Rainwater Harvesting

Lesson 4: Schoolyard Site Exploration

INTRODUCTION

In this lesson, students will examine the schoolyard for physical evidence of where rainwater flows. Starting with school buildings, they will obtain information and evaluate how rainwater is currently managed on campus. Working in teams, they will communicate their findings and use their knowledge to construct an explanation for stormwater management and use this information to creatively design solutions for any problems they discover. They will investigate physical patterns of rainwater runoff on their school grounds by looking for evidence of erosion and interpreting the best location to collect and/or direct water to irrigate plants.

Teaching Strategies

The goal of this lesson is for students to draw upon personal experience to look for and find relationships between an idealized rainwater harvesting system and real-life. Students will be using observation skills and their understanding of how rainwater flows through the environment to decide on the best location to harvest rain.

To help students make the shift from specific to abstract, have them take the perspective of giving advice to someone at another school.

To help students make sense of what happens when rain falls on the soil at your school, conduct a soil "jar test." The infiltration rate of soil is an important factor when sizing basins. This topic will be introduced at the end of this lesson and reinforced in future lessons.

OBJECTIVES

- DISTINGUISH: **Analyze and interpret data** from a schoolyard investigation and use it to select a good site for rainwater harvesting.
- BUILD THE SYSTEM: Analyze the project site and identify all rainwater management system components available to incorporate into a rainwater harvesting system design.

MATERIALS AND EQUIPMENT

- Measuring tapes and clipboards for the schoolyard
- Copy of an aerial map of your schoolyard for each student
- Graph paper
- Worksheet: *Schoolyard Inspection Datasheet*

ADDITIONAL RESOURCES

- Optional Handout: *Soil Texture Triangle*
- Optional Handout: *Soils Interpretation Help Sheet*

The Rainwater Harvesting Unit is adapted with permission from the Arizona Project WET, Rainwater Harvesting Aqua STEM Program.

LESSON SUMMARY

In this lesson, students will use aerial images of their campus and an onsite investigation to learn how rainwater is currently managed on campus. They will then use the information gathered during the inspection to help them start planning their own rainwater harvesting system.

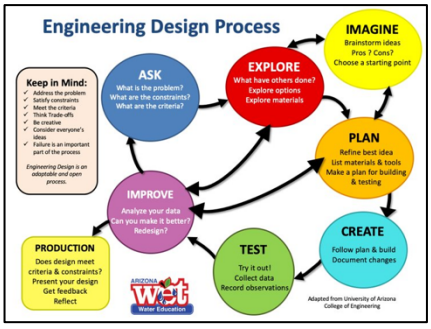
ADVANCED PREPARATION

Prior to leading students on the onsite inspection, you may want to conduct your own investigation of how rainwater is managed on campus. You should note where downspouts are located, assess which direction roofs drain, where, and notice how and where water flows across your campus, including areas of erosion as well as high and low spots. Ultimately you will want to determine where the rainwater originates, flows, and leaves the site on your campus.

In preparation for the campus tour, create an aerial image of your campus for students to use. You may wish to lighten the copies to make it easier for students to mark-up. During the on-site inspection, ask students to complete questions 1-6 on the Schoolyard Inspection Datasheet. This will give them some of the background information necessary to begin thinking about how they would like to design their rainwater harvesting system.

Optional - Identify a spot on the school grounds where one group of students may dig a hole to obtain a soil sample for a jar test for the class or perform a perc test. They will need to dig close to a foot down prior to taking the sample. The jar test will help students understand what will happen when rainwater falls on school ground. Also, the infiltration rate of soil is an important factor in sizing basins for rainwater harvesting. This topic is introduced at the end of this lesson and will be revisited in future lessons.

PRESENTATION GUIDE



Connect to the Unit

In Lesson 3, students were introduced to the Engineering Design Process (EDP) and began to ask questions pertaining to the design of a rainwater harvesting system. The goal of the system is to manage stormwater runoff, provide shade, and support plant health by meeting vegetation's water needs. Students are working toward creating an integrated design—one that combines benefits—by applying the ***Principles of Rainwater Harvesting - Stacking Functions.***

Launch the lesson

In this lesson, students will continue using the EDP to design their rainwater harvesting system. They are still in the "asking" phase of the EDP but will now begin the process of "exploring" by touring the campus. This is how the EDP works! It's not a linear process. As a reminder:

DISTINGUISH

• What is the Engineering Design Process? What is it not?

Specifically, remind them the EDP is a way of working that has many steps. It will take several weeks to complete the process, but by using this process they will be designing with effective solutions; not ones that are made up on the fly. Using the EDP takes time, but it also delivers great results.

DISTINGUISH

• Define the problem.

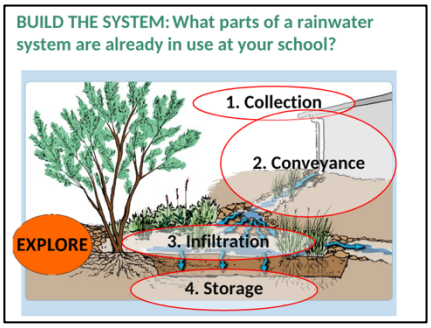
Inform the students they will be going outside to look at the campus from the perspective of an engineer. Their goal is to design a rainwater harvesting system that meets the Criteria and Constraints discussed in *Lesson 3 – Rainwater Harvesting and the Engineering Design Process.* Remind them of the problem they are trying to solve.

Refer to the posted Criteria and Constraints lists in your classroom. Which Criteria & Constraints can be specified, clarified, or quantified by this exploration? Should any new Criteria & Constraints be added to the list?

DISTINGUISH

• Identify areas on campus where water collects naturally or by design.

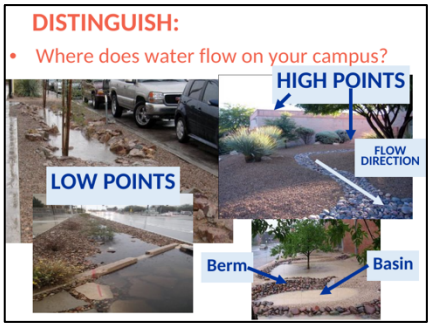
Show students an overhead or map view of your campus. Ask them to distinguish which areas have permeable or impermeable surfaces. Using the aerial view, see if they can identify which areas need shade and could be watered using a rainwater harvesting system. Have them construct claims based on the evidence for factors that would make a good site for a rainwater system. Ask them: "What limiting factors could exist in terms of optimal project sites?" (e.g., distance away from the landscape to be watered or the size of the collection area.)



BUILD THE SYSTEM

• What parts of a rainwater system are already in use at your school?

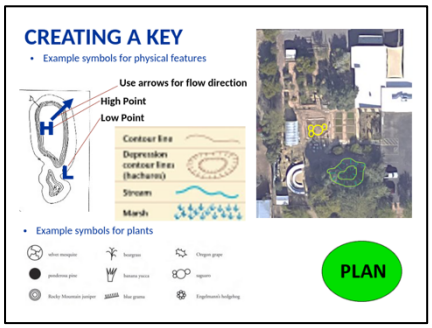
As a reminder, solicit input on the four processes involved in harvesting rainwater as introduced in *Lesson 2 – What is Rainwater Harvesting?* (collection, storage, conveyance, and infiltration). Have them keep these processes in mind during the schoolyard investigation.



DISTINGUISH

• Where does the water flow on your campus?

It's important for students to notice where the water is flowing on campus. Students will need a way to incorporate their schoolyard observations into their rainwater harvesting design. Show them this slide to introduce them to some of the landscape features they'll be looking for. They'll need a way to record their observations for use in their engineering design.

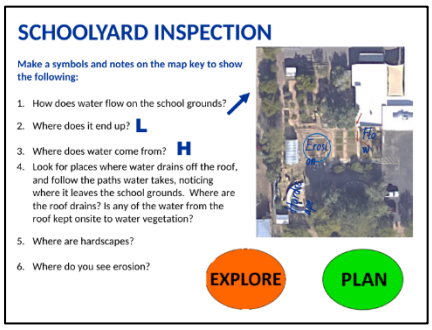


Using Symbols and Creating a Map Key

Introduce students to the use of symbols as a way of recording data on their school yard map. They should create symbols for physical structures, like hardscape, and symbols to delineate where water flows.

Have students also designate symbols for the existing plants which need to be watered. They may use the symbols already provided on the *Schoolyard Inspection Datasheet* or create their own key.

NOTE: Students will learn about different types of plants and their watering requirements later in the unit. This knowledge will influence their ultimate rainwater harvesting system design.



Schoolyard Inspection

While outside, students working in groups will be completing Questions 1 – 6 on the *Schoolyard Inspection Datasheet*:

1. How does water flow on the school grounds?
2. Where does it end up?
3. Where does water come from?
4. Look for places where water drains off the roof and follow the paths water takes, noticing where it leaves the school grounds. Where are the roof drains? Is any of the water from the roof kept onsite to water vegetation?
5. Where are hardscapes?
6. Where do you see erosion?

Part 1

Distribute the Schoolyard Inspection Datasheet and the aerial image of your campus (from Google Maps) to students and lead them outdoors for a campus tour. Remind them to complete Questions 1 – 6 while outdoors.

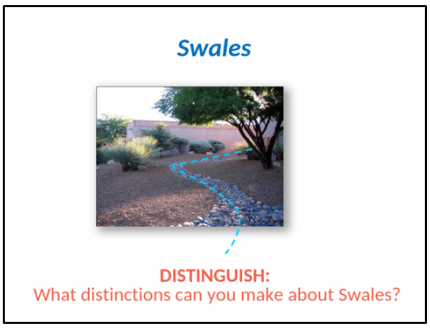
Encourage students to explore the schoolyard and observe any recognizable patterns on how rain/stormwater flows on their campus. Have them work in their groups asking each other questions to further define the problem and support the four processes involved in

rainwater harvesting. If you can manage to do the schoolyard inspection on a rainy day, even better!

Ask them to construct an explanation of how high and low spots may work with their designs, and whether erosion could be prevented by better water management.

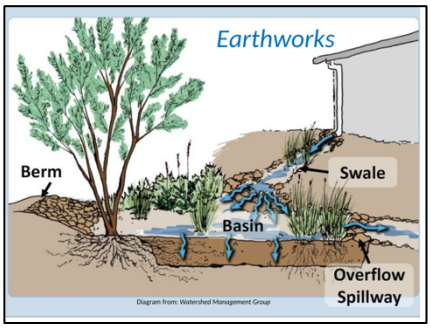
Part 2:

As they continue their investigation, have students analyze and delineate the areas they believe would be best for collection, conveyance, infiltration, and storage. What evidence do they have for their claims? Each group will be focusing in on one site for the development of their rainwater harvesting system. Allow each group to choose a different site if possible.



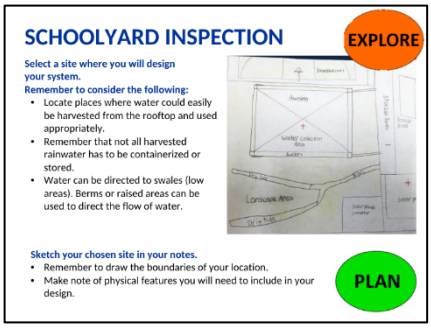
Follow the steps 8 – 10 on the back page of the datasheet. Have students measure and draw the boundaries of the location they choose on their map.

If there is already vegetation in the area, have students count the types of plants and record them on the Schoolyard Inspection Datasheet.



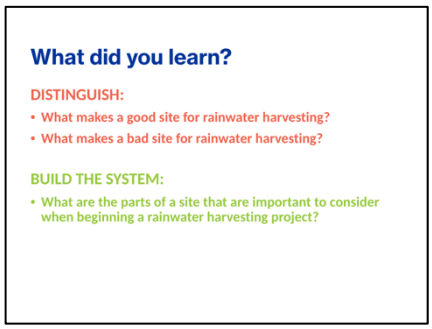
Back in the classroom, provide the students with the information on *berms*, *basins* and *swales* (on this slide and the next). Collectively, they are all called *earthworks*. Students will be designing passive rainwater harvesting systems using earthworks. They should look for opportunities to direct the water flow to their earthwork design. Water flow can be directed by swales. Swales are dug out of the earth with a shallow slope to convey water in a controlled manner. Soil that is excavated to create a swale can be used to create a berm.

A berm is a raised and elongated mound perpendicular to the slope of the land. Berms are used to slow surface runoff to allow infiltration in an adjacent area. Basins are low areas that collect and infiltrate water.



Have students sketch their chosen site to scale on a larger piece of graph paper (at least 8.5” x 11”) to use later in the engineering design project. Label all parts and processes. They will need to take measurements of the collection area as well as the location of the rain basin(s).

Note: Students are likely to forget to record some important items when they are in the field so more than one trip outdoors maybe required. Decide how you might need to manage students coming and going from the field to your classroom.



Have a group discussion on what the students observed and the problems they identified. Tell them to discuss in their groups how the problems that they found could be solved. Then ask, "Could your rainwater harvesting design address any of the problems?"

Have students review the Criteria and Constraints lists and add any new ones from their site inspections.

Conclusion

DISTINGUISH

• What makes a good site for rainwater harvesting?

To wrap up, discuss what physical features might make for a good rainwater harvesting site. Ask them how many of these features they have in their chosen site. Discuss possible ways to change their site to collect more rainwater or include more basins.

• What makes a bad site for rainwater harvesting?

Did they notice any areas on campus where they wouldn't want to put a rainwater harvesting system? What might be some of the limitations of those areas? (confined spaces, too much pedestrian traffic, difficulty getting water where it is needed)

Ask students to discuss why they chose their particular site for harvesting rain. Based upon your discussions, are there things they can change to improve their ability to harvest rain?

BUILD THE SYSTEM

• What are the parts of a site that are important to consider when beginning a rainwater harvesting project?

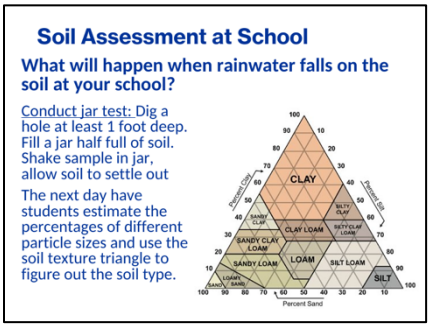
Have students develop an answer to this question in small groups, and then share. This may inspire some groups to want to collect more information to add to their site map. (students can do this during lunch or recess if needed)

- Could any of the existing parts of the rainwater management system be utilized for collecting rainwater?
- How will rainwater be conveyed or transported to their chosen site?
- How will it infiltrate into the soil? Is there a way for students to enhance infiltration on their site?

• Are there constraints to this site that they may not be able to see? (pipes and utility lines underground)

• Is there room for trees to spread their root structure at their site?

****OPTIONAL BUT ENCOURAGED****

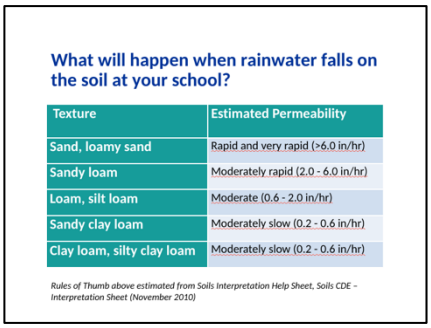


Option 1: Soil Assessment at School to estimate infiltration/percolation rate.

What will happen when rainwater is collected in a basin at your schoolyard?

Conduct a jar test (see *Soil Texture Triangle.docx).* Dig a hole at least 1 foot deep. Fill a jar half full of soil and fill the rest of the way with water. Shake the sample in the jar, allow the soil to settle out.

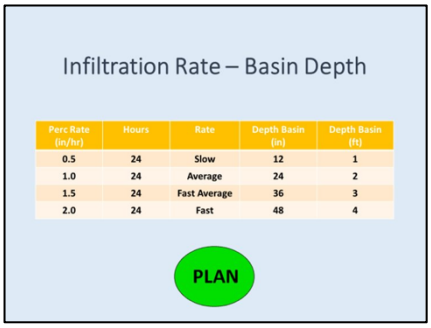
The next day have students use a ruler to measure the thicknesses of each particle size (sand, silt and clay) and the total soil sample. Use the measurements to estimate the percentages of different particle sizes and use the soil texture triangle to figure out the soil type.



If there is time, students can also assess their soil type by feel. Have students use the chart on the back of the *Soil Texture Triangle* as a guide.

Sandier or more gravelly soils will allow water to infiltrate faster. Silt and clay inhibit the flow of water into the ground.

Based upon the results of the jar test for your school, use the data table to estimate how fast or slow they think the water will enter the ground.



Option 2: Infiltration Rate and Sizing Basins

When designing and sizing basins for rainwater harvesting, it is important to take into consideration the following factors:

Soil Texture: Permeability varies greatly based upon soil composition. Sand and sandy loam soils have a higher degree of permeability and allow for relatively rapid release of waters collected in a basin. The opposite occurs with clay loam and silty clay loam which will hold retained waters for a much longer period of time.

For optimal rainwater harvesting as well as public health and safety, the following considerations must be made:

✓ **No standing water allowed.** Due to State of New Mexico water rights laws, water must infiltrate through the basin within 96 hours. Standing water could become a breeding site for mosquitos.

✓ **Infiltration Rate Determines Optimal Basin Depth**. Knowing the infiltration rate or perc rate (inches/hour) of water into our soil tells us what the maximum depth our rainwater harvesting basin should be. A *Fast Average* infiltration rate will allow for a basin depth of 3 feet deep. As the infiltration rate slows the maximum depth for a basin decreases.

✓ **Slope Safety.** Steeply sloped basins can be hazardous to people and pets. A general rule of thumb is to maintain a 3:1 slope ratio (or less) when creating berms and basins. This means for every 3 units of horizontal distance on a slope, you go down 1 unit vertically.