



Operation and maintenance of stormwater infiltration practices

Green Infrastructure: Bioretention practices can be an important tool for retention and detention of stormwater runoff. Because they utilize vegetation, bioretention practices provide additional benefits, including cleaner air, carbon sequestration, improved biological habitat, and aesthetic value.

Information: Due to the similarities of the majority of inspection and maintenance tasks required for both bioretention practices and infiltration practices, the Operations and Maintenance sections for both bioretention and infiltration practices have been combined into a single wiki page.

The most frequently cited maintenance concern for infiltration practices is surface clogging caused by organic matter, fine silts, hydrocarbons, and algal matter. Common operational problems include

- standing water;
- clogged filter surface; and
- inlet, outlet or under-drains clogged.

Recommendations described below are aimed at preventing these common problems.

Contents

- 1 Design phase maintenance considerations
- 2 Construction phase maintenance
- 3 Post-construction operation and maintenance
 - 3.1 Inspection and maintenance planning
 - 3.2 Summary of typical maintenance regime
- 4 Estimated hours to perform maintenance activities
- 5 Erosion protection and sediment monitoring, removal, and disposal – protecting your investment
- 6 Seeding, planting, and landscaping maintenance – keeping it looking good
- 7 Sustainable service life for infiltration and bioretention BMPs
 - 7.1 Infiltration rate service life before clogging
 - 7.2 Nitrogen reduction
 - 7.3 Phosphorus reduction
 - 7.4 Heavy metals retention
 - 7.5 Polycyclic aromatic hydrocarbons (PAHs) reduction
- 8 Typical maintenance problems and activities for infiltration practices

- 9 Maintenance agreements
- 10 Maintenance inspection reports
- 11 References
- 12 Useful links
- 13 Related pages



Design phase maintenance considerations

Implicit in the design guidance is the fact that many design elements of infiltration systems can minimize the maintenance burden and maintain pollutant removal efficiency. Key examples include

- limiting drainage area;
- providing easy site access (*REQUIRED*);
- providing pretreatment (*REQUIRED*); and
- utilizing native plantings (see Plants for Stormwater Design (<http://www.pca.state.mn.us/publications/manuals/stormwaterplants.html>)).

For more information on design information for individual infiltration practices, link here (http://stormwater.pca.state.mn.us/index.php/Category:Design_criteria).

Construction phase maintenance

Proper construction methods and sequencing play a significant role in reducing problems with operation and maintenance (O&M). In particular, with construction of these practices, the most important action for preventing operation and maintenance difficulties is to ensure that the contributing drainage area has been fully stabilized prior to bringing the practice on line.

Warning: It is required that the contributing drainage area has been fully stabilized prior to bringing the practice on line

Inspections during construction are needed to ensure that the infiltration practice is built in accordance with the approved design and standards and specifications. Detailed inspection checklists should be used that include sign-offs by qualified individuals at critical stages of construction, to ensure that the contractor's interpretation of the plan is acceptable to the professional designer. An example construction phase inspection checklist is provided below.

Infiltration practices construction inspection checklist.

Link to this table

To access an Excel version of form (for field use), click here.

Project:

Location:

Site Status:

Date:

Time:

Inspector:

The Chesapeake Stormwater Network has developed materials that illustrate inspection and maintenance of BMP practices. These include information on visual inspections (<http://chesapeakestormwater.net/wp-content/uploads/downloads/2013/10/FINAL-VERSION-BIORETENTION-ILLUSTRATED-102113.pdf>) and two videos (<http://chesapeakestormwater.net/training-library/design-adaptations/stormwater-bmp-maintenance/>). Visit their maintenance page (<http://chesapeakestormwater.net/training-library/stormwater-bmp-maintenance/>). **NOTE: These materials provide useful guidance but should not be used for compliance with Minnesota permits.**

Construction Sequence	Satisfactory / Unsatisfactory	Comments
1. Pre-Construction		
Pre-construction meeting		
Runoff diverted (Note type of bypass)		
Facility area cleared		
Soil tested for permeability		
Soil tested for phosphorus content (include test method)		
Verify site was not overdug		
Project benchmark near site		
Facility location staked out		
Temporary erosion and sediment protection properly installed		
2. Excavation		
Lateral slopes completely level		
Soils not compacted during excavation		
Longitudinal slopes within design range		
Stockpile location not adjacent to excavation area and stabilized with vegetation and/ or silt fence		
Verify stockpile is not causing compaction and that it is not eroding		
Was underlying soil ripped or loosened		
3. Structural Components		
Stone diaphragm installed per plans		
Outlets installed pre plans		
Underdrain installed to grade		
Pretreatment devices installed per plans		
Soil bed composition and texture conforms to specifications		
4. Vegetation		
Complies with planting specs		
Topsoil complies with specs in composition and placement		
Soil properly stabilized for permanent erosion control		
5. Final Inspection		
Dimensions per plans		
Pre-treatment operational		
Inlet/outlet operational		
Soil/ filter bed permeability verified		
Effective stand of vegetation stabilized		
Construction generated sediments removed		
Contributing watershed stabilized before flow is diverted to the practice		
Comments:		

Actions to be taken:

Post-construction operation and maintenance

Warning: A maintenance plan clarifying maintenance responsibility is *REQUIRED*. Effective long-term operation of infiltration practices necessitates a dedicated and routine maintenance schedule with clear guidelines and schedules. Proper maintenance will not only increase the expected lifespan of the facility but will improve aesthetics and property value.

Inspection and maintenance planning

A maintenance plan clarifying maintenance responsibilities is *REQUIRED*. Effective long-term operation of bioretention and infiltration practices necessitates a dedicated and routine maintenance schedule with clear guidelines and schedules. Proper maintenance will not only increase the expected lifespan of the facility but will improve aesthetics and property value.

Some important post-construction considerations are provided below along with *RECOMMENDED* maintenance standards.

- A site-specific O&M plan that includes the following considerations should be prepared by the designer prior to putting the stormwater practice into operation.
 - Inspection checklists
 - Routine maintenance checklists
 - Operating instructions for outlet component
 - Vegetation maintenance schedule
- A legally binding and enforceable maintenance agreement (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#Maintenance_agreements) should be executed between the practice owner and the local review authority.
- Adequate access must be provided for inspection, maintenance and landscaping upkeep, including appropriate equipment and vehicles.
- Maintenance activities should be careful not to cause compaction. No vehicles will be allowed within the footprint of the filtration or infiltration area. Foot traffic and stockpiling should be kept to a minimum.
- The surface of the ponding area may become clogged with fine sediment over time. Core aeration or cultivating of non-vegetated areas may be required to ensure adequate filtration.
- BMP areas generally should not be used as dedicated snow storage areas, but can be with the following considerations.
 - Snow storage should not occur in areas designated as potential stormwater hotspots for road salt (http://stormwater.pca.state.mn.us/index.php/Potential_stormwater_hotspots#Infiltration_guidance).
 - Areas designed for infiltration should be protected from excessive snow storage where sand and salt is applied.
 - Specific snow storage areas should be assigned that will provide some filtration before the stormwater reaches the BMP areas. **NOTE: Chloride will not be attenuated in infiltration BMPs.**
 - When used for snow storage, or if used to treat parking lot runoff, the BMP area should be planted with salt tolerant and non-woody plant species (<http://stormwater.pca.state.mn.us/index.php/Minnesota>



Example of a failing bioinfiltration system. Failure was due to clogging of the media surface by incoming sediment.

plant lists).

- Practices should always be inspected for sand build-up on the surface following the spring melt event.
- General maintenance activities and schedule are provided below.

Summary of typical maintenance regime

The list below highlights the assumed maintenance regime for an infiltration or bioinfiltration basin or trench, tree trench, or dry swale with check dams. Note that some items pertain only to vegetated systems.

- First year after planting
 - Adequate water is crucial to plant survival and temporary irrigation will be needed unless rainfall is adequate until plants mature
- As needed
 - Prune and weed to maintain appearance
 - Stabilize or replace mulch when erosion is evident
 - Remove trash and debris
 - Mow filter strip
 - Renew mulch to replace that which has decomposed
 - Replace vegetation whenever percent cover of acceptable vegetation falls below 90 percent or project specific performance requirements are not met. If vegetation suffers for no apparent reason, consult with horticulturist and/or test soil as needed
- Semi-annually
 - Inspect inflow and pretreatment systems for clogging (off-line systems) and remove any sediment
 - Inspect filter strip/grass channel for erosion or gullyng. Sod as necessary
 - Herbaceous vegetation, trees and shrubs should be inspected to evaluate their health and replanted as appropriate to meet project goals
 - Remove any dead or severely diseased vegetation
- Annually in fall
 - Inspect and remove any sediment and debris build-up in pretreatment areas
 - Inspect inflow points and infiltration surface for buildup of road sand associated with spring melt period, remove as necessary, and replant areas that have been impacted by sand/salt build up
- Annually in spring
 - Cut back and remove previous year's plant material and remove accumulated leaves if needed (or controlled burn where appropriate)



Maintenance of vegetated infiltration practices is critical during the establishment period. Although some plants look healthy in this photo, maintenance is needed to remove sediment from the filter strip and inflow area, remove weeds from the basin, re-vegetate some areas, and add mulch to some areas.

Estimated hours to perform maintenance activities

All estimated hours listed below would be to perform maintenance on a commercially sized bioinfiltration or bioretention basin approximately 1,000 square feet in size that has adequate pretreatment, has been planted with containerized plants, and mulched appropriately.

- **Plant Establishment Period (First two years)**
 - Bi-monthly weeding – 4 visits at 3 hours per visit
 - Plant replacement – 1 replacement planting in the Fall, 4 hours (assuming 10 percent plant loss)
 - Spring cleanup (cut back of previous years vegetation) – 2 hours

- Erosion, sediment, and pretreatment cleanout – 1 hour (assuming vacuum truck clean-out of sump catch basin or sediment fore bay)
- **Regular Maintenance (After first two years)**
 - Bi-monthly weeding – 4 visits at 2 hours per visit
 - Plant replacement – 1 replacement planting in the Fall, 2 hours (assuming 5 percent plant loss)
 - Spring cleanup (cut back of previous years vegetation) – 4 hours
 - Tree and shrub pruning – 2 hours (every third year)
 - Erosion, sediment, and pretreatment clean-out – 4 Hours (assuming vacuum truck clean-out of sump catch basin or sediment forebay once per year and at least one bi-yearly sediment removal from the bottom of the basin)

Erosion protection and sediment monitoring, removal, and disposal – protecting your investment

Regular inspection of not only the BMP but also the immediate surrounding catchment area is necessary to ensure a long lifespan of the water quality improvement feature. Erosion should be identified as soon as possible to avoid the contribution of significant sediment to the BMP.

Pretreatment devices need to be maintained for long-term functionality of the entire BMP. Accumulated sediment in forebays, filter strips, water quality sump catch basins, or any pretreatment features will need to be inspected yearly. Timing of cleaning of these features is dependent on their design and sediment storage capabilities. In watersheds with erosion or high sediment loadings, the frequency of clean out will likely be increased. A vacuum truck is typically used for sediment removal. It is possible that any sediment removed from pretreatment devices or from the bottom of a basin may contain high levels of pollutants. All sediments, similar to those retrieved from a stormwater pond during dredging, may be subjected to the MPCA's guidance for reuse and disposal (<https://www.pca.state.mn.us/sites/default/files/wq-strm4-16.pdf>).

If a grassed filter strip or swale is used as pretreatment, they should be mowed as frequently as a typical lawn. Depending on the contributing watershed, grassed BMPs may also need to be swept before mowing. All grassed BMPs should be swept annually with a stiff bristle broom or equal to remove thatch and winter sand. The University of Minnesota's Sustainable Urban Landscape Series website (<http://www.extension.umn.edu/garden/landscaping/>) provides guidance for turf maintenance, including mowing heights.

Sediment loading can potentially lead to a drop in infiltration or filtration rates. It is recommended that infiltration performance evaluations follow the four level assessment systems in Stormwater Treatment: Assessment and Maintenance (<http://stormwaterbook.saf1.umn.edu/>) (Gulliver et al., 2010).

Seeding, planting, and landscaping maintenance – keeping it looking good

Plant selection during the design process is essential to limit the amount of maintenance required. It is also critical to identify who will be maintaining the BMP in perpetuity and to design the plantings or seedings accordingly. The decision to install containerized plants or to seed will dictate the appearance of the BMP for years to come. If the BMP is designed to be seeded with an appropriate native plant based seed mix, it is essential the owner have trained staff or the ability to hire specialized management professionals. Seedings can provide plant diversity and dense coverage that helps maintain drawdown rates, but landscape management professionals that have not been trained to identify and appropriately manage weeds within the seeding may inadvertently allow the BMP to become infested and the designed plant diversity be lost. The following are minimum requirements for seed establishment and plant coverage.

- At least 50 percent of specified vegetation cover at end of the first growing season, not including REQUIRED cover crop
- At least 90 percent of specified vegetation cover at end of the third growing season
- Supplement plantings to meet project specifications if cover requirements are not met
- Tailor percent coverage requirements to project goals and vegetation. For example, percent cover required for turf after one growing season would likely be 100 percent, whereas it would be lower for other vegetation types.



This bioretention basin utilizes several native species.

For information on plant selection, link here (http://stormwater.pca.state.mn.us/index.php/Minnesota_plant_lists).

For proper nutrient control, bioretention BMP's must not be fertilized unless a soil test from a certified lab indicates nutrient deficiency. An exception is a one-time fertilizer application during planting of the cell, which will help with plant establishment. Irrigation is also typically needed during establishment.

Weeding is especially important during the plant establishment period, when vegetation cover is not 100 percent yet. Some weeding will always be needed. It is also important to budget for some plant replacement (at least 5 to 10 percent of the original plantings or seedings) during the first few years in case some of the plants or seed that were originally installed don't become vigorous. It is highly recommended that the install contractor be responsible for a plant warranty period. Typically, plant warranty periods can be 60 days or up to one year from preliminary acceptance through final inspections. If budget allows, installing larger plants (#1 Cont. vs 4" Pot) during construction can decrease replacement rates if properly cared for during the establishment period.

Weeding in years after initial establishment should be targeted and thorough. Total eradication of aggressive weeds at each maintenance visit will ultimately reduce the overall effort required to keep the BMP weed free. Mulch is highly effective at preventing weeds from establishing while helping retain moisture for plant health. Mulch renewal will be needed two or three times after establishment (first five years). After that, the plants are typically dense enough to require less mulching, and the breakdown of plant material will provide enough organic matter to the infiltration/filtration practice.

Rubbish and trash removal will likely be needed more frequently than in the adjacent landscape. Trash removal is important for prevention of mosquitoes and for the overall appearance of the BMP.

Sustainable service life for infiltration and bioretention BMPs

The service life of infiltration practices depends upon the pollutant of concern.

Infiltration rate service life before clogging

Infiltration rate appears to drop immediately after installation and then level off at a sustainable level (Jenkins et al. (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2010; Barrett et al. (<http://www.deeproot.com/blog/blog-entries/the-role-of-trees-and-plants-in-bioreten-tion>), 2013). Planted bioretention columns even showed a slight increase in infiltration rate after the initial drop (Barrett et al., 2013). Plant roots are essential in macropore formation, which help to maintain the infiltration rate. If proper pretreatment is present, service life for infiltration should be unlimited. However, if construction site

runoff is not kept from entering the infiltration cell, clogging will occur, limiting or eliminating the infiltration function of the system, thus requiring restorative maintenance or repair (Brown and Hunt (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2012).

Nitrogen reduction

An important mechanism of nitrogen removal in vegetated infiltration systems is plant uptake since nitrogen is essential for plant growth. If the BMP has an internal water storage zone, soluble nitrogen is also removed through denitrification, a microbially-mediated process that only occurs under anoxic conditions. Denitrification requires organic matter as a carbon source, which is supplied by decaying root matter and mulch. Particulate bound nitrogen in stormwater runoff will typically be removed through sedimentation. All of these processes are self-sustaining, and the service life of an infiltration system designed for nitrogen reduction should be very long. In oxygenated systems where denitrification is not an important process, leaching of nitrate is likely. In systems having soils with a high organic matter content, organic nitrogen can be converted to nitrate, resulting in additional loss of nitrogen through leaching (Liging and Davis (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2014).

Phosphorus reduction

With design optimized for phosphorus reduction, service life can be more than three decades (Lucas and Greenway (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2011c). Sediment bound phosphorus is removed through sedimentation, while removal of soluble phosphorus in bioretention depends on the type of media used. If the media is already saturated with P (i.e. its P binding sites are full), it will not be able to retain additional dissolved P and the P in stormwater will tend to leach from the media as it passes through the biofilter (Hunt et al. (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2006). It is highly recommended that the P-index of the media at installation be below 30, which equates to less than 36 milligrams per kilogram P, to ensure P removal capacity. Laboratory research has suggested an oxalate extractable P concentration of 20 to 40 milligrams per liter will provide consistent removal of P (O'Neill and Davis (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2012). After an effective loading of the equivalent of more than three decades of P into bioretention ecosystems optimized for P reduction, researchers in Australia showed that excellent P retention was still occurring. Keys to maximize P reduction in these systems included P sorptive soils or soil amendments (e.g. aluminum water treatment residuals [WTR] or Krasnozern soils [K40], a highly aggregated clay), use of coir peat (a source of organic matter low in phosphorus), and healthy vegetation. The systems with aluminum water treatment residuals still retained up to 99 percent of applied PO₄-P in storm water after the equivalent of 32 years of treatment. After 110 weeks of effluent loading at typical stormwater concentrations, the equivalent of 48 years of bioretention loads, phosphate retention from storm water by the K40 soils treatment was 85 percent. "Comparison with the K40 treatments over the loading and dosing regimes suggest that the WTR treatments will perform at least as well as the K40 treatment under similar exposure of 48 years" (Lucas and Greenway (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2011).

Heavy metals retention

Metals are typically retained in infiltration systems through sedimentation and adsorption processes. Since there are a finite amount of sorption sites for metals in a particular soil, there will be a finite service life for the removal of dissolved metals. Morgan et al. (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References) (2011) investigated cadmium, copper, and zinc removal and retention with batch and column experiments. Using synthetic stormwater at typical stormwater concentrations, they found that 6 inches of filter media composed of 30 percent compost and 70 percent sand will last 95 years until breakthrough (i.e. when the effluent concentration is 10 percent of the influent concentration). They also found that

increasing compost from 0 percent to 10 percent more than doubles the expected lifespan for 10 percent breakthrough in 6 inches of filter media for retainage of cadmium and zinc. Using accelerated dosing laboratory experiments, Hatt et al. (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References) (2011) found that breakthrough of Zn was observed after 2000 pore volumes, but did not observe breakthrough for Cd, Cu, and Pb after 15 years of synthetic stormwater passed through the media. However, concentrations of Cd, Cu, and Pb on soil media particles exceeded human and/or ecological health levels, which could have an impact on disposal if the media needed replacement. Since the majority of metals retainage occurs in the upper 2 to 4 inches of the soil media (Li and Davis (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2008), long-term metals capture may only require rejuvenation of the upper portion of the media.

Polycyclic aromatic hydrocarbons (PAHs) reduction

Accumulation of polycyclic aromatic hydrocarbons (PAHs) in sediments has been found to be so high in some stormwater retention ponds that disposal costs for the dredging spoils were prohibitively high. Research has shown that rain gardens, on the other hand, are “a viable solution for sustainable petroleum hydrocarbon removal from stormwater, and that vegetation can enhance overall performance and stimulate biodegradation.” (Lefevre (http://stormwater.pca.state.mn.us/index.php/Operation_and_maintenance_of_stormwater_infiltration_practices#References), 2012b).

Typical maintenance problems and activities for infiltration practices

The following table summarizes common maintenance concerns, suggested actions, and recommended maintenance schedule.

Typical maintenance problems and activities for infiltration practices

Link to this table

Inspection Focus	Common Maintenance Problems	Maintenance Activity	Recommended Maintenance Schedule	Applicable Infiltration Practices ¹
	Clogging, sediment deposition	Ensure that contributing catchment areas to practice, and inlets are clear of debris	Monthly	1,2,3,4,5,6,7
Drainage Area and Drawdown Time	Erosion of catchment area contributing significant amount of sediment	In case of severely reduced drawdown time, scrape bottom of basin and remove sediment. Disc or otherwise aerate/scarify basin bottom. De-thatch if basin bottom is turf grass. Restore original design cross section or revise section to increase infiltration rate and restore with vegetation as necessary.	Upon identification of drawdown times longer than 48 hours or upon complete failure	1,2,3,4,5,6
Pretreatment	Pretreatment screens or sumps reach capacity	Remove sediment and oil/grease from pretreatment devices/structures.	Minimum yearly or as per manufacturer's recommendations	1,2,3,4,5
	Vegetative filter strip failure	Reduce height of vegetative filter strip that may be limiting in-flow. Re-establish vegetation to prevent erosion. Leave practice off-line until full reestablishment.	Mow grass filter strips monthly. Restore as necessary	1,2,4,6
Site Erosion	Scouring at inlets	Correct earthwork to promote non-erosive flows that are evenly distributed	As necessary	1,2,3,6

Inspection Focus	Common Maintenance Problems	Maintenance Activity	Recommended Maintenance Schedule	Applicable Infiltration Practices ¹
	Unexpected flow paths into practice	Correct earthwork to eliminate unexpected drainage or created additional stable inlets as necessary	As necessary	1,2,3,6
	Reduced drawdown time damaging plants	Correct drainage issues as described above	Replace with appropriate plants after correction of drainage issues	2,6,8
Vegetation	Severe weed establishment	Limit the ability for noxious weed establishment by properly mowing, mulching or timely herbicide or hand weeding. Refer to the MDA Noxious Weed List (http://www.md.a.state.mn.us/plants/pestmanagement/weedcontrol/noxiouslist.aspx)	Bi-monthly April through October	2,6,8

¹1=Infiltration Basin; 2=Bioinfiltration Basin; 3=Infiltration Trench; 4=Dry Well; 5=Underground Infiltration; 6=Dry Swale with Check Dams; 7=Permeable Pavement; 8=Tree Trench/Tree Box

Maintenance agreements

A Maintenance Agreement is a legally binding agreement between two parties, and is defined as "a nonpossessory right to use and/or enter onto the real property of another without possessing it." Maintenance Agreements are often required for the issuance of a permit for construction of a stormwater management feature and are written and approved by legal counsel. Maintenance Agreements are often similar to Construction Easements. A Maintenance Agreement is required for one party to define and enforce maintenance by another party. The Agreement also defines site access and maintenance of any features or infrastructure if the property owner fails to perform the required maintenance.

Maintenance Agreements are commonly established for a defined period such as five years for a residential site or 10 to 20 years for a commercial/governmental site after construction of the infiltration practice. Maintenance agreements often define the types of inspection and maintenance that would be required for that infiltration practice and what the timing and duration of the inspections and maintenance may be. Essential inspection and maintenance activities include but are not limited to drawdown time, sediment removal, erosion monitoring and correction, and vegetative maintenance and weeding. If maintenance is required to be performed due to failure of the site owner to properly maintain the infiltration practices, payment or reimbursement terms of the maintenance work are defined in the Agreement. Below is an example list of maintenance standards from an actual Maintenance Agreement.

1. Plants shall be watered daily for two weeks after the garden installation is complete.
2. In the first year, rainwater gardens require vigilant weeding and should be weeded monthly. The need for weeding will decrease as plants become established.
3. Dead plant material and garbage or other debris shall be removed from the rain garden.
4. Areas devoid of mulch shall be re-mulched on an annual basis.
5. The rainwater garden shall be inspected annually for sediment trapped in the pretreatment area and in the garden itself. If possible, accumulated sediment should be removed.
6. Shrubs shall be pruned as necessary to keep a neat appearance.
7. Plants that do not survive shall be removed and replanted.

8. Side slopes must be inspected for erosion and the formation of rills or gullies at least annually and erosion problems must be corrected immediately.
9. If gardens are properly planned and designed (protected from sediment and compaction and incorporating a sufficient turf pretreatment area), a rainwater basin is likely to retain its effectiveness for well over 20 years. After that time, inspection will reveal whether sedimentation warrants scraping out the basin and replanting it (possibly with salvaged plants).

In some project areas, a drainage easement may be required. Having an easement provides a mechanism for enforcement of maintenance agreements to help ensure infiltration practices are maintained and functioning. Drainage Easements also require that the land use not be altered in the future. Drainage Easements exist in perpetuity and are required property deed amendment to be passed down to all future property owners.

As defined by the Maintenance Agreement, the landowner should agree to provide notification immediately upon any change of the legal status or ownership of the property. Copies of all duly executed property transfer documents should be submitted as soon as a property transfer is made final.

- Example Maintenance Agreement 1
- Example Maintenance Agreement 2
- Example Maintenance Agreement 3

Maintenance inspection reports

- Maintenance inspection report for infiltration basins
 - upload MS Word version File:Maintenance inspection report for infiltration basins.docx
- Maintenance inspection report for bioinfiltration basins
 - upload MS Word version File:Maintenance inspection report for bioinfiltration basins.docx
- Maintenance inspection report for infiltration trench
 - upload MS Word version File:Maintenance inspection report for infiltration trench.docx
- Maintenance inspection report for dry well
 - upload MS Word version File:Maintenance inspection report for dry well.docx
- Maintenance inspection report for underground infiltration facilities
 - upload MS Word version File:Maintenance inspection report for underground infiltration facilities.docx
- Maintenance inspection report for dry swale with check dams
 - upload MS Word version File:Maintenance inspection report for dry swale with check dams.docx
- Maintenance inspection report for permeable pavement
 - upload MS Word version File:Maintenance inspection report for permeable pavement.docx
- Maintenance inspection report for tree trench/tree box
 - upload MS Word version File:Maintenance inspection report for tree trench-tree box.docx

Link to Chesapeake Stormwater visual indicators form (<http://chesapeakestormwater.net/wp-content/uploads/downloads/2012/06/Visual-Indicators-Form.pdf>).

References

- Aprill, W. and Sims, Ronald C. 1990. *Evaluation of the Use of Prairie Grasses for Stimulating Polycyclic Aromatic Hydrocarbon Treatment in Soil*. Biological Engineering Faculty Publications. Paper 41.
- Brown, R.A. and Hunt, W.F. 2010. *Impacts of construction activity on bioretention performance*. Journal of Hydrologic Engineering. 15(6), 386-394.
- Gulliver, J.S., A.J. Erickson, and P.T. Weiss (editors). 2010. *Stormwater Treatment: Assessment and Maintenance*. University of Minnesota, St. Anthony Falls Laboratory. Minneapolis, MN.

- Hatt, B.E., Steinel, A., Deletic, A., and Fletcher, T.D. 2011. *Retention of heavy metals by stormwater filtration systems: Breakthrough analysis*. Water, Science, and Technology. 64(9), 1913-1919.
- Henderson, C.F.K. 2009. *The Chemical and Biological Mechanisms of Nutrient Removal from Stormwater in Bioretention Systems*. Thesis. Griffith School of Engineering, Griffith University.
- Hunt, W.F., Jarrett, A.R., Smith, J.T., and Sharkey, L.J. 2006. *Evaluating bioretention hydrology and nutrient removal at three field sites in North Carolina*. Journal of Irrigation and Drainage Engineering. 132(6), 600-608.
- Jenkins, G, J.K., Wadzuk, B.M., and Welker, A.L. 2010. *Fines accumulation and distribution in a stormwater rain garden nine year postconstruction*. Journal of Irrigation and Drainage Engineering. 136(12), 862-869.
- LeFevre, G.H., M. Raymond, P. Hozalski, J. Novak. 2012a. *The role of biodegradation in limiting the accumulation of petroleum hydrocarbons in raingarden soils*. Water Research 46: 6753-6762.
- Lefevre, G.H., P.J. Novak, R.M. Hozalski. 2012b. *Fate of naphthalene in laboratory-scale bioretention cells: implications for sustainable stormwater management*. Environmental Science and Technology 46(2):995-1002.
- Li, H. and Davis, A.P. 2008. *Heavy metal capture and accumulation in bioretention media*. Environmental Science & Technology. 42, 5247-5253.
- Liging, Li, and A.P. Davis. 2014. *Urban stormwater runoff nitrogen composition and fate in bioretention systems*. Accepted for publication in ES&T.
- Lucas, W.C. 2005. Green Technology: The Delaware Urban Runoff Management Approach (http://www.dnr.ec.state.de.us/dnrec2000/Divisions/Soil/Stormwater/New/DURMM_TechnicalManual_01-04.pdf). Prepared For Delaware Department of Natural Resources And Environmental Control Division of Soil And Water Conservation.
- Lucas, , W. C. and M. Greenway. 2007a. A Comparative Study of Nutrient Retention Performance In Vegetated and Non-Vegetated Bioretention Mecocosms (http://documents.irevues.inist.fr/bitstream/handle/2042/25537/1089_318lucas.pdf?sequence=1). Novatech 2007 Session 5.2.
- Lucas, W. C. and M. Greenway. 2007b. *Phosphorus Retention Performance in Vegetated and Non-Vegetated Bioretention Mecocosms Using Recycled Effluent*. Conference Proceedings: Rainwater and Urban Design Conference 2007.
- Lucas, W. C. and M. Greenway. 2008. *Nutrient Retention in Vegetated and Non-vegetated Bioretention Mesocosms*. Journal of Irrigation and Drainage Engineering. 134 (5): 613-623.
- Lucas, W. C. and M. Greenway. 2011a. *Hydraulic Response and Nitrogen Retention in Bioretention Mesocosms with Regulated Outlets: Part I—Hydraulic Response*. Water Environment Research 83(8): 692-702.
- Lucas, W. C. and M. Greenway. 2011b. *Hydraulic response and nitrogen retention in bioretention mesocosms with regulated outlets: part II--nitrogen retention*. Water Environment Research 83(8): 703-13.
- Lucas, W. C. and M. Greenway. 2011c. *Phosphorus Retention by Bioretention Mesocosms Using Media Formulated for Phosphorus Sorption: Response to Accelerated Loads*. Journal of Irrigation and Drainage Engineering. 137(3): 144–153.
- Morgan, J.G., K.A. Paus, R.M. Hozalski and J.S. Gulliver. (2011). Sorption and Release of Dissolved Pollutants Via Bioretention Media (<http://purl.umn.edu/116560>). SAFL Project Report No. 559, September 2011.
- O’Neill, S.W. and Davis, A.P. (2012). *Water treatment residual as a bioretention amendment for phosphorus. I: Evaluation studies*. Journal of Environmental Engineering. 138(3), 318-327.

Useful links

- Chesapeake Stormwater Network (<http://chesapeakestormwater.net/wp-content/uploads/downloads/2013/10/FINAL-VERSION-BIORETENTION-ILLUSTRATED-102113.pdf>) TECHNICAL BULLETIN No. 10. Bioretention Illustrated: A Visual Guide for Constructing, Inspecting, Maintaining and Verifying the Bioretention Practice
- Archived webcast from Chesapeake Stormwater Network (http://chesapeakestormwater.net/events/webcasts4-implementers-and-the-bay-tmdl-urban-bmp-verification/?utm_content=Mike&utm_source=VerticalRes)

ponse&utm_medium=Email&utm_term=%5BWebcast%5D%20Trust%20But%20Verify%3A%20Urban%20BMP%20Verification%20in%20the%20Chesapeake%20Bay&utm_campaign=CSN%27s%20Mid-Summer%20Classic) - TRUST BUT VERIFY: Urban BMP Verification in the Chesapeake Bay

Related pages

- Infiltration portal (<http://stormwater.pca.state.mn.us/index.php/Infiltration>)
- Overview for infiltration
- Types of infiltration
- Design criteria for infiltration
- Construction specifications for infiltration
- Operation and maintenance of stormwater infiltration practices
- Assessing the performance of infiltration
- Calculating credits for infiltration
- Cost-benefit considerations for infiltration
- Case studies for infiltration
- External resources for infiltration
- References for infiltration
- Requirements, recommendations and information for using infiltration basin/underground infiltration BMPs in the MIDS calculator
- Understanding and interpreting soils and soil boring reports for infiltration BMPs
- Determining soil infiltration rates
- Cold climate considerations for infiltration practices - See [1] (http://stormwater.pca.state.mn.us/index.php/Cold_climate_impact_on_runoff_management#Infiltration), [2] (http://stormwater.pca.state.mn.us/index.php/Cold_climate_impact_on_runoff_management#Infiltration_practices)

Retrieved from "https://stormwater.pca.state.mn.us/index.php?title=Operation_and_maintenance_of_stormwater_infiltration_practices&oldid=51345"

This page was last edited on 17 February 2021, at 21:32.

Template:Footer

© 2021 by Minnesota Pollution Control Agency • Powered by MediaWiki