9-12

SUBJECTS:

Science (Physical Science), Social Studies (Economics, Political Science)

TIME:

1 class period

MATERIALS:

Copies of background information Student sheets

OBJECTIVES

The student will do the following:

- 1. Determine the directions of groundwater flow using flow nets.
- 2. Apply the concept of pressure head and groundwater flow conditions to solve several logistical problems.

BACKGROUND INFORMATION

Flow nets provide a general knowledge of the regional groundwater flow patterns that the hydrologist can use to determine such information as areas of recharge and discharge. Freeze and Cherry (1979, pg. 168) have stated that flow nets are an important concept of hydrology. They state, "The proper construction of flow nets is one of the most powerful analytical tools used by the hydrologist to analyze groundwater flow."

In water table aquifers, groundwater behaves much like surface water in its patterns of flow. For instance, the water table surface, in porous media such as sand and gravel, generally follows the topography of the land (Figure 1a). Similar to surface water flowing from the top of a hill down into a stream valley, groundwater flows from the groundwater divide to the lower elevation and may discharge into the stream valley as a spring.

Figure 1a

The surface of the water table is referred to as potentiometric surface because it represents the elevation (or total head) of the groundwater and can be defined by water levels in wells. The potentiometric surface is represented on a map by a series of contour lines (equipotential lines) that connect points of similar head in an aquifer (Figure 1b). These lines and surfaces are similar to the land surface and the contour lines represented on a topographic map. Once the potentiometric surface has been defined by the equipotential lines, the groundwater flow direction can be determined. Groundwater flows perpendicularly to equipotential lines and from the higher to the lower head.

Reading: Xeroxed attachment from Driscoll, 1987, pages 79-81.

Figure 1b

Terms

discharge area:

an area where groundwater flowing toward the surface escapes as a spring, seep, or baseflow or by evaporation and transpiration

equipotential line:

a line in a two-dimensional groundwater flow field such that the total hydraulic head is the same for all points along the line

flow line:

the line of flow of groundwater

flow net:

the set of intersecting equipotential lines and flow lines representing twodimensional steady flow through porous media

groundwater divide:

a crest of the water table with flow going in opposite directions on either side

homogeneous:

(1) uniform throughout in structure or make-up (for a substance or material); (2) of the same or similar nature or kind (for a group)

hydraulic head:

the height of the free surface of a body of water above a given subsurface point; the sum of elevation, pressure, and velocity components at a given point in an aquifer

infiltration:

the flow of water downward from the land surface into and through the upper soil layers

isotropic:

having physical properties, such as conductivity and elasticity, that are the same regardless of the direction of measurement

potentiometric surface:

a surface that represents the level where water will rise in a tightly cased well. The

water table is the potentiometric surface for an unconfined aquifer.

recharge area:

an area where infiltration moves downward into an aquifer

unconfined aquifer:

an aquifer containing unpressurized groundwater having an impermeable layer below but not above it

water table:

upper surface of the zone of saturation of groundwater

water-table aquifer:

an unconfined aquifer

PROCEDURE

I. Setting the stage

- A. Copy the Background Information and Student Sheet for students.
- B. Make transparencies of figures in Background Information.

II. Activity

A. From the potentiometric surface map shown in the Student Sheet, have students sketch the path of water movement for groundwater that originates at the circled 800 in the upper left hand corner of the map. Assume the aquifer is homogeneous and isotropic. (Figure and exercise for IRIS Groundwater Hydrology Program, Regional Flow Course I, Module B- Lesson 2.) The student should use straight edges with right angle to make his/her flow lines perpendicular to the equipotential lines.

B. In class discussion, ask the students these questions.

1. Where is the groundwater flowing according to your constructed flow lines?

Answer: They should show that groundwater from the 800 line splits and flows towards the cities of Waukesha and Milwaukee.

2. What could create the closed loop configuration of the equipotential lines Around Milwaukee and Waukesha?

Answer: City wells and their constant pumping created a bowl shape

from pulling water down toward wells.

3. If the cities of Milwaukee and Waukesha turned off all the pumps in their public water supplies, what would happen to the potentiometric surface? To what point would the groundwater be flowing?

Answer: The surface would eventually flatten out, and the equipotential lines would become straight and almost parallel to the shore of Lake Michigan. Groundwater would be flowing towards Lake Michigan. (This question shows how an aquifer can be affected by a high volume of withdrawal from pumps in the water supply wells. The volume extracted can change the configuration of the potentiometric surface.)

III. Follow-up

- A. Have students research the source of their community's water supply. Have them call or write to the city water board or authority to find out specifics about their aquifer (if groundwater is the source).
- B. Invite someone from the local water system to speak to the class if groundwater is used, and/or schedule trip to a well field.

IV. Extensions

If your area uses groundwater in any capacity, get potentiometric surface maps in the area. The local or state environmental or geological agencies may have access to these. Complete the same exercise with these maps.

RESOURCES

Freeze, R. A. and Cherry, J. A., Groundwater, Prentice-Hall, Inc., 1979, p. 604.