponding fluctuations, and saturated soil conditions for 48 hours; native plant species and/or hardy cultivars that are not invasive and do not require chemical fertilizers or pesticides should be used to the maximum extent feasible.
- The bioretention area should be covered with 2-4 inches (average 3 inches) of mulch at startup and an additional placement of 1-2 inches of mulch should be added annually.
- An optional gravel drainage layer may be installed below planting media to augment storage volume.
- An overflow device is required at the top of the ponding depth.
- Dispersed flow or energy dissipation (i.e. splash rocks) for piped inlets should be provided at basin inlet to prevent erosion.

Simple Sizing Method for Bioretention with no Underdrain

If the Simple Design Capture Volume Sizing Method described in **Appendix III.3.1** is used to size a bioretention area with underdrains, the user calculates the DCV and designs the system with geometry required to draw down the DCV in 48 hours. The sizing steps are as follows:

Step 1: Determine the Bioretention Design Capture Volume

Calculate the DCV using the Simple Design Capture Volume Sizing Method described in **Appendix III.3.1**.

Step 2: Determine the 48-hour Ponding Depth

The depth of effective storage depth that can be drawn down in 48 hours can be calculated using the following equation:

$$d_{48} = K_{DESIGN} \times 4$$

Where:

d_{48} = bioretention 48-hour effective depth, ft

K_{DESIGN} = bioretention design infiltration rate, in/hr (See **Appendix VII**)

This is the maximum effective depth of the basin below the overflow device to achieve drawdown in 48 hours. Effective depth includes ponding water and media/aggregate pore space.

Step 3: Design System Geometry to Provide d_{48}

Design system geometry such that

$$d_{48} \geq d_{EFFECTIVE} = (d_P + n_M d_M + n_G d_G)$$

Where:

d_{48} = depth of water that can drain in 48 hours

$d_{EFFECTIVE}$ = total effective depth of water stored in bioretention area, ft

d_P = bioretention ponding depth, ft (should be less than or equal to 1.5 ft)

n_M = bioretention media porosity

d_M = bioretention media depth, ft

n_G = bioretention gravel layer porosity; 0.35 may be assumed where other information is not available

d_G = bioretention gravel layer depth, ft

Step 4: Calculate the Required Infiltrating Area

The required infiltrating area (i.e. measured at the media surface) can be calculated using the following equation:

$$A = DCV / d_{EFFECTIVE}$$

Where:

A = required infiltrating area, sq-ft (measured as the media surface area)

DCV = design capture volume, cu-ft (see Step 1)

$d_{EFFECTIVE}$ = total effective depth of water stored in bioretention area, ft (from Step 3)

This does not include the side slopes, access roads, etc. which would increase bioretention footprint.

Capture Efficiency Method for Bioretention with no Underdrain

If BMP geometry has already been defined and deviates from the 48 hour drawdown time, the designer can use the Capture Efficiency Method for Volume-Based, Constant Drawdown BMPs (See **Appendix III.3.2**) to determine the fraction of the DCV that must be provided to manage 80 percent of average annual runoff volume. This method accounts for drawdown time different than 48 hours.

Step 1: Determine the drawdown time associated with the selected basin geometry

$$DD = (d_{EFFECTIVE} / K_{DESIGN}) \times 12 \text{ in/ft}$$

Where:

DD = time to completely drain infiltration basin ponding depth, hours

$$d_{EFFECTIVE} \leq (d_P + n_M d_M + n_G d_G)$$

d_P = bioretention ponding depth, ft (should be less than or equal to 1.5 ft)

n_M = bioretention media porosity

d_M = bioretention media depth, ft

n_G = bioretention gravel layer porosity; 0.35 may be assumed where other information is not available

d_G = bioretention gravel layer depth, ft

K_{DESIGN} = basin design infiltration rate, in/hr (See **Appendix VII**)

Step 2: Determine the Required Adjusted DCV for this Drawdown Time

Use the Capture Efficiency Method for Volume-Based, Constant Drawdown BMPs (See **Appendix III.3.2**) to calculate the fraction of the DCV the basin must hold to achieve 80 percent capture of average annual stormwater runoff volume based on the basin drawdown time calculated above.

Step 4: Check that the Bioretention Effective Depth Drains in no Greater than 96 Hours

$$DD = (d_{EFFECTIVE} / K_{DESIGN}) \times 12$$

Where:

DD = time to completely drain bioretention facility, hours

$d_{EFFECTIVE}$ = total effective depth of water stored in bioretention area, ft (from Step 3)

K_{DESIGN} = basin design infiltration rate, in/hr (See **Appendix VII**)

If DD_{ALL} is greater than 96 hours, adjust bioretention media depth and/or gravel layer depth until DD is less than 96 hours. This duration is based on preventing extended periods of saturation from causing plant mortality.

Step 5: Determine the Basin Infiltrating Area Needed

The required infiltrating area (i.e. the surface area of the top of the media layer) can be calculated using the following equation:

$$A = DCV / d_{EFFECTIVE}$$

Where:

A = required infiltrating area, sq-ft (measured at the media surface)

DCV = design capture volume, adjusted for drawdown time, cu-ft (see Step 1)

$d_{EFFECTIVE}$ = total effective depth of water stored in bioretention area, ft (from Step 3)

This does not include the side slopes, access roads, etc. which would increase bioretention footprint. If the area required is greater than the selected basin area, adjust surface area or adjust ponding depth and recalculate required area until the required area is achieved.

Configuration for Use in a Treatment Train

- Bioretention areas may be preceded in a treatment train by HSCs in the drainage area, which would reduce the required volume of the bioretention cell.
- Bioretention areas can be incorporated in a treatment train to provide enhanced water quality treatment and reductions in runoff volume and rate. For example, runoff can be collected from a roadway in a vegetated swale that then flows to a bioretention area. Similarly, bioretention could be used to manage overflow from a cistern.

Additional References for Design Guidance

- CASQA BMP Handbook for New and Redevelopment:
<http://www.cabmphandbooks.com/Documents/Development/TC-32.pdf>
 - SMC LID Manual (pp 68):
http://www.lowimpactdevelopment.org/guest75/pub/All_Projects/SoCal_LID_Manual/SoCal_LID_Manual_FINAL_040910.pdf
 - Los Angeles County Stormwater BMP Design and Maintenance Manual, Chapter 5:
http://dpw.lacounty.gov/DES/design_manuals/StormwaterBMPDesignandMaintenance.pdf
 - San Diego County LID Handbook Appendix 4 (Factsheet 7):
<http://www.sdcounty.ca.gov/dplu/docs/LID-Appendices.pdf>
 - Los Angeles Unified School District (LAUSD) Stormwater Technical Manual, Chapter 4.
http://www.laschools.org/employee/design/fs-studies-and-reports/download/white_paper_report_material/Storm_Water_Technical_Manual_2009-opt-red.pdf?version_id=76975850
- County of Los Angeles Low Impact Development Standards Manual, Chapter 5:
http://dpw.lacounty.gov/wmd/LA_County_LID_Manual.pdf