The Groundwater Model

Pre-visit lesson for "Water In, Water Out"

Grade: 5th – 12th Grade
Learning Objective: Students will understand the interactions between surface water and groundwater.
Summary: Students will observe what happens to surface water (creeks and lakes) and the groundwater we use in at least two different scenarios.
Skills: Observation, critical thinking, analysis
Teaching Time: 30 – 40 minutes
Vocabulary: Infiltration, water table, aquifer, confining layer, unconfined layer, artesian, surface water, replenish, saltwater intrusion, drought, and runoff
Materials: Groundwater model and accessories (all provided)

Background Information:
The groundwater model is a wonderful visual tool, showing how groundwater moves through the ground, as well as the relationship between surface water and groundwater. It can also be used to show the effects of nonpoint source water pollution on both surface water and groundwater. A manual can be provided upon request that offers even more activities. What is outlined below is the presentation we do when asked to come into a classroom.

If you would rather have us show you how to use the groundwater model, please call us at (253) 798-2179, or e-mail us at: pcsolidwaste@co.pierce.wa.us.

Procedure:
The groundwater model is quite heavy, so when taking it out of the case or trunk, proceed with care.

Step One:

- Place the model on the two wooden stands located in the accessory bin.
- Remove the styro-foam pads from the top of the model.
- All holes in the sides of the model should be plugged with plastic plugs, and the plug with the surgical tubing (in the accessory bin) should be screwed into the hole in the back of the model (representing the lake).

Step Two:

- Using the two 500-ml plastic bottles, fill the model with water by squeezing water out of the bottles over the top of the model and then tipping the bottles upside down and placing one bottle on each side of the model at the top of the empty columns at the far left and right of the model.
- The columns will fill with water and seep into the model. Fill it until the level is just at the surface, just below the top layer of rock.
- Remove the bottles and refill one of them.

Step Three:

- Select one color of dye (food coloring) and place some into one of the needle-nosed plastic rinse bottles.
- Place the needle-nose into the top of the second well from the left side of the model (not counting the injection wells).
- Squeeze the bottle slowly to have the dye flow out of the bottle and into the well.
- When the dye reaches the bottom of the well, keep squeezing for one more second and then stop.
- Remove the bottle from the top of the well and place the needle-nose in the top of the well that is three from the left side of the lake.
- Fill this well in the same fashion.
- There should be a little dye seeping from the bottom of each well, but not too much.
- If none is seeping out, add a little more dye until a little begins to seep.
- Pour any remaining dye in the needle-nosed bottle back into the container from which you got the dye.
- The dye does not represent pollution, but rather shows which direction the water in the ground will travel.

Step Four:

- Place the plastic tray from the accessory bin behind the groundwater model and under the rubber tubing plugging the hole in the lake.
- From the accessory bin, take out the hand pump with the tubing and plastic flask connected to it and place it within reach. You are now ready for the lesson.

Lesson:

1. Tell the students the groundwater model represents the earth's crust, and that you are viewing a cross-section of the crust down into the earth as much as 800 feet.

   There are many different layers of rock, sand, gravel, and clay, all in different combinations as lava and ice flows at one time or another covered the land in Pierce County.

2. Begin by marking the level at which the water line appears along each well with a vis-a-vis pen, and mark the level of water in the semi-circle, which can be referred to as a creek, and the level of water in the lake.

   Tell the students these lines represent the water table; below these lines all of the spaces in between the rocks and sand particles are filled with water. Above these lines, there may be water in the soil, but air exists in the spaces as well.

3. Ask the students what "confined" and "unconfined" mean?

   Confined means something has to remain where it is, possibly in a tight, cramped spot.

   Unconfined means something is free to move about.

   Water in the unconfined aquifer (the upper portion of the groundwater model, but below the water table) slowly moves through the ground.

   In Pierce County, water in the unconfined aquifer moves, on average about three feet per day. Water in the confined aquifer does not move; it is trapped by the confining layer of clay above. (You may want to draw a line with the vis-a-vis pen along the top of the confining clay layer as it is sometimes hard to see the difference in color between the clay and the sand above.) Over the long history of the earth, water has slowly made its way below the clay layer. Pressure has built over time as more and more water became trapped below the confining layer of clay.

4. Ask the students what would happen to this water that is under pressure if we gave it an opportunity to escape, say if we sunk a pipe into it?

   If the pressure was great enough, water would rise to the surface of the earth, being pushed or forced out from the pressure it is under.

   This is kind of the same as when you shake up a can of soda pop and then give it an opportunity to escape by opening it. This is what is meant by the term "artesian."

   Artesian doesn't mean "fresh" or "clean" as some bottled water advertisements would lead you to believe; it means "under pressure," and if you give it an outlet, that pressure may cause it to come to the surface of the earth.

   So, artesian wells are ones that do not need any pumps to bring the water to the surface because they tap into confined aquifers, aquifers that are under pressure. (FYI, artesian wells are named for the former province of Artois in France, when the first artesian well was drilled by Carthusian monks in 1126.)

5. Pipes, or wells, that are sunk into the unconfined aquifer <u>do</u> need pumps. Tell the students that is what they are going to do now: pump out some water.

Scenario One: Irrigating your Crop

1. Ask your students to be "farmers," and ask them what they would like to grow on their farms. This might be a good time to brainstorm the kinds of fruits and vegetables that can grow in the climate of Pierce County (*apples, berries, pumpkins, potatoes, carrots, corn, lettuce, peas, and many others).* When they've chosen something, tell them it is time to water their crops.

2. Chose one student to come up and do the pumping.
   - Place the nozzle at the end of the tube connected to the plastic flask into the top of the first pumping well (it is between the two wells you have put dye into, goes only halfway down into the model, and has a small rectangular box at the bottom).
   - Have the student begin to pump the hand pump. You'll have to hold the nozzle in the top of the well to make a good seal.
   - Water should begin to travel up the tubing and into the plastic flask.
   - The student should not have to pump too hard – maybe once per second.
   - Tell the students, "You can see that water is being pumped from the ground and into the fields, which is represented by the plastic flask.
   - The flask could also represent a home, a school, or a business; anywhere water is used every day, because here in Pierce County, almost all of the water we use comes from groundwater. The water is pumped out of the ground from wells (or of its own accord if it is an artesian well) and used for many purposes."

3. Have another student pump if you wish, but what you want to do is keep an eye on the dye moving in the model towards the bottom of the well being pumped. Make sure it is clear the dye is moving in that direction and ask, "What is happening to our dye?"

   It is moving toward the bottom of the well being pumped.

   Explain that even though water is being removed only from directly below the well being pumped, it starts a chain reaction as water moves to replenish the water pumped out, and it affects the water that could be a great distance away.

If you wish, you may have another student or two pump from the lower pumping well (the one that goes into the confined aquifer and has a rectangular box at the bottom) by putting the nozzle at the end of the tube connected to the plastic flask into the top of the well, and watch as the dye turns to start heading lower into the model towards the bottom of the lower well as it is being pumped. "Of course, if it were truly a confined aquifer, we would not need to pump the water; it would come to the surface by itself due to the fact it is under pressure."

4. Now have them focus their attention on the half-circle which represents a creek. It will most likely be half full or even empty. "What happened?"

   Water drained from the creek to also help replenish the water being pumped out.

   So water moves in the ground to help replenish groundwater that has been pumped out, but surface water, that is, water that can be seen on the surface of the earth like wetlands and ponds and creeks, soaks down into the earth to help replenish the water that has been pumped out as well.

Scenario Two: Swimming at the Lake

Take the 500-ml bottle filled with water and begin to squeeze out water over the top of the model and ask the students, as you are doing so, what this represents.

Rain. Stop when the model has the same amount of water in it as when you started (the water is again at the line you drew across for the level of the lake).

1. Have the students focus their attention on the lake. Say something like, "Pretend it is the end of the school year, and to celebrate, you decide to go swimming at a nearby lake." (Have the students give the name of a local swimming lake.)

2. As you say the next part:
   - Undo the clip on the rubber tubing on the back drain of the lake so water drains out of the lake into the plastic tray.
   - Allow the lake to drain out until the level is in the smaller, bottom part of the lake.
   - Pinch the clip so it squeezes the tubing to stop the water from draining out.
   - "But we've been having a drought and unusually high temperatures for about a month, so that when your friends and you get to the lake, you all notice the level of the lake is way down."

- (After you stop the
- water from draining out, mark the lake level where it is now quickly.)
- "Well, there is still plenty of water in the lake, so your friends and you jump in and splash around all day and have a great time, and then you pack up and go home.

3. "July 4th goes by, the summer is moving on, but we still haven't had any rain, so now it's been two months since we've had any rain. And even though it hasn't been as hot, we're still having a drought.

   So you think, 'Hey, we had such a good time swimming in the lake last month, let's do it again!' You call up all your friends and they say, 'Yeah, what a great idea!'

   So you meet at the lake again, but when you all get there, you notice the level of the lake is a lot higher than it was last month when you all went swimming." (Mark where the level of the lake is now.)

   "How can this be? It hasn't rained for two months? Where did the water come from?"

   Water from the ground moved in to replenish the water that had evaporated from the lake.

   "So we see there is a relationship between surface water and groundwater – sometimes surface water, that is, creeks, rivers, lakes, wetlands, and ponds replenish groundwater, and sometimes groundwater replenishes surface waters."

4. If you have time, and especially if you are located near Puget Sound, you may want to talk about saltwater intrusion (the infiltration of salt water into wells and drinking water).

   You should not pump any water out of the groundwater model unless you pump from the pumping wells.

   But you can have the students imagine if their wells were the ones near the sides of the model, and the reservoirs at the sides of the model were Puget Sound, based upon what they have learned about water a distance from a well moving to replace the water being pumped out, do they think water from Puget Sound might move in to replace the pumped-out water?

   Yes.

   And indeed, this is happening to a number of wells located near Puget Sound. The people getting water from these wells must install and frequently replace filters to filter out the salt in the water.

To clean-up:

- The first thing to do is get any remaining dye out of the wells into which you put the dye. Students will want to help and it goes pretty fast.
- Pump out the dye into the plastic flask and then empty the contents of the flask.
- If the model is not already next to a sink, take the model to a sink with a drain board and remove the wooden stand on the right-hand side of the model so that it tips to the right.
- Place the right edge of the model over the sink and remove the bottom plug on that side so that any water remaining in the model will drain out.
- When the water is drained out, replace the plug in the side of the model, remove the plug with the rubber tubing from the back, and put the styro-foam pads in the proper places on the top of the model.
- Place the model back in the case with one small, rectangular styro-foam piece on each side and the big styro-foam pad on top.
- All of the other accessory parts can be placed in the accessory bin.

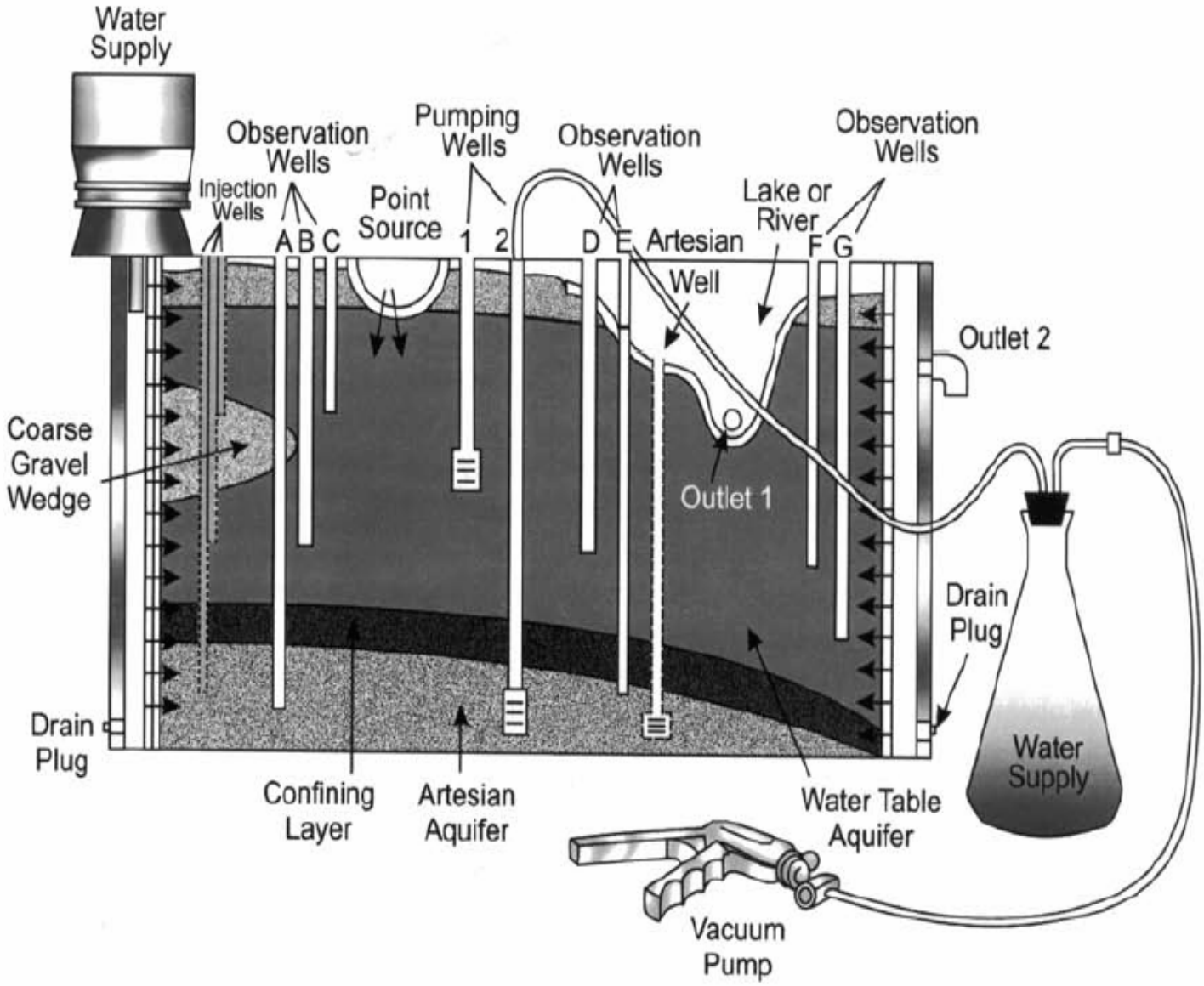

Figure 1 Components of the Model

Note: Do not use the injection wells. Liquid placed in the wells takes too long to disperse.