Rain Garden

Pollutant Removal Effectiveness

Pollutant	**Effectiveness**
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

Primary Functions

Bioretention	Yes
Volume Retention	Yes
Biofiltration	Yes

Rain gardens are shallow bioretention areas with engineered or native soils. A variety of plants are used to increase infiltration and nutrient uptake including trees, shrubs, grasses, and other plants suitable for the climate. Rain gardens may be designed with various layers of soil, sand, and aggregate. They may also be designed with the existing soils at the site if the soils are expected to adequately infiltrate, support vegetation, and remove pollutants. They can be topped with a wood or rock mulch, any organic material, or other landscaping features. Performance is increased with high carbon soils. Sand and aggregate layers below the soil layers may provide filtration and storage. Rain gardens are usually well-received by the public for their aesthetic qualities.

Slopes leading to the garden bottom are gentle or steep based on site constraints, such as within urban areas. Ponding depths are typically between 1 to 18 inches. Underdrains and impermeable liners are necessary when subsurface concerns exist such as proximity to a structure, poorly infiltrating soils beneath the cross-section of the garden, or groundwater concerns. When a rain garden must be lined, its volume retention function is eliminated, pollutant removal effectiveness is diminished, and it functions primarily as a detention device; however, it still provides treatment through biofiltration. A bypass mechanism either within the rain garden or upstream of the rain garden should be considered for flood events.

Design Criteria

Parameter	Min. Value	Max. Value	Notes
Depth to Historical High Groundwater	2 ft	No Maximum	-
Side Slopes	No Minimum	3H:1V	-
Ponding Depth	No Minimum	18 in.	-
Drawdown Time	12 hrs	72 hrs	24 to 48 hours preferred. Drawdown time may also depend on local mosquito abatement regulations. (should we add our regs?)
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design. Infiltration rate should be low enough to allow biofiltration process to occur. During design, infiltration rate, drawdown time, and the soil matrix depth will be directly related
Freeboard	No Minimum	No Maximum	Freeboard per jurisdiction standards (ours?) . For public safety, consider requiring freeboard and a minimum 6 inch embankment when ponding depth is greater than 6 inches.

Rain Garden Effectiveness

Effective rain gardens provide an aesthetically pleasing method for retaining and treating storm water. Visiting rain gardens during rain events will reveal if the garden is draining properly. Rain gardens are performing properly if they are retaining their design volume and treating runoff. Creating and following through on maintenance guidelines are critical to ensuring that a rain garden remains functional.

There are many possible indications that a rain garden has failed or is near failure, such as: ponding beyond the design ponding depth during small storm events, drawdown time exceeds design drawdown time, larger than expected sediment buildup within or upstream of the rain garden, irregular settling of the rain garden bottom creating standing water, sloughing of side slopes, excessive and unmaintained vegetation, lack of vegetation, and no maintenance or no record of maintenance. Although this is not an all-inclusive list, being aware of these items will assist in determining what steps need to be taken to remediate a failing rain garden.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Does groundwater meet the minimum separation requirement?	☐	☐ (red)
Is there available right-of-way, property, or easement?	☐	☐ (red)
Is the design infiltration rate within acceptable rates?	☐	☐ (red)
Is contaminated groundwater present?	☐ (red)	☐
Is the drainage area to the rain garden less than 5 acres? (If no, consider an infiltration basin or subdividing to create smaller drainage areas.)	☐	☐ (red)
Do utility conflicts make installation of the rain garden technically infeasible?	☐ (red)	☐
Do geotechnical conditions exist that would compromise the stability of the rain garden or surrounding structures?	☐ (red)	☐
Does the rain garden provide storage for 100% of the water quality volume? (If no, it may still be appropriate to construct the rain garden if it is technically infeasible to capture 100% of the water quality volume.)	☐	☐ (red)
Does an overflow outlet structure or bypass mechanism exist?	☐	☐ (red)

Vegetation

Refer to Vegetation Guidance by BMP Type.

Installation

Excavation

Rain gardens, like other BMPs whose functionality is dependent on infiltration, will fail if proper care is not taken during excavation and construction. Excavators and heavy machinery should not be used within the rain garden area if infiltration is expected to occur through the rain garden bottom. Additional excavation beyond the rain garden's footprint may be required depending on site conditions to provide soil stability or to be able to tie-in to the surrounding grade.

Activities During Construction

Avoid using heavy machinery within the rain garden footprint during construction as doing so will compact the soils and diminish their infiltrating capabilities. Light machinery and even walking within the rain garden's footprint will also compromise infiltration. Compaction of native soils or backfill below the rain garden subsoils is acceptable if doing so does not prevent infiltration from occurring.

Flows During Construction

Flows during construction should be diverted away from the rain garden to prevent construction site sediment from clogging soils. Scheduling installation of the rain garden shortly after excavation will minimize the impact of unnecessary storm water flows from entering the excavated area. The introduction of unwanted sediment can be prevented by placing fiber rolls or silt fences around the rain garden perimeter during construction.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.
- Follow landscaping guidance to ensure that vegetation establishes after installation.

Installation Costs

The following cost items are typically associated with rain garden construction

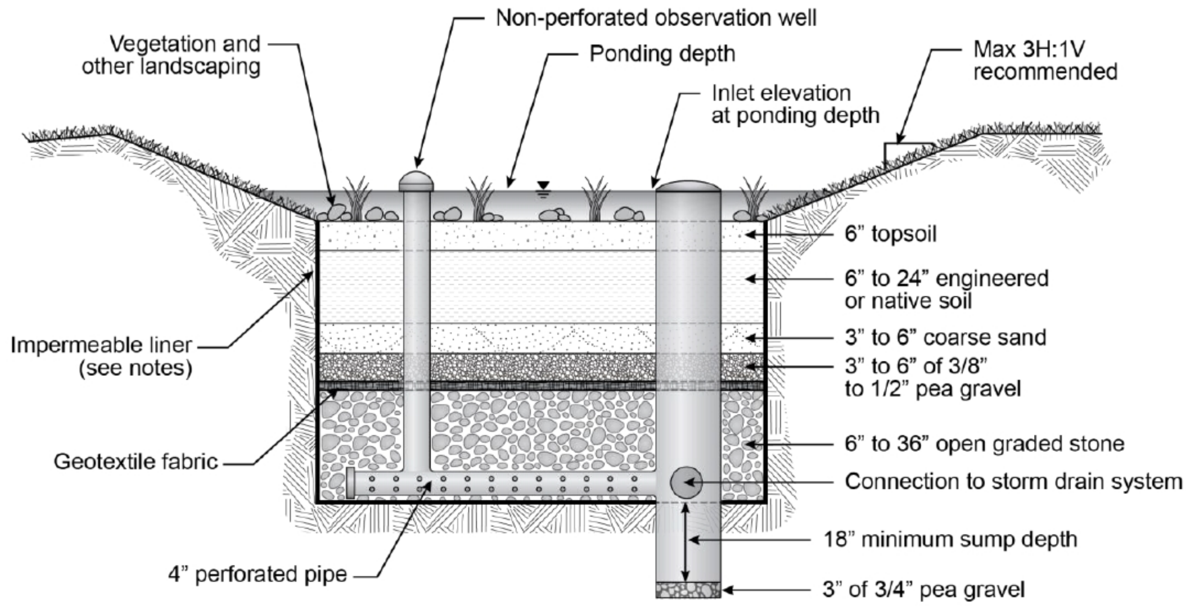
- Excavation
- Grading
- Fine grading
- Granular borrow fill
- Landscaping and vegetation
- Top layer
- Engineered soil
- Coarse sand
- Crushed gravel
- Open graded stone
- Geotextile fabric
- Outlet structure or upstream bypass structure (for larger storm events)
- Observation wells
- Curb and gutter
- Impermeable liner (if needed)
- Underdrain system (if needed)
- Irrigation system (if needed)

Maintenance

Refer to Maintenance and Maintenance Costs in the Preface to Fact Sheets for general information related to maintenance of bioretention BMPs.

Maintenance Activities

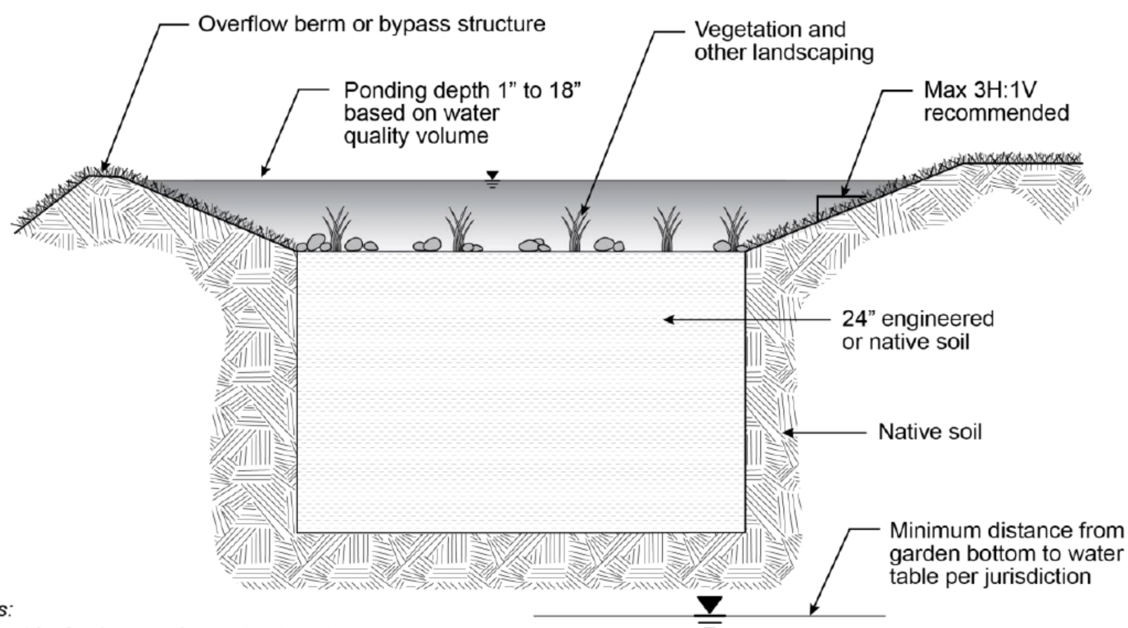
Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for adequate vegetation coverage, and impaired or failing vegetation	Semiannual (Spring, Fall)	Reseed/replant barren spots, Notify the engineer if failing vegetation persists	Low
Inspect side slopes for erosion, rilling, and sloughing	Semiannual (Spring, Fall)	Regrade side slopes if soughing does not impact slope stability. Notify the engineer if sides slope stability has been compromised and is affecting the functionality of the basin	Low
Inspect for trash and debris within basin and at inlet and outlet structures	Semiannual (Spring, Fall) or as needed	Remove and dispose of trash and debris.	Low
Inspect for large deposits of sediment on basin bottom indicating soil clogging	Semiannual (Spring, Fall) or as needed	Remove and dispose of built up sediment when buildup causes reduction in size of basin or if buildup results in standing water. Notify the engineer in the case of standing water as it may indicate clogging within the basin's soil layers	Low
Inspect for standing water within rain garden or within observation well	Semiannual (Spring, Fall) or as needed	Notify the engineer for further inspection	Medium
Inspect for failure of additional feature such as underdrains or irrigation systems	Semiannual (Spring, Fall) or as needed	Repair as needed	Medium



Notes:
- *Impermeable liner around all sides and bottom of rain garden if groundwater concerns exist*
- *Dimensions shown may vary based on site conditions*
- *Consider forebay or other pretreatment*

Rain Garden with Underdrain System

Not to scale



Notes:
- *Consider forebay or other pretreatment*
- *Consider upstream bypass for large storm events*

Rain Garden in Native or Engineered Soils

Not to scale

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Bioretention Cell

Pollutant Removal Effectiveness

Pollutant	Effectiveness
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

Primary Functions

Bioretention	Yes
Volume Retention	Yes
Biofiltration	Yes

Bioretention cells are shallow bioretention areas with engineered soil. They typically differ from rain gardens by having a delineation such as a curb, wall, or other distinct boundary. Similar to a rain garden, a variety of plants are used to increase infiltration and nutrient uptake including trees, shrubs, grasses, and other plants suitable for the climate. They may be designed with native soils or various layers of soil, sand, and aggregate. They can be topped with a wood or rock mulch, any organic material, or other landscaping features. Performance is increased with high carbon soils. Sand and aggregate layers below the soil layers provide filtration and storage.

Ponding depths are usually between 1 to 18 inches. In areas with high foot traffic, it may be necessary to provide a safety bench of soil within the cell and a minimum side slope leading to the cell bottom. Underdrains and impermeable liners are necessary when subsurface concerns exist such as proximity to a structure, poorly infiltrating soils, or groundwater concerns. When a bioretention cell must be lined, its volume retention function is eliminated, its pollutant removal effectiveness is diminished, and it functions primarily as a detention device; however, it still provides treatment through biofiltration. A bypass mechanism either within the bioretention cell or upstream of the cell should be considered for flood events.

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Design Criteria

Parameter	Min. Value	Max. Value	Notes
Depth to Historical High Groundwater	2 ft	No Maximum	-
Ponding Depth	No Minimum	18 in.	-
Drawdown Time	12 hrs	72 hrs	24 to 48 hours preferred. Drawdown time may also depend on local mosquito abatement regulations. (should we add our regs?)
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design. Infiltration rate should be low enough to allow biofiltration process to occur. During design, infiltration rate, drawdown time, and the soil matrix depth will be directly related
Freeboard	No Minimum	No Maximum	Freeboard per jurisdiction standards (ours?) . For public safety, consider requiring freeboard and a minimum 6 inch embankment when ponding depth is greater than 6 inches.

Bioretention Cell Effectiveness

Effective bioretention cells provide an aesthetically pleasing method for retaining and treating storm water. Inspecting bioretention cells during rain events will reveal if the cell is draining properly. Bioretention cells are performing properly if they are retaining their design volume and treating runoff. Creating and following through on maintenance guidelines are critical to ensuring that a bioretention cell remains functional.

There are many possible indications that a bioretention cell has failed or is near failure, such as: ponding beyond the design ponding depth during small storm events, drawdown time exceeds design drawdown time, larger than expected sediment buildup within or upstream of the cell, excessive and unmaintained vegetation, lack of vegetation, obstructions at the inlet and outlet locations, and no maintenance or no record of maintenance. Although this is not an all-inclusive list, being aware of these items will assist in determining what steps need to be taken to remediate a failing bioretention cell.

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Does groundwater meet the minimum separation requirement?	☐	☐ (red)
Is there available right-of-way, property, or easement?	☐	☐ (red)
Is the design infiltration rate within acceptable rates?	☐	☐ (red)
Is contaminated groundwater present?	☐ (red)	☐
Is the drainage area to the bioretention cell less than 5 acres? (If no, consider an infiltration basin or subdividing to create smaller drainage areas.)	☐	☐ (red)
Do utility conflicts make installation of the bioretention cell technically infeasible?	☐ (red)	☐
Do geotechnical conditions exist that would compromise the stability of the bioretention cell or surrounding structures?	☐ (red)	☐
Does the bioretention cell provide storage for 100% of the water quality volume? (If no, it may still be appropriate to construct the rain garden if it is technically infeasible to capture 100% of the water quality volume.)	☐	☐ (red)
Does an overflow outlet structure or bypass mechanism exist?	☐	☐ (red)

Vegetation

Refer to Vegetation Guidance by BMP Type.

Installation

Excavation

Bioretention cells, like other BMPs whose functionality is dependent on infiltration, will fail if proper care is not taken during excavation and construction. Excavators and heavy machinery should not be used within the excavated area if infiltration is expected to occur through the bioretention cell bottom. Additional excavation beyond the footprint may be required depending on site conditions to provide soil stability or to be able to tie-in to the surrounding grade.

Activities During Construction

Avoid using heavy machinery within the bioretention cell footprint during construction as doing so will further compact the soils and diminish their infiltrating capabilities. Light machinery and even walking within the bioretention cell's footprint will also compromise infiltration. Compaction of native soils or backfill below the bioretention cell subsoils is acceptable if doing so does not prevent infiltration from occurring.

Flows During Construction

Flows during construction should be diverted away from the bioretention cell to prevent construction site sediment from clogging soils. Scheduling installation of the bioretention cell shortly after excavation will minimize the impact of unnecessary storm water flows from entering the excavated area. The introduction of unwanted sediment can be prevented by placing fiber rolls or silt fences around the bioretention cell perimeter during construction.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.
- Follow landscaping guidance to ensure that vegetation establishes after installation.

Installation Costs

The following cost items are typically associated with bioretention cell construction.

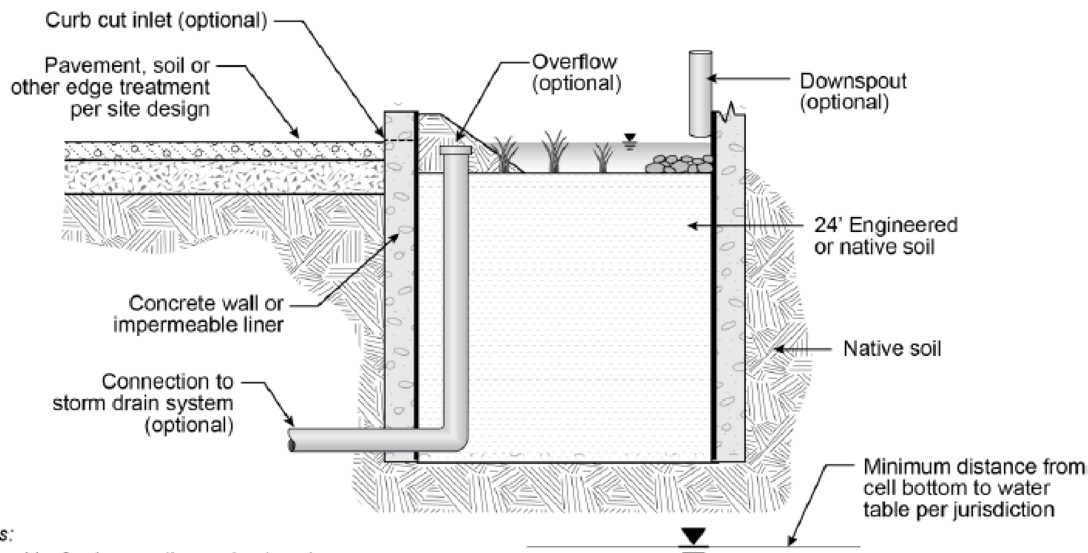
- Excavation
- Landscaping and vegetation
- Top layer
- Engineered soil
- Coarse sand
- Crushed gravel
- Open graded stone
- Geotextile fabric
- Outlet structure or upstream bypass structure (for larger storm events)
- Observation wells
- Curb and gutter
- Impermeable liner (if needed)
- Underdrain system (if needed)
- Irrigation system (if needed)

Maintenance

Refer to Maintenance and Maintenance Costs in the Preface to Fact Sheets for general information related to maintenance of bioretention BMPs.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for adequate vegetation coverage, and impaired or failing vegetation	Semiannual (Spring, Fall)	Reseed/replant barren spots, Notify the engineer if failing vegetation persists	Low
Inspect for trash and debris within basin and at inlet and outlet structures	Semiannual (Spring, Fall) or as needed	Remove and dispose of trash and debris.	Low
Inspect for standing water within bioretention cell or within observation well	Semiannual (Spring, Fall) or as needed	Notify the engineer for further inspection	Medium
Inspect for failure of additional feature such as underdrains or irrigation systems	Semiannual (Spring, Fall) or as needed	Repair as needed	Medium



Notes:
- *Consider forebay or other pretreatment*
- *Consider upstream bypass for large storm events*

Bioretention Cell in Native or Engineered Soils

Not to scale

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Bioswale

Pollutant Removal Effectiveness

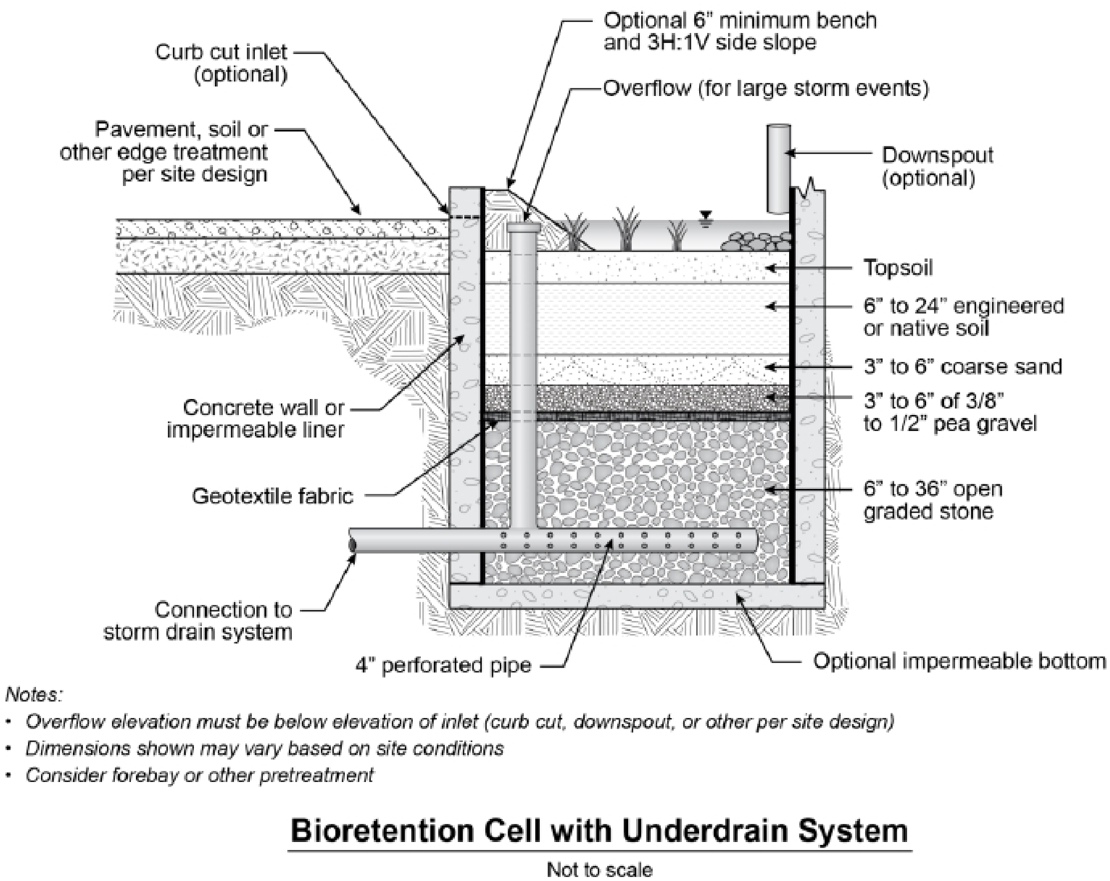
Pollutant	Effectiveness[1]
Sediment	Medium
Nutrients	Medium
Metals	Medium
Bacteria	Medium
Oil/Grease	High

[1] Removal effectiveness is increased for all pollutants as retention increases

Primary Functions

Bioretention	Yes
Volume Retention	Some
Biofiltration	Yes

Bioswales are vegetated open channels designed to convey and treat storm water runoff. They are appropriate when it is desirable to convey flows away from structures or as an alternate conveyance method to pipes,



More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

concrete channels, or curbed gutters. Bioswales reduce peak flow rates, reduce flow velocities, filter storm water pollutants, and can also reduce runoff volume through infiltration.

The primary functions of bioswales are bioretention and treatment through biofiltration. Conveying runoff through bioswales allows the runoff to be filtered through two processes: bioretention through a native or engineered soil matrix and biofiltration through the above ground vegetation.

Although volume retention may be accomplished within the native soil or a subsoil matrix of engineered soil and gravel layers, retention is not its primary function. However, retention volumes may be determined by designing ponding areas within the swale or creating check dams. There is research to support the quantification of infiltration when runoff is simply conveyed through the swale (no ponding) but design parameters vary widely. Monitoring bioswales for volume reduction is the most reliable source for future estimates of expected reduction.

Design Criteria

Parameter	Min. Value	Max. Value	Notes
Length	Based on hydraulic residence time	No Maximum	-
Longitudinal Slope	0.50%	5%	Underdrain recommended below minimum slope
Bottom Width	No minimum	No maximum	-
Side Slope	No minimum	3H:1V	Per jurisdiction requirements
Flow Velocity	No minimum	1.0 ft/s	Maximum permissible shear stress may also dictate maximum flow velocity
Flow Depth	No minimum	2/3 vegetation height	Flow depths greater than vegetation height will bypass the biofiltration processes
Freeboard	No minimum	No maximum	Per jurisdiction requirements (?)
Vegetation Coverage	≥ 65%		Biofiltration is significantly reduced when vegetation coverage is less than 65%
Hydraulic Residence Time	5 min	No maximum	-

Bioswale Effectiveness

Bioswales are effective when they can accomplish their design goals of conveying flows to a downstream receiving structure, BMP, or other receiving area. Flows through the swale should be relatively steady and uniform during a rain event unless retention areas and check dams are part of the swale design. Established vegetation with adequate coverage is an indication of a healthy bioswale along with minimal sediment and lack of invasive vegetation.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
If longitudinal slope is less than minimum, can an underdrain be installed?	☐	☐ (red)
If an underdrain is needed, is sufficient hydraulic head available for proper drainage?	☐	☐ (red)
Do flows result in a shear stress greater than the maximum permissible for selected vegetation?	☐ (red)	☐
Do utility conflicts make instillation of the bioswale technically infeasible?	☐ (red)	☐
Will bioswale provide conveyance for larger storm events? (If yes, the geometry of the bioswale will need to accommodate the larger events)	☐	☐
Is the bioswale providing pretreatment for a downstream BMP?	☐	☐
Is the bioswale connecting directly to the storm drain network? (If yes, the outlet structure elevation will need to be determined)	☐	☐

Vegetation

Refer to Vegetation Guidance by BMP Type.

Installation

Excavation

Bioswale construction is a relatively straightforward process of excavating the swale's subsurface trench prior to backfilling with any underdrain system, open graded stone, engineered soil, and geotextile fabric. Additional excavation beyond the swale's footprint may be required depending on site conditions to provide soil stability or to be able to tie-in to the surrounding grade.

Activities During Construction

Crews should avoid stepping within the trench except when necessary as doing so will compact the native soil that is expected to infiltrate runoff.

Flows During Construction

Flows during construction should be diverted away from the bioswale to prevent construction site sediment from clogging soils and to prevent erosion of the swale bed. Scheduling installation of the bioswale shortly after excavation will minimize the impact of unnecessary storm water flows from entering the excavated area. The introduction of unwanted sediment can be prevented by placing fiber rolls or silt fences around the bioswale perimeter during construction. Creating the upstream inlet or connection should be the last construction activity before flows are permitted to be conveyed as designed through the bioswale.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.
- Follow landscaping guidance to ensure that vegetation establishes after installation.

Installation Costs

The following cost items are typically associated with bioswale construction.

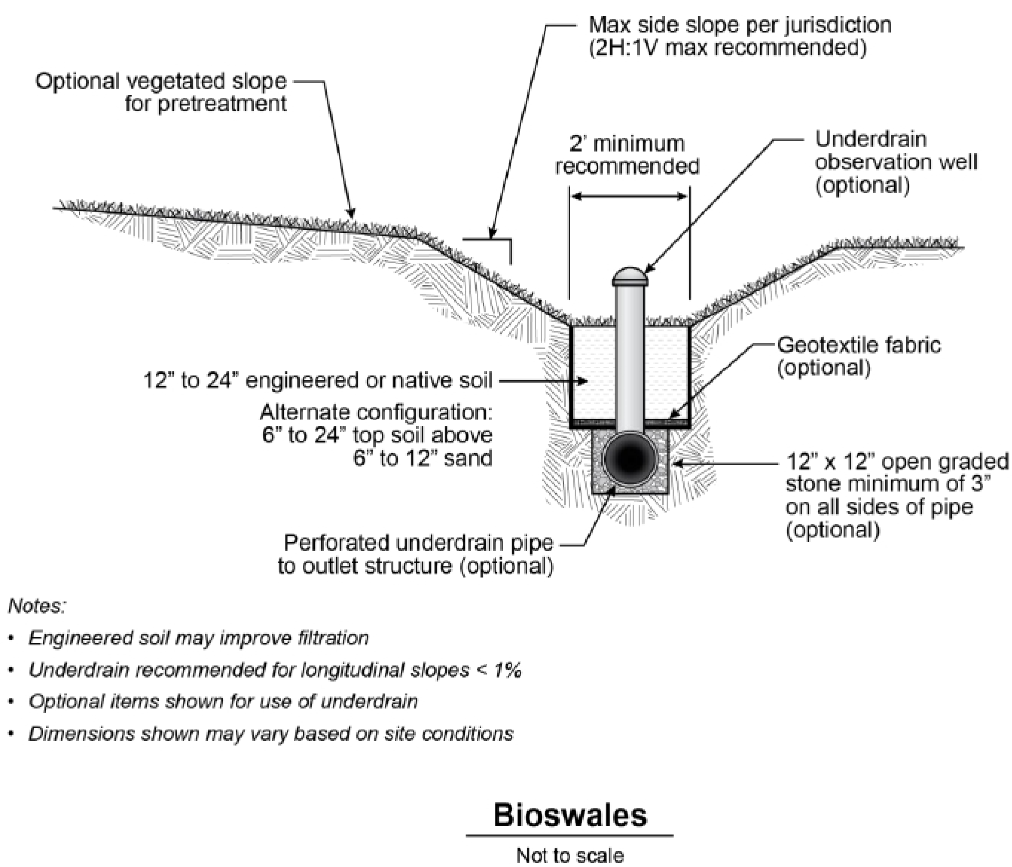
- Excavation
- Grading
- Fine grading
- Granular borrow fill
- Landscaping and vegetation
- Top layer
- Engineered soil
- Open graded stone
- Geotextile fabric
- Impermeable liner
- Outlet structure or upstream bypass structure (for larger storm events)
- Observation wells
- Underdrain system (if needed)
- Outlet protection such as riprap or other (if needed)

Maintenance

Refer to Maintenance and Maintenance Costs in the Preface to Fact Sheets for general information related to maintenance of bioretention BMPs.

https://www.epa.gov/water-research/water-research-webinar-series**Maintenance Activities**

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for adequate vegetation coverage, and impaired or failing vegetation	Semiannual (Spring, Fall)	Reseed/replant barren spots, Notify the engineer if failing vegetation persists	Low
Inspect side slopes for erosion, rilling and sloughing	Semiannual (Spring and Fall)	Regrade side slope if stability is not affected by sloughing. Notify engineer if stability is affecting basin functionality	Low
Inspect for trash and debris within basin and at inlet and outlet structures	Prior to mowing, at least semiannually	Remove and dispose of trash and debris.	Low
Inspect for standing water within bioswale or within observation well	Semiannual (Spring, Fall)	Notify the engineer for further inspection	Medium
Inspect vegetation height	As needed	Mow swale as needed	Low



More i
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Vegetated Strip

Pollutant Removal Effectiveness

Pollutant	**Effectiveness**[1]
Sediment	High
Nutrients	Medium
Metals	Medium
Bacteria	High
Oil/Grease	High

[1] Removal effectiveness is increased for all pollutants as retention increases

Primary Functions

Bioretention	Yes
Volume Retention	Some
Biofiltration	Yes

Vegetated strips are designed to receive and treat sheet flow from adjacent surfaces. This is accomplished by slowing runoff velocity to allow for pollutants and sediments to settle and by filtering out pollutants in the vegetation before entering the storm sewer system. Vegetated strips are best utilized for storm water treatment from roads, parking lots, and other impervious surfaces.

The primary functions of vegetated strips are bioretention and biofiltration. Volume Retention Some Bioretention within a vegetated strip occurs as runoff enters the soil and

pollutants are removed through physical, chemical, and biological processes. Biofiltration Yes Similar biofiltration processes occur to provide treatment when runoff passes

through the strip's vegetation. Biofiltration is significantly reduced when vegetation coverage is less than 65%. In arid locations a gravel strip may be used as a substitute for the vegetated strip. The lack of vegetation will cause biofiltration and bioretention to be greatly reduced; however, the runoff velocity will still be decreased and allow for pollutants and sediments to settle out. Volume retention through infiltration will also occur as runoff enters the gravel's void spaces.

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Design Criteria

Parameter	Min. Value	Max. Value	Notes
Length (direction of flow travel)	15ft	No Maximum	-
Longitudinal Slope	No minimum	4H:1V	Per jurisdiction requirements (?)
Flow Velocity	No minimum	1.0 ft/s	Maximum permissible shear stress may also dictate maximum flow velocity
Flow Depth	No minimum	2/3 vegetation height	Flow depths greater than vegetation height will bypass the biofiltration processes
Freeboard	No minimum	No maximum	Per jurisdiction requirements (?)
Vegetation Coverage	≥ 65%		Biofiltration is significantly reduced when vegetation coverage is less than 65%

Vegetated Strip Effectiveness

Vegetated strips are effective when they can accomplish their design goals of conveying sheet flow to the receiving area. Flows through the vegetated strip should be relatively steady and uniform during a rain event and should not create rilling or other visible signs of erosion. Established vegetation with adequate coverage is an indication of a healthy vegetated strip along with minimal sediment and lack of invasive vegetation.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Is the vegetated strip length greater than or equal to the minimum required length?	☐ (red)	☐
Do flows result in a shear stress greater than the maximum permissible for selected vegetation?	☐ (red)	☐
Is the vegetated strip providing pretreatment for a downstream BMP?	☐	☐
Is the slope in the direction of flow less than or equal to the jurisdiction's standards?	☐	☐ (red)

Vegetation

Refer to Vegetation Guidance by BMP Type.

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Installation

Vegetated strips can be installed as part of normal construction activities. An appropriate grass such as turf sod should be installed per specifications. If additional vegetation such as shrubs or bushes will be used within the strip, follow landscaping guidance to ensure that vegetation establishes after installation. To maximize infiltration performance, minimize use of heavy machinery.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.

Installation Costs

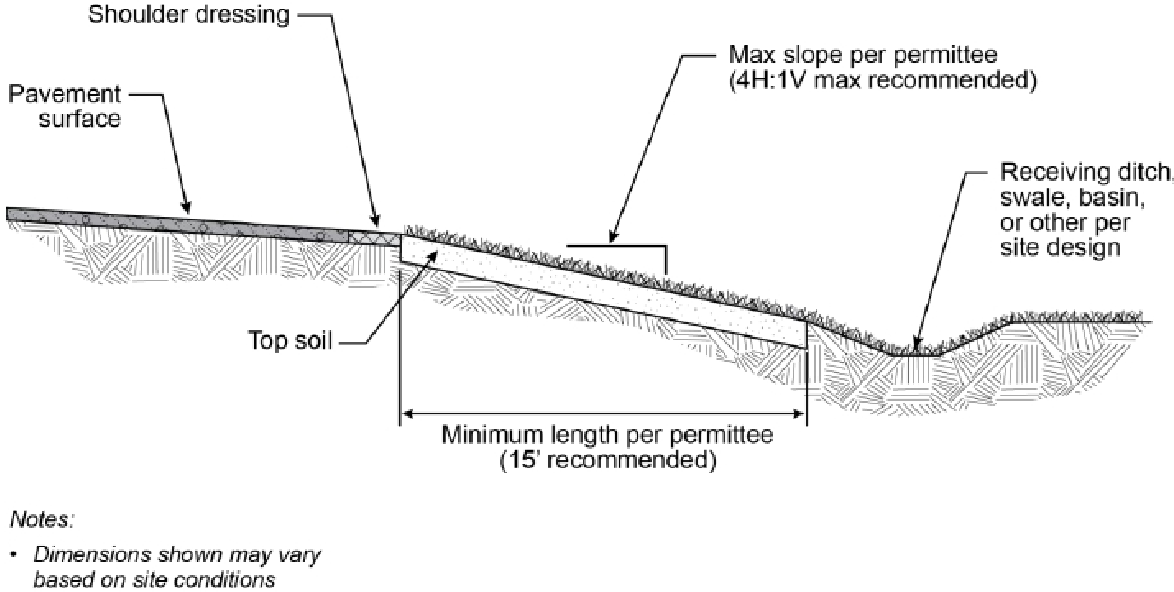
The following cost items are typically associated with bioswale construction

- Grading
- Landscaping and vegetation
- Topsoil
- Engineered soil
- Shoulder dressing upstream of vegetated strip

Maintenance

Refer to Maintenance and Maintenance Costs in the Preface to Fact Sheets for general information related to maintenance of bioretention BMPs.

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect upstream end of vegetated strip for sediment buildup that may be impeding sheet flow	Semiannual (Spring, Fall) or as needed	Remove and dispose of sediment buildup	Low
Inspect grass length	As needed	Mow strip as needed	Low
Inspect side slopes for erosion, rilling and sloughing	Semiannual (Spring and Fall)	Regrade side slope if stability is not affected by sloughing. Notify engineer if stability is affecting basin functionality	Low
Inspect for adequate vegetative coverage, and impaired or failing vegetation	Semiannual (Spring, Fall) or as needed	Reseed/replant barren areas. Notify engineer if issue persists	Low



Vegetated Strips

Not to scale

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Tree Box Filter

Source: Montgomery County, Maryland Department of Environmental Protection

Pollutant Removal Effectiveness

Pollutant	**Effectiveness**
Sediment	High
Nutrients	Medium
Metals	Medium
Bacteria	High
Oil/Grease	High

Primary Functions

Bioretention	Yes
Volume Retention	Varies[1]
Biofiltration	Yes

[1] Volume retention may be achieved with a bottomless vault

Tree box filters are bioretention systems that are appropriate in urban drainage areas where space is limited. An underground concrete vault contains the soil matrix that provides bioretention and has a grated top where vegetation grows. Tree box filters are typically designed as flow-through devices, meaning that they do not retain storm water but rather allow flows to pass through them. However, a bottomless concrete vault will function as a bioretention system that provides infiltration Primary Functions into the native soils. Manufacturers have developed proprietary designs for tree box filters, but they may also be designed.

The primary functions of tree box filters are bioretention and treatment. Runoff from the contributing drainage area enters the tree box through an inlet where bioretention occurs. Storm water is treated by the physical, chemical, and biological processes that occur within the mulch, soil matrix, and plant roots.

Design Criteria

Refer to Design Criteria in the Preface to Fact Sheets for discussion of design criteria parameters. Tree box filters may be proprietary devices; follow manufacturer specifications to determine design criteria on a case-by-case basis.

Design Criteria

Parameter	Min. Value	Max. Value	Notes
Depth to historical high groundwater	2 ft	No Maximum	May be less than 2 feet if tree box filter has impermeable bottom
Ponding Depth	No minimum	12 in	-
Drawdown Times	12 hours	72 hours	24 to 48 hours preferred. Drawdown time may also depend on local mosquito abatement regulations (ours?)
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design. Infiltration rate should be low enough to allow biofiltration processes to occur. During design, infiltration rate, drawdown time, and the soil matrix depth will be directly related

Tree Box Filter Effectiveness

Tree box filters are effective when they maintain their bioretention and biofiltration capabilities. Proper inspection and maintenance of tree box filters will ensure that the chemical and biological processes that treat runoff perform optimally. Qualified inspection crews are necessary to determine if soils and vegetation are healthy.

The tree box must be able to function hydraulically. Flows must be able to pass through the filter without backing up or maintenance will be required.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Is there adequate space for a tree box filter?	☐	☐
Is there sufficient hydraulic head for tree box filter to connect to storm drain network?	☐	☐
If retention is desired, will the design infiltration rate permit a reasonable drawdown time?	☐	☐
If retention is desired, is depth to the historical high groundwater from the filter bottom greater than the jurisdiction’s minimum separation requirement?	☐	☐

Vegetation

Refer to Vegetation Guidance by BMP Type.

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

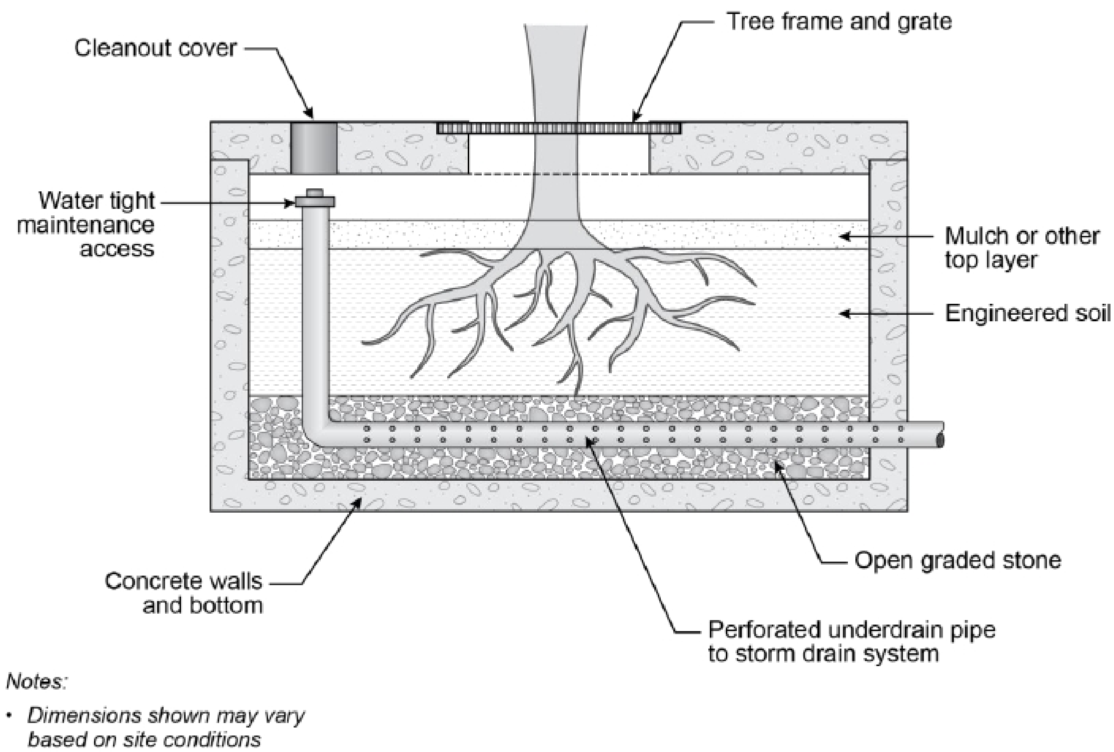
Maintenance

Refer to Maintenance and Maintenance Costs in the Preface to Fact Sheets for general information related to maintenance of bioretention BMPs.

Maintenance Activities

Proper maintenance of tree box filters will be per the manufacturer's specifications, but it typically includes the following:

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for trash and debris within tree box filter and at inlet and outlet structures	Semiannual (Spring, Fall) or as needed	Remove trash, debris and sediment	Low
Inspect performance	Semiannual (Spring and Fall)	Replenish media filter layer with new mulch	Medium
Inspect for invasive species	Semiannual (Spring and Fall)	Prune and weed filter box	Medium



Tree Box Filters

Not to scale

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Green Roof

Pollutant Removal Effectiveness

Pollutant	**Effectiveness**[1]
Sediment	High
Nutrients	Medium[2]
Metals	High
Bacteria	High
Oil/Grease	-

[1] Removal effectiveness is increased for all pollutants as retention increases
[2]Use of organic matter to establish vegetation may increase nutrient leaching

Primary Functions

Bioretention	Yes
Volume Retention	Yes
Biofiltration	Yes

A green roof is a vegetated system that is designed to retain and treat rooftop runoff. The primary functions of green roofs are bioretention, volume retention, and filtration. Green roofs capture storm water within the pore space of the soil and vegetation and the moisture is then released through evapotranspiration.

Green roofs can be classified as either extensive or intensive systems. Extensive systems are those in which the soil media is up to 6 inches in depth and support smaller grasses and other vegetative species that do not have deep root systems. Intensive systems are those that support root systems greater than
6 inches such as those from trees and bushes.

The design of green roofs should be done with the coordination of qualified landscaping, structural, and maintenance teams. Vegetation selection and the proper maintenance of vegetation are critical items in the overall performance and functionality of the green roof. The integrity of the roof structure must also be accounted for as large volumes of plants, soils, water, and the weight of the green roof structure will create additional loads on the building.

Design Criteria

Refer to Design Criteria in the Preface to Fact Sheets for discussion of design criteria parameters.

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Design Criteria

Parameter	Extensive	Intensive	Notes
Drawdown Time	12 hours	12 hours	-
Grow Media Depth	< 6 in	6 + in	-
Vegetation	Low growing, low water-use vegetation such as sedum, herbs, grasses, perennials	More complex gardens including the species listed for extensive green roofs, but also incorporating trees and shrubs	-
Load	12-54 lb/sf	72 + lb/sf	-
Roof Slope	5:1 maximum	5:1 maximum	-
Access	Required for maintenance	Required for maintenance	-
Irrigation	Simple irrigation. Only needed during droughts and plant establishment if well designed	Complex irrigation	-
Drainage	Simple drainage system	Complex drainage system	-

Green Roof Effectiveness

Green roofs provide an aesthetically pleasing method for retaining and treating storm water runoff. Healthy plants and soils are indications that the green roof is performing as expected. Excessive drainage through the soil layer may be an indication that the soils and vegetation are not retaining runoff; consequently, the evaporation and transpiration processes are not occurring. Qualified horticulturists and/or green roof contractors should be involved in determining the health and effectiveness of the green roof.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Has a landscape architect been involved in the vegetation selection?	☐	☐ (red)
Has a structural engineer been involved in the green roof design?	☐	☐ (red)
Are maintenance crews trained and aware of maintenance responsibilities?	☐	☐ (red)
Does the green roof provide storage for 100% of the water quality volume? (If no, it may still be appropriate to construct the green roof if it is technically infeasible to capture 100% of the water quality volume)	☐	☐ (red)
Will the green roof partially cover or fully cover the roof?	-	-
Will the green roof be extensive or intensive?	-	-

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Vegetation

Refer to Vegetation Guidance by BMP Type.

Installation

Green roof installation should be done with proper oversight from qualified environmental or green roof specialists. Any requirements related to working on rooftops should be followed. During construction, vegetation and the growth media should be protected from erosion until vegetation has been established.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.

Installation Costs

The following cost items are typically associated with rain garden construction.

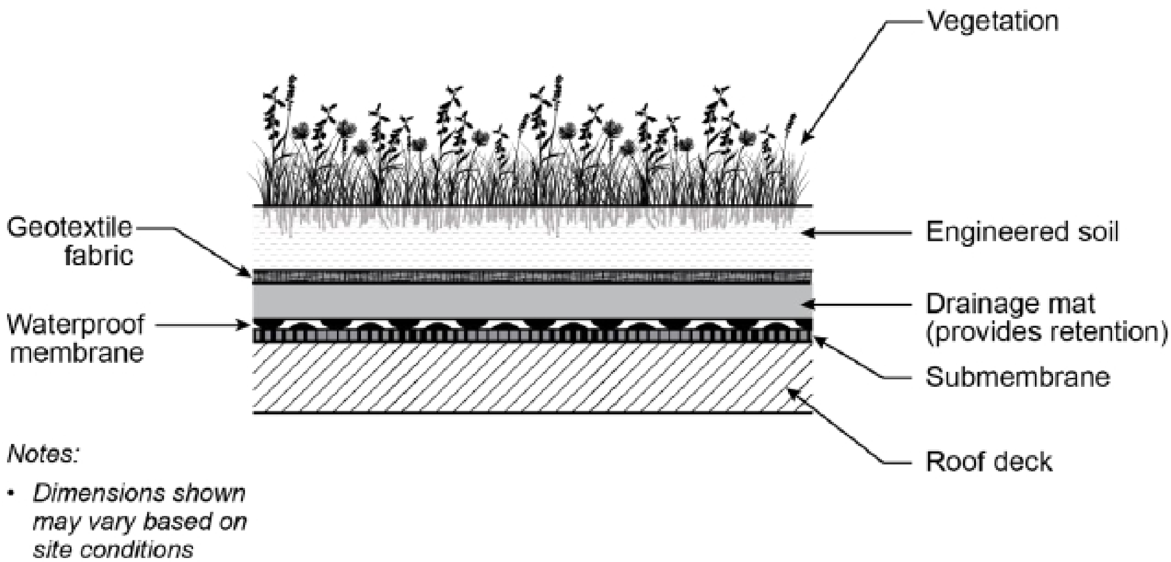
- Vegetation and landscaping expertise
- Horticulturist expertise
- Structural expertise

Maintenance

Refer to Maintenance and Maintenance Costs in the Preface to Fact Sheets for general information related to maintenance of green roofs.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect weed growth	2-4 weeks during growing season	Remove weeds before they flower	High
Inspect fertilization	Annually	Apply fertilizer in accordance with manufacturer recommendations. Avoid hottest/driest parts of the year	Medium
Inspect water retention	Semiannual (Spring and Fall) or as needed	If natural precipitation is not adequate for vegetation, water plants	High



Green Roof

Not to scale

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Pervious Surfaces

Pollutant Removal Effectiveness

Pollutant	Effectiveness[1]
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

[1] Removal effectiveness is increased for all pollutants as retention increases

Primary Functions

Bioretention	Yes[1]
Volume Retention	Yes
Biofiltration	Some

[1] Bioretention occurs in the subsurface and not within the pervious surface

Pervious surfaces such as permeable pavement, concrete pavers, pervious concrete, modular open pavers, and other types of pervious surfaces provide structural support for light vehicle or pedestrian traffic while also providing open space for storm water infiltration.

The primary function of pervious surfaces is volume retention, but some filtration is possible depending on the type of paver and subsurface selected. A modular open paver that, when installed, provides a certain percentage of pervious area in the form of grass, will allow for filtration processes to occur. Another source of filtration is the choker layer directly beneath the pervious surface.

The subsections beneath the pervious surface are typically a choker layer composed of small gravel and a storage layer of larger rock beneath. Underdrains may be required if existing soils do not adequately infiltrate.

Design Criteria

Refer to Design Criteria in the Preface to Fact Sheets for discussion of design criteria parameters.

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Design Criteria

Parameter	Min. Value	Max. Value	Notes
Drain Time	12 hours	72 hours	-
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design
Depth to Historical High Groundwater	2 ft	No maximum	-

Pervious Surface Effectiveness

Pervious surfaces are effective when runoff from the design storm depth can enter the porous spaces of the pervious surface and successfully infiltrate into the native soil or drain through an underdrain system. Visual inspection of the pervious surface can reveal reasons for failure: for example, sediment-laden sheet flows that are conveyed to the pervious surface, or a down drain might be introducing organic material. Both scenarios are likely to contribute to clogging within the porous spaces of the pervious surface or within the sublayers.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Will an underdrain system be required?	☐	☐
If an underdrain is needed, is there sufficient head for the underdrain system to drain?	☐	☐ (red)
Has the proposed pervious surface performed successfully in similar climate conditions?	☐	☐ (red)

Installation

Excavation

Pervious surfaces will fail if proper care is not taken during excavation and construction. Excavators and heavy machinery should not be used if infiltration is expected to occur through the underlying soils beneath the pervious surface’s subsection.

Activities During Construction

Avoid using heavy machinery on the revealed soil during construction. Crews should avoid unnecessarily walking on the underlying soils when possible. Compaction of native soils or backfill below the pervious surface subsoils is acceptable if doing so does not prevent infiltration from occurring.

Flows During Construction

Flows during construction should be diverted away from the exposed underlying soil to prevent erosion. Scheduling installation of the pervious surface within a short time span after excavation will minimize the impact of unnecessary storm water flows from entering the excavated area. The introduction of unwanted sediment and storm water flows can be prevented by placing fiber rolls or silt fences around the excavated perimeter during construction.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.

Installation Costs

The following cost items are typically associated with construction of pervious surfaces.

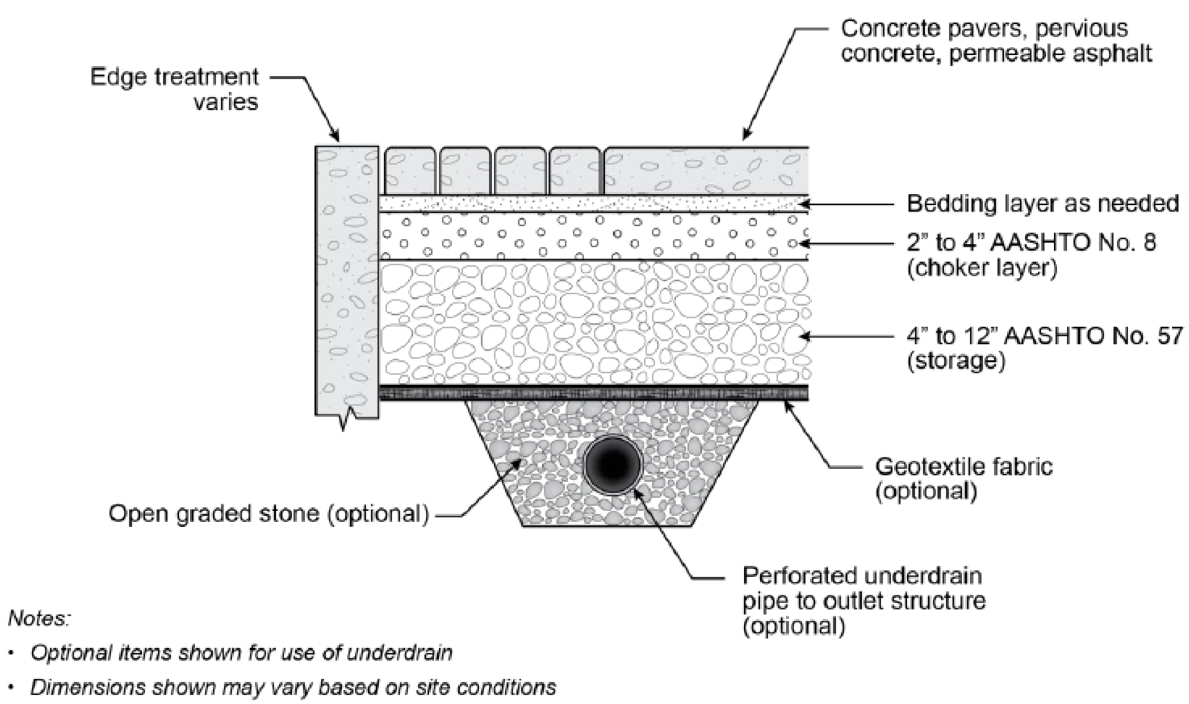
- Excavation
- Grading
- Fine grading
- Pervious surface
- Top layer
- Engineered soil
- Choker layer
- Open graded stone
- Geotextile fabric
- Impermeable liner
- Observation wells (if needed)
- Underdrain system (if needed)

Maintenance

Refer to Maintenance and Maintenance Costs in the Preface to Fact Sheets for general information related to maintenance of pervious surfaces.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for sediment accumulation	Semiannual (Spring, Fall)	Use vacuum sweeper followed by pressure washing	Medium
Inspect for weed growth	Semiannual (Spring, Fall)	Remove weeds	Low
Inspect for standing water on surface or within observation well (if used)	Semiannual (Spring and Fall)	Notify engineer for further inspection	Low
Inspect surface for deterioration	Annual	Notify engineer for further inspection	Low
Inspect exfiltration and drainage performance	As needed, at least annually	Notify engineer for further inspection	Medium



Pervious Surfaces

Not to scale

quality/stormwater/updes/DWQ-2019-000161.pdf

Infiltration Basin

Pollutant Removal Effectiveness

Pollutant	Effectiveness
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

Primary Functions

Bioretention	Yes
Volume Retention	Yes
Biofiltration	Yes

Infiltration basins are shallow depressions that use existing soils to retain and provide treatment for storm water runoff. Infiltration basins function by capturing and infiltrating runoff over a specified drawdown time.

The primary functions of infiltration basins are bioretention, volume retention, and filtration. The existing soils remove pollutants through physical, chemical, and biological processes before the storm water reaches the groundwater. Filtration occurs as runoff interacts with grass and other vegetation within the basin and as runoff infiltrates through the soil.

Infiltration basins are typically designed for larger drainage areas where it may be impractical for a BMP such as a bioretention area that requires more maintenance of specialized vegetation over a larger area.

Pretreatment of runoff may take place in a forebay that will allow for particulate settling. Forebays are typically sized for a percentage of the water quality volume; typically ranging from 10% to 25%.

Design Criteria

Refer to Design Criteria in the Preface to Fact Sheets for discussion of design criteria parameters.

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Design Criteria

Parameter	Min. Value	Max. Value	Notes
Water Quality Volume	0.1 ac-ft (4356 cf)	No maximum	-
Freeboard	1 ft		-
Overflow Spillway Length	3 ft spillway length		-
Invert Slope	0% (flat basin bottom)		-
Interior Side Slope	No minimum	3H:1V	-
Drawdown Time	24 hours	72 hours	48 hours recommended
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design
Depth to Historical High Groundwater	2 ft	No maximum	-

Infiltration Basin Effectiveness

Effective infiltration basins take advantage of open spaces for retaining and treating storm water. Established vegetation with adequate coverage is an indication of a healthy infiltration basin along with minimal sediment and lack of invasive vegetation. Side slopes should be stable and show little to no signs of erosion or rilling. Slope sloughing is an indication that geotechnical remediation is needed.

During the design storm event, infiltration basins should, at most, pond up to the water quality outlet. After the rain event, runoff within the basin should infiltrate through the bottom soils within the design drawdown time.

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Does groundwater meet the jurisdiction's minimum separation requirement?	☐	☐
Is there available right-of-way, property, or easement for the infiltration basin?	☐	☐
Is contaminated groundwater present at the infiltration basin location?	☐	☐
Is the water quality volume above the 4,356 cf threshold	☐	☐
Does the infiltration basin provide storage for 100% of the water quality volume? (If no, it may still be appropriate to construct the infiltration basin if it is technically infeasible to capture 100% of the water quality volume)	☐	☐
Do utility conflicts make installation of the infiltration basin technically infeasible?	☐	☐
Do geotechnical condition exist that compromise the stability of the infiltration basin or surrounding structures?	☐	☐
Does an overflow outlet structure or bypass mechanism exist?	☐	☐
Is a fence required?	☐	☐

Vegetation

Refer to Vegetation Guidance by BMP Type.

Installation

Excavation

Installation of infiltration basins is a relatively straightforward process of excavation and grading; however, the basin will fail if proper care is not taken during construction. Excavators and heavy machinery should not be used within the basin area to avoid soil compaction.

Activities During Construction

Avoid using heavy machinery within the infiltration basin footprint during construction as doing so will compact the soils and diminish their infiltrating capabilities. Installation of an outlet structure may require machinery.

Flows During Construction

Flows during construction should be diverted away from the infiltration basin to prevent construction site sediment from clogging soils. Seeding or laying turf sod should occur within a short time span after excavation to minimize the impact of unnecessary storm water flows from entering the basin area. The introduction of unwanted sediment can be prevented by placing fiber rolls or silt fences around the basin perimeter during construction.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.
- Follow landscaping guidance to ensure that vegetation establishes after installation.

Installation Costs

The following cost items are typically associated with infiltration basin construction.

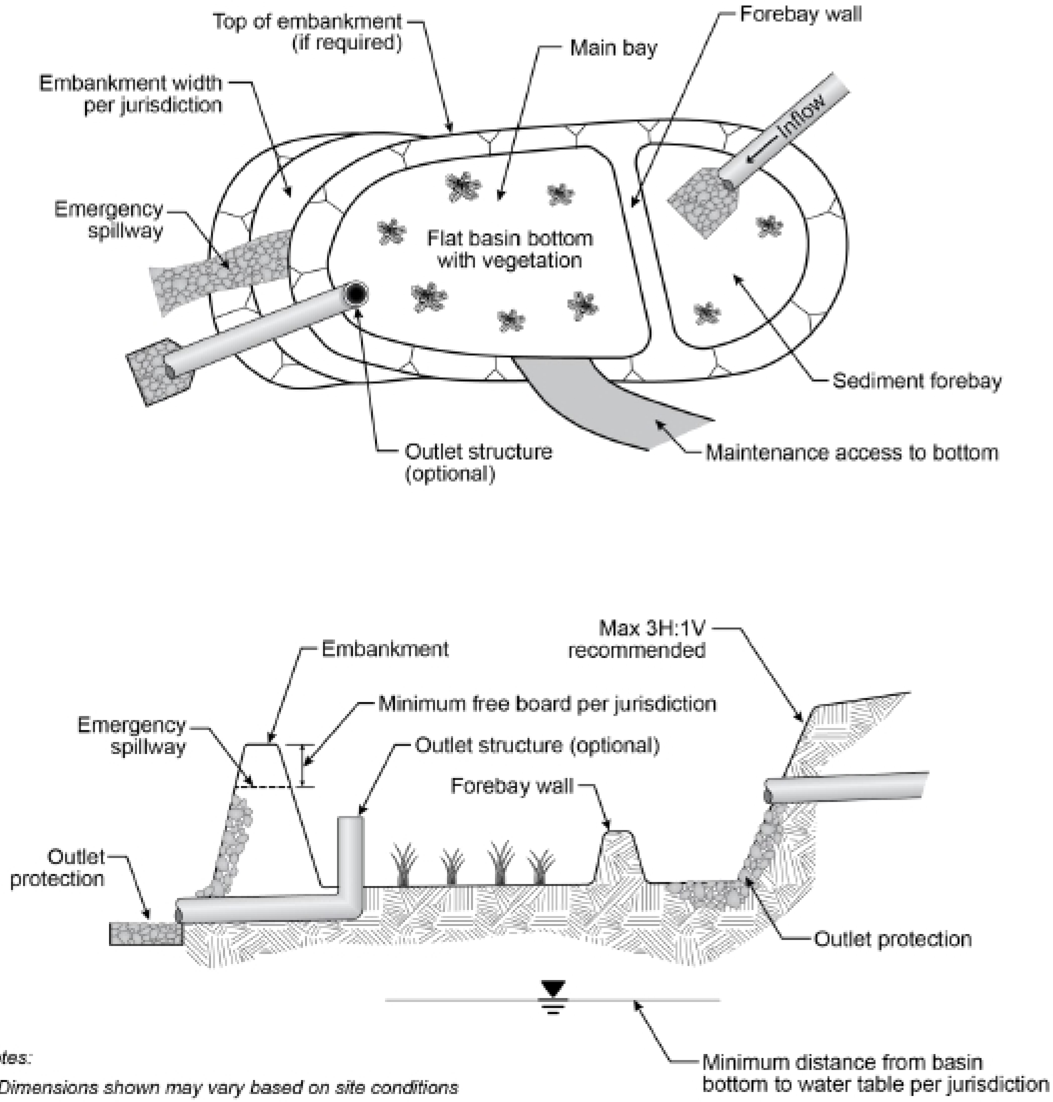
- Excavation
- Grading
- Outlet structure or upstream bypass structure (for larger storm events)
- Forebay and associated items: outlet protection, forebay wall, and connection between forebay and main bay.

Maintenance

Refer to Maintenance and Maintenance Costs in the Preface to Fact Sheets for general information related to maintenance of infiltration BMPs.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for trash and debris at inlet and outlet structures	Semiannual (Spring, Fall) or as needed	Remove and dispose of trash and debris	Low
Inspect grass length	As needed	Mow basin grass	Low
Inspect pre-treatment diversion structures for sediment build-up	Semiannual (Spring and Fall)	Remove and dispose of sediment buildup	Low
Inspect topsoil for sediment build-up	Semiannual (Spring, Fall) or as needed	Notify engineer for further inspection	Low
Inspect for standing water above trench or within observation well (if used)	Semiannual (Spring, Fall)	Notify engineer for further inspection	Low



Notes:

- *Dimensions shown may vary based on site conditions*
- *Forebay connection type to main bay will vary: outlet pipe, gabion wall, notched concrete wall, and others are acceptable*
- *Consider upstream bypass for large storm events*

Infiltration Basin

Not to scale

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Infiltration Trench

Source: NHDES Soak Up the Rain

Pollutant Removal Effectiveness

Pollutant	Effectiveness
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

Primary Functions

Bioretention	Yes[1]
Volume Retention	Yes
Biofiltration	Some

[1] Bioretention occurs in subsurface and not within the trench

Infiltration trenches are linear excavations that are backfilled with a combination of gravel, open graded stone, and sand layers that provide storage within the pore space of the specified layers. Although typically linear, infiltration trenches can be any shape provided that the footprint and depth are sized to retain the water quality volume.

The primary function of infiltration trenches is volume retention. The trench is designed such that the water quality volume is retained and stored within the gravel and sand layers. Depending on the design of the trench, pollutant removal occurs via filtration as runoff passes through an initial pea gravel layer and ultimately through the bottom sand layer. A geotextile fabric is also recommended along the sidewalls of the trench and under the pea gravel layer.

Design Criteria

Refer to Design Criteria in the Preface to Fact Sheets for discussion of design criteria parameters.

Design Criteria

Parameter	Min. Value	Max. Value	Notes
Depth of Trench	2 ft	No maximum	Maximum depth determined by jurisdiction
Longitudinal Trench Slope	0%	1%	-
Width	2 ft	No maximum	-
Drawdown Time	12 hours	72 hours	-
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design
Depth to Historical High Groundwater	2 ft	No maximum	-

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Infiltration Trench Effectiveness

Effective infiltration trenches take advantage of limited or narrow spaces where bioretention areas or infiltration basins are impractical. Visible sediment buildup on the top layer of the trench could be an indication that clogging is present within the trench or that runoff is simply passing over the trench and not being captured. Although some vegetation intrusion or organic debris is likely not a concern, proper grooming and maintenance will contribute to a trench's extended life-span.

During the design storm event, runoff should be conveyed toward and enter the trench per the design plans. Recent new construction, regrading, or resurfacing within the contributing drainage area should be noted as it may impact flow paths or the introduction of new pollutants.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Does groundwater meet the jurisdiction's minimum separation requirement?	☐	☐
Is the infiltration rate of the existing soils within acceptable rates?	☐	☐
Is contaminated groundwater present at the infiltration basin location?	☐	☐
Do utility conflicts make installation of the infiltration basin technically infeasible?	☐	☐
Do geotechnical condition exist that compromise the stability of the infiltration basin or surrounding structures?	☐	☐
Does the infiltration basin provide storage for 100% of the water quality volume? (If no, it may still be appropriate to construct the infiltration basin if it is technically infeasible to capture 100% of the water quality volume)	☐	☐
Does an overflow outlet structure or bypass mechanism exist?	☐	☐

Vegetation

Vegetation is not typical for an infiltration trench.

Installation

Excavation

Excavation for infiltration trenches is typically linear but alternate geometries are possible. During excavation, light machinery should be used to avoid excessive compaction.

Activities During Construction

Avoid using heavy machinery within the infiltration trench footprint during construction as doing so will compact the soils and diminish their infiltrating capabilities.

Flows During Construction

Flows during construction should be diverted away from the infiltration trench to prevent construction site sediment from clogging soils. The introduction of unwanted sediment can be prevented by placing fiber rolls or silt fences around the trench perimeter during construction.

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.

Installation Costs

The following cost items are typically associated with infiltration trench construction.

- Excavation
- Landscaping and vegetation
- Pea gravel
- Open graded stone
- Sand layer
- Geotextile separator

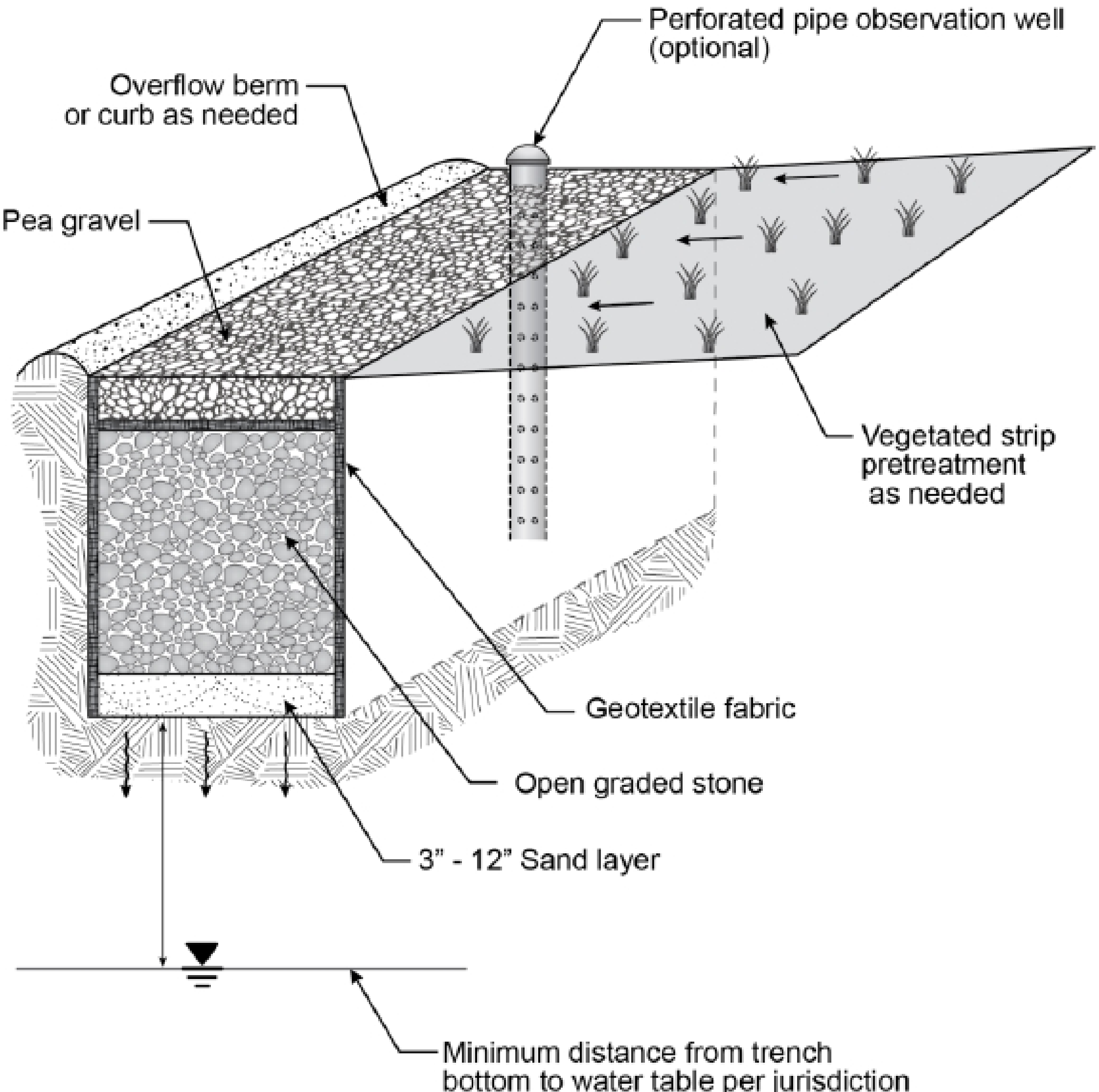
Maintenance

Refer to Maintenance and Maintenance Costs in the Preface to Fact Sheets for general information related to maintenance of infiltration BMPs.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for trash and debris at inlet and outlet structures	Semiannual (Spring, Fall) or as needed	Remove and dispose of trash and debris	Low
Inspect grass length	As needed	Mow basin grass	Low
Inspect pre-treatment diversion structures for sediment build-up	Semiannual (Spring and Fall)	Remove and dispose of sediment buildup	Low
Inspect tree growth near trench	Semiannual (Spring, Fall)	Remove trees in vicinity of the trench	Low
Inspect for standing water above trench or within observation well (if used)	Semiannual (Spring, Fall)	Notify engineer for further inspection	Low

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf



Notes:

- *Dimensions shown may vary based on site conditions*

Infiltration Trench

Not to scale

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Dry Well

Pollutant Removal Effectiveness

Pollutant	Effectiveness
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

Primary Functions

Bioretention	Yes
Volume Retention	Yes
Biofiltration	No

Dry wells are underground storage areas that are sized to retain the water quality volume and infiltrate runoff into the existing soils.

The primary functions of dry wells are bioretention and volume retention. Bioretention does not occur within the dry well but occurs in the native soils immediately surrounding the dry well.

Dry wells contribute to aquifer recharge and as such classify as a subclass of Underground Injection Control (UIC) Class V wells. Refer to the DWQ website on storm water drainage wells (link below) for more information relating to the UIC Program.

Storm Water Drainage Wells: https://deq.utah.gov/legacy/programs/water-quality/utah-underground-injection-control/drainage-wells/index.htm

Design Criteria

Refer to Design Criteria in the Preface to Fact Sheets for discussion of design criteria parameters.

Design Criteria

Parameter	Min. Value	Max. Value	Notes
Depth to Historical High Groundwater	2 ft	No maximum	-
Drawdown Time	12 hours	72 hours	-
Building Setback	10 ft	No maximum	-
Design Infiltration Rate	0.25 in/hr	6 in/hr	Field testing required for final design

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Dry Well Effectiveness

Effective dry wells optimize infiltrating soils within limited space to retain storm water runoff while not introducing stability concerns to nearby development or structures. The design storm volume within a functioning dry well will drawdown within the design time and leave no standing water inside of the well. Pretreatment should be provided prior to entering the dry well and the pretreatment method should be determined based on the expected pollutants. Entry to the dry well should be unobstructed and free of debris that will restrict flows from entering.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Does groundwater meet the jurisdiction's minimum separation requirement?	☐	☐ (red)
Is the infiltration rate of the existing soils within acceptable rates?	☐	☐ (red)
Is contaminated groundwater present at the dry well location?	☐ (red)	☐
Do utility conflicts make installation of the infiltration dry well technically infeasible?	☐ (red)	☐
Do geotechnical condition exist that compromise the stability of the infiltration dry well or surrounding structures?	☐ (red)	☐
Is pretreatment provided upstream of or within the dry well	☐	☐ (red)

Installation

Excavation

Excavate area in which dry well will be placed.

Activities During Construction

Take proper safety measures to cover the excavated dry well area before putting the dry well in place. If the dry well is designed to infiltrate through the well bottom, place and level gravel within the excavation to provide a foundation for the well structure.

Flows During Construction

Flows during construction can enter the dry well if the grated manhole lid contains a filtering material.

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Additional Guidance

- Require certificates of compliance to verify that construction items meet specification requirements.
- Obtain a permit through the UIC Program

Installation Costs

The following cost items are typically associated with dry well construction.

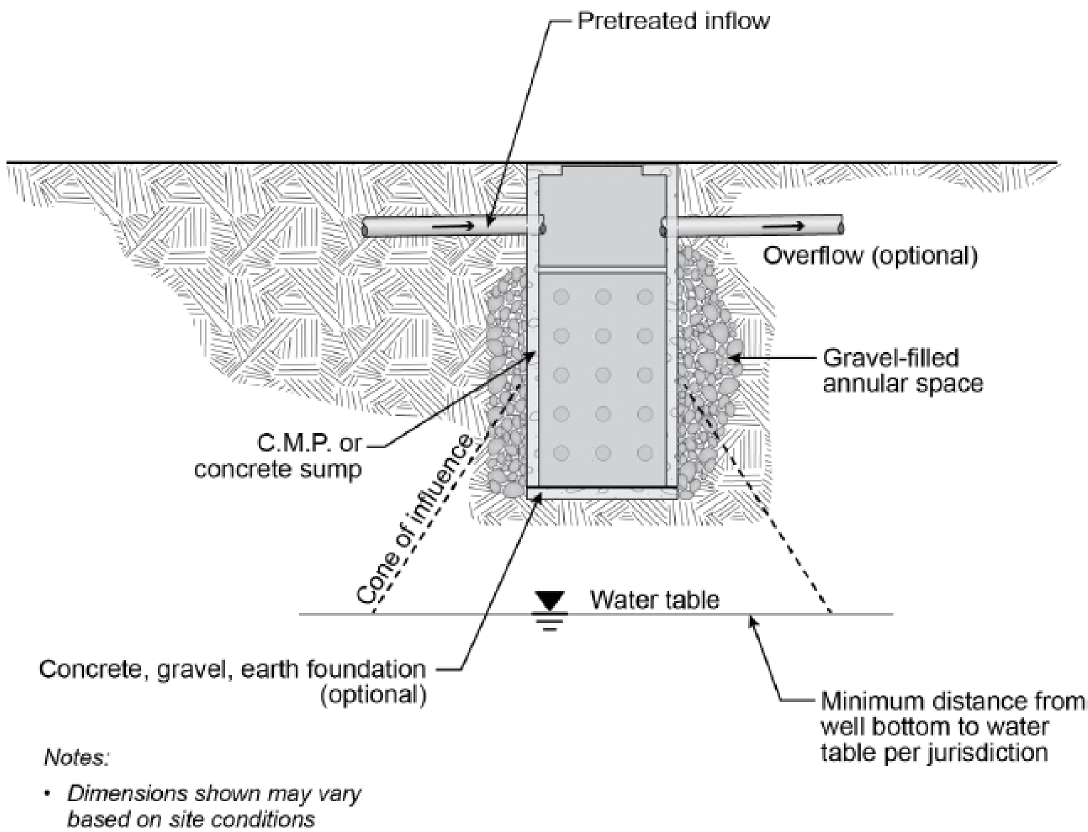
- Excavation
- Dry well
- Permit application fees for Class V Injection Wells
- Gravel-filled annular space surrounding dry well
- Pretreatment upstream of dry well
- Overflow connection to downstream system
- Gravel foundation (optional)

Maintenance

Refer to Maintenance and Maintenance Costs in the Preface to Fact Sheets for general information related to maintenance of dry wells.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect water depth	Initially after every major storm, then annually	Remove and dispose of built up sediment when build up causes reduction in detention capacity. Notify the engineer.	Medium
Inspect inlet for obstructions	Semiannual (Spring and Fall) or as needed	Remove obstructions	Low
Inspect structural elements	As determined by jurisdiction	Repair or reconstruct deficient structural components	Medium



Dry Well

Not to scale

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Underground Infiltration Galleries

Source: StormTech

Pollutant Removal Effectiveness

Pollutant	Effectiveness
Sediment	High
Nutrients	High
Metals	High
Bacteria	High
Oil/Grease	High

Primary Functions

Bioretention	Yes
Volume Retention	Yes
Biofiltration	No

Underground storage devices are proprietary alternatives to above ground storage when space at the project site is limited. They may be sized for the 90th percentile volume similar to how they are sized for flood control volumes. When underground storage is used for water quality, its primary functions are bioretention as runoff infiltrates into the underlying soil and volume retention. They are constrained by subsurface conditions such as depth to the historical high groundwater, soil infiltration rates, and other site-specific
constraints that prevent infiltration. Designing underground storage devices is Primary Functions done with the assistance of the device manufacturer.

Pretreatment for underground systems will vary. Pretreatment removes sediment that will potentially clog elements of the underground system such as geotextile fabrics or bedding layers. If the manufacturer does not include a pretreatment system as part of the device, it may be necessary to design a separate pretreatment system such as a settling basin upstream before entering the underground system.

Underground systems are typically modular and allow for configurations that range from large areas such as would be needed underneath a parking lot to linear installations like within a park strip or underneath a bioswale.

Design Criteria

Underground storage devices are proprietary devices; follow manufacturer specifications to

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Underground Infiltration Effectiveness

With regular maintenance and inspection, it can be determined if the underground system is performing as expected. As part of the design process, determine how the system will be inspected. Possible inspection methods include the use of observation wells or structural vaults at tie-in locations with the site's storm drain network. Inspect for any soil displacement or movement at the perimeter of the system and any depressions above the system.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Does groundwater meet the minimum separation requirement?	☐	☐ (red)
Is the infiltration rate of the existing soils within acceptable rates?	☐	☐ (red)
Is contaminated groundwater present?	☐ (red)	☐
Do utility conflicts make installation of the device technically infeasible?	☐ (red)	☐
Do geotechnical conditions exist that would compromise the stability of the device or surrounding structures?	☐ (red)	☐
Is pretreatment provided upstream of or within the underground storage device?	☐	☐ (red)
Is the soil bearing capacity of the underlying soil sufficient for the system?	☐	☐ (red)
Will the underground system support the expected loads above it?	☐	☐ (red)

Installation

Excavation

Excavate the footprint of the underground system.

Activities During Construction

Avoid using heavy machinery within the excavated footprint during construction as doing so will compact the soils and diminish their infiltrating capabilities. Avoid using heavy machinery on top of the underground system as well. Follow all installation guidelines from the manufacturer.

Flows During Construction

Flows during construction should be diverted away from the excavated area to prevent construction site sediment from clogging soils.

Additional Guidance

- Follow all manufacturer's requirements.

Installation Costs

The following cost items are typically associated with installation of underground storage systems.

- Excavation
- Geotextile fabric
- Underground storage devices
- Aggregate (bedding, overlay, other as needed)
- Observation wells
- Pretreatment upstream of system (if not provided)

Maintenance

Underground systems are typically designed with accessible pretreatment areas such as a manhole. Refer to manufacturer's guidelines.

Maintenance Activities

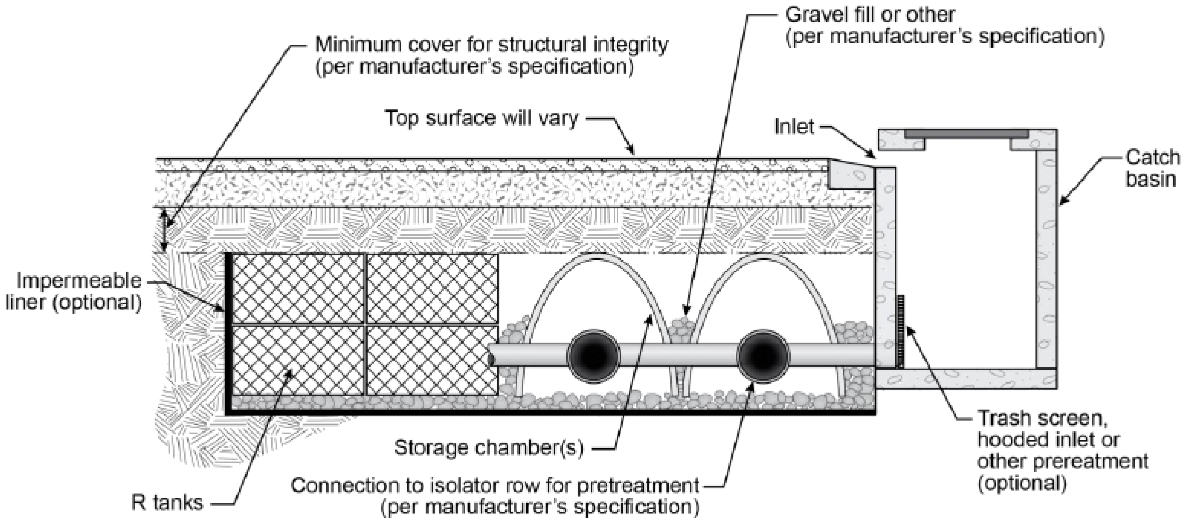
Typical maintenance activity includes removal of sediment or debris within the pretreatment area. High pressure washing of geotextile fabrics or replacement of filter fabrics may also be needed. Refer to manufacturer's guidelines for specific activities and frequency of inspections.

Manufacturers

The following table of manufacturers is for reference only and does not constitute an endorsement.

Manufacturer	Device Type(s)	URL
StormTech	Chambers	http://www.stormtech.com/
ACF Environmental	Chambers R Tanks	https://www.acfenvironmental.com
ConTech	Chambers	https://www.conteches.com

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf



Notes:

- *Configurations will vary*
- *Impermeable liner around undergroundsystem if groundwater concerns exist*
- *If impermeable liner is used, provide outlet to prevent standing water*

Underground Infiltration Gallery

Not to scale

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf

Harvest and Reuse

Pollutant Removal Effectiveness

Pollutant Removal Effectiveness:

Pollutant removal will vary based on the ultimate use of the harvested runoff.

Primary Functions

Bioretention	Varies
Volume Retention	Yes
Biofiltration	Varies

Harvest and reuse refers to any type of runoff collection system that captures rainfall, stores it temporarily, and reuses it for irrigation, landscaping, or other non-potable uses. Harvest and reuse systems inherently retain the volume of runoff that it captures. Depending on the subsequent use after being captured, they also provide bioretention and filtration to the released runoff.

Harvest and reuse systems may be used in lieu of directly connecting rooftop drains to storm sewer systems; where downdrains discharge to impervious surfaces and the opportunity for irrigation or landscaping exists; as part of a home owner's irrigation plan; or for any other non-potable purpose where storm water is determined to be acceptable such as vehicle or machinery washing.

As of 2010, Utah's legislative code 73-3-1.5 requires that if more than 100 gallons of rainwater (13.4 cf) are captured, it must be registered through the Utah Division of Water Rights

(https://waterrights.utah.gov/forms/rainwater.asp). The code also limits the total capture to 2,500 gallons (334.2 cubic feet). See the code for additional requirements.

Design Criteria

Design criteria for harvest and reuse devices or systems will vary widely. The governing principles of harvest and reuse are based on the system's function and capacity. For example, a rain barrel that provides occasional irrigation to a flower bed should be appropriately sized for the 90th percentile volume and be able to release the volume within an appropriate time that does not flood out the flower bed. A larger harvest and reuse system, such as an underground detention vault or above ground pond will be required to meet geotechnical or structural design criteria. The applications of harvest and reuse systems are endless; specific design criteria should be determined on a case-by-case basis with site-specific consideration.

Harvest and Reuse Effectiveness

The effectiveness of a harvest and reuse system is dependent on its use. Detention devices should be free of standing water to prevent stagnation and vector concerns. Systems that provide irrigation or that are part of landscaping features should be inspected regularly to ensure proper performance.

Designer Checklist

If the answer to these questions corresponds to a response box that is red, the BMP should either not be used or additional measures need to be taken to address the issue.

	Yes	No
Will stagnation of runoff be prevented by frequent release of the harvested runoff?	☐	☐ (red)
Does quantity of harvested runoff require registration with the Division of Water Rights?	☐	☐

Installation

Installation of harvest and reuse systems will vary depending on its use. Rain barrels can simply be connected to a down drain. More complicated systems require additional coordination.

Depending on the quantity of runoff being harvested, it will be necessary to register the detention device with the Division of Water Rights.

Installation Costs

The following cost items are typically associated with harvest and reuse systems.

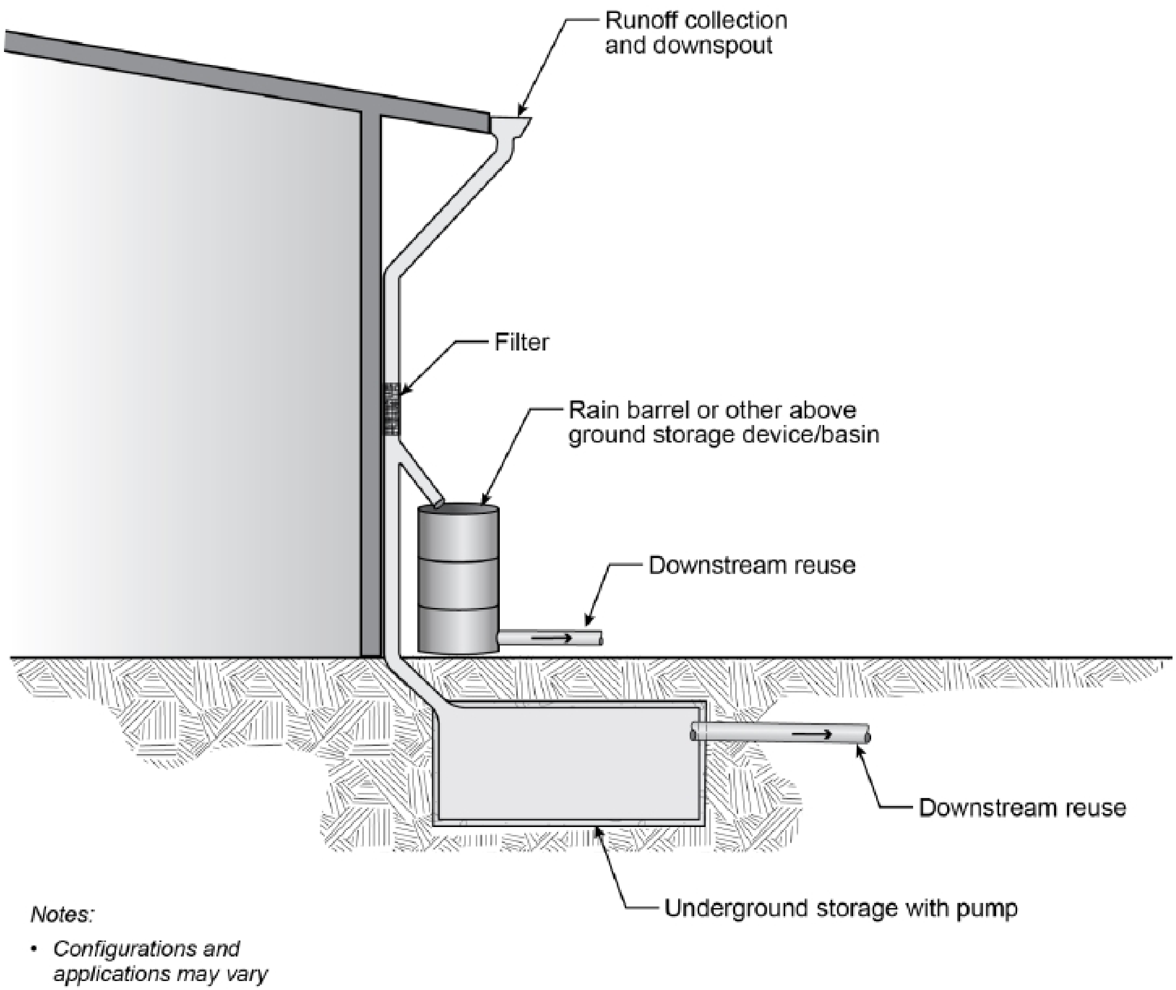
- Detention device
- Upstream connection to detention device
- Other items will be dependent on site-specific use

Maintenance

Refer to Maintenance and Maintenance Costs in the Preface to Fact Sheets for general information related to maintenance of harvest and reuse systems.

Maintenance Activities

Inspection	Inspection/Maintenance Frequency	Maintenance Activity	Effort
Inspect for mosquitos	Semiannual (Spring and Fall)	Implement larvicide or other remediation	Low
Inspect harvesting device for leaking	Semiannual (Spring and Fall)	Replace harvesting device	Low
Inspect condition of system components	Semiannual (Spring and Fall)	Replace or repair components	Medium



Harvest and Reuse

Not to scale

More information can be found at https://documents.deq.utah.gov/water-quality/stormwater/updes/DWQ-2019-000161.pdf