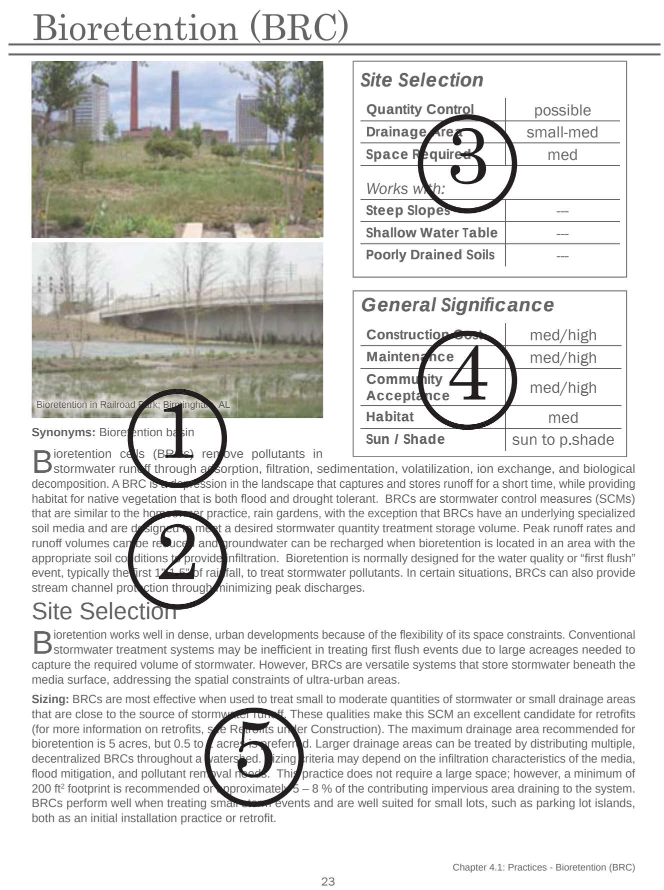
How to Use This Handbook

Below are example sections for each stormwater control measure (SCM) subchapter. This guidance explains to the reader where they can find specific information related to each practice. These samples are intended to familiarize the reader with the layout for the practices outlined throughout the handbook.



Bioretention (BRC)

Site Selection	
Quantity Control	possible
Drainage Area	small-med
Space Required	med
Works with:	
Steep Slopes	---
Shallow Water Table	---
Poorly Drained Soils	---

General Significance	
Construction Cost	med/high
Maintenance	med/high
Community Acceptance	med/high
Habitat	med
Sun / Shade	sun to p.shade

Bioretention in Railroad Park; Birmingham, AL

Synonyms: Bioretention basin

Bioretention cells (BRCs) remove pollutants in stormwater runoff through adsorption, filtration, sedimentation, volatilization, ion exchange, and biological decomposition. A BRC is a depression in the landscape that captures and stores runoff for a short time, while providing habitat for native vegetation that is both flood and drought tolerant. BRCs are stormwater control measures (SCMs) that are similar to the homeowner practice, rain gardens, with the exception that BRCs have an underlying specialized soil media and are designed to meet a desired stormwater quantity treatment storage volume. Peak runoff rates and runoff volumes can be reduced and groundwater can be recharged when bioretention is located in an area with the appropriate soil conditions to provide infiltration. Bioretention is normally designed for the water quality or "first flush" event, typically the first 1"-1.5" of rainfall, to treat stormwater pollutants. In certain situations, BRCs can also provide stream channel protection through minimizing peak discharges.

Site Selection

Bioretention works well in dense, urban developments because of the flexibility of its space constraints. Conventional stormwater treatment systems may be inefficient in treating first flush events due to large acreages needed to capture the required volume of stormwater. However, BRCs are versatile systems that store stormwater beneath the media surface, addressing the spatial constraints of ultra-urban areas.

Sizing: BRCs are most effective when used to treat small to moderate quantities of stormwater or small drainage areas that are close to the source of stormwater runoff. These qualities make this SCM an excellent candidate for retrofits (for more information on retrofits, see Retrofits under Construction). The maximum drainage area recommended for bioretention is 5 acres, but 0.5 to [illegible] acres is preferred. Larger drainage areas can be treated by distributing multiple, decentralized BRCs throughout a watershed. Sizing criteria may depend on the infiltration characteristics of the media, flood mitigation, and pollutant removal needs. This practice does not require a large space; however, a minimum of 200 ft^2 footprint is recommended or approximately 5 – 8 % of the contributing impervious area draining to the system. BRCs perform well when treating small storm events and are well suited for small lots, such as parking lot islands, both as an initial installation practice or retrofit.

Chapter 4.1: Practices - Bioretention (BRC)

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1. Synonyms

Other Low Impact Development (LID) manuals or information may refer to practices as different names. This section states any aims to state any interchangeable names associated with the practice.

2. Practice

A brief introduction to the practice is offered here to summarize information about the practice in a short paragraph.

3. Site Selection Table

The Site Selection Table is designed for a quick look at what site characteristics will or will not work for each practice.

Quantity Control [yes, no, or possible]: All practices in this handbook are stormwater quality practices. In other words, the practices are designed to treat stormwater runoff to reduce pollutant loads. However, all practices are not designed for stormwater quantity control because a large volume of stormwater is unable to be stored. In some practices such as bioretention, quantity control is possible, meaning that if designed properly it can help control quantity, but it is not typically considered a quantity control practice.

Drainage Area Size [small, medium (med), or large]: Drainage area size refers to the acreage that drains to the LID practice. The ratings for drainage area sizes are relative to other SCM drainage area requirements. For example, swales and bioretention drain small acreages, while constructed stormwater wetlands drain large acreages.

Space Required [small, medium (med), or large]: Similarly to drainage area size, the rating for the space or land area (footprint) required by the practice is based on the comparison made between SCMs.

Steep Slopes [check mark (yes) or --- in table (no)]: When a practice works with a steep slope, regrading of the area to a gentle slope (3 – 5:1) is not necessary. A steep slope is considered to be greater than a 3:1 slope. Some SCMs will require a relatively flat surface to function or cannot handle increased flow velocities associated with steep slopes.

Shallow Water Table [check mark (yes) or --- in table (no)]: Practices such as bioretention require a minimum of two feet between the bottom of the cell and the water table. Intercepting the water table is only appropriate when practices such as constructed stormwater wetlands need to maintain a permanent pool.

Poorly Drained Soils [check mark (yes) or --- in table (no)]: Some practices are not appropriate for poorly drained soils. Practices with standing water such as wet swales and constructed stormwater wetlands work well in poorly drained soils. Practices such as bioretention and infiltration swales that are designed to infiltrate stormwater require well-drained soils.

4. General Significance Table

The General Significance Table provides a quick reference for construction cost, maintenance, community acceptance, habitat, and sunlight requirement for the practice.

Construction Cost [low, medium (med), or high]: Construction cost compares each practice in relationship to the cost to construct them. It should be noted that in cases where equipment or labor is donated or inkind, cost would be decreased. Practices that require intense soil movement will cost more to construct.

Maintenance [low, medium (med), or high]: The purpose of maintenance is to keep the SCM functioning for its intended use. Maintenance frequency is dependent on location of practice, client or owner preferences, surrounding land use, etc. The rating for maintenance compares each practice according to maintenance burden. For example, practices that may have a tendency to clog such as bioretention and permeable pavement will have increased maintenance activities and frequency in comparison to a swale.

Community Acceptance [low, medium (med), or high]: Community acceptance rates the practice on whether it is readily accepted by community members. Practices such as swales are generally more easily accepted because they are commonplace on roadsides and they aren't a "new" idea. Lesser known practices may require education and community wide understanding.

Habitat [low, medium (med), high, or – (not applicable)]: Habitat refers to whether a practice positively contributes to or provides an environmental benefit or habitat for wildlife. For example, constructed stormwater wetlands provide more habitat for wildlife compared to permeable pavement.

Sun / Shade [sun to part shade (sun to p. shade), sun and/or shade (either), or – (not applicable)]: Some practices are better suited to sunny conditions, especially those that aim to treat or kill pathogenic bacteria.

5. Site Selection

The Site Selection Section offers a more in depth look at site selection for the practice. It may include information related to hydrologic soil group, infiltration rate, drainage area size, and seasonally high water table.

Site Selection: Constraints & Limitations Table: This table summarizes constraints that might be encountered and a recommendation for each.

6. Design

Components: The Components Section focuses on each part of the SCM, including pretreatment, wetland zones, underdrains, and any other element that may need to be designed or is a critical part of the practice.

Design Guidance: The Design Guidance Section gives design formulas and each step of the design process for the practice.

Design Example: The Design Example presents a design problem and a step by step design process.

7. Construction

The Construction Section focuses on construction activities, sequencing, plant installation and establishment, and soil testing.

8. Vegetation

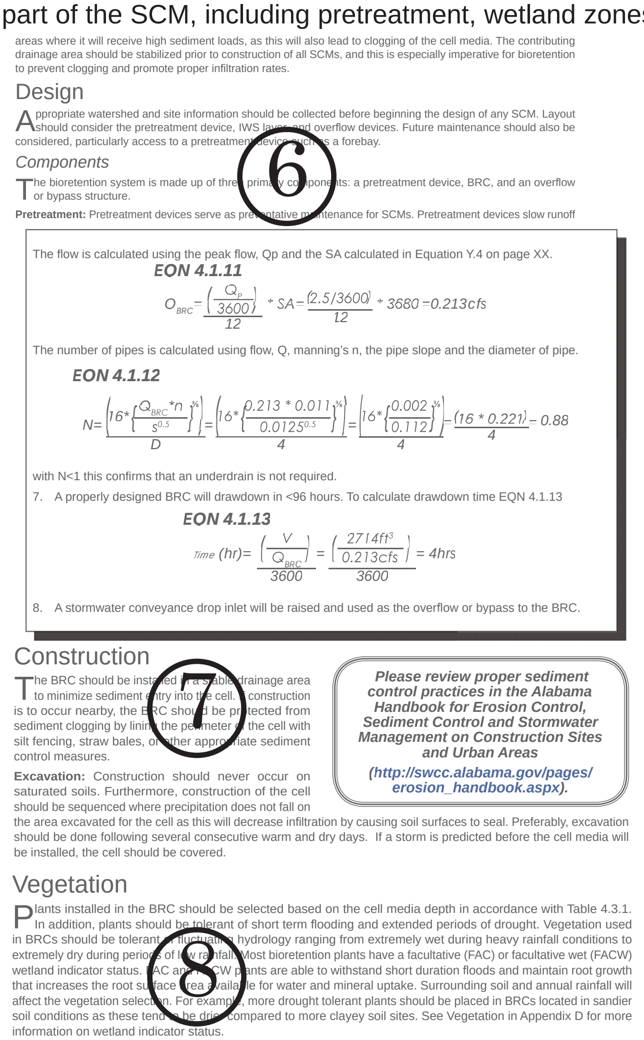
The Vegetation Section provides information on plants specific to the practice.

Vegetation Design Guidelines: This bulleted list gives suggestions pertaining to plant spacing, layout, aesthetics, plant types, etc.

Vegetation Design Example: The vegetation design example presents a design problem to show how to design the practice, shows a vegetation list, and presents a landscape drawing or graphic (to scale).

Plant List: Plant lists are offered for each practice that utilizes vegetation. Recommended plants are native to all or a portion of Alabama (except turfgrasses).

Botanical Name – The Botanical Name provides the genus and species for the plant.



areas where it will receive high sediment loads, as this will also lead to clogging of the cell media. The contributing drainage area should be stabilized prior to construction of all SCMs, and this is especially imperative for bioretention to prevent clogging and promote proper infiltration rates.

Design

Appropriate watershed and site information should be collected before beginning the design of any SCM. Layout should consider the pretreatment device, IWS layer, and overflow devices. Future maintenance should also be considered, particularly access to a pretreatment device such as a forebay.

6

Components

The bioretention system is made up of three primary components: a pretreatment device, BRC, and an overflow or bypass structure.

Pretreatment: Pretreatment devices serve as preventative maintenance for SCMs. Pretreatment devices slow runoff

The flow is calculated using the peak flow, Qp and the SA calculated in Equation Y.4 on page XX.

EQN 4.1.11

$$O_{BRC} = \frac{\left(\frac{Q_P}{3600}\right)}{12} * SA = \frac{(2.5/3600)}{12} * 3680 = 0.213cfs$$

The number of pipes is calculated using flow, Q, manning's n, the pipe slope and the diameter of pipe.

EQN 4.1.12

$$N = \frac{\left(16*\left\{\frac{Q_{BRC}*n}{s^{0.5}}\right\}^{3/8}\right)}{D} = \frac{\left(16*\left\{\frac{0.213 * 0.011}{0.0125^{0.5}}\right\}^{3/8}\right)}{4} = \frac{\left(16*\left\{\frac{0.002}{0.112}\right\}^{3/8}\right)}{4} = \frac{(16 * 0.221)}{4} = 0.88$$

with N<1 this confirms that an underdrain is not required.

7. A properly designed BRC will drawdown in <96 hours. To calculate drawdown time EQN 4.1.13

EQN 4.1.13

$$Time\ (hr) = \frac{\left(\frac{V}{Q_{BRC}}\right)}{3600} = \frac{\left(\frac{2714ft^3}{0.213cfs}\right)}{3600} = 4hrs$$

8. A stormwater conveyance drop inlet will be raised and used as the overflow or bypass to the BRC.

Construction

The BRC should be installed in a stable drainage area to minimize sediment entry into the cell. If construction is to occur nearby, the BRC should be protected from sediment clogging by lining the perimeter of the cell with silt fencing, straw bales, or other appropriate sediment control measures.

7

Excavation: Construction should never occur on saturated soils. Furthermore, construction of the cell should be sequenced where precipitation does not fall on the area excavated for the cell as this will decrease infiltration by causing soil surfaces to seal. Preferably, excavation should be done following several consecutive warm and dry days. If a storm is predicted before the cell media will be installed, the cell should be covered.

Please review proper sediment control practices in the Alabama Handbook for Erosion Control, Sediment Control and Stormwater Management on Construction Sites and Urban Areas (http://swcc.alabama.gov/pages/erosion_handbook.aspx).

Vegetation

Plants installed in the BRC should be selected based on the cell media depth in accordance with Table 4.3.1. In addition, plants should be tolerant of short term flooding and extended periods of drought. Vegetation used in BRCs should be tolerant of fluctuating hydrology ranging from extremely wet during heavy rainfall conditions to extremely dry during periods of low rainfall. Most bioretention plants have a facultative (FAC) or facultative wet (FACW) wetland indicator status. FAC and FACW plants are able to withstand short duration floods and maintain root growth that increases the root surface area available for water and mineral uptake. Surrounding soil and annual rainfall will affect the vegetation selection. For example, more drought tolerant plants should be placed in BRCs located in sandier soil conditions as these tend to be drier compared to more clayey soil sites. See Vegetation in Appendix D for more information on wetland indicator status.

8

Common Name – Only one of the plant's common names is given, though plants may have more.

Habit – The Habit describes whether the plant is considered a herbaceous perennial, grass, tree, or shrub. For more information on these plant habits, see the Appendix D on Vegetation.

Prefers – This describes the plant's sunlight preference, which may be sun, shade, or a combination of both.

Comments – Any recommendations for cultivars or other general comments about the plant are provided here.

9. Maintenance

The Maintenance Section introduces routine maintenance tasks in order to maintain the functionality of the practice.

Maintenance Schedule: An example maintenance schedule shows how often tasks should be completed and gives helpful comments for each task.

Maintenance

(9)

Clogging: The most common failure mechanism of a BRC is clogging of the cell media. The underdrain pipe can be unclogged via the clean out pipe(s). However, if water remains ponded on the cell surface and clogging persists, it may be necessary to remove and replace the top few inches of media. Following this replacement, if the cell surface continues to remain ponded for longer than 12 hours, then the cell media is likely clogged and will need to be completely replaced. Extended surface ponding provides favorable conditions for mosquito breeding and is detrimental to plants unaccustomed to extended flooding.

Mulch: The top 1 to 2" of mulch and 4" of media have been shown to accumulate sediment and metals. Periodic replacement of these top layers can facilitate removal of sediment bound phosphorus and metals. Upon the need to dispose of any potentially contaminated mulch or media associated with BRCs, the ADEM Environmental Services Branch should be contacted for guidance associated with the requirements for waste determination and disposal procedures. For more information, please call 334-271-7700 or 1-800-533-2336.

Table 4.1.8
Maintenance Schedule

Task	How Often	Comments
Mulching	As needed, full replacement every 2 to 3 years	Bare areas from erosion should be replaced as necessary. Mulching can be done any time of the year, but the best time is late spring after soil has warmed. Mulch should be replaced annually if the watershed is high in heavy metals.
Re-planting	When plants die	If plants consistently suffer from mortality consider using more appropriate plant species for the area.
Weeding	Twice a year	Weeding should decrease over time as vegetation establishes.
Inspect plants	Monthly until establishment, then twice a year	Inspect for diseased or insect infested vegetation.
Inspection	After 0.5" or greater rainfall event	Visually inspect all components including any pretreatment, pipes, or IWS where applicable.
Fertilization	At planting	Most BRCs are used in nutrient sensitive watersheds. Fertilizing beyond plant establishment will increase nutrients leaving the BRC.
Unclog Underdrain Pipes	As needed	Ponded surface water should drain away within 12 hours or less (i.e. eliminate standing water conditions). If water remains ponded on the surface of the cell for longer than 12 hours this may indicate that the underdrain pipe or cell media is clogged.
Pruning	Annually	Pruning will help maintain plant shape. See Vegetation in Appendix D for pruning recommendations.
Sediment Removal	As needed	If sediment clogs the media, the top few inches may need to be removed and replaced. Removed sediment should be properly disposed of as it may contain toxic materials such as heavy metals. Contact the ADEM Environmental Services Branch for guidance at 334-271-7700 or 1-800-533-2336.
Trash Removal	As needed	In high traffic areas, frequent trash removal will be necessary.
Mulch removal from outlets	As needed	Mulch may collect in the outlet or overflow during heavy rains.

Pollutant Removal

(10)

Table 4.1.9
Pollutant Removal Table

Sediment	Nutrients		Metals	Pathogens	Temperature
	N	P			
a.85%	40%	45%	No Data	No Data	No Data
b.80%	50%	60%	MOD	No Data	No Data
c.80%	50%	60%	MOD	No Data	No Data

a. NCDENR, 2007*
b. City of Auburn, 2011
c. Georgia Manual, 2001

* Research has demonstrated pollutant removal efficiencies of 60% for both N and P in the Coastal Plains.

Bioretention pollutant removal is dependent on the presence of plants, microorganisms, specialized cell media, and mulch; the absence of one of these components decreases the pollutant removal efficiency associated with the BRC. Bioretention shows greater than 35% reduction in nutrients and a minimum of 80% reduction in total suspended solids (TSS). Nutrient removal is more variable compared to TSS, which is likely due to the complexities of chemical breakdown processes and the behavior of nutrients.

References

(11)

Alabama Soil and Water Conservation Committee. 2009. Alabama Handbook for Erosion Control, Sediment Control, and Stormwater Management on Construction Sites and Urban Areas. Montgomery, AL.

Brown, R.A., W.F. Hunt, and S.G. Kennedy. 2009. Designing Bioretention with an Internal Water Storage (IWS) Layer: Design guidance for an innovative bioretention feature. North Carolina Cooperative Extension. AG-588-19W.

Brown, R.A. and W.F. Hunt. 2009. Improving Exfiltration from BMPs: Research and Recommendations. North Carolina Cooperative Extension.

Christian, K. J., A. N. Wright, J. L. Sibley, E. F. Brnatley, J. A. Howe. and C. LeBleu. 2012. Effect of Phosphorus Concentration on Growth of Muhlenbergia capillaris in Flooded and Non-Flooded Conditions. Journal of Environmental Horticulture 30(4): 219-222.

City of Auburn Manual. 2011.

Davis, Allen P., William F. Hunt, Robert G. Traver, and Michael Clar. 2009. Bioretention Technology: An Overview of Current Practice and Future Needs. Journal of Environmental Engineering, March.

Davis, Allen P. 2007. Field Performance of Bioretention: Water Quality. Environmental Engineering Science, 24(8) 1048-1063.

Davis, A. P., M. Shokouhian, H. Sharma, and C. Minami, C. 2006. Water Quality Improvement Through Bioretention Media: Nitrogen and Phosphorus Removal. Water Environment Research 78 (3), 284–293.

Davis, A. P., M. Shokouhian, H. Sharma, and C. Minami. 2001. Laboratory Study of Biological Retention for Urban Storm Water Management, Water Environment Research 73(1), 5-14.

Dylewski, K. L., A. N. Wright, K. M. Tilt, and C. LeBleu. 2012. Effect of Previous Flood Exposure on Flood Tolerance

10. Pollutant Removal

The Pollutant Removal Section contains detailed information on pollutant load reductions specific to the practice.

Pollutant Removal Table: The Pollutant Removal Table shows pollutant removal efficiency data noted in other LID manuals or municipalities. Pollutant removal efficiency is expressed as a percent and represents the reduction in pollutant concentration measured in outflow from the SCM compared with inflow to the SCM. Pollutant removal efficiencies listed in the Pollutant Removal Table are based on sampling data, modeling, and best professional judgment. For more information on pollutant removal, please see Pollutant Removal in Appendix A on Stormwater Hydrology.

Sediment – Shows a reduction in total suspended solids (TSS).

Nutrients – Shows a reduction in N (total nitrogen) and P (total phosphorus).

Metals – Shows a reduction in metals such as zinc.

Pathogens – Shows a reduction in pathogenic bacteria such as *E. coli*.

Temperature – Shows a reduction in temperature.

11. References

This lists any source(s) that was used to gain knowledge or information regarding the practice section.