Rainwater Harvesting

Lesson 7: Calculating Plant Water Needs

INTRODUCTION

Using spreadsheets and reference material, students will calculate how much water they need to meet the watering requirements of their plants in their project area. Students will relate the plants' water needs to available harvested water. Students will analyze and interpret how selected plants will meet the engineering design criteria of providing shade and serving other functions in the integrated design of the rain basin.

Teaching Strategies

To design a successful rainwater harvesting system, students need to understand the concept of supply versus demand. In an ideal system, supply should be equal to demand. In this lesson, students calculate the watering needs for the specific plants in the chosen landscape. They learn to distinguish the differences between watering needs for larger plants (trees and shrubs) and low-lying vegetation, such as native and non-native plants.

OBJECTIVES

- DISTINGUISH: **Analyze and interpret** how selected plants will meet the engineering design criteria of providing shade and serving other functions in the integrated design of the rain basin.
- BUILD THE SYSTEM: Use **mathematics and computational thinking** to calculate the watering needs for the project site.
- RELATE: Identify relationships between the amount of water required for native and non-native plants.
- TAKE A PERSPECTIVE: From the perspective of the data collected to this point, **construct explanations and design solutions** for what your rainwater harvesting system will accomplish.

MATERIALS AND EQUIPMENT

- Handout: *Lesson 6 Proposed Plants Worksheet.docx*
- Handout: *Lesson 6 Proposed Plants Canopy Area.docx*
- Handout: *Supply worksheet.pdf* (already completed in Lesson 5)
- Worksheet: *Water Budget Calculation Worksheet_Santa Fe.pdf*

LESSON SUMMARY

In this lesson, students will apply mathematics and computational thinking to the demand side of their water harvesting system. In terms of the Engineering Design Process they will Imagine, Improve and Plan.

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

Imagine

Students will:

1. Use the types and number of plants they chose in Lesson 6 and calculate the annual water requirement for each.
2. Compare annual water requirements to the annual volume of water they are harvesting from their collection area.

Improve and Plan

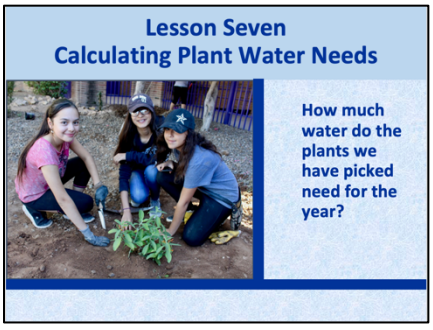
Using the values from the **Imagine** step, students will:

1. Refine plant selection
2. Calculate annual plant water requirements
3. Compare annual plant water requirements to annual harvested water available
4. Adjust plant selection and collection surface area until volume of water is balanced between needs and supply.

PRESENTATION GUIDE

Connect to the Unit

In Lesson 6, students explored the water needs of different types of plants. They learned that plants can be categorized by Very Low, Low, Moderate, High, and Very High water needs. In our area, Very Low and Low water plants are typically native species. Students evaluated the use of native vs. non-native plants in their gardens and engaged in an experiment to observe evapotranspiration. Finally, students researched the watering needs of plants for the landscape they intend to create.



Launch the lesson

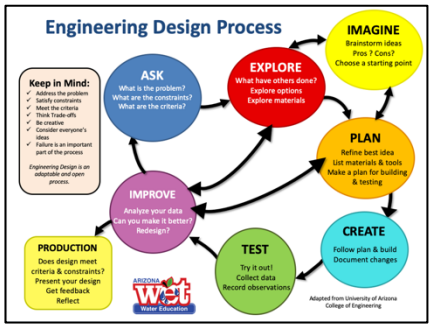
In this lesson, students will calculate the water demand for the plants on their project landscape. They will determine how to increase shade while meeting the watering requirements of their plants through passive rainwater harvesting. Students will:

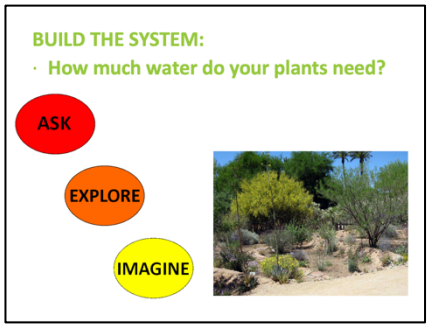
- Determine how much water is needed for the plants they would like to grow.
- Begin to envision the size of their basins to infiltrate this volume of water.

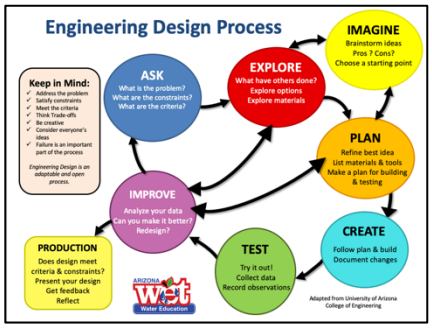
Remind the students of the driving question and orient them to where they are in the process of answering that question:

• What do we know?

Students should now know: the amount of rainfall they can collect for their site, how water moves through their site, the types of plants, and the number of each type of plants.







• What don't we know?

Students need to determine the specific water needs for their landscape in order to sustain it throughout the year.

Where are we in the Engineering Design Process?

Students are Imagining, Improving and Planning in their effort to find the best solution as defined by our criteria and constraints.

DISTINGUISH

• What functions does my rainwater harvesting system provide?

Students should be able to list functions beyond just providing shade. Other functions may include infiltrating water, cooling through evapotranspiration, habitat, attract pollinators, reduce flooding, and soil building.

RELATIONSHIP

• What are the relationships between the chosen plants and the function(s) that each plant serves?

Each element in an integrated design should serve more than one function, and every function is supported by many elements. Relate the elements or structures to functions in your system.

BUILD THE SYSTEM

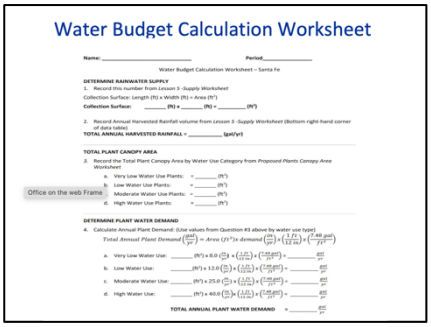
• How much water do your plants need?

Students will learn and apply the factors involved in calculating the water needed to sustain the plants on their project site. At this point, students should have identified the existing types of vegetation and their plant water use needs. Students should also have identified in their designs the number and corresponding water use requirements of each plant type. Do not move forward with the lesson until this information is acquired.

- Handout: *Lesson 6 Proposed Plants Worksheet.docx*
- Handout: *Lesson 6 Proposed Plants Canopy Area.docx*

Engineering Design Steps

Direct students through the Imagine, Improve, and Plan steps:


Water Budget Calculation Worksheet

Name: _____ Period: _____

Water Budget Calculation Worksheet – Santa Fe

DETERMINE RAINWATER SUPPLY

1. Record this number from *Lesson 5 -Supply Worksheet*

Collection Surface: Length (ft) x Width (ft) = Area (ft²)

Collection Surface: _____ (ft) x _____ (ft) = _____ (ft²)

2. Record Annual Harvested Rainfall volume from *Lesson 5 -Supply Worksheet* (Bottom right-hand corner of data table)

TOTAL ANNUAL HARVESTED RAINFALL = _____ (gal/yr)

TOTAL PLANT CANOPY AREA

3. Record the Total Plant Canopy Area by Water Use Category from *Proposed Plants Canopy Area Worksheet*

a. Very Low Water Use Plants: = _____ (ft²)
b. Low Water Use Plants: = _____ (ft²)
c. Moderate Water Use Plants: = _____ (ft²)
d. High Water Use Plants: = _____ (ft²)

DETERMINE PLANT WATER DEMAND

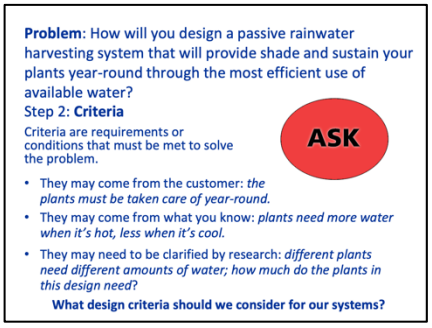
4. Calculate Annual Plant Demand: (Use values from Question #3 above by water use type)

Total Annual Plant Demand $\left(\frac{gal}{yr}\right)$ = *Area* (ft^2) *x demand* $\left(\frac{in}{yr}\right) \times \left(\frac{1\ ft}{12\ in}\right) \times \left(\frac{7.48\ gal}{ft^3}\right)$

a. Very Low Water Use: _____ (ft²) x 8.0 $\left(\frac{in}{yr}\right)$ x $\left(\frac{1\ ft}{12\ in}\right)$ x $\left(\frac{7.48\ gal}{ft^3}\right)$ = _____ $\frac{gal}{yr}$
b. Low Water Use: _____ (ft²) x 12.0 $\left(\frac{in}{yr}\right)$ x $\left(\frac{1\ ft}{12\ in}\right)$ x $\left(\frac{7.48\ gal}{ft^3}\right)$ = _____ $\frac{gal}{yr}$
c. Moderate Water Use: _____ (ft²) x 25.0 $\left(\frac{in}{yr}\right)$ x $\left(\frac{1\ ft}{12\ in}\right)$ x $\left(\frac{7.48\ gal}{ft^3}\right)$ = _____ $\frac{gal}{yr}$
d. High Water Use: _____ (ft²) x 40.0 $\left(\frac{in}{yr}\right)$ x $\left(\frac{1\ ft}{12\ in}\right)$ x $\left(\frac{7.48\ gal}{ft^3}\right)$ = _____ $\frac{gal}{yr}$

TOTAL ANNUAL PLANT WATER DEMAND = _____ $\frac{gal}{yr}$

- Complete the *Water Budget Calculation Worksheet Santa Fe.pdf* worksheet.
- Did your water budget balance?
    - If yes, continue to the **Create** phase.
    - If not, adjust plants and harvest surface area as necessary
- Repeat steps.


Problem: How will you design a passive rainwater harvesting system that will provide shade and sustain your plants year-round through the most efficient use of available water?

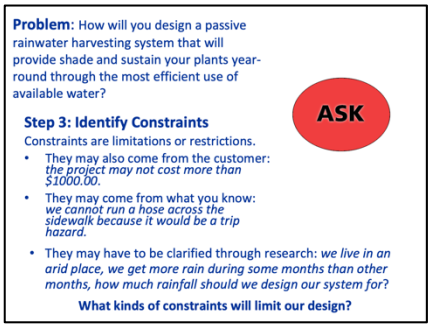
Step 2: **Criteria**

Criteria are requirements or conditions that must be met to solve the problem.

ASK

- They may come from the customer: *the plants must be taken care of year-round.*
- They may come from what you know: *plants need more water when it's hot, less when it's cool.*
- They may need to be clarified by research: *different plants need different amounts of water; how much do the plants in this design need?*

What design criteria should we consider for our systems?


Problem: How will you design a passive rainwater harvesting system that will provide shade and sustain your plants year-round through the most efficient use of available water?

Step 3: Identify Constraints

Constraints are limitations or restrictions.

ASK

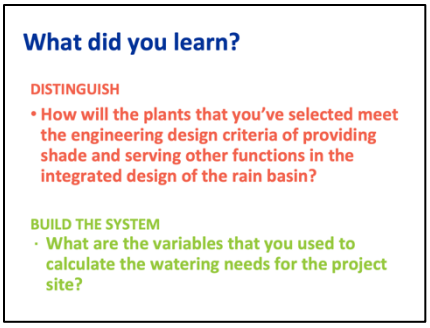
- They may also come from the customer: *the project may not cost more than $1000.00.*
- They may come from what you know: *we cannot run a hose across the sidewalk because it would be a trip hazard.*
- They may have to be clarified through research: *we live in an arid place, we get more rain during some months than other months, how much rainfall should we design our system for?*

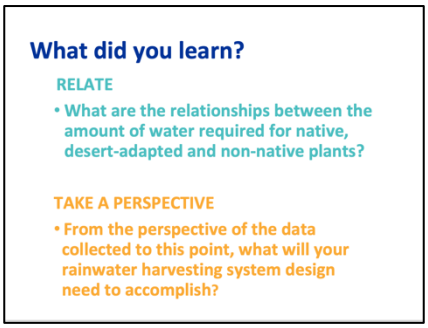
What kinds of constraints will limit our design?

What is your total water demand?

Once students have completed the demand worksheets and applied DSRP thinking to analyze and interpret the data, return to your criteria and constraints lists. Ask them:

- Which of the criteria and constraints questions does this exploration answer?
- Which criteria and constraints have been specified, clarified, or quantified by this exploration?
- What new criteria and constraints should be added to each list based on this exploration?





Conclusion

DISTINGUISH

• How will the plants that you've selected meet the engineering design criteria of providing shade and serving other functions in the integrated design of the rain basin?

BUILD THE SYSTEM

• What are the variables that you used to calculate the watering needs for the project site?

RELATE

• What are the relationships between the amount of water required for native and non-native plants?

TAKE A PERSPECTIVE

• From the perspective of the data collected to this point, what will your rainwater harvesting system design need to accomplish?