LESSON TITLE	Design a Dam				
SUBJECT (S):	Environmental Science, Physical Science, Earth Science, Ecology, Life Science				
GRADE LEVEL:	6-12	**AUTHOR:**	Rebecca L. McKinney, MS		
TYPE OF LESSON (activity, lab, project…)	Lab			**DAY(S):**	3+

OBJECTIVE

Students will design and build a dam, on a budget, to prevent the flow of water, then evaluate its effectiveness and answer questions about its impact to the environment.

NGSS/CC STANDARDS

NGSS
Science and Engineering: 2, 3, 4, 6, 8
Crosscutting Concepts: 6
Core Ideas: ESS3, PS2, LS2, ETS1

PERFOMANCE EXPECTATIONS
Earth & Space Sciences: HS-ESS3-4; MS-ESS3-4
Physical Sciences: HS-PS2-3, HS-PS2-6
Life Sciences: HS-LS2-6, HS-LS2-7; MS-LS2-1, MS-LS2-4
Engineering: HS-ETS1-2, HS-ETS1-3; MS-ETS1-1

CC MATH
HS - HSN.Q.A.3, MP.2; MS – MP.2, MP.4, 6.SP.B.4, 6.SP.B.5

CC ELA/LITERACY
HS - WHST. 9-12.1, 9-12.2; MS – SL.8.4, WHST.6-8.2, RST.6-8.7

ASSESSMENT(S) & GRADING/RUBRIC

Completion of lab and worksheets. (Most of the questions in the conclusions section are based on opinion.)

Consider giving additional points for more effective dams.

Students could write a formal lab report.

SUBJECT AREA(S):

This lab could easily fit within the following courses as follows:
PHYSICAL SCIENCE: pressure (water), forces, potential energy (storing water for purposes of energy), engineering design

EARTH or ENVIRONMENTAL SCIENCE: importance of water to society, water as a resource, the water cycle, human impact on earth, natural resources, roles of water in earth surface processes, impact to ecosystem

LIFE SCIENCE: cycles of matter (water), impact to ecosystems

TEXTS/MATERIALS/TECHNOLOGY/AUDIO-VIDEO/OTHER RESOURCES:

2 liter bottle (2 liter bottles are recommended because they are easily found, but any plastic container that will hold water can work, ie. Plastic shoe boxes, greenhouse trays, etc. You can have groups bring in their own 2 liter bottles), sand/gravel, dropper, graduated cylinder, ruler, beaker, water, food coloring

Building supplies: scissors, glue, hot glue and glue gun (hot glue is an excellent option), pipe cleaners, popsicle sticks, air hardening clay, toothpicks, paper clips, string, straw, tape, rubber bands, plastic bag, paper

INSTRUCTIONAL STRATEGIES/PROCEDURES/GROUPING:

Day 1: Lead students to discuss the following questions. This can be small group discussion or full class discussion.

Ask: What are dams used for?

Ask: What are the dangers of a dam failure?

Talk briefly to students about the importance of the design of dams. Show students various designs online. For example:
http://members.optusnet.com.au/~engineeringgeologist/page6.html
http://community.dur.ac.uk/~des0www4/cal/dams/fron/contents.htm
http://blog.thecivilengg.com/types-of-dams/
http://www.planete-tp.com/en/dams-on-rivers-a172.html

Have the class form into teams of 2 to 4 students then pass out the worksheets. (You can make the group size up to 6, but it is not recommended). Worksheets can be filled out per team or individually. Briefly explain the purpose of the lab. Explain to students they will have to purchase items from within their $5,000 budget and can only use these items to build their dam. They will only be given one opportunity to purchase their supplies. If they break the items, they will not get replacements.

Students will use the rest of the class period to begin the design phase of the lab. For this part, each student should come up with a detailed design. Make sure 2 liter bottles are available so students can take measurements.

DAY 2: Groups should review the completed designs and select the design they will build. The remaining class day should be for purchasing materials, building the dam and making their ravine.

DAY 3: Depending on your classes, you might have to give them an additional day to build. If they are done building, they can move on to the first testing phase, which takes 30 minutes.

DAY 4: Have students observe how their dams held up overnight. Many groups will notice that water will be on both sides of the dam. After students acquire their data, have them make their graph, analyze their data and draw conclusions using the series of follow-up questions in the Conclusions section of the worksheet.

SAFETY/SECURITY ISSUES:

If using a hot glue gun, caution students about potential burns from the hot tip, hot glue and (possibly) melted plastic bottle.

REFERENCES

http://britishdams.org

http://members.optusnet.com.au/~engineeringgeologist/page6.html

NOTES/REFLECTIONS/EXTENSIONS:

NOTES: Most students will realize that if their dam leaks it will be from the bottom or sides. They will not have sealed it well to the walls of the bottle, if they even chose to seal it to the walls. Point out to students how some of their water goes into the sand. This concept of ground water is often times quite challenging for students to understand. Using colored water is a nice addition.

EXTENSIONS: Students could redesign their dam after the first experiment and retest to increase effectiveness. You could consider having them elevate their dam higher in the ravine. Students could design a dam that also has the ability to let water flow to the other side as needed.

If you want to do this lab on a smaller scale you could allow students to build in water bottles instead of soda bottles.

You can vary the supplies you give to the students. The listed materials are only suggested. Conversely, you can allow students to build the dam out of any item of their choosing. The budget constraint is a realistic way for them to realize the importance of engineering design and that there are costs involved in building.

NAME _____ DATE _____

DESIGN A DAM

Dams have numerous uses including flood control, generation of electricity, and storage of water that can be used by cities and farmland. Dams have to withstand the intense pressure of water on one side, while often times needing to have the ability to release water to the opposing side under controlled conditions. Dams must be able to endure natural disasters such as extreme weather or earthquakes. The integrity of the dam is so critical, that if it is structurally flawed, the dam could break and release millions of gallons of water toward unsuspecting people.

BUDGET

During this lab, you will design and build a model dam in a ravine in order to hold a reservoir of water and then test the dam's effectiveness. You will be allocated a budget of *$5,000* and you may not go beyond this budget.

MATERIALS PROVIDED: 2 liter bottle, sand/gravel, dropper, graduated cylinder, ruler, beaker, water

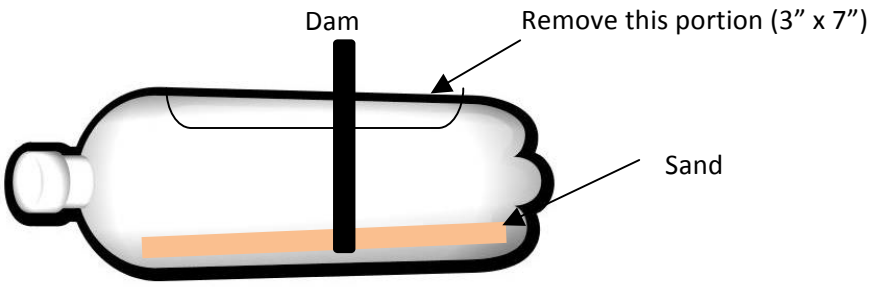
MATERIALS FOR PURCHASE:

Item	Cost	Item	Cost
Scissors	$50	Toothpick	$25
Regular glue	$50	Paperclip	$50
1 hot glue stick (with glue gun)	$200	20 cm of string	$100
Pipe cleaner	$200	Straw	$200
Popsicle stick	$200	10 cm tape	$100
Air hardening clay (small ball)	$3000	Plastic bag (small)	$200
Rubber band	$100	Paper	free

BUILDING THE RAVINE AND DESIGNING THE DAM

METHODS

1. Lay the 2 liter bottle on its side.
2. Cut off the top portion of the 2liter bottle (approximately 3 inches x 7 inches) but leave both of the ends in place.
3. Place a minimum of 1 inch of sand/gravel at the bottom of the bottle.
4. You must design your dam to fit inside the bottle, spanning the width of the bottle.
    a. You can seal your dam to all sides of the bottle.
    b. The dam should sink deep into the sand/gravel mixture.



DESIGN PHASE

During the design phase, each group must provide a minimum of 4 different sketches in which you identify which supplies would be used and dimensions of the dam from all perspectives. Sketches can be placed in the spaces below or attached.

Sketch #1

Sketch #2

Sketch #3

Sketch #4

CHOSEN DESIGN. Identify the design you have agreed to work with. Explain why this is the best design for the dam.

CONSTRUCTION PHASE

You will now get the opportunity to build your dam. You must first purchase your supplies. Fill in the table below with the materials you will need and the total cost. Remember, you cannot exceed $5,000.

MATERIALS

Item	Cost	Quantity	Cost x Quantity
Scissors	$50		
Regular glue	$50		
1 hot glue stick (with glue gun)	$200		
Pipe cleaner	$200		
Popsicle stick	$200		
Air hardening clay (small ball)	$3000		
Rubber band	$100		
Toothpick	$25		
Paperclip	$50		
20 cm of string	$100		
Straw	$200		
10 cm tape	$100		
Plastic bag (small)	$200		
Paper	free		
		TOTAL COST	

INSTRUCTIONS to build dam: Detail below how to build your dam.

TEST PHASE

You will now test the effectiveness of your dam.

QUESTION: What percentage of water will your dam successfully hold back?

HYPOTHESIS

METHODS: Once your dam is built and in place, measure and add water (600-800 mL) to one side of your dam. Mark the level on your bottle with a marker. You will allow your dam to sit for 30 minutes then measure how much water has leaked to the other side of the dam by using the dropper and graduated cylinder to quickly remove the fluid that has leaked across. Write down your observations of locations of leaks and any structural issues of your dam. You will then allow your dam to sit over night. Take measurements of total water leaked after 24 hours.

RESULTS

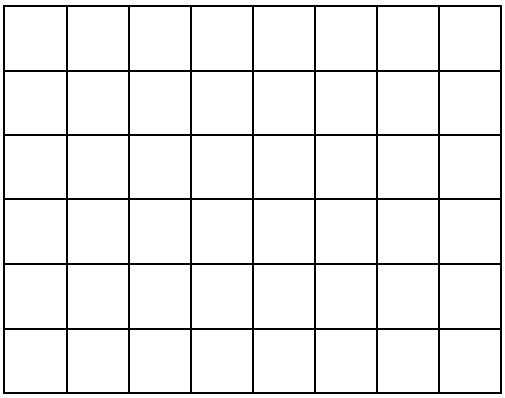
TABLE 1	**Amount of water leaked (mL)**	**% water held back**
Water added at start		n/a
0 minutes	O mL	100%
30 minutes		
24 hours		

Calculate % of water the dam held back after 30 minutes and after 24 hours.

$$\frac{wateradded - waterleaked}{wateradded} x100 = \%$$

List your observations about the dam. Note locations of leaks, areas of weakness, and flaws in the design.

MAKE a graph of your findings about the effectiveness of your dam. Place *amount of water leaked* on the y-axis and *time (0 min, 30 min, 24 hours)* on the x-axis.



CONCLUSIONS

1. What percentage of the water did your dam successfully hold back? _____

2. Do you accept or reject your initial hypothesis? EXPLAIN.

3. Was there a design flaw in your dam? EXPLAIN.

4. On a molecular level, which building material do you believe was the most important for the structure of the dam? EXPLAIN.

5. If you had to redesign your lab, what would you do differently? Why?

6. Make a list of pros and cons about the impacts that could occur to an ecosystem after a dam is built.

7. Assume that the dam has to be built to retain water for human use. What could be done In order to reduce human impact on the local ecosystem? List and explain at least two ideas.

8. If building the dam is necessary for a city to function, does this override the needs of the local ecosystem? EXPLAIN.