Rain Garden to the Rescue

Grade: *6* | **Time:** *4-5, 60 minute periods*

Standards:

Georgia Performance Standards in Science S6E5.j

Next Generation Science Standards ESS3.A, ESS3.C, ESS2.C, MS-ESS3-1, MS-ESS3-3, MS-ESS3-4, MS-ESS2-4

Supplies

Per class:

- 4 Garden spades
- 4 Measuring wheels (1,000 ft)

Bring Your Own:

BYO: plants or seeds for rain garden
BYO: computers/internet for student research

Garden Connection:

Students will design and install a rain garden to filter contaminants from run-off water.

STEM Connection:

Students will use technology such as a measuring wheel and calculator to compute various formulas, including the square footage of impervious surfaces, rainwater harvesting formulas, and the permeable area needed to harvest rainwater. Students will also design and install a rain garden.

Overview

Students will measure the impervious area on campus, including the school building and paved surfaces, in order to calculate the size of a rain garden large enough to filter the "first flush" of runoff from a rainstorm; then observe the flow of runoff on school property and determine locations where a rain garden should be located in order to filter water before it enters ditches, creeks or storm drains; design a rain garden, and install it.

Essential Questions

How can I design and build a rain garden that will filter contaminants and pollutants from run-off water on school grounds?

Engage

Students will watch a video and read an article regarding ocean pollution and make the connection that, regardless of where one lives, contaminants and pollutants washed away by run-off water end up in waterways and eventually in oceans.

Explore

Students will calculate the area needed to capture and clean the 'First Flush', (the first ¾"-1" of rain after a dry spell) when the majority of pollutants are flushed from a hard surface such as a roof, driveway, parking lot or sidewalk.

Explain

Students will explain and defend their selection of location, size and design of the rain garden using evidence from tests of soil compaction, studies of water flow direction during rainstorms (or topo maps), location of nearest storm drain, ditch or creek, and research on suitability of plants selected.

Environmental Stewardship

Students will install a rain garden on school grounds.

Evaluate

A rubric is provided to assess student performance expectations. Questions for discussion are also provided.

Extend

Students may design rain gardens for other local community buildings.

Standards

GEORGIA PERFORMANCE STANDARDS IN SCIENCE

S6E6. Students will describe various sources of energy and with their uses and conservation

b. Identify renewable and nonrenewable resources.

S6E5. Students will investigate the scientific view of how the earth's surface is formed

h. Describe soil as consisting of weathered rocks and decomposed organic material
i. Explain the effects of human activity on the erosion of the earth's surface
j. Describe methods for conserving natural resources such as water, soil, and air

NEXT GENERATION SCIENCE STANDARDS

ESS3.A: Natural Resources
Humans depend on Earth's land, ocean, atmosphere, and biosphere for many different resources. Minerals, fresh water, and biosphere resources are limited, and many are not renewable or replaceable over human lifetimes. These resources are distributed unevenly around the planet as a result of past geologic processes. (MS-ESS3-1)

ESS3.C Human Impacts on Earth Systems
Typically as human populations and per-capita consumption of natural resources increase, so do the negative impacts on Earth, unless the activities and technologies involved are engineered otherwise. (MS-ESS3-3), (MS-ESS3-4)

ESS2.C: The Roles of Water in Earth's Surface Processes … Global movements of water and its changes in form are propelled by sunlight and gravity. (MS-ESS2-4)

Teacher Preparation

- Contact your local university's agricultural extension office for inexpensive soil testing
- Select area suitable to dig 18" deep to perform a compaction test
- Arrange for student access to computers with internet access

Teacher Background Information

University of Wisconsin-Madison Arboretum Rain Garden Curriculum Sampler: http://uwarboretum.org/eps/tools_for_teachers.php
Rain Garden Perc Test Directions with Pictures
http://ddoe.dc.gov/sites/default/files/dc/sites/ddoe/publication/attachments/Rebate%20Perc%20Test%20FINAL_0.pdf

Rain Garden Handbook
http://www.cob.org/documents/pw/environment/green%20building/rain-garden-handbook-lake-whatcom-edition.pdf

Midway: A Message from the Gyre (short video)
http://vimeo.com/25563376

Gyre video (optional additional video on plastic pollution and how it affects the oceans)
http://video.nationalgeographic.com/video/141204-gyre-video-complete

Surfrider Foundation: Calculation of Rainwater Harvest Potential
http://www.surfrider.org/coastal-blog/entry/5191

Surfrider Foundation: Ocean-Friendly Gardening Annual Report
http://www.surfrider.org/images/uploads/publications/OFG-Annual-Report-2013_FNL.pdf

LESSON PROCEDURES

Engage

1. Watch the powerful short film "Midway: A Message from the Gyre" to understand how all pollution ends up in the ocean. http://vimeo.com/25563376 Consider also watching the National Geographic video linked above.

2. Read articles from NOAA's Marine Debris Blog and conduct a land-based micro-plastic clean up. Collect bits of plastic trash in mason jars to create an exhibit. Discuss how pollutants and contaminants on the ground or hard surfaces include both particles (largely plastic) and unseen chemicals. Students can track Students can track marine debris (plastic pollution) using the Marine Debris Tracker web site or app: http://www.marinedebris.engr.uga.edu

Explore

Students will determine the infiltration rate based on the extent of soil compaction (clayeyness) and figure how infiltration rate affects size of area needed for a rain garden which is big enough to filter the 'First Flush', which is the first ¾"-1" of rain that runs off roofs and paved areas into streets, storm drains, rivers and – eventually – the ocean. Divide the class into teams of four and divide the tasks outlined below among them. (Or let every team complete all the tasks by taking turns with tools).

Calculate Infiltration Rate by digging a 12" x 12" hole and filling it with water. Let the water drain completely from the soil; then fill the hole with water again. Use a stopwatch (or cell phone timer app) to record how long it takes for all the water to drain from the hole this time. If it takes longer than 45 minutes, then the soil is compacted and the infiltration depth should be considered 6". If the water drains out of the hole in less than 45", consider the infiltration depth to be 12". If unable to dig a hole then use a visual test: Soil could be considered compacted if it is too hard to dig and the area is barren or plants look down-trodden even after watering.

Calculate Area of Impermeable Surface to be served by Rain Garden and Amount of Rainwater in First Flush- For every 1" of rain and 1,000 square feet of impermeable surface (roof, driveway, parking lot, sidewalk), there is about 620 gallons of water. That means that about .62 gallons of rainwater can be captured per square foot of impermeable surface. To figure out the area of impermeable surface (roof, sidewalk, driveway, or parking area) use a measuring wheel to calculate the area (multiply width x length for a regular rectangular shape; or divide an irregular shape into smaller regular shapes for ease of measurement). The square footage of a roof should be considered the same whether it is pitched or flat, because it equals the length x the width of the exterior walls below. Multiply total area x .62 gal to get rainwater capture.

Calculate Size of Rain Garden Needed to Filter First Flush- With well-drained (sandy) soils, assume an infiltration depth of 12" for your absorption area, and divide the total gallons to be captured by 7.48 (which is the number of gallons in one cubic foot of area). For example: 620 gals/7.48 = 83 cu. ft. Double that size if soils are clayey and only drain to 6" deep.

Example calculations:
400 square foot roof, draining to 1 rain gutter downspout 400 sq. foot roof x .62 = 248 gallons of water in first flush
248/7.48 = 33 sq. ft. garden size needed if water is infiltrates to 12" depth, or 66 sq. ft. for infiltration to 6" depth.
For 12" infiltration depth - A rain garden (or dry stream) needs to be 6 feet by 6 feet, or 3 feet wide x 11 feet long.
For 6" infiltration depth - Double the size of rain garden needed to absorb the first flush with 12" infiltration.

Research Appropriate Plants: Students will research plants that are native to the area, including those with roots that can remain wet and plants that prefer more well-drained soil. Bonus if students select an attractive variety of rain garden plants that also attract pollinators (bees, butterflies or pollinating birds and bats) or hyperaccumulators (which are unharmed by taking up pollutants or toxins and can therefore bio-remediate the soil). Performa a do-it-yourself soil test or contact your local extension office for soil testing, to find out more about soil conditions that affect plant selection. (An "Available Metals Test" ($30) checks for manganese, iron, copper, zinc, sodium, aluminum, lead, nickel, and cadmium). A chart of hyperaccumulating plants and the metals they absorb can be found on Wikipedia.

Design Challenge: Students will use data collected and observations of area or topography maps to design a rain garden that meets the following criteria:

- Size sufficient for a "dry stream bed" or "rain garden" built to filter first flush of rain from roof and/or paved parking.
- Plant selections are appropriate for area (native plants that can withstand wet roots and drying soils)
- Location of rain garden between the source of runoff (roofs or paved surfaces) and the nearest storm drain, ditch or creek

Explain from Evidence

Students will explain and defend their selection of location, size and design of rain garden using evidence from tests of soil compaction, studies of water flow direction during rainstorms (or topo maps), location of nearest storm drain, ditch or creek, and suitability of plants.

Environmental Stewardship

Students will plan, organize, and implement the installation of a rain garden. Students may ask nurseries for donations of selected plants, appeal to parents and teachers for plant starts shared from their gardens, contact a native plant society and request plants that have been rescued from sites being developed, collect and plant seeds, or hold fundraisers to generate funds to purchase plants.

Evaluate

A rubric is provided to assess student performance expectations.

Students should be able to explain and discuss the following, by the end of the lesson:

1. What is storm water runoff?
   Storm water runoff is the rain water you see flowing over parking lots and roadways, or gushing out of a downspout, during a storm.

2. How does groundwater move?
   Groundwater moves through small openings found in rocks and sediments under the influence of gravity. This natural phenomenon allows surface water and groundwater generally to move from higher elevations to lower elevations.

3. What is permeability?
   Material that is capable of being permeated, having pores or openings that permit liquids or gases to pass through it.

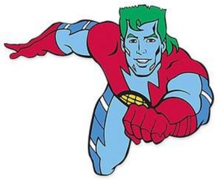
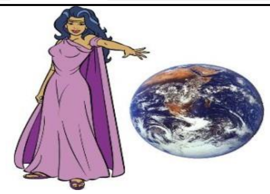
4. How does the pollution from impermeable surfaces end up in the water systems?
   Runoff carries pollutants to the streams, rivers, and oceans.

5. How do you determine the soil's infiltration rate?
   The infiltration rate is the velocity or speed at which water enters into the soil. It is usually measured by the depth (in mm) of the water layer that can enter the soil in one hour. An infiltration rate of 15 mm/hour means that a water layer of 15 mm on the soil surface, will take one hour to infiltrate.

Extend

Future lessons could include design of rain gardens for other local community buildings, based on the same protocols.

Name: ____________________ ***Date:*** ______________________ ***School:*** _______________________

Level of Mastery Benchmark or Performance Measure	 EMERGING Not yet proficient 1 point	 COMPETENT Partially proficient 4 points	 PROFICIENT Mastered task 5 points	TOTAL POINTS
Calculate Rainwater Harvesting Potential	*Can identify potential surfaces, but unable to calculate harvesting value.*	*Understands the concept of harvesting rainwater, but needs assistance using the formulas.*	*Accurately calculates flat surface areas (roof, paved areas) and use the results to determine the rainwater harvesting value.*	
Soil Compaction and Infiltration	*Does not understand compaction or infiltration rate.*	*Can calculate infiltration rate and can illustrate compaction, but cannot explain the relationship between them.*	*Can draw conclusions about the level of soil compaction and calculate infiltration rate.*	
Plant Research	*Understands that plants slow erosion, does not complete research.*	*Understands plant's role in erosion, but does not select native plants or consider soil condition.*	*Understands plant's role in erosion and selects native plants suitable for soil condition.*	
Rain Garden Design	*Rain garden design does not meet location or size requirements.*	*Designs rain garden located between source of rainwater from roofs or paved surfaces and storm drain or ditch/creek, but does not meet size requirements or use appropriate plants.*	*Designs rain garden based on calculations that is of sufficient size and uses appropriate plants located between source of rainwater from roofs or paved surfaces and storm drain or ditch/creek.*	