Westmoreland Conservation District

WESTMORELAND CONSERVATION DISTRICT

PRESENTS a PRIMER on

STORMWATER MANAGEMENT

BIORETENTION in CLAY SOILS

3rd edition

enter

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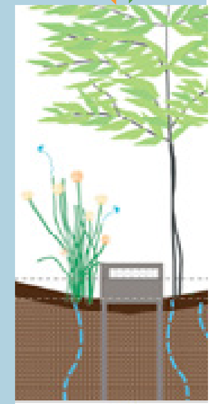

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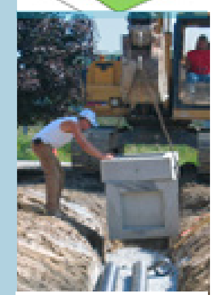

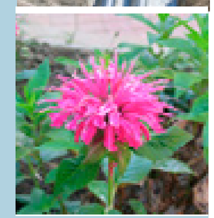

ABOUT THE BIORETENTION IN CLAY SOILS PRIMER v. 3

ADOBE ACROBAT
This PDF is designed to be read by Adobe Acrobat Reader, version 8 and higher.

CREDIT:
Content
Westmoreland Conservation District
Precipitation Summaries & Calculations
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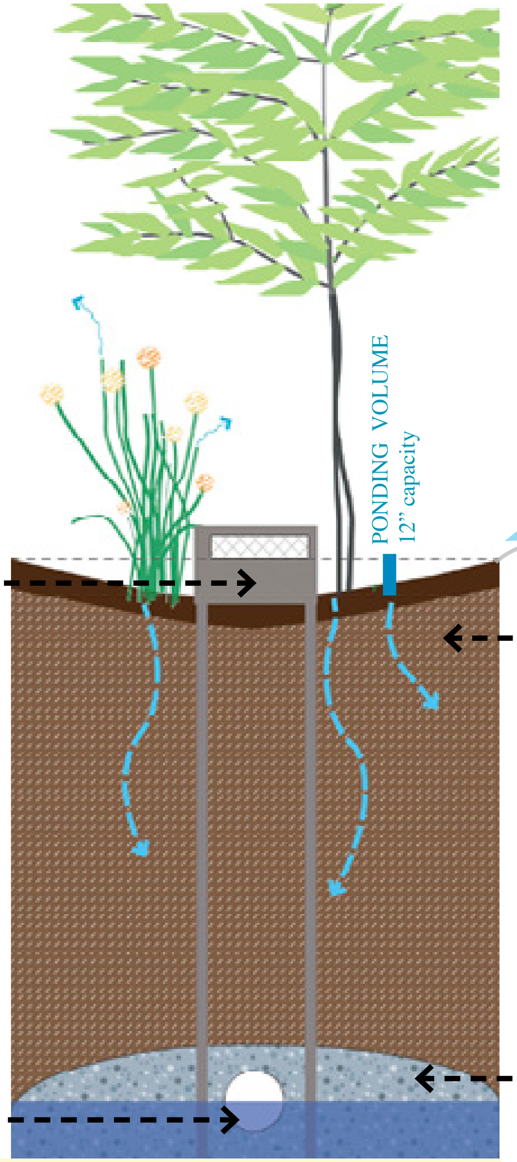
ENGINEERING

The design of living engineering systems calls for careful consideration of the six elements listed here.

Design calculations must accurately determine the volume of water to be treated and the size of the bioretention cell. Underdrains make sure that 1" rains are captured in 24 hours.



1 OVERFLOW DRAIN

The overflow drain drains off high levels of runoff levels water during short, intensive rain events. Stable, well-anchored inlets, like concrete are best.

2 UNDERDRAIN

In this region, an underdrain is necessary in clay soils and compacted fill. Size the underdrain pipe according to the expected inflow (6" min). The overflow drain connects to the underdrain which can then connect to existing storm sewers, infiltration basins, or stormwater wetlands.

> Pipe: See PennDOT design manual, Section 610.2(a) 1c for perforated plastic underdrain.

Note: an underdrain control valve may be needed to minimize rate and volume of de-watering the bioretention cell.

TYPICAL DIMENSIONS IN A PARKING LOT

WIDTH: 6-8' min., 10'-12' ideal (commercial). **DEPTH:** 4' min. incl 12" gravel envelope
LENGTH: **Varies,** 10x width typical for parking lots; 2x width for residential
SIDE SLOPES: 3:1 maximum, stabilize with vegetation

3 BIORETENTION PLANTS

Landscape plants in bioretention cells are subject to demanding microclimates and highly variable moisture and climatic conditions, especially in parking lots.

4 3" MULCH

Coarsely shredded hardwood bark has proven to be durable and is less likely to wash away. Dissipator strips made of grass or gravel at runoff entry points, like curb cuts, slow down the entering water and filter out debris—important for long-term system stabilization and maintenance.

5 CONSTRUCTED SOIL MIX

In our experience, this is the most critical element for long-term success. This mix provides mechanical and chemical qualities that encourage soil biota and microflora that help clean runoff waters. The soil mix must be moderately fast draining (2-4 in/hr).

> Ideal Soil Blend:
> 50% topsoil (remove all rocks and foreign matter)
> 30% sand or pea gravel
> 20% compost

Topsoil used in constructed soil must be less than 10% clay. Too much clay quickly clogs a system. Excessive sand dries them out. Minimize soil mix compaction during construction. Designers can assume that uncompacted soil mix has a 20% void space.

6 GRAVEL ENVELOPE

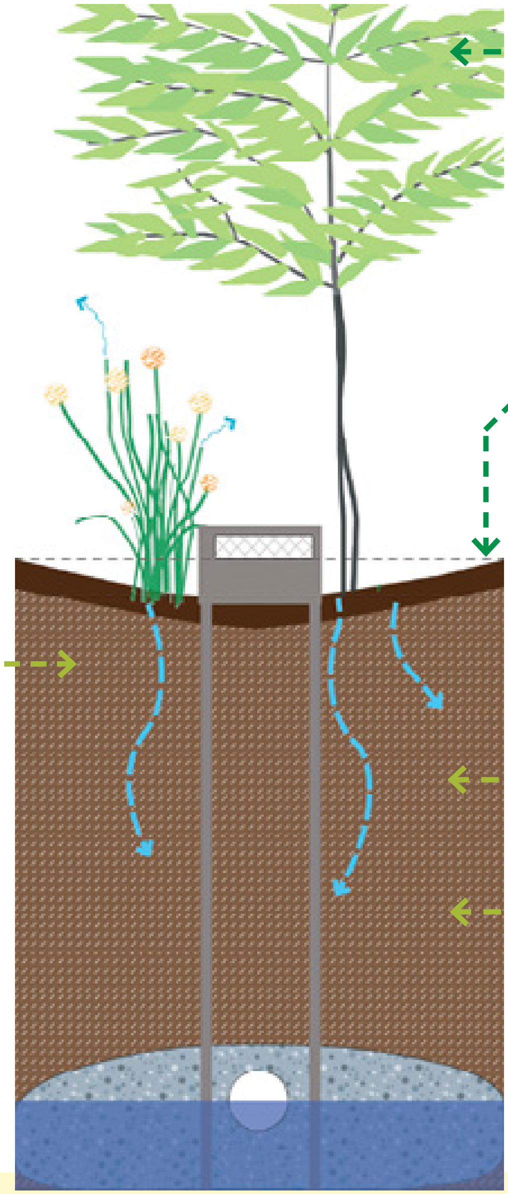
A geotextile fabric envelopes the gravel-underdrain area, allowing for water to pass through, while keeping soil out.

> Geotextile Fabric: Class 1 woven or non-woven geotextile as specified in PennDOT's Design Manual, Section 735.
>
> Coarse Aggregate: PennDOT No. 57 (No. 2B).

Designers can assume that the gravel envelope has a 40% void space.

ECOLOGY

Bioretention cells emulate functions within the upper layer of forest soils, where water, plants, soils, and micro-flora interact to clean and infiltrate water, sustain plant communities, and recharge groundwaters. Forest soils cycle and assimilate pollutants and metals through interactions among plants, soil, and the organic layer—the three major elements of the bioretention concept.



SOIL BIOTA & POLLUTANT REDUCTION

In addition to soils providing water and nutrients to plants, they provide a physical, chemical and biological matrix for living organisms. Soil biota existing within the soil layer are critical to the filtering of nutrients and pollutants and maintaining soil fertility. Soil particles themselves play a role, clay for instance, (due to its molecular and magnetic properties) provides adsorption sites for hydrocarbons, heavy metals, nutrients and other pollutants (EPA Office of Water, 1999).

EVAPOTRANSPIRATION

Large amounts of water are pulled up into trees, shrubs, and all plants from the surrounding soil in a process called transpiration. Water is drawn up into leaves during photosynthesis, and once utilized, is returned to the air as water vapor. This process creates a pump-like effect, in which a constant flow of moisture from the roots is pulled upward to replace that which escapes to the air. A growing plant transpires 5-10 times as much water as it can hold (Environment Canada). Some dissolved pollutants are carried up into plant tissues and rendered harmless.

MULCH LAYER

After runoff hits the dissipator strip, the mulch layer acts like leaf litter on a forest floor by slowing the rate of water entering bioretention areas. As runoff slows, sediments and colloids fall out of suspension and dissolved pollutants and toxins are carried into the bioretention cell for treatment.

The mulch layer plays a critical role in heavy metal uptake with nearly all the metal removal occurring in the top few inches of the bioretention area. Heavy metals affiliate strongly with organic matter in this layer. Microorganisms in the mulch layer are credited for degrading petroleum-based solvents (hydrocarbons) and other pollutants.

WATER COOLING

In warm months, heated runoff from impervious surfaces is cooled within bioretention facilities, better to support aquatic life upon discharge.

INFILTRATION (and EXFILTRATION)

Due to extremely small particle size and platelet structure, native clay or clay/silt soils have a limited capacity for infiltration, nonetheless they infiltrate rainwater when uncompacted. In a bioretention cell, with properly engineered soils, a 1" rainfall (over a 24-hr period) can be completely managed through infiltration, absorption, and exfiltration into surrounding clay or compact urban fill. Soil infiltration testing yields good information to assist the design and sizing process.

ADDITIONAL WATER CLEANING

Often, some water will remain under the drain, creating anaerobic conditions. Though this condition is undesirable in the plant root zone, specific pollution removal occurs here, namely, denitrification, the transformation and reduction of nitrates.

PRECIPITATION: Annual Rain Volume

Average Precipitation Amounts by Year, Allegheny County, PA	
(year)	(inches)
2011	48.3
2010	38.8
2009	31.1
2008	36.1
2007	40.0
2006	36.9
2005	34.0
2004	50.4 *
	39.5"

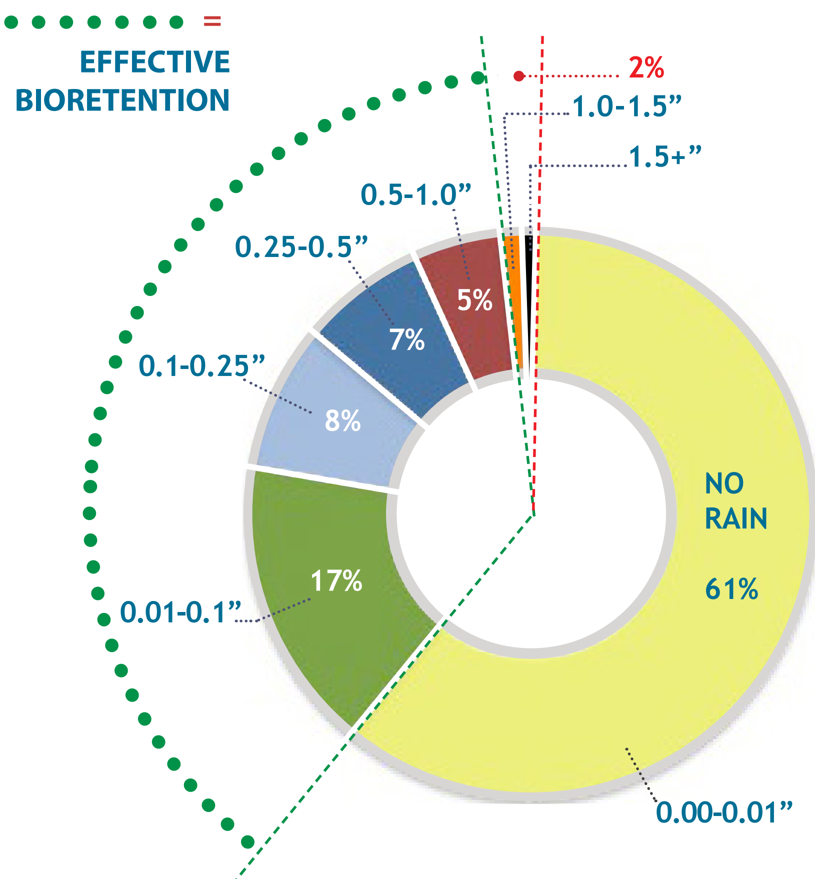
* Hurricane Ivan, in September 2004, accounted for an atypical 7-10" of rain over three days.

The average annual rainfall in Allegheny County, Pennsylvania from 2004 to 2011 was **39.5".**

Meteorology and landscape characteristics, like physiography, influence where rain and snow end up falling on the ground. It's not unusual for a person to drive through a downpour in one area only to travel on dry roads two or five miles away. Large regional landscapes affect rain and snow fall—both amounts increase by a modest percentage as Great Lakes-driven weather moves eastward from Allegheny County towards the Appalachian Mountains.

3 Rivers Wet Weather's Calibrated Radar Rainfall Data was summarized by Landbase Systems on the Precipitation charts in this section.

PRECIPITATION:
All Days in a Year



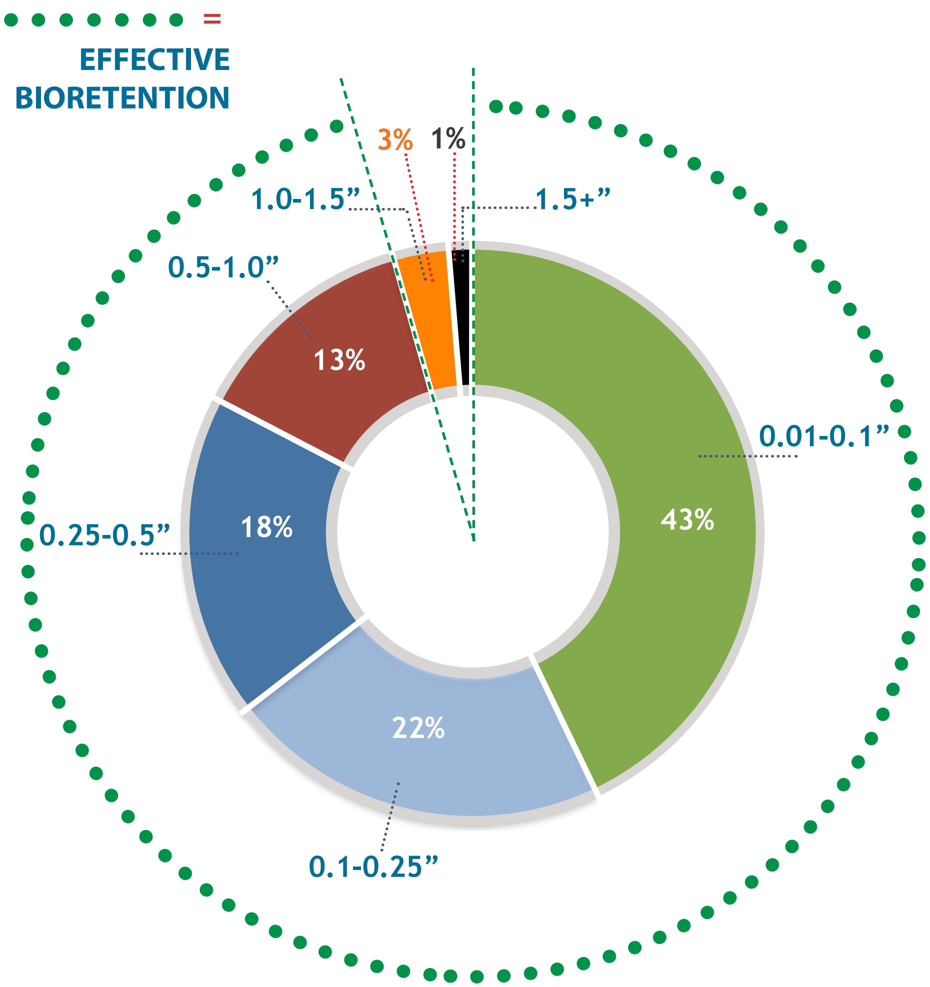
ALL DAYS in an AVERAGE YEAR — RAIN & NO RAIN

One can see from the graphic to the left that 61% of days in a year in this region of Southwest Pennsylvania has virtually no rain (0.0-0.1”); 78% of days has less than 1/10” of precipitation; and, 5% of all days receives between 0.5” to 1.0”—1/3 of annual precipitation.

Design criteria for bioretention as specified in this Primer calls for managing 1” of runoff in 24 hours. (Though when properly designed and maintained, they can efficiently handle greater volumes). Intercepting up to 1” of precipitation represents an average of 91% of annual rainfall (or about 36” per year).

Precipitation Ranges *(inches)*	**Average # Days per Year**	**Percent of ALL Days per Year**	**Percent of Annual Precipitation**
0.0 - 0.01	223	61%	<1%
0.01 - 0.10	61	17%	7%
0.10 - 0.25	31	8%	13%
0.25 - 0.50	26	7%	24%
0.50 - 1.0	18	5%	31%
1.0 - 1.5	4	1%	13%
1.50+	2	1%	12%
	365	**100%**	**100%**

PRECIPITATION: Rain Days in a Year



RAIN DAYS in an AVERAGE YEAR

The graphic to the left illustrates that the vast majority of annual precipitation we receive in Southwest Pennsylvania (39.5" average) is well below 1". In fact, 83% of all annual precipitation is 1/2" per day or less.

96% of all precipitation days fall into the design criteria for bioretention cells to manage 1" of stormwater in a 24-hour period—as specified in this Primer. Well-designed and well-maintained rain gardens with underdrains can readily manage inflows from larger, far more infrequent storms.

Precipitation Ranges *(inches)*	Average # Days per Year	Percent of RAIN Days per Year	Percent of Annual Precipitation
0.01 - 0.1	61	43%	7%
0.1 - 0.25	31	22%	13%
0.25 - 0.50	26	18%	24%
0.50 - 1.0	18	13%	31%
1.0 - 1.5	5	3%	13%
1.50+	2	1%	12%
	143	**100%**	**100%**

IF we control runoff from the small rain events less than 1/2", then we can control most of the runoff most of the time. Most non-point source pollution would be reduced most of the time too! By capturing and retaining the first 1/4" of runoff, we would solve many of the combined sewer overflows in the region.

DESIGN & SIZING 1 of 2

Assumptions when sizing rain gardens:

1. **Size to capture and treat a 1-inch rainfall event.**
The vast majority of rainfall events in southwest PA accumulate less than 1 inch of water (see Rainfall Event charts). To calculate runoff volume, multiply the square area of a roof and/or paving by 1/12 of a foot (or 0.0833 feet) to determine cubic feet.

2. **Three layers are necessary to capture, treat and infiltrate stormwater runoff: the surface storage area, soil mix, and underdrain.**
The surface capture, constructed to the appropriate depth, initially holds water on the surface of the rain garden. The soil mix contains water in its 20% pore spaces and supports rain garden plants. The gravel envelope (clean stone wrapped in geotextile fabric0 holds 40% in its pore spaces, and the perforated pipe drains off excess water.

3. **Surface capture depth should be at least 6-inch ponding depth (residential), not to exceed 12-inch ponding depth (commercial).**
The surface capture volume should be equal to the 1-inch storm volume.

4. **Interior slopes should be a 3:1 slope ratio.** Rain gardens are depressed landscape beds that capture the initial flush of runoff waters. Their interior slopes should not be steeper than a 3:1 ratio for maintenance purposes and reduce erosion.

5. **The recommended width of a residential rain garden is 10 feet; a commercial rain garden, 12 feet.** These dimensions allow 3:1 side slopes to reach the proscribed 6-inch depth for a residential rain garden, and a12-inch depth for commercial rain gardens. Note, it is good practice to design a 2:1 length to width ratio so that water entering one end of the rain garden and has an adequately long flow length.

6. **The recommended soil mix depth is 18 to 24 inches, but may increase to 36 inches or more depending on storage volume needs and the proposed plant materials.** (Larger trees need deeper soil). This is a minimum depth because while all three layers of the rain garden are to be of uniform length and width, the soil and stone layers hold a greater volume of water than the surface layer. The assumed percentage of total water volume stored in the soil layer is, at any time, 20%. This assumption is based on the recommended soil mix: 50% topsoil, 30% sand, and 20% compost. (Very important for topsoil to not contain more than 10% clay). The volume of water retained in the soil layer will change by altering the soil mix percentages. For example, if a 1:1:1 ratio of topsoil, compost, and sand is used, the rate of downward percolation slows and the soil will retain closer to 50% of the total volume. Likewise, if too much sand is used in the mix, the rate of percolation increases, less water is retained, and the rain garden will be less effective. For this reason, sand should be used in limited quantities. Subsequently, too much topsoil (often very dense clay in this area) will be nearly impermeable, and the rate of

DESIGN & SIZING 2 of 2

percolation slows significantly. Our experience has demonstrated that going the extra mile and creating a proper soil "mix" rather than using what soil is available on-site is beneficial in the end. A note on sand: there is a difference between using "artificial" sand (crushed from rock) and natural sand (found on a river bank or other natural water worked source). Artificial sand is composed of flattened particles that are more prone to compaction which limit the soil's permeability.

7. **The recommended stone depth is 12 inches.** This is a minimum depth because while all three layers of the rain garden should be of uniform length and width, the soil and stone layers must actually hold a greater volume of water than the top layer since these layers slowly drain rainwater. The assumed percentage of total water volume that is actually stored in the stone layer at any time is 40%. The stone should be wrapped in a geotextile fabric to separate the stone from adjacent soil volumes to allow water through but not soil particles that may clog the voids meant for water storage. A perforated underdrain pipe system may be required to bleed excess water from the rain garden.

Equations:

1. Surface Area of Roof-or-Paved Area: length X width = surface area (sq ft.)

Note: Only the portion of the roof or paved area that drains into the rain garden (via downspout or outlet pipe) is factored in.

2. Water Volume Output: surface area X 0.0833ft = runoff volume (cu. ft.)

This establishes the volume of run off during a 1-inch rain event.

3. Surface Width Dimension: runoff volume = [(Tw X L) + ({Tw/2} X L)] X D / 2

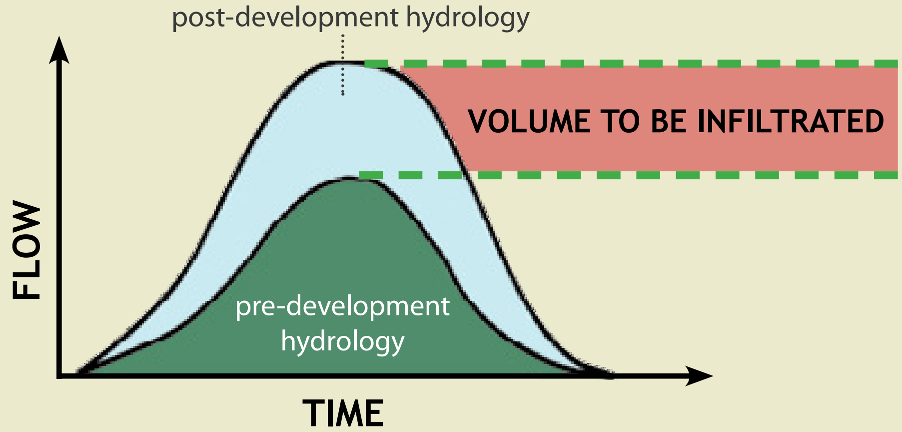
This equation determines the volume of a trapezoid. We already know what volume the trapezoidal storage basin must hold. What we want to know is the width dimension. So the equation is re-arranged to calculate the Tw value knowing the values of volume, length, and depth. The bottom width is simply half the top width. Recall that the assumed length is either 10 ft (residential) or 12 ft (commercial) and the depth is either 0.5 ft (residential) or 1 ft (commercial).

Where: Tw = top width;
L = length (10 feet residential or 12 feet commercial);
D =depth (0.5 foot residential or 1 foot commercial).
All units are in FEET.

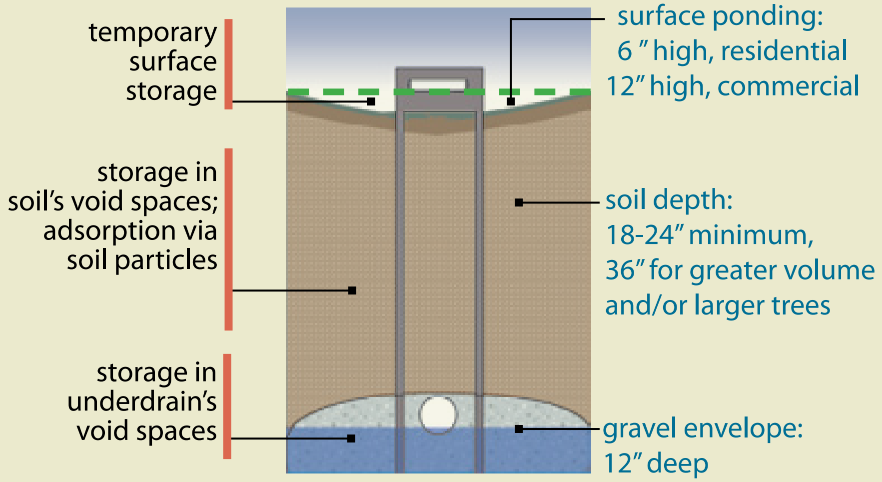
The top width of the top storage basin is the overall width of the rain garden. Altering the widths of the soil layer or stone layer (such that the layers were not all of uniform width) to accommodate for the increased volume of water that these two lower layers is a complicated calculation left out of the Primer. That is why the depths listed above are minimum depth values. They may be increased to handle greater volumes of water.

DESIGN & SIZING: RECAPS

Mimicking Natural Systems through Infiltration



3 Functional Layers for Stormwater Capture



Quick Volume Calculations

Homeowner

One-quarter inch (0.25") of rain per hour on 100 sq. ft. of sloped impervious surface (such as a roof or driveway) generates about 15 gallons of runoff per hour.

Commercial +

One-tenth inch (0.1") of rain per hour on 1,000 sq. ft. of sloped impervious surface generates about 61 gallons of runoff per hour...

In a year with 37" of precipitation, 1,000 square feet would shed about 22,600 gallons if 98% runs off.

BENEFITS OF RAIN GARDENS

Bioretention cells are also called 'rain gardens' because they are designed to be attractive landscaped areas. They also effectively:

1. Clean runoff water by removing or reducing pollutants and sediments

At the surface level, the rain garden mechanically filters out macro-pollutants like lawn debris, trash and cigarette butts. As water descends the soil substrate, pollutant removal occurs through adsorption of metals and other harmful substances onto soil particles. Soil also provides a matrix for biological pollutant removal by hosting beneficial bacteria that also neutralize some pollutants. Rain garden plants themselves take up nutrients such as phosphorus which would otherwise cause stream pollution in receiving waters. The very bottom of the rain garden, below the underdrain, is where denitrification of runoff water occurs through anaerobic action.

2. Manage runoff quantity from 1" or less rain events

Studies have shown that rainstorms with one inch of precipitation or less constitute the vast majority of our annual precipitation in Southwestern PA. Stream channels receive their basic shape—cross section, slope, length, and sinuosity from these small 'channel-forming' storms — not from hurricane size storms. However, if a stream is overloaded by runoff from impervious areas, its banks will erode to vertical drop-offs, its streambed will be scoured, and it will lose aquatic habitat. Runoff from the roof of one house is not much and can be stored in a relatively small rain garden. If enough rain gardens managed enough roof water, imagine how much of a difference that would make to a stream below!

3. Mitigate peak flow from larger storm events and reduce nuisance flooding

It is important to understand the difference between flood control and rain gardens. Flood control is what engineers build to protect people from large, infrequent storms. Examples of flood control are dams, concrete-lined channels, and levees. Rain gardens are designed for management and treatment of small, frequent rain and snow events, not large destructive storms. They can however safely manage water from large infrequent storms—this is why they need a berm and overflow pipe to drain off high volumes. Well designed rain garden overflows allow for high water events without causing damage to the system or surrounding areas. The design standard for the function of a rain garden is the small, frequent storm—83% of which are less than 1/2". The rain garden will also reduce runoff from larger events by that one inch, which in effect makes the effects of the larger storm smaller.

BENEFITS 2 of 2

4. Become landscape assets in urban and built environments

Anyone who has parked in a large parking lot understande the concept of the 'asphalt wasteland'. On a hot summer day, the surface of a parking lot can be hot enough to fry an egg. When hot runoff from a hot parking lot drains through a rain garden, it immediately begins to cool down before it enters a stream. Uncontrolled heat buildup in urban areas, known as the 'urban heat island effect', is just one of the ills that a rain garden can help cure. The trees, plants, and water held by the rain garden help to cool the local environment and provide aesthetic value and habitat for birds and other creatures. Choosing rain garden plants which produce berries for birds is a plus!

5. Prevent de-watering of small watersheds

A hidden effect of urbanization is the dewatering of small watersheds. As more open space gets covered by impervious surfaces, less and less rain water soaks into the ground. As the ground dries up, there's less groundwater to feed the forests and the base flow of small streams. Especially in the summer and early fall, when it's driest, streams depend on springs and groundwater seeps to keep their water fresh, and sustain all the little stream creatures. A loss of 'base flow' in a stream is devastating to the stream's ecology. Rain gardens in urban areas help replenish vital groundwater levels.

6. Fix past mistakes

Many places in Southwest Pennsylvania suffer a lack of stormwater controls. It wasn't until the 1980s that the first stormwater ordinances were written; by then much land had been developed without even the most basic BMPs. Rain gardens give a property owner the opportunity to make things right often without major infrastructure changes. Stormwater management, in the form of a rain garden retrofit, can fit into a parking lot's existing islands, landscape beds, unused bays, and underutilized corners. Adding up the volumes controlled by numerous rain gardens may well equal or exceed the volume provided by one detention pond or underground tank—and rain gardens are less expensive and much more attractive!

7. Address combined sewage overflow problems

Southwest Pennsylvania leads the state in Combined Sewer Overflow (CSO) problems. A century ago when sewers were first installed in cities, they were combined—storm drainage from streets and roofs went into the same pipe as water from toilets and sinks. Those pipes went straight to the rivers. Decades of development created an ever-increasing demand on these old systems. Many sewage treatment plants lack adequate capacity and overflow in small rain events. Many CSOs open up in rains less than 1/4", somes discharge in a 1/10" rain. Creating rain gardens to capture runoff in an area with combined sewers can reduce CSOs and protect our rivers and public health.

EVALUATION 1 of 5

WATER QUALITY MANAGEMENT

Runoff waters contain a spectrum of potential pollutants. Pennsylvania's focus on sediment and nutrient reduction is, at times, reduced to the following three aspects. Percentages express reduction in infiltration systems from two sources:

Total suspended Solids (TSS)	53-91%	85%
Total Phosphorous (TP)	64%	85%
Nitrate (N)	(116)-16%	30%

Source: PA DEP's 2006 SWM BMP Manual Ch 8.6.1 Analysis of Water Quality Impacts from Land Development

Whether you call it a rain garden, a bioinfiltration cell, or bioretention, it effectively removes many pollutants from runoff waters. Common pollutants of stormwater include trash, automotive chemicals, volatile hydrocarbons and sediments. Researchers have studied how pollutants are removed in rain gardens through the following mechanisms:

Volatilization. Pollutants, particularly those associated with petroleum or oil and grease, that evaporate.

Sedimentation. In standing water, heavier particles settle out into the mulch and soil surface.

Adsorption. Certain dissolved pollutants in the stormwater "stick" to soil particles in the soil mix. In the case of clay, magnetic charges at the ends of clay particles attract positively charged contaminants.

Absorption. Water-borne pollutants soak into the soil and follow a number of pathways: percolation through the bioretention system (draining off), transformation through microbial action, adsorption, accumulation, volatilization via plant uptake.

Microbial action. Bacteria and other microorganisms break down pollutants into less environmentally harmful substances.

Plant resistance and uptake. Decaying plant material increases absorption and provides habitat for microbes that break down pollutants. Some plants take up some pollutants through their roots.

Filtration. Particles are captured by the filtering action of mulch and soil.

Adapted from: "Are Rain Gardens Mini Toxic Cleanup Sites?" January 22, 2013, By Lisa Stiffler of the Sightline Institute, Copyright 2013 Sightline Institute.

EVALUATION 2 of 5

WATER QUANTITY MANAGEMENT

- **Properly designed bioretention cells will capture, retain, and exfiltrate water from 1/8" up to 1" rain events.**
- **Runoff from a 1" rain within 24 hours should drain within 1 to 2 days maximum.**
- **In a large10- or 25- year storm, an integrated system of bioretention cells can help mitigate peak flows and reduce nuisance flooding.**
- **Rain gardens manage water quality effectively for large areas when integrated with other stormwater BMPs, referred to as a 'treatment train'.**

Flood Control vs. Stormwater Management

In Southwest Pennsylvania, the '100 year storm,' has a 1% chance of occurring in any particular year, yielding about 6" of rain over 24 hours. Flood control systems—dams, channels, levees, etc., are designed to handle this type of rainfall event. However, these events are rare! Rain gardens are not flood control structures. They are sized to handle 1" of rain over 24 hours. The pie chart under Rainfall Events, shows 81% of annual precipitation, and almost 98% of our rainstorms, are less than or equal to one inch. Therefore, if you can manage one inch of rain, you are managing a huge percentage of storms.

BMP INTEGRATION

In Southwest Pennsylvania's clay-based soils and compact urban fill, it is essential that bioretention systems have underdrains to facilitate timely drainage of large runoff volumes.

Rain gardens by themselves, are effective in small drainage areas, up to six acres. On large sites, or as part of a larger stormwater management plan, they integrate well with other types of stormwater BMPs, such as, inputs from rooftops, rain barrels, or cisterns; and, outputs to level spreaders, stormwater wetlands, infiltration basins, sub-surface storage, on-site storm sewers, and detention basins.

Though most rain gardens are relatively small, integrating them into a site's BMP plan can increase their combined effectiveness several fold. For instance:

- Their small size allows them to fit into many possible site locations. Numerous infiltration points would help replicate pre-development hydrology conditions and recharge groundwater.
- Rain gardens make efficient use of small areas like parking lot islands and traffic control medians. Captured runoff volume in numerous rain gardens can add up to quite a large number—an amount that does not have to be held elsewhere, thereby reducing the need for, or size of, detention ponds, underground tanks or other BMPs.

EVALUATION 3 of 5

- Rain gardens are easy to clean and maintain. Litter can be removed by hand, and most maintenance can be performed with hand tools—saving the expense of bringing large equipment onto a site to otherwise clean out a detention pond or an underground tank.

PA DEP recommends that BMPs like rain gardens and bio-infiltration swales not exceed a 5:1 loading ratio. This translates to 5,000 square foot of drainage area into no less than 1,000 square feet of a stormwater BMP. It is also advantageous to combine BMPs in a 'treatment train'—a networked series where the first device handles the first flush, the second one receives excess flow, and maybe a third BMP for additional cleaning. Each cell successively manages stormwater quantity and improves water quality. Networked BMPs are proven to be more effective for water quality improvement than stand-alone BMPs.

CONSTRUCTION CONSIDERATIONS

It is important that bioretention cells are constructed after a site has been fully stabilized, when the drainage area into the rain garden is paved or fully vegetated. If installed during construction, rigorous erosion and sedimentation controls must be deployed around the bioretention cell to prevent siltation of the gravel envelope, underdrain, connector pipe, or inlet. This is critical for the long-term functioning of the rain garden.

- **Installation of a bioretention cell should be last in the construction sequence**, allowing time to stabilize the drainage area into the cell. Otherwise, a newly constructed rain garden can become 'capped' with sediments and not allow infiltration.
- **Construction of the bioretention device should follow engineered plans** with special attention to proper depth and placement of underdrain material, soil mix, and double-checking elevations for top of invert and top of berm to ensure proper functioning.
- **Maintenance is important for longevity and peak performance of bioretention systems.** A schedule for inspections throughout the year should be set by the property owner or manager to check plant health, debris, clogging, and overall structural integrity of the bioretention facility.

LIABILITIES

A bioretention cell is a sensitive, living engineering system. Its drawbacks on commercial sites are:

- **Winter salt may damage plants in a rain garden. Alternative methods of managing winter snow and ice should be used on site (i.e. plowing).**

Plant choices are important for rain gardens where winter salting is applied, or where spray from passing vehicles and snow trucks may reach the garden. Many species (see Plant List) are salt tolerant, but too much salt will harm plants. Rain garden maintenance should go hand in hand with site maintenance.

EVALUATION 4 of 5

Rain gardens may need soil and/or plant replacement every 10 to 15 years, depending on pollutant loading, or a malfunction in the cell.

Maintenance and monitoring is important to any stormwater management device. Each bioretention cell should be checked after major rain events and several times per year, especially during seasonal changes. Leaf litter, trash, and other fallout that clogs curb cuts or obstructs the overflow must be removed as often as possible. Plant material should be trimmed or replaced as needed to maintain healthy growth. A 3-inch layer of shredded bark mulch needs to be maintained to reduce volunteer weeds, facilitate pollutant removal, and keep moisture in the soil layer. From a pollutant loading standpoint, a rain garden that receives water from a roof has a lesser burden than one receiving runoff from a parking lot.

Bioretention cells are susceptible to clogging from upslope erosion sources. It is important to construct them in stable watersheds.

Bioretention relies on unobstructed infiltration to function properly. Areas upslope of a rain garden that drain into to it must be stabilized. Mud and construction debris can 'cap' a bioretention device with very fine particles (especially clay) which inhibits infiltration. It will become a pond instead of a rain garden. We always recommend that the underdrain, soil mix, mulch, and plantings of a rain garden be installed last, after construction is finished and the site has been stabilized.

COST EFFECTIVENESS

Relative to progressive stormwater BMPs in clay soils, 'bioretention is the most economical option up to 6 acres, followed by wet ponds from mid-sized watersheds, and stormwater wetland for watersheds over 10 acres.' Costs are based on both construction costs and annual operation, including inspection and maintenance. (The Economics of Structural Stormwater BMPs in North Carolina. North Carolina State University).

At a time when so much of our infrastructure is in need of replacement or repair and so few communities can foot the bill, we need resilient and affordable solutions that satisfy many objectives at the same time. Green infrastructure is one solution. Bioretention facilities and other types of green infrastructure can provide more benefits at less cost than conventional stormwater conveyance and detention systems. A growing body of research and experience across the country demonstrates how green infrastructure improves the triple-bottom line at multiple scales. EPA's green infrastructure website provides access to current cost-benefit analyses, tools, and case studies for developers and communities to review and inform their decision-making process.

Green infrastructure reduces stormwater runoff and improves water quality. These benefits can be measured by quantifying the costs associated with: 1) less grey infrastructure, 2) less water treatment, 3) less flooding and, 4) improved water quality discharged into streams. In environmetal economics, one

EVALUATION 5 of 5

approach is called 'avoided cost', that is, determining how much it would cost to convey, manage, and clean the amount of runoff water that was reduced by green infrastructure. A community could also quantify the value of well managed storm water in a watershed by measuring the economic benefits that result from improved fish habitat, riparian corridor restoration, recreation (fishing and trail use), aesthetics, and higher property values.

In Mount Pleasant Borough, 20 residential rain gardens and 9 commercial rain gardens were installed over a 4-year period. Each residential rain garden, on average, is 150 square feet with 6 inches of ponding depth, 24 inches of soil mix, and 12 inches of stone underdrain. Each one captures approximately 600 to 1200 square feet of roof, or, 375 -750 gallons of water in a 1-inch storm. These rain gardens cost approximately $25 per square foot for excavation, installation of all layers, and landscaping. Commercial rain gardens averaged 500 square feet with 12 inches of ponding depth, 24 inches of soil mix, and 12 inches of stone underdrain protected by a concrete curb. They cost approximately $35 per square foot.

SEASONAL INFLUENCES

In winter, plants transpire very little. However, their root systems continue to interact with soil bacteria, air and water, and provide moderate cleaning benefits to runoff and snow melt.

Rain gardens can be attractive year-round. In Winter, the proper choice of plants provide interesting color and textures. Ornamental grasses and perennial flower heads, for instance, provide a soft sculptural effect in the winter garden; fruiting trees and shrubs provide winter food and shelter for birds and small animals.

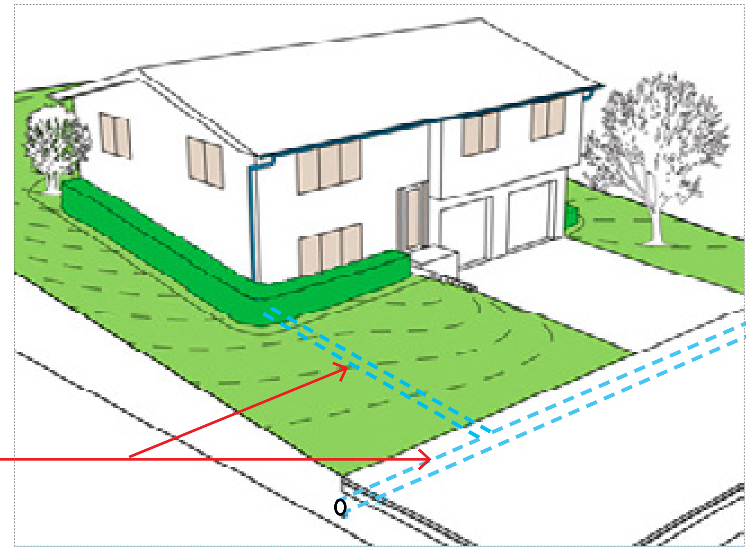
The winter function of a rain garden as a stormwater control is helped by good design and construction. The ponding area of a rain garden will store runoff from melting snow from a roof or a parking lot. Some rain gardens, depending on their design, can be used to store plowed snow in the same way as snow trucks use elevated traffic islands in parking lots. Stockpiled snow will melt and infiltrate into the underdrain that's protected from freezing (because it's below the frost line) and will carry away the meltwater.

From a hydrologic cycle standpoint,Southwest Pennsylvania rain gardens receive a similar amount of precipitation each month year-round. While it is true that evapo-transpiration is less in the winter, rain gardens continue to reduce peak flows and store runoff in the surface, soil mix, and underdrain materials.

RESIDENTIAL RAIN GARDEN 1 of 3

1

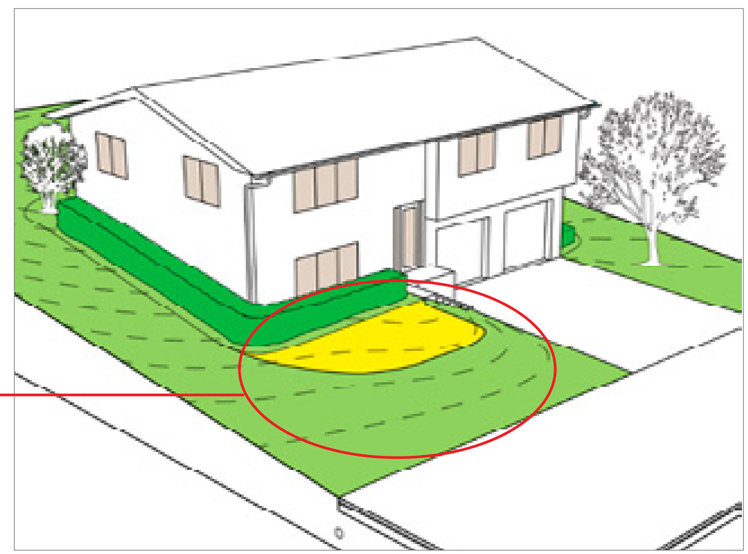
In most urban and suburban homes, the downspout connects to an existing storm or combined sewer. Here, both downspout and sewer are shown as dashed, blue lines.



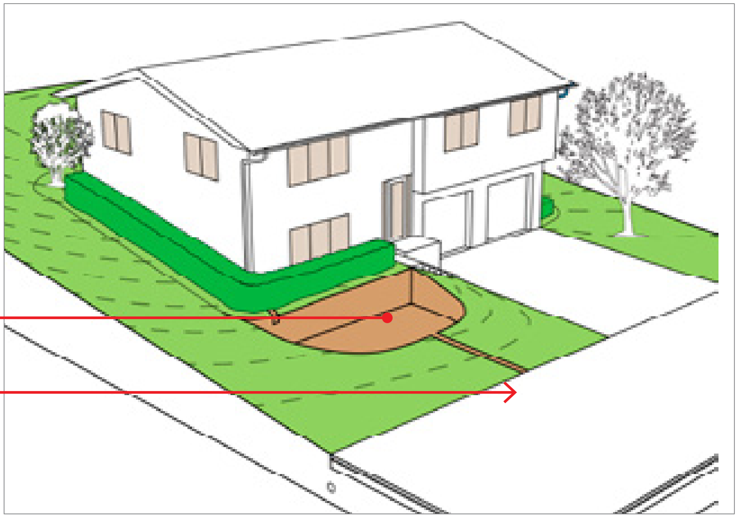
2

The first critical step early in the planning process is to locate one's above and below ground utilities.

Rain gardens are sited near the downspout and at least 10' away from the house.



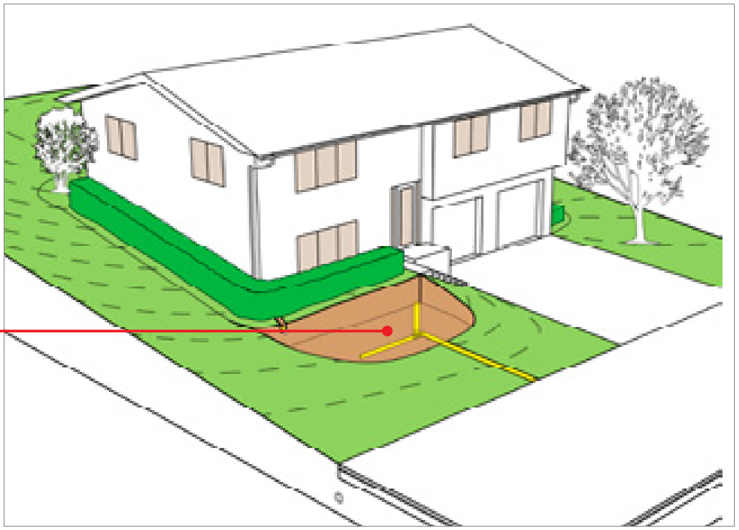
RESIDENTIAL RAIN GARDEN 2 of 3



3

The rain garden depression is excavated to a depth of 3-4 feet. Twelve inches for the underdrain and gravel envelope; 18-24" minimum for soil depth if one is planting shrubs and perennials, or 24-36" for medium to large trees; and 3" for mulch.

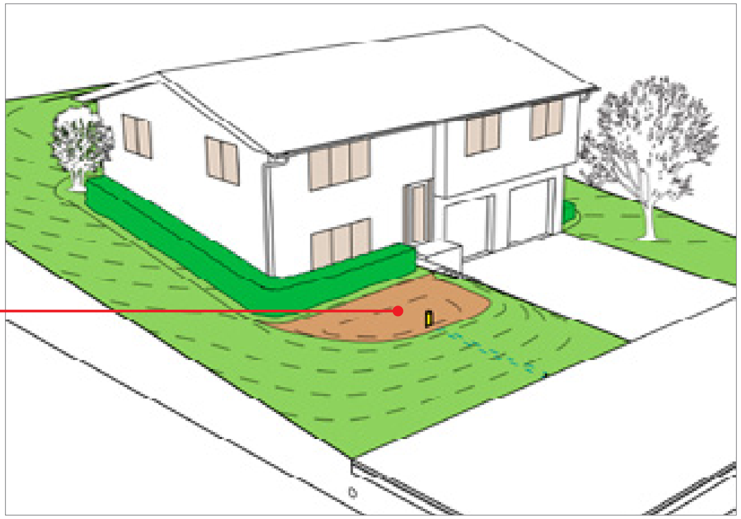
The trench is excavated to where the outlet pipe will discharge to the street or other approved outlet. An outlet pipe must not discharge where it would run off into a neighbor's yard.



4

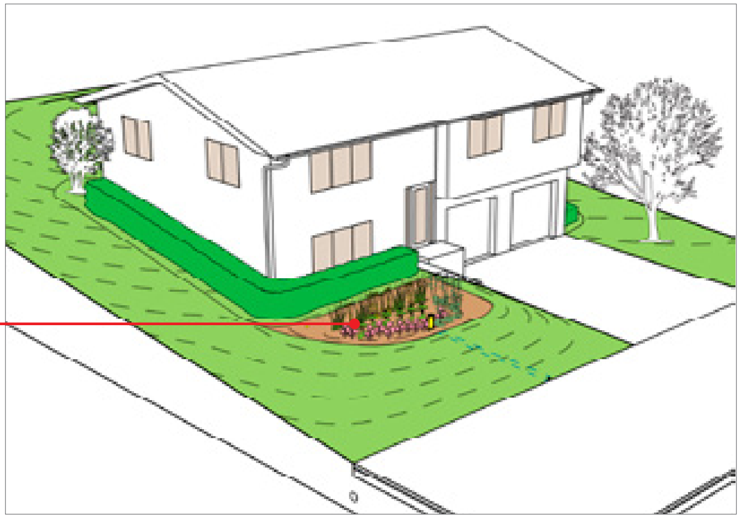
An underdrain and overflow system are installed in the bottom of the excavation. The underdrain includes a perforated pipe, covered in clean stone and wrapped in a geotextile fabric. A riser pipe or concrete inlet relieves a rain garden from a sudden influx of water. When the ponding level reaches 6" high, the water drains into the vertical outlet, and in this case, discharges out to the street.

RESIDENTIAL RAIN GARDEN



5

The soil mix is backfilled on top of the underdrain to a proscribed depth for plants chosen for the rain garden. A 6-inch deep ponding area is left on the surface with gentle side slopes; a 6-inch high berm prevents ponded water from 'spilling' out of the rain garden.



6

The completed rain garden includes plants to uptake the water, a 3-inch mulch layer to reduce weeds and retain soil moisture, and a rock dissipator where the downspout drains into the garden (to reduce erosion). The area around the garden, disturbed by construction, should be seeded with grass or stablilized with mulch or groundcovers.

LESSONS LEARNED:
1. Sedimentation

A stable drainage area is required for a fully functioning bioinfiltration cell. Bioinfiltration cells should be constructed **after** a site has been fully stabilized **or** only if the cell is well protected from sedimentation and runoff during construction.


Sediment clogs an unfinished cell after a rain-storm


Silt fence fails, allowing sediment to cover a cell


A thin crust of silt clogs the surface of a cell

Unstablilized soils upstream of a bioretention cell are likely to generate sediment-laden runoff that enters the cell, fills the depression, clogs the drainage system and impairs long-term infiltration capacity. If, during construction, a bioinfiltration cell becomes covered in sediment, sediment must be removed.

LESSONS LEARNED:

2. Underdrain / Gravel Envelope

An underdrain (gravel envelope) is highly recommended for the proper functioning of bioinfiltration cells. Underdrains should remain free of debris, sediment, and mulch for peak performance. Maintenance of the gravel envelope can be avoided by attention to detail during construction.

Sediment clogs the fabric layer after a rainstorm

Same inlet structure, with sediment removed and a new fabric layer installed before the soil mix is backfilled

The gravel underdrain should be wrapped in a woven or non-woven geotextile fabric designed to allow water in, but keep soil particles out. If during construction, the fabric layer is compromised by sediment, it should be replaced with clean fabric before the soil mix layer is added. Construction sediment, in this region, can be expected to have a high clay and/or content which can clog geotextile fabrics.

LESSONS LEARNED:

3. Discovery Process

Underground utilities and conditions should be identified prior to the design of a bioinfiltration cell. Sometimes, however, unmapped utilities or unknown conditions, like old field drains, may be encountered during construction.

An old field drain found during excavation

Unmapped field drain is sleeved and tied into the new underdrain

Pavement removal in older communities may include several layers

Unmapped utilities should be identified and dealt with in the field, adjusting the design as necessary to accommodate them. Existing field drains can be tied into the surface of a bioinfiltration cell or into the new underdrain system. Beware of multiple layers of older pavements when working in developed areas.

LESSONS LEARNED:
4a. Overflow Outlets

Setting the overflow outlet is important part of the construction process. The outlet structure must be stable, set at the proper elevation to capture ponded water (with no overflow outside the cell), and be kept free from clogging.


A well-anchored inlet in a stable drainage area


Poorly anchored inlet; wobbly


Inlet set too high


Long cells require multiple inlets


Long cells with multiple inlets need check dams at each inlet


Finely shredded mulch clogs an overflow riser

LESSONS LEARNED:

4b. Overflow Outlets

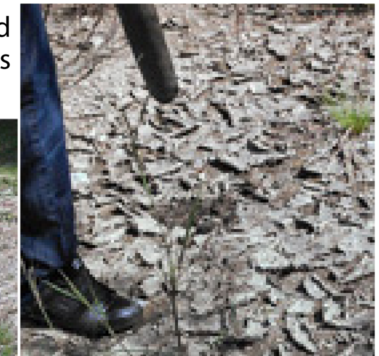
What we're shooting for: Free flowing water in an underdrain system; clean and free of debris

Installing overflow inlets calls for solid anchoring to prevent failure and breakage; setting the top elevation above the surface of the cell (to allow for ponding), and below the berm elevation(to avoid water leaving the cell). They need to be visually inspected at least twice a year, Spring and Fall, and after every major rain event. If an overflow structure is clogged by floating debris, leaves, mulch, or trash it will need to be cleaned out. (Ponded water needs unobstructed access to the overflow drain).

LESSONS LEARNED:
5a. Constructed Soil Mix

Well-constructed soil mixes are critical to proper, long-term functioning of bioinfiltration cells. Soils that drain too slowly or not all (due to excessive silts / clay), may need to be replaced years before they become exhausted of their beneficial bacteria, or saturated with contaminants found in runoff, (especially from parking lots). Bad soil mixes need to be removed and replaced. Well prepared soil mixes last for years.

Non-infiltrating surface water that evaporated and created an algal crust in the process



When soils are exceedingly slow to infiltrate, plants can die for a lack of oxygen in their root zone.

Newly installed plants 'pop up' from their holes in non-draining soils. Arrows point to two such plants in photo, left.

LESSONS LEARNED:

5b. Constructed Soil Mix

What we're shooting for: Well-constructed soil mixes, right ingredients, right proportions, uncompacted.

The recipe for a well constructed soil mix is: 50% topsoil, 30% sand and 20% compost. The topsoil should include less than 10% clay content, otherwise the mix will not allow for proper infiltration. The soil mix and plants should be monitored for health over time to determine if replacement is necessary. Current research shows that in a properly functioning rain garden plants can thrive from 5-10 years.

LESSONS LEARNED:

6a. Stable Drainage Areas & Dissipators

Stone or grass dissipator strips placed at the edge of bioretention cells reduce the energy of incoming runoff waters. At this interface, water slows down, sediments and litter drop out, and the mulch behind it is more likely to stay in place and not wash away. The area draining into bioretention cells should, ideally, be kept free from sediments and debris.

Finely shredded mulch dislodged by the force of incoming concentrated flows

A rock dissipator clogged with anti-skid material that needs to be cleaned out

LESSONS LEARNED:

6b. Stable Drainage Areas & Dissipators

What we're shooting for: The drainage area in and around a newly constructed rain garden is stabilized via hydroseeding. A river rock stone apron receives water coming into the rain garden.

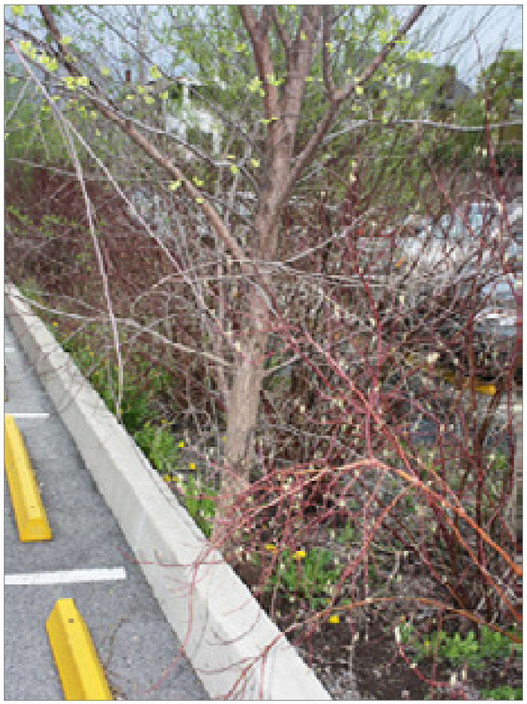
A stable rock dissipator at a curb cut

River rock or heavy vegetation should be placed where concentrated water enters bioinfiltration cells. Stone dissipators should be maintained and kept clear of clogging debris. After rain garden installation, the surrounding disturbed area needs to be finally stabilized with hydroseeding, grass, groundcovers, or mulch.

LESSONS LEARNED:

7. Maintenance

Bioinfiltration cells are landscape beds that need consistent maintenance: seasonal weeding and pruning, and annual mulch replenishment. Result: healthy plants, no weeds or invasive species, attractive community assets



A weed tree appears at the curb from lack of maintenance

Weeding in the Spring

A fresh layer of shredded bark mulch is added

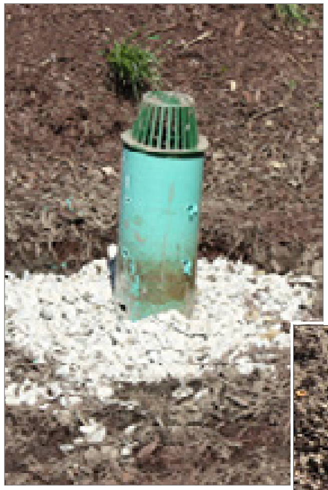
Mulch in rain gardens should be shredded hardwood bark, of a coarse and stringy texture so that it 'knits' together. (River rock can also be used to "mulch" cells where high flows are expected). Bark mulch must be renewed once a year, and may need to be replaced every 3 years. Weeding is a necessary maintenance task in a rain garden, especially as the plants are become established. Over time, mulch and plants work together to shade out unwanted volunteer species.

LESSONS LEARNED:

8a. Problem Solving

If ponding times are excessive in small rain events, the underdrain may be clogged or compromised and will need to be accessed and flushed out (via the overflow drain) or dug up and reconstructed. This 4-photo sequence shows before, after, and how the problem was solved.

1) Problem: Water remains ponded for several days in a row after a rainstorm. (Black platforms will support a future train set)



2) Two feet of soil mix was removed from around the riser; several 1/2" holes were drilled into the riser and gravel was placed back around it

3) Fabric was wrapped around the new stone to separate the gravel from the soil and mulch. Water now drains sideways into the riser.

LESSONS LEARNED:
8b. Problem Solving

What we're shooting for: Simple, effective problem solving. 4) This quick repair on the underdrain system keeps this rain garden (and its rail system) functioning properly. Yellow arrow points to the repaired riser.

One solution to a clogged rain garden is to remove a volume of soil mix surrounding the overflow riser, drill several one-half inch holes into its sides and backfill the excavation with gravel. Separate the gravel backfill from the soil and mulch with geotextile fabric. This allows ponded water to drain sideways into the overflow riser and down into the underdrain.

LESSONS LEARNED:
9. Flow Splitter

If the contributory area is too great for a bioinfiltration cell, the cell will be overwhelmed and damages may occur. Flow splitters remove excess runoff and divert it past the cell.

A rain garden in a parking lot is overwhelmed in a small storm, the 4-inch pipe in the background is flowing full.

The same rain garden after a flow splitter was installed. The same 4″ pipe now delivers an amount of water adequate for the rain garden's size. The rest of the split flow goes to the municipal storm sewer.

In retrofit projects, where bioinfiltration cells are placed in developed areas, contributory watershed size is sometimes hard to determine. Flow-splitters capture runoff upslope of a cell and 'split' it, diverting a portion to the rain garden and the rest typically goes to a storm sewer.

APPENDIX: WATER CYCLE

Natural Systems

The water cycle is earth's natural recycling system! What comes down, goes back up. Precipitation can follow a number of paths: rain or snow falls directly into creeks, rivers, lakes, and oceans; or lands on the ground and run across woodland soils and eventually infiltrates (or, falls on paved areas and transports pollutants that it encounters on its way into sewers that discharge into streams and rivers).

Water that descends returns to the atmosphere during evaporation from water bodies, and from transpiration where vegetation pulls up water from the ground for use during photosynthesis, and releases it back to the air through leaves as water vapor. The processes of evaporation and transpiration that create water vapor, leave pollutants behind where they are stored in soils, land masses, and water bodies all over the world. Only clean water is returned to the atmosphere.

There is never any NEW water on the planet, it is always recycling.

The Water Cycle includes:

Evaporation liquid water heated by the sun and released to the air as vapor

Transpiration the pump-like effect where plants pull water from the earth, use it in photosynthesis and release water vapor through their leaves

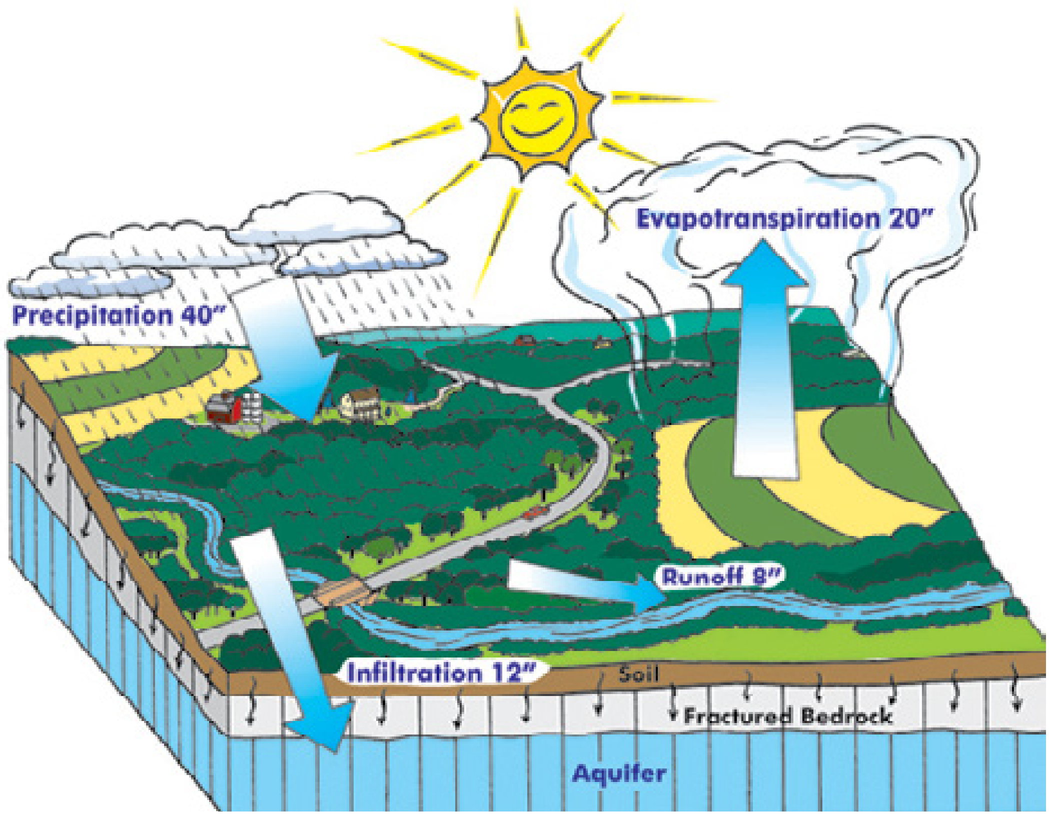
Condensation water droplets in the atmosphere that depending on thermal gradients may condense into clouds.

Precipitation rain, snow, sleet or hail, even fog

Infiltration the process of water seeping into soils and bedrock fissures, where it feeds forests, recharges groundwater, and sustains perennial base flow of streams

Runoff water travelling across the ground surface

APPENDIX: WATER CYCLE

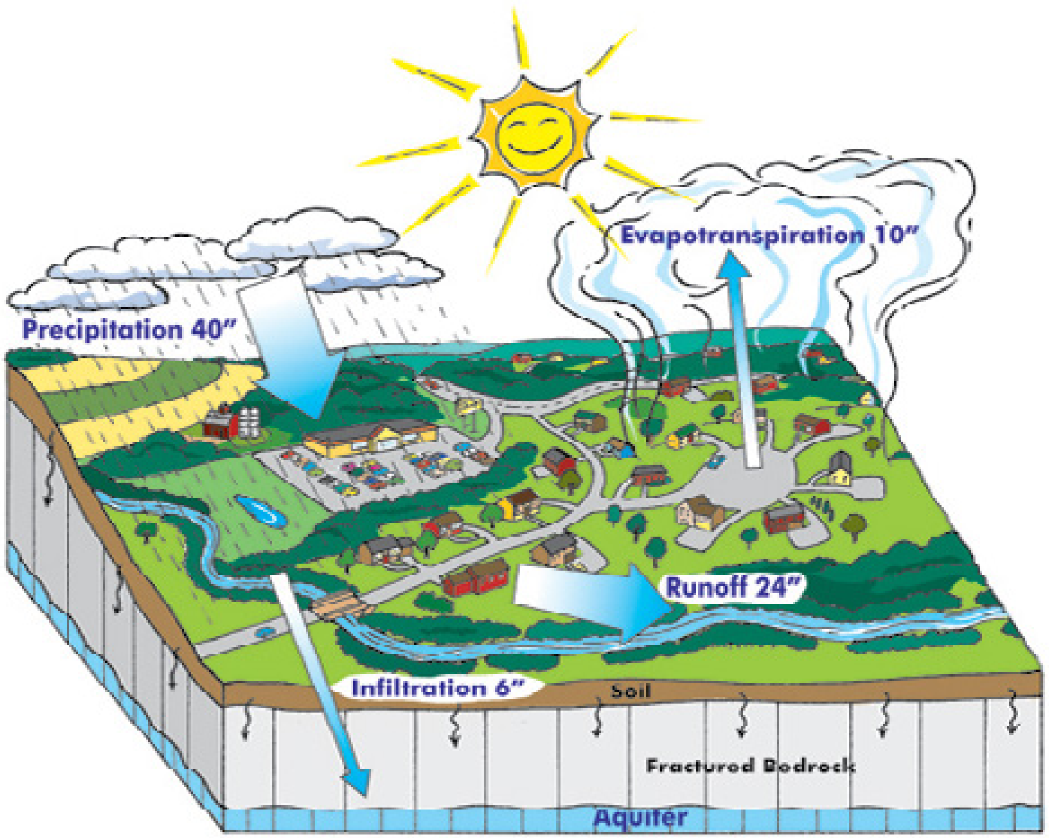


Pre-development

This illustration shows a tract of land that is considered open space, mainly woodlands and some agriculture. In this scenario, of the 40" that falls each year, half of that is returned to the sky by through evaporation and transpiration. (Hence, evapotranspiration). Over a quarter of it, or 12", soaks into the ground and infiltrates undisturbed soils. The remaining 8", is surface flow or runoff.

The fate of surface flow depends on several landscape factors: slope of the land, soil type, how saturated the soil is from previous rain or snow events, and what the "cover" is, such as forest leaf litter or grass. Its fate also depends on the amount of rain and its intensity. A steep wooded hillside wet from previous rain is going to shed a hard rain that will flow downhill to a lowpoint. On the other hand, a gently sloping corn field with a standing crop that hasn't seen rain for a week will easily absorb a light to moderate rain and infiltrate water.

APPENDIX



Post-development

Take that same tract of land, develop it with subdivisions, strip malls, commercial buildings, roadways and parking, and the water cycle changes dramatically. When dense vegetation is reduced by half, so is evapotranspiration. Wherever impervious surfaces like roofs, roads, and parking lots cover half of the ground the rainwater that soaks into the soil is halved. The amount of rainfall left to runoff the land triples from the Pre-Development scenario!

A lot of water-borne pollution comes directly from land surfaces. Rain picks up and transports sediments, debris, chemicals, and many types of pollutants. Fine particles and contaminant-laden runoff degrades streams and reduces the diversity and abundance of hundreds of species—insects, fish, amphibians, plants—that thrive in stream ecosystems. The negative consequences, including economic impacts, can be far-reaching.

Water is the most common substance on earth, yet less than 1% of Earth's fresh water is available for human use. The rest of the water is salt water, frozen as ice, is too deep or too contaminated to use.

Clean, fresh water sustains life, it ***is*** important to protect it.

LINKS

As more communities practice bioretention, more good information is becoming available online. One can find guidance and results from various state agencies, non-profit organizations, and public-private partnerships. Here are just a few of the many resources on the Internet that we have used:

National

Center for Watershed Protection, EPA funded educational materials and projects
www.cwp.org/
American Society of Landscape Architects, Stormwater case studies across the country
www.asla.org/ContentDetail.aspx?id=31301
Portland, Oregon's Stormwater Accomplishments
www.portlandoregon.gov/bes/34598
Philadelphia, Pennsylvania's Stormwater Accomplishments
http://phillywatersheds.org/
Maryland's Stormwater Accomplishments
www.rainscaping.org/index.cfm/fuseaction/home.home/index.htm (Maryland's accompishments)
Soil Mapping
http://websoilsurvey.nrcs.usda.gov/app/HomePage.htm (PA soil mapping)
Stream Flow Data
http://water.usgs.gov/osw/streamstats/pennsylvania.html (PA stream and watershed data)
Rain Data
www.noaa.gov

Pennsylvania

Pennsylvania Dept. of Environmental Protection's *Pennsylvania Stormwater Best Management Practices Manual*
www.elibrary.dep.state.pa.us/dsweb/View/Collection-8305
A big picture overview on the importance and positive impacts of progressive stormwater management. Case studies from Harrisburg to Philadelphia.
www.stormwaterpa.org/
An excellent resource all about Pennsylvania trees and stewardship.
www.patrees.org/municipal-resources

Western Pennsylvania

Calibrated Radar Rainfall Data for Allegheny County and much more.
www.3riverswetweather.org/ See Resources
A good resource to learn about (and buy) native plants for rain gardens
http://raingardenalliance.org/

PLANT LIST

YOU WILL FIND:

29 plants proven to work in rain gardens and bioinfiltration swales in SW Pennsylvania.

WCD suggests plant layouts that fill in nicely, and, supply durable plant power to help evapotranspire annual rain events.

PLANT SELECTION CONSIDERATIONS

The plants selected for bioretention cells in parking lots are the same ones we recommend for residential rain gardens.

Environmental and microclimate **conditions in a parking lot are challenging for plants:** full sun, summer heat, wind exposure, frozen soils in winter and road salt. The water that feeds the plants comes directly from rain and snow and runoff from impervious areas. In drought conditions, however, rain garden plants may need to be thoroughly watered.

Criteria for Rain Garden Plants include: relatively low-maintenance, commercial availability, no tap roots or thorns, and no invasive species. Low groundcovers were avoided due to the need for mulch replacement. Tall, canopy trees are suggested only for well-engineered streetscape plantings. This Plant List is only a starting point! We encourage you to research the cultivars of the plants listed here and discover new ones.

TREES

Julie Makin; 4028mdk09 / flickr

Janet Novak / Connecticut Botanical Society

Missouri Botanical Garden

LSU Horticulture Dept; Missouri Botanical Garden

	Sweetbay	**Serviceberry**	**'Winter King' Hawthorn**	**American Hophornbeam**
	Magnolia virginiana	*Amelanchier arborea*	*Crataegus viridis 'Winter King'*	*Ostrya virginiana*
	Native | Deciduous	Native | Deciduous	Native | Deciduous	Native | Deciduous
Height *(mature)*	**15 - 25 feet**	**15 - 25 feet**	**20 - 25 feet**	**25 -30 feet**
Canopy *(mature)*	**12 - 15 feet**	**12 - 15 feet**	**20 - 25 feet**	**15 - 20 feet**
Features	**Attractive Small Tree**	**White Spring Flowers**	**Red Berries in Winter**	**Horizontal Branching**
Characteristics	Single- or multi-stemmed tree, with an attractive upright shape. The large white, cup-shaped flowers are showy and fragrant. Red seed pods follow and provide wildlife food. Prefers moist soils over hot and dry.	An attractive slender tree, with single or multiple stems. Smooth bark. Profuse white flowers in Spring followed by edible blue fruit, enjoyed by birds and people. Good orange-red Fall color.	A disease-free tree with four season interest: silver bark, glossy leaves, profuse white flowers, and showy red berries. Horizontal branching pattern with age.	A graceful small tree with dark green leaves and flowers that resemble hops. Russet orange Fall color. Slow growing. Dependable performer. Drought tolerant once established.

TREES

Sally, Andy Wasowski / wildflower.org

River Birch

Betula nigra

Native | Deciduous

Missouri Botanical Garden

Red Maple

Acer Rubrum

Native | Deciduous

Robert H. Mohlenbrock / USDA-NRCS

Atlantic White Cedar

Chamaecyparis thyoides

Native | Evergreen

	River Birch	Red Maple	Atlantic White Cedar
Height *(mature)*	30 - 50 feet	35- 45 feet	35-50 feet
Canopy *(mature)*	15 - 35 feet	12 - 15 feet	10 - 15 feet
Features	Exfoliating Bark	Crimson Fall Color	Columnar Evergreen
Characteristics	A fast grower that is hardy and pest free. River birch tolerates Summer heat and thrives in moist soils. It is typically multi-stemmed. The peeling bark reveals cinnamon undertones and provides constant seasonal interest.	Red Maple is fairly fast growing. Its positive qualities include red flowers in Spring, silver gray bark year-round, and strong red color in Fall. It is a dependable grower in wet or dry soils.	Dark bluish-green foilage on fairly short branches. Slender, upright form. Soil tolerant, prefers sandy moist conditions. Does not like shade. Disease and insect free.

Note on Soil Depth

Soil in a rain garden should be an engineered mix of topsoil, sand and compost. The depth of the soil mix is determined by two things: the proposed plants for the rain garden and the amount of water to be stored. (See Primer: Design & Sizing).

Perennials and grasses with vigorous roots require at least 18 inches of soil mix. Shrubs, ranging from 3 to 6 feet in height, should have minimum 24 inches of soil.

Trees require at least 36 inches of soil. Deeper soil pockets can be designed into a rain garden by reducing the extent of the underdrain and/or having deeper sections off to the sides. The available space is a big determinant. Deeper soil 'pockets' may not require deeper excavation, and should not compromise the underdrain layer.

SHRUBS

Missouri Botanical Garden

Missouri Botanical Garden

fossilflowers.org

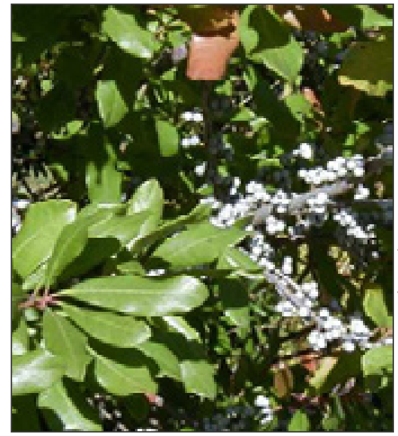
hornbakergardens.com

	'Hummingbird' Summersweet *Clethra alnifolia 'Hummingbird'*	**'Blue Muffin' Viburnum** *Viburnum dentatum 'Blue Muffin'*	**New Jersey Tea** *Ceanothus americanus*	**Fragrant Sumac 'Gro-Low'** *Rhus aromatica 'Gro Low'*
	Native | Deciduous	Non-native | Deciduous	Native | Deciduous	Non-Native | Deciduous
Height *(mature)*	**2.5 feet**	**3 - 4 feet**	**3 - 4 feet**	**3 - 4 feet**
Spread *(mature)*	**3 - 4 feet**	**3 - 4 feet**	**3 -5 feet**	**6 - 8 feet**
Features	**Late Summer Flowers**	**Blue Berries in Fall**	**Profuse Spring Flowers**	**Yellow to red Fall color**
Characteristics	Low, compact rounded shrub with glossy, dark green foliage. Fragrant white flowers July-Aug. Sun or shade. Prefers damp organic soils. Salt tolerant; deer resistant. Loved by birds and bees.	Compact and durable. It has showy white flowers that turn into deep blue berries that are enjoyed by song birds. Moisture tolerant.	A small rounded shrub with a profuse display of white flowers in early Summer. Tolerates diverse soil conditions. Attracts butterflies and hummingbirds.	Dependable and hardy, 'Gro-Low' is a low-mounding shrub and vigorous spreader. Orange-red Fall color. Tolerant of varied site conditions.

SHRUBS


Wouter Hagens
John Hixson Lady Bird Johnson Wildflower Ctr.


www.colesvillenursery.com

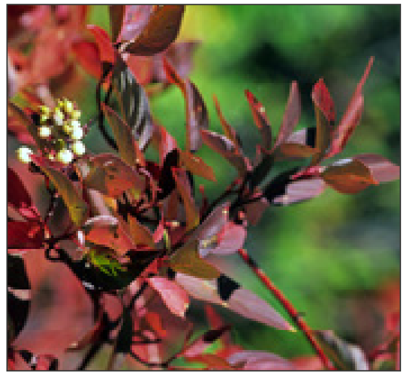

Missouri Botanical Garden


LSU Horticulture Dept.
Jeff McMillan USDA-NRCS PLANTS Database

	Dw. Cranberry Bush Viburnum	**Inkberry Holly 'Densa'**	**Bayberry**	**Sweetspire**
	Viburnum trilobum 'Compactum'	*Ilex glabra 'Densa'*	*Myrica pennsylvanica*	*Itea virginica*
	Native | Deciduous	Native | Evergreen	Native | Deciduous	Native | Deciduous
Height *(mature)*	**4 - 6 feet**	**5 feet**	**5 - 7 feet**	**6 feet**
Spread *(mature)*	**4 - 6 feet**	**5 feet**	**4 -6 feet**	**6 feet**
Features	**Crimson Fall Color**	**Glossy Evergreen**	**Winter Grey Berries**	**White spring flowers**
Characteristics	A dependable dwarf shrub with good features: leaf texture, white flowers, red fruit, and crimson fall color. It can decline in excessively wet soils.	A slow-growing, small-leaved holly with an upright-oval shape. Holds lower branches well. Fairly tolerant of winter salt, with strong environmental adaptabilty.	A hardy shrub that tolerates diverse soils. Attractive blue-gray berries persist well into Winter and provide food for birds. Salt tolerant. Will spread with time. Leaves and berries fragrant to the touch.	A moderately slow grower. Abundant, fragrant flowers appear mid-June to mid-July, with burgundy-red foliage in Fall. Tolerant of varied soil and moisture conditions.

SHRUBS


(c)2007 Derek Ramsey


Sally, Andy Wasowski / wildflower.org


pllantsgalleryblogspot.com

	Profusion Beautyberry	**Redosier Dogwood**	**Tricolor Gray Willow**
	Callicarpa bodinieri 'Profusion'	*Cornus sericea*	*Salix cinera 'Variegata'*
	Native | Deciduous	Native | Deciduous	Native | Deciduous
Height *(mature)*	6 - 8 feet	6 - 8 feet	5 - 10 feet
Spread *(mature)*	6 feet	6- 8 feet	5 - 10 feet
Features	Purple Berries in Winter	Bright Red Bark in Winter	Midsummer Tri-color Leaves
Characteristics	A vigorous bushy shrub with small lavender flowers July-Aug. Showy violet-purple fruits in Fall, enjoyed by birds. Does well in sun or light shade. Blooms on second year wood.	Fast growing, develops into large clumps over time. A real four season shrub: leaves, flowers, berries that are loved by birds, outstanding red bark in Winter. Hardy.	Rounded form with light green leaves mottled with cream and salmon. Colors are most intense in mid-Summer, then loses the pink notes. Trim back in Winter. Prefers full sun, moist soils.

Notes on Plant Spacing

Well-spaced rain garden plants maximize evapotranspiration functions, avoid overcrowding, and reduce invasive species. Perennials and shrubs may reach mature size in a rain garden. Trees, however, may not reach mature size in commercial settings depending on a number of factors, such as stress from pollutant loading, extended droughts, size of root area, or rate of growth.

Each plant species should be spaced according to their approximate mature size or size at 3 years of growth.

Rules of thumb:

Trees, 12 foot min. on center

Shrubs, 3 - 6 feet on center

Perennials, 2 - 3 feet on center

Ornamental grasses vary.

PERENNIALS

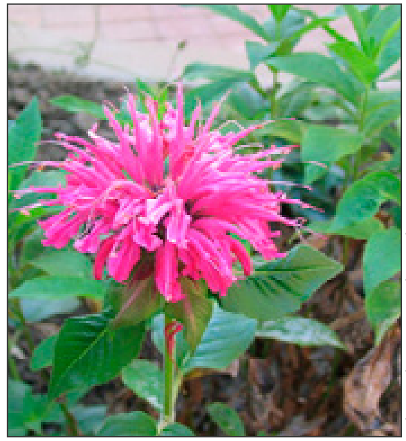
	 Dorot A. Wojslaw	 Sally, Andy Wasowski / wildflower.org	 Jennifer Anderson @ USDA-NRCS	 Missouri Botanical Garden
	'Stella D'Oro' Daylily	**Wood Geranium**	**New England Aster**	**Meadow Sage 'May Night'**
	Hemerocallis 'Stella d'Oro'	*Geranium maculatum*	*Aster novae angliae 'Purple Dome'*	*Salvia nemerosa 'May Night'*
	Non-native	Native	Native	Non-native
Height *(mature)*	**12 - 20"**	**18" - 2 feet**	**18" - 2 feet**	**18" - 2 feet**
Features	**Compact Daylily**	**Nicely Textured Leaves**	**Purple flowers in Fall**	**Violet Flower Spikes**
Characteristics	This compact daylily is very popular due to its compact form and profuse, dependable flowering. Soil and moisture tolerant, and resists pests. Plant 2' on center for a showy display.	Clump forming, good 'en masse'. Attractive deeply lobed leaves; long-lasting pink flowers in Spring. Prefers light shade. Will do well in full sun if watered during drought. Deer resistant. Plant 2' on center.	'Purple Dome' has a compact, mounded habit. It features a rich display of purple, daisy-like flowers in early Fall. Plant 2' on center for a showy display.	Upright, tidy shape with long-lasting, deep violet-blue flower spikes in May-June. Flowers attract birds, butterflies, bees. Plant 2-3' on center.

PERENNIALS

David G. Smith / Delawarewildflowers.org

Black-eyed Susan

Rudebeckia hirta



Alan Sylvester / Wikimedia

Beebalm

Monarda didyama 'Marshall's Delight'

Thomas L. Muller / LBJWC

Red Cardinal Flower

Lobelia cardinalis

Derek Ramsey

H. Zell / Wikimedia Commons

Purple Coneflower

Echinacea purpurea

	Black-eyed Susan	Beebalm	Red Cardinal Flower	Purple Coneflower
	Native	Native	Native	Native
Height *(mature)*	**2 - 3 feet**	**2 - 3 feet**	**2 - 4 feet**	**2 - 4 feet**
Features	**Bright Yellow Flowers**	**Butterfly Magnet**	**Intense Red Spikes**	**Long-blooming**
Characteristics	Persistent, showy yellow flowers June-Sept. Brown flower centers stay on through Winter, adding interest. Soils must be well drained. Attracts butterflies. Deer resistant and drought tolerant. Plant 3' on center.	Upright, clumping habit. Manageable spread (less aggressive than many Monardas). Flowers in mid-Summer. Good mildew resistance (cut to ground if afflicted). Deer resistant. Attracts hummingbirds, butterflies, and bees.	An upright plant with erect, intensely red flower spikes in July-Sept. Attracts hummingbirds and butterflies. Will need water during droughts.	A hardy native perennial, tolerant of diverse soil and growing conditions. Flowers June-Aug, the flower's central cone will persist into Winter. Attracts birds and butterflies.

ORNAMENTAL GRASSES

Ribbon Grass

Phalaris arundinacea 'Picta'

Native (naturalized)

Height *(mature)* **18" - 2 feet**

Features **Variegated Spreader**

Characteristics A vigorous spreading grass. Variegated with cream and green stripes. Light tan flower spikes appear from Jun-Oct. Soil tolerant, likes moisture. Full sun to part shade. Plant 2-3' on center. Cool season grass.

wolfhillgardencenter.com

Dw. Fountain Grass 'Hameln'

Pennisetum alopecuroides 'Hameln'

Non-native

2 - 3 feet

Feathery Texture

Clump forming, with 2' high fuzzy flower spikes up to in Summer that last through late Fall. Graceful texture, effective en masse. Plant 3' on center. Warm season grass.

Peter Gorman / flickr

Anya Quinn / flickr

Little Bluestem

Schizachyrium scoparium

Native

2 - 4 feet

Fall & Winter Colors

Tight clumps with upright habit, finely textured. Blue-green foliage in Summer turns mahogany in Fall. Soil tolerant. Full sun for best color. Plant 2-4' on center. Warm season grass.

Notes on Maintenance

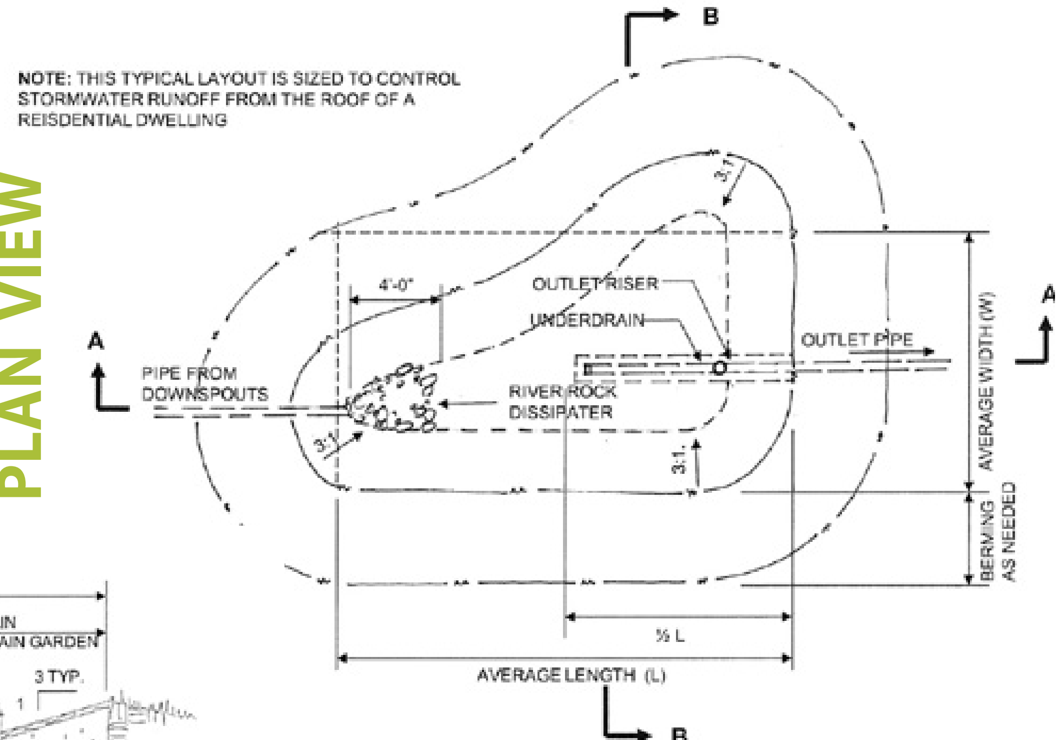
Ornamental grasses are low maintenance, deer resistant, drought tolerant, and withstand the tough microclimates of parking lots. They provide a lot and ask for little. Every year though, they must be cut back to a few inches above the soil level before new growth emerges.

Cool season grasses, like Ribbon Grass, need to be cut down in late Fall - early Winter (Nov-Feb). Their new growth emerges in early Spring when frost has largely passed.

Warm season grasses, like Fountain Grass and Bluestem, wait to emerge with warmer weather. Cut these back in early Spring (Apr-May). Their best colors and flowers occur in late Summer into Winter. Make this part of your maintenance schedule–it's worth it!

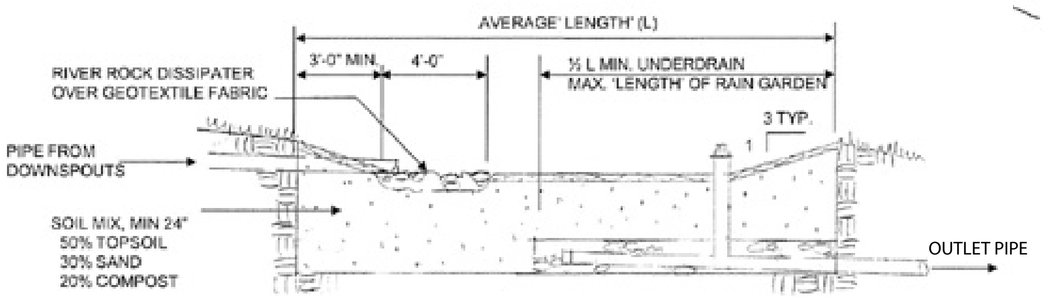
TYPICAL RAIN GARDEN

PLAN VIEW

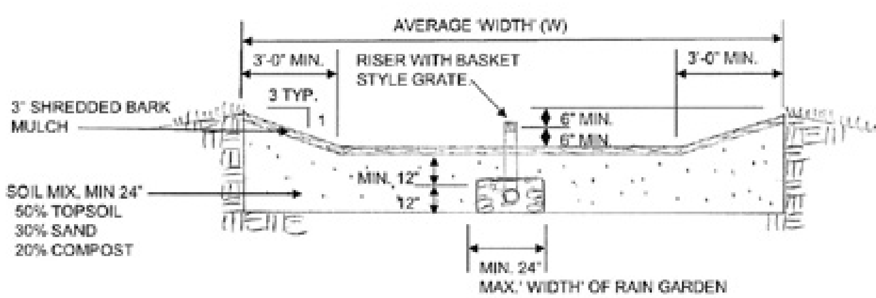


not to scale

CROSS-SECTION



SECTION AA



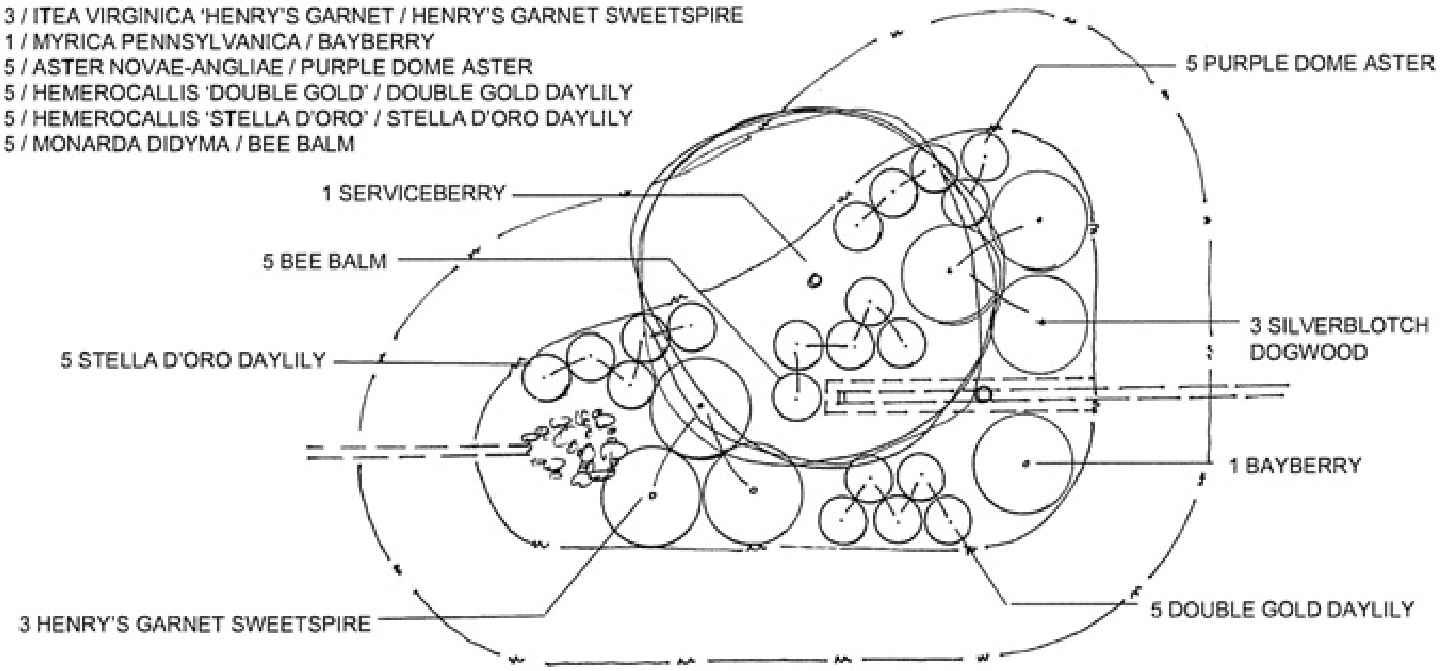
SECTION BB

PLANTING PLAN 1

PLANT LIST

QUANTITY / BOTANICAL NAME / COMMON NAME

1 / AMELANCHIER CANADENSIS / SERVICEBERRY
3 / CORNUS AUREO-MARGINATA / SILVERBLOTCH DOGWOOD
3 / ITEA VIRGINICA 'HENRY'S GARNET / HENRY'S GARNET SWEETSPIRE
1 / MYRICA PENNSYLVANICA / BAYBERRY
5 / ASTER NOVAE-ANGLIAE / PURPLE DOME ASTER
5 / HEMEROCALLIS 'DOUBLE GOLD' / DOUBLE GOLD DAYLILY
5 / HEMEROCALLIS 'STELLA D'ORO' / STELLA D'ORO DAYLILY
5 / MONARDA DIDYMA / BEE BALM



TYPICAL RAIN GARDEN PLANTING

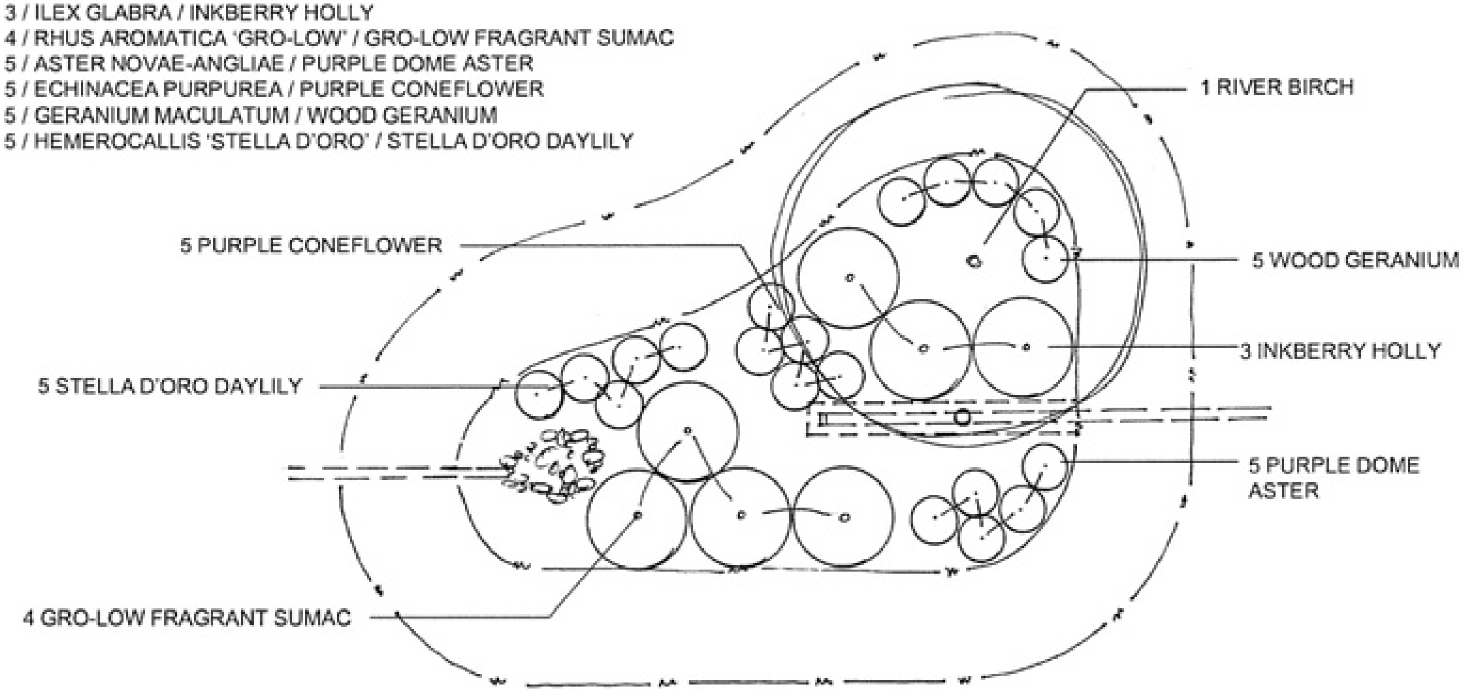
not to scale

PLANTING PLAN 2

PLANT LIST

QUANTITY / BOTANICAL NAME / COMMON NAME

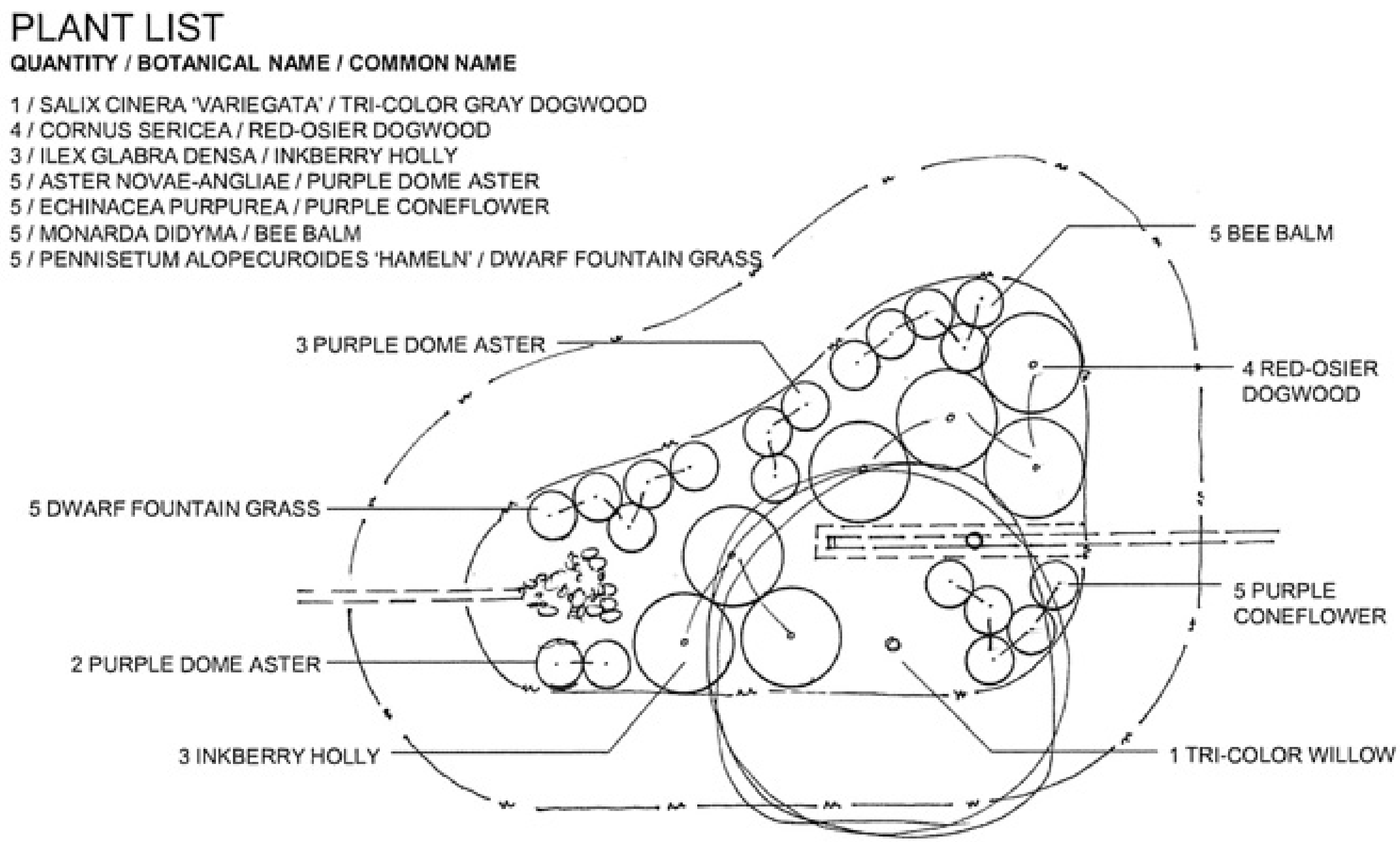
1 / BETULA NIGRA / RIVER BIRCH
3 / ILEX GLABRA / INKBERRY HOLLY
4 / RHUS AROMATICA 'GRO-LOW' / GRO-LOW FRAGRANT SUMAC
5 / ASTER NOVAE-ANGLIAE / PURPLE DOME ASTER
5 / ECHINACEA PURPUREA / PURPLE CONEFLOWER
5 / GERANIUM MACULATUM / WOOD GERANIUM
5 / HEMEROCALLIS 'STELLA D'ORO' / STELLA D'ORO DAYLILY



TYPICAL RAIN GARDEN PLANTING

not to scale

PLANTING PLAN 3



TYPICAL RAIN GARDEN PLANTING

not to scale

INSTALLATION AND MAINTENANCE NOTES

INSTALLATION

Limits of the proposed rain garden should be in a permanent stormwater easement.

Protect the rain garden location from compaction as much as possible during construction.

Keep sediments out of the rain garden before, during, and after construction. For instance, only begin construction after the area that drains into it is stabilized. Construct only where shown on plans.

Excavate to the proposed invert depth indicated on your plans, and scarify all soil surfaces. Do not compact the subgrade.

Install and connect the overflow riser, the underdrain (in coarse, clean stone wrapped in geotextile fabric) and the outlet pipe that drains to an approved outlet point.

Backfill rain garden with engineered soil mix as specified in the Primer and Photo Gallery. Overfill 5-10% to allow for settling. Hand compaction is fine.

Presoak soil, ideally 2-3 days, before planting. This will settle the soil and facilitate final grading (by hand) to achieve finished elevations.

Side slopes should not exceed 3:1 horizontal to vertical.

Plant vegetation according to the planting plan; mulch afterwards; install erosion protection at inflow and outflow points to prevent scouring.

MAINTENANCE

While vegetation is establishing roots and filling in, pruning and weeding will likely be necessary.

Detritus (leaf litter, etc.) should be removed at least twice a year—after leaf fall and before Spring growth.

Perennials and grasses should be cut back at the end of the growing season, or before the start of Spring growth. (More specifics under Plant List Ornamental Grasses).

Remove and replace mulch every 2 to 3 years.

Inspect rain gardens at least twice a year and, ideally, after every major rain event.

Look for:

- Sediment buildup
- Erosion & scouring at inflow & outflow points
- Mulch movement
- Vegetation health
- Riser & outlet functions

Replace, repair, re-mulch and re-plant material as needed to maintain peak rain garden functionality.

PHOTO CREDITS

TREES	
Atlantic White Cedar	Robert H. Mohlenbrock / USDA-NRCS Plants Database http://plants.usda.gov
Red Maple	Missouri Botanical Garden www.missouribotanicalgarden.org
River Birch	Sally and Andy Wasowski www.wildflower.org
Serviceberry	Janet Novak / Conneticutt Botanical Society www.ct-botanical-society.org
Sweetbay Magnolia	LARGE: 4028mdk09 / flickr INSET: Julie Makin / Lady Bird Johnson Wildflower Center. www.wildflower.org
Hawthorn 'Winter King'	Missouri Botanical Garden www.missouribotanicalgarden.org
American Hop Hornbeam	LARGE: Missouri Botanical Garden www.missouribotanicalgarden.org
	INSET: Louisiana State University Horticulture Dept. Lawn & Garden Plant Materials Database www.horticulture.lsu.edu/plantmaterials/default.htm
SHRUBS	
Bayberry	Missouri Botanical Garden www.missouribotanicalgarden.org
Beautyberry 'Profusion'	(c) Derek Ramsey, 2007 / Wikimedia Commons commons.wikimedia.org
Fragrant Sumac 'Gro Low'	www.hornbakergardens.com
Inkberry Holly 'Densa'	www.colesvillenursery.com
New Jersey Tea	www.fossilflowers.org
Redosier Dogwood	Sally and Andy Wasowski www.wildflower.org
Summersweet	Missouri Botanical Garden www.missouribotanicalgarden.org
Sweetspire	LARGE: Jeff McMillan / USDA-NRCS PLANTS Database http://plants.usda.gov
	INSET: Louisiana State University Horticulture Dept. Lawn & Garden Plant Materials Database www.horticulture.lsu.edu/plantmaterials/default.htm
TriColor Gray Willow	
Viburnum 'Blue Muffin'	LARGE: Missouri Botanical Garden INSET: Missouri Botanical Garden
ViburnumDw. Cranberrybush	LARGE: INSET: Wouter Hagens / Wikimedia Commons
PERENNIALS	
Aster 'Purple Dome'	Jennifer Anderson @ USDA-NRCS PLANTS Database
Beebalm	Alan Sylvester / Wikimedia Commons commons.wikimedia.org
Black-eyed Susan	David G. Smith www.Delawarewildflowers.org
Cardinal flower	Thomas L. Muller / Lady Bird Johnson Wildflower Center. www.wildflower.org
Daylily 'Stella D'oro	Dorot A. Wojslaw
Meadow Sage	Missouri Botanical Garden www.missouribotanicalgarden.org
Purple Coneflower	LARGE: H. Zell / Wikimedia Commons INSET: (c) Derek Ramsey, 2007 / Wikimedia Commons commons.wikimedia.org
Wood Geranium	Wasowski, Sally and Andy www.wildflower.org
GRASSES	
Ribbon Grass	Westmoreland Conservation District www.wcdpa.com
Dwarf Fountain Grass	www.wolfhillgardencenter.com
Little Bluestem	LARGE: Peter Gorman / flickr www.flickr.com INSET: Norman G. Flaigg / Lady Bird Johnson Wildflower Center. www.wildflower.org
Cover: Robin with berry	http://t0.gstatic.com/images?q=tbn:ANd9GcQWJPXzFAJFF9qOS3K4QPHIl5xd0nuXyL9T6qqFPvc9OSWDAIUv_A

PHOTO GALLERY

YOU WILL FIND:

9 diverse bioretention applications:

GREENFORGE

SCOTTDALE LIBRARY

VANDERGRIFT STREETSCAPE

MOUNT PLEASANT BOROUGH PARKING LOT

WESTMORELAND COUNTY COMMUNITY COLLEGE:

BIOINFILTRATION SWALE &

RAIN GARDEN

RESIDENTIAL RAIN GARDENS:

RESIDENCE A

RESIDENCE B

RESIDENCE C

BIORETENTION / BIOINFILTRATION / RAIN GARDEN: MANY NAMES, ONE PRINCIPLE

A library's roof drains into a bioretention cell; a residential rain garden captures roof runoff; a 400' long swale with multiple catchment cells replaces the low side of a parking lot--they all capture water that would otherwise quickly drain off into storm sewers. Each bioretention system intercepts water, slows it down, retains it, infiltrates it, and lets plants do the work of evapotranspiration. Each system is designed and engineered to mimic the natural processes of retaining water in soils and plants.

The projects shown here represent effective and readily achievable systems working in Westmoreland County, Pennsylvania.

GreenForge

This bioretention cell at GreenForge receives runoff from 2,000 square feet of roof. The design and installation is similar to cells receiving runoff from parking lots. After excavating the trench, workers place a 2'x2' concrete inlet box as an overflow drain.

Clean crushed stone is installed 12" deep around a 6" perforated pipe (underdrain) in a geotextile envelope. The underdrain connects to the overflow drain which is connected to a storm sewer system.

Project Partners:
Westmoreland Conservation District
GreenForge, Inc.
Pennsylvania Dept. of Environmental Protection
Ligionier Construction Company

GreenForge

The engineered soil mix (50% topsoil, 30% sand, 20% compost) was mixed at the contractor's yard and trucked to the site. It is placed 2.5' deep over the underdrain and not compacted. Side slopes in the rain garden are kept at 3:1.

Hardy perennials such as, geranium and daylily, and ornamental shrubs like bayberry and dogwood, were planted to provide seasonal interest throughout the year.

GreenForge

A 3-inch layer of shredded harwood bark mulch is added to, or replaced, every 2-3 years. The mulch layer suppresses volunteer weeds, facilitates pollutant removal, and retains moisture in the soil layer—important aspects for peak performace of bioretention cells.

To capture 1" of rainfall from the roof, the cell needs 167 cu. ft. of storage capacity. The void space in the gravel envelope accounts for 60 cu. ft., the soil mix for 112.5, totaling 172.5 cu. ft. Plus, the cell's surface storage totals more than 300 cu. ft.—plenty of storage for larger storms to slowly pass through the system without damage.

Scottdale Library

An abandoned section of a borough street between the Gazebo Park and Public Library is an ideal site for a rain garden retrofit.

The existing pavement layers were removed and the ground excavated to a 4-foot depth. The existing street inlet was left intact.

Project Partners:
Westmoreland Conservation District
Scottdale Library
Jacobs Creek Watershed Association
Scottdale Borough
Pennsylvania Dept. of Environmental Protection
Country Farms, Inc.
The Primrose Path

Scottdale Library

A stone underdrain with perforated drainage pipe is wrapped in a geotextile fabric layer that separates the constructed soil mix from the gravel envelope below it. A downspout from the Library is extended into the new rain garden.

A topsoil-sand-compost mix (ratio of 50:30:20) is placed to a 2-foot depth over the stone underdrain layer. A 12-inch ponding depth is left between the surface of the rain garden and the top of inlet.

Scottdale Library

The rain garden is planted in Ribbon Grass with shredded bark mulch. Stone is placed at the end of the Library's downspout to dissipate the inflow of water.

The rain garden after two growing seasons. Ribbon Grass is a vigorous spreader and flourishes in this 15' x 30' rain garden.

Vandergrift Streetscape

Before, Vandergrift's Columbia Avenue streetscape had wide sidewalks and little shade.

A 7-foot width of existing concrete and asphalt sidewalk was removed and trenched to a 4-foot depth.

Project Partners:
Westmoreland Conservation District
Vandergrift Borough
Vandergrift Improvement Program
Pennsylvania Dept. of Environmental Protection
Bruce Construction, LLC
J. Buzella Concrete Company

Vandergrift Streetscape

The trench was filled with a structural soil containment system (Silva Cells™) to hold a bioinfiltration soil mix of topsoil-sand-compost (ratio of 50:30:20) to promote healthy tree growth.

The Silva Cells (TM) come with 'lids' strong enough to support pavement layers above and protect the soil below from compaction. Lids were left off where the tree pits were proposed. A porous stone layer was installed on top of the lids to support the proposed paving system.

Vandergrift Streetscape

Contractors installed a porous concrete paving over the stone layer, leaving openings for the trees. The porous concrete and stone layer allow rainwater to drain freely through the sidewalk into the soil mix below to feed the tree roots.

Littleleaf Linden and London Plane canopy trees were planted in the tree pits now surrounded with porous concrete paving. Trees evapotranspire significant amounts of stormwater runoff that is captured and retained in the soil mix.

Mount Pleasant Borough Parking Lot

In Mount Pleasant Borough's public parking lot, four new rain gardens were installed. Each took up one parking space. The intent: introduce BMPs into a neighborhood that had very little stormwater management controls and where adjacent properties were affected by flooding.

After the pavement was removed, each site was excavated to a depth of four feet.

Project Partners:
Westmoreland Conservation District
Mount Pleasant Borough
Mount Pleasant Parking Authority
Pennsylvania Dept. of Environmental Protection
W. G. Land Company

Mount Pleasant Borough Parking Lot

Construction stage shows the concrete curb formwork, the gravel envelope in place and the untrimmed overflow riser in back left corner.

A worker finishes wrapping the gravel envelope, draping the geotextile fabric over the gravel envelope. This keeps the constructed soil mix out of the underdrain.

Mount Pleasant Borough Parking Lot

The engineered soil mix of topsoil/sand/compost (ratio of 50:30:20) is delivered into place.

Above, in the foreground and background are two of the four newly landscaped and mulched rain gardens. Each rain garden has two curb cuts with rock dissipators. Rock dissipators serve two important functions: they slow down runoff entering a rain garden thereby reducing erosion and trap litter and debris.

Mount Pleasant Borough Parking Lot

Two rain gardens in November, at the end of their first growing season.

Two years after installation and numerous rain events, the parking lot rain gardens successfully capture and treat runoff from each storm.

Westmoreland County Community College Bioinfiltration Swale

The area between the red dashed line and the grass is the proposed site of a bioinfiltration swale, 25′ wide x 400′ long. The swale is comprised of four individual infiltration cells. The intent: protect the small tributary to the left by intercepting, retaining, and infiltrating uncontrolled runoff water coming off the parking lot.

Project Partners:
Westmoreland Conservation District
Sewickley Creek Watershed Association
Westmoreland County Community College
Pennsylvania Dept. of Environmental Protection
The Silvis Group, Inc.

Westmoreland County Community College Bioinfiltration Swale

The project started with digging up and removing over 10,000 square feet of existing impervious surface.

Each of the four bioinfiltration cells was excavated to a 4-foot depth.

Westmoreland County Community College Bioinfiltration Swale

Each bioinfiltration cell has a concrete inlet box that connects to a perforated pipe underdrain (wrapped in a gravel envelope) that connects to a clean out.

A constructed soil mix of topsoil-sand-compost (ratio of 50:30:20) was placed 24-inches deep over the gravel envelope / underdrain.

Westmoreland County Community College Bioinfiltration Swale

Each cell works independently to collect runoff water and provide infiltration. Storms in excess of 1-inch can overflow each cell two ways: via the overflow inlet in each cell; and, in major rain events, the stone-lined channels (to the left) carry cleaner water safely to the tributary.

WCCC bioinfiltration swale project after a light rain in October 2009, two months after installation.

Westmoreland County Community College Rain Garden

The rain garden location prior to construction. The intent: divert runoff waters into a treatment cell where water quantity will be managed and water quality improved, thereby protecting the nearby stream.

The overflow outlet riser is set during construction. This will be accessed by high storm waters that originate in storms of short duration and in excess of 1-inch; or, it can be used by the high waters in the cell stemming from back-to-back rain storms, when rain garden soil is saturated. The overflow pipe leads to the adjacent stream.

Project Partners:
Westmoreland Conservation District
Sewickley Creek Watershed Association
Westmoreland County Community College
Pennsylvania Dept. of Environmental Protection
The Silvis Group, Inc.

Westmoreland County Community College Rain Garden

Surface grading of the rain garden's specific soil mix of topsoil-sand-compost (ratio of 50:30:20). Side slopes in the rain garden are not to exceed 3:1 horizontal to vertical, in order to prevent erosion.

Landscaping plants are spaced to fill in the garden when they reach their mature size.

Westmoreland County Community College Rain Garden

Three plant species are used here: Variegated Red Twig Dogwood, daylilies, and a variegated ornamental grass. A 3-inch layer of (undyed) shredded hardwood mulch is recommended in treatment cells to help remove pollutants and reduce weeding.

The WCCC rain garden 18 days after installation.

Residental Rain Garden – A

Step 1 in rain garden design: Locate your utilities! Here, the underground utilities have been located and flagged prior to any disturbance.

The homeowner's intent is to expand an existing landscape bed to include a rain garden that captures roof runoff from one downspout. Marking paint delineates the edges of the future rain garden.

Project Partners:
Westmoreland Conservation District
Mt. Pleasant Borough
Pennsylvania Dept. of Environmental Protection
Homeowners
Jupina Landscaping, Inc.

One-quarter inch (0.25") of rain per hour on 100 square feet of sloped impervious surface (roof or driveway) generates about 15 gallons of runoff per hour.

Residental Rain Garden – A

Rain garden excavation can be done carefully with little disruption to immediate surroundings. Rain gardens should be located at least 10′ from a building to prevent seepage.

The gravel envelope, above, consists of black geotextile fabric that wraps around the gravel, which in turn surrounds a perforated PVC pipe—the underdrain. The pipe riser (topped with a basket grate) connects to the underdrain and drains off excess water during large storms. In Southwest PA's clay soils, underdrains are necessary to bleed off excess water to the street or other approved outlet point.

Residential Rain Garden – A

The rain garden freshly completed. To the left, the downspout empties into a rock apron which slows and spreads the water across the surface. A variety of shrubs, grasses and perennials thrive on the water stored in the layers of the rain garden. For $2,000 to $5,000 on average, a residential rain garden can reduce wet spots in yards and control runoff in the neighborhood.

1 - 2 3 - 4 5

Residental Rain Garden – B

Rain garden excavation begins in the area marked and approved by the designer and homeowner.

Excavation goes approximately four feet deep. A berm on the low end of the rain garden will keep the water in.

Project Partners:
Westmoreland Conservation District
Mt. Pleasant Borough
Pennsylvania Dept. of Environmental Protection
Homeowners
The Silvis Group

Residental Rain Garden – B

The rain garden has been excavated, and positive drainage has been established from a high point to a low point. The black material is geotextile fabric that will wrap around the PVC pipe and its surrounding gravel. Geotextiles are used to keep soil out of underground drainage systems.

A carefully blended soil mix of topsoil-sand-compost (ratio of 50:30:20) is poured on top of the gravel envelope.

Residental Rain Garden – B

Good sizing allows for appropriate surface ponding and depth. Hand grading is ideal as it reduces compaction of backfill soil.

With construction complete, the disturbed area is hydroseeded. Next, the riser outlet will be trimmed to an elevation below the top of berm, but above the mulch layer, this allows water to pond temporarily.

Residental Rain Garden – B

The rain garden's first summer, July 2011. On the corner of the house is the downspout that has been disconnected from the sewer and now empties out into the far end of the rain garden.

The month of May, still early in the rain garden's second year. Shrubs include Beautyberry and Gro-Low Fragrant Sumac. The perennials are Cardinal Flower and Beebalm, all looking healthy.

Residental Rain Garden – C

This rain garden, under construction, is relatively shallow (less than three feet deep). It shows the soil mix and some of the plants in place, and the overflow riser (to be trimmed). The intent: intercept a downspout on its way to the street.

The newly completed rain garden is surrounded with a hydroseeded lawn mix. Toward the back is where the downspout empties onto a rock apron to slow and distribute the roof water across the surface of the garden. An overflow riser will capture rain water in excess of 1-inch storms and direct it to an approved outlet point.

Project Partners:
Westmoreland Conservation District
Mt. Pleasant Borough
Pennsylvania Dept. of Environmental Protection
Homeowners
Jupina Landscaping, Inc.

1 - 2 3 - 4

Residental Rain Garden – C

The beginning of the first growing season. Plants used: Dwarf Fountain Grass, Cardinal Flower, Beebalm, Liriope, and Iris.

The same rain garden after two growing seasons. The homeowner added annuals to extend the seasonal color palette.