Rain Garden Design & Maintenance

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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

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

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

- Key feature for LID/conservation design
- Focus on water quality volume - known as first flush (first 1/2” 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
Field Infiltration Measurements

- **Community Rain Gardens**
  - Costick Center – Farmington Hills
    - Cell A = 0.5 in/hr  
    - Cell B = <0.1 in/hr
  - Lathrup Village (80/15/5) = 19.7 in/hr
  - Wayne City Hall Bioswales = <0.1 in/hr
  - Newburgh Point Wayne Co. (25/50/25) = 2.9 in/hr
  - Beech Park = 4.1 in/hr

- **Homeowner Rain Gardens**
  - Kearney = 7.4 in/hr
  - Piotrowski = 0.1 in/hr (clay pocket)
  - Hart-Negich = 20 in/hr
  - San Rosa/Avila Swales (two gardens) = 20+ in/hr
Effect of Sand on Field Capacity

![Graph showing the effect of sand content on field capacity. The x-axis represents % Sand Content by Volume, ranging from 0 to 100. The y-axis represents % of Water Retained, ranging from 0 to 140. The graph shows a downward trend as the sand content increases.]
Effect of Sand on Permeability

![Graph showing the effect of sand content on permeability. The x-axis represents the percentage of sand content by volume, ranging from 0 to 100. The y-axis represents permeability in inches per hour, ranging from 0 to 60. The graph shows a downward curve indicating an increase in permeability as the sand content increases.](image-url)
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 (5%) in the mix.

- If soil mixture is balance compost/sand and garden is maintained, limiting infiltration rate is from native soils – not planting mix.

- Overall, be aware of the impact your soil mix will have on your rain garden drainage 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
- \( i < 0.5 \text{ in/hr} \) \( \Rightarrow \) 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 captured
  - 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

\[
SA = 0.07 * \left( C_{imp} * DA_{imp} + C_{green} * DA_{green} \right)
\]

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

- Simplified by Dr. Carpenter for local conditions

- Assumptions
  - 1” of rainfall will be captured (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

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

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

Runoff coefficient spectrum

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

DA 1

- not within 10' of foundation
- > 30' from down spout
- roof and lawn drainage area to back rain garden
- roof drainage area to front rain garden
- close to down spout
- rain garden length
- rain garden width
Rain Garden Design Solution Sheet
Run-off Method

\[DA = \frac{7500}{7} \text{ sq ft total with 2000 sq ft roof & 5500 sq ft backyard}\]
\[C_{imp} = 0.9\]
\[C_{green} = 0.25\]

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

$DA = 7500$ sq ft total with 2000 sq ft roof & 5500 sq ft backyard
$c = 0.4$
$depth = 2.5$ ft
$ponding = 0.5$ ft
$i = 1$ ft day (sandy soils)

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

$SA =$ surface area of rain garden (ft$^2$)
$DA =$ drainage area (ft)
$depth =$ planting bed depth (ft)
$i =$ infiltration rate (ft / day)
$c =$ runoff coefficient
$ponding =$ 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>
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<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 -
  http://www.goprincedegeorgescounty.com/Government/Agency
  Index/DER/ESD/Bioretention/bioretention.asp