Create a Rain Garden:

Preventing Water Pollution in Your Community

A Manual for Student Service Projects

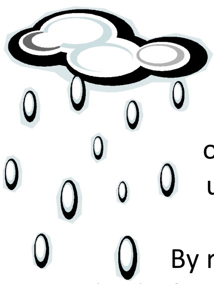
This manual is intended to assist groups in the planning, design, installation, and advertisement of a rain garden in their community. A large focus of this project is to improve public awareness of stormwater issues and to educate people on how they can improve stormwater management on their own property. The manual is designed to provide step by step instructions for school groups wanting to beautify and improve their local environment with rain gardens. It also provides example documents that can be adapted and used for organizing rain garden development as well as educating and promoting involvement from the public.

Table of Contents:

What is a Rain Garden?

A rain garden is an attractive native plant garden with a special purpose: to capture, soak up and filter stormwater runoff from roofs, driveways, parking lots and other impervious surfaces before it enters local lakes, ponds, rivers or bay. Rain gardens use the concept of bioretention; a water quality practice in which plants and soils remove pollutants from stormwater naturally.

Why Should You Create a Rain Garden?



In addition to adding beauty to your community, rain gardens help protect water quality by reducing stormwater runoff. Stormwater runoff is considered one of the main sources of water pollution nation-wide. As watersheds become developed, rainwater quickly runs off paved surfaces such as roofs, parking lots and driveways increasing flooding while picking up and carrying pollutants into storm drains and surface waters.

By reducing stormwater runoff, rain gardens effectively change these trends. While an individual rain garden may seem like a small contribution, collectively they produce substantial environmental benefits. Rain gardens work for us in several ways:

- Increasing the amount of water that filters into the ground which recharges groundwater;
- Helping protect communities from flooding and drainage problems;
- Reducing erosion of stream banks;
- Helping protect surface waters from pollutants carried by stormwater such as lawn fertilizers and pesticides, oil and fluids that leak from cars, bacteria from pet waste, litter, among others;
- Enhancing the beauty of yards and neighborhoods;
- Providing habitat for birds, butterflies, and other beneficial insects.

Developing Your Goals and Work Plan

You may be installing a rain garden in a neighbor's yard, a local municipal property with high stormwater runoff, or a school in your community. Whatever the case, you will want to understand the goals of the project and develop a work plan accordingly. Some of your goals will be to:

- Reduce impacts of stormwater runoff in your community.
- Enhance awareness of stormwater runoff and non-point source pollution.
- Design, establish, and maintain an educational and sustainable landscape in your community.
- Promote environmental stewardship and community pride.

Your work plan should align with your goals. Whether you are working by yourself or with a group, organize each component of the project, and assign jobs to each participant. Your timeline will vary depending on how you set up your project. Finding the right location and funding your rain garden will be the main factor in determining timing. Develop a timeline based on the work plan tasks. Continue to update and assess your progress and adjust the timeline as necessary.

See ***Appendix A*** for a Work Plan and Sample Timeline

Choosing a Location

The location of your rain garden should depend on your budget, stormwater management needs, and accessibility to the public. The rain garden should be located in a place where it will receive runoff. Check to make sure runoff flows to your site, or could flow with minor modifications, such as cutting a space out of a curb. It should also be located in an area that is visible to the public. A large focus of this project is to improve public awareness of stormwater issues and educate people on how they can improve stormwater management on their own property. For this reason, place the rain garden in a public area that can be seen by members of your community. Most likely this area will be located on a commercial, industrial or institutional property, so stormwater management regulations will have to be taken into consideration and a professional will be needed to assess the site.

Seeking Community Help and Support

Getting the community involved installing your rain garden helps to reduce costs, educate the public, and develop a sense of pride and ownership within the community. Volunteers can be recruited to help with rain garden construction, provide professional assistance, loan equipment, or offer their property as a location for the rain garden. Even though your rain garden may require the use of paid contractors and engineers, you can invite the community to help plant the rain garden. Seek help from parents, local businesses and professionals in the field.

See ***Appendix B*** for a Sample Parent News Letter
See ***Appendix C*** for a Sample Donation Request Letter
See ***Appendix D*** for a list of Professional Contacts

Developing your Budget

The cost of a rain garden can vary substantially based on size, location, plant variety, soil amendments needed, and availability of volunteers. Residential rain gardens average about $3 to $4 per square foot, depending on soil conditions and the density and types of plants used. Commercial, industrial and institutional site costs can range between $10 to $40 per square foot, based on the need for meeting stormwater regulations and hiring professional contractors. You can locate and design your rain garden to meet your budget.

You can hold fundraisers or look for funders to help with the costs of building your rain garden. You can apply for grants through government organizations such as the Department of Environmental Management, Environmental Protection Agency or US Department of Agriculture, or search for local natural resource organizations that may have funding available. Other options are to ask businesses in your area or your local Department of Publics Works to loan you materials that you will need during installation. If you receive donations or loans from organizations, be sure to recognize them in your publicity campaign.

See ***Appendix E*** for Sample Budget

Sizing and Planning your Rain Garden

It is important to go through all of the necessary steps to plan the design of your rain garden. Most of the calculations and tests can be done on your own using the pre-installation checklist and soil test provided. A professional contractor will be needed to confirm your work and assess the site.

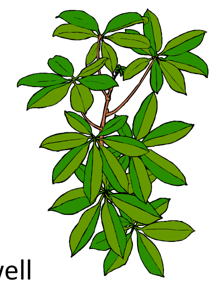
The size of the rain garden will depend on how deep the garden will be, what type of soils the garden will be planted in, and how much roof and/or lawn will drain to the garden. The following websites and manuals provide detailed descriptions of how to calculate rain garden size, examine soil properties, and determine garden depth. Read through these materials carefully before beginning your rain garden project.

See ***Appendix F*** for Sizing and Planning Steps

Rain Garden Manuals:

- Coastal Resources Management Council: http://www.crmc.ri.gov/news/2007_0207_stormwater.html
- Reference CT Brochure: http://www.sustainability.uconn.edu/landscape/05-rain_gardens.html

Selecting Plants



Depending on the location and person responsible for maintenance, you can design rain gardens that are low maintenance, high in habitat value, or have an aesthetic focus. You can begin your plant selection process with the help of the RI Coastal Plant Guide Website: http://www.uri.edu/cels/ceoc/coastalPlants/CoastalPlantGuide.htm. By choosing the "+" sign above the rain garden column, you can determine the kinds of RI native plants that do well in the dry and wet conditions common to rain gardens. A landscape architect or other professional should be consulted after you choose plants to confirm that the plants align to the maintenance goals and thrive in that environment. Once plants have been chosen, you will have to review your budget to account for the costs.

See ***Appendix F*** for Sizing and Planning Steps

Advertising Your Rain Garden

One of the main goals of this project is to educate people about stormwater pollution and how they can be part of the solution. A great way to do this is by publicizing the rain garden construction and planting event. This will help to recruit volunteers and spread stormwater awareness. The best outreach campaigns use several techniques. Advertising options include:

- Asking your school's science teachers to allow you to make a short presentation describing the project and its purpose
- Creating signs and brochures and placing them in your school, public libraries, recreation centers, and walking trails
- Developing a web site or adding the information to your school's existing web site

- Running an advertisement in school newspapers and parent newsletters at your school
- Discussing the event at various club meetings, community associations, church groups, youth groups, and/or service organization meetings
- Organizing a planting ceremony for the day of the event and inviting press and community to attend
- Distributing press releases about a week in advance to local newspapers, radio stations, and online blogs, calendars, etc. (Take pictures during the event to include in follow-up publicity)
- Working with a local sign distributor to create signage that will be placed permanently at rain garden site

See ***Appendix G*** for Sample Press Releases

Rain Garden Construction and Planting

It is not enough to have the plants ready for your event—some final preparations need to be made to make your construction and planting day a success. Since there will be many tasks to complete, and volunteers to help, it is useful to organize materials and delegate responsibilities before construction.

See ***Appendix H*** for Construction Day Checklist

If you are going to have a press event to publicize the rain garden installation, hold it when the rain garden is to be planted. This will be beneficial for many reasons: the other stages of rain garden construction can be technical and may take longer than expected, there is a great sense of accomplishment from having a site go from being bare to being covered with vegetation, the planted garden creates a great visual backdrop for photos and television footage, and a planting event can use many volunteers that need not have great skill or strength.

Maintenance

Your rain garden will require maintenance after installation. The garden should be watered thoroughly once a day, unless there is a significant rainfall, for fourteen days or until the plants are established. Once established, a routine maintenance schedule should be followed for the rain garden. Use the instructions provided in the rain garden manuals you downloaded for maintenance suggestions.

Resources

This manual has been adapted from the following sources:

Healthy Landscapes: http://www.uri.edu/ce/healthylandscapes/raingarden.htm

LID Sustainable School Projects: http://www.lowimpactdevelopment.org/school/index.html

Rain Gardens: A How-to Manual for Homeowners. Roger Bannerman and Ellen Considine. http://clean-water.uwex.edu/pubs/raingarden/rgmanual.pdf

Watershed Activities to Encourage Restoration http://www.watershedactivities.com

Appendix A - *Work Plan and Sample Timeline*

Communications and Publicity Tasks:

- Solicit parent involvement and help (See Appendix B for Sample Parent Newsletter)
- Secure partners and community involvement (See Appendix C for Donation Request)
- Develop educational materials and PowerPoint to present to classes and organizations
- Take pictures of site before, during and after rain garden construction.
- Plan and develop publicity campaign (See Appendix G for Sample Press Release)
- Design and order public signage for rain garden
- Advertise work days on school website and newsletters and ask for volunteers.

Site Selection and Design Tasks:

- Brainstorm possible rain garden locations based on land use type, budget, stormwater necessity, and public access.
- Visit a rain garden that is already operating (Find a RI rain garden here: http://www.ristormwatersolutions.org/SW_ri_lidtour.html)
- Request assistance from a Landscape Architect, Soil Scientist, or Professional Engineer (See Appendix D for professional contact list).
- Perform soil test or send soil sample to UCONN soil laboratory (See Appendix F for Sizing and Planning Steps)
- Determine rain garden size and depth (See manuals for directions)
- Determine materials needed for rain garden (tools, soil amendments, and plants) and include them in your budget.
- Prepare construction procedure and design diagram for volunteers.

Financial Planning and Logistics Tasks:

- Develop Budget (See Appendix E for Sample Budget)
- Perform communications and publicity financial tasks:
  - Solicit community donations
  - Determine publicity costs (signage, education materials, etc.)
  - Order materials
- Perform Site Selection financial tasks:
  - Determine location based on budget
  - Solicit professional assistance
  - Order materials
- Organize pick up or delivery times
- Develop a construction day plan and materials list (See Appendix H for Construction Day Checklist)

Week 1:

- ☑ Research rain gardens and stormwater runoff. Be able to describe what non point pollution is and how rain gardens are part of the pollution solution.
- ☑ Read through materials.

Week 2:

- ☑ Develop a budget.
- ☑ Investigate sources of funding through grants, fundraisers or donations.
- ☑ Brainstorm possible rain garden locations based on land use type, budget, stormwater necessity, and public access.

Week 3:

- ☑ Seek out support and help from parents in school news letter and website.
- ☑ Continue to investigate funding opportunities.
- ☑ Request assistance from a Landscape Architect, Soil Scientist, or Professional Engineer to help determine location.

Week 4:

- ☑ Finalize rain garden location.
- ☑ Begin securing partnership involvement by requesting donations, volunteers, or loaning of materials from public works department, local businesses, residents and organizations.

Week 5:

- ☑ Perform soil test or send soil sample to UMass Cooperative Extension.
- ☑ Determine rain garden sizing.
- ☑ Plan education and publicity campaign.

Week 6:

- ☑ Have professional confirm sizing and develop a planting design.
- ☑ Review budget to incorporate soils amendments and plants.
- ☑ Develop educational and publicity materials to present to classes and organizations

Week 7:

- ☑ Finalize funding and donation arrangements.
- ☑ Begin publicizing in school newspapers, websites, libraries, local businesses.

Week 8:

- ☑ Set a rain garden installation date (arrange for multiple work days and set installation ceremony date).
- ☑ Determine method of transporting and storing materials for installation day.
- ☑ Continue education and publicity campaign.

Week 9:

- ☑ Order materials and organize pick up, delivery and storage of materials.
- ☑ Continue education and publicity campaign – order sign for rain garden.
- ☑ Advertise work days on school website, newsletters, press releases, and flyers.

Week 10:

- ☑ Prepare plant and construction design diagram for volunteers.
- ☑ Develop construction day procedures.
- ☑ Prepare materials for installation day.
- ☑ Send press releases to local newspapers and invite them to event.

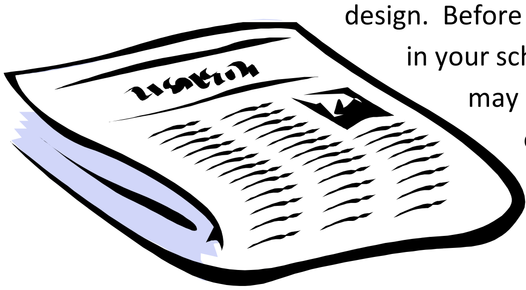
Week 11: Rain Garden Installation Week!!!

- ☑ Take before pictures of site.
- ☑ Confirm volunteer jobs.
- ☑ Bring all materials to site.
- ☑ Build a rain garden!

Week 12: Wait! You're Not Finished!!

- ☑ Water rain garden and determine maintenance schedule.
- ☑ Follow up with press and send pictures of rain garden and event.
- ☑ Send thank you notes to volunteers and donors.

Appendix B – <u>Parent News Letter</u>



It is very likely that you will need professional assistance to help you with your rain garden sighting and design. Before contacting the professionals in your area, send out an announcement in your school's parent news letter asking for volunteers and assistance. There may be a parent that is a landscape architect, soil scientist, or professional engineer and is willing to help. This is also a great way to begin publicizing the work you plan on doing.

<u>Sample Parent News Letter Announcement:</u>

[Your group name] is Seeking Help with Rain Garden!

The [your group name] has begun a project to build a rain garden at [location of proposed rain garden] and is looking for help to design and install it. Rain gardens are very important since they capture, soak up, and filter stormwater. Stormwater runoff is considered one of the main sources of water pollution nation-wide. As land becomes developed, rainwater quickly runs off paved surfaces such as roofs, parking lots and driveways, increasing flooding, while picking up and carrying pollutants into [local water body] and other local water bodies. Rain gardens are effective systems that help to change these trends.

In order to properly install a rain garden, the [your group name] will need some professional assistance and some helpful hands to facilitate construction. Please let them know if you or any one you know has experience with landscaping, soils, professional engineering, or are willing to help. You can contact [your name] at [your phone # and/or address]. They are looking forward to creating a cleaner and more beautiful community and hope you can help to make a positive difference in our local environment.

Appendix C – __Sample Donation Request Letter__

You can use this letter format to ask local businesses or organizations for donations or to lend you supplies or materials that you might need for your rain garden. If you ask for financial assistance, be very clear about how the money will be used. Before you make your request, find out exactly how much money you will need. Be sure to treat the local business with respect and courtesy and ensure that they will be acknowledged in your publicity campaign and signage. If there is more than one person in your group, have your entire group sign the letter. Often by making a trip to the local business or organization, they feel a personal connection to your group and might be more likely to help you.

__Sample Donation Request Letter:__

Dear Mr./Ms. ___________________ ,

My name is [your name], and I am writing on behalf of [your group name]. As member of [your group name], we are trying to make a positive difference in our local environment through our actions. We have begun a project to build a rain garden at [location where rain garden will be installed]. Rain gardens are very important since they soak up stormwater that flows off of parking lots, driveways, and roofs before it able to pick up and carry pollutants to [local water body] and other local water bodies. Our goal is to make our community a better place by protecting our water systems and the animals and people that enjoy them.

In order to complete this project, we need [write down a short list of the equipment or materials you need that the business you are writing to could donate or lend to you, or specific dollar amount and what it will be used for]. We would be most grateful if [name of business/organization] could [donate/ lend] any of these items to help us install our rain garden. If you are interested, we will be sure to acknowledge [name of business/organization] in our publicity and signage of the rain garden and we will keep you informed with regular updates on the progress of our rain garden.

Please contact me at [your phone # and/or email address] if you are able to help. If we don't hear from you within a week, we will contact you personally. Thank you for your time and for considering this request. We look forward to working with you and creating a cleaner and more beautiful community.

Sincerely,
(Your name signed)
Your name typed

Appendix D – Professional Contacts

For information on funding opportunities and possible grants:

- Your town's Department of Public Works
- Rhode Island Department of Environmental Management: 401-222-6800, http://www.dem.ri.gov
- United State Department of Agriculture: http://www.usda.gov

Dig Safe - Before you dig, make sure there are no utilities lines:

- DIG-SAFE (1-888-DIG-SAFE) www. digsafe.com

Soil Professionals:

- Listing of Southern New England Certified Soil Scientists: http://nesoil.com/ssssne/Registry_2009.pdf
- Natural Resources Conservation Service: http://www.ri.nrcs.usda.gov/contact/
- UCONN Soil Testing Resources and Form: http://soiltest.uconn.edu/sampling.php
- UMass Soil Testing Resources and Form: http://www.umass.edu/soiltest/

Landscape Architect and Plants:

- RINLA – Rhode Island Nursery and Landscape Association: http://www.rinla.com/index.asp
- RIASLA –Rhode Island Chapter of American Society of Landscape Architects http://www.riasla.org
- Out in Front Horticulture: Dave Renzi , treefairy@cox.net, 401-294-7335
- Rhode Island Wild Plant Society, www.riwps.org for more information on native plant sources.
- New England Wildflower Society, 508-877-7630, www.newfs.org
- New England Wetland Plants, 413-548-8000 www.newp.com
- RI Coastal Plant Guide: http://www.uri.edu/cels/ceoc/coastalPlants/CoastalPlantGuide.htm

Sign Distributors:

- Signs By Tomorrow, Warwick, RI, 401-826-6446 http://www.signsbytomorrow.com/warwick/
- Search for signs: http://www.signsrhodeisland.com/

RI Stormwater Regulations:

- DEM Stormwater Design and Installation Standards Manual: http://www.dem.ri.gov/programs/benviron/water/permits/ripdes/stwater/t4guide/desman.htm
- Coastal Resources Management Council: http://www.crmc.ri.gov/news/2007_0207_stormwater.html

Appendix E – Sample Budget

This information has been adapted from the Rutgers Cooperative Extension Rain Garden Training information: http://www.water.rutgers.edu/Rain_Gardens/RGWebsite/landscaper.html
The cost is based on a 300 sq. ft rain garden and seems comparable to local rain garden costs.

	Item	Cost/unit	# of units	Total Cost	Donated / Loaned
Standard Supplies	White mark-out paint	$5	1	$5	
	Landscape pins	$1/pack	4	$4	
	Weed block fabric	$12	2	$24	
	Hose (75' soaker hose)	$14	1	$14	
	Shovels/soil rakes				✓
	UCONN Soil Texture Test	$12	1	$12	
Bobcat Rental (not always required)	Rental	$200	1	$200	
	Fuel	$50	1	$50	
	Delivery	$80	1	$80	
	Insurance	$20	1	$20	
Delivery Fees (not needed if picking up)	Mulch	$65	1	$65	
	Plants	$175	1	$175	
Soil Amendments	Organic Fertilizer	$6	1	$6	
	Mulch	$28/yard	2	$56	
	1 ½" stone	$25/ton	2	$50	
	¾" crushed stone	$28/ton	2	$56	
	Coarse Sand, Concrete, or Bank run sand	$35/ton	3	$105	
Plants	1 gallon container shrub	$4.75	15	$71.25	
	Gallon Perennials	$4.25	10	$42.50	
	Quart Perennials	$2.00	5	$10	
	2" plugs	$0.65	50	$32.50	
Professionals and Labor	Soil Scientist				✓
	Landscape architect				✓
	Student Time				✓
Total Cost				$1,078.25	

Your Rain Garden Costs

	Item	Cost/unit	# of units	Total Cost	Donated / Loaned
Standard Supplies	White mark-out paint				
	Landscape pins				
	Weed block fabric				
	Hose (75' soaker hose)				
	Shovels/soil rakes				
	UMass Soil Texture Test				
Bobcat Rental (not always required)	Rental				
	Fuel				
	Delivery				
	Insurance				
Delivery Fees (not needed if picking up)	Mulch				
	Plants				
Soil Amendments					
Plants					
Professionals and Labor	Soil Scientist				
	Landscape architect				
	Student Time				
Total Cost					

Appendix F – Sizing and Planning Steps

This material is adapted from Rutgers Cooperative Extension Rain Garden Resources.

Things to Remember:

- Call 1-800 – DIG – SAFE for a utility mark-out.
- Do not put rain garden in places where the water already ponds or the lawn is always soggy.
- Do not put rain garden in former sites of built-in pools or parking lots.
- Place in full or partial sunlight as a first option.
- Select a flat part of the yard for easier digging as a first option.
- Avoid large tree roots.

Step 1 – Determine Contributing Drainage Area

Determine the surfaces you want to capture stormwater from and measure the area:

Surface	Contributing Drainage Area (Square Feet)
Rooftop*	
Driveway/Parking Lot	
Other	
Total Drainage (Square Feet) =	

*Be sure to find the area of the roof that actually feeds to that downspout. Multiply the roof area by the estimated percentage of the roof that feeds to the rain garden downspout.

% Roof feeding to downspout	Area of Roof	Contributing Area

Step 2 – Determine Location

The Rain Garden location must meet the following criteria as specified in RI Stormwater Design and Installation Standards Manual:

- Be at least 10 ft from building
- Is not over utilities (already called 1 – 800 – DIG - SAFE)
- Is at least 15 ft from a septic tank or field and 25 ft from a private drinking well.
- Is uphill or level with a septic tank
- Has a slope that is less than 12% (12' height over 100' length)
- Seasonably high water table and bedrock is at least 2 ft from the proposed bottom of rain garden depression.

Step 3 – Percolation Test

When you conduct a site visit, a percolation test can be used to check the drainage in a potential rain garden site. This is helpful in determining site suitability or if you may require soil amendments.

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 (this will give you saturated soil conditions).

3. Refill the empty hole with water again. Measure the depth of the water with a ruler. Record depth in the table below.
4. Check the depth of water with a ruler every hour for at least 4 hours. Record depths for each hour in the table below.
5. Calculate the percolation rate (how many inches of water drained per hour).

Time	Depth (inches)
0 hour (before walking away)	
1st hour	
2nd hour	
3rd hour	
4th hour	
Percolation rate (inches/hour)	

JUST IN CASE…

[Depth at 0 hour (inches) - Depth at 4th hour (inches)]/4 hours = Percolation Rate (inches/hour)

EXAMPLE…

[10"-6.5"]/4 hours = 0.875"/hour

Interpreting the Percolation Rate Results:

A rate of one inch per hour to one and a half inches per hour is considered ideal for a rain garden. If the water does not drain in 12 hours, the site is only appropriate if the soils are amended (see professional).

Step 4 – Determine Slope

The slope of the land will help to determine the depth of the rain garden. To find the slope of the rain garden location, a string should be tied to the base of an uphill stake then tied to a downhill stake using a string level to be sure the string is perfectly level.

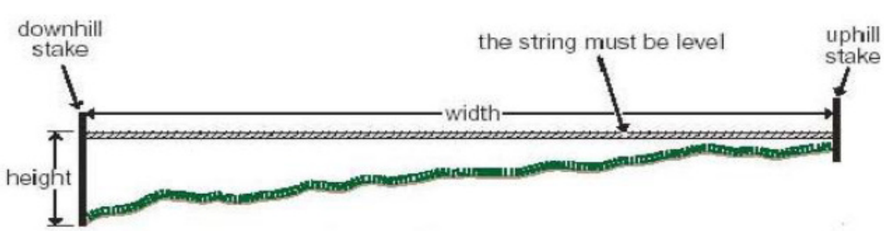


Figure 1: Measuring Slope (Credit: University of Wisconsin)

String Level found at Home Depot

To calculate the percent slope, divide the height (distance the string is above ground on the downhill stake) by the width (distance between the two stakes), which should both be in feet. Multiply this number by 100 to obtain the percent slope.

	Measurement (Feet)
Height	
Width	
[height/width] x 100 = **Percent Slope**	

Step 5 – Determine Rain Garden Depth

The depth of the rain garden depends upon the percent slope (calculated in Step 4). Use the table below to determine the typical depth of the rain garden.

Percent Slope	Typical Depth
Less than 4%	3 – 5 inches
Between 5% - 7%	6 – 7 inches
Between 8% - 12%	8 inches
Greater than 12%	Consider another location

NOTE: Rain gardens with poor percolation rates should be shallower with a larger surface area since they percolate slowly.

Step 6: Soil Texture and Compaction

A. Soil Texture

Test more than one area of potential rain garden location. Take soil sample 6" below the proposed rain garden depth. Have a soil test done by UConn Soil Testing Lab (http://soiltest.uconn.edu/sampling.php).

B. Soil Compaction

Conduct wire flag test (poke wire flag in ground)

- Easily penetrates 6"-8" or more
- Compacted, difficult to insert

Step 7 – Determine Rain Garden Size

The size of the rain garden is based upon the drainage area (calculated in Step 1), and predominant soil texture (determined from soil test). The following table provides sizing factors, based on soil type and depth, which can be multiplied by the drainage area to determine size.

Rain Garden Sizing Factors			
	3-5" deep	**6-7" deep**	**8" deep**
Sandy soil	0.19	0.15	0.08
Silty soil	0.34	0.25	0.16
Clayey soil	0.43	0.32	0.20

You will need to interpret your soil results to classify your texture as "sandy, silty, or clayey". Under "Comments" in your soil report it will indicate Soil Textural Classification. An example would be Loamy Sand. The first texture: Loamy is the adjective describing the primary soil texture, which is the second texture: Sand. Use the following chart adapted from CT NRCS Rain Garden Site and Soil website to determine your general soil type.

Soil Texture	General Soil Type
Sand	Not Suitable for Rain Garden
Clay	
Loamy Sand	Sandy
Sandy Loam	
Silt Loam	Silty
Loam	
Silt	
Sandy Clay	Clayey
Sandy Clay Loam	
Silty Clay Loam	
Silty Clay	
Clay Loam	

Once you have determined your sizing factor, you can multiply this value by the drainage area.

Example Sizing Calculation:

Drainage Area = 450 ft^2
Rain Garden Depth = 8 in
Predominant Soil Type = Silty
Sizing Factor = 0.16

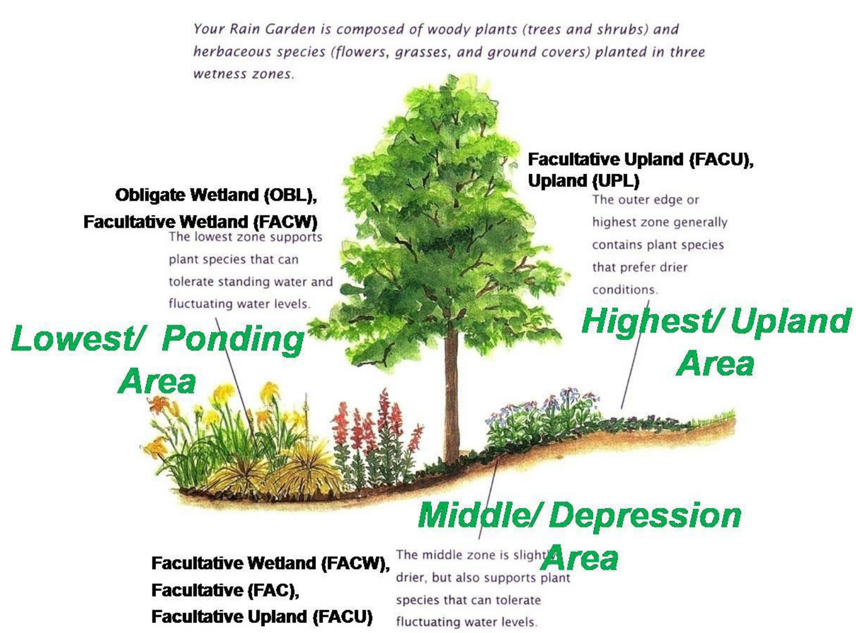
Drainage Area x Sizing Factor = Rain Garden Area

$450\ ft^2 \times 0.16 = 72\ ft^2$

Step 8 – Planting Methods and Materials

A. Create Design

- ◯ Use the RI Plant Guide to find proper plants for your rain garden: http://www.uri.edu/cels/ceoc/coastalPlants/CoastalPlantGuide.htm
- ◯ List plants for ponding area
- ◯ List plants for depression area
- ◯ List plants for upland area
- ◯ Determine if plants will be mixed or massed
- ◯ Sketch a rain garden design



Cross section image credit: University of Wisconsin

B. Spacing

Plant Size	Typical Spacing
Plugs	12” – 15”
2” – 4” pots	15” – 18”
≥ 6” pots	Depends on species
Trees and shrubs	Depends on species

C. Number of plants

Determine the number of plants for the rain garden by dividing the size of the rain garden (in square feet) by 100. Then, multiply this number by the number of plants recommended in the table below (determined from the plant size typical spacing).

Number of Plants Needed for 100 Square Foot Rain Garden	
Spacing	**Number of Plants**
12”	100
16”	56
18”	45
24”	25
48”	6

Just In Case:

[Size of Rain Garden(measured in square feet)/100] x Number of Plants(from Table) = Total # of Plants

Example:
200ft2 Rain Garden with Plugs (12” Spacing)
[200ft2/100] x 100 = 200 Plants

200ft2 Rain Garden with 2”-4” Pots (18” Spacing)
[200ft2/100] x 45 = 90 Plants

Step 9 – Final Factors

A. Add Mulch

The rain garden will need a 2- 3 inch thick layer of non-dyed, aged shredded hardwood mulch. Here is a table to help you determine amount of mulch needed:

Size of Rain Garden	Approximate Amount of Mulch
50 ft^2	0.50 yd^3
100 ft^2	1.0 yd^3
200 ft^2	2.0 yd^3

B. Summarize the Design

Once you have determined the size of the rain garden, you can calculate the amount of soil amendments and mulch you need to purchase.

Depth of Rain Garden (Step 5)	
Size of Rain Garden (Step 7)	
Amount of mulch needed (Step 8)	
Other materials needed (Step 6A and 6C)	

C. Professional Considerations

A professional contractor or landscape architect is required to confirm these important features:

- Determine Inlet – Determine or design a way for water to enter the rain garden.
- Determine Overflow – Consider how the design will handle large storms.
- Choose Plants – A professional will help to determine plants that will thrive in this environment and double check the choices you made using the RI Coastal Plant Guide: http://www.uri.edu/cels/ceoc/coastalPlants/CoastalPlantGuide.htm

Appendix G – <u>Sample Press Releases</u>

Contact: [your name and title]

[City/town]

[Phone and fax number]

FOR IMMEDIATE RELEASE *(To be released prior to installation date)*

(Your Group) is Part of the Pollution Solution

Building a rain garden to beautify the community and improve water quality

(City, Town Name), R.I. – (Date) – The members of (Your group) are taking important steps to protect Narragansett Bay. On (Date) they will be installing a rain garden at (Location).

A rain garden is an attractive native plant garden with a special purpose: to capture, soak up and filter rain water runoff before it enters local water bodies. When it rains, water collects remnants of our everyday activities such as litter, motor oil, bacteria from pet waste, excess fertilizers and pesticides, and leaves and grass clippings. This polluted stormwater runs off roofs, driveways, parking lots and other hard surfaces to storm drains and then directly to local waters. Pollutants in stormwater close beaches and fishing grounds, threaten water resources, harm natural areas, and contribute to flooding. Rain gardens allow stormwater to soak into the ground instead of flowing into storm drains or local waterways.

In collaboration with (Partners) and donations from (Donors), (Your group) is working to install a rain garden at (Location). The students have studied how stormwater has affected our local water bodies and decided to take steps to improve their community. (Describe why you chose the site and how it will impact the area).

(Your group) invites you to the installation ceremony on (Date). You can volunteer or just stop by to show your support for their hard work and dedication to improving the community. (Your group) has worked hard to organize the event and is looking forward to planting a beautiful garden at (Location) that will also help to reduce stormwater in (your town). To volunteer at the event, contact (your information).

Every drop of rain you keep on your property helps to keep our local waters clean. To learn more about rain gardens and how you can install a rain garden on your property (provide website or contact information).

Contact: [your name and title]

[City/town]

[Phone and fax number]

FOR IMMEDIATE RELEASE *(To be released after installation date)*

(Your Group) is Part of the Pollution Solution

Building a rain garden to beautify the community and improve water quality

(City, Town Name), R.I. – (Date) – You may have noticed a new garden located at (Location). On (Date) the members of (Your group) installed a rain garden with the goals of beautifying the area and improving the health of Narragansett Bay and local water bodies.

Members of the (your group) noticed a problem with rain runoff near (Location). (Describe some of the problems associated with the area prior to installing the rain garden – quote local residents on what it was like before). Under the guidance of their advisor, (Advisors name), they discovered that there are solutions to the stormwater pollution problem. They decided it was a perfect spot to build a rain garden.

A rain garden is an attractive native plant garden with a special purpose: to capture, soak up and filter rain water runoff before it enters local water bodies. When it rains, water collects remnants of our everyday activities such as litter, motor oil, bacteria from pet waste, excess fertilizers and pesticides, and leaves and grass clippings. This polluted stormwater runs off roofs, driveways, parking lots and other hard surfaces to storm drains and then directly to local waters. Pollutants in stormwater close beaches and fishing grounds, threaten water resources, harm natural areas, and contribute to flooding. Rain gardens allow stormwater to soak into the ground instead of flowing into storm drains or local waterways.

In collaboration with (Partners), (Your group) has spent (length of project time) planning, designing, and publicizing the rain garden. (Be sure to credit companies and organizations that lent or donated materials or money)

On (date) students in (your group) completed the final step of their project by planting native plants in their rain garden. Volunteers and community members supported their efforts by lending a hand planting or spreading mulch and attending the installation ceremony. (Quote volunteers and community members from the event.)

Every drop of rain you keep on your property helps to keep our local waters clean. To learn more about rain gardens and how you can install a rain garden on your property (provide website or contact information).

Appendix H – <u>Construction Day Checklist</u>

☑ Prior to Construction:

- ○ Keep a running list of Materials you will need (this is a general list of – your materials and amounts will vary):
  - Topsoil
  - Mulch
  - Soil Amendments
  - Plants
  - Screwdrivers
  - Hammers
  - Shovels
  - Rakes
  - Garden Hose
  - String and Stakes
  - Wheelbarrows
  - Gardening Gloves

- ○ Be sure you have enough tools to share among participants
- ○ Provide refreshments and snacks if possible or at least provide water
- ○ Create and print a sign-in sheet
- ○ Create and print a liability waiver form
- ○ Prepare a task list so that you use your volunteer's time and skills wisely
- ○ Print Rain Garden Brochure and Fact Sheet to distribute to volunteers and onlookers
- ○ Label the tools
- ○ Create and print a Construction Sequence
- ○ Print the rain garden schematic with plants labeled
- ○ Call key volunteers and asked them to arrive early and be Team Leaders
- ○ Put together an emergency medical kit and set up an emergency plan in case of an accident
- ○ Make sure that bathroom facilities are available for volunteers
- ○ Make sure to have access to water hose if possible
- ○ Contact local newspaper

☑ Day of Construction:

- ○ Take "Before" photo
- ○ Position plants where they are to be planted
- ○ Place tools in a central location
- ○ Put Emergency Kit on hand in the central location
- ○ Greet and organize volunteers:
  - Have volunteers sign in and sign liability waiver

- Delegate responsibilities
- Provide info on emergency plan, bathroom locations, and refreshments
- Announce the schedule and breaks
- Distribute and explain construction sequence
- Take photo of all volunteers

○ Take photos of all the construction phases, emphasizing the volunteers

☑ Post - Construction:

○ Water the rain garden
○ Take "After" photo
○ Follow up with press – provide pictures and details
○ Send out thank you cards to all who participated
○ Visually inspect and repair erosion monthly
○ Every 6 months, in the spring and fall, add a fresh mulch layer
○ Prune excess growth annually or more often
○ After rainstorms, inspect the garden and make sure that drainage paths are clear and that ponding water dissipates over four to six hours

Runoff Volume: The Importance of Land Cover

Grade Level: 9-12

Time: 1 - 2 class periods

Learning Objectives:

- Quantify the volume of water that runs off different land uses in a watershed.
- Analyze the difference between land uses and what characteristics impact runoff.
- Hypothesize impacts that stormwater runoff might have on a community.

Extension Lessons:

This lesson can be adapted for more complex calculations that include watersheds with multiple land use covers. This would require students to calculate a weighted Curve Number.

Rhode Island Grade Span Expectations Addressed:

<table>
<tr><td rowspan="4">Science</td><td colspan="2">LS2 (9-11) - 3 Using data from a specific ecosystem, explain relationships or make predictions about how environmental disturbance (human impact or natural events) affects the flow of energy or cycling of matter in an ecosystem.</td></tr>
<tr><td>LS2 (9-11) – 3b</td><td>Describing ways in which humans can modify ecosystems and describe and predict the potential impact.</td></tr>
<tr><td colspan="2">LS4 (9-11) - 9 Use evidence to make and support conclusions about the ways that humans or other organisms are affected by environmental factors or heredity</td></tr>
<tr><td>LS4 (9-11) - 9b</td><td>Providing an explanation of how the human species impacts the environment and other organisms.</td></tr>
<tr><td rowspan="4">Math</td><td colspan="2">Numbers and Operators</td></tr>
<tr><td>M(N&O)–10–4</td><td>Accurately solves problems that involve but are not limited to proportional relationships, percents, ratios, and rates. (The problems might be drawn from contexts outside of and within mathematics including those that cut across content strands or disciplines.)</td></tr>
<tr><td colspan="2">Geometry and Measurement</td></tr>
<tr><td>M(G&M)–10–6</td><td>Solves problems involving perimeter, circumference, or area of two-dimensional figures (including composite figures) or surface area or volume of three-dimensional figures (including composite figures) within mathematics or across disciplines or contexts.</td></tr>
<tr><td rowspan="4">Civics and Government</td><td colspan="2">C&G 4: People engage in political processes in a variety of ways.</td></tr>
<tr><td>C&G 4
(9-12)–3</td><td>Students participate in a civil society by critically reflecting on their own civic dispositions (e.g., recognition of the capacity to make a difference)</td></tr>
<tr><td colspan="2">C&G 5: As members of an interconnected world community, the choices we make impact others locally, nationally, and globally.</td></tr>
<tr><td>C&G 5
(9-12) -3</td><td>Students demonstrate an understanding of how the choices we make impact and are impacted by, an interconnected world by predicting outcomes and possible consequences of a conflict, event, or course of action</td></tr>
</table>

Runoff Volume: The Importance of Land Cover

Name: ____ Date: ___________________

Purpose:

To understand and quantify how different land uses impact the amount of stormwater runoff.

Things to Know

> **What is Stormwater Runoff?**
> Precipitation that does not infiltrate into the earth, but flows over the land. Too much runoff can lead to flooding, polluted waters, and reduced groundwater

The surface that rain falls upon will determine whether water will infiltrate into the ground or runoff the landscape. Hydrologists have categorized different land uses and their potential for runoff by assigning *Curve Number* values to various landscapes. Curve numbers were developed by what is currently known as the Natural Resources Conservation Service (NRCS) when they first started studying runoff volume and graphically representing it with rainfall retention curves. Curve numbers help to determine how much water will runoff a surface given a specific rainfall amount. The figures on the following page are examples of curve number values assigned to different landscapes. The higher the curve number, the more rain will runoff the land surface. In the charts below, you will notice that not only does the type of land use determine the curve number, but also the *Hydrologic Soil Group* (A, B, C, D). A group "A" soil is one that has a low runoff potential when thoroughly wet, meaning water will still infiltrate into the soil even after large rainfall events and saturated conditions. A group "B" soil has moderately low runoff potential, a group "C" soil has moderately high runoff potential, and a group "D" soil has a high runoff potential. These soil classifications are typically made by a professional soil scientist. Knowing the type of land cover that resides on a landscape and the hydrologic soil group, one can determine the Curve Number for a site and therefore, how much runoff the landscape will produce.

> **What is a Curve Number?**
> A number assigned to a land use type that determines how much water will runoff the landscape.

> **What are Hydrologic Soil Groups?**
> A set of four soil groups (A, B, C, D) that are defined by their ability to infiltrate water.

Curve Numbers Resource Page (See Hydrology 101 for footnote definitions):

Cover description		Curve numbers for hydrologic soil group			
Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	53	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

Cover description		Curve numbers for hydrologic soil group			
Cover type and hydrologic condition	Average percent impervious area [2]	A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82

Part 1:

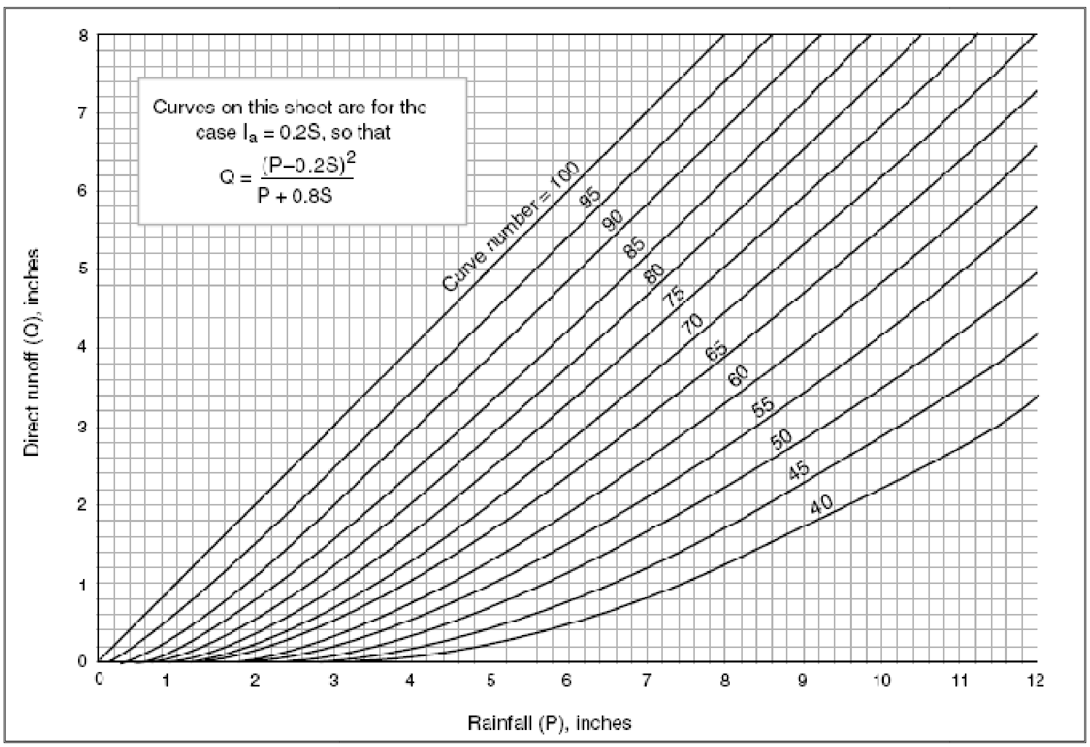
Determine the volume of water that will runoff 100 acres of forest in a typical storm producing 2.8 inches of rain.

Knowns:

Area of land = 100 acres
Rainfall amount = 2.8 inches
Conversion factors:
  12 inches = 1 foot
  43,560 square feet = 1 acre

If 2.8 inches of rain fall on a 100 acre area, what is the volume of water that will runoff the surface of the land?

1) Determine the curve number for a wooded area in good hydrologic condition with soil Hydrogroup B using the charts above: _______________
2) Knowing the amount of rain and the curve number, use the graph below to determine the inches of runoff that would result from a 2.8 in storm: ______________________



3) In order to determine the total volume of water that runs off, every variable has to have the same units. Convert the area of land to square feet, and the runoff amount to feet.
  Area of land = _____________________ ft^2
  Direct runoff = ____________________ ft
4) Calculate the volume (ft^3) of runoff by multiplying the area times the depth of runoff.

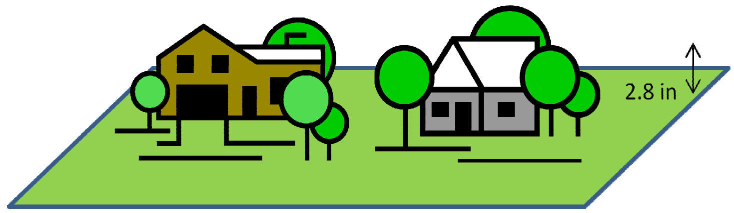
____

Part 2:

Determine the volume of water that will runoff 100 acres of residential land in a typical storm producing 2.8 inches of rain.

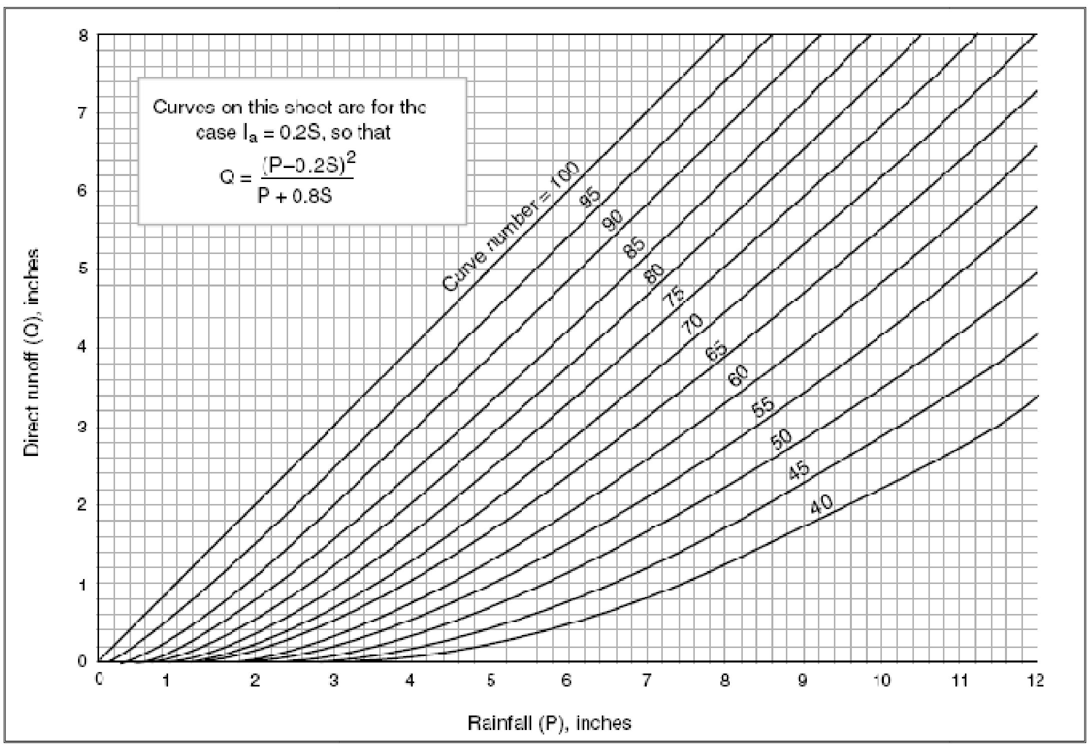
Knowns:

Area of land = 100 acres
Rainfall amount = 2.8 inches
Conversion factors:
12 inches = 1 foot
43,560 square feet = 1 acre



If 2.8 inches of rain fall on a 100 acre area, what is the volume of water that will runoff the surface of the land?

1) Determine the curve number for a residential area with ¼ acre lots sizes and with soil Hydrogroup B using the charts above: ___________________
2) Knowing the amount of rain and the curve number, use the graph below to determine the inches of runoff that would result from a 2.8 in storm: _______________________



3) In order to determine the total volume of water that runs off, every variable has to have the same units. Convert the area of land to square feet, and the runoff amount to feet.
   Area of land = ______________________ ft^2
   Direct runoff = _____________________ ft
4) Calculate the volume (ft^3) of runoff by multiplying the area times the depth of runoff.
   ____

Analysis Questions:

1) Compare the two runoff volumes for the different land uses. How much larger is the residential runoff volume than the wooded runoff volume?

____

2) A football field is a little bit larger than an acre. Consider a 1 acre football field being covered with a foot of water. That is equal to 43,560 cubic feet (ft^3). How many football fields of water came off of the wooded land versus the residential land?

____

____

3) What are some characteristics of a forested area that prevents rain from running off?

____

____

4) What are some characteristics of a residential area that cause runoff?

____

____

5) Impervious surfaces are surfaces that do not allow water to infiltrate. What are some examples of impervious surfaces you would find in a residential neighborhood?

____

____

6) Cities have a large amount of impervious surfaces. Perform the same calculations as Part 1 and 2 for an urban commercial and business area with hydrologic soil group B.
Curve Number = _____________ Runoff inches = ______________
Volume of runoff in cubic feet = ________________________________

7) How do you think large runoff volumes could impact nearby streams?

____

____

8) How do you think large runoff volumes could impact a community?

____

____

9) Think of the kinds of things you or your parents do in your yard or things you see in the street. What kinds of materials could get picked up by runoff and carried to local streams or water bodies?

____

____

10) Brainstorm some ways you might be able to prevent water from running off the impervious surfaces you have in your yard or school.

____

____

Why Is Stormwater Runoff So Bad?

<u>Teacher Resource Page</u>

<u>Grade Level:</u> 9-12

<u>Time</u>: 1 - 2 class periods and homework

<u>Learning Objectives:</u>

- Understand the impacts that stormwater runoff has on your community.
- Develop educational materials for rain garden outreach activities.

<u>Extension Lessons:</u>

This lesson can be adapted for more complex calculations that include watersheds with multiple land use covers. This would require students to calculate a weighted Curve Number.

<u>Rhode Island Grade Span Expectations Addressed:</u>

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</table>

Why Is Stormwater Runoff So Bad?

Name: ____ Date: __________________

Purpose:

To understand the impacts that stormwater runoff has on your community and develop educational materials for community outreach.

Procedure:

1. Read the Hydrology 101 document to get an understanding of how stormwater impacts the environment.
2. Utilize other resources to learn more about stormwater and its environmental impact.
3. Create a poster, PowerPoint presentation, signage for rain garden, brochure or factsheet on stormwater and its impacts to use for public outreach during your rain garden project.
4. Include the following topics in your outreach materials:
    a. Runoff Volume
    b. Runoff Flow
    c. Flooding Potential
    d. Stream Erosion
    e. Groundwater Recharge
    f. Pollution Sources
    g. The Benefits of Rain gardens
5. Present your outreach materials to classes at schools, local community organizations, potential donors or volunteers, and others in the community.
6. Use the following space to brainstorm your method of communication and content.

Rain Gardens Slow Stormwater Flow

Grade Level: 9-12

Time: 1 - 2 class periods

Learning Objectives:

- Graphically represent precipitation, inflow and outflow of runoff in a rain garden.
- Quantify the functions of a rain garden and how it minimizes stormwater problems.
- Describe the pollutant removal functions of a rain garden.

Extension Lessons:

This lesson can be adapted for more complex calculations and excel use by using rain depth and roof area to calculate inflow to rain garden. More information on the rain garden site can be found at: http://nemo.uconn.edu/research/raingarden.htm

Rhode Island Grade Span Expectations Addressed:

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<tr><td rowspan="4">Math</td><td colspan="2">Functions and Algebra</td></tr>
<tr><td>M(F&A)–10–2</td><td>Demonstrates conceptual understanding of linear and nonlinear functions and relations through an analysis of constant, variable, or average rates of change, intercepts, domain, range, maximum and minimum values, increasing and decreasing intervals and rates of change; describes how change in the value of one variable relates to change in the value of a second variable; or works between and among different representations of functions and relations (e.g., graphs, tables, equations, function notation).</td></tr>
<tr><td colspan="2">Geometry and Measurement</td></tr>
<tr><td>M(G&M)–10–6</td><td>Solves problems involving perimeter, circumference, or area of two-dimensional figures (including composite figures) or surface area or volume of three-dimensional figures (including composite figures) within mathematics or across disciplines or contexts.</td></tr>
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</table>

Rain Gardens Slow Stormwater Flow

Name: ____ Date: __________________

Purpose:

To understand and quantify how rain gardens help reduce the negative impacts of stormwater.

Things to Know:

Rain gardens are shallow depressions in the landscape that intercept, treat, and infiltrate stormwater. They are typically planted with native plants, are covered with a mulch layer, and often times look just like a regular garden you might have in your backyard. Most rain gardens are designed to capture the first one inch of rainfall flowing off a nearby impervious surface which helps to treat the majority of pollutants that are washed off in the beginning of a storm event and helps to infiltrate water.

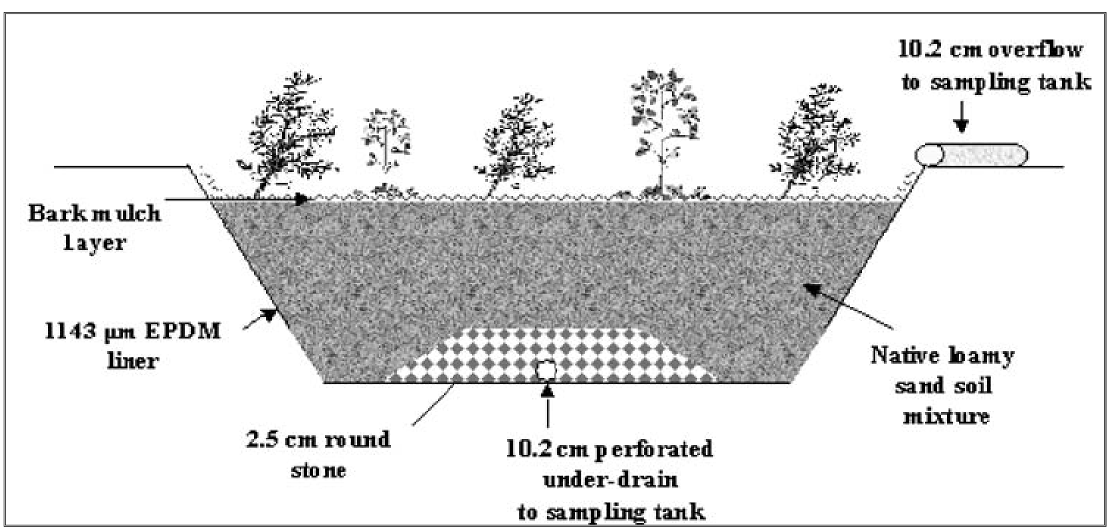
Rain gardens perform many processes that help to reduce the negative environmental effects caused by development. A research rain garden was installed in Haddam, CT in 2002 as a study done by the University of Connecticut. The rain garden was sited next to a roof downspout so as to capture the precipitation flowing off the roof. A cross section of the rain garden can be seen in the diagram below. One difference between the study rain garden and a normal one you might plant in your front yard is that it has a liner and an underdrain pipe at the bottom. This was installed so as to collect and record the volume of water captured by the rain garden and the pollutants that were removed. In a normal situation, the rain garden would allow the water to infiltrate into the natural soils below. The following information is adapted from data provided courtesy of Dr. Michael Dietz of University of Connecticut.

Roof area draining to Rain Garden = 1,150 ft^2

Rain Garden Surface area = 98.8 ft^2

Depth of Rain Garden = 6 inches

Depth of rain fall event = 0.81 inches



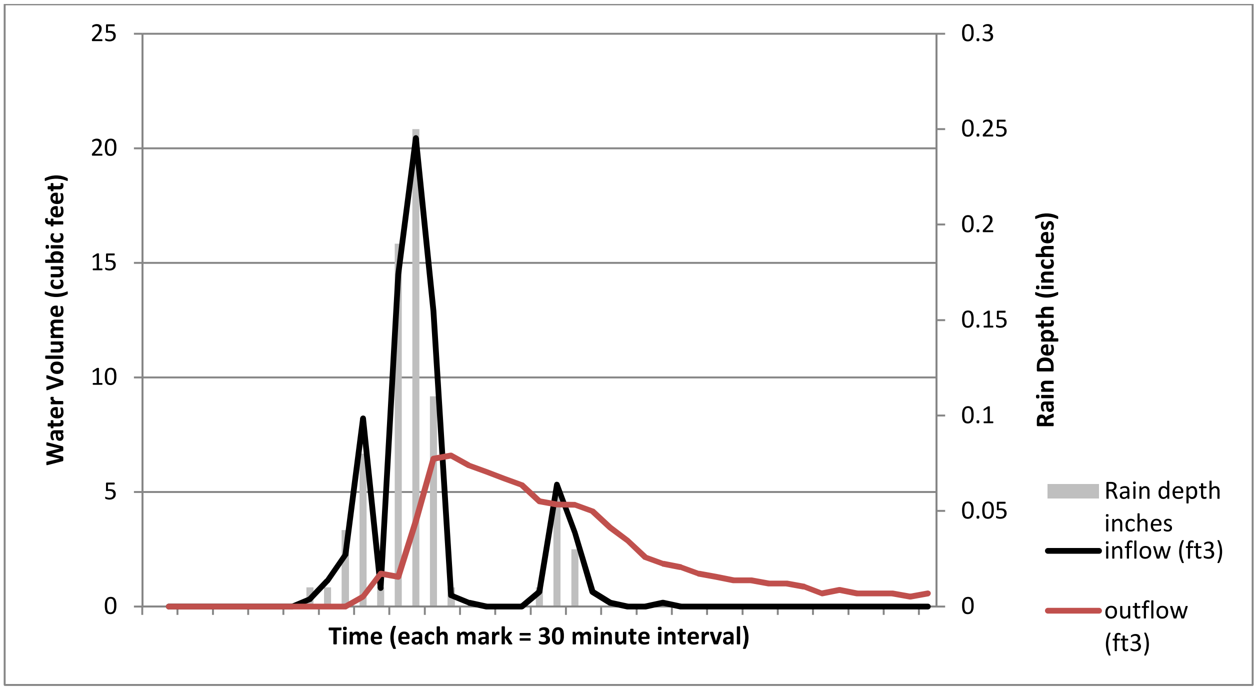
Part 1:

The following data provides information for one storm that took place at the Haddam rain garden site on October 2, 2003. The information collected at 30 minute intervals includes rain depth, inflow into the rain garden, and outflow as observed at the underdrain at the bottom of the rain garden. The source of water entering the rain garden (inflow) was a gutter connecting the top of the roof (size given above) to the rain garden. This information will help us to analyze how rain gardens impact the flow of runoff. We can use this data to observe how the volume of water moving out of the gutter, compares to the volume of water moving into the underdrain at the bottom of the rain garden.

1) Enter the following data into an excel spreadsheet or prepare a piece of graph paper and calculator to perform calculations.
2) Find the sum of the rain, inflow and outflow columns.
3) Create a graph of the data you entered. There should be three separate sets of data that you plot:
    a. Rain depth = bar graph
    b. Inflow volume = line graph
    c. Outflow volume = line graph
4) Title your axes and provide a legend for interpretation.
5) The graph should look like the example below.

Time (hr)	***Rain depth (in)***	***Inflow vol (ft3)***	***Outflow vol (ft3)***
0	0	0.000	0.000
0.5	0	0.000	0.000
1	0.01	0.322	0.000
1.5	0.01	1.127	0.000
2	0.04	2.254	0.000
2.5	0.08	8.211	0.433
3	0.01	0.805	1.431
3.5	0.19	14.490	1.292
4	0.25	20.447	3.720
4.5	0.11	12.880	6.442
5	0.01	0.483	6.589
5.5	0	0.161	6.156
6	0	0.000	5.877
6.5	0	0.000	5.583
7	0	0.000	5.305
7.5	0.01	0.644	4.586
8	0.06	5.313	4.447
8.5	0.03	3.220	4.439

Time (hr)	***Rain depth (in)***	***Inflow vol (ft3)***	***Outflow vol (ft3)***
9	0	0.644	4.161
9.5	0	0.161	3.441
10	0	0.000	2.869
10.5	0	0.000	2.150
11	0	0.161	1.864
11.5	0	0.000	1.717
12	0	0.000	1.431
12.5	0	0.000	1.292
13	0	0.000	1.144
13.5	0	0.000	1.144
14	0	0.000	0.997
14.5	0	0.000	1.005
15	0	0.000	0.858
15.5	0	0.000	0.223
16	0	0.000	0.167
16.5	0	0.000	0.050
17	0	0.000	0.030
17.5	0	0.000	0.000
18	0	0.000	0.000



Analysis:

1) How many inches of rain fell during this event? ____

2) What was the total water volume flowing into the rain garden? ____________________________

3) What was the total water volume flowing into the underdrain? _____________________________

4) If the roof has a drainage area of 1,150 ft^2, what is the volume (ft^3) of water flowing off the surface of the roof during this storm event? (*1 foot = 12 inches*)

____

____

5) What value does question #4 represent from your sum calculations completed in Part I?

____

6) Why do you think the total inflow was less than the total outflow of the rain garden? (*Tip: think about the area exposed to rain.*)

____

____

7) Describe some of the trends you see on your graph.____________________________________

____

____

8) How does precipitation relate to the inflow volumes with respect to time?

____

____

9) How does precipitation relate to the outflow volumes with respect to time?

____

____

10) What is the difference in peak flow between the inflow and outflow volumes?

____

____

11) Using your knowledge of the negative impacts of stormwater, why is the change in peak flow so important?____

____

____

12) The underdrain was place in the rain garden for study purposes. Why would it be useful to have all of that water infiltrate into the soil?____

____

____

Rain gardens can also treat pollutants that may be in runoff through the following processes:

a. Filtration - particles and suspended solids are filtered out in the mulch and soil
b. Assimilation – plants can take in nutrients and use them for energy and to grow
c. Adsorption – organic soils can absorb metals and nitrates with the ionic attraction of holding a substance to a solid surface
d. Degradation - microbes found in soils can degrade toxic chemical compounds
e. Transfer - bacteria found in soils can convert Nitrogen to forms that can be used by plants or released into the atmosphere.

13) What kinds of pollutants do you think you might find in stormwater runoff?

____

____

14) Describe how a rain garden might help solve problems in your community.

____

____

____

Hydrology 101 – A Reference Document for Teachers and Students

(Words in italic are defined at the end of document)

Background:

As our natural landscape becomes more and more developed, it can have severe impacts on the natural *hydrology* of the landscape and our *watersheds*. In a naturally vegetated and undisturbed landscape, precipitation that falls onto the ground is allowed to infiltrate into the soils below, evaporates, or is taken up and used by plants and then released into the atmosphere through transpiration (as seen in Figure 1).

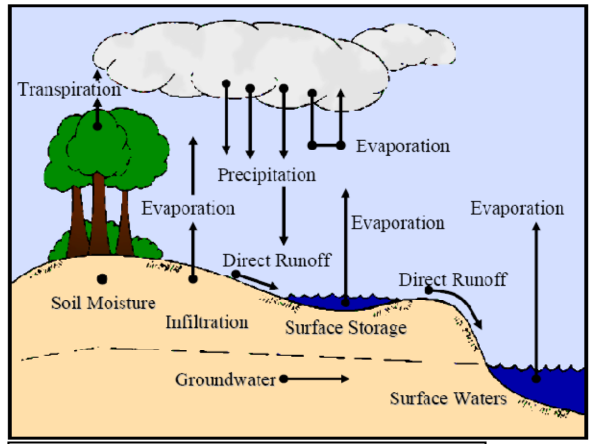


Figure 1 – Source: RI Stormwater Design and Installation Standards Manual.

In this kind of natural setting, approximately 50 percent of water actually infiltrates into the ground, 40 percent is transferred back to the atmosphere through evaporation and transpiration (evapotranspiration), while only 10 percent flows over the landscape as runoff and into nearby streams or water bodies (See Figure 2). As land becomes developed the percentage of infiltration and runoff can change drastically. When land is altered and built upon, some of the basic characteristics of the landscape no longer exist. Instead of a healthy vegetated landscape with soils that have useful properties and microbial activity that allow water to infiltrate, be cleaned of possible contaminants, and restore groundwater levels, *impervious surfaces* are placed on top of the earth's surface in the form of houses, driveways, roads, and sidewalks. These surfaces do not allow water to infiltrate into the ground and can increase the amount of runoff over the land to 55 percent of rainfall in extreme urban settings.

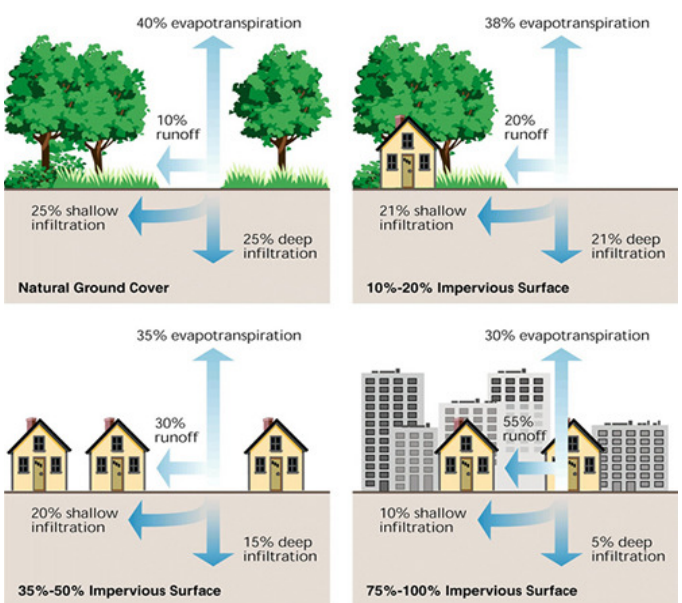


Figure 2 – Source: Minnesota Water: Let's Keep it Clean Act
http://www.cleanwatermn.org/resources/Hard-Surfaces.aspx

During development, not only is the landscape transformed and covered in impervious surfaces, but many times areas that aren't covered with impervious have been stripped of its natural vegetated cover, healthy topsoil has been cleared away, and the site sloped and shaped to allow easy access for large machinery and building placement. These activities can greatly impact the land that is not covered with impervious surfaces, making them compacted and bare, conditions that are not conducive for plant growth or infiltration. The landscape that is left after development is one that is extremely different from its original state, and one that does not perform useful and natural hydrologic functions. For many years this kind of development has been taking place all over the U.S and it has had detrimental effects on the health of our local water bodies, flood risks, and availability of clean drinking water found in groundwater aquifers and surface waters that many people rely on.

Runoff Volume:

When precipitation falls onto the landscape, its fate is largely determined by the characteristics of the site it hits (soils, impervious surfaces, vegetation, amount of saturation currently in landscape, etc.), and the amount of precipitation that falls. In Rhode Island, we have an average yearly rainfall amount of 51 inches/year. This rain can fall in large or small storm events. Hydrologists have classified certain storm events and the amount of rain produced by them into statistical categories such as the 1 year storm, 10 year storm or 100 year storm. For example in RI, the 100 year storm refers to a large storm that produces over 8.5 inches of rain within a 24 hour period, and has a 1% chance of occurring each year (Note: A 100 year storm does not mean it occurs once every 100 years, but rather has a 1 out of 100 chance of occurring, thus a 1% chance). Figure 3 below is taken from the RI Stormwater Design and Installation Standards Manual and describes the rainfall amount for different storm events in Rhode Island. (RI Stormwater Manual)

RI County	24 – hour (Type III) Rainfall Amount (inches)*						
	1 – Year	2 – Year	5 – Year	10 – Year	25 – Year	50 – Year	100 -Year
Providence	2.7	3.3	4.1	4.9	6.1	7.3	8.7
Bristol	2.8	3.3	4.1	4.9	6.1	7.3	8.6
Newport	2.8	3.3	4.1	4.9	6.1	7.3	8.6
Kent	2.7	3.3	4.1	4.8	6.2	7.3	8.7
Washington	2.8	3.3	4.1	4.9	6.1	7.2	8.5

Figure 3 – Source: RI Stormwater Design and Installation Standards Manual

*All Rhode Island County rainfall values were obtained from the Northeast Regional Climate Center (NRCC) using regional rainfall data processed by NRCC from the period of record through December 2008.

The surface that rain falls upon will determine whether water will infiltrate into the ground or runoff the landscape. Hydrologists have also categorized different land uses and their potential for runoff by assigning *Curve Number* values to various landscapes. Curve numbers were developed by what is currently known as the Natural Resources Conservation Service (NRCS) when they first started studying runoff volume and graphically representing it with rainfall retention curves. These curve numbers help to determine how much water will runoff a surface given a specific rainfall amount. Figure 4 and Figure 5 on the following page are examples of curve number values assigned to different landscapes. The higher the curve number, the more rain will runoff the land surface. In the charts below, you will notice that not only does land cover determine the curve number, but also the *Hydrologic Soil Group* (A, B, C, D). A group "A" soil is one that has a low runoff potential when thoroughly wet, meaning water will still infiltrate into the soil even after large rainfall events and saturated conditions. A group "B" soil has moderately low runoff potential, a group "C" soil has moderately high runoff potential, and a group "D" soil has a high runoff potential (NRCS, 2007). These soil classifications are typically made by a professional soil scientist. Knowing the type of land cover that resides on a landscape and the hydrologic soil group, one can determine the curve number for a site. Knowing the curve number of an area and the amount of rainfall, the amount of water that runs off the landscape can be determined. See the graph (Figure 6) below to determine runoff amounts for a given curve number and rainfall amount.

Figure 4 – Curve Numbers for Agricultural Lands, Source: TR - 55

Cover description: Cover type	Hydrologic condition	Curve numbers for hydrologic soil group: A	B	C	D
Pasture, grassland, or range—continuous forage for grazing. [2]	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow—continuous grass, protected from grazing and generally mowed for hay.	—	30	58	71	78
Brush—brush-weed-grass mixture with brush the major element. [3]	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30 [4]	48	65	73
Woods—grass combination (orchard or tree farm). [5]	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods. [6]	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30 [4]	55	70	77
Farmsteads—buildings, lanes, driveways, and surrounding lots.	—	59	74	82	86

1 Average runoff condition, and $I_a = 0.2S$.

2 *Poor:* <50%) ground cover or heavily grazed with no mulch.
Fair: 50 to 75% ground cover and not heavily grazed.
Good: > 75% ground cover and lightly or only occasionally grazed.

3 *Poor:* <50% ground cover.
Fair: 50 to 75% ground cover.
Good: >75% ground cover.

4 Actual curve number is less than 30; use CN = 30 for runoff computations.

5 CN's shown were computed for areas with 50% woods and 50% grass (pasture) cover. Other combinations of conditions may be computed from the CN's for woods and pasture.

6 *Poor:* Forest litter, small trees, and brush are destroyed by heavy grazing or regular burning.
Fair: Woods are grazed but not burned, and some forest litter covers the soil.
Good: Woods are protected from grazing, and litter and brush adequately cover the soil.

Figure 5 – Curve Numbers for Urban Developed Lands, Source: TR - 55

Cover description: Cover type and hydrologic condition	Average percent impervious area [2]	Curve numbers for hydrologic soil group: A	B	C	D
Fully developed urban areas (vegetation established)					
Open space (lawns, parks, golf courses, cemeteries, etc.) [3]:					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50% to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved; open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only) [4]		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-inch sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82

1 Average runoff condition, and $I_a = 0.2S$.

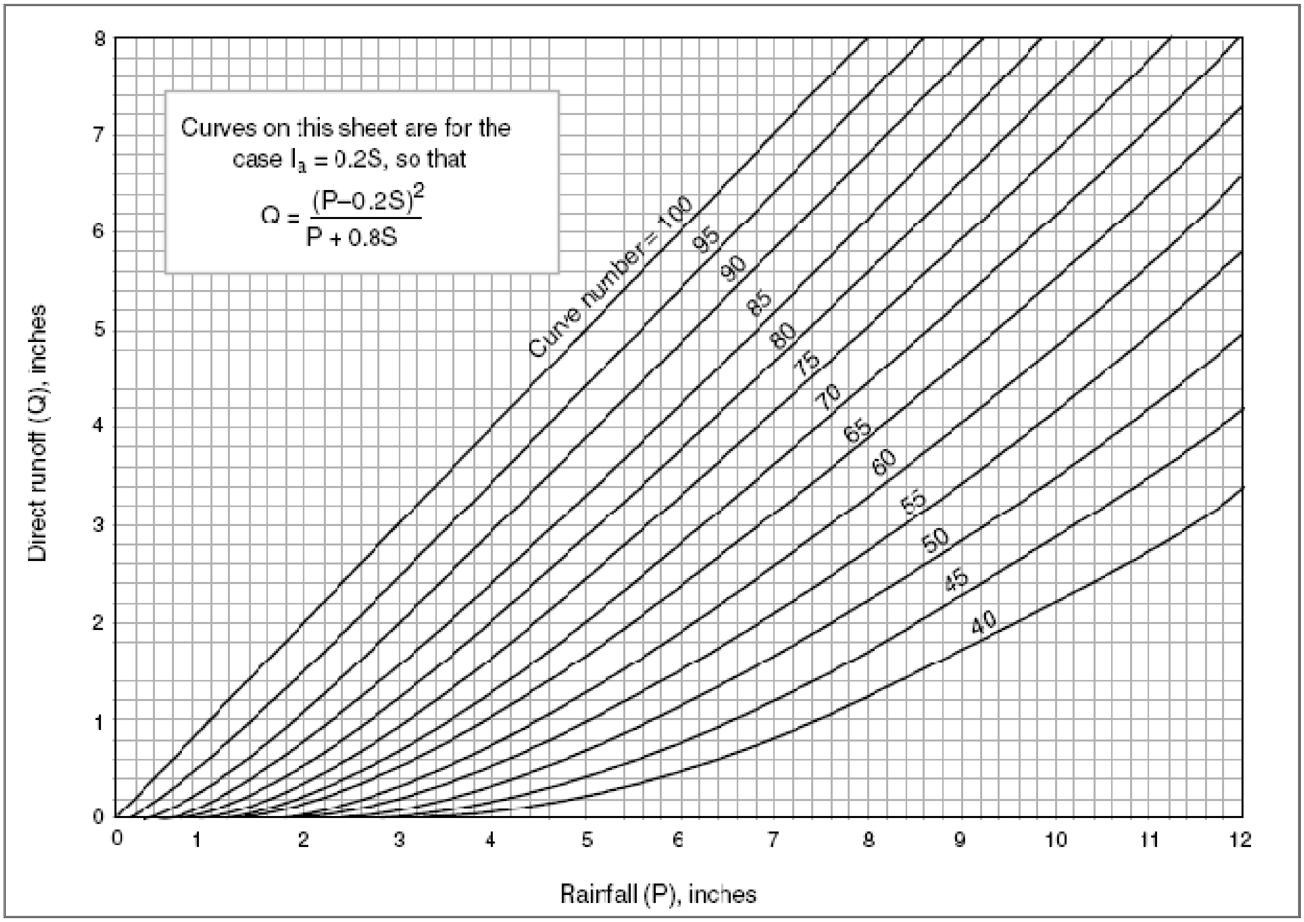
2 The average percent impervious area shown was used to develop the composite CN's. Other assumptions are as follows: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition. CN's for other combinations of conditions may be computed using figure 2-3 or 2-4.

3 CN's shown are equivalent to those of pasture. Composite CN's may be computed for other combinations of open space cover type.

4 Composite CN's for natural desert landscaping should be computed using figures 2-3 or 2-4 based on the impervious area percentage (CN = 98) and the pervious area CN. The pervious area CN's are assumed equivalent to desert shrub in poor hydrologic condition.

5 Composite CN's to use for the design of temporary measures during grading and construction should be computed using figure 2-3 or 2-4 based on the degree of development (impervious area percentage) and the CN's for the newly graded pervious areas.

Figure 6 – Inches of runoff for various rainfall and curve numbers, Source: TR - 55

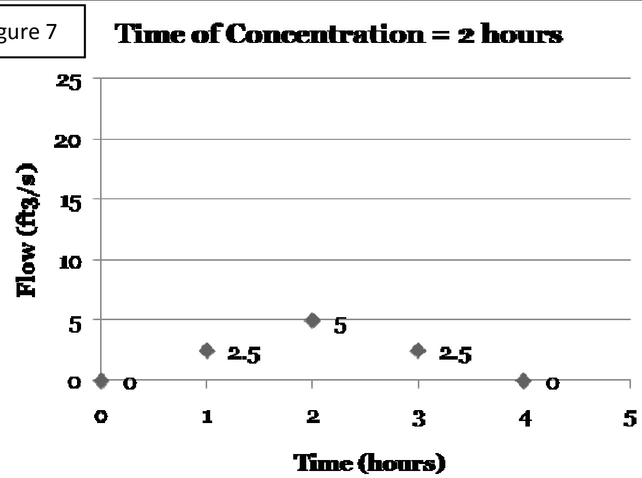


The actual volume of runoff can also be determined for a given area by knowing the rainfall amount, curve number, and drainage area you are analyzing (see example calculation in the Runoff Volume: The Importance of Land Cover Lesson). As you can see from the charts, highly developed landscapes have higher curve numbers. For example, an impervious area such as a paved parking lot has a curve number of 98; whereas a wooded area in good hydrologic condition with a hydrologic soil group "B" has a curve number of 55. By using the graph above, one can see that for a rainfall event that produces 2 inches of rain, the parking lot (curve number = 98) would have approximately 1.8 inches of runoff, while the wooded area (curve number = 55) would have no runoff at all. Over a large area, this can drastically change the volume of water that runs off the surface of a landscape. In the following sections, you will discover how this increase in runoff volume can contribute to serious problems on the landscape and within a community.

Runoff Flow:

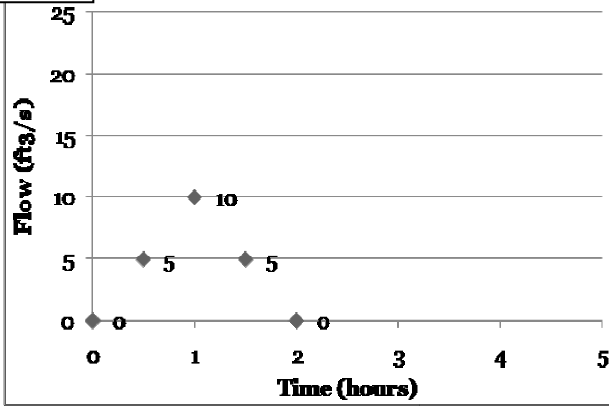
Development has an obvious impact on the volume of runoff that flows over a landscape, but there are other hydrologic impacts resulting from impervious surfaces. Not only is there an increase in volume of *stormwater runoff*, but there is also an increase in the rate of flow. *Flow* is the volume of water that is transported in a certain time period. The point when a drainage outlet such as a stream or river experiences its maximum flow rate is called *peak flow*. When a storm occurs and water runs over a natural landscape, it is typically slowed down by vegetation, and variations in slope and landscape shapes. This kind of natural landscape contributes characteristics to a site's time of concentration. *Time of concentration* is the amount time that it takes for water flowing over the landscape to travel from the furthest point in the watershed to a drainage outlet. For naturally vegetated landscapes that slow down the flow of runoff, this time of concentration can be very high, meaning it takes a long time for water from the furthest reaches of a watershed to get to a stream or river and contribute to the *peak flow*. When the natural landscape is developed and covered with smooth impervious surfaces like parking lots, roads, and storm drains, the speed that water flows over the landscape to a stream or drainage outlet can be extremely fast. This decreases the time of concentration drastically. (NRCS, 1986) The graphs and tables below (Figure 7, 8, and 9) depict how time of concentration impacts the peak flow rates for a watershed generating 36,000 ft^3 of runoff in a given storm.

Figure 7



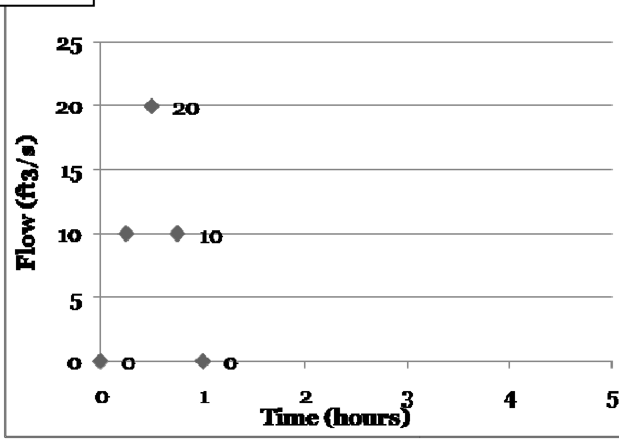
Time (Hours)	Flow (ft^3/s)	Length of Interval(hrs)	Total Flow/ Interval (ft^3)
0	0		
		1	4,500
1	2.5		
		1	13,500
2	5		
		1	13,500
3	2.5		
		1	4,500
4	0		
		Total Flow	36000

Figure 8



Time (Hours)	Flow (ft³/s)	Length of Interval(hrs)	Total Flow/ Interval (ft³)
0	0		
		0.5	4,500
0.5	5		
		0.5	13,500
1	10		
		0.5	13,500
1.5	5		
		0.5	4,500
2	0		
		Total Flow	36000

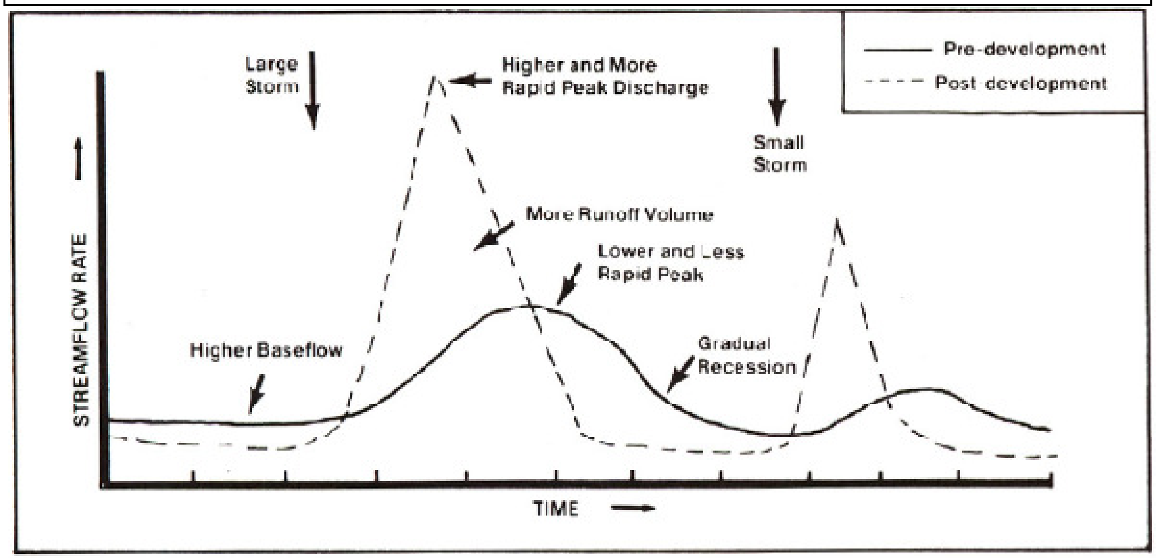
Figure 9



Time (Hours)	Flow (ft³/s)	Length of Interval(hrs)	Total Flow/ Interval (ft³)
0	0		
		0.25	4,500
0.25	10		
		0.25	13,500
0.5	20		
		0.25	13,500
0.75	10		
		0.25	4,500
1	0		
		Total Flow	36000

These graphs are a practical example of how given the same volume of runoff, variations in time of concentration can greatly impact peak flow. Since development alters the landscape to decrease time of concentration, a more appropriate visual aid can be used that compares flow rates in an undeveloped landscape versus a developed landscape.

Figure 10 - Undeveloped vs. Developed stream flow rates in large and small storms, Source: RI Stormwater Design and Installation Standards Manual (Adapted from MDE, 2000).



Impervious surfaces and development have not only increased the volume of runoff flowing over the landscape and into local water bodies, it also increases the rate at which that water flows into surface waters. As you will see in the following sections, this increase in peak flow contributes to the negative impacts of stormwater runoff.

Flooding Potential:

Floods are a major concern for many communities around the world. The loss of life during a major flood event can devastate a community. Damage to homes, buildings and property can contribute millions if not billions of dollars worth of monetary loss to a community. Despite the potential devastation and loss to a community, many housing developments and factories are built on naturally flood prone properties. In addition, changes in land use in the form of increased development can contribute to flooding hazards as well as expand flood prone zones. As developed areas increase runoff volumes and peak flow rates, more water ends up draining to streams and rivers at a faster rate. *Floodplains* that have evolved over time to handle flooding in a natural hydrologic setting are now overwhelmed with the high volumes and rates of runoff. Storms generating larger rainfall amounts that were once infiltrated into soils now run over the landscape and overtop stream banks. Many emergency flood maps have not revised high risk flood areas due to changes in land use, so more and more developments are being built in areas that historically are not prone to flooding, but are now hazardous. It is important for the public to understand the risks associated with increased stormwater runoff due to development in order to be prepared for flooding events that have not been historically common. (Dunne and Leopold)

Stream Erosion:

The high volume and velocity of runoff entering a stream or river can drastically alter the geometry of the stream that has evolved over time. Streams and rivers have developed their shapes and sizes based on many factors including depositional loads, geology, and flow of water. Streams and rivers are not designed to handle all flows and tend to discharge onto an adjacent floodplain when the stream or river overflows. In addition, stream channels are self – adjusting, which means that any changes made by man, climate, or vegetation will cause the stream to alter its shape and conditions. (Dunne and Leopold) Developed land is one example of a man made change to the landscape that alters the geometry of a stream. Water moving at a high velocity has more energy. When it enters a stream bank, it can scour the sides of the stream, eroding away the channel that has evolved over time. As banks are eroded, plant roots that once protected stream banks are exposed and trees can topple over. Without the protection of trees and vegetated buffers, the setting is even more prone to erosion. The sediments that were scoured away at the point where runoff enters the stream, is carried downstream and deposited. This alters the geometry of the channel downstream as well. If the downstream channel is filled with sediment, the stream is unable to accommodate for excess water in flooding conditions and the downstream area is much more prone to flood. Stream bank erosion is a problem facing many streams and rivers that not only contributes to flooding, but can also severely impact the ecological habitat of the system.

Groundwater Recharge:

One component of hydrology that often goes unnoticed is the abundant water found underground in the voids or spaces within rocks or soil (*groundwater)*. The saturated zone under the surface of the Earth contains 21 percent of the entire world's freshwater and 97 percent of all the world's unfrozen fresh water on Earth. If this underground source of water has high volumes and supplies water to wells, it is called an *aquifer* (Dunne & Leopold). Groundwater is an extremely important resource for people all over the country. Approximately 30 percent of Rhode Islanders rely on groundwater for their drinking supply through private or public wells (RI Stormwater Manual). In addition, groundwater provides many of our streams, rivers and lakes with their water supply and helps to maintain an environmentally sufficient flow that allows organisms and habitats to survive during dryer times. When groundwater seeps into stream channels it is called base flow. Stormwater runoff can have serious impacts on the quality and quantity of groundwater. As precipitation falls and hits a developed landscape, the amount of water infiltrating into the ground is dramatically reduced. This prevents groundwater aquifers from restoring the water it loses to wells, streams or evaporation. The restoration of groundwater due to precipitation is called recharge. So as more and more water runs off our land due to the addition of impervious surfaces and people continuing to extract water through wells, our groundwater resources become depleted. This can eventually lead to reduced volumes of water that can be used as drinking water, causing people to have to find other water sources or dig deeper and deeper wells. Urbanization has been found to decrease stream base flow as a result insufficient groundwater recharge (Ferguson and Suckling, 1990). If a river or stream can not maintain an environmental base flow, many organisms that rely on that flow will not survive. In addition, as the volume of groundwater decreases, the risk for contamination increases. With a wealth of water underground, small amounts of pollutants that infiltrate will be extremely diluted, whereas with a smaller volume of groundwater, even low levels of pollutants can contaminate a groundwater aquifer. The impacts of development have severe consequences on the physical characteristics of natural hydrology, but they also contribute to a great deal of habitat loss and polluted waters that humans and other organisms rely on and enjoy.

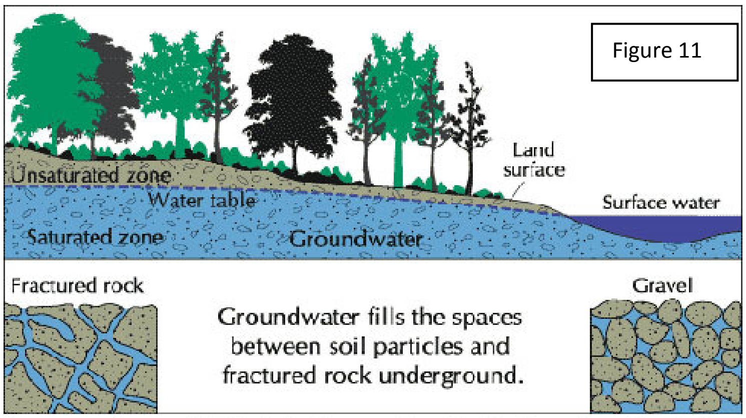


Image compliments of US Geological Survey, adapted by The Groundwater Foundation.

Pollution Sources:

Human actions on a landscape can produce multiple sources of pollution. As water runs over the landscape, it can pick up these pollutants and carry them to the closest surface water body. These pollutants are considered "*non-point" pollutants* since they are the result of various activities happening all over the landscape and can be extremely harmful to plants, animals and impact the enjoyment of and reliance on local water bodies for people. One serious impact to water quality comes in the form of sediment. Sediment can come from stream bank erosion as described earlier, construction sites, and winter roadway sanding. The presence of excess sediment in a stream, river, lake or bay can smother organisms, reduce light penetration necessary for submerged plants, and can elevate channels to cause flooding and navigation problems. Another source of pollution carried by stormwater runoff is nutrients. Typically nutrients are needed in aquatic habitats as food sources for various organisms. Due to human impact the levels of nutrients entering water bodies is extremely high and in long term or extreme cases can lead to algal blooms that eventually block sunlight and deplete oxygen in waters. This can create dead zones similar to where the Mississippi River drains into the Gulf of Mexico. Fertilizers (used in agriculture or on residential lawns), animal waste (agricultural or pet waste), and sewage are major contributors to the excess levels of nutrients. Often animal waste and sewage that enters water bodies through leaking septic tanks and wastewater treatment discharges, carry pathogens that are harmful to public health. Pathogens are the most common pollutant that causes beach and shellfish bed closures. In addition to these sources of contamination, there are toxic pollutants that contribute to poor water quality. Stormwater can pick up many harmful chemicals before entering a stream, river, lake or bay. Oils and greases, heavy metals, pesticides and other toxic chemicals that harm wildlife and bioaccumulate in food chains are washed away from cars, machinery, industrial activities, paints, landfills and improperly disposed household chemicals. Other sources of pollution are trash and debris found in urbanized areas (RI Stormwater Standards Manual). These pollutants degrade the quality of water we find in streams, lakes, bays and aquifers causing loss of aquatic life, drinking water contamination risks, and beach and fishing area closures.

Rain Gardens

Rain gardens are shallow depressions in the landscape that intercept, treat, and infiltrate stormwater, are typically planted with native plants and covered with a mulch layer. Often times they look just like a regular garden you might have in your backyard, but are specifically designed to handle runoff from a nearby impervious surface that allow infiltration, recharge aquifers, and reduce peak flows (Dietz, 2005). Most rain gardens are designed to capture the first one inch of rainfall flowing off a surface which helps to treat the majority of pollutants that are washed off in the beginning of a storm event and accounts for approximately 90% of yearly Rhode Island storms (Clayton & Schueler, 1996).

Rain gardens perform many processes that help to reduce the negative hydrologic and biologic effects caused by development. The first and most important characteristic of a rain garden is the placement and ability to capture runoff. The rain garden is sited down gradient from a driveway or roof downspout and can capture the runoff with plants and soils. The rain garden allows for infiltration of runoff into the planting soil and native soils underneath the garden which can recharge groundwater resources and reduce runoff volumes. Soil can remove pollutants through a number of processes. The soil acts as a filter to remove many particles and suspended solids as runoff infiltrates through the mulch and soil. Through the process of adsorption, the ionic attraction of holding a substance to a solid surface, organic soils can adsorb metals and nitrates. In addition, the microbes found in soils can help to degrade toxic chemical compounds. Bacteria can be found in well oxygenated soils that can convert ammonia compounds into a soluble form that plants can use. In parts of the soil that do not have much oxygen (in an area that pools with water regularly) different microorganisms can transfer nitrates to gaseous forms that are released into the atmosphere. Plants in addition to the treatment from the soil, take out pollutants found in stormwater runoff through the process of assimilation. Plants use the nutrients for energy to grow. (Prince George's County) The processes that occur in an easy to install rain garden, are extremely beneficial to maintaining good water quality and hydrologic functions.

Rain gardens are an ideal management practice for stormwater related issues that fall into a group of practices called low impact development. As people begin to fully understand the problems associated with traditional development and urbanization, a new set of principles need to be developed to allow for functional landscapes that promote natural hydrologic processes to take place. Low impact development is a technique used to minimize the impacts of development on the landscape. For example, town planners are promoting the use of new methods of development such as reducing road, parking and driveway widths, and clustering homes in order to minimize the land disturbed in a development. In addition, new technologies help to reduce the amount of stormwater runoff. Green roofs are an excellent way to capture precipitation right at the point it hits a building. Green roofs have a special roof that has a thin layer of soil and is planted with small shrubs that can capture and absorb precipitation. Another practice that is being used more often is the use of permeable pavements for driveways and parking lots. These are specially designed materials that can handle the weight of cars without compacting the soil below and allows water to infiltrate the surface. Many of the low impact development practices are highly engineered and put in place at the time of development if not before. Rain gardens are a practice that are easy to build and can be installed even after development on any kind of site and provide functions that can restore the natural hydrologic functions of our landscape.

Poor land use decisions have left us in a precarious situation where 45 percent of our water bodies are polluted due to non-point pollution (National Ass. Land Trust). In addition the natural hydrologic processes we rely on to maintain stable streams and groundwater levels have been altered by the same poor land use choices. Fortunately, there is a way to counteract many of the problems caused by development and urbanization.

Definitions:

Aquifer: A body of saturated rock through which water can move.

Watershed: The divide separating one drainage basin from another.

Hydrology: The science encompassing the behavior of water as it occurs in the atmosphere, on the surface of the ground, and underground.

Impervious Surface: A surface that does not allow water to infiltrate through.

Hydrologic Soil Group: A set of four soil groups that are defined by their ability to infiltrate water.

Curve Number: A number assigned to a land cover that describes how much water will runoff the surface.

Stormwater Runoff: Rainfall that does not infiltrate into the earth and flows over the land.

Flow: The volume of water that is transported in a certain time period

Peak Flow: Maximum stream flow rate during a storm.

Time of Concentration: The amount time that it takes for water flowing over the landscape to travel from the furthest point in the watershed to a drainage outlet.

Flood Plain: The area adjacent to a river that floods periodically

Groundwater: Water found underground in the voids or spaces within rocks or soil.

Non-point Pollution: Pollution sources that can not be contributed to a specific point, but rather encompass many different sources of pollution spread out over the landscape.

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Educational Benefits of the Rain Garden Program

Outdoor Learning Experience Components:

In 1998 the State Education and Environmental Roundtable, a group compromised of representative from educational agencies across twelve states, went about observing and collecting data from 40 different schools nationwide that were effectively implementing various environmental educational programs that aligned to a specific framework. The schools and classrooms observed were ethnically and socio-economically diverse and all incorporated major components of this environmental education framework which include interdisciplinary, collaborative, student centered, hands-on, and engaging learning. Programs that incorporate such characteristics can promote an enthusiasm for learning among students. With proper planning and implementation, teachers can guide students to use their school's surroundings and community to construct unique and effective learning experiences that can incorporate standardized curriculum guidelines. (Lieberman, Gerald A.; et al.)

Bringing students out of the classroom has immediate impacts on the scope of possible learning experiences. All of a sudden a course that followed a strict curriculum opens itself up to inquiry based learning that is susceptible to a variety of questions and unknowns. Utilizing the outdoor environment in a school program can break down the barriers that typically separate one discipline from another, promote hands on problem solving skills, and encourage the appreciation for the natural environment around them (Lieberman, Gerald A.; et al.). Fieldwork provides learners with new opportunities to develop knowledge and skills in ways that add value over a typical indoor classroom experience (Dillon, Justin; et al.). Many studies have found that utilizing one's local environment in a hands-on, project based program can optimize understanding and has the ability to change a students' attitude toward environmental issues which lead to behavior changes (Roy Ballantyne; et al.). Although simply locating a program outdoors can encourage discussions and questions that might otherwise be neglected, it is not the simple solution for environmental education programs to be successful. Enjoying an outdoor program is not enough if the aim is to promote learning, attitude and behavior change (Roy Ballantyne; et al.). Although research suggests that students remember fieldwork and outdoor learning experiences for many years, this does not translate to effective learning and optimal understanding (Dillon, Justin; et al.).

A comprehensive program must be successfully designed in order to promote student learning and elevate the experience to one that inspires change within a student. In a review of over 150 studies focused on outdoor learning, Dillon, Justin; et al. found that these experiences must be properly thought out, planned, taught, and followed up on in order to be effective. Preparing the students with concepts, information about the geographic location, and logistical processes can greatly influence the value of the experience. The program must also be designed so that students are not focusing on filling out worksheets and getting the right answer, but are exploring their surroundings under the guidance of a teacher that can act as a role model who is respectful and appreciative of the natural environment (Dillon, Justin; et al.). Other components of a program that can lead to successful student learning and foster a sense of ownership for environmental action and behavior are experiential circumstances in which students are actively performing tasks and the involvement in group projects that require information gathering or field research (Roy Ballantyne; et al.). A program should also follow up with proper lessons, presentations and discussions that can link the outdoor experience with indoor learning (Dillon, Justin; et al.). Studies have also shown that the length of a program can impact a shift in student behavior (Bogner, 1998). Comparing one day environmental programs with those that are five days, showed that the longer the program, the higher the likelihood that a student would change his/her behaviors (Bogner, 1998). The factors that encompass a given outdoor learning experience can heavily influence student learning and the ability to question attitudes and behaviors within the environment. The rain garden project and accompanying lessons and approaches described within these pages were included to ensure an excellent learning experience.

Outdoor Learning Experiences Benefits

Once an outdoor environmental project has been developed and implemented, the benefits of such a project can be examined in a variety of ways. The State Education and Environmental Roundtable study that followed 40 different schools implementing comprehensive environmental education programs described in Lieberman, Gerald A.; et al. quantitatively and qualitatively studied the advantages to these kinds of programs. Multiple quantitative analyses were completed by collecting standardized test scores, grade point averages, discipline referrals, and attendance records; and comparing them to students not involved in the outdoor environmental learning program. Students involved in the environmental learning programs had academic benefits in all areas of data collection. Other measureable benefits were apparent when studying these programs throughout the U.S. For example, outdoor environmental programs allowed for students to become more engaged and enthusiastic about their learning which in turn resulted in better achievement in reading, writing, math and social studies assessments, and decreased discipline and classroom management issues. (Lieberman, Gerald A.; et al.)

Students that are involved in projects, not just environmentally focused projects, but ones that incorporate knowledge of multiple disciplines, practical issues that need to be worked out in order to move forward, and cooperative engagement with peers, can develop critical thinking skills that would otherwise be inactive in a typical classroom setting. Programs that incorporate reasoning and problem solving improve the thinking skills among students and allow for students to synthesize information and think strategically to complete a project. Learning is more effective when students find the material and experience to be personally meaningful. This can also contribute to students feeling a greater sense of pride and ownership in their accomplishments. (Lieberman, Gerald A.; et al.)

Bringing these projects outside can also aid in student appreciation of their environment. When students are involved in such a way that they begin to feel a sense of ownership, they begin to understand that they have control over many of the actions that impact their environment negatively and can make changes and inspire others to alter behaviors in order to improve the environment around them. Programs that cultivate these kinds of critical thinking and cooperative skills with respect to the outdoor surroundings foster the development of environmental stewardship within students.

Benefits Beyond the Student

The purpose of the rain garden installation project is to solve stormwater problems within a community and to provide a lasting educational experience for students that will promote behavior and attitude change in local environmental issues. Studies have revealed specific components of a project that help to alter student behavior and instill a sense of stewardship for the surrounding environment. It has also been shown that there are specific components to a project that promote communication between student and parents that can actually enhance environmental knowledge and influence environmental change in adults (Roy Ballantyne; et al.). It is difficult to increase environmental awareness among adults. The media can provide some environmental information but does not contribute to behavior change (Roy Ballantyne; et al.) Environmental science is an area in which new information is growing at a fast rate and each generation is more informed then the previous (Storm, 1988). Many social science studies reviewed by Ballantyne et al. reveal that children can influence parents' values, attitudes and decisions. Programs that encourage young people to discuss environmental issues with their parents can influence awareness and action among adults as well as children.

A specific study was performed by Ballantyne et al. in which children and parents were interview after an environmental education program to see how children communicate what they have learned to their parents. As many as 73 percent of parents reported discussing the project with their children, however the depth of the discussion varied widely. Some reported that children described the program without any particular perspective or opinion, others revealed that their children discussed environmental information and issues, while others went as far as describing actions that could be taken at home or within the community to help solve environmental problems. Although it is beneficial to see such a large quantity of students discussing school projects with their parents, in order to instill behavior change among children and adults, specific components of a program should be incorporated to foster that kind of discussion. Parents described situations that enhanced a discussion of environmental information and concerns. For example, projects where students focused on a local issue; one that demonstrated the existence and consequences of an environmental problem within their community; were extremely important in fostering communication of attitude and behavior changes. In addition, projects that required students to do homework or present information at school were found to aid parent involvement and therefore discussion. In addition, the enthusiasm that a student portrays when describing enjoyable experiences outside of the classroom tend to promote discussion. (Roy Ballantyne; et al.)

Since stormwater pollution and the impacts of development on natural hydrology is an environmental issue that has immediate impacts on individual communities around the country, it is important to educate multiple generations of citizens to promote a change in behavior and action. This can be achieved by consciously planning intergenerational communication into projects and lessons by incorporating local issues, getting parents involved in homework, having student present their work publicly, and working in an enjoyable outdoor environment. As a result the enhanced discussion between parents and students can lead to improved public knowledge and action.

Rain garden project

The rain garden project and lesson plans found in the accompanying pages comprise many of the principles of an outdoor environmental project that enhances student learning and can reach beyond the student. It is a project that can engage students in the science and civics of their own community. The field-based, collaborative, community problem solving skills will help students become passionate about learning because they will see they can make a difference. Learning is more than knowing standardized content. With this rain garden project, students will be able to solve important issues that will benefit the health and sustainability of their community.

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