Bioinfiltration/ Bioretention

Description

Bioinfiltration and bioretention SMPs, or rain gardens, are vegetated depressions or basins that use surface storage, vegetation, planting soil, outlet controls, and other components to treat, detain, and retain stormwater runoff. These SMPs provide high-performance and cost-effective stormwater management, green space, and triple bottom line benefits. Both SMPs reduce stormwater volume and pollution by filtering runoff through a vegetated soil medium that promotes evapotranspiration. Bioinfiltration SMPs remove stormwater via infiltration into surrounding soils while bioretention SMPs attenuate runoff with flow-regulating underdrains. These SMPs can be found in a variety of configurations from relatively large and open vegetated basins to small-scale SMPs contained within flow-through planter boxes.

Key Advantages

- Flexible layout and easy to incorporate in landscaped areas
- Very effective at removing pollutants and reducing runoff volumes
- Generally one of the more cost-effective stormwater management options
- Relatively low maintenance activities costs
- Can contribute to better air quality and help reduce urban heat island impacts
- Can improve property values and site aesthetics through attractive landscaping
- Eligible for inclusion in an Expedited PCSMP Review project

Key Limitations

- May need to be combined with other SMPs to meet the Flood Control requirement
- May have limited opportunities for implementation due to the amount of open space available at the site

DEVELOPMENT ATTRIBUTES

Construction Costs	LOW
Operations & Maintenance Costs	MODERATE
Likeliness of Failure	LOW
Ground-Level Encroachment	HIGH
Building Footprint Encroachment	MODERATE
Triple Bottom Line Benefits	HIGH

COMPLIANCE ATTRIBUTES

Water Quality Effluent Pollutant Load: **Bioinfiltration**	Water Quality Effluent Pollutant Load: **Bioretention**	Water Quality Infiltration & Volume Reduction: **Bioinfiltration**	Water Quality Infiltration & Volume Reduction: **Bioretention**	Water Quality Evapotranspiration	Water Quality Rate Control	Channel Protection/ Flood Control/ PHS Rate Control
LOW	MODERATE	HIGH	MODERATE	MODERATE	Yes	MODERATE

A description of each evaluated attribute can be found in the SMP Hierarchy Ranking Criteria in Section 3.2.2.

Porous Pavement

Description

Porous pavement provides the structural support of conventional pavement, but allows stormwater to drain directly through the pavement surface into an underlying stone bed and the soil below, thereby reducing surface stormwater runoff. Porous pavement surfaces include, but are not limited to, porous asphalt, porous concrete, permeable pavers, reinforced turf, and artificial, or synthetic, turf. Interlocking pavers have openings filled with stone to create a porous surface. For all of these pavement types, stormwater flows through the porous surface during a rain event, then drains into the sub-base beneath the pavement, where it is stored until it infiltrates into the soil.

Key Advantages

- Can be used in place of traditional paved surfaces
- Can fit into spaces of almost any size and be integrated into many different site layouts
- Reduces ponding and icing that can be associated with traditional hardscape surfaces
- Provides ancillary benefits such as better conditions for trees, reduced heat island effect, quieter vehicular traffic, and reduced vehicular glare compared to standard asphalt
- With permeable paver, reinforced turf, and DIC artificial turf athletic field surface types, eligible for inclusion in an Expedited PCSMP Review project

Key Limitations

- Not recommended for high traffic loading areas or on heavy industrial sites where vehicles or equipment may contribute heavy sediment or gross pollutant loads to porous surfaces
- Typically not suitable for steep slope applications
- Requires frequent maintenance with specialized equipment to maintain performance
- May degrade more rapidly if located in areas with frequent vehicular turning

DEVELOPMENT ATTRIBUTES

Construction Costs	MODERATE
Operations & Maintenance Costs	MODERATE
Likeliness of Failure	HIGH
Ground-Level Encroachment	LOW
Building Footprint Encroachment	LOW
Triple Bottom Line Benefits	MODERATE

COMPLIANCE ATTRIBUTES

Water Quality Effluent Pollutant Load	Water Quality Infiltration & Volume Reduction	Water Quality Evapotranspiration	Water Quality Rate Control	Channel Protection/ Flood Control/ PHS Rate Control
MODERATE	HIGH	MODERATE	Yes	MODERATE

A description of each evaluated attribute can be found in the SMP Hierarchy Ranking Criteria in Section 3.2.2.

Green Roofs

Description

Green roofs, also referred to as vegetated roofs, eco roofs, and roof gardens, consist of a layer of vegetation that covers an otherwise conventional flat or moderately pitched roof. A green roof is composed of multiple layers which may include a waterproofing roof protection layer, moisture interception layer, drainage layer, leak detection layer, an engineered planting medium, and specialized plants. Through the appropriate selection of materials, green roofs can provide runoff volume reduction and runoff peak rate attenuation.

Key Advantages

- Manage stormwater runoff without occupying surface-level space
- Well-suited for sites at which roofs make up a large fraction of the total impervious area and for sites with ground-level space constraints
- Enhance building aesthetics and market value
- Help regulate building temperature in both the summer and winter, thus reducing cooling and heating costs
- Reduce urban heat island effect by providing evaporative cooling
- Can improve air quality by filtering particulate matter
- Extend the service life of the roof
- Eligible for inclusion in an Expedited PCSMP Review project

Key Limitations

- May need to be combined with other SMPs to meet the Flood Control requirement
- More expensive to install than most conventional roofs
- May have limited retrofit feasibility for existing buildings and structures due to structural capacity issues

DEVELOPMENT ATTRIBUTES

Construction Costs	HIGH
Operations & Maintenance Costs	HIGH
Likeliness of Failure	LOW
Ground-Level Encroachment	LOW
Building Footprint Encroachment	LOW
Triple Bottom Line Benefits	HIGH

COMPLIANCE ATTRIBUTES

Water Quality Effluent Pollutant Load	Water Quality Infiltration & Volume Reduction	Water Quality Evapotranspiration	Water Quality Rate Control	Channel Protection/ Flood Control/ PHS Rate Control
LOW	LOW	HIGH	Yes	LOW

A description of each evaluated attribute can be found in the SMP Hierarchy Ranking Criteria in Section 3.2.2.

Subsurface Infiltration

Description

Subsurface infiltration SMPs are typically stone beds, or basins, with storage pipes beneath landscaped or paved surfaces. Stormwater flows into the subsurface infiltration SMP where it collects within the aggregate void space and infiltrates into the surrounding soil. Dry wells, infiltration trenches, and infiltration beds are a few examples of this SMP type.

Key Advantages

- Manages stormwater runoff without occupying surface or rooftop space
- Can be sited, through flexible design options, beneath lawns and recreational areas, as well as parking lots and other impervious areas when space constraints exist
- Can be a good option to meet the Flood Control requirement for constrained sites

Key Limitations

- Can be more costly and difficult to install and maintain than surface practices like bioinfiltration SMPs
- Not appropriate for runoff with high sediment loads without aggressive pretreatment
- Require strict adherence to regularly scheduled inspections because the maintenance needs are not easily visible
- Typically results in additional maintenance costs due to access limitations and Occupational Safety and Health Administration (OSHA) requirements
- Does not improve natural aesthetics or provide the ancillary environmental benefits associated with vegetated SMPs, such as habitat creation and improved air quality

DEVELOPMENT ATTRIBUTES

Construction Costs	MODERATE
Operations & Maintenance Costs	MODERATE
Likeliness of Failure	HIGH
Ground-Level Encroachment	LOW
Building Footprint Encroachment	HIGH
Triple Bottom Line Benefits	LOW

COMPLIANCE ATTRIBUTES

Water Quality Effluent Pollutant Load	Water Quality Infiltration & Volume Reduction	Water Quality Evapotranspiration	Water Quality Rate Control	Channel Protection/ Flood Control/ PHS Rate Control
LOW	HIGH	LOW	Yes	HIGH

A description of each evaluated attribute can be found in the SMP Hierarchy Ranking Criteria in Section 3.2.2.

Cisterns

Description

Cisterns are storage tanks, located either above or below ground, that hold rainwater for beneficial reuse. Cisterns are multi-function systems that help to meet the Stormwater Regulations and collect water for reuse. Rainwater may be collected from rooftops or other impervious surfaces and conveyed to cisterns for storage. Stored water may drain by gravity or be pumped to its ultimate end use.

Key Advantages

- Can be used to provide rate control within small/constrained spaces
- Decrease demand on the municipal water supply and water costs for the end user, when used as part of a rainwater harvesting system in accordance with City, State, and Federal code restrictions
- Can be sited, through flexible design options, beneath lawns, recreational areas, parking lots, other impervious areas, or within buildings when space constraints exist
- Provide educational benefits, especially at public and/or highly visible sites

Key Limitations

- May not be able to fully meet the Water Quality requirement
- Limited to circumstances where there is a year-round water demand that can replenish storage capacity between storms
- May be subject to additional City, State, and Federal code restrictions
- Require draining before a freeze when located on the surface, to prevent structural damage
- Require strict adherence to regularly scheduled inspections because the maintenance needs are not easily visible
- Does not improve aesthetics or provide the ancillary environmental benefits associated with vegetated SMPs, such as habitat creation and improved air quality

DEVELOPMENT ATTRIBUTES

Construction Costs	LOW
Operations & Maintenance Costs	MODERATE
Likeliness of Failure	MODERATE
Ground-Level Encroachment	MODERATE
Building Footprint Encroachment	LOW
Triple Bottom Line Benefits	MODERATE

COMPLIANCE ATTRIBUTES

Water Quality Effluent Pollutant Load	Water Quality Infiltration & Volume Reduction	Water Quality Evapotranspiration	Water Quality Rate Control	Channel Protection/ Flood Control /PHS Rate Control
MODERATE	MODERATE	LOW	Yes	MODERATE

A description of each evaluated attribute can be found in the SMP Hierarchy Ranking Criteria in Section 3.2.2.

Blue Roofs

Description

Blue roofs, also known as controlled flow roof drain systems, are detention SMPs that provide temporary storage and slow release of rainwater on a rooftop. Blue roof systems are an effective practice for controlling runoff from buildings with flat or mildly sloped roof surfaces. On blue roofs, water is temporarily detained on the roof surface using rooftop check dams or roof drain restrictors. In all cases, outflow is controlled using orifices prior to discharge, which is typically directed to the building's storm drains, scuppers, or downspouts.

Key Advantages

- Manage stormwater runoff without occupying surface-level space
- Well-suited for sites at which roofs make up a large fraction of the total impervious area and for sites with ground-level space constraints
- Easy to install if structural and waterproofing requirements are met
- Can cost less than other SMPs

Key Limitations

- Require regular inspection and maintenance of roof surface and roof drains
- Require strict adherence to regularly scheduled inspections because the maintenance needs are not easily visible
- May have limited storage capacity with slopes greater than 2%
- Offer limited benefit on sites where roof area makes up only a small fraction of the total impervious area
- Do not improve aesthetics or provide the ancillary environmental benefits associated with vegetated SMPs, such as habitat creation and improved air quality

DEVELOPMENT ATTRIBUTES

Construction Costs	MODERATE
Operations & Maintenance Costs	LOW
Likeliness of Failure	MODERATE
Ground-Level Encroachment	LOW
Building Footprint Encroachment	LOW
Triple Bottom Line Benefits	MODERATE

COMPLIANCE ATTRIBUTES

Water Quality Effluent Pollutant Load	*Water Quality Infiltration & Volume Reduction*	*Water Quality Evapotranspiration*	*Water Quality Rate Control*	*Channel Protection/ Flood Control/ PHS Rate Control*
MODERATE	LOW	MODERATE	Yes	MODERATE

A description of each evaluated attribute can be found in the SMP Hierarchy Ranking Criteria in Section 3.2.2.

Ponds & Wet Basins

Description

Ponds and wet basins are earthen depressions constructed with a substantial permanent water pool to provide both temporary and long-term storage of stormwater runoff, and they can be used to attenuate peak flows and provide Water Quality treatment through both pollutant removal and slow release. These SMPs attenuate peak flows through the use of an outlet control structure and provide storage capacity above the permanent pool, while water held within the system, including the permanent pool, is treated through a variety of physical, chemical, and biological processes. Wet basins can also achieve minimal volume reduction through evapotranspiration.

Key Advantages

- Can be effective at providing Water Quality requirement treatment and flow attenuation while also providing aesthetic amenities and wildlife habitat
- Can easily be converted from a dry detention basin
- Can contribute to better air quality and help reduce urban heat island impacts

Key Limitations

- Require a dedicated, large ground surface area
- May contain deep water, which can pose a safety hazard and may require fencing to restrict access
- Can sometimes attract geese and other wildlife that may conflict with the intended site use of surrounding areas
- Can provide a mosquito breeding habitat along shallow edges if not designed appropriately

DEVELOPMENT ATTRIBUTES

Construction Costs	LOW
Operations & Maintenance Costs	MODERATE
Likeliness of Failure	MODERATE
Ground-Level Encroachment	HIGH
Building Footprint Encroachment	HIGH
Triple Bottom Line Benefits	MODERATE

COMPLIANCE ATTRIBUTES

Water Quality Effluent Pollutant Load	Water Quality Infiltration & Volume Reduction	Water Quality Evapotranspiration	Water Quality Rate Control	Channel Protection/ Flood Control/ PHS Rate Control
MODERATE	LOW	MODERATE	Yes	HIGH

A description of each evaluated attribute can be found in the SMP Hierarchy Ranking Criteria in Section 3.2.2.

Subsurface Detention

Description

Subsurface detention SMPs are underground structures that are used to temporarily detain and release stormwater. They can include vaults, stone storage, pipe storage, and plastic grid storage.

Key Advantages

- Manages stormwater runoff without occupying surface or rooftop space
- Can be sited, through flexible design options, beneath lawns, recreational areas, parking lots, buildings, or other impervious areas when space constraints exist
- Allows for easily adaptable footprints that can fit into almost any size space and be integrated into many different site layouts

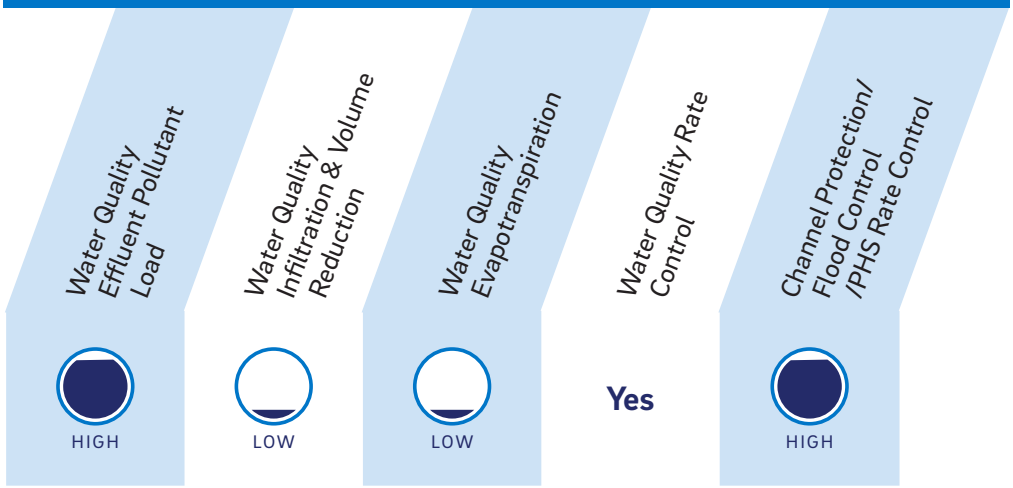
Key Limitations

- May need to be combined with other SMPs to meet the Water Quality requirement
- Can be more costly and difficult to install and maintain than surface practices like bioretention SMPs
- Require strict adherence to regularly scheduled inspections because the maintenance needs are not easily visible
- Require additional maintenance costs due to access limitations and Occupational Safety and Health Administration (OSHA) requirements
- Does not improve aesthetics or provide the ancillary environmental benefits associated with vegetated SMPs, such as habitat creation and improved air quality

DEVELOPMENT ATTRIBUTES

Construction Costs	LOW
Operations & Maintenance Costs	MODERATE
Likeliness of Failure	HIGH
Ground-Level Encroachment	LOW
Building Footprint Encroachment	LOW
Triple Bottom Line Benefits	LOW

COMPLIANCE ATTRIBUTES



A description of each evaluated attribute can be found in the SMP Hierarchy Ranking Criteria in Section 3.2.2.

Media Filters

Description

Media filters are structures or excavated areas containing a layer of sand, compost, organic material, peat, or other filter media. They reduce pollutant levels in stormwater runoff by filtering sediments, metals, hydrocarbons, and other pollutants. Filtered stormwater is released to a sewer, receiving water, or downstream SMP. Media filters are designed to allow higher rates of stormwater flow than traditional filters and enable smaller SMP footprints by allowing for faster filtration. Facilitating evapotranspiration, vegetated media filters are useful in meeting the Water Quality requirement when placed upstream of a noninfiltrating SMP. Non-vegetated media filters can assist in meeting the Water Quality requirement when placed upstream or downstream of a non-infiltrating SMP.

Key Advantages

- Have highly flexible designs and configurations that can be useful in meeting the Water Quality requirement where space-constrained, highly developed, or otherwise challenging locations prevent the use of traditional surface-level or rooftop SMPs and infiltration is not feasible
- Can be designed to be visible from the surface or completely subsurface, located beneath parking lots or other impervious areas

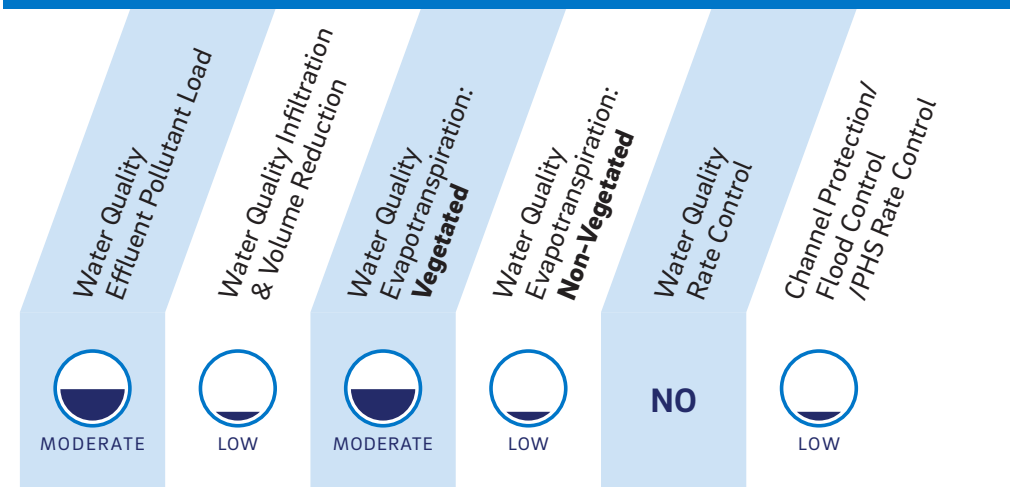
Key Limitations

- Do not offer, when non-vegetated, many of the ancillary benefits associated with surface vegetated SMPs, including aesthetic value, improved air quality, and habitat creation
- Do not reduce the volume of stormwater runoff like bioretention basins and green roofs do
- May have sizing requirements that result in large footprints due to filtration rates for filter media such as sand

DEVELOPMENT ATTRIBUTES

Construction Costs	LOW
Operations & Maintenance Costs	HIGH
Likeliness of Failure	HIGH
Ground-Level Encroachment	LOW
Building Footprint Encroachment	LOW
Triple Bottom Line Benefits: Vegetated	MODERATE
Triple Bottom Line Benefits: Non-Vegetated	LOW

COMPLIANCE ATTRIBUTES



A description of each evaluated attribute can be found in the SMP Hierarchy Ranking Criteria in Section 3.2.2.