University of Arizona
Department of Hydrology and Water Resources
Dr. Marek Zreda

HWR431/531 - Hydrogeology
Test 2 - two hours
12 December 1997
(open books and notes)

The test contains 7 problems on 7 pages.

Problem 1. (10 points, 2 points each)

Circle the best answer. Justify your answer either by stating why it is best or by stating why other answers are incorrect.

(a) The ratio of external to internal kinetic energy of molecules is called
- (1) the Peclet number
- (2) the Reynolds number
- (3) the Stokes number
- (4) none of the above

(b) A contaminant plume moves in a uniform flow system. The contaminant concentration
- (1) always decreases
- (2) always increases
- (3) stays constant
- (4) decreases or increases depending on the specific discharge
- (5) none of the above

(c) In a groundwater system with CaCO3 and NaCl (in solution or/and solid), if we double the concentration of NaCl, the solubility of CaCO3
- (1) decreases
- (2) stays the same
- (3) increases
- (4) increases or decreases, depending on temperature

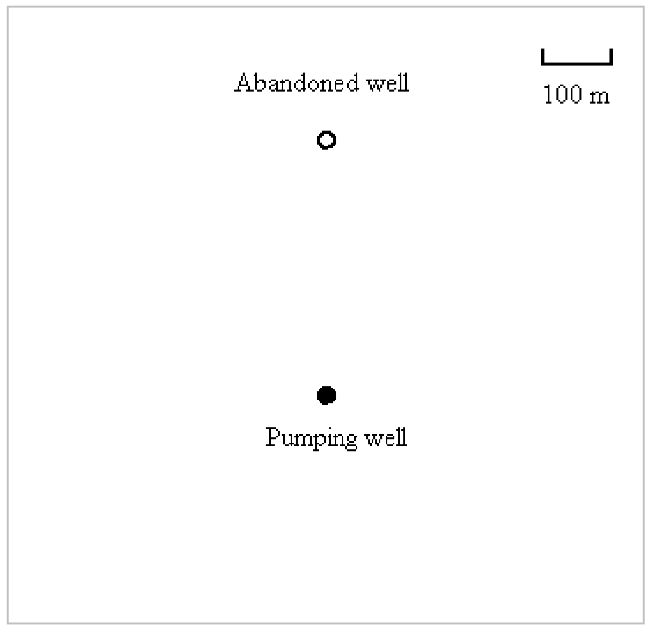
(d) The Theis equation is most appropriately used for
- (1) transient flow from an injecting well and into the aquifer
- (2) steady state flow towards a pumping well
- (3) transient flow between two lakes with variable water levels
- (4) steady state flow between two lakes with constant water levels
- (5) none of the above

(e) We saturate a previously dried soil sample with wateer. During the process, we measure moisture content C and corresponding pressure P. If we now saturate the sample and then decrease the moisture content to the same level C, the pressure will be
- (1) equal to P
- (2) greater than P
- (3) smaller than P
- (4) don't know what your'e talking about
- (5) know the answer, but won't tell

Problem 2. (10 points, 5 points each)

An abandoned well located 400 m from a municipal water well was used by miss Magda of the Devil's Grail Enterprises, Inc. as an illegal hazardous waste disposal site. The aquifer is confined, has thickness 10 m, transmissivity 10^{-2} m^2/s, and porosity 0.2. The municipal well is 1.0 m in diameter and has been pumping steadily at 0.1 m^3/s for 20 days. Measured drawdown in the abandoned well is 6.2 m.

(a) On the provided map, draw a qualitative (but realistic) contour map of drawdown around the pumping well. Calculate the travel time from the abandoned well to the pumping well.



(b) A first trace of the contaminant has just been detected in a monitoring well 50 m from the municipal well. It has caused a panic among the people responsible for the quality of water. They hired an outside consultant. The consultant recommended that the pumping process be reversed. The municipal well should become an injection well. After some time, the contaminant would flow back to the abandoned well, where it would be neutralized. Will the plan work? Why or why not? Discuss qualitatively, but in detail.

Problem 3. (20 points, 5 points each)

(a) In sand having 1-mm median grain size and porosity 0.25, how high must specific discharge be to make mechanical dispersion coefficient equal to the effective molecular diffusion coefficient? Make any necessary and reasonable assumptions.

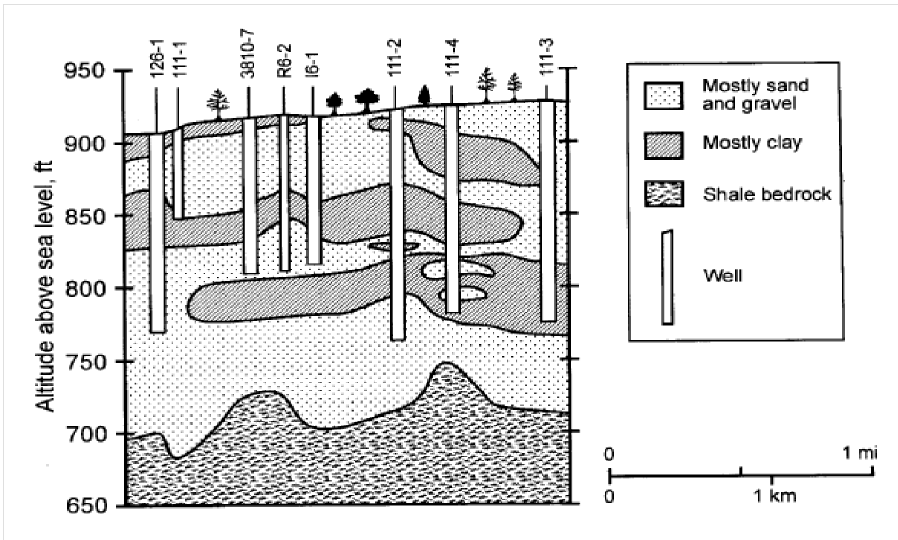
(b) Prove that a decrease in atmospheric pressure results in increasing water levels in wells penetrating a confined aquifer.

(c) You are conducting a pumping test in a confined aquifer which has transmissivity $T = 10^{-4}$ m^2/s and storativity $S = 10^{-4}$. The observation well is 100 m from the pumping well. How long will you have to pump before you can apply the Jacob semi-log analysis of drawdown with time?

(d) A fully penetrating well is installed in a confined aquifer of thickness 12 m, hydraulic conductivity 10^{-4} m/s and storativity 0.001. The well is pumped at a rate of 100 l/min for 10 hr. The pumps are then shut down. What is the drawdown 5 m from the well when the pumping is stopped? What is it four hours later?

Problem 4. (20 p., 4 p. each)

The figure shows a cross section of an aquifer system (note vertical exaggeration). The transmissivity of the confined aquifer is 10000 ft^2/d and the storativity is 5E-4. Well I6-1 is an irrigation well that is used periodically during the growing season.



(a) What will be the drawdown 1000 ft away from well I6-1 if it is pumped at a constant rate of 110,000 ft^3/d for 30 days?

(b) At what rate can well I6-1 be pumped for 30 days so that the drawdown will not exceed 5 ft at a distance 1 mile from it?

(c) How much time is required for well I6-1 pumping continuously at 110,000 ft^3/d to cause 1 ft of drawdown 1 mile away?

(d) What assumptions did you make for parts a, b, c? Which of these assumptions are likely to be invalid in this system?

(e) Consider other existing wells in this aquifer system for drinking-water supply. Briefly describe their advantages and disadvantages.

Problem 5. (20 points, 5 points each)

A falling-head permeameter is constructed by ponding 20 cm of water at t=0 above a saturated soil column of height L=100 cm. The ponded water, which is held above the column in a chamber of the same area as the column, falls to 0 cm in 1 hour.

(a) Calculate the hydraulic conductivity for this column.

(b) Repeat the calculations approximately by assuming that the specific discharge through the column was constant in time and equal to 20 cm/hr and that the height of ponded water was held at 10 cm (average water level in part a) for the whole experiment. Compare the result calculated by Darcy's law with these approximations and calculate the percentage of error.

(c) Repeat parts a and b for the case where the soil column is only 5 cm high.

(d) Explain the reason for the difference in these two results.

Problem 6. (10 points, 5 points each)

In an accident 25 years ago, a large quantity of nitrates (distribution coefficient K_d=0) and an organic solvent (K_d=0.5 ml/g) was dumped on the soil surface as a massive pulse. Rainfall and evaporation records indicate that about 1000 cm of water has infiltrated into the soil since that time. From soil coring, it was determined that the average water content of the soil profile is 0.25 and the bulk density is 1.5 g/cm^3.

(a) Calculate the approximate positions of the nitrate and solvent pulses today.

(b) If the water table depth is 50 m, calculate the arrival time for both pulses at the water table. What assumptions about long-term conditions do you have to make?

Problem 7. (20 points, 3 points each, except (g) - 2 points)

A spill from a high-level storage tank releases the radionuclides shown in the table.

Nuclide	Activity (ci)	Half life (yr)	K_d (ml/g)	D_x (cm^2/s)	D_y (cm^2/s)	D_z (cm^2/s)
A	400	33	8	1E-4	1E-5	1E-6
B	400	28	52	1E-3	1E-5	1E-7
C	400	2.7	40	1E-5	1E-5	1E-5
D	400	20	0.1	1E-6	1E-5	1E-6

Answer the following questions and justify your answers. Use quantitative reasoning, for example, "nuclide A will ... because its half life is shortest/longest."

(a) Which nuclide will be first to arrive at the property boundary?

(b) Which will be last?

(c) Which will have the lowest maximum concentration at the property boundary?

(d) Which will have the highest maximum concentration?

(e) Which will have the smallest spread around the center in the direction of flow?

(f) Which will have the largest spread in the direction of flow?

(g) Which will have the same spread around the center of mass in all directions, that is, in the flow direction, transverse, and vertically as well?