Strength of Water

Subject: Science (Earth Science, Environmental Science, Aquatic Science, Physics)

Grade level: 6-8

Rationale or Purpose: While this exercise is applicable to multiple topics, as written here, it addresses the power of groundwater to prevent subsidence. Subsidence of the ground surface occurs water filling pore spaces is removed. Water is not compressible, so the overlying sediment and rock is supported. Removal of the water leaves only air space, which is easily compressed by the overburden. This exercise demonstrates how both water and gas react when pressure is applied.

Materials:

- sheet of aluminum foil (one per class)
- solid metal object (such as scissors; one per class)
- clear plastic soda bottle with lid (one per team)
- glass and rubber eye dropper (one per team)
- water

Lesson Duration: 50 minutes.

Objectives:

- Science 112.22 (1A), demonstrate safe practices during lab investigations
- Science 112.22 (2A), plan and implement investigative procedures
- Science 112.22 (2B), collect data by observing
- Science 112.22 (2C), analyze and interpret information
- Science 112.22 (3A), analyze scientific explanations
- Science 112.22 (3E), connect science concepts with history of science
- Science 112.22 (6A), identify changes in position, motion and speed by force
- Science 112.22 (14B), identify relationships between groundwater and surface water

- Science 112.23 (1A), demonstrate safe practices during lab investigations
- Science 112.23 (2A), plan and implement investigative procedures
- Science 112.23 (2B), collect data by observing
- Science 112.23 (2C), analyze and make inferences from direct and indirect evidence
- Science 112.23 (3A), analyze scientific explanations
- Science 112.23 (3E), connect science concepts with history of science

- Science 112.24 (1A), demonstrate safe practices during lab investigations
- Science 112.24 (2A), plan and implement investigative procedures
- Science 112.24 (2B), collect data by observing
- Science 112.24 (2C), analyze and make inferences from direct and indirect evidence
- Science 112.24 (3A), analyze scientific explanations
- Science 112.24 (3E), connect science concepts with history of science

- Science 112.24 (12C), predict the results of modifying Earth's water cycle
- Science 112.24 (14C), describe how human activities have modified the Earth

Activity:

Step 1: Open discussion with the class on the compressibility of various objects.

1a: Ensure the class understands what compressibility means: the ability to be reduced in volume by squeezing.

1b: Take a sheet of aluminum foil and make a very loosely packed ball. Ask the class if the ball can be compressed; allow a student to try. Now ask the class if the aluminum itself was compressed. Since it wasn't, have the class create a hypothesis regarding how the ball was compressed, but the aluminum wasn't; write the hypothesis on the board.

1c: Take a solid metal object (such as scissors) and ask if this metal can be compressed by anyone in the room; allow them to try. Have the class create a hypothesis regarding the compressibility of metal; write it on the board.

1d: Ask the class if water can be compressed. If the class doesn't agree, take a vote and write the winning hypothesis on the board ("water is compressible" or (water is not compressible").

Step 2: As a class, lead the students through developing a test to see if water is compressible. Students should figure out that they will need a flexible, water-tight container that they can squeeze.

Step 3: Hand out the student direct sheet.

Step 4: Have students record on their sheet which they think is more compressible: water or air.

Step 5: Give each team a soda bottle and lid. Have them record which is more compressible: a bottle with only air inside or a bottle with only water inside. The lid should be on tightly each time the bottle is squeezed. Instruct the students to clean up any spilled water immediately.

Step 6: Give each team an eyedropper. Instruct the students to fill it about 2/3 with water and place in water-filled bottle. The goal is to have the dropper just barely float, so the amount of water in the eyedropper will have to be increased or decreased based on air pressure.

Step 7: Have the students put the lid on the bottle tightly and squeeze. They should record what happens when they squeeze the bottle.

Step 8: Have students complete the question sheet and turn in.

Modification: None.

Student Product: Students will have a completed a question sheet and have produced a Cartesian diver.

Closure: Mention that solids and liquids (such as the metal and water examined in class) are actually slightly compressible, but the change is far too small to be measured in your classroom. Ensure that the class understands how the Cartesian

diver works: the air in the eyedropper is compressed much more easily than water. Therefore, more water enters the eyedropper when the bottle is squeezed. This increases the density of the eyedropper, causing it to sink.

Students should already be familiar with how pumping lowers the level of the water table, but remind them, specifying that pore spaces previously filled with water is later filled only with air because of the pumping. Given the fact that students can compress air with only a single hand, ask the class how much more pressure could be exerted by hundreds of feet of rock overlying the now empty pore spaces in the aquifer. Describe how this subsidence is happening in several major cities around the world, including Houston. Have the students brainstorm on the impacts of subsidence in metropolitan areas, and what can be done to stop/alleviate it.

Assessment or evaluation: Completion of question sheet. Additionally, much of the Closure could be presented as written questions.

Extension: **[optional]**

1. Attach paper clips to the eyedropper and put looped objects in the bottom of the bottle to create a game. Students can race to be the fastest to pick up two objects.
2. Decorate the eyedropper to look like a human diver.
3. After building the Cartesian diver, add salt to the water and put the same diver in the bottom, replace lid, and squeeze. Does the diver behave the same?
4. If eyedroppers are not available, use a pen lid (that has no holes) with modeling clay attached to the stem of the lid. Drop in the water with the clay end at the bottom. You will need to vary to amount of clay to get it to just barely float.
5. Have students research the origin of the Cartesian diver. It is named after the French mathematician and philosopher Rene Descartes, but he never wrote about it. Instead, one of Galileo's students, Raffaelo Maggiotti first described it.

Dennis R. Ruez, Jr.
Environmental Science Institute, The University of Texas at Austin

Name: _____ ***Date:*** _____

Strength of Water

Student Data Sheet

1. Create a hypothesis: which will be more compressible, water or air?

2. Which bottle were you able to squeeze more?

3. What happens when you squeeze the bottle with water and the eyedropper?

4. Which was denser before you squeezed the bottle?

5. Which was denser while you were squeezing the bottle?

6. Given what you know about the relative compressibility of water and air, which is being compressed more: the water in the bottle or the air in the eyedropper?

7. Why did the diver move the way it did when you squeezed the bottle?