Surveying a Rain Garden

Background: Surveying is the science of measuring and mapping the land, a skill essential for engineers, geoscientists, and city planners. By collecting precise measurements, land surveyors can determine the shape, slope, and volume of landscapes or features such as rain gardens. This lesson introduces students to surveying concepts and prepares them for applying the same techniques outdoors to measure a rain garden (or a depression).

Key Question: How do scientists measure the shape of the land?

Timeframe: 2 class periods (~90 minutes)

STANDARDS

NGSS: MS-ETS1-4, MS-ESS2-2, HS-ESS3-4
SDG 9: Industry, innovation, and infrastructure
SDG 11: Sustainable cities and communities

MATERIALS

- meter sticks
- bubble level (circular bullseye level)
- corner bracket (corner brace)
- duct tape
- thick string
- objects of varying heights
- long level (I-beam level)
- stakes
- painters tape
- permanent marker
- tape measure(s)
- aerial image/diagram of rain garden (or depression to be surveyed)
- data table
- clipboards (optional)

PREPARATION

1. Inside surveying lab:
   a. Set up a reference elevation (preferably less than a meter from the ground) using string stretched taut across two supports, making it as level as possible. Alternatively, *you could utilize a height that is common around the classroom (e.g., the surface of lab tables).*

   b. Set out objects of varying height under the reference elevation for students to measure.

   c. Optionally, mark points on the string with tape where students should collect measurements.

2. Surveying outside:
   a. Make a diagram or utilize an aerial picture of the rain garden you will be surveying. Draw your planned transects (between 4-10 depending on the size of the rain garden) and letter them. See Figure 1.

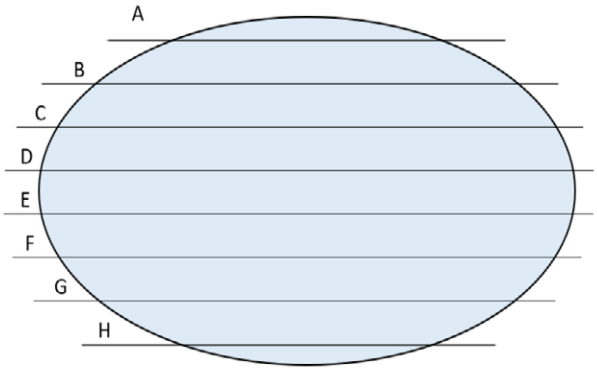

Figure 1. Example of a transect diagram.

   b. Outside, insert stakes along the transects across the rain garden. Have the ends of the transects go about a foot or so past the edge of the rain garden. Write the letter of the transect on the end stakes.

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c. Tie string across the transect stakes so it remains at a constant elevation. Utilize a large level between stakes as needed. Ensure all transects are also level (so between stakes of a single transects and each transect string is at the same elevation). See Figure 2.

Figure 2. A rain garden with strings marking the transects.
R. Ford, EPA-ORD

d. Select a central point in the middle the rain garden. Place a piece of tape at that point and similarly along each transect so all the centers line up. Label the tape on each transect "Center."

e. Along each transect, place tape tags evenly* where students will take measurements. Ideally you want at least 10, and no more than 20 measurements along a transect.

f. You may want students to take measurements more often near the edges. In this case, be sure you communicate with students the next day when they graph the transects.

g. Label the tape tags with numbers.

3. Prepare data tables:

a. Access an **electronic version of the Data Table** and edit it to reflect your rain garden (e.g., the number of transects, number of measurement tags, distance between the tags). In the example provided, tags were placed every 50 cm or so and the distances between the tags were provided to students where the "Center" tag was 0.

b. Plan how students will share data. For example, make a form (similar to **this form**) where students can input their data and it gets compiled for students to process.

Hands-on Investigation

Engage

1. Ask students:
   a. How could we measure a depression in the ground that isn't flat or uniform?

   b. Have you ever noticed **survey markers**, **tripods with instruments,** or **people surveying** around? What do you think those are used for?

2. Show the Practical Engineering video, "**How does land surveying work**?"

3. Connect the video to the challenge–students are tasked to figure out how much water the rain garden can hold and so they need to measure its shape.

Explore: In class surveying lab

1. Group the students in teams which they will work with throughout these activities (and for the remainder of the rain garden project if you are completing the whole curriculum).

2. Share the reference elevation with students (e.g., the string, the lab table). Go through the procedure of measuring the object's height and depth (from the string down to the top of the object) with students. Optionally, you can have students measure the object for more measurement practice. Go through roles that are included on the "Introduction to Surveying – Measurement Lab" handout: Equipment Handler, Data Reader, Data Recorder, Quality Control Officer (If there are only three students, this is the role that can be a second role for a student).

3. Have student groups conduct their measurements and make notes of any issues/questions/procedural adjustments at each station.

Explain

1. Compare student measurements from the in-class surveying lab.

2. Address any issues with data collection (e.g., sig figs, incorrect/missing units). If the class does not agree on a measurement, ask what they should do and follow through with their procedure (e.g., taking the average, remeasuring).

3. **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?

4. Go through the procedure measuring the rain garden and answer any remaining questions to prepare students for fieldwork in Elaborate.

Elaborate: Surveying the rain garden

1. In the classroom, review safety expectations and measurement procedures with students. Display an aerial image or diagram of the rain garden and where the transects are crossing it. Explain that the transects they see (which were prepared ahead of time) serve as cross sections of the rain garden.

2. Go out to the rain garden, and orient the students to the rain garden, including the locations of the transects and the measurement locations/tags.

3. Have one group demonstrate the procedure and conduct a couple measurements for the class with your guidance.

4. Group Data Collection:
   a. In the same groups, have students measure vertical distances from the reference line down to the surface at marked intervals along the transects. Students will also measure the distances from their transect to the transects on either side.

   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.

5. 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.).

Evaluate

1. As a class, compile and process all transect data into one dataset. Examine it for missing entries, unusual values, or inconsistencies between groups. Discuss how scientists validate data (replication, remeasurement, averaging). If necessary, identify measurements that should be repeated.

2. Reflect on the process:
   - What was easy or difficult about measuring depth from a reference elevation?
   - How confident are you in the class dataset? Why?
   - How might errors or inconsistencies in our measurements affect the results of our volume calculations?
   - If another school wanted to repeat this activity, what advice would you give them?

3. Connect the experience back to real-world surveying. Ask students:
   - Who needs accurate land measurements in their work (e.g., engineers, hydrologists, construction crews, city planners)?
   - Why is accuracy so important in these fields?

4. Summarize by reinforcing that students now have a dataset to create a model of the rain garden and calculate its volume/storage capacity in the next lesson.