Does it Soak Right In?

Students investigate differences in how quickly water soaks into the ground in order to gain an understanding of factors in groundwater recharge.

Level(s): 6-8

Subject(s): Science; Math

Virginia SOLs: Science: 6.1 e,f,h; 6.9 a Math: 6.10; 6.20

Objectives:
Students will be able to:
1. Explain how percolation and runoff are affected by different types of surfaces.

2. Explain the relative benefits of percolation versus runoff.

Materials:
For each student group:
- Student Data Sheet
- 5 cups of water in a jug bottle or bucket
- empty coffee can with both ends removed by a teacher prior to activity
- duct tape
- graduated cylinder or measuring cup
- stopwatch
- ruler
- small mallet (optional)

Estimated Time: two 45-minute sessions

Background Information: *Soils and Drainage*, p.88.

Preparation:
1. Collect the necessary number of coffee cans and cut off both ends. Use duct tape to cover any sharp edges.

2. Select five areas in the schoolyard and/or other accessible area (one for each student group of 4-5 students), each with a different land surface (i.e. grass, mulch, compacted clay soil, loose garden soil, sand, gravel drive) and erect signs identifying each one with a letter or a number. *Note*: concrete surfaces have been left off this list because they are difficult to work with using this procedure.

Activity Procedure:

Session One:

1. Define and discuss *percolation* (and/or *infiltration*) with the class. Ask students to speculate about the relationship between percolation and runoff. Ask students to share examples of surfaces with slow percolation, fast percolation and no percolation. Discuss the advantages of percolation (filter and recharge groundwater for wells, provide water to the roots of plants) versus runoff (carry pollution into bodies of water, cause erosion and flooding).

2. Divide students into groups of 4-5 and give each group a copy of the Student Data Sheet.

3. Read aloud the percolation test directions from the Student Data Sheet, and ensure the students understand the procedure. Help the groups determine which of their members will be responsible for each of the five "Group Jobs." If there are four members in the group, the roles of *Keeper of the Can* and *Observer* can be combined.

4. Write the surfaces of the four testing areas on the board and direct the groups to complete the *Predictions* potion of the *Student Data Sheet*.

5. Take the students outside and show them the four testing areas. Direct each group to start at a different area.

6. Instruct students to complete their tests by following the directions on the Student Data Sheet. Remind them to record their results on the Student Data Sheet.

Session Two:

1. Have each student write a summary of the data collected by his or her group. Direct them to answer the following questions in their summaries:
   - Were their predictions correct? Why, or why not?
   - Which of the surfaces had quick percolation rates? Which had slow rates?
   - Were there any surfaces that did not percolate at all? What is the impact of these types of surfaces on the Chesapeake Bay or other waterways?

2. Ask each group to report orally their results for each land surface tested. Create a class chart to display the reported data. Have students analyze the data on the chart. Ask students to find the average number of seconds it took for each land surface to absorb the water. Have them calculate the mode, medium and range as well.

3. As a class, discuss the results of the percolation tests. Ask the following questions:
   - Which land areas around the school have a high rate of percolation? Which have a low rate? What would you expect the percolation rate of a concrete or asphalt surface to be? How could you measure it using the coffee can method?

- What does the percolation rate tell you about the soil's ability to filter pollutants of water?
- What does the percolation rate tell you about runoff from various surfaces in the schoolyard?

Assessment Opportunities:

1. Have students explain how percolation and runoff are affected by different types of surfaces.

2. Have students explain the relative benefits of percolation versus runoff.

Extensions:

1. Have students create a line or bar graph to display the test results for the group and the class.

2. Use a spreadsheet program to record and report test results.

3. Investigate the design and function of rain gardens. Consider the possibility of designing and creating a rain garden on a low wet spot on your campus.

Additional Reference Material:

Rain Gardens: www.dof.virginia.gov//rfb/rain-gardens.shtml

www.hort.vt.edu/geaton/projects/index.htm

Adapted from **Lessons from the Bay**, Virginia Department of Education

Does It Soak Right In?

Student Data Sheet

Group Jobs

As a group, choose who will be responsible for each task.

Timekeeper: times the water as it soaks into the surface

Name: ____________________________________

Data Recorder: records the result in the Data Chart

Name: ____________________________________

Keeper of the Can: pushes the can into the testing surfaces

Name: ____________________________________

Water Pourer: pours the water (group members assist in measurement of water)

Name: ____________________________________

Observer: observes what happens to the water and leads the group in deciding which data to record.

Name: ____________________________________

Predictions

What do you think will happen with each different land surface?
Write your predictions below:

Surface A: ____________________________________

Surface B: ____________________________________

Surface C: ____________________________________

Surface D: ____________________________________

Surface E: ____________________________________

Percolation Test

Directions:

1. Place the coffee can on the testing surface. Push the can down about ½ inch into the surface of the ground (if possible).

2. Pour 1 cup (240 ml) of water into the can.

3. As soon as all the water is poured into the can, time how long it takes for the water to soak into the surface. Stop timing when all the water has soaked in.

4. Write type of surface and the time in the Data Chart below. *If there is still water above the surface after 5 minutes, stop timing and measure the amount of water left in the can, using your ruler.*

Data Chart

Surface	Time	Amount of water left in can (inches/cm)
A:		
B:		
C:		
D:		
E:		

Soils and Drainage

Soils handle water in two major ways - drainage down through the soil and runoff water across the surface. Soil *drainage* is the rate at which water moves down through the soil. Drainage is influenced by soil texture (percent of sand, silt, clay and humus) and soil structure (arrangement of soil particles). The presence of water, land slopes, impervious subsurface layers, and compacted soil surface can also affect drainage. Soils can be divided into three basic classifications: *sands*, *loams*, and *clays*. There is great variation within these basic groups, but these categories will suffice for the purpose of describing how much water the soil can hold and how quickly water drains through it.

Sandy Soils, referred to as "light" soils, contain large-sized soil particles that are loose and easy to work. Water quickly drains through sandy soils.

Clay Soils are commonly known as "heavy" soils. Consisting of very small, tightly packed soil particles, clays have a high water-holding capacity. On the other hand, if they are compacted, water will run off without infiltrating into the soil.

Loamy Soils are "intermediate" between sands and clays. Composed of many different sized soil particles and humus, they combine fertility and moisture-holding capacity with good drainage.

Soil *pores*, or the spaces between soil particles that are available to hold water, are created by the arrangement of soil particles. A soil made up of particles that are all the same size and shape will have uniform soil pore sizes. For example, a sand soil containing only one size of particles will have one size of pores, and these will fill and empty water all at the same time. A clay soil made up of uniform clay particles will also fill and empty water at the same time, but clay can pull and hold onto water much longer than sand. In general, the smaller the pore, the longer it holds water. Clay can actually hold water so strongly that a grass root cannot absorb it. Sand holds water so weakly that it sinks to deep before a grass plant has a chance to absorb very much.

Water Contamination Experiment

Students perform a demonstration of how pollution can contaminate ground water and the water drawn from a well.

Level(s): 6

Subject(s): Science

Virginia SOLs:

Objectives:
Students will be able to explain how pollution can contaminate the groundwater and the water drawn from a well.

Materials:

- a plastic cup for each student
- 6 inches of nylon net for each student
- a plastic tie for each student
- one eyedropper for every 3 students
- one bottle of vegetable-oil food dye (red, green or blue) for every 3 students
- enough water to fill each student's cup
- enough potting soil to fill each student's cup
- a pencil for each student

Estimated Time: 30-40 minutes

Background Information: *Major Pollutants of Fresh Water*, p.103.

Activity Procedure:
1. Each student should wrap the nylon around their pencil and secure it with a plastic tie.

2. Put the nylon-wrapped pencil in the middle of the cup so it can act as a "well."

3. Carefully place the soil in the cup around the nylon-wrapped pencil

4. Finally, untie the plastic tie and slip the pencil out of the soil (allowing the nylon to remain in the hole) and pour water into the cup.

5. After a few minutes, the water should appear in the opening of the well.

6. Students should remove the water with the eye dropper and see that it is clear in color.

7. After returning the water to the well, students can add a drop of food dye to the surrounding soil to represent contamination. After a few minutes, remove water again with the eyedropper. This time the water should have color in it from the dye.

8. Discuss with the students what kinds of pollution could enter the ground water and end up in well water. Include such pollutants as fertilizers, animal waste, sewage from leaking septic systems, motor oil, and various household products such as cleansers, paint, paint thinner, bleach, weed killer and metal polish. Point out that groundwater also enters nearby streams, rivers, lakes and ponds. Conclude by discussing the proper disposal of hazardous items.

Assessment Opportunities
Have students explain how pollution can contaminate the groundwater and the water drawn from a well.

Drinking Water Activities, p.41

Why Water Pollutes Easily

Students investigate filtration and the causes/sources of pollution.

Level(s): 8

Subject(s): Science, Chemistry

Virginia SOLs: PS.2 b,d; PS.4 c

Objectives:
Students will be able to explain:
1. the difference between a solution and a suspension.
2. one method for removing particles from a suspension.
3. why it is necessary to properly dispose of hazardous household products.

Materials:
- Funnel (or cut the top off a 2-liter plastic bottle)
- Cheesecloth or coffee filter
- Aquarium gravel or sand
- Litmus paper and or pH meter
- White vinegar (acid)
- 2 large beakers (or cut the top off 2-liter plastic bottles)

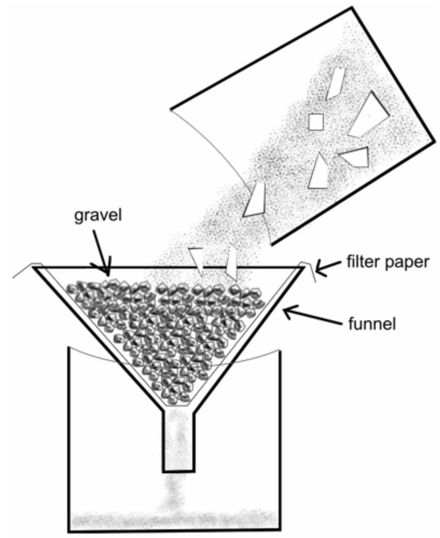
Estimated Time: 45-50 minutes

Background Information: *Water and Drinking Water Quality*, p.72**;** *Acid Rain*, p.82.

Preparation:
1. Collect two 2-liter plastic bottles for each student group and cut off the tops.
2. Cut several sheets of clean white paper into small pieces (or use the litter from a hole punch).

Activity Procedure:
1. Review with the class the properties of water (see background information).
2. Ask: What is the difference between chemicals in solution and chemicals in suspension?
3. Divide the class into groups of 2 or 3 students. Have them put the cheesecloth or coffee filter in place at the bottom of the funnel. Fill the funnel with aquarium gravel or sand.
4. Stir the small pieces of clean paper into a large beaker with 200 ml of water and then add 20 ml of the acid. Demonstrate the presence of the acid using the litmus paper.

5. Pour the mixture of suspended solids and acidic solution through the gravel in the funnel. Drain the mixture into a clean beaker. Observe how the gravel filters out the suspended solid. Tell the students that the aquarium gravel represents the soil or gravel under a landfill.



6. Test the liquid for acid. **Ask**: "Why is the acid still present? Does the water look clear? Is it pure? Would you want a local soft drink bottling plant to use this water in their product?"

   If you use a pH meter, note whether there is any difference between the two readings. (This experiment can be performed by students.)

7. Discuss differences between suspensions and solutions. Point out that suspensions contain larger particles in the water and that these particles can be trapped in the gravel, while chemicals in solution are so small that most are not filtered out by passing through gravel or soil. This is the case for some liquid hazardous wastes if dumped on the ground or poured down storm sewers or into septic tanks and drain fields. For example, some household drain cleaners are far more acidic than the solution in this demonstration.

   Explain that most landfills in the United States do not have liners to keep solutions of household hazardous waste and rainwater from migrating into the soil and the groundwater. (Note: federal laws now require all landfills to have liners and barriers and to meet strict requirements to minimize runoff and groundwater contamination.

8. **Ask**: "What can you do at home to prevent harmful household products from contaminating groundwater?" (*Use less harmful products where possible, buy only the amounts of product that you need to acid storing, use product according to instructions, dispose of containers as indicated on labels.*)

Assessment Opportunities:
Have students explain:
1. the difference between a suspension and a solution.

2. one method for removing particles from a suspension.

3. why it is necessary to use and properly dispose of hazardous household products.

Extensions: do the activity *Pollution in Groundwate*r

Adapted from **Action for a Cleaner Tomorrow,** pp. 498-499.

Pollution in Groundwater

Students perform an experiment that demonstrates how pollution in solution can get into the groundwater after it enters a pond.

Level(s): 8

Subject(s): Science, Chemistry

Virginia SOLs: PS.2 b,d; PS.4

Objectives:
Students will be able to:
1. Explain the connection between surface water and the groundwater.

2. Explain how groundwater can become polluted if hazardous products are poured down household drains.

Materials:
For each student group
- 8 pint jars (4 with tight-fitting lids)
- masking tape
- pencil or marker
- water
- funnel
- 1 tablespoon of cooking oil
- 1 tablespoon of vinegar
- 1 tablespoon of laundry detergent
- I cup of soil
- PH paper
- Chart: *How Clear is the Solution?*

Estimated Time: 45-50 minutes

Background Information: *Groundwater and Aquifers*, p. 96.

Activity Procedure:
1. Discuss with students the fact that the water in groundwater and surface water (such as streams and ponds) intermingles and flows back and forth between the two. Also discuss sources of water pollution including nutrients (nitrogen and phosphorous) from fertilizer, sewage and animal waste, oil and gas residue from roads and parking lots, and household products such as cleansers, paints and solvents that are emptied down drains or otherwise improperly disposed of. Finally, emphasize that while septic systems efficiently clean most waste water, many hazardous household products can flow into the groundwater from a septic system.

2. Divide the students in to groups and instruct them to use masking tape to make a label for each jar as follows: #1A, #2A, #3A, #4A, #1B, #2B, #3B, #4B.

4. Fill the first four jars (series "A") half full of water. Observe the water in jar #1A. Have students describe it on their chart.

5. Put 1 tablespoon of oil in jar #2A, put on the lid tightly and shake it. Have students record their observations.

6. Put 1 tablespoon of vinegar I jar #3A, put on the lid and shake it. Students record their observations.

7. Put 1 tablespoon of detergent in jar #4A, out on the lid and shake it. Record observations.

8. Use the second set of jars to continue this activity. Fill the funnel ¾ full of soil and place it into jar #1B.

9. Pour the contents of jar #1A through the funnel into jar #1B. Record observations.

10. Move the funnel with soil to empty jar #2B. Pour the contents of jar #2A (oil) through he funnel into jar #2B. Record observations.

11. Repeat the steps with jar #3 (vinegar) and #4 (detergent). Record observations. Use pH paper to determine if the soil filtered out the vinegar in jar #3A.

12. Have the class discuss their findings and answer the following questions:
    - If these elements were added to a real pond and seeped into the groundwater, how would it affect the water?
    - How would animals and people be affected?
    - Why did we use the same soil in the experiment?

Assessment Opportunities:
Ask students to explain:
1. the connection between surface water and the groundwater.

2. how groundwater can become polluted if hazardous products are poured down household drains.

Extensions: Do the activity *Groundwater Recharge-Discharge*.

Adapted from **Action for a Cleaner Tomorrow,** pp. 500-501.

How Clear is the Solution?

JAR	OBSERVATIONS
#1A	
#2A	
#3A	
#4A	
#1B	
#2B	
#3B	
#4B	

Groundwater and Aquifers

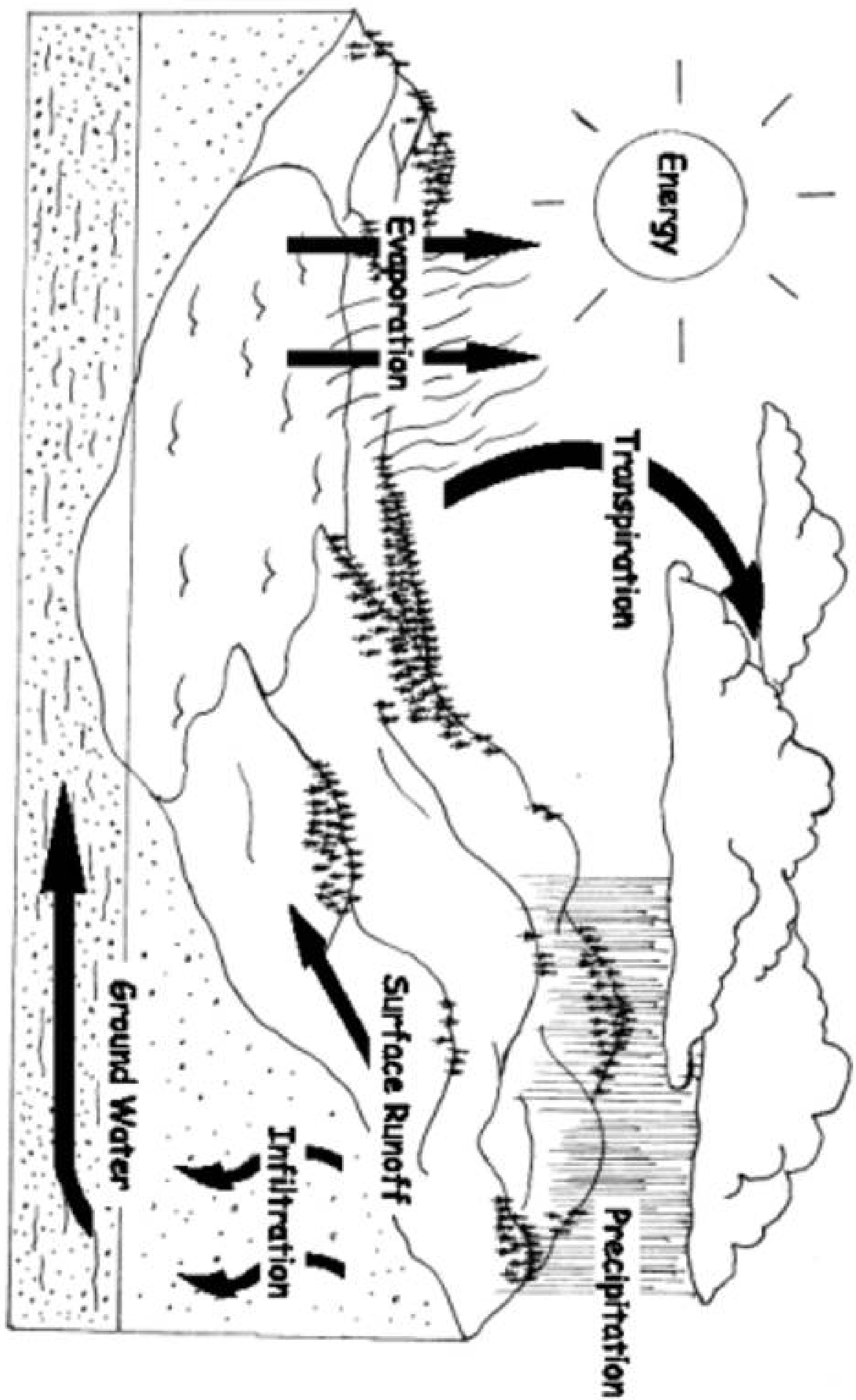
Water stored in spaces (pore spaces) between particles of granular materials (rock and soil) is called *groundwater*. When the pore space is completely saturated, the zone holding the water is called an *aquifer* and the surface of the top of the saturated zone is called the *water table*. Water is added to an aquifer by 1) precipitation percolating downward, 2) water moving horizontally by capillary action, or 3) pressure from water moving from above (infiltration).

If the water table is higher than the adjoining land (such as on a hillside), the water can escape from the aquifer as *springs*. In some areas, fresh-water marshes or lakes develop where surrounding topography holds a water table that is higher than the valley floor. Water continually seeps into the lakes or the marsh. Lakes, rivers and reservoirs obtain some of their water directly from precipitation (rain or snow), but most of the water added to these surface-water sources comes from water infiltrating and percolating from surrounding aquifers.

Water can be obtained from aquifers by pumping it up through holes drilled from ground level down to the water table. These holes are called *wells*. If the surrounding water table is higher than the point where the well is drilled, water may come to the surface under its own pressure. Such a well is called an *artesian* well. Wells drilled during the early days of the settlement of Virginia were quite shallow because less water was being used in those days, and the water table was closer to the surface Today, shallow wells are prone to contamination because pollutants can easily reach the water table.

If the demand for water increases or if insufficient precipitation occurs to recharge the aquifer, the water table is lowered. When the water table drop, shallow wells go dry, and reservoirs, streams and rivers contain less water. In times of extended drought, springs and streams can also dry up and stop running.

The depth of a well depends on the depth of the water table and the structure of the underground soil and rock. Deep wells generally produce purer water. Underground water from deep wells has percolated through greater volumes of rock and soil and thus have been better filtered to remove contaminants. But deeper wells have disadvantages. They require more energy to pump the water, and they produce water that has been in contact with rock for long periods of time. Small amounts of rock dissolve in the water and the water contains more minerals than shallow wells. Hence the water from deep water tables is described as being **hard water**. Hard water requires more soap for washing clothes and dishes. Mineral deposits build up inside water pipes, shortening their usable lives.


Energy
Evaporation
Transpiration
Precipitation
Surface Runoff
Infiltration
Ground Water

Groundwater Recharge-Discharge

Students will set up a model to show how precipitation recharges both groundwater and surface water, and to demonstrate how the two are connected.

Level(s): 6-7

Subject(s): Earth Science

Virginia SOLs: 6.5 b,e; 6.7 c,d; LS.7 a;

Objectives:
Students will be able to:

1. Identify several sources of recharge for groundwater.
2. Identify several sources of discharge for groundwater.
3. Explain how water moves from recharge to discharge areas
4. Discuss the connection between surface water and ground water.

Materials:
For each group of 2 or 3 students:
- a clear plastic container at least 15 cm wide by 22 cm long by 6 cm deep
- sufficient pea-sized gravel to fill the container approximately 2/3 full.
- two 16 oz (472 ml) paper cups
- one pump dispenser for soft-soap or hand-lotion container
- 16 oz of water
- one grease pencil or erasable marker
- colored powdered-drink mix or food coloring
- twigs or small plants to represent trees in the model (optional)

Estimated Time: 45-50 minutes

Background Information: *Groundwater and Aquifers*, p.96.

Preparation:
1. Using an ice pick or awl, punch 8-10 small holes in the bottom of one of the paper cups for each group.
2. Fill the clear containers 2/3 full of pea-sized gravel

Activity Procedure:
1. Divide the class into groups of 2 or 3 students. Provide each group with one clear container filled 2/3 with pea-sized gravel, one 16 oz. cup with holes punched in the

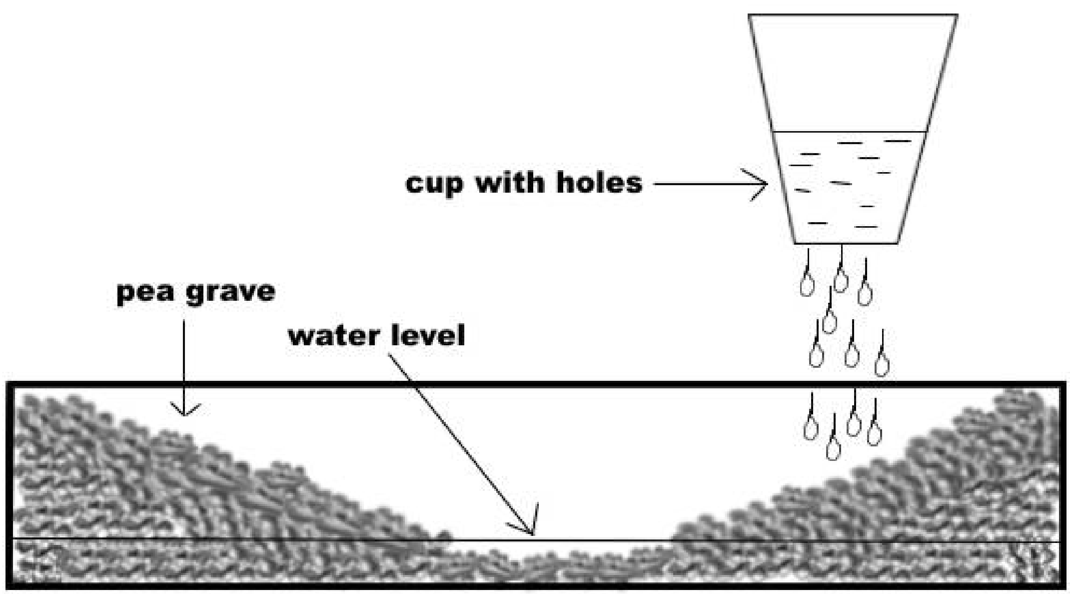
bottom, one 16 oz cup with no holes, and one pump dispenser.

2. Students make models to represent hills and a valley. One student from each group fills the 16 oz cup without holes in the bottom with water. Instruct each group to make a valley in the center of the model by pushing gravel to the farthest opposiet ends of the container so the valley extends completely across the width of the container. About 2 cm of pea-sized gravel remains in the bottom of the valley.

3. Explain to the students that the gravel mounds on both sides of the container represent hills with a valley in between. The students can place twigs and small plants on the hills to represent trees. Have each group choose a student to hold the 16 oz cup with holes over the model. Then add 16 oz of water to the cup. Tell the students that they are simulating rain. Have the students observe how the water infiltrates into the gravel and becomes ground water.

4. Introduce the word ***recharge***, and explain that it means the addition of water to the groundwater system. Observe that water is standing above the gravel in the valley. Have the students use a grease pencil or erasable marker to draw a line identifying the water level in the container. The line should traverse the entire model, identifying the water level under the hills and in the valley. There will be a pond (or river) in the valley.

5. Explain that they have identified the top of the ground water in their model. The top of the ground water is called the ***water table***. Discuss with the students how the ground water becomes a pond in the valley. This is because the water table is higher than the gravel (permeable land surface) in the valley. The bottom of the container represents an impermeable layer above which the groundwater collects.



6. Have the students insert the pump into one of the hills on the side of the valley, pushing the bottom down to the ground water. Allow each of the students to press the pump 20-30 times after the water in the pump has started to flow. Catch the water in the paper cup with no holes in the bottom. After each student takes a turn pumping, instruct them to observe the location of the water table in relation to the grease-pencil line. Where did the water go? What happened to the pond? Discuss ***discharge***: the removal of water from the ground. Discharge can be through water pumped from a well, water that pools above the surface of the land in a pond or stream or can issue forth from the land in the form of a spring. Discuss the effect of ground-water pumping on streams and lakes (and other wells).

Assessment Opportunities:

1. Where does ground water come from? *Answer: precipitation (rain, snow, sleet, etc). Also water can move from a stream or pond into the ground around it to recharge the groundwater.*

2. What would happen in the students' neighborhood (name a local stream or pond) if a well was drilled near the body of water and enough water pumped to lower the water table around the stream or pond? *Answer: Some water from the stream or pond would be removed by the pump through the well and the water level could go down (or even go dry).*

Extension:

Sprinkle colored powered drink mix or food coloring on top of one of the hills and repeat the activity by having it rain on the model. Discuss the movement of pollution from the hill to the groundwater to the lake.

From **Drinking Water Activities of Students, Teachers and Parents**, pp 28-29.