HYDROGEOLOGY MODELS INVESTIGATION: Design and Test a System

Investigative Question: What is the best system to reduce runoff and increase recharge?

Goal: Students will design and test a system to reduce surface water runoff, flooding, and erosion.

Objectives:
Knowledge: Student will understand surface types are part of a landscape and drainage systems and how a well-built system can reduce negative land use impacts such as runoff and erosion.
Key Concepts & Skills: Students will work in groups to create a hydrogeology system to demonstrate how the ground surface of the earth can impact the flow of water and accompanying soil erosion. Students will demonstrate following directions, using measuring tools, use evidence to support reasoning.
Value: Students understand how the landscape can affect water runoff and recharge. Students will consider effect of humans on land use change and that humans can mitigate negative effects through careful planning and land use design.

Virginia SOL: Science (2018): 6.1, 6.6, 6.8, 6.9. Mathematics (2016): 6.2 (extension to 6.1, 6.3, 6.9, 6.14, 6.15, 6.16)

Materials
- ◊ Hydrogeology model tanks: soil, concrete, grass, native plants (1 set/group)
- ◊ Measuring beakers (1000 ml; 3/group)
    - ▪ One labeled with a blue recharge, 2 with red runoff
- ◊ Graduated cylinders (1000 ml; 1/group)
- ◊ Water buckets (5 gallon) with a beaker in each
- ◊ Garden watering cans (1/group)
- ◊ Laminated photos of the 4 models (1 set/group)
- ◊ Laminated scenario card (5 scenarios; 1 scenario/student team) + one extra
- ◊ Data sheets (1/student team)
- ◊ Adult datasheets (1 per student team) and instructions

Special Safety: Adult chaperones or the teacher should be the ones moving hydro models.

Blandy Background Information
Blandy Experimental Farm serves many purposes, one of which is as a nature preserve. The buildings and offices are dependent upon groundwater; thus, their water source must be protected. There is no other water source available; so, when Blandy builds structures or changes the landscape, Blandy must design systems to ensure that (1) the underground water supply can be replenished when it rains and (2) the existing wetlands (Lake Georgette, Rattlesnake Spring, and Lake Arnold) are not polluted with excessive soil erosion during storm water events.

Hydro model Background information
There are 4 common ground surfaces that the students will investigate. Here is a description of each surface and how it typically interacts with rainwater.

Concrete
Concrete is a non-porous surface; thus, little to no water is absorbed. The majority of the rain (if not all) simply runs off the surface. If concrete is not graded properly so that the water is directed off the concrete, puddles or pools of water will form. Over time, this puddling will break down the concrete and cause cracks and erosion.

Soil
Most students anticipate that the soil will absorb and recharge the most water. In reality, the results from the soil tanks will be similar to that of concrete with one exception. The runoff water will erode the soil. The water from the soil runoff tube should look dark brown and muddy. The soil in our area is mostly clay and will compact over time. This makes it difficult for water to percolate through the soil. The top layer of soil may become muddy, but the water will mainly penetrate only the subsurface of the tank; little, if any, water will percolate through the soil to recharge the groundwater supply.

Grass
Grass should have a mixture of both runoff water and groundwater recharge (used for well water). Grass is a carpet plant that grows thick root systems. The blades of grass intercept precipitation and cause the rain drops to break into smaller droplets; the blades also reduce the velocity of the raindrops allowing more time for the water to infiltrate the soil rather than quickly flowing off the surface. While the grass root systems help to break up the soil, the interweaving of the roots make it slightly more difficult for the water to penetrate through the entire tank. Think about what the surface looks like to a water droplet. The grass will appear like a dense forest of obstacles for runoff, so the water can stay long enough to penetrate the soil. However, once the water goes into the soil, it is trapped again by the root system; some of this water will percolate into the groundwater system, though. Both the runoff and recharge water should appear fairly clean. This is because the root system holds onto the soil particles and prevents erosion.

Native Plants *Caltha palustrius* Marsh marigold (Ranunculaceae)
Native plants should produce the most groundwater recharge. This is due to its well-developed root system. Then, the root system breaks up the soil and creates channels for the water to pass down on it's way to the groundwater system. In addition, the water coming out of the tank should be fairly clean when compared to the soil. This is because the root system holds onto the soil and prevents erosion. The leaves of the native plants also intercept precipitation, reducing both the size and the velocity of the raindrops. This physical process promotes groundwater recharge and reduces runoff erosion.

Procedure

1. Inquiry Discussion
   a. Students have already worked with the hydro models prior to their visit to Blandy Experimental Farm. Engage students by asking what their prior knowledge of these models is and how they work.
      i. Ask students what is a model?
      ii. Why is a model important? How can a model help when building an education center?
      iii. What does each of these models represent? (what are the models made of)
      iv. What do the red and blue pipes of the models represent? (red- runoff, blue- recharge or ground water)
      v. What happened when we pour water on each of the hydro models?
      vi. Remind students that they worked with the models in their classrooms. Now they will take that knowledge from that activity to build a system. Ask students what is a system. Why are systems important?
   b. Tell students that they each have a scenario on their table along with pictures of the four hydro models. Each group needs to read their scenario (a problem) and design a system/solution that will reduce runoff and increase groundwater recharge.
   c. Students may need an example. Feel free to use the bus parking lot as an example as to how they should arrange the pictures and record their information.
   d. The bus parking lot will be paved. Using your knowledge of how water runs on pavement/concrete, what problems may arise when that area is paved? (This is a good example for students since they observed this area when they got off the buses.)
   e. Instruct students to read through their scenario and come up with possible systems to solve the problem. The goal is to use these model surfaces together to design a system where the majority of the water ends up either as groundwater recharge or as clean runoff water that would ultimately end up in our rivers and streams. **NOTE: Some scenarios will not need to use all 4 ground surfaces.**
   f. While students are working with their scenarios, ask chaperones/parents/ teachers to take a look at their datasheet and instructions. Guide them to the highlighted points on the datasheet. These are most important.

<u>Emphasize proper model use</u>.

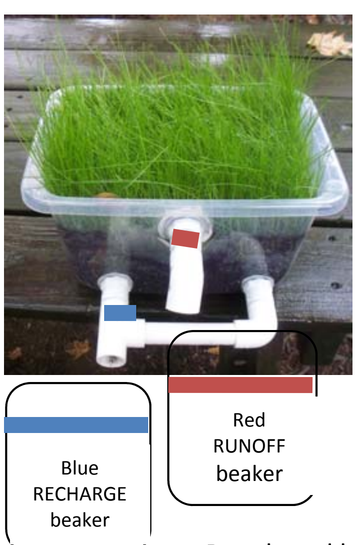
1. **Instruct students NOT to wiggle the water out-flow pipes.** Wiggling the pipe will break the silicon seal and cause more water to flow out than designed.
2. Also **instruct students NOT to tip the models to get more water to flow out of them**. We can't tip the earth; thus, we should not tip the models. The point is not to get the most water out of each pipe but to observe how the various surfaces impact surface water runoff and groundwater recharge.
3. **Do NOT permit students to move the models.** Only teachers and chaperones should move the models as they need to be handled carefully.
4. Once parents and chaperones place the models into the order of the system, groups may begin their experiment.

g. Before moving to next step, instruct students to have all information recorded in their journal and an 'OK' from staff before next steps.

2. Experiment:
   a) 1000 mL of water is measured and is poured in the watering can. This needs to be "rained" onto the first model.
   b) Capture recharge (blue pipe) in a blue container. *you may elect a student to always be the recharge person.
   c) Capture runoff (red pipe) in a red container. *multiple students can take turns capturing and pouring the runoff.
   d) SAVE recharge (blue pipe/container) in a blue container to the side. All recharge will be collected and measured at the end.
   e) Pour captured runoff (red pipe) into the next model in the series. (Be sure a blue recharge container and red runoff container are in place to capture outflow before pouring)
   f) Repeat steps b-e for all models in the system, or until there is no runoff [illegible] to the next model.
   g) Record the total saved blue recharge on student and adult data sheets. Record any red runoff from the final model on student and adult data sheets.
   h) Students *may* choose to redesign their system after the first trial. If so, the redesign and reasoning need to be recorded on their datasheets.
   i) Attempt for a total of 2-3 trials of the system (steps 1-7).
   j) Please remember to ask chaperones and teachers to fill out their own data sheet.

Remember:
- Red Runoff is poured to the next model.
- Blue Recharge gets saved to the side!

3. Conclusion: Ask students to reflect.
   a. Did the system they build reduce runoff and increase groundwater?
   b. What were some challenges?
   c. What do we need to consider when building a new building? Can you think of examples of a system that worked well or failed in their neighborhood?



Hydrogeology System Design and Experiment
Student Data Sheet

Scenario #:________________

Design:
Draw and label your system design here. Use arrows to show the flow of water.

Predict:
How will your system design help solve the problem in your scenario?

Test
Record the amount of water flowing from the pipes.

	TOTAL Amount of RUNOFF (mL)	TOTAL Amount of GROUND WATER RECHARGE (mL)
TRIAL 1		

Record what the water looked like flowing from the pipes.

	Water Color/Can you see through it?	Water Dirtiness (particles in the water?)
TRIAL 1		

Check:
Did your system solve the problem for your scenario? What worked, what didn't?

Redesign.

Engineers often redesign a system after they test it if the system did not solve the problem they had. After your system test you may have another idea for how to solve the problem. If your system worked well the first time, it is always good to run a second or third trial.

Draw and label your redesign.

Predict:

How will your system redesign help solve the problem in your scenario?

Test.

Record the amount of water flowing from the pipes.

	TOTAL Amount of RUNOFF (mL)	TOTAL Amount of RECHARGE (mL)
Trial 1		
Trial 2		
Trial 3		

Record what the water looked like flowing from the pipes.

	Water Color/Can you see through it?	Water Dirtiness (particles in the water?)
Trial 1		
Trial 2		
Trial 3		

You will write a recommendation on how to solve the problem back in your class at school. You will need to use this evidence to support your solution!