

“SPONGE CITY” ENGINEERING DESIGN

OBJECTIVE:

Students will understand the importance water conservation and of the saying, “Every Drop Counts”, as they build a model city to capture water, not shed water, and will learn the difference between an aqua duct and an aquifer. Students will learn that when a city is built to harness water, store and reuse it, the architecture and design of that city will need to change. Students will learn the crucial importance of designing a waterproof city vs. a water-capturing city, or rather, a “sponge city”.

PURPOSE:

To educate students on the importance of water and its pathways within an urban landscape, as well as to emphasize the importance of architectural design within the scope and measure of engineering future cities and their water capturing potential. Special focus will be paid to the capture and harnessing potential of water within a model city and its structures, as well as to the transport and storage capacities of water within city limits, and finally, design will extend to creative recycling technologies designed by the students.

VOCABULARY:

“Water Harnessing and Capture”, “Aquifer”, “Watershed”, “Aqua duct”, “Water Barrel”, “Gutter”, “Storm drain”, “Filtered Water”, “Recycled Water”, “Greenspace”, “Water Conservation”, “Drought”, “Pollution”

TIME NEEDED:

1.5 hours (30-45 minute class prep and Introduction; 45 minute lab)

CLASS PREP AND INTRODUCTION:

1. In a class setting or in small groups, have students view the animation at the following YouTube links:



LOS ANGELES AREA WATER SHED <https://www.youtube.com/watch?v=cH5Y8XvlcVc>



(Aerial Tour of the L.A. Aquaduct)

<https://www.youtube.com/watch?v=KDrgKxzDmn8>

(SANTA ANA WATERSHED):

<https://www.youtube.com/watch?v=4NxSBi7M4sA>

1. Ask students what they think a watershed is? (EXTENSION: Have students look up which watershed they live in and where their water comes from?)
2. Ask students what they think an aqueduct is? Ask students what they think the difference is between an aqueduct and an aquifer?
3. Have students write their answers on a sticky note and post on a central spot in the classroom where Teacher can read off to class and discuss comments. (Allow time for students to ask questions, and to discuss possible misconceptions without correcting.)
4. Next, in either a class setting or in small groups, have students view some or all of the short documentaries at the following YouTube links:
L.A. RIVER <https://www.youtube.com/watch?v=o4dHDIde9Os>
https://www.youtube.com/watch?v=_zoiS4WAoHk
<https://www.youtube.com/watch?v=e9nmoBCM3uo>
<https://www.youtube.com/watch?v=4b4YZP6ikus>
https://www.youtube.com/watch?v=TTf8zQbr_6E
<https://www.youtube.com/watch?v=sMzRa0dxbxA>
5. Ask students what they think of the L.A. River? What is the problem in this particular river? What has happened over time? Can the river be cleaned up or fixed in some way?
6. Have students write their answers on a sticky note and post on a central spot in the classroom where Teacher can read off to class and discuss comments. (Allow time for students to ask questions, and to discuss possible misconceptions without correcting.)
7. Finally, in either a class setting or in small groups, have students view the following YouTube links that will give students an idea of how to engineer and design a creative water harnessing structure.

WATER BARREL RAINWATER CAPTURING SYSTEM:

<https://www.youtube.com/watch?v=MYTNciCplmw>

<https://www.youtube.com/watch?v=1rKiSD4A1K4>

OTHER WATER SAVING/CONSERVATION/HARNESSING TECHNIQUES:

<https://www.youtube.com/watch?v=YdwKDVzh1cs>

8. Finally, in either a class setting or in small groups, read the following Introduction with the students before beginning the engineering design lab below.

INTRODUCTION:

Many cities and countries around the world are beginning to see the need for and necessity of the idea to conserve water, for many reasons. For instance, Chengdu, a very large city in China, wants to be one of the first to engineer and design a “Sponge City”, where long time drought and water-logging conditions have rendered the city’s waterways, rivers, and lakes almost useless due to pollution. In the hopes that a down pouring of rain can be captured and re-directed below ground to be stored, filtered, and repurposed for later use, the city hopes to combat its current environmental woes. In many parts of the world, the issues of limited and contaminated water loom heavy on the financial purses of city governments and can impact the health of its population over time. This means that new “sponge city” water conservation technologies and architectural designs will be needed in the future of cities being built around the world, and most likely, big money will be spent for an engineer with new ideas on how to harness and capture water. To become the “new modern”, the “new” landscape for a city of the future, and its skyline may look very different than today.

LAB:

NAME: _____ **DATE:** _____ **PERIOD:** _____

SPONGE CITY: DESIGN ENGINEERING LAB:



A "Sponge city" refers to a city where its urban underground water system operates like a sponge to absorb, store, leak and purify rainwater, and release it for reuse when necessary.

MATERIALS:

(per group): Banana Cardboard Packing Box or Cardboard Lid (large enough to fit two feet long by 1.5 feet. wide); modeling clay – 2 boxes of 4 colors each; 2 various dishwashing sponges – hand size; 1 small funnel; 1 cardboard paper towel tube, minus the paper towels; 1 paper bowl and 1 paper cup – any size; 1-2 sheets of blue tissue paper; 1 piece of 8 X 11 green felt; 1 coffee filter; masking tape and sharpie; access to various colors of tempura paint, for adding color to finished model.

TEACHER ONLY:

Graduated Cylinder; 50 mL water per group; small watering can

HYPOTHESIS:

If we create a model of a city designed to capture, store and re-use water, then we predict that only _____ mL will leak off of our model and that we will capture _____% of all water poured onto our model.



PROCEDURE:

1. Divide students into groups of 3 or 4. Have students obtain 1 Banana Cardboard Packing Box or Cardboard Lid (see materials list above), modeling clay – 2 boxes of 4 colors each, 2 various dishwashing sponges – hand size, 1 small funnel, 1 cardboard paper towel tube, minus the paper towels, 1 paper bowl and 1 paper cup – any size, 1-2 sheets of blue tissue paper, 1 piece of 8 X 11 green felt, 1 coffee filter and some masking tape and a sharpie.
2. Next, have students sit down and discuss the dimensions of their city. Have them draw in the space below a rough sketch of their design. Discuss with students the Mission, Engineering Parameters, Model Requirements and the Engineering Design Focus on the following page.



TEAM NAME:

MISSION:

REDESIGN AND ENGINEER A FUTURISTIC CITY, LIKE LOS ANGELES, AND TURN IT INTO “SPONGE CITY”, SO THAT EVEN AFTER A DOWNPOUR OF RAIN:

ENGINEERING PARAMETERS:

- 1) NO MORE THAN 10 ML OF RAINWATER IS “LOST” (POURED OFF).
- 2) CAPTURED WATER GETS FILTERED OR IS SAFE TO TOUCH (NOT TO DRINK).
- 3) “L.A. RIVER” (or waterway relative to your area) IS REDIRECTED SO THAT FRESH WATER IS DIRECTED UNDERGROUND TO AN AQUIFER FOR STORAGE (NOT TO THE OCEAN OR A LAKE). REMEMBER, THE L.A. RIVER IS CONSIDERED POLLUTED! WHAT WILL YOU DO TO THE WATER BEFORE OR AFTER IT GETS INTO THE L.A. RIVER? (GIANT AQUIFER)

MODEL REQUIREMENTS:

YOUR MODEL MUST INCLUDE:

- A) AT LEAST 1 SKYSCRAPER
- B) 1 PARK OR OPEN GREEN SPACE
- C) 1 HOME AND BACKYARD
- D) L.A. RIVER SYSTEM
- E) COMMERCIAL BUSINESS PARK OR FACTORY
- F) FREE WAY/ROADS
- G) OCEAN OR NEAREST LAKESIDE / COASTLINE (1 EDGE OF MODEL)

ENGINEERING DESIGN FOCUS:

- 1) WHERE DOES THE WATER GO WHEN IT RAINS?
 - A) ROOFTOPS
 - B) STREETS
 - C) GUTTERS/STORMDRAINS
- 2) HOW WILL YOU CAPTURE/HARNESS THIS WATER?
 - A) WATER SHED
 - B) WATER BARREL SYSTEM

*REMEMBER – WATER WILL FALL ON YOUR ENTIRE MODEL.

3. When students are ready, have them begin building and constructing their “Sponge City”, according to the parameters listed above. (This may take one class period and is amazing to watch 😊.) Allow students to choose roles if necessary: who will be the Head Engineer; who will be the Reporter and Speaker for the group when presenting; who will be the Safety Engineer; and who will be the Water Conservation Scientist?

4. Have students label using masking tape and a sharpie the following structures: Aqua duct, Aquifer, Watershed, and any other pertinent water conservation design/structure.
5. Finally, when students have completed their models, begin testing and recording data on the following Data Table.
6. For all groups, record data below on the Data Table and compare. (You may assign a winner and prize if the spirit so moves you.)

DATE TABLE:

SPONGE CITY #1 – TEAM NAME:	mL water collected as runoff	NOTES
SPONGE CITY #2 – TEAM NAME:	mL water collected as runoff	NOTES
SPONGE CITY #3 – TEAM NAME:	mL water collected as runoff	NOTES
SPONGE CITY #4 – TEAM NAME:	mL water collected as runoff	NOTES
SPONGE CITY #4 – TEAM NAME:	mL water collected as runoff	NOTES
SPONGE CITY #6 – TEAM NAME:	mL water collected as runoff	NOTES
SPONGE CITY #7 – TEAM NAME:	mL water collected as runoff	NOTES
SPONGE CITY #8 – TEAM NAME:	mL water collected as runoff	NOTES

7. When students are ready to test their models, have the Reporter explain the Engineering Design of the model, focusing first on the different sides of the model, showing the different structures built, and the as well as their creative ideas for harnessing and capturing water within their model city and its structures, as well as explain the transport and storage capacities of water within their city limits, and finally, explain any design that attempted to use recycled/filtered water.
8. Teacher ONLY: Sprinkle 50 mL of water on each model, one by one, over a sink or other water – safe area. Collect and measure how much water leaks off using a graduated cylinder and record data.

RESULTS:

- 1) Which group's "Sponge City" performed the best? Which one the least?
- 2) What technologies or engineering designs did the winning group include? What made these designs successful?
- 3) What designs were not successful in retaining water? What happened and why did they not work at capturing or harnessing water?

*BONUS QUESTIONS:

- 1) What importance does water conservation play in the construction of a city today? What about in a city of the future? Research and cite one engineering technique or design that cities are using already to conserve or store water.
- 2) Research and cite a future architectural design that will be engineered to aid cities in either harnessing and capturing water, storing and transporting water, or recycling and filtering water for other uses.

SUMMARY CONCLUSION:

Please write a 3-5-sentence paragraph using at least 5 of the words from the word bank below. Try to describe what happened during this lab according to your data and what you learned from your data.



WORD BANK:

"Water Harnessing and Capture ", "Aquifer", "Watershed", "Aqua duct", "Water Barrel", "Gutter", "Storm drain", "Filtered Water", " Recycled Water", "Greenspace ", "Water Conservation", "Drought", "Pollution"
