Bioswales

In a Nutshell

Bioswales, also known as vegetated swales, are stormwater runoff conveyance systems used to partially treat water quality, diminish flooding potential, and move stormwater away from infrastructure. Bioswales are linear in design and despite some disagreement within the field, the length to width dimension ratios are typically recommended to be or exceed 2:1. Bioswales are best suited for residential, industrial, and commercial areas with low stormwater flow.

The “How To”

General Information

The basic function of a bioswale is to direct and control the flow of stormwater. They are often used in conjunction with or replacement of traditional stormwater piping systems. Bioswales are typically found in parking lots, road medians, and parallel to roadways to better direct and filter the stormwater runoff. Organizations or communities desiring to use bioswales should spend appropriate planning time finding a location where bioswales would be most effective. Land that has a slight slope is best but the land can be dug and moved to provide for this.

Design and Construction Guidelines

According to the Environmental Protection Agency, there are eight key design factors that must be considered when determining the location, size, and design of a bioswale.

1. Location - Bioswales are typically located along property boundaries with a natural slope. They can also be used in place of gutters and curbs in parking lots.
2. Soil Requirements - Gravelly and course sandy soils should not be used in bioswales as they do not support dense vegitation. Alkaline soils and subsoils should be used, if available, in order to promote the

removal and retention of metals from the stormwater. Care must be taken to avoid compaction of the soil during construction.

3. Vegetation - The effectiveness of the swale is increased if a fine, close-growing, water-resistant grass is chosen. Pollution control objectives should be a main consideration in determining which grasses and bushes to plant within the swale. Reed canary grass, grass-legume mixtures, and red fescue are good swale grasses.
4. General Channel Configuration - In order to maximize the wetted channel perimeter of the swale, it is recommended that a parabolic or trapezoidal cross-section with side slopes no steeper than 1:3 be utilized.
5. Flows - Bioswales are generally not used where the maximum flow rate exceeds five cubic feet per second.
6. Sizing Procedures - The total surface area of the swale should be one percent of the area that drains to the swale. In order for the swale to best treat stormwater runoff, the depth of the stormwater should not exceed the height of the grass within the swale.
7. Construction - Compaction of the soil should be avoided as it reduces infiltration and inhibits the growth of grass. Damaged areas should be repaired immediately to maintain desired level of treatment and to prevent further erosion and damage.
8. Check Dams - Check dams can be installed within a bioswale to increase water storage, reduce flow velocities, and promote additional infiltration. Check dams should not be made out of Earthen material as these tend to erode. If the slope of the bioswale exceeds four percent, it is recommended to install check dams every fifty feet.

Plant Lists

In order for bioswales to provide the greatest result, it is best to use native plants and grasses. According to the Missouri Botanical Garden's Native Landscaping Manual, appropriate native plants for Missouri include:

- Drummond's aster (Aster drummondii)
- Yellow-fruited sedge (Carex annectans)
- White turtlehead (Chelone glabra)
- Queen of the pirate (Filipendula rubra)
- Copper iris (Iris fulva)
- Soft rush (Juncus effusus)
- Blue lobelia (Lobelia siphilitica)
- Meadow phlox (Phlox maculata)
- Culver's root (Veronicastrum virginicum)

When Constructing a Bioswale, DO NOT...

- Build a bioswale in an area where the stormwater flow is too high. This can cause ditching, damage to the plants, and erosion problems
- Build a bioswale that is too flat or too broad as this will not allow proper drainage and water will simply sit in the ditch instead of soak into the ground
- Use plants that are incapable of handling both large amounts of water and periods of no water
- Compact the soil within the bioswale

Operation and Maintenance

Bioswales require relatively low maintenance compared to traditional stormwater piping. Weeds should be kept under control, any erosion or damage that occurs should quickly be repaired, and the height of the plants should be tall enough so the flow of the water remains shallower than the plant height.

Planning & Zoning

Sample Local Ordinances

The Missouri Department of Natural Resources' Missouri Guide to Green Infrastructure: Integrating Water Quality into Municipal Stormwater Management offers an entire chapter designed at ways to integrate green infrastructure into municipal ordinances.

Ordinances directly related to rules and regulations concerning bioswales are difficult to find but nuisance ordinances may be applicable if the bioswale is not maintained. Section 215.010 of the Municipal Code of the City of Wentzville defines "nuisance" elaborately. Some examples that may apply to bioswales are listed below.

Nuisance Defenitions Potentially Applicable to Bioswales

- Any filth, garbage, ashes, foul, nauseous or unclean water, liquid or substance which is conducted, cast, thrown or permitted or suffered to escape from any kitchen, house, tenement or other place or premises into or upon any street, sidewalk, alley or other public place or upon private property of another
- Any cellar, vault, private drain, pool, sewer or sink suffered or permitted to become noxious, foul, offensive or injurious or detrimental to the public health, and any stagnant water, animal or vegetable matter or other substance liable to become putrid, offensive and unhealthy suffered or permitted to exist in or upon any lot, house, building or enclosure
- Any trash or debris, including, but not limited to, weed cuttings, cut and fallen trees and shrubs, rubbish and trash, lumber not piled or stacked twelve (12) inches off the ground, rocks or bricks, tin, steel, parts of derelict cars or trucks, broken furniture, any flammable material which may endanger public safety or any material which is unhealthy or unsafe ... debris and other items in such fashion so as to avoid harmful effects, spillover, the blowing or scattering of litter, or any other hardship to other property owners

Municipal Incentives

Some municipalities offer financial incentives to homeowners who install a bioswale on their property. Champaign, Illinois, for example, offers incentives for several stormwater management practices including bioswales. Contact your municipality or water department for more information.

For residents living in select municipalities within St. Louis County, the Deer Creek Watershed Alliance is offering a RainScape Rebate program for residents who wish to landscape their yards to improve stormwater management. Landowners must apply for the rebates and may select a variety of RainScaping options including creating a bioswale, planting a rain garden, creating a green roof, developeing lawn alternatives, installing a cistern, installing a rain barrel, or amending soil. Some practices, such as rainwater harvesting, qualify for rebates but must be accompanied by a plant-based solution.

Dollars & Cents

Cost of Implementation

The price of a bioswale varies greatly depending on size, location, and type of plants. The Public Works Department of the City of Lincoln, Nebraska quotes a bioswale as costing between $0.10 and $0.50 per cubic foot. Compared to underground storm sewer lines, however, the cost of creating a bioswale is significantly less. When designing the bioswale, consideration should be given to any structural components such as an underdrain or overflow structure, which will add to the cost..

Cost of Maintenance

Some of the potential costs for maintaining a bioswale are listed below. Each application is different and this list is not necessarily exhaustive. The use of native plants will likely cost less to maintain compared to non-native varieties.

- Labor costs of removing debris/trash
- Labor costs of trimming weeds, bushes, grass
- Cost of new plants should old ones die/wash away

Measuring Success

Benefits of a Bioswale

- Increased stormwater runoff management
- Filtration system improves water quality by removing pollutants from runoff
- Vegetation and plants are typically more aesthetically appealing than concrete drains and curbs
- Vegetation and plants tend to attract more wildlife
- Standing water is absorbed which reduces the presence of mosquitoes
- Lower maintenance costs than traditional sewers and drains

Future Success of Bioswale Implementation

Bioswales are a low-maintenance, cost-efficient method of improving water quality and controlling stormwater runoff. Best suited to be placed near impervious pavement like parking lots, bioswales offer a way to control erosion and storm damage while filtering the water and still maintaining high levels of cost efficiency. It is safe to assume that traditional building materials such as concrete and pavement will continue to be used in the future development of roadways and parking lots and, as such, bioswales will continue to be a useful and efficient option. As long as the bioswale is built to optimal dimensions and appropriate plants are chosen, a bioswale can last quite a long time with very minimal maintenance.

Discover More

In the US Army Corps of Engineers' Engineer Research and Development Center's Public Works Technical Bulletin 200-1-62, bioswales are discussed specifically beginning on page B-85. The entire bulletin pertains to Low Impact Development for Sustainable Installations specifically discussing stormwater design and planning.

The Center for Neighborhood Technology provides tools for evaluating green infrastructure practices throughout your neighborhood. The Center also provides descriptions of green infrastructure practices and options.

The City of Salem, Oregon offers a page dedicated to bioswales. Stormwater filtration systems and bioswale design considerations and performance objectives are main topics discussed.

Chicago Wilderness, a regional alliance dedicated to protecting nature and enriching life, provides an example of how a bioswale is an effective stormwater management option at a site containing a school and school district administrative offices.

Case Studies

Anita B. Gorman Discovery Center

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Description

Bioswale landscaping in the parking lot scrubs pollutants from street and parking lot runoff, and the bioswales' native plants lessen the need for year-round maintenance. Curb breaks allow water to enter the bioswales. A geothermal heat pump comprised of 84 (200-foot deep) wells beneath the parking lot provides energy efficient heating and cooling to the building's 90-ton HVAC system.

The project provides reduction of storm water impacts on the community and nearby Brush Creek. By re-introducing native plantings in the bioswales, planners took advantage of opportunities to enhance remnant habitats. Practices such as this can help long-term restoration of miniature biomes representative of native Missouri.

Cost $0

Lessons Learned

1. Since this was the first bioswale of its kind in Kansas City, there were many lessons learned that changed the way new bioswales are constructed. The bioswale was dug too deep, 2-3 feet. This has caused erosion and difficulty in growing plants on the sides.
2. The bioswale drains out of its sides. This leaves only two escape routes for water. The water run-off into the parking lot. It also has an 18 inch pipe running underneath it. This size is too big for the size of the bioswale.
3. The previous director of the bioswale experimented with different plant species. This caused the bioswale to grow too tall, over 4 feet. You were no longer able to see across it. Now it is being planted with native species and more water loving plants.
4. Because of the lessons of this bioswale, they have changed construction and planting in new bioswales.

Maplewood Neighborhood Bioswales

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Description

The bioswales are part of a larger project in the Maywood Avenue project. Maywood Avenue is a neighborhood that is located on the near north side of Toledo, Ohio

The Maywood Project is a neighborhood scale project that utilized Low Impact Development (LID), or green infrastructure, to reduce stormwater runoff and improve water quality. The green infrastructure components consisted of bioretention, homeowner rain gardens, and rain barrels. The rain garden construction included excavation, soil preparation, native plantings, drainage pipes under driveways, and sidewalks to connect the areas.

4 bioswales were installed. There were 2 small ones that were 8 feet long, one medium that was 13 feet long, and one large that is also 13 feet long. Each bioswale takes up 60% of the road, or 760 feet. The storage volume of the 1stbioswale is 7.8 cf/if and the equivalent runoff is .14 inches. The storage volume for the second is 13.8 cf/il and the equivalent runoff is .25 inches. The storage volume for the third bioswale is 20.5 cf/il and the equivalent runoff is .37 inches. Finally, the storage volume for the fourth bioswale is 21.8 cf/if and the equivalent runoff is .40 inches.

American Rivers role was to educate the residents who lived on the two blocks where the bioswales were installed.

Cost $0

Lessons Learned

There needs to be lots of follow-up with the residents. The residents were the ones who had to maintain the bioswales. Unfortunately, the neighborhood has gone through many changes since the bioswales were installed. Many houses were abandoned or sold and there is a different dynamic.

Many of the bioswales have been neglected, and some residents have even dug up the original plants and planted their own personal plants. This has changed the dynamic of the street.

Finally, it is important to involve the utility companies from the beginning of the project. There were delays in the project due to utility changes, and these were not originally factored into the timeline.

Meadowlake Farms Bioswale

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Description

A vegetated swale (or bioswale) is a shallow storm water channel that is densely planted with a variety of grasses, shrubs, and/or trees designed to slow, filter, and infiltrate storm water runoff. Check dams can be used to improve performance and maximize infiltration, especially in steeper areas.

Vegetated swales are broad, shallow, earthen channels designed to slow runoff, promote infiltration, and filter pollutants and sediments in the process of conveying runoff. Water is filtered through the soil to under drains and the swale is quickly dewatered, preventing standing water. Vegetated swales are an excellent alternative to conventional curb and gutter conveyance systems, because they provide pretreatment and can distribute storm water flows to subsequent BMPs.

Meadow Lake is a 50-acre lake in a residential area in Bloomfield Township. It is tributary to the Franklin Branch of the Rouge River. A 30-inch storm sewer serves a large area north of the lake and discharges into the lake via the roadside ditch at its north end. The storm sewer carries runoff from residential and commercial areas as well as a golf course and a school. Historically, the storm water discharged from the sewer has been a source of significant amounts of sediment, nutrients, and other pollutants. The discharges have been the subject of frequent concern and complaints from the residents of the lake.

To improve the quality of the storm water reaching the lake, enhance habitat for wildlife, and provide a visual amenity, a bioswale was created by converting a roadside ditch to a wetland. This was done by land balancing and establishing wetland plants native to Michigan. The main design of the bioswale includes four distinct planting zones each consisting of a monoculture of plants with similar flowering color. This provides a landscaped appearance without sacrificing the water quality benefit of the bioswale.

The design features infiltration trenches filled with one-inch x three-inch crushed aggregate. The space constraints of the site prevent the use of inline detention for water storage so the infiltration trenches will provide an area where storm water will be detained and allowed to seep into the soil profile. In addition to the infiltration trenches, the current swale will be widened from six feet to 12 feet which will aid in reducing flow velocities and encourage uptake and infiltration of the storm water.

Cost $0

Lessons Learned

Benefits

- Air quality improvement
- Can replace curb and gutter for site drainage and provide significant cost savings
- Enhances site / community aesthetics
- Groundwater recharge
- Storm water runoff volume reduction
- Water quality improvement

Impediments

- Space is a concern; unless designed for infiltration, there is limited peak and volume control

Decreased costs

- Overall maintenance
- Maintenance labor

Increased costs

- Design

Milwaukee Bioswales

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Description

The project involved multiple biowswales throughout the city of Milwaukee. Ultimately, they did 90 miles of retrofits.

In the Westlawn area they received a grant to install 45 acres of bioswale as part of a larger project.

The City of Milwaukee installed 18 bioswales along 6thstreet between Tloward and Grange.

They did a project retrofitting the parking lot of an old mall with a large bioswale.

Finally, a community garden on 6th street retrofitted their parking lot with a bioswale.

Cost $1

Lessons Learned

The operation and maintenance of the biowswales. They need to be constantly maintained and there need to be people in place to constantly do it.

There were construction woes, such as mislabeled electrical and sewer lines.

There have been lessons in finding out what the best plants for the bioswales and what soil amendments will be best to maintain water quality.

Missouri Botanical Garden Parking Lot Project

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Description

The Missouri Botanical Garden's parking lot renovations constructed over the past few years demonstrate a variety of stormwater best management practices (BMPs) utilizing multiple types of porous pavements and a large scale engineered rain garden (bioretention system) plus a series of smaller rain gardens. The installation and use of these BMPs will help capture and hold rain water on site and significantly reduce runoff, flash floods, soil erosion and water pollution.

- The large engineered rain garden or bioretention system in the east parking lot was constructed with special rock and fiber filters, rain garden soil and native plants. A series of smaller rain gardens linked by French drains were installed on the west parking lot.
- The porous concrete, porous asphalt and porous pavers allows water to go right through the paving surface into an underground reservoir where it filters into the soil.
- Grasscrete pavers previously installed were retained which allow tree roots necessary water access.
- A 2500 foot porous rubberized paved sidewalk leads into the parking lot.

These areas will capture 100 percent of the stormwater runoff of the associated parking lot from a typical St. Louis rain event (1.14 inches or less in a 24-hour period). More importantly, this collection of stormwater capture strategies is intended to provide education, demonstration and when possible, evaluation of best management practices.

Cost

Porous Pavements

Estimated “turnkey” costs, materials and installation, for porous pavements:

- Rubber – approximately $11/sq. ft.
- Pavers and concrete – approximately $10/sq. ft.
- Asphalt – approximately $8-$9/sq. ft.

Lessons Learned

Lessons Learned:

Key Considerations Related to Porous Pavements

- **Need to be closely monitored to assure ADA compliance.**
- **The depth required for installation in heavily compacted areas.**
- **Ongoing maintenance needed to maintain porosity.**
- **Snow removal has to be managed differently from conventional parking lot.**
- **Signage during and after installation is essential to prevent unanticipated compaction.**

Key Considerations Related to Bioretention Areas

- **Implement strategies to continually maintain forebay free of litter and debris.**
- **Check dams are important to retain water to adequately drain into aquifer.**
- **Plant selections should include flood-tolerant as well as dry-loving native plants.**
- **Utilizing native plants increase water filtration as well as biodiversity.**

- **Maintain water diversion barriers while plants become established.**

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