2.3 Puddles to Gardens

AGE RANGE
9th—12th grade

TIME REQUIRED
90 minutes

ACTIVITY OVERVIEW
Engage: Rain Garden Introduction
Explore: Tour of Potential Locations
Explain: Drainage Calculations
Elaborate: Rain Garden Planning
Evaluate: Presentations

MATERIALS
Student Worksheet
graph paper
pencil
tape measure
long handle shovel
ruler
hose or watering can

BASED ON:
"Rain Gardens" by Kids Gardening

LESSON TOPIC: Community implementation of rain gardens

ACTIVITY SUMMARY: Students explore the mathematics involve with planning a rain garden.

OBJECTIVES:

Students will be able to:

- Understand the impact of stormwater runoff and water pollution on the environment.
- Explore the ability of plants to absorb and filter water.
- Design a rain garden for their school.

LESSON BACKGROUND: In suburban and urban settings, much of the rain that falls hits impervious surfaces such as roofs, parking lots, and roads, where it cannot be absorbed. It becomes runoff, moving across the ground to areas where it can be absorbed or into local waterways, either directly or via storm sewers. In urban settings, as little as 15% of the water may be absorbed where it falls and up to 55% will run off. Not only does this result in lower groundwater reserves which endangers drinking water supplies and can ultimately cause land to sink (subsidence), it also creates a significant amount of water to deal with above ground.

Although rain is an important contributor for recharging local waterways, the problem with runoff from urban environments is what the runoff is carrying. As the water moves across surfaces such as streets, parking lots, and roofs, it picks up all sorts of pollutants, from nutrients like nitrogen and phosphorous that fuel algal blooms to pesticides, herbicides, oil, grease, heavy metals, and

harmful bacteria. These pollutants can kill water life and interfere with the delicate balance of the aquatic ecosystem.

A rain garden is a garden planted in a low area to encourage water collection. This design enables rain gardens to trap stormwater before it becomes runoff and filter it before it's absorbed into the soil. The plants in a rain garden have high tolerance for excess moisture and the increased levels of nutrients often found in stormwater. Rain gardens are most useful if situated downhill from impervious surfaces, such as rooftops and roads, and are designed to collect runoff from those surfaces. They slow down the flow of stormwater by collecting it in the sunken garden area and allowing it to absorb into the soil rather than cause erosion and carry pollutants into our waterways.

Note: this lesson has the option to explore an area outside after a rain and to use tools to collect soil samples and plant. Consider safety measures you need to put in place.

VOCABULARY:

Conservation Planning	To maintain natural values and assets in a specific landscape or seascape with competing uses, values, and other threats and opportunities.
Stormwater Runoff	Rain that falls on streets, parking areas, sports fields, gravel lots, rooftops or other developed land and flows directly into nearby lakes, and rivers.

ENGAGE:

Introduce the students to this lesson by observing a rain event or by walking around the school following a rain event. If your class time overlaps with an active rainstorm have the student watch the rain. Ask students: What happens to the water once it hits the ground? If your class time occurs after a rainstorm has passed, take the students outside to observe areas of flowing or standing water. Ask students: How is the water from rain managed at our school? If no periods of rain coincide with your class, ask them to recall rain experiences at school or home.

Make the connection of rain gardens to wetland plants. Rain gardens bring the benefits of wetlands -water filtration, reducing runoff, limiting erosion, and providing animal habitat – to areas beyond the coast.

EXPLORE:

Materials:

- graph paper
- pencil
- tape measure
- long handle shovel
- ruler
- hose or watering can

Procedure:

1. Divide students into pairs or small groups.
2. Take the class on a tour of the school ground to identify a good location to build a rain garden, looking for an area lower in elevation and at least 10 ft away from buildings. The garden should not be placed over a septic system or under mature trees to protect the roots.
    a. This lesson will only be for the students to plan the garden, but if your supplies allow and your school is willing, you may be able to implement your garden. Make sure to call your local utilities hotline to have them mark any underground lines on the property before you dig your garden.
3. Once you identify a possible site, test the drainage of the soil. It is important for the garden to contain well-draining soil so that the collected water dissipates within two to four days. If water sits for too long, plant roots will suffocate, and insect breeding will become a problem. Ideal rain garden soil is comprised of 20-25% leaf mulch or compost, sandy soil, and topsoil.
    a. To test the drainage of the soil in each a potential rain garden location:
        i. Dig a hole 6 inches wide and 18 inches deep in each location
        ii. Fill each hole with water and measure depth with a ruler.
        iii. Check on water depth every hour and record results.
    b. If all the water drains within a few hours, the site has excellent drainage. If the water drains within 24 hours, then it is still an acceptable site for a rain garden. If the water has not drained in 48 to 72 hours, then you should choose a different location.

Rain Garden Examples:

Image: Rain gardens, such as the one at the Mississippi State University Landscape Architecture Facility (left), are designed to channel and filter excess rainwater. Diagram on the right is from City of Durham, NC. Bottom shows rain garden picture overlaid with diagram of water flow, from Alabama Cooperative Extension System.

EXPLAIN:

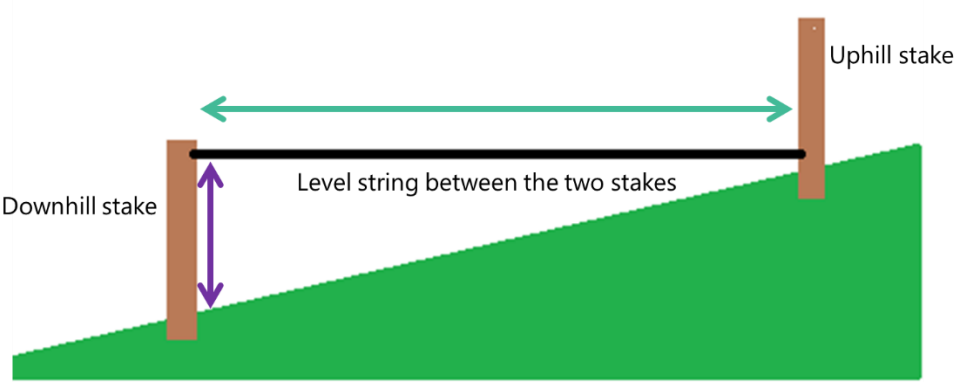
To design an effective rain garden, students will need to consider the drainage from the test earlier as well as the slope. Calculations can be conducted inside, and then include an outside exploration.

How to Calculate Drainage Area:

To determine the size of the area that will drain into the rain garden, measure the amount of impervious surfaces surrounding the location of your rain garden.

length (ft) x width (ft) = _____ft ^{2} (drainage area)

How to Determine the Slope or Necessary Depth of the Rain Garden:



1. Place a stake at the uphill end for the rain garden and another at the downhill end.
2. Level the string between the two stakes.
3. Measure the total length of the string (teal arrow) and height of the string at the downhill stake (purple arrow) in inches.
4. Divide the height by the length of the string and multiply the result by 100. This is the slope as a percentage.

Slope = (height/length) x 100

The slope into the rain garden will help you figure out how deep the soil in your garden needs to be. Once you have calculated the slope, use the chart to identify the appropriate soil depth for your rain garden.

Slope	Depth
<4%	3-5 inches
5-7%	6-7 inches
8-12%	8+ inches

How to Determine the Soil Type in Your Rain Garden:

1. Grab a handful of moist soil and roll it into a ball in your hand.
2. Place the ball of soil between your thumb and the side of your forefinger and gently push the soil forward with your thumb, squeezing it upwards to form a ribbon about ¼" thick.
3. Try to keep the ribbon with a uniform thickness and width. Repeat the motion to lengthen the ribbon until it breaks under its own weight. Measure the ribbon and evaluate according to these specifications:
    a. Sand: soil does not form a ribbon at all
    b. Silt: soil forms a weak ribbon <1.5 inches before breaking
    c. Clay: soil forms a ribbon >1.5 inches long

EXTENSON: A more in-depth soil texture analysis can be conducted as part of this lesson by following "The Jar Test" procedure.

Materials:

- Straight edged, clear jar
- Permanent marker
- Ruler
- Timer
- 1 tablespoon of powdered dishwashing detergent
- Mesh sieve or old colander

Procedure:

1. Using a mesh sieve or old colander, sift the soil to remove any debris, rocks, and large organic matter (leaves, sticks, roots, etc.).

2. Fill the jar ⅓ full of the soil to be tested

Jar filled a ⅓ of the way full with soil.
Andrew Jeffers, ©2018, Clemson Extension

3. Fill the remainder of the jar with clean water and leave some space at the top.

4. Add 1 tablespoon of powdered dishwashing detergent.

5. Cap the jar and shake vigorously until the soil turns into a uniform slurry.

6. Set on a level surface and time for one minute.

7. Place a mark the outside of the jar, showing the coarse sand layer settled at the bottom of the jar.

Jar showing the coarse sand layer settled at the bottom of the jar.
Andrew "Drew" Jeffers, ©2018, Clemson Extension

8. Leave the jar in a level spot for 2 hours.

9. Mark the top of the next settled layer with the permanent marker. This is the silt layer.

Jar showing the silt layer.
Andrew "Drew" Jeffers, ©2018, Clemson Extension

10. Leave the jar on a level spot for 48 hours.

11. Mark the top of the next settled layer with the permanent marker. This is the clay layer that has settled on top of the silt layer.

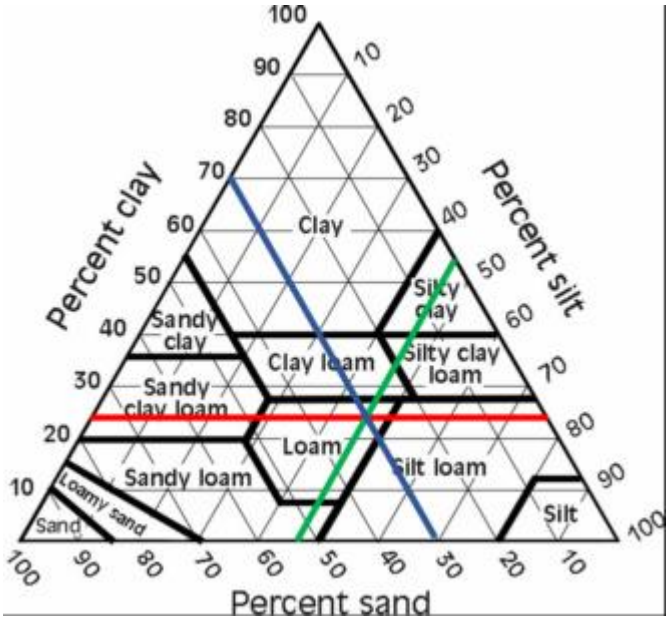
Jar showing the clay layer.
Andrew "Drew" Jeffers, ©2018, Clemson Extension

12. Using a ruler, measure and record the height of each layer, and the total height of all three layers. Use the soil texture analysis worksheet below to record results.

Using a ruler, measure and record the height of each layer, and the total height of all three layers. Andrew "Drew" Jeffers, ©2018, Clemson Extension

Procedure for using a soil texture triangle to estimate the soil type:

1. Use the soil texture triangle to estimate the soil type for the site.
2. The clay percentages are listed on the left side of the triangle. Lines corresponding to clay percentages extend from the percentages reading left to right (see red line).
3. The silt percentage is on the right side, with lines extending downwardly, diagonally right to left (see green line).
4. The sand percentage is on the right side, with lines extending upwardly, diagonally right to left (see blue line).
5. Track the lines with the percentages measured and find the spot on the triangle where all three lines intersect. The region where these lines intersect indicates the soil type present. The example shown represents a loam soil texture.



Soil Texture Analysis “The Jar Test” Worksheet:

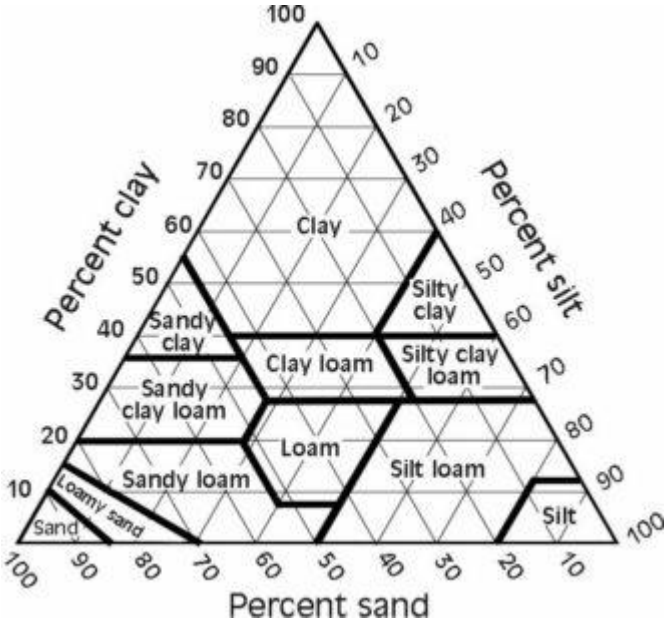
Insert your measurements from the jar in the spaces below:

Height of sand layer _____inches / cm

Height of silt layer _____inches / cm

Height of clay layer _____inches / cm

Total height of layers _____inches / cm



% SAND=(sand height)/(total height) x 100 =_____ % SAND

% SILT=(silt height)/(total height) x 100 =_____ % SILT

% CLAY=(clay height)/(total height) x 100 =_____ % SILT

Adapted from: Soil Texture Analysis “The Jar Test” Procedure by Andrew "Drew" Jeffers, Spartanburg Cooperative Extension, Horticulture and Natural Resource Agent, Clemson University

Note: the lesson can be paused here for the day.

How to Determine the Size Factor of Your Rain Garden:

1. Locate the soil type of your rain garden on the left hand column of the table below.
2. Locate the depth you calculated for your rain garden in the second row of the table below.
3. Identify where the soil type and depth intersect in the table to find the proper size factor for your garden.
4. Use this number in the equation below to determine the appropriate size of your rain garden.

Soil Type	Depth		
	3-5 inches	6-7 inches	8+ inches
Sand	0.19	0.15	0.08
Silt	0.34	0.25	0.16
Clay	0.43	0.32	0.20

How to Determine the Size of Your Rain Garden:

Size Factor x Drainage Area = Rain Garden Area

Example: Suppose a rain garden was determined to have a drainage area of 1,000ft^2. It has a slope of 5%, requires a depth of 6-7 inches, and has clay soil. To determine the recommended size of the rain garden: 0.32 (Size Factor) x 1,000 ft^2 (Drainage Area) = 320ft^2 (Rain Garden Size)

ELABORATE:

Students continue to work in groups to plan out their rain garden. Have students plan the size of their rain garden and select plants. They can map out their garden using graph paper. Graph paper also comes in poster size, and can be used by students to create a larger scale plan. The design of the garden can be varied between students but should include the following components:

1. Ponding area or depression. To help capture runoff, the garden base should be shaped like a saucer with the middle deeper than the edges. The land leveling between the middle (generally 6" deep) and edges should be gradual so that water is spread out throughout the garden. Because of this shape, the edges of the garden will usually be drier than the middle which will need to be considered when selecting plant materials.
2. Well-draining soil. Well-draining soil is important to ensure quick absorption of runoff. During planting and maintenance, it is important to avoid compacting the soil, which will decrease its effectiveness.

3. Tough plants. Plants chosen for the rain garden must be able to tolerate extremes of wet and dry soil. Rain gardens are typically planted with shrubs and perennials. Because the rain garden functions better with deep rooting plants, annuals are not part of the usual design. Native plants are often the best choices because they will be well suited to the environmental conditions of your climate.
4. Mulch. Mulch is needed to protect the soil from erosion and insulate the garden from extreme wet and dry conditions. Shredded bark mulch is preferable because it does not wash away as easily as lighter bark chips.
5. A grass buffer strip. A grass buffer strip around the garden is important to slow the speed at which the runoff enters the garden and to decrease soil erosion.
6. A berm. A berm made from at least six inches of soil or rocks helps to keep the runoff in the garden long enough to allow it to be absorbed into the soil. Make sure that if your garden does overflow, the overflow will head to storm drains rather than towards structures.

Students may use this list as a resource to select suitable plants for rain gardens in the Gulf South. Information from Mississippi State University Extension.

Small and Large Trees			**Perennials**	
Common name	**Scientific name**		**Common name**	**Scientific name**
Swamp red maple	*Acer rubrum var. drummondii*		Joe pye weed	*Eupatorium fisulosum*
Bald cypress	*Taxodium distichum*		Cardinal flower	*Lobelia cardinalis*
Green ash	*Fraxinus pennsylvanica*		Stokes aster	*Stokesia laevis*
Swamp black gum	*Nyssa sylvatica var. biflora*		Rose mallow	*Hibiscus lasiocarpus*
Willow oak	*Quercus phellos*		Texas star hibiscus	*Hibiscus coccinea*
Black willow	*Salix nigra*		Louisiana iris	*Iris spp*
Sweet bay magnolia	*Magnolia virginiana*		Boltonia	*Boltonia asteroids*
Pond cypress	*Taxodium ascendens*		Coreopsis	*Coreopsis lanceolata*
Mayhaw	*Crataegus opaca*		Swamp sunflower	*Helianthus angustifolius*
Ironwood	*Carpinus caroliniana*		Blue flag iris	*Iris virginica*
Wax myrtle	*Myrica cerifera*		Blazing star	*Liatris spicata*
			Cinnamon fern	*Osmunda cinnomomea*
Shrubs			Royal fern	*Osmunda regalis*
Gallberry holly	*Ilex glabra*		Goldenrod	*Solidago canadensis*
Yaupon holly	*Ilex vomitoria*		Ironweed	*Vernonia spp.*
Dwarf palmetto	*Sabal minor*		Obedient plant	*Physostegia virginiana*
Chokeberry	*Aronia arbutifolia*		Horsetail	*Equisetum hyemale*
Buttonbush	*Cephalanthus occidentalis*			

Summersweet	*Clethra alnifolia*		**Grasses and Sedges**	
Sweetspire	*Itea virginica*		River oats	*Chasmanthium latifolium*
Titi	*Cyrilla racemiflora*		Blue sedge	*Carex glauca*
Buckwheat tree	*Cliftonia monophylla*		Woolgrass	*Scirpus cyperinus*
			Muhly grass	*Muhlenbergia capillaries*
			Panic grass	*Panicum virgatum*
			Little bluestem	*Andropogon virginicus*
			Spikerush	*Eleocharis spp.*

For any additional assistance needed for planning a rain garden please reach out to your local extension service. Mississippi educators can reach out to Christine E.H. Coker, Ph.D., GRP.

Email address: christine.coker@msstate.edu
Title: Associate Research and Extension Professor of Urban Horticulture
Mississippi State University Coastal Research and Extension Center
Beaumont Horticultural Unit

EVALUATE:

Students can present their rain garden design to the class, making sure to answer the following questions:

- What is the impact of stormwater on rivers, streams, and lakes?
- What are some ways each individual can reduce their impact on local waterways?
- State some reasons to mitigate stormwater runoff.
- State the purpose of rain gardens.
- State your scenario conclusions.
- Showcase your garden design.
- Showcase a listing of selected plants and why they were selected for use in the rain garden.

How to Calculate Drainage Area:

To determine the size of the area that will drain into the rain garden, measure the amount of impervious surfaces surrounding the location of your rain garden. *Make sure to pay attention to units.*

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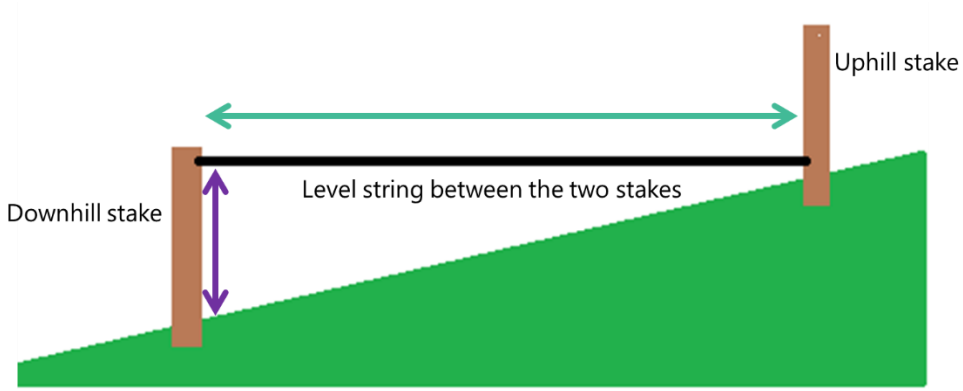

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DO NOW:

Compare the benefits of living shorelines and bulkheads.

EXIT TICKET:

How do plants help reduce flooding?