



MRT 386-3 Groundwater Flow Modeling

Number of questions: Five (05)

Answer all questions

Time allocation: Three (03) hours

Mark allocation: 100

1.

- (a) Write an account on the physics of groundwater flow with special emphasis on potentiometric head and its energy relationships. (10 marks)
- (b) Potentiometric contours of a regional groundwater system are indicated in Figure 1.1. Give a detailed description of the regional groundwater flow regime. Use illustrated diagrams to support your explanation. (10 marks)

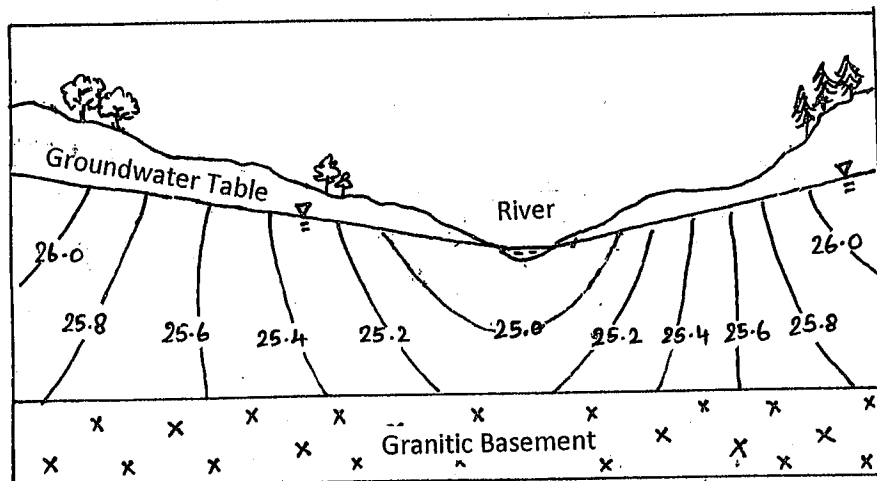


Figure 1.1. Potentiometric contours of a regional groundwater system.

2. An aquifer system consists of three stratigraphic units with an areal extent of 2 km x 1.5 km. The top layer of the sequence is made up of unconsolidated sand which acts as an unconfined aquifer. An impermeable clay layer constitutes the middle part of the formation. The bottom layer is a sandstone which is being exploited as a productive confined aquifer. The sedimentary formation rests on impermeable granitic basement. The aquifer system is constrained by two ridges on West and East. Groundwater flow in both aquifers are found to be from North to South. A community water supply scheme extracts groundwater from the confined aquifer through a deep tube well located in the central part of the area.

- (a) Show the above setting in perspective view in a labeled diagram. (05 marks)
- (b) Project the anticipated hydraulic head contours of the confined aquifer onto the surface when the well is continuously being pumped at a fixed rate. Complete the flow net by drawing flow lines. Indicate flow velocity vectors. (15 marks)

3. (a) What are the types of information you could obtain from a groundwater flow model? (05 marks)

- (b) Describe in detail how you would formulate a mathematical groundwater flow model for the scenario presented in Question 2. (Note: Your answer should NOT be biased to procedures/steps/syntax of any computer program) (15 marks)

4. (a) Explain why iterative techniques are needed in solving a set of simultaneous equations. (05 marks)

- (b) Figure 4.1 shows piezometer readings in the Northeastern part near a pumping well. Four piezometer readings are missing and therefore they are indicated as  $h_{2,2}$ ,  $h_{3,2}$ ,  $h_{2,3}$ , and  $h_{3,3}$ . The subscripted indices correspond with a 2-D finite difference grid. If the groundwater flow to the well is at steady state, the hydraulic head at any given node of the grid ( $h_{i,j}$ ) can be expressed as

$$h_{i,j} = \frac{h_{i-1,j} + h_{i+1,j} + h_{i,j-1} + h_{i,j+1}}{4}$$

Demonstrate how you would estimate the unknown hydraulic head values using an iterative technique. (15 marks)

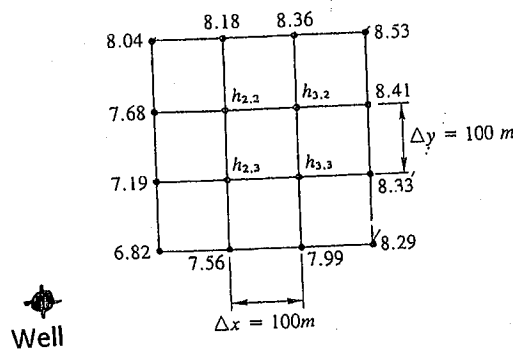


Figure 4.1. Finite difference grid showing hydraulic heads near a pumping well.

5.

The generalized groundwater flow equation takes the following form. Symbols have the standard meanings.

$$\frac{\partial}{\partial x} \left( K_x \frac{\partial h}{\partial x} \right) + \frac{\partial}{\partial y} \left( K_y \frac{\partial h}{\partial y} \right) + \frac{\partial}{\partial z} \left( K_z \frac{\partial h}{\partial z} \right) + W = S_s \left( \frac{\partial h}{\partial t} \right)$$

Describe each component of this equation and explain how each one accounts for various conditions of different groundwater settings.

(20 marks)

