Groundwater Hydrology Exercise 3: Calculation Problems

Report due: June 20, 9:00

1. Single-well response test (4pt)

The table lists a data set of a 'bail-out test' conducted in a piezometer. The water level (WL) is expressed as the elevation below the top of casing. The piezometer is made of a straight PVC pipe having an inside diameter ($2r$) of 4.4 cm and an outside diameter ($2R$) of 5.2 cm. The bottom 50-cm of PVC is perforated and in direct contact with the sediment.

Time (min)	WL (m)	$h - h_s$ (m)	H/H_0
Static	2.400		
0	3.300		
1	3.120		
2	3.012		
3	2.860		
5	2.685		
8	2.578		
11	2.480		
15	2.446		
20	2.413		

(a) Calculate normalized head (H/H_0) and fill in the table.

(b) Plot H/H_0 against time on a semi-log chart and determine the basic time lag (T_b).

(c) Estimate the hydraulic conductivity (K) of the sediment using the Hvorslev method (Eqs. 1.6 and 1.7 in lecture slides). Clearly explain your steps.

2. Dupuit-Forchheimer equation (4pt)

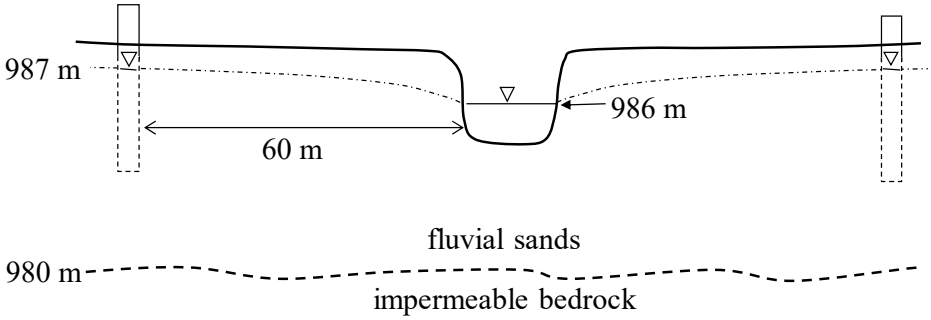
The diagram below shows a cross section of a stream and an unconfined aquifer connected to the stream. The aquifer consists of fluvial sand, which is underlain by impermeable bedrock. The diagram below shows the elevation of the water table in an observation well, the stream water surface, and the bedrock surface. The fluvial sand is reasonably uniform and has a horizontal hydraulic conductivity of 5×10^{-4} m s^{-1}. Groundwater flow direction is normal to the stream.

(a) Using Dupuit-Forchheimer equation (Eq. 2.2 in lecture slides, also see below), estimate the rate of groundwater discharge (m^3 s^{-1}) from the left bank into one-meter section of the stream.

$$Q = \frac{wK_h}{2l}(h_2^2 - h_1^2)$$

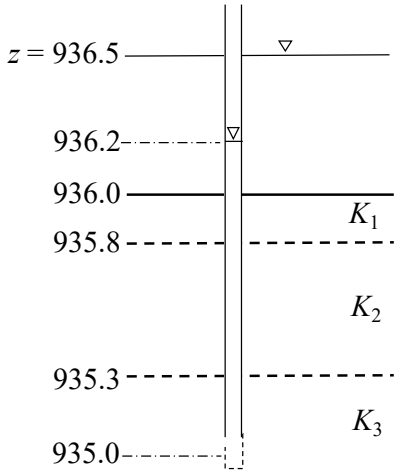
where Q is flow rate, w is the length of the stream section, l is the distance between the stream bank and the observation well, h_2 is the thickness of the aquifer at the well, and h_1 is the thickness of the aquifer at the stream bank.

(b) Assume that the diagram represents the condition of a 500-m long stream section. Based on your calculation above, estimate the total amount of groundwater (m^3) that the 500-m section receives in a day.



3. Groundwater seepage estimation (4pt)

A piezometer is installed under a lake. The water surface is at an elevation of 936.5 m, and the lakebed is at 936.0 m. The piezometer water level, mid-screen depth, and sediment layer boundaries are indicated in the figure.



The vertical hydraulic conductivity of the layers are; $K_1 = 1 \times 10^{-6}$ m s^{-1}, $K_2 = 2 \times 10^{-4}$ m s^{-1}, and $K_3 = 3 \times 10^{-5}$ m s^{-1}. The groundwater flow is strictly vertical and is at steady state.

(a) Is this in an area of groundwater discharge or recharge?

(b) Estimate specific discharge q (mm d^{-1}) into or out of the lakebed.