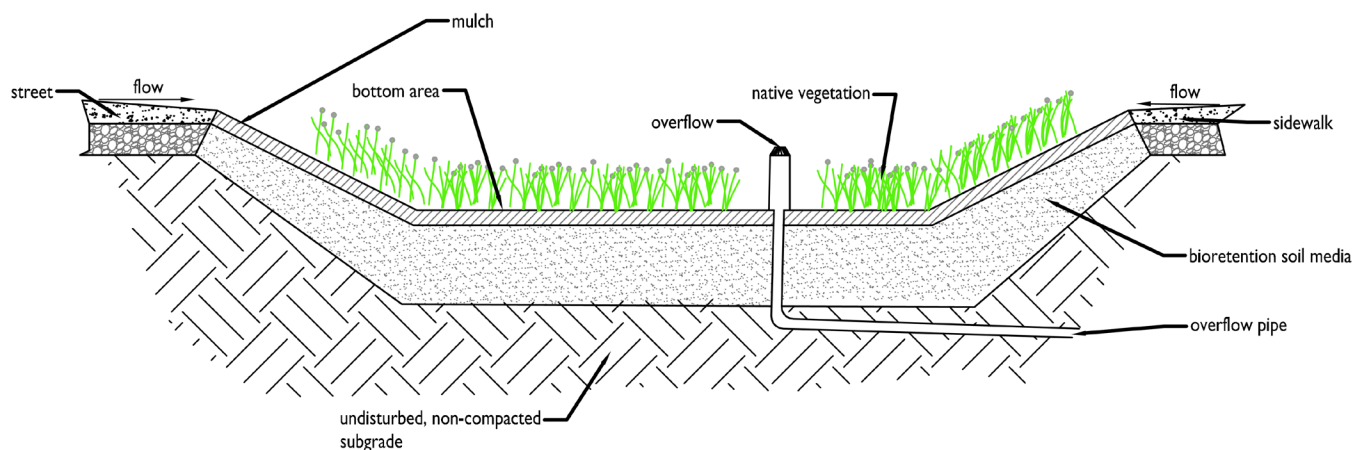


Bioretention System

Bioretention facilities are engineered facilities that store and treat stormwater by filtering it through a specified soil profile. Water that enters the facility ponds in an earthen depression or other basin (e.g., concrete planter) before it infiltrates into the underlying bioretention soil. Stormwater that exceeds the surface storage capacity overflows to an adjacent drainage system. Treated water is either infiltrated into the underlying native soil or collected by an underdrain and discharged. An underdrain system can be comprised of perforated or slotted pipe, wrapped in an aggregate blanket.

Facility objects that are often associated with a bioretention unit include:

- Inlet
- Overflow
- Underdrains (optional)
- Signage



Key Operations and Maintenance Considerations

- Protect the facility from external loads (e.g. trucks, riding mowers, other heavy equipment) to preserve the proper function of bioretention soils. Because the risk of compaction is higher when soils are saturated, any type of loading in the bioretention facility (including foot traffic) should be avoided during wet conditions. All maintenance activities must be performed in a manner to prevent compaction of the bioretention soil.
- Erosion control measures must be maintained in areas of concentrated flows (e.g., pipes inlets or narrow curb cuts). Inspect flow entrances, ponding area, and surface overflow areas periodically, and replace soil, plant material, and/or mulch layer in areas if erosion has occurred. Properly designed facilities with appropriate flow velocities should not have erosion problems except perhaps in extreme events. If erosion problems occur, the following should be reassessed:

- (1) flow volumes from contributing areas and bioretention cell sizing; (2) flow velocities and gradients within the cell; and (3) flow dissipation and erosion protection strategies in the pretreatment area and flow entrance. If sediment is deposited in the bioretention area, immediately determine the source within the contributing area, stabilize, and remove excess surface deposits.
- Establish and follow a maintenance schedule for visual inspection and remove sediment if the volume of the ponding area has been compromised.
- Corrective maintenance for excessive drawdown times may include clearing underdrain obstructions or tilling the bioretention soil media. Partial or complete replacement of bioretention soil media may be necessary.
- Regular maintenance of vegetation includes weeding and pruning. Plants require irrigation during the first 2 to 3 years of establishment and during extended dry periods. Replace all dead plants and, if specific plants have a high mortality rate, assess the cause and replace with appropriate species.
- The soil mix and plants are selected for optimum fertility, plant establishment, and growth. Nutrient and pesticide inputs should not be required and may degrade the pollutant processing capability of the bioretention area, as well as contribute pollutant loads to receiving waters. If in question, have soil analyzed for fertility.
- Replace mulch annually in bioretention facilities where heavy metal deposition is high (e.g., contributing areas that include gas stations, ports and roads with high traffic loads). In residential settings or other areas where metals or other pollutant loads are not anticipated to be high, replace or add mulch as needed (likely 3 to 5 years) to maintain a 2 to 3 inch depth.
- Soil mixes for bioretention facilities are designed to maintain long-term fertility and pollutant processing capability. Estimates from metal attenuation research suggest that metal accumulation should not present an environmental concern for at least 20 years in bioretention systems, but this will vary according to pollutant load. Replacing mulch media in bioretention facilities where heavy metal deposition is likely provides an additional level of protection for prolonged performance. If in question, have soil analyzed for fertility and pollutant levels.
- Presence of pests such as geese or rodents can generally be corrected by ensuring that drawdown time matches facility design function and plants are spaced at proper densities.
- If an underdrain is present, remove trash, debris and sediment from the inlet orifice biannually.
- Irrigate or hand-water vegetation as needed to help plants establish in the first few years after installation and as needed after plants are established. The following schedule is recommended:
 - Provide summer watering deeply, but infrequently, every one to two weeks during the first summer or as needed during prolonged dry periods.
 - Provide summer watering deeply, but infrequently, every two to four weeks during the second and third summers or as needed during prolonged dry periods.
 - Provided summer watering as needed after plants are established.

Plant Material

Table 7: Plant List for Bioretention System and Rain Garden*

Moist to Wet Soil Conditions (Facility Bottom to Bottom of Overflow)			Table continues next page.	
<u>Type</u>	<u>Botanical Name</u>	<u>Common Name</u>	<u>O.C. Spacing</u>	<u>Allowed ROW**</u>
Herbaceous	<i>Carex densa</i>	Dense sedge	12"	Y
Herbaceous	<i>Carex morrowii</i>	Ice Dance	12"	Y
Herbaceous	<i>Carex obnupta</i>	Slough Sedge	12"	N
Herbaceous	<i>Deschampsia cespitosa</i>	Tufted Hair Grass	12"	N
Herbaceous	<i>Juncus patens</i>	Spreading Rush	12"	Y
Shrub	<i>Cornus sericea 'Kelseyii'</i>	Kelsey Dogwood	24"	Y
Shrub	<i>Spiraea betulifolia</i>	Birchleaf Spiraea	24"	N
Shrub	<i>Spiraea densiflora</i>	Sub-alpine Spiraea	24"	Y
Shrub	<i>Spiraea japonica</i>	Japanese spirea cultivars	24"	Y
Groundcover	<i>Rubus calcynoides & pentalobus</i>	Creeping Bramble	12"	N
Accent	<i>Camassia leichtinii</i>	Great Camas	12"	N
Accent	<i>Camassia quamash</i>	Common Camas	12"	N
Tree	<i>Acer campestre 'Evelyn'</i>	Elizabeth Hedge Maple	30'	Y
Tree	<i>Betula jacquemontii</i>	Jacquemontii Birch	60'	N
Tree	<i>Celtis occidentalis</i>	Hackberry	50'	N
Tree	<i>Koelreuteria paniculata</i>	Goldenrain Tree	30'	Y
Tree	<i>Nyssa sylvatica</i>	Black tupelo	50'	Y
Tree	<i>Prunus virginiana 'Canada Red'</i>	Canada Red Chokecherry	25'	Y
Tree	<i>Quercus shumardii</i>	Shumard Oak	70'	Y
Tree	<i>Rhamnus purshiana</i>	Cascara	30'	N
Dry Soil Conditions (Overflow and Above)				
<u>Type</u>	<u>Botanical Name</u>	<u>Common Name</u>	<u>O.C. Spacing</u>	<u>Allowed ROW</u>
Herbaceous	<i>Deschampsia cespitosa</i>	Tufted Hair Grass	12"	N
Herbaceous	<i>Helictotrichon sempervirens</i>	Blue Oat Grass	12"	Y
Shrub	<i>Cornus sericea 'Kelseyii'</i>	Kelsey Dogwood	24"	Y
Shrub	<i>Euonymous japonicas 'Microphyllus'</i>	Boxleaf Evergreen	24"	Y
Shrub	<i>Mahonia aquifolium 'Compacta'</i>	Oregon Grape	24"	Y
Shrub	<i>Spiraea betulifolia</i>	Birchleaf Spiraea	24"	N
Shrub	<i>Spiraea densiflora</i>	Sub-alpine Spiraea	24"	Y
Shrub	<i>Spiraea japonica</i>	Japanese spirea cultivars	24"	Y
Groundcover	<i>Arctostapylos uva-ursi</i>	Kinnickinnick	12"	Y
Groundcover	<i>Fragaria chiloensis</i>	Coastal Strawberry	12"	Y
Groundcover	<i>Mahonia repens</i>	Creeping Oregon Grape	12"	N

Stormwater Treatment, Flow Control, and Conveyance Facility Components

Accent	<i>Camassia leichtinii</i>	Great Camas	12"	N
Accent	<i>Camassia quamash</i>	Common Camas	12"	N
Accent	<i>Iris douglasiana</i>	Douglas Iris	12"	N
Accent	<i>Iris tenax</i>	Oregon Iris	12"	N
Tree	<i>Acer campestre 'Evelyn'</i>	Elizabeth Hedge Maple	30'	Y
Tree	<i>Betula jacquemontii</i>	Jacquemontii Birch	60'	N
Tree	<i>Celtis occidentalis</i>	Hackberry	50'	N
Tree	<i>Koelreuteria paniculata</i>	Goldenrain Tree	30'	Y
Tree	<i>Prunus virginiana 'Canada Red'</i>	Canada Red Chokecherry	25'	Y
Tree	<i>Quercus shumardii</i>	Shumard Oak	70'	Y
Tree	<i>Rhamnus purshiana</i>	Cascara	30'	N

Selected plants shall not include any plants from the State of Washington Noxious Weed List. Refer to clark.wa.gov/weed/ for a current list of noxious weeds.

*Adapted from Portland Bureau of Environmental Services *2014 Stormwater Management Manual*, Appendix F.4., Planting Templates and Plant Lists

** Plant species allowed in Clark County street Rights of Way

Bioretention System			
Drainage System Feature	Potential Defect	Conditions When Maintenance Is Needed	Minimum Performance Standard
Note: table spans multiple pages.			
General	Pests	Signs of pest infestations (IPM protocol threshold(s) are exceeded), including rodent holes or mounds that disturb dispersion flow paths.	<p>Pests are not present or engaged in activities that present a significant public health risk or compromise to the intended design function of the facility. Pests that have exceeded acceptable thresholds have been addressed using appropriate IPM measures.</p> <p>Standing water that may allow mosquito breeding has been removed and cause of standing water has been addressed (see "Ponded Water").</p> <p>Pest-damaged vegetation has been removed.</p>
Facility Area	Trash and Debris	Trash and debris present in facility area.	Facility area is free of trash and debris.
	Pet Waste	Large volumes of feces from domestic pets are present.	<p>Pet waste removed.</p> <p>Pet waste station or additional signage installed, if appropriate.</p>
	Mulch	Mulch depth is less than 2 inches or the	Mulch has been restored to a depth of 2 to 3

Bioretention System			
Drainage System Feature	Potential Defect	Conditions When Maintenance Is Needed	Minimum Performance Standard
Note: table spans multiple pages.			
		facility has bare spots without mulch cover.	inches and is appropriate to the location within the facility (e.g. compost mulch in the bottom and wood chips on side slopes).
Facility Bottom Area	Sediment	Sediment accumulated to extent that infiltration rate is reduced, water can be seen to be ponding, or surface storage capacity is significantly impacted.	Source of sediment has been identified and controlled. Excess sediment has been removed, and damaged vegetation and mulch has been replaced.
	Leaves	After fall leaf drop, leaves have accumulated in the facility in a manner to pose a risk of impeding water flow or clogging the outlet.	Leaves have been removed.
	Ponded Water	Water overflows during storms smaller than the design event, or ponded water remains in the basin more than 48 hours after the end of a storm.	Cause of excessive ponding has been identified by investigating: 1) potential that debris build-up is impeding infiltration; 2) condition of underdrain (if present); 3) potential that other water inputs are present (e.g. groundwater, illicit connections); 4) facility size is appropriate to contributing area; and 5) condition of bioretention soil media. Cause of excessive ponding has been corrected. Engineer has been consulted where necessary.
Earthen Side Slopes and Berms	Erosion At Inlets/ Outlets	Erosion (gullies/ rills) greater than 2 inches deep around inlets, outlet, and alongside slopes.	For channels or cuts over 3 inches deep, temporary erosion control measures have been put into place until permanent repairs are made. Source of erosion has been addressed/ eliminated and eroded areas repaired per design specifications, with additional stabilizing material (cobble, vegetation, etc.) added as necessary.
	Erosion of Side Slopes	Erosion of sides causes slope to become a hazard.	Source of erosion has been addressed and side slopes repaired to design specifications. Slopes have stabilizing material where necessary.
	Settlement	Settlement greater than 3 inches (relative to undisturbed sections of berm).	Slopes and berm have been restored to design elevations/ heights.
	Berm Leaking	Downstream face of berm wet; seeps or leaks evident.	Any seeps or leaks have been plugged and berm material and compaction are per design specifications. Engineer has been consulted where necessary.

Stormwater Treatment, Flow Control, and Conveyance Facility Components

Bioretention System			
Drainage System Feature	Potential Defect	Conditions When Maintenance Is Needed	Minimum Performance Standard
Note: table spans multiple pages.			
	Rodents In Berm	Any evidence of rodent holes or water piping in berm.	Rodents have been eradicated (see "Pests In Facility"). Holes have been filled and berm compacted (see "Berm Leaking").
Concrete Sidewalls	Damage to Concrete	Cracks or failure of concrete sidewalls.	Concrete sidewalls have been repaired, or replaced if repair is insufficient.
Rockery Sidewalls	Rockery Sidewalls Insecure	Rockery sidewalls are insecure.	Rockery sidewalls have been repaired to design standard, with consultation/ inspection by a professional engineer as necessary (walls over 4 foot height).
Low Permeability Check Dams and Weirs	Sediment or Other Debris Blocking	Sediment, vegetation, or debris accumulated at or blocking (or having the potential to block) check dam, flow control weir or orifice.	No blockage present of check dam, flow control weir, or orifice. Any likely immediate sources of additional debris or sediment (e.g. additional dead plant material, erosion issue, etc. upstream) addressed or removed.
	Erosion or Undercutting	Erosion and/or undercutting present.	Eroded and/or undercut areas have been repaired and sources of issue addressed to prevent further erosion/undercutting at weir.
	Grade Board Not Level	Grade board or top of weir damaged or not level.	Grade board is undamaged (repaired or replaced) and level.
Inlet	Erosion at Inlet	Concentrated flows are causing erosion at inlet.	A cover of rock or cobbles or other erosion protection measure (e.g., matting) is in place to protect the ground where concentrated water enters the facility (e.g., a pipe, curb cut or swale).
Splash Block Inlet	Water Misdirected from Inlet	Water is not being directed properly to the facility and away from the inlet structure.	Splash block(s) reconfigured/ repaired to direct water to facility and away from structure.
Curb Inlet/Outlet	Leaf Accumulation at Curb Cut	Accumulated leaves or other debris at curb cuts (inlets and outlets) can block water flow and proper function of the facility. Maintenance is particularly important in the fall.	Curb cuts and adjacent gutters are free of leaves and debris, and water can flow freely into (and out of) the facility.
Pipe Inlet/Outlet	Pipe Is Damaged	Pipe is damaged.	Pipe repaired or replaced to design specifications.
	Pipe Is Clogged	Pipe is clogged, completely or partially. Problem material may include leaves, debris, trash, roots, sediment, or other material.	Pipe is unclogged and free of any obstructions. Pipe functioning at design capacity.
	Access Is Blocked	Vegetation is blocking access for inspection.	Area within 1 foot of inlets/outlets is clear of vegetation, and access pathways are clear and maintained where necessary.
Trash Rack	Trash and Debris	Trash or other debris is present on trash rack. Capacity may be reduced by buildup of trash or debris.	Trash rack is free of trash, leaves, debris, or other foreign material.

Bioretention System			
Drainage System Feature	Potential Defect	Conditions When Maintenance Is Needed	Minimum Performance Standard
Note: table spans multiple pages.			
	Bar Screen Damage	Bar screen on trash rack is damaged or missing.	Bar screen has been repaired/ replaced to design specifications.
Overflow	Overflow Blocked	Overflow capacity is reduced by sediment or debris.	Overflow area is free of sediment and debris and capacity functions per design standards.
Underdrain Pipe	Reduced Capacity	Plant roots, sediment, or debris may reduce the capacity of the underdrain. Symptoms may include ponded water in facility bottom area.	Underdrain pipe is free of plant roots, sediment and debris. Infiltration and pipe capacity functioning per design function.
Vegetation (continues on next page)	Poor Vegetation Health	Less than 75% of planted vegetation is healthy with a generally good appearance (unless project O&M manual or record drawing stipulates more or less than 75% survival rate).	At least 75% of planted vegetation is healthy with generally good appearance. Any conditions found that were deleterious to plant health have been corrected where possible. Routine maintenance schedule, including watering, has been updated as necessary to ensure continued plant health and satisfactory appearance.
	Diseased Plant Material	Diseased plants or plant material is present in the facility.	Diseased plants and plant parts have been removed and disposed of in an approved location (off-site). Potential sources of and conditions exacerbating disease have been addressed (see Pacific Northwest Plant Disease Management Handbook). Vegetated areas replanted as necessary to maintain vegetative coverage per design.
	Vegetation Needs Pruning	Trees and shrubs need regular maintenance and/or corrective pruning.	Trees and shrubs pruned per routine maintenance schedule, appropriate to individual species and age of plants. All pruning of mature trees done under direct supervision of ISA certified arborist.
	Large Trees and Shrubs Interfering	Large trees and shrubs interfere with operation of the facility or access for maintenance.	Trees and shrubs have been pruned using most current ANSI A300 standards and ISA BMPs. Trees and shrubs removed if necessary for operation of facility per design function.
	Dead Vegetation	Standing dead vegetation is present (particularly in fall and spring).	Standing dead vegetation has been removed from site; gaps in vegetation have been replaced with new plantings where necessary, or appropriate erosion control measures put in place until vegetation replacement is feasible.
	Maintenance Needed Around Mature Trees	If conditions warrant maintenance work or planting of new vegetation around mature trees (within the dripline), appropriate care must be taken to avoid adverse impacts to the mature tree(s).	The most current ANSI A300 standards and ISA BMPs have been followed to the extent practicable (e.g., take care to minimize any damage to tree roots and avoid compaction of soil) when working around and under mature trees. New plantings under mature

Stormwater Treatment, Flow Control, and Conveyance Facility Components

Bioretention System			
Drainage System Feature	Potential Defect	Conditions When Maintenance Is Needed	Minimum Performance Standard
Note: table spans multiple pages.			
			trees include mainly plants that come as bulbs, bare root or in 4-inch pots; new plants in no larger than 1-gallon containers.
	Stakes or Guys Present	Stakes or guys present in plantings installed for over 1 year.	Stakes or guys have been removed from new vegetation after 1 year since installation. Holes have been backfilled where necessary.
	Vehicular Sight Lines Impaired By Vegetation	Vegetation causes some visibility (line of sight) or driver safety issues.	Vegetation has been pruned to appropriate height and spread to maintain sight clearances. If continued (regular) pruning of a given plant have been necessary, plant(s) have been relocated to a more appropriate location and replaced with plant(s) of appropriate mature size.
	Emergent Vegetation Compromises Conveyance	Emergent vegetation compromises conveyance (may become too dense).	Emergent vegetation has been thinned and does not impede conveyance.
	Noxious Weeds Present	Noxious weeds are present among the site vegetation. Remove, bag, and dispose of Class A & B noxious weeds immediately per WA law. Make reasonable attempts to remove and dispose of Class C noxious weeds. See http://www.nwcb.wa.gov/ . Follow Integrated Pest Management (IPM) protocols.	Noxious weeds are not present on site above thresholds established by WA law.