Rain Garden Design & Maintenance

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Auburn Hills Community Center
What is a Rain Garden?
What is a Rain Garden?

© State of Minnesota Stormwater Manual
Rain Gardens

Lathrup Village, MI
Courtesy of Lillian Dean
Rain Garden or Bioretention Cell

- Buffer
- Plants
- Mulch
- Ponding
- Planting Mix
- Underdrain (optional)
- Additional Storage (optional)
- In-situ soils
Why have a Rain Garden?
Hydrologic Cycle

40% evapotranspiration
10% runoff
25% shallow infiltration
25% deep infiltration
Natural Ground Cover

38% evapotranspiration
20% runoff
21% shallow infiltration
21% deep infiltration
10%-20% Impervious Surface

35% evapotranspiration
30% runoff
20% shallow infiltration
15% deep infiltration
35%-50% Impervious Surface

30% evapotranspiration
55% runoff
10% shallow infiltration
5% deep infiltration
75%-100% Impervious Surface

http://www.nrcs.usda.gov/technical/stream_restoration/scrhimage.htm
Rain Gardens - Benefits

- Key feature for LID/conservation design
- Focus on water quality volume – know as first flush (first ½” to 1” of rainfall) & represents 90% of all rainfall events
- Filter and removal mechanism - remove sediments (85%), nutrients (50% - 80%), metals (95%), and hydrocarbons (80%)
- Stormwater master plan => rain gardens can have tremendous impact on a watershed
Rain Gardens – Benefits

- Improved natural habitat & biodiversity
- Less drug depended turf grass to mow
  (reduces carbon emission – global warming)
- Landscaping improves property values
- Joy of gardening
How do Rain Gardens work?
How do Rain Gardens work?

- Rain Gardens capture and filter stormwater
- Numerous physical and biological processes including evapotranspiration, adsorption, filtration, plant uptake, microbial activity, decomposition, and volatilization
- Planting mix comprised of sand, topsoil, and compost - topped with mulch
How do Rain Gardens work?

- **Mulch**
  - Filter pollutants & microorganism degrade hydrocarbons
  - Protects planting mix from eroding and holds moisture in during dry season

- **Planting Mix**
  - Absorbs and degrades pollutants
  - Clay specifically good at absorbing hydrocarbons and heavy metals
  - Sand improves drainage
  - Compost provides nutrients and increases retention
How much sand, topsoil, or compost should I use?
Rain Garden Mix Designs

- Numerous recommended mix designs have been published
- For new community developments mix designs might be specified by municipality
- Example Mix Designs:
  - 50% sand, 30% topsoil, 20% compost
  - 20 – 40% sand & 60 – 80% compost (SOCWA)
- Balance sand & compost based on your specific site and native soils
Effect of Sand on Field Capacity

The graph shows the relationship between the percentage of water retained and the percentage of sand content by volume. As the sand content increases, the percentage of water retained decreases significantly.
Effect of Sand on Permeability

![Graph showing the effect of sand content by volume on permeability. The x-axis represents % Sand Content by Volume ranging from 0 to 100, and the y-axis represents Permeability (in/hr) ranging from 0 to 60. The graph indicates an increasing trend of permeability with increasing sand content.]
Implications for Rain Garden Design

- If the goal of the rain garden is to maximize water retention (clay soil sites), limit amount of sand & topsoil => 80% compost
- If goal is to promote infiltration into permeable soils, then increase amount of sand => 50% compost
- If hydrocarbons or heavy metals are a concern, include topsoil with clay in the mix.
- Overall, be aware of the impact your soil mix will have on your rain garden performance.
How do I design a Rain Garden?
How do I design a Rain Garden?

Observation or Quantitative
Rain Garden Infiltration

- Infiltration of native soils is key for performance
- Need native soil information for proper design
  - HSG maps (soil type A (1 to 3 in/hr); B (0.5 in/hr); C (0.2 in/hr); D (< 0.1 in/hr)
- Home test
  - 18” hole – fill with water; drain, refill and record
  - Infiltration rate \( (i) \) = rate fall/time = inches/hour
  - If original fill takes more than 48 hours = clay
  - Key is infiltration at “bottom” of the rain garden
Rain Garden Infiltration

- Improve infiltration by tilling or ripping
- $i > 0.5 \text{ in/hr}$ then basic rain garden design
- $i < 0.5 \text{ in/hr} \implies \text{underdrain or overflow}$
- Above seasonal water table
Rain Garden Sizing

- Total area flowing into a rain garden should be less than 1 ac total and ½ acre impervious
- Minimum rain garden dimensions are commonly 10 ft by 20 ft
  - any size will work as a landscaping feature
- Recommended planting mix depth is 2.5 ft (1 ft to 4 ft)
- Ponding depth is typically 6” to 18”
- Recommend 24 to 48 hours to drain (< 72 hours)
Rain Garden Design Techniques

- Homeowner How-to Manuals available from U of Wisc. Ext., VA Dept of Forestry, & SOCWA
- Numerical Design Techniques
  - Run-off Method
  - Simplified Darcy’s Law
Rain Garden Design
Run-off Method

- Developed in the Mid-Atlantic

- Assumptions
  - 1” of rainfall will be capture
  - 2.5 ft and 4ft of planting depth with 50/30/20 mix
  - 6” ponding with 48 hour drainage time
  - Doesn’t consider native soils

\[
SA = 0.07 \times (C_{imp} \times DA_{imp} + C_{green} \times DA_{green})
\]

- \(SA\) = surface area of filter bed (rain garden) (\(ft^2\))
- \(C_{imp}\) = runoff coefficient of impervious surfaces = 0.9
- \(C_{green}\) = runoff coefficient of green areas = 0.25
- \(DA\) = drainage area (\(ft^2\))
Rain Garden Design

Simplified Darcy’s Law

- Simplified by Dr. Carpenter for local conditions
- Assumptions
  - 1” of rainfall will be capture (90% of all rain events)
  - Excess rainfall should be bypassed
  - Well maintained rain garden with mix of compost/sand
  - 48 hour drainage time
  - Includes infiltration rate of native soils
Rain Garden Design
Simplified Darcy’s Law

\[ SA = \frac{0.04 \times c \times DA \times depth}{(i) \times (depth + ponding)} \]

- \( SA \) = surface area of rain garden (ft\(^2\))
- \( DA \) = drainage area (ft)
- \( depth \) = planting bed depth (ft)
- \( i \) = infiltration rate (ft / day)
- \( c \) = runoff coefficient (between 0.1 and 0.9)
- \( ponding \) = average ponding depth (ft)

Runoff coefficient spectrum

Native 0.1 0.3 0.5 0.7 0.9 Lawn Patio Roof/Drive
Bioretention Cell
Design Example

DA 1
Rain Garden Design Solution Sheet  
Run-off Method  

\[ DA = 7500 \text{ sq.ft total with } 2000 \text{ sq.ft roof } \& 5500 \text{ sq.ft backyard} \]  
\[ C_{imp} = 0.9 \]  
\[ C_{green} = 0.25 \]  

Solution:  

\[ SA = 0.07 \left( C_{imp} \cdot DA_{imp} + C_{green} \cdot DA_{green} \right) \]  
\[ SA = 0.07 \left( 0.9 \cdot 2000 + 0.25 \cdot 5500 \right) = 222.25 \text{ ft}^2 \]  

Dimensions of Rain Garden = 20 feet by 11 feet
Rain Garden Design Solution Sheet
Darcy’s Law

\[ DA = 7500 \text{ sq ft total with 2000 sq ft roof & 5500 sq ft backyard} \]
\[ c = 0.4 \]
\[ depth = 2.5 \text{ ft} \]
\[ ponding = 0.5 \text{ ft} \]
\[ i = 1 \text{ ft/day (sandy soils)} \]

\[ SA = \frac{0.04 \times c \times DA \times depth}{(i) \times (depth + ponding)} \]

\[ SA = \text{surface area of rain garden (ft}^2) \]
\[ DA = \text{drainage area (ft)} \]
\[ depth = \text{planting bed depth (ft)} \]
\[ i = \text{infiltration rate (ft/day)} \]
\[ c = \text{runoff coefficient} \]
\[ ponding = \text{average ponding depth (ft)} \]

Solution:

\[ SA = \frac{0.04 \times 0.4 \times 7500 \times 2.5}{(1) \times (2.5 + 0.5)} = 100 \text{ sq ft} \]

Dimensions of Rain Garden = 12 feet by 8 feet
### Rain Garden Design

#### Comparison

- 1000 sq ft of roof (all impervious)
- 2.5 ft of planting depth & 0.5 ft ponding
- Sand (1.0 ft/day) & Clay (0.2 ft/day)

<table>
<thead>
<tr>
<th></th>
<th>Simplified Darcy’s</th>
<th>Run-off</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>30 sq ft</td>
<td>63 sq ft</td>
</tr>
<tr>
<td>Clay</td>
<td>150 sq ft</td>
<td>63 sq ft</td>
</tr>
</tbody>
</table>
Where should I locate my Rain Garden?
Rain Garden Design
Location & Landscaping

- Observe natural flow paths
- Direct water from down spouts and pavement into the garden
- Create berms with overflows
- Not within 10 ft of building foundation
- Avoid underground utilities - Call Miss Dig!
- Avoid disturbing mature trees & drip zones
- Avoid areas of standing water
Rain Garden Design
Location & Landscaping

- Limit erosive velocities enter garden
- Site slopes (min 10H:1V - max 3H:1V)
- Buffer zones to limit fines and reduce velocities (rock, grass, etc.)
- Multiple smaller gardens might be more effective than one larger garden especially in clay soils
- Proper landscaping and plant choice is essential
- 2” to 3” of aged hardwood mulch (max!)
References & Resources

- SOCWA Healthy Lawns and Gardens -
  http://www.socwa.org/lawn_and_garden.htm
- Rain Gardens of West Michigan -
  http://www.raingardens.org/Index.php
- Virginia Department of Forestry – Rain Gardens Technical Guide
  http://www.dof.virginia.gov
- Minnesota Stormwater Manual -
- USEPA Bioretention fact sheet -
  http://www.epa.gov/owm/mtb/biortn.pdf
- Univ of Wisconsin DNR –
  http://clean-water.uwex.edu/pubs/home.htm#rain
- LID Urban Design Tools -
  http://www.lid-stormwater.net/
- Prince George’s County, D.E.S. Bioretention -