Rain Garden Overview and Design

Roger Williams Park Botanical Center
Providence, RI
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What is a rain garden?

- Short answer: a depression in the landscape designed to collect and infiltrate stormwater
- Besides performing this function, they also look really nice
What’s going on in there?

- Reduction in stormwater volume
  - Infiltration
  - Evapotranspiration

- Filtration of coarse particles
  - Sediment
  - Bacteria

- Pollutants retained
  - Taken up by plants (nitrogen, phosphorus)
  - Adsorbed to mulch, soils, or organic matter (metals)
  - Broken down by microorganisms and sunlight (hydrocarbons, bacteria)
  - Converted to gaseous form

A Word on Terminology...

- **BIORETENTION**: Commercial applications-engineered design, modified soils, usually have underdrains
  - RI DEM Stormwater Design and Installation Standards Manual
  - Prince George’s County, MD

- **RAIN GARDENS**: Home-scale, not typically engineered, use existing soils
  - Wisconsin design manual
  - UConn design manual
  - Rutgers design manual
  - CRMC guidance
Rain Gardens

Vegetated areas designed to infiltrate and process stormwater

Residential Rain Gardens

Waterford, CT

Maryland
Ponding area

- Ponding is good, but not for more than 24 hours

Haddam rain garden

Infiltrated 99% of roof runoff!!

http://nemo.uconn.edu/successes/case_studies/haddam_demo/demosite_rain_garden.htm
Sizing and placing a rain garden

Rain garden placement

- Must be at least 10 feet from foundation with basement or where top of foundation is below ponding level
- Avoid placing within 15 ft of septic system or 25 ft to private drinking well
- Avoid placing in wet areas of yard- a rain garden IS NOT a water garden!
- Site to most effectively catch storm runoff
- Consider overflow
Important site considerations for rain gardens

- Avoid areas with:
  - Shallow (<3 feet) depth to bedrock
  - Seasonal high water table (<2 ft from bottom)

- Be aware of the infiltration capacity of native soils

- Watch for steep slopes
  - 25 ft setback up-gradient from natural slopes >15%

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**Slope**

\[
\text{Height} \div \text{Width} \times 100 = \% \text{ Slope}
\]

- For flat areas, no berm needed
- Moderate slopes, use berm
- Heavier slopes, use retaining wall design
- **More than 12\% slope, look for another location**
RI DEM requires residential systems be at least 25 ft up-gradient from slopes >15%
Nemostudent, 3/22/2011
Different siting applications

• Take water from:
  - Roof
  - Parking lot/road
  - Turf/mixed use

Roof

• Typically intercept gutter downspout leader
  - Can pipe, or run over pervious area first
Roof

- Drains to turf, sloped to garden

Parking lots/roads

- Either curbless, or can use curb cuts
Parking lots/roads

- Curbless

Alternate cul-de-sac
Parking lots & roads

- Provide forebay or turf filter area for sediment accumulation and cleanout
  - Preserves integrity of garden
  - Easier to maintain

Mixed use

- Can be difficult to figure out watershed and measure areas
  - Observe in rain storm
  - Break it up into shapes
Considerations for all types:

- Where flow is concentrated or in a pipe, provide something to break up energy
  - Reduces erosion potential
All types: Overflow

- For rain gardens, typically adjacent turf or wooded area
  - Avoid concentrating flow—spread it out to reduce erosion potential

Soils

- Simple percolation test
  - Dig hole 6 inches deep, and fill with water.
  - If there is still water in the hole after 24 hours, the site is **not suitable** for a rain garden
Soils

Better percolation test:

Steps:
1. Dig a hole 12 inches deep by 6 inches in diameter.
2. Fill hole with water and let stand until all the water has drained into the ground.
3. Refill the empty hole with water again. Measure the depth of water with a ruler.
4. Check the depth of water with a ruler every hour for 4 hours.
5. Calculate how many inches of water drained per hour.

~1.5 inches of water draining per hour is ideal

Soils

• My infiltration rate is only 0.8 inches per hour... will it still work?
  • YES, with some simple amendments or sizing adjustments

• My infiltration rate is only 0.5 inches per hour... will it still work?
  • Perhaps... but find out why
Soils

• Ball test: Squeeze a moistened ball of soil in the hand

• Soils break with slight pressure - Sand or sandy loam
• Stay together but change shape easily - Sandy loams and silt loams
• Soils resist breaking - clayey or clayey loam

Soil Ribbon Test

• Ribbons less than 1”
  • Feels gritty = coarse texture (sandy) soil
  • Not gritty feeling = medium texture soil high in silt

• Ribbons 1-2”
  • Feels gritty = medium texture soil
  • Not gritty feeling = fine texture soil

• Ribbons greater than 2” = fine texture (clayey) soil
Soils

- Send sample to county Extension Office for sand/silt/clay and/or nutrient analysis

- Sandy or loamy soils best, but others can be used with amendments

Soils

- What if the texture is OK, but the soil doesn’t drain?

- High water table
  - Pick a different site or see difficult sites information

- Compaction—the silent killer of rain gardens...
  - New construction especially prone
Site preparation

- AVOID COMPACTION!!!
  - Compacted soil will **cause** a rain garden or bioretention area to fail

- If it is highly compacted, need to remove, or loosen and aerate

Important factors with rain gardens

- SOIL COMPACTION before, during construction
Soil Amendments

- For compaction, loosen up and remove some of the compacted soil, and replace with sand/compost mixture

- For clay soils:
  - Make garden larger (based on soil sizing coefficient) and shallower, and amend with sand and some compost

- For very sandy soils:
  - Amend with compost to slow down the infiltration

- For urban fill soils, other adjustments may be needed

Roger Williams Park Site Specific Limitations

**BEFORE**

- 5” Loamy Sand
- 10” Fill
- Total Depth = 15”

**AFTER**

- 5” Loamy Sand
- 3” Mulch
- 1” Compost
- 5” Loamy Sand
- 6” Rain Garden Depth
Let’s get digging!

Installation

• Call hotline to locate underground utilities (at least 3 days in advance) 1 – 800 – DIG - SAFE

• Mark area to be dug

• Smaller gardens can be dug by hand (friends+beer=rain garden), or equipment can be rented for larger gardens
Installations, continued

- Dig out 8-9 inches of soil, keeping the bottom fairly level
  - A string or board can be used as a guide
  - Berm the bottom end, if necessary
  - Provide a gradual slope to the sides
  - Typical ponding depth is 4-8 inches (aim for 6 inches)
Installation by hand
(18 hands!)

Rain Garden Excavation

- Avoid compaction/sealing of bottom with bucket

Yelm High School, WA
Foot traffic only

Erosion

- Don’t allow runoff from an open, unstabilized construction site to enter the garden
  - Surface of bioretention will become clogged
North Kingstown Example

- Roof runoff from the North Kingstown Town Hall contributing to road flooding

North Kingstown Example

- Area Marked with flags and topsoil removed
North Kingstown Example

- Area dug out and underground pipe connecting gutter installed

Planting

- See the RI Coastal Plant Guide for plants to use in this area

http://www.uri.edu/cels/ceoc/coastalPlants/CoastalPlantGuide.htm
Plants

• Native or well-adapted non-natives

• Plants that like wet feet, but can tolerate extended dry periods

• NOT wetland plants!

• Can use different plantings for different parts of rain garden
**Mulch**

- Best is aged, shredded hardwood bark mulch
  - About 3 inches in depth

- NOT pine bark nuggets!
  - They float

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**Important factors with Rain Gardens**

- Make sure storage depth is correct at installation
A well-installed Rain Garden...

- Has open flow paths, overflow and an adequately sized storage area
- Has proper materials installed
- Has NON-COMPACTED soils!
- Is only used after the surrounding site is stabilized
- Has proper plantings/ground cover
- Has a provision for short term care (watering), and in arid climates irrigation

Bioretention specifics
Bioretention profile

- Flow entrance
- Overflow
- Bark mulch layer
- Bioretention soil mixture
- 12” of crushed stone (1-2”)
- Perforated under-drain

Bioretention soil mix

- RI Design and Installation Standards Manual defines bioretention soil mix as follows:
  - sand 85-88%
  - silt 8-12%
  - no more than 2% clay
  - organic matter in the form of leaf compost 3-5%

Addition of 20% volume leaf compost required only with soil depth < 4 ft, or more if soil fine content is < 12%.

- For a rain garden, native soils amended with compost and mulch layer is recommended
Bioretention

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Installation materials

- Soil mix, plants, mulch (underdrain, crushed stone)
- Filter fabric only placed above underdrain
  - Not needed for residential sites
  - Don’t line bioretention, don’t wrap underdrain pipe
- Non-woven geotextile

What about a liner?

- Lining is only needed in very specific applications
- Partial lining where you don’t want water to go
- Full lining in “hot spots”
  - Gas stations, industrial facilities, brown field sites
  - Bioretention is just a filter in these cases
Underdrains

- Purpose is to reduce potential for extensive surface ponding
- RI Stormwater Design and Installation Standards Manual recommends underdrains to assist in dewatering
- Highly recommended for commercial/urban bioretention
- Slotted (ADS) or perforated (PVC) pipe at bottom or just above bottom of bioretention, surrounded by crushed stone/gravel blanket

Crushed stone

- 1-2 inch washed crushed stone around pipe, then a pea-stone gravel “blanket” on top, before soil mix gets applied.
Underdrains

- Drain to grade (best) or stormwater system (OK)
- Underdrains can be placed on a minimum 3'-0” wide section of geotextile. Pipe is placed next, followed by the gravel bedding.
  - Filter fabric should be used only on top of the portion of the pea gravel layer that is over the underdrain

From RI Stormwater Manual (2010)
Underdrains

- Elevated drain
  - Increases chance of infiltration into native soils
  - Provides good environment for denitrification

Overflow

- Typically stormwater system
Sizing Your Rain Garden
How Big Should it Be?

• Simple method
  • Sized to store 1 inch of runoff from 100% impervious watersheds

• Soil Based method
  • Multiply drainage area by soil sizing coefficient

Simple Sizing

• Calculate area of roof feeding to garden
Simple Sizing, continued

• 50 feet x 30 feet = 1500 square feet

• 1500 feet / 2 = 750 square feet
  • This is because only half the roof contributes to the garden

• 750 square feet / 6 = 125 square feet
  • This just sizes the garden to hold 1 inch of water from the roof in a 6 inch deep rain garden

Sizing, continued

• 125 square feet
  • Garden can be shaped in a variety of ways
Why 1 inch?

- In the East and Midwest, around 90% of storms are 1” or less
- Wisconsin design guide
- UConn design guide
- Bioretention manual
Is it really that big of a deal? 1 inch isn’t much, right?

Let’s see how Google sees the world

- 24,879 ft²
- 1 inch of rain = 15,509 gallons
- Average year = 48 inches...
  - 744,432 gallons!
- This is one small area!
**Soil Based Sizing Method**

Rain Garden Surface Area in *Sandy Soils (Sands, Loamy Sands and Sandy Loams)* (square feet)

<table>
<thead>
<tr>
<th>Drainage Area (Square feet)</th>
<th>for 4 inch deep garden</th>
<th>for 6 inch deep garden</th>
<th>for 8 inch deep garden</th>
</tr>
</thead>
<tbody>
<tr>
<td>200</td>
<td>38</td>
<td>30</td>
<td>16</td>
</tr>
<tr>
<td>400</td>
<td>76</td>
<td>60</td>
<td>32</td>
</tr>
<tr>
<td>600</td>
<td>114</td>
<td>90</td>
<td>48</td>
</tr>
<tr>
<td>800</td>
<td>152</td>
<td>120</td>
<td>64</td>
</tr>
<tr>
<td>1000</td>
<td>190</td>
<td>150</td>
<td>80</td>
</tr>
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</table>

- Calculate size of rain garden
  - For sandy soils, with a 6” deep garden, multiply drainage area by 0.15 to obtain size, or use chart

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**Your turn!**

Drainage area

Rain Garden Location

Watershed is 100% impervious = 1,917 ft²
Simple example

- If watershed is 100% impervious, size to capture 1 inch of runoff
- $1917 \text{ ft}^2 / 6 = 320$ square feet (6 inches deep)

Soil Based Sizing Example

- Drainage Area = 1917 ft$^2$
- Rain Garden Depth = 6 in
- Soil Type = Sandy
- Surface area = 150 ft$^2$/1000 ft$^2$ of drainage area

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Or use 0.15
Roger Williams Park Example

- $1917 \text{ ft}^2 \times 0.15 = 288 \text{ ft}^2$

*This area is different from the basic sizing example due to factoring in the sandy soils*

One plot was not big enough for our required rain garden area so we will be oversized.

RWP Botanical Center
Rain Garden Schematic
1 Floral Avenue
Providence, RI

Walkway slope = 1% toward storm drain
one plot was not large enough to accommodate our required rain garden area - we are oversized. Just mention or leave textbox.

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For Mixed-Use Drainage Areas

• Based on “Water Quality Volume”
  • 1 inch

• Use equation \( WQ_v = \frac{(P)(R_v)(A)}{12} \)
  • \( P = 1.0 \) inch
  • \( R_v = 0.05 + 0.009(I) \)
  • \( I = \) Percent impervious (1-100)
  • \( A = \) Total watershed area (square feet)

From Bioretention Manual (Prince George’s County, 2009)

References of interest:

RI NEMO
  • http://www.stormwatersolutions.org
UCONN NEMO
  • http://nemo.uconn.edu/
Low Impact Development
  • http://epa.gov/region01/topics/water/lid.html
  • http://www.lowimpactdevelopment.org/
GreenScapes New England-
  • http://epa.gov/region01/topics/waste/greenscapes.html
Rain Gardens
  • http://www.raingardennetwork.com/
  • http://www.raingardens.org/Index.php
  • http://www.dnr.state.wi.us/runoff/rg/
Sample Planting Schemes

Step 6: Maintenance

- Similar to other landscaped areas
  - Yearly mulch, if desired
  - Prune plants, if desired
  - Irrigate/water as necessary

- Sediment removal if required

- **MOST IMPORTANTLY:** Maintain flow paths and storage area
Rain gardens are easier

Maintenance (bioretention)

- Flow paths and storage
- Watch for sediment accumulation
we have a presentation on maintenance - might be geared toward bioretention

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Branford Police Station

Flow paths and erosion