Exploring an Onsite Rain Garden — Curriculum Outline

Background: Stormwater runoff is a growing issue in many communities, contributing to flooding, erosion, and water pollution. Rain gardens – shallow, vegetated depressions designed to capture and absorb runoff – are one effective mitigation strategy that can also serve as outdoor learning spaces. This set of lessons engages students in surveying a rain garden (or any depression) to better understand its structure and capacity. Through classroom practice and fieldwork, students learn the basics of surveying, practice measurement techniques, and apply them to build a three-dimensional model of the depression. They then calculate its volume and analyze how its size relates to stormwater management. These activities connect directly to core Science and Engineering Practices while giving students experience with tools and methods used by professionals in geoscience, engineering, and environmental management.

Grade Level: 6-12

Duration: Six 50-minute lessons

STANDARDS

NGSS: MS-ESS2-4, MS-ESS3-3, MS-ETS1-1, HS-ESS2-5, HS-ESS3-4, HS-ETS1-2, HS-ETS1-3

Common Core Math: CCSS.MATH.CONTENT.7.RP.A.2, CCSS.MATH.CONTENT.7.G.A.1, CCSS.MATH.CONTENT.7.G.B.6, CCSS.MATH.CONTENT.HSA.CED.A.1, CCSS.MATH.CONTENT.HSG.MG.A.1

SDG 6: Clean water and sanitation

SDG 11: Sustainable cities and communities

Learn more about the United Nation's Sustainable Development Goals (SDGs) and explore resources for educators from UNESCO.

LESSONS WITHIN THIS CURRICULUM

Day	Lesson Title
1	Introduction to Stormwater Runoff
2	Introduction to Surveying
3	Surveying the Rain Garden
4	Building a 3-Dimensional Model
5	Calculating the Volume of the Rain Garden
6	Assessing the Rain Garden

A rain garden shortly after a rain event.
Credit: R. Ford, EPA-ORD

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DAY 1: INTRODUCTION TO STORMWATER RUNOFF

Objective: Students will explore how stormwater runoff affects their school grounds and how on-site features like rain gardens or natural depressions can help manage runoff.

Activities

1. **Watershed Demonstration:** Use a model (such as an **EnviroScape**) to demonstrate how stormwater moves across a landscape. Show how water infiltrates into pervious surfaces (like soil or grass) but runs off impervious surfaces (like pavement or rooftops). Add "pollutants" (e.g., cocoa powder, sprinkles, or food coloring) to illustrate how runoff carries materials into nearby streams, rivers, or storm drains.

2. **Class Discussion:**
   - What causes stormwater runoff?
   - How do human activities (pavement, chemicals, trash, etc.) make the problem worse?
   - Why is it important to manage stormwater?
   - What strategies might reduce the impacts of runoff?

3. **On-site Exploration:** Take students outside to examine a rain garden or a natural depression on school grounds. Encourage them to consider:
   - How does this rain garden or depression capture and hold water?
   - Where is the water coming from? Where is it going?
   - How does this feature help our school and community?

4. **Predicting the Drainage Area:** If time allows, have students spread out across the schoolyard and choose a spot where, if they were a raindrop, they would eventually flow toward the rain garden. This helps students visualize the drainage area (or contributing area) that feeds into the garden. Discuss how topography guides the movement of water across the landscape. Point out any engineered modifications (e.g., trenches, berms, redirected downspouts) that expand or channel the contributing area into the rain garden.

5. **Framing the Challenge:** Present students with the central task at hand, *"How can we measure the performance of a rain garden?"* Explain that one way to evaluate performance is to calculate how much water the depression can capture and store, reducing the volume entering storm drains. In small groups, have students brainstorm possible methods for measuring or estimating the rain garden's capacity. Encourage them to think about what information they would need (e.g., depth, shape, drainage area, rainfall) and how scientists might collect those data.

DAY 2: INTRODUCTION TO SURVEYING

Objective: Students will be introduced to land surveying as a method for measuring landforms, and will practice a simplified surveying technique in class.

Activities:

1. **Reintroduce the Challenge:**
   a. Begin by reminding students they are being asked to figure out how much water the rain garden can hold.

   b. Give students a couple of minutes to gather their thoughts from the previous day, and then share ideas as a class.

   c. Emphasize that in order to answer this, they need to know the shape and depth of the depression.

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2. **Introduce Land Surveying:** Introduce surveying as a real-world method for mapping land surfaces with the help of Practical Engineering's short video, "**How does land surveying Work**?"

3. **In-Class Surveying Lab:**
   a. Share that students will take two measurements of items around the room: 1) measuring from the ground up to the top of the object, and 2) measuring downward from a common reference elevation to the top of the object.

   b. Have students work in their groups to practice the procedures, ensuring they are rotating roles throughout.

   c. Compare answers as a class and address any issues with data collection (e.g., sig figs, incorrect units).

4. **Group Discussion:**
   - How does the information we get from the two types of measurements differ?
   - Which method will we want to use tomorrow in the rain garden? Why do you think it is helpful in determining the shape/volume?
   - Why is consistency in measurement important when multiple people are collecting data?

DAY 3: SURVEYING THE RAIN GARDEN

Objective: Students will collect field measurements of the rain garden to create a dataset describing its shape and depth, forming the foundation for later volume calculations.

Activities

1. **Field Setup and Orientation:** Review safety expectations and measurement procedures with students. Explain that the transects they see (which were prepared ahead of time) serve as cross sections of the rain garden.

2. **Group Data Collection:**
   a. In groups, students measure vertical distances from the reference line (string or fixed elevation) down to the surface at marked intervals along the transects.

   b. Each group should complete at least two transects, and every transect should be measured by more than one group to ensure replication and quality control.

3. **Data Compilation:** Ask students to share their data with each other so all students have access to the full dataset. Highlight the importance of precision, consistent units, and labeling (transect number, measurement location, depth in cm, etc.).

4. **Preliminary Review:** As a class, examine the dataset for missing or unusual values. Discuss how scientists check for accuracy and identify potential sources of error, and decide if there are any measurements that need to be repeated in the field.

DAY 4: BUILDING A 3-DIMENSIONAL MODEL

Objective: Students will process their collected data to construct and interpret a 3-D model of the rain garden.

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Activities

1. **Review the Goal:** Remind students that the purpose of surveying was to understand the shape and capacity of the rain garden. Emphasize they will be building a model to help them visualize its capacity and prepare them to calculate the volume.

2. **Graph the Transects:** Each group will create a set of transect graphs for the rain garden. Groups should consider how they will deal with transects that have multiple data sets. Groups need to ensure consistent axes (depth vs. distance) so their graphs can be compared and combined. All graphs need to have the same axes. Encourage students to make copies or take photos of their completed graphs to use for later analysis.

3. **Build the Model:**
    a. Each group should label their transects on the inside and then cut each graph along the X axis and the graphed line.

    b. Line up transects in order at equal spacing and tape them so they hang downward (e.g., on a cooling rack) to form a 3-D model of the rain garden.

4. **Discuss the Model:**
    - How does this model compare to the real thing?
    - What does the bottom of this model represent? What about the top?
    - Where would water pool first, and how would it spread as more rainfall accumulates?
    - If it continued to rain until the rain garden was "full", where would the water fill to?

DAY 5: CALCULATING THE VOLUME OF THE RAIN GARDEN

Objective: Students will use their transect data to estimate the total volume of the rain garden by breaking cross-sections into geometric shapes and applying area and volume calculations.

Activities

1. **Introduce Integration:** Using a loaf of sour dough bread (or another load that is irregular), ask students how they might determine the volume of an entire loaf if no two slices are the same? Guide them to the idea of slicing and adding the volumes of individual sections, connecting this to how scientists approximate complex shapes.

2. **Processing Each Transect:**
    a. Students should use their copies or photos of their transect graphs from the previous day.

    b. Revisit the discussion from Day 4: water will not fill to the string (reference elevation), but instead to the lowest outlet point or edge of the rain garden.

    c. As a class, determine or measure this "overflow height" (either by assessing the edges of each transect or by going back into the field and making visual observations of the rain garden). Then have students draw a line at that elevation across each transect

    d. For each transect, students should break each area between the line and the bottom of the rain garden into geometric shapes of which they know how to calculate the area (e.g., rectangles, triangles, trapezoids).

    e. They should then calculate the area of each shape and sum them up for the total cross-sectional area.

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3. **Determining Width:** With the measurements students collected between transects, discuss as a class how to best 'assign' a width to each transect. Then have student groups determine the width for each.

4. **Convert Area to Volume:** Students will then multiply their calculated cross-sectional area by their calculated width to calculate the volume represented by each transect.

5. **Volume of the Rain Garden:**
   a. Add together all the transect volumes to estimate the rain garden's overall storage capacity.

   b. Share results from all groups. Compare calculations across groups; calculate class averages, ranges, and discuss potential variability or error.

6. **Class Discussion:**
   - How did breaking the depression into shapes help simplify a complex problem?
   - What sources of error might have affected our volume estimates?
   - How might professionals calculate rain garden volume more precisely?

DAY 6: ASSESSING THE RAIN GARDEN

Objective: Students will reflect on their findings, evaluate their volume estimates, and consider how rain gardens manage stormwater over time.

Activities

1. **Review the Process:** Recap Days 1–5, emphasizing that students surveyed, modeled, and calculated the storage capacity of the rain garden. Clarify that their estimate represents a *maximum storage capacity*—as if the garden were a container that holds water until full.

2. **Demo/Thought Experiment:**
   a. Show a clear container filled with water and ask, *"What did we assume when we calculated volume?"* (That water fills and stays until it reaches the brim.)

   b. Poke a few small holes in the side of the container (or imagine them) and pour in more water. Ask, *"What happens now?"*

   c. Highlight that, unlike a sealed container, a rain garden allows water to infiltrate at the same time that new water comes in. This means it actually manages *more* water than just its volume, or storage capacity.

3. **Wrap-Up Discussion:**
   - How does our calculated volume (storage capacity) compare to how a rain garden really functions?
   - What factors (infiltration, overflow points, rainfall intensity) would change how much water is managed in the rain garden?
   - What questions could we explore next (e.g., plant growth, infiltration testing, monitoring rainfall vs. water levels)?

4. **Community Connections:** Encourage students to connect their learning to real-world stormwater management. Discuss careers such as hydrologists, environmental engineers, and conservation specialists. As a next step, consider inviting a professional (e.g., from a local conservation district) to share about their job and the other stormwater infrastructure in your community.

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