Rain Garden Overview and Design

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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

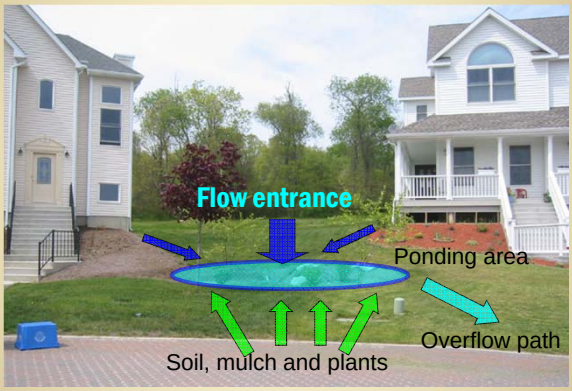
What's going on in there?

- 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
- Prince George's County, MD
- **RAIN GARDENS:** Home-scale, not typically engineered, use existing soils
  - Wisconsin design manual
  - UConn design manual

Bioretention/rain gardens



Vegetated areas designed to infiltrate and process stormwater

Residential Rain Gardens

Waterford, CT

Maryland

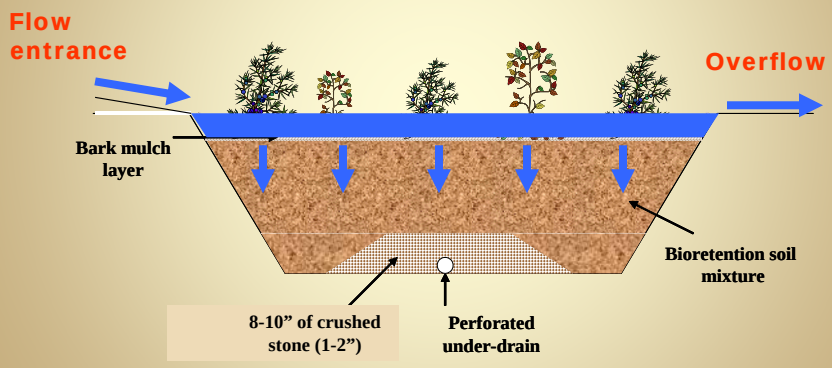
Haddam rain garden

Infiltrated 99% of roof runoff!!

http://nemo.uconn.edu/successes/case_studies/haddam_demo/demosite_rain_garden.htm

Bioretention specifics

Bioretention profile



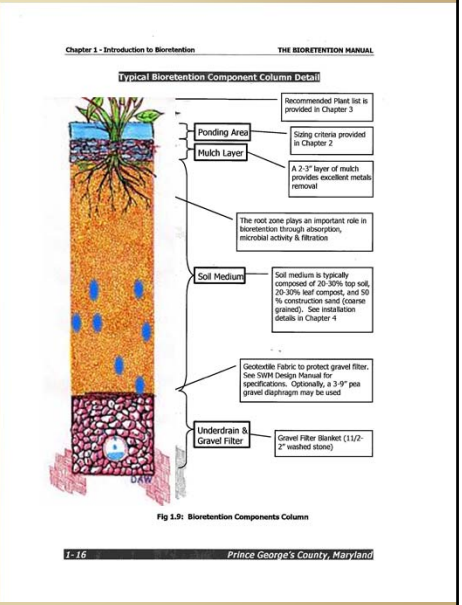
Ponding area

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

Installation materials

- Soil mix, underdrain, crushed stone, plants, mulch

- Avoid filter fabric!!
  - Not needed for residential sites
  - For commercial, use non-woven geotextile only if needed



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

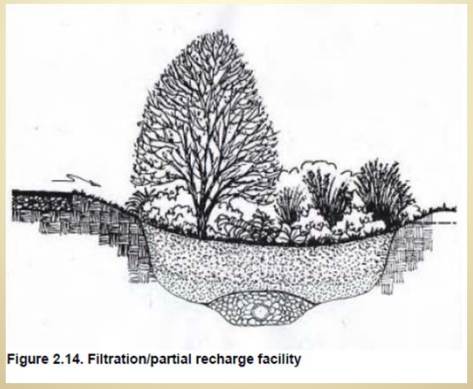
Research bioretention

Underdrains

- Purpose is to reduce potential for extensive surface ponding
- Bioretention manual recommends underdrains for all residential rain gardens
  - May not be necessary
  - Make a decision based on site and soils
- 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

Underdrains

- Drain to grade (best) or stormwater system (OK)
- **DO NOT** wrap in filter fabric!

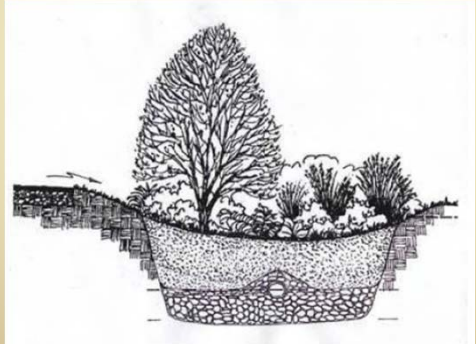


From Bioretention Manual (2009)

Underdrains

Underdrains

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



From Bioretention Manual (2009)

Sizing and placing a rain garden

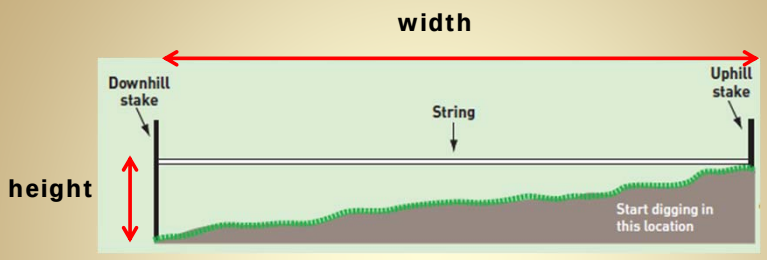
Rain garden placement

- More than 10 feet from foundation with basement
- Avoid placing over septic system or close to well
- Avoid placing in wet areas of yard-don't forget, a rain garden IS NOT a water garden!
- Site to most effectively catch storm runoff
- Consider overflow

Important site considerations for bioretention/rain gardens

- Avoid areas with:
  - Shallow (<3 feet) depth to bedrock
  - Seasonal high water table
- Be aware of the infiltration capacity of native soils
- Watch for steep slopes

Slope



$$\frac{\text{Height}}{\text{Width}} \times 100 = \% \text{ Slope}$$

- For flat areas, no berm needed
- Moderate slopes, use berm
- Heavier slopes, use retaining wall design
- **More than 20% slope, look for another location**

Different siting applications

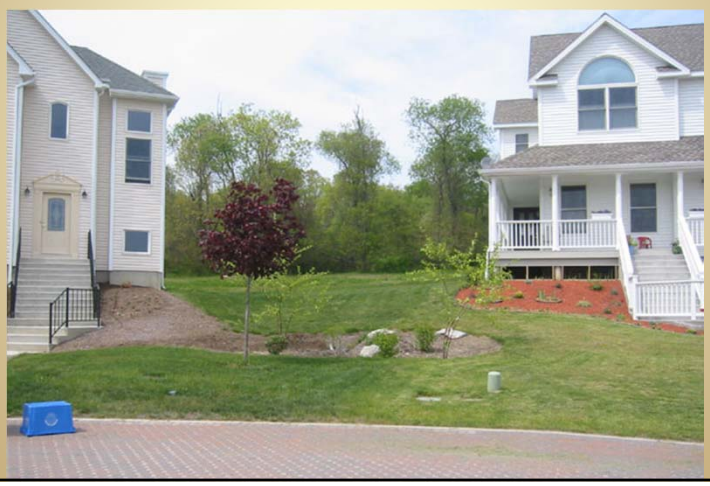
- Take water from:
  - Roof
  - Parking lot/road
  - Turf/mixed use

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 retrofit with curb cuts

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

North Carolina. From Traver, et al., 2007

Mixed use

- Can be difficult to figure out watershed and measure areas
- Observe in rain storm
- Break it up into shapes
  - Get help from your student!

UConn Rain Garden

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

Check 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**
- My infiltration rate is only 0.5 inches per hour… will it still work?
  - Perhaps… but find out why

Bioretention soil mix

- 50-60% sand
- 20-30% topsoil
  - Low clay content
- 20-30% **leaf** compost
  - Low phosphorus

- For a rain garden, sandy loam, loamy sand, loam soils usually OK as is

Source: The Bioretention Manual (PGC, 2009)

Soils

- Ball test: Roll moistened soil into a ball in hand and see how it forms
  - Hard ball – Clay/Silt soil
  - Soft ball – Loamy soil
  - No ball – Sandy soil

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

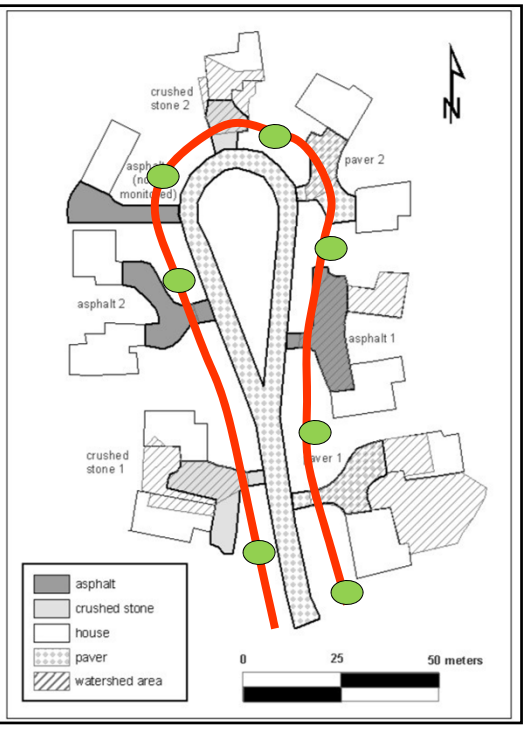
- Send sample to county Extension Office for sand/silt/clay and/or nutrient analysis
- **Loamy soils best, but others can be used with amendments**

Soils

- What if the texture is OK, but the soil doesn't drain?
- High water table
  - Pick a different site
- 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 bioretention

- 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 and shallower, and amend with sand and some compost

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

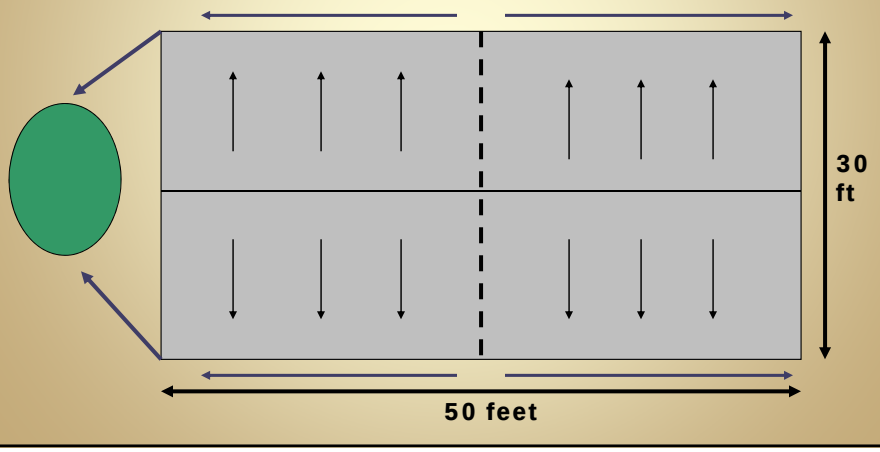
Sizing

How Big Should it Be?

- Simple method
  - Sized to store 1 inch of runoff from 100% impervious watersheds
- Bioretention Manual method
  - Based on 1 inch storage, but can be used on mixed use watersheds

Simple Sizing

- Calculate area of roof feeding to garden



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

Why 1 inch?

- In the East and Midwest, around 90% of storms are 1" or less
- Wisconsin design guide
- UConn design guide
- Bioretention manual

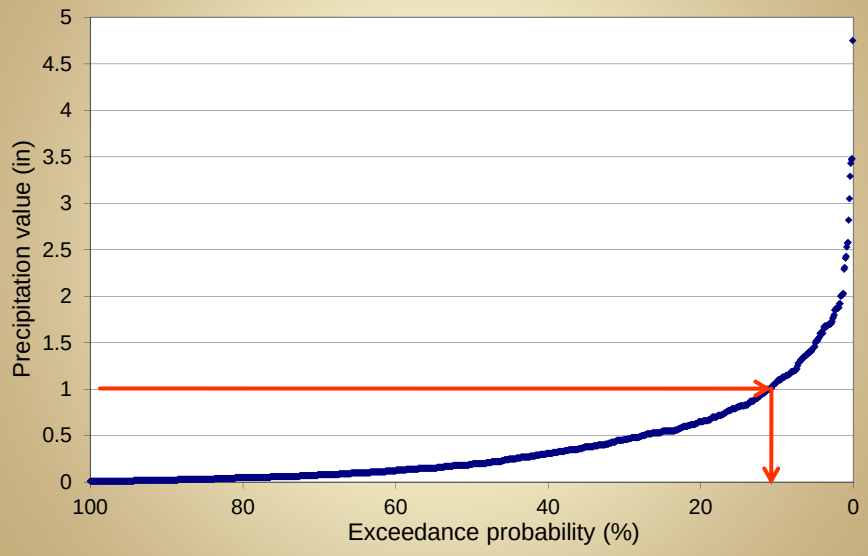
Is it really that big of a deal ? 1 inch isn't much, right?

Let's see how Google sees the world

- 79,550 ft²
- 1 inch of rain= **49,593 gallons**
- Average year=50 inches…
  - **2,479,640 gallons!**
- **This is one roof!**

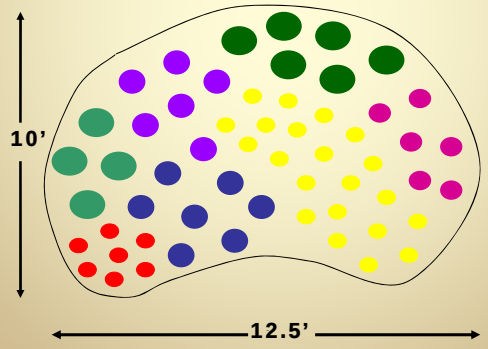
Precipitation Probability

Groton daily non-zero precipitation (in), 1974-2008



Sizing, continued

- 125 square feet
  - Garden can be shaped in a variety of ways



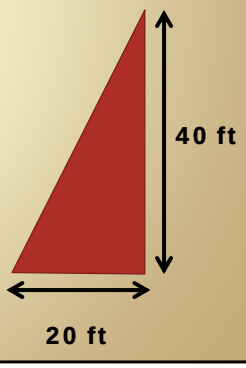
Your turn!

- Outside this building

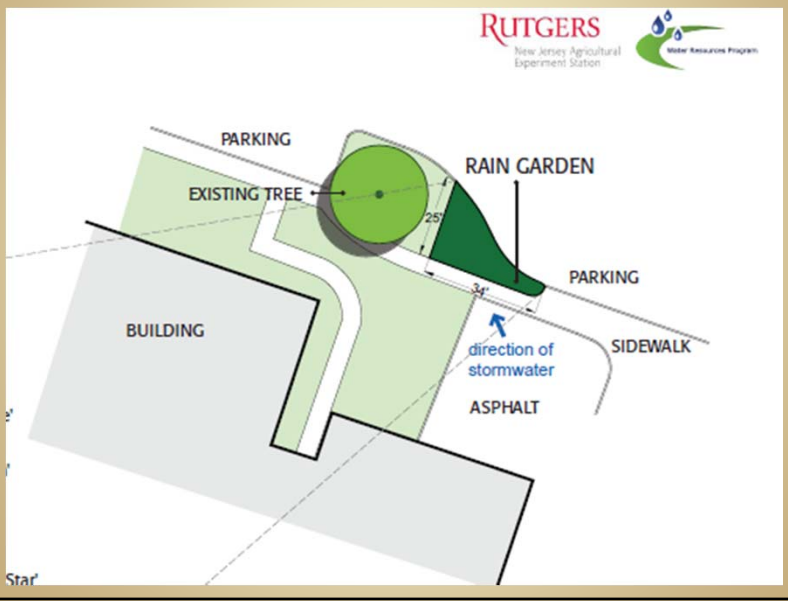
- Watershed is 100% impervious: **2394 ft²**

School example

- Since watershed is 100% impervious, use simple method
- Divide total area by 6
  - Gives rain garden size, with 6" ponding depth
- 2394 ft^2/6 = 399 ft^2 (say 400 ft^2)
- Area of a triangle?
  - ½ x base x height



How about 34 ft x 25 ft?

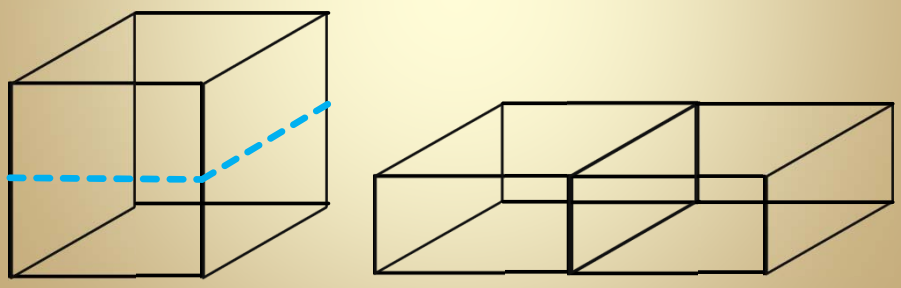


Bioretention Manual Method

- Based on "Water Quality Volume"
  - 1 inch
- Use equation $WQ_v = [(P)(R_v)(A) / 12]$
  - P= 1.0 inch
  - $R_v = 0.05 + 0.009(I)$
  - I=Percent impervious (1-100)
  - A=Total watershed area (square feet)

Bioretention manual method

- Gives volume in cubic feet
- For 6" ponding depth, double the size



UConn Rain Garden

A bit more complicated…
(but not impossible!)

- Grass: **8694 ft²**
- Sidewalk: **1914 ft²**
- Total watershed area: **10,608 ft²**

- **Hints:**
  - Find out what percent of watershed is impervious
  - Use equation $WQ_v = [(P)(R)(A) / 12]$
    - P= 1.0 inch
    - R= 0.05 + 0.009(I)
    - I=Percent impervious (1-100)
    - A=Total watershed area (square feet)
  - Convert to square feet, 6 inches deep

Solution

- Grass: **8694 ft²**
- Sidewalk: **1914 ft²**
- Total watershed area: **10,608 ft²**
- Percent impervious:
  - **(1914 ft² / 10,608 ft²)*100 = 18%, so I=18**
- P= 1.0 inch
- R=0.05 + [0.009 x (18)] = 0.212
- WQ_v = (1 x 0.212 x 10,608) / 12 = 0
- 187 ft² (12 inches deep)
- Multiply by 2 (for 6 inches deep) = **375 ft²**

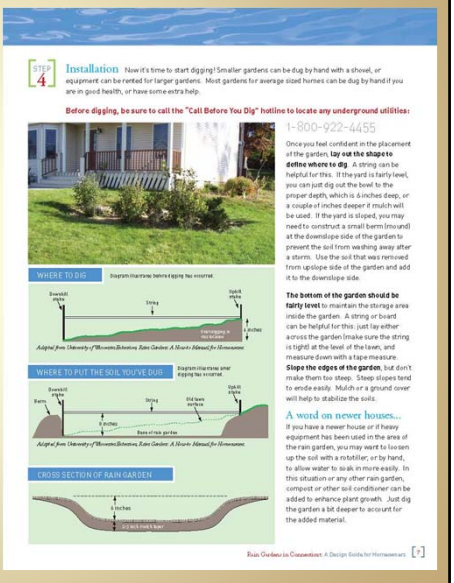
Let's get digging!

Installation

- Call hotline to locate underground utilities (at least 2 days in advance) **1-800-922-4455 or 811**
- Mark area to be dug
- Smaller gardens can be dug by hand **(friends+beer=rain garden),** or equipment can be rented for larger gardens

Installation, 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)**



STEP 4

Installation Now it's time to start digging! Smaller gardens can be dug by hand with a shovel, or equipment can be rented for larger gardens. Most gardens for average sized homes can be dug by hand if you are in good health, or have some extra help.

Before digging, be sure to call the "Call Before You Dig" hotline to locate any underground utilities:

1-800-922-4455

Once you feel confident in the placement of the garden, **lay out the shape to define where to dig**. A string can be helpful for this. If the yard is fairly level, you can just dig out the bowl to the proper depth, which is 6 inches deep, or a couple of inches deeper if mulch will be used. If the yard is sloped, you may need to construct a small berm (mound) at the downslope side of the garden to prevent the soil from washing away after a storm. Use the soil that was removed from upslope side of the garden and add it to the downslope side.

The bottom of the garden should be fairly level to maintain the storage area inside the garden. A string or board can be helpful for this: just lay either across the garden (make sure the string is tight!) at the level of the lawn, and measure down with a tape measure. **Slope the edges of the garden**, but don't make them too steep. Steep slopes tend to erode easily. Mulch or a ground cover will help to stabilize the soils.

A word on newer houses...

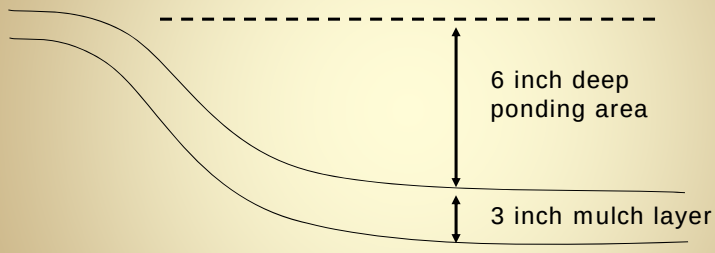
If you have a newer house or if heavy equipment has been used in the area of the rain garden, you may want to loosen up the soil with a rototiller, or by hand, to allow water to soak in more easily. In this situation or any other rain garden, compost or other soil conditioner can be added to enhance plant growth. Just dig the garden a bit deeper to account for the added material.

WHERE TO DIG

WHERE TO PUT THE SOIL YOU'VE DUG

CROSS SECTION OF RAIN GARDEN

Depth



Installation by hand

(18 hands!)

Bioretention excavation

- Avoid compaction/sealing of bottom with bucket

Foot traffic only

Erosion

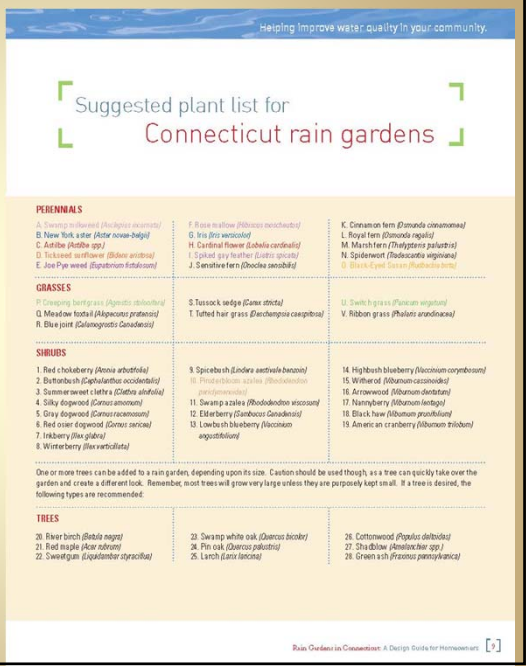
- Don't allow runoff from an open, unstabilized construction site to enter the garden
  - Surface of bioretention will become clogged

Important factors with bioretention

- Make sure storage depth is correct at installation

Planting

- See the UConn or Rutgers publications for plants to use in this area



Helping improve water quality in your community.

Suggested plant list for
Connecticut rain gardens

PERENNIALS

A. Swamp milkweed *(Asclepias incarnata)*
B. New York aster *(Aster novae-belgii)*
C. Astilbe *(Astilbe spp.)*
D. Tickseed sunflower *(Bidens aristosa)*
E. Joe Pye weed *(Eupatorium fistulosum)*
F. Rose mallow *(Hibiscus moscheutos)*
G. Iris *(Iris versicolor)*
H. Cardinal flower *(Lobelia cardinalis)*
I. Spiked gay feather *(Liatris spicata)*
J. Sensitive fern *(Onoclea sensibilis)*
K. Cinnamon fern *(Osmunda cinnamomea)*
L. Royal fern *(Osmunda regalis)*
M. Marsh fern *(Thelypteris palustris)*
N. Spiderwort *(Tradescantia virginiana)*
O. Black-Eyed Susan *(Rudbeckia hirta)*

GRASSES

P. Creeping bentgrass *(Agrostis stolonifera)*
Q. Meadow foxtail *(Alopecurus pratensis)*
R. Blue joint *(Calamagrostis Canadensis)*
S. Tussock sedge *(Carex stricta)*
T. Tufted hair grass *(Deschampsia caespitosa)*
U. Switch grass *(Panicum virgatum)*
V. Ribbon grass *(Phalaris arundinacea)*

SHRUBS

1. Red chokeberry *(Aronia arbutifolia)*
2. Buttonbush *(Cephalanthus occidentalis)*
3. Summersweet clethra *(Clethra alnifolia)*
4. Silky dogwood *(Cornus amomum)*
5. Gray dogwood *(Cornus racemosum)*
6. Red osier dogwood *(Cornus sericea)*
7. Inkberry *(Ilex glabra)*
8. Winterberry *(Ilex verticillata)*
9. Spicebush *(Lindera aestivale benzoin)*
10. Pinxterbloom azalea *(Rhododendron periclymenoides)*
11. Swamp azalea *(Rhododendron viscosum)*
12. Elderberry *(Sambucus Canadensis)*
13. Lowbush blueberry *(Vaccinium angustifolium)*
14. Highbush blueberry *(Vaccinium corymbosum)*
15. Witherod *(Viburnum cassinoides)*
16. Arrowwood *(Viburnum dentatum)*
17. Nannyberry *(Viburnum lentago)*
18. Black haw *(Viburnum prunifolium)*
19. American cranberry *(Viburnum trilobum)*

One or more trees can be added to a rain garden, depending upon its size. Caution should be used though, as a tree can quickly take over the garden and create a different look. Remember, most trees will grow very large unless they are purposely kept small. If a tree is desired, the following types are recommended:

TREES

20. River birch *(Betula nagra)*
21. Red maple *(Acer rubrum)*
22. Sweetgum *(Liquidamber styraciflua)*
23. Swamp white oak *(Quercus bicolor)*
24. Pin oak *(Quercus palustris)*
25. Larch *(Larix laricina)*
26. Cottonwood *(Populus deltoides)*
27. Shadblow *(Amelanchier spp.)*
28. Green ash *(Fraxinus pennsylvanica)*

Rain Gardens in Connecticut: A Design Guide for Homeowners [9]

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

Plants

Mulch

- Best is aged, shredded hardwood bark mulch
  - About 3 inches in depth
- NOT pine bark nuggets!
  - They float

A well-installed bioretention area…

- 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

References of interest:

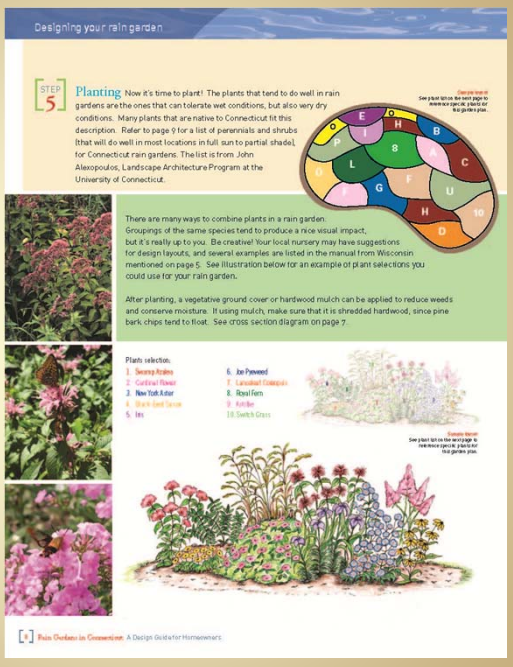
NEMO
- http://www.nemo.uconn.edu

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 layouts



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

Branford Police Station

More excess mulch…

Flow paths and erosion

Any questions?