BIORETENTION
FACT SHEET

Bioretention is a shallow basin or landscaped depression designed to store, infiltrate and treat stormwater runoff. It is excavated and backfilled with well-draining, engineered soil media and planted with native vegetation, grasses or sod. Bioretention systems can also enhance habitat, mitigate for heat island effects and improve water quality.

They are designed to temporarily hold (24 hours post rain event) and slowly infiltrate stormwater runoff. Bioretention systems use many pollutant removal mechanisms (i.e., infiltration, absorption, adsorption, evapotranspiration, microbial and biological decomposition, plant uptake, sedimentation and filtration) to improve stormwater quality prior to it leaving the system. Filtered runoff can exfiltrate into surrounding native soils, or these systems can be designed to use an underdrain to collect and return filtered runoff to the conveyance system. Bioretention systems are most effective when used to treat small to moderate quantities of stormwater.

As with any type of infrastructure, bioretention and other green infrastructure practices require maintenance to ensure continued functionality. Key maintenance activities include stabilizing erosion and removal of sediment, trash and debris, particularly if inlet or outlet structure openings are impeded. General inspections and assessment of five critical features can keep the practice operational. Visual clues for inspection can be used at any time, but it is ideal to inspect the bioretention system shortly after a moderately-sized rainfall event (~ 1 inch) and, again, 24-hours later to ensure runoff is entering the bioretention cell and infiltrating.

Bioretention systems are often visual additions to the landscape and while the vegetation has a role in supporting pollutant removal, the plant health and plant density is related to the overall aesthetic value. Rating these conditions is highly subjective. When possible reference a landscaping plan and the overall site objectives.

BIORETENTION POLLUTANT REMOVAL[1]

- **85%** of suspended solids
- **80%** of phosphorus
- **60%** of nitrogen
- **90%** of fecal coliform
- **95%** of metals

Resources are required to inspect and properly maintain bioretention systems. The maintenance cost as a percentage of capital cost is estimated at 5-7%.[2]

A 2015 report by American Society of Civil Engineers found the median annual maintenance cost for bioretention was $0.68/sq. ft. (range of $0.13 to $2.30/sq. ft.) and median cost of $850/yr. per location.[3]

1 Georgia Stormwater Management Manual. Atlanta, 2016. 2016 Edition. https://atlantaregional.org/natural-resources/water/georgia-stormwater-management-manual/

2 USEPA (1999). "Preliminary data summary of urban stormwater best management practices." EPA-821-R-99-012, Washington, DC.

3 Clary, J. and Piza, H. (2017). "Cost of Maintaining Green Infrastructure." ASCE. Reston, VA.

For more a more detailed inspection checklist reference:

gacoast.uga.edu/stormwater-management

Five Critical Features to Inspect

1 Drainage Area

The drainage area and surrounding landscape that will contribute runoff to the practice is essential to its overall function. Unstable areas that are sources of sediment or drainage ways, including overland flow and pipes, that have pollutants such as trash, debris, sediment, and grass clippings can hinder the performance of the bioretention cell by clogging the main treatment area or contributing additional nutrient and pollutant loads.

2 Inlet Structures or Pretreatment Device

There are various types of inlet structures and pretreatment devices such as forebays, weirs, filter strips, grass channels and rock-lined plunge pools. If these structures are impeded or there is evidence of erosion or that runoff is not entering the cell (i.e., short-circuiting) maintenance is required to restore function. It is important to confirm that these structures are configured properly to maintain longevity of the bioretention media.

3 Main Treatment

The surface of the bioretention system is the primary location for infiltration of stormwater. Physical clues such as accumulation of fine sediment, stains, mosquito larvae or plant stress are evidence of surface clogging and subsequent maintenance needs. The vegetation is an important part of the practice because it aids in infiltration, evapotranspiration and pollutant uptake, and it provides aesthetic appeal.

4 Underdrain

Not all bioretention systems are designed with an underdrain; however, cleanouts are good indicators. If cleanout caps are broken or missing, runoff could short-circuit through the system. If there are signs of an underdrain blockage, a professional may be required to complete the necessary maintenance.

5 Emergency Overflow or Outlet Structure

Emergency overflows and outlet structures are necessary for rain events that are larger than the bioretention system was designed to treat. There is often a safety risk associated with the failure of these features and any signs of blockages or structural damage should be addressed immediately following inspection. It is important to confirm that these are configured for the bioretention cell to allow for the appropriate maximum and average surface ponding depth.

BIOSWALES
FACT SHEET

Bioswales, or dry enhanced swales, are vegetated open channels designed to capture and treat stormwater. Unlike other stormwater green infrastructure, bioswales are configured in a linear fashion for conveyance.

Bioswales are often vegetated, improving aesthetics, reducing the velocity of stormwater and assisting with pollutant removal; but do not confuse them with a grassed channel or ditch. Much like other bioinfiltration practices (i.e. bioretention), bioswales utilize an engineered soil media and underdrain to enhance pollutant removal. Bioswales should be designed with less than a 4% longitudinal slope. Berms or check dams can be used in bioswales to promote surface ponding, infiltration, and settlement of sediment and pollutants.

Like all infrastructure, green infrastructure practices such as bioswales require proper maintenance to perform long-term. Accumulation of sediment, litter, debris and improper vegetation growth are a result of poor maintenance. During vegetation establishment, more frequent inspections are required to inspect for erosion. If the bioswale isn't draining within 48 hours after a moderately-sized rain event (~1 inch), check the inlet and outlet structures and media surface for clogging. Bioswales are frequently used parallel to roadways; therefore, specific care should be given to ensure vegetation does not block lines of sight and overflow does not create driving hazards. Maintenance costs for bioswales are not extensively documented; however, due to the similarities in design and function, average maintenance costs are expected to be comparable to bioretention (median cost ~$0.70/sq. ft.).

BIOSWALES POLLUTANT REMOVAL[1]

80% of suspended solids

50% of phosphorus

50% of nitrogen

95% of metals

1 Georgia Stormwater Management Manual. Atlanta, 2016. 2016 Edition. https://atlantaregional.org/natural-resources/water/georgia-stormwater-management-manual/

PERMEABLE PAVEMENT

(PERVIOUS CONCRETE OR POROUS ASPHALT) FACT SHEET

Permeable pavement systems have structural units that include void, or open, spaces, allowing stormwater to infiltrate and get treated and stored in an underlying gravel base. The stormwater is then filtered through native soils or is discharged through an underdrain. Permeable pavement systems include, permeable pavers (bricks or blocks), along with pervious concrete and porous asphalt. Pervious concrete and porous asphalt are similar in that their mixtures consist primarily of larger aggregate, which creates void spaces within the material. The pervious concrete or porous asphalt is applied over an open-graded gravel base course that is used for structural strength, stability and storage of stormwater. It is important that the subgrade not be overly compacted during placement.

These systems are designed to reduce peak flows and volumes of stormwater runoff. They are advantageous for groundwater recharge, particularly in areas where land values are high, as vehicles can drive and park on this stormwater practice. Placement of these systems where in-situ subsoils have an infiltration rate greater than 0.5 in./hr. is recommended. When underlying soils have low permeability, permeable pavement systems can utilize an underdrain to return filtered runoff to the conveyance system. Permeable pavement is designed to reduce runoff and improve water quality for average rain events (1.2 inches), but they can be designed to handle larger storm events with heavier rain. The ratio of impervious area to porous asphalt surface area should be no greater than 3:1. The ratio of impervious area to pervious concrete surface area should be no greater than 1:1.

POROUS ASPHALT POLLUTANT REMOVAL[1]

- **80%** of suspended solids
- **50%** of phosphorus
- **50%** of nitrogen
- **60%** of metals

PERVIOUS CONCRETE POLLUTANT REMOVAL[1]

- **80%** of suspended solids
- **50%** of phosphorus
- **65%** of nitrogen
- **60%** of metals

As with any type of infrastructure, pervious concrete, porous asphalt and other green infrastructure practices require maintenance to ensure continued functionality. It is important to avoid compaction and clogging of these pavement systems, beginning with construction. Undesirable vegetation, sediment accumulation and debris are common culprits of clogged permeable pavement systems. General inspection and assessment of three critical features can keep the practice operational. Street sweeping can be effective for source control and routine maintenance of the top layer. Surface cleaning is required to remove debris and undesired vegetation that clog the top layer of the permeable pavement system. Locations that are highly trafficked or near overhanging vegetation may need more frequent surface cleaning to maintain higher infiltration rates.

Three Critical Features to Inspect

1 Drainage Area

The condition of the drainage area or surrounding landscape that will contribute runoff to the practice is essential to its overall function. Unstable areas that are sources of sediment or drainage ways that have pollutants such as trash, debris, sediment, and grass clippings can hinder the performance of the permeable pavement by clogging the pavement surface or contributing additional nutrient and pollutant loads.

2 Inlet and Outlet Structures

If inlet or outlet structures are impeded, this could mean a number of things. Structural damage might be present, there might be evidence of erosion, or runoff may not be flowing over the pavement surface and maintenance is required to restore function.

3 Pavement Surface

Physical clues such as accumulation of fine sediment, stains, standing water, as well as cracking or settling of pervious concrete or porous asphalt are evidence of surface clogging, structural damage and subsequent maintenance needs. Pervious concrete raveling (i.e. aggregate becoming loose) and no visible pore space can reduce functionality or become a hazard to the public. This should be inspected regularly and replaced if needed.

Maintenance costs vary based on many factors. The maintenance cost as a percentage of capital cost is estimated at 3-5%; however, more robust local datasets are needed.[2]

1 Georgia Stormwater Management Manual. Atlanta, 2016. 2016 Edition. https://atlantaregional.org/natural-resources/water/georgia-stormwater-management-manual/

2 Clary, J. and Piza, H. (2017). "Cost of Maintaining Green Infrastructure." ASCE. Reston, VA.

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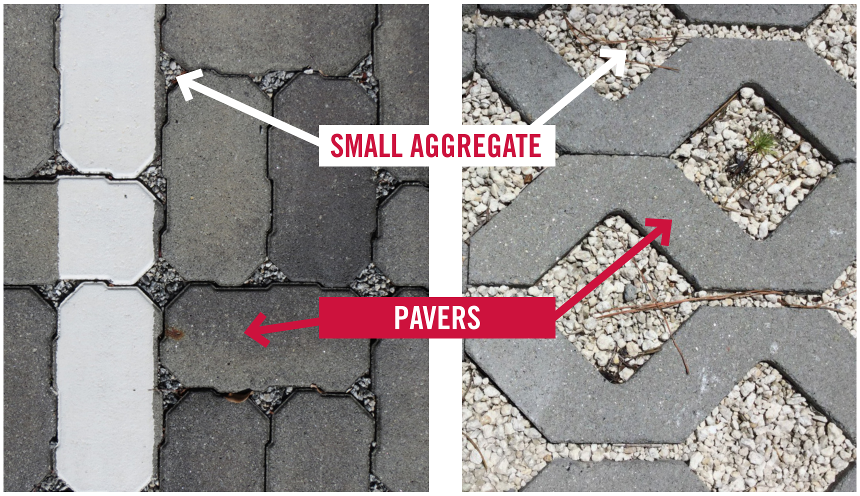
PERMEABLE INTERLOCKING PAVERS FACT SHEET

Permeable pavement systems have structural units that include void, or open, spaces, allowing stormwater to infiltrate and get treated and stored in an underlying gravel base. The stormwater is then filtered through native soils or is discharged through an underdrain. Permeable pavement systems include, permeable pavers (bricks or blocks), along with pervious concrete and porous asphalt. Permeable pavers use pervious void space located between the pavers that is often filled with small aggregate.

Permeable pavement systems are designed to reduce peak flows and volumes of stormwater runoff. They are advantageous for groundwater recharge, particularly in areas where land values are high, as vehicles can drive and park on this stormwater practice. Placement of these systems where in-situ subsoils have an infiltration rate greater than 0.5 in./hr. is recommended. When underlying soils have low permeability, permeable pavement systems can utilize an underdrain to return filtered runoff to the conveyance system. There are many different shapes, styles, and materials used to create the pavers used in these systems. Permeable Pavement is designed to reduce runoff and treat the water quality rain event (1.2 inches); however they can also be designed to handle larger storm events and store larger volumes of runoff. The ratio of impervious area to permeable paver surface area should be no greater than 3:1.

PERMEABLE PAVEMENT POLLUTANT REMOVAL[1]

80%	of suspended solids
50%	of phosphorus
50%	of nitrogen
60%	of metals



As with any type of green infrastructure, permeable pavers require maintenance to ensure continued functionality. It is important to avoid compaction and clogging of these pavement systems, beginning with construction. Undesirable vegetation, sediment accumulation and debris are common culprits of clogged permeable pavement systems. General inspection and assessment of three critical features can keep the practice operational. Street sweeping and hydro-excavation can be effective for source control and routine maintenance of the top layer. Surface cleaning is required to remove debris and undesired vegetation that clog the top layer of the permeable pavement system. Locations that are highly trafficked or near overhanging vegetation may need more frequent surface cleaning to maintain higher infiltration rates.

Three Critical Features to Inspect

1 Drainage Area

The condition of the drainage area and surrounding landscape that will contribute runoff to the practice is essential to its overall function. Unstable areas that are sources of sediment or drainage ways that have pollutants such as trash, debris, sediment, and grass clippings can hinder the performance of the permeable pavement by clogging the pavement surface or contributing additional nutrient and pollutant loads.

2 Inlet and Outlet Structures

If inlet or outlet structures are impeded, this could mean a number of things. Structural damage might be present, there might be evidence of erosion, or runoff may not be flowing over the pavement surface and maintenance is required to restore function.

3 Pavement Surface

The void space between the surface of the permeable pavers is the primary location for infiltration of stormwater. Physical clues such as accumulation of fine sediment, stains, standing water, and paver settling are evidence of surface clogging and subsequent maintenance needs. Any missing aggregate needs to be replaced to maintain optimal performance of the system. Pavers that have been damaged (signs of cracks, splitting, or structural damage) need to be replaced to maintain public safety.

Maintenance costs vary based on many factors. The maintenance cost as a percentage of capital cost is estimated at 3-5%; however, more robust local datasets are needed.[2]

1 Georgia Stormwater Management Manual. Atlanta, 2016. 2016 Edition. https://atlantaregional.org/natural-resources/water/georgia-stormwater-management-manual/

2 Clary, J. and Piza, H. (2017). "Cost of Maintaining Green Infrastructure." ASCE. Reston, VA.

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