FLOW-THROUGH ANALOG GROUNDWATER MODELS:
LESSON PLANS AND ACTIVITIES FOR TEACHERS

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This project's intent is to provide teachers and other instructors the materials they need to easily and effectively help their students learn about groundwater, particularly groundwater on Long Island. In addition to two models, instructors will receive additional materials to facilitate the greatest amount of learning with a minimum of time effort for the instructor.

Two flow-through Plexiglas models which simulate groundwater behavior are available to borrow from the Department of Earth and Space Science at SUNY Stony Brook. The Eastern Model is the larger of the two and most closely approximates groundwater movement in aquifers in eastern Long Island (Figs. 1 & 3). The Central Model is more analogous to a cross section near the Nassau-Suffolk border (Figs. 2 & 3). The models are simple and safe to use; the only chemicals used while running the models are water and food dye.

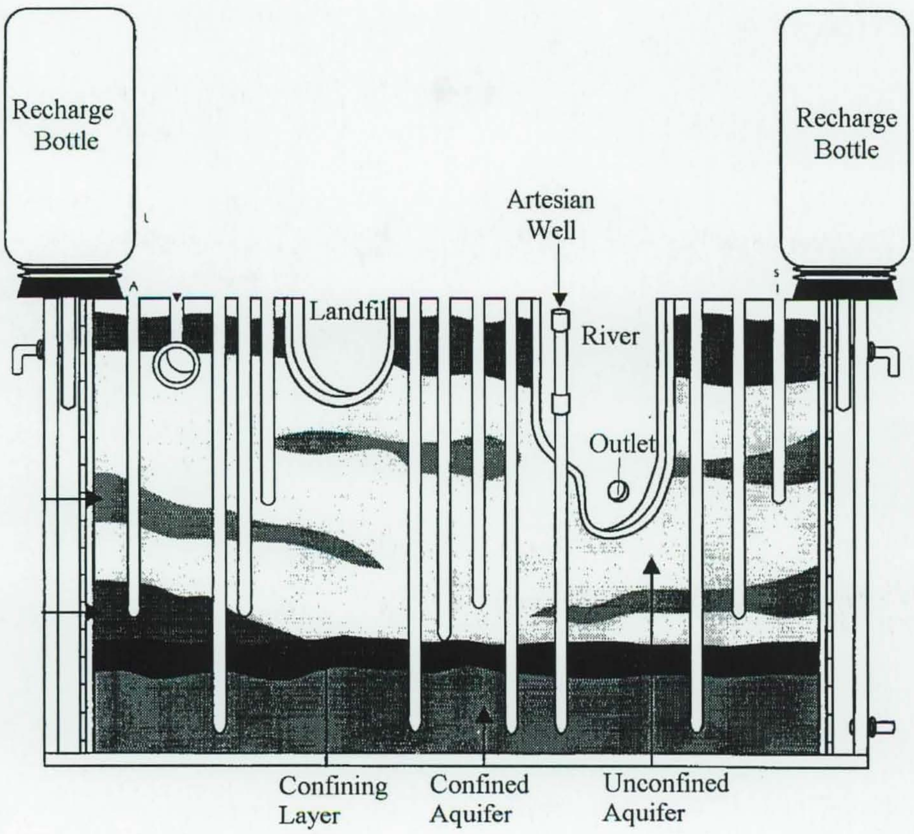

Fig. 1. The Eastern Model

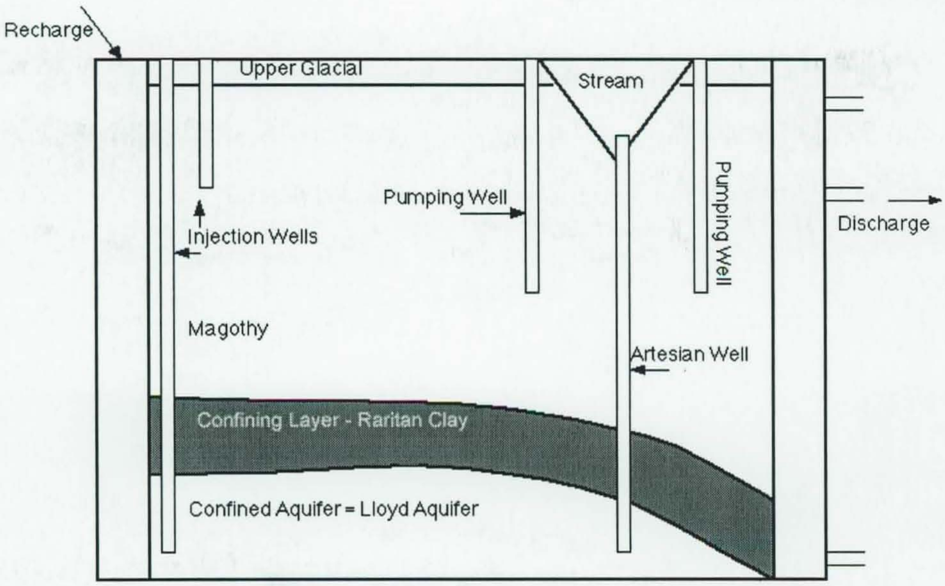

Fig. 2. The Central Model

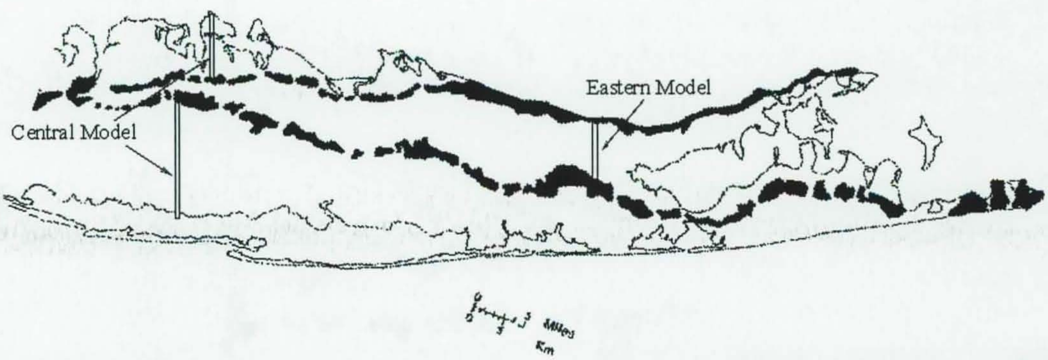

Fig. 3. Areas which the models most closely approximate.

Both Models can demonstrate the following concepts (Fig. 4):

- Movement of groundwater.
- Movement of pollutants in aquifers
- Water table.
- Potentiometric surface.
- Artesian wells.
- Drawdown and cone of depression.
- Recharge and discharge.
- Confined and unconfined aquifers and confining layers.
- Long Island aquifers.

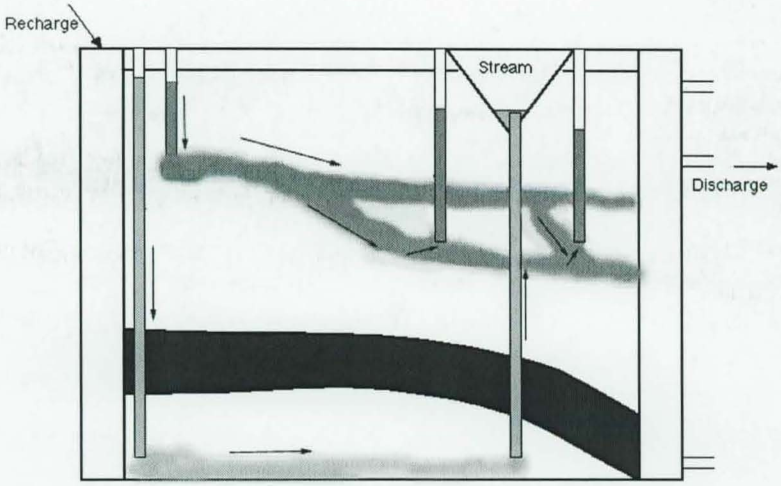

Fig. 4. The Central Model demonstrating some groundwater concepts with dye injected into the two leftmost wells.

The models are accompanied by a user's manual and a video. The manual contains instruction for use of the models, background information on Long Island groundwater and groundwater in general, lesson plans for elementary and secondary level classes, additional activities and labs, overheads, and a list of additional resources. The video is divided into two parts, and is approximately twenty minutes long. The first half of the video consists of a demonstration of how to operate the models and is intended for instructors. The second half of the video consists of a short demonstration of groundwater concepts. It can be used not only by instructors, but also in classrooms to supplement other activities and demonstrations.

Lesson plans, examples of which are included here, are organized in a traditional format. However, the activities are presented in both constructivist formats and more traditional formats. This was done for two reasons. First, some instructors are uncomfortable with constructivist structuring of activities and prefer more directed activities. Second, even teachers who are comfortable with learner-directed inquiry may not have much of confidence with groundwater concepts. The more traditionally formatted activities can then be used by the instructor to guide questioning, assessment, and student inquiry.

Most of the activities included with the Models are suitable for learners of all levels; they contain multiple entry and exit points, as well as multiple solutions and solution paths. Although suited to any classroom, the flexibility of the activities enables the activities to accommodate different learning rates and makes them particularly useful in classrooms which include special-education students and non-English speakers.

Two sample lesson plans and one activity, presented in constructivist format, are included in this abstract. It is intended that all the lesson plans, activities, and some short demonstrations will be available on the World Wide Web sometime in the future. To borrow the models after April 19, 1997, please contact Glenn Richard, the Education Specialist in the Department of Earth and Space Science at Stony Brook. His phone number is (516)632-8336, and his email is richard@sbmp04.ess.sunysb.edu.

Middle School and Secondary Porosity and Permeability Activity

Major Objective: Students will understand properties of aquifer materials that are relevant to water flow.
Enabling Objective: Students will determine the porosity and permeability of samples, and relate how they are important to groundwater.
Statement: What are the porosities and permeabilities of certain sediments?
Materials

For each group of students)

- 3 one-liter soda bottles, with bottoms cut off and screens in caps.
- 300 - 500 ml each of gravel, coarse sand and fine sand (not measured exactly).
- Stopwatch (or a watch/clock with second hand)
- 1 500 or 1000 ml beaker
- 3 250 - 500 ml beakers
- graduated cylinder (at least 100 ml)
- china marker
- ring stands or clamp stands to hold upside-down bottles
- graph paper

For entire class

- Eastern Model
- Central Model

Vocabulary:

Porosity	Rate	Error
Permeability	Variable	Grain size

Procedure

1. Using the two models, demonstrate how water moves through the sediments of the aquifers.
   a) Using the Eastern Model, inject dye simultaneously into the well in the coarse wedge and the well to the left which is in the finer sand. The dye will move much more rapidly through the coarser materials. You can quantify this by measuring off 5cm or 2" from each of these wells before injecting, then timing how long it takes for the dye to move through the two different materials.
   b) Using the Central Model, inject dye into any well. The dye will move rapidly through the areas at the bases of the wells which are filled with gravel, then slowly through the rest of the aquifer.
2. Take some time to question students as to why this is so.
3. Ask students if there is a way to determine the permeability of a material in a more precise way.
4. Distribute activity sheet(s) and materials.
   a) Constructivist: Allow students to develop their own experiments, gather their own data and present it in the most meaningful way for them. After, ask them and other students to critique their methods, assumptions, and how they presented their data. Look at some of the questions presented at the end of the directed activity for more ideas for oral assessment.
   b) Directed: Have students perform experiment. Ask them to present their data.
5. If time permits, allow students to re-perform the experiment, incorporating a column of mixed sediments, if possible.
6. Have students determine the permeabilities of the sediments by water displacement.
7. Students should then relate this to the porosity values they obtained.

Additional Information: After students are done with this activity, have them keep the sediments separate. Place them in the buckets they came in to dry.

Additional Questions:

1. Which do you think is most effective for showing that the sediments have different permeabilities, tables, histograms, or line graphs? Why?
2. What did you use to represent permeability, the average time or the rate of flow? Why?
3. Should Trial 1 be included in the calculation of the average flow rate? Why or why not? How does your average change when you exclude them? What does this do to the flow rate?
4. What are the error sources in this experiment?
5. What are the variables in this experiment? Are they independent or dependent? What other variables might you study in this experiment?
6. What implications do porosity and permeabilities have for aquifers, and in particular, residence time, recharge rate, and the movement of water and pollutants?

Elementary Activity to show how sand can act as a filter in aquifers.

Major Objective: Students will understand how the materials in an aquifer can filter out many contaminants.

Enabling Objective: Students will be able to demonstrated and explain how sand can help clean dirty water.

Statement: What does an aquifer do to dirty water?

Materials:

For each group of students or for demonstration:
Tall column of 2-liter soda bottles.
Fine sand.
Muddy water (add soil to water if necessary)
2 1000 ml beakers or 1-2 quart pitchers.
A stand or clamp to hold the coda bottle column upright.

Vocabulary:

Aquifer Pollution Dissolved Filter Particles

Procedure:

1. Fill soda bottle column with 1-3 feet of sand.
2. Pour dirty water (you may want to measure the volume of the water, to see if it all comes out).
3. Observe and compare the appearance of the water before and after passing through the sand. It will be cleaner.

Additional Information:

Point out that the sand is filtering out particulate matter, not necessarily things that are dissolved in the water. Point out that not all pollution is particulate in nature; in fact, many of the more dangerous contaminants in groundwater can travel great distances before being diluted to safe levels (they don't just disappear).

Two ways to show this:

1. Place concentrated food dye in a liter of water, run it through the column.
2. Take concentrated salty water and pour it through. Don't allow students to taste it, though (for health reasons, as the sand you are provided with is used by classes from all over Long Island over and over). Place a few drops of the 'filtered' water on a slide or watchglass and wait for the water to evaporate, leaving some salt behind.

Questions:

1. What happened?
2. Can you tell me how the sand is making the water cleaner?
3. How can we use this idea in real life?
4. Is there a way we can see how much cleaner the water is?

In your group:

Using the materials and tools provided and the diagram below, design and perform and experiment that will accurately measure the flow rate of water through the different sediments.

Procedure:

1. Design and perform your experiment.
2. Present your data and methodology.
3. Critique your method.