

MRT 387-1 Simulation of Groundwater Systems

This is a practical examination

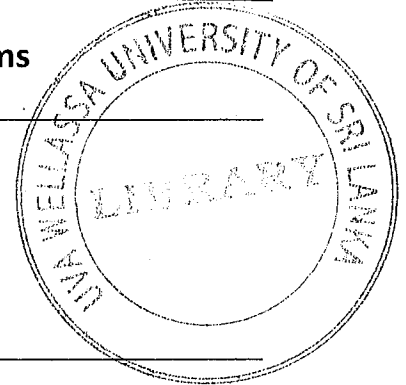
Number of questions: Two (02)

Answer **all** questions

Question 1: Manual plotting, Question 2: Computer simulation

Time allocation: Two (02) hours

Mark allocation: 100



1. A regional groundwater system is schematically represented in Figure 1.1. Hydraulic head distribution on a longitudinal profile of this system has been calculated using a groundwater flow model and is shown in Figure 1.2. (Note that both figures have large vertical exaggerations).

(a) Contour the hydraulic heads and indicate the flow lines on Figure 1.2 using the given values and symbols.

(20 marks)

(b) Briefly describe the regional groundwater flow pattern (Space is provided in Figure 1.2).

(10 marks)

2. An aquifer system consists of two stratigraphic units with an areal extent of 1 km x 600 m. It is bounded by no-flow boundaries on the West and East. The North and South boundaries of the aquifer system are two rivers that are in full hydraulic contact with both stratigraphic units. These two boundaries can be considered as fixed-head boundaries. A community water supply scheme extracts groundwater from three wells that penetrate both stratigraphic units (Figure 2.1).

Create a groundwater model for the above scenario using the MODFLOW program suite. Save your data in your working folder named "EX14_your_index_number" on Z: Drive.

Use following input data to create the model.

Upper layer : Unconfined

Lower layer : Confined

Grid dimensions : 50 columns and 30 rows with 20m square cells

Fixed-head boundaries along northern and southern borders in both layers

Top of upper layer : 10m

Top of bottom layer : 6m

Bottom elevations calculated

Time step : $9.46728E+07$ s.

Initial hydraulic heads : North 8.5m, South 7.0m (both layers)

Horizontal hydraulic conductivity (m/s): Upper 0.0001, Lower 0.0005

Vertical hydraulic conductivity (m/s) : Upper 0.00001, Lower 0.00005

Effective porosity : Both layers 0.25

Recharge : $7E-09$ m/s (upper layer only)

Well 01; Location (Grid cell) and Pumping rate (m³/s): (10,10,1) -1E-10,
(10,10,2) -0.0060

Well 02; Location (Grid cell) and Pumping rate (m³/s): (45,15,1) -1E-10,
(45,15,2) -0.0045

Well 03; Location (Grid cell) and Pumping rate (m³/s): (25,25,1) -1E-10,
(25,25,2) -0.0050

Assuming a homogeneous and an isotropic aquifer system, run a steady-state flow simulation.

- (a) Produce the hydraulic head distribution pattern of the lower stratigraphic unit (lower layer) using a contour plot when all three wells are in continuous operation. (50 marks)
- (b) Plot the flow lines of the lower layer and overlay the contours. Indicate velocity vectors. Save the graphics in picture format. (20 marks)

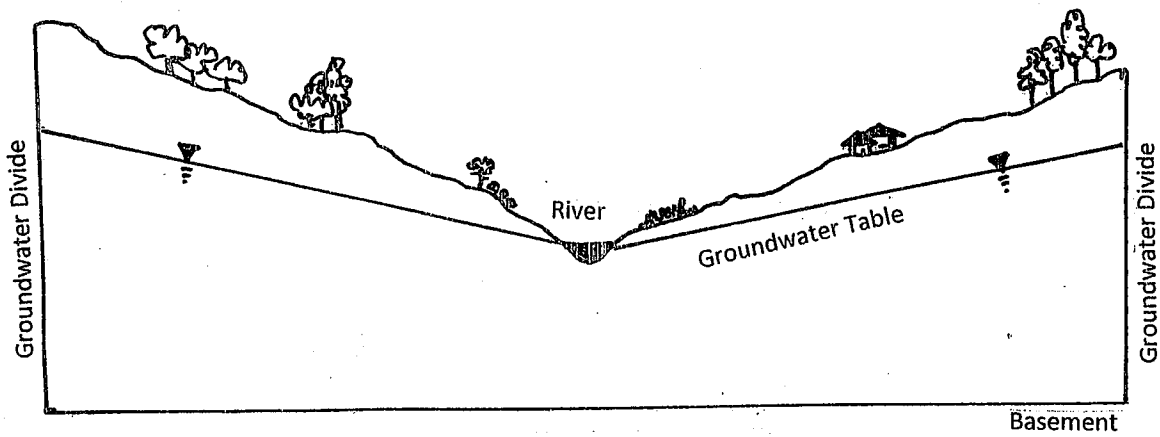


Figure 1.1. Regional Groundwater System (Not to scale)

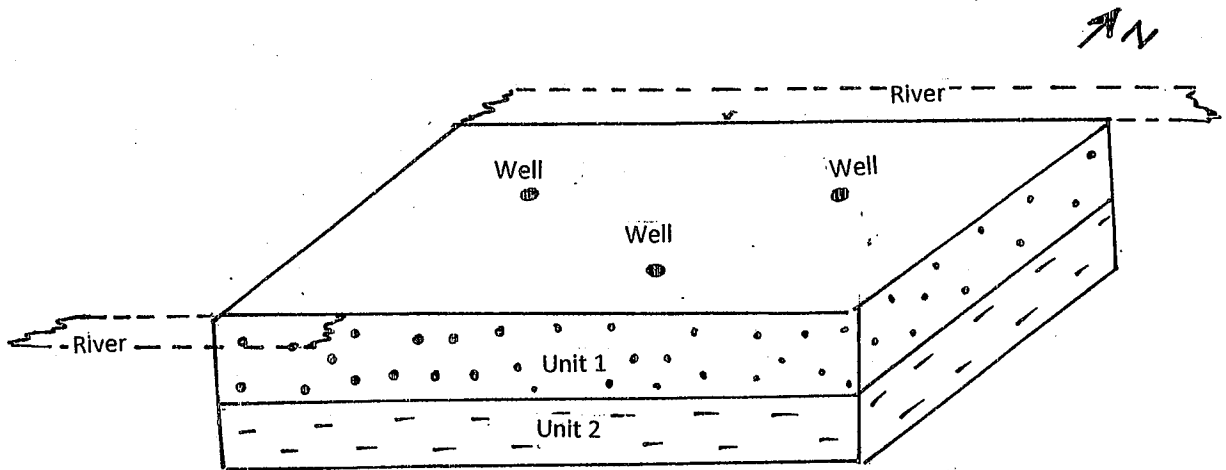


Figure 2.1. Aquifer System (Not to scale)



| | | | | | | | | | | | |
|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 23.00 | 22.40 | 21.80 | 21.20 | 20.60 | 20.00 | 20.00 | 20.60 | 21.20 | 21.80 | 22.40 | 23.00 |
| 22.35 | 22.07 | 21.69 | 21.29 | 20.91 | 20.63 | 20.63 | 20.91 | 21.29 | 21.69 | 22.07 | 22.35 |
| 21.99 | 21.84 | 21.61 | 21.35 | 21.12 | 20.97 | 20.97 | 21.12 | 21.35 | 21.61 | 21.84 | 21.99 |
| 21.77 | 21.69 | 21.55 | 21.39 | 21.25 | 21.17 | 21.17 | 21.26 | 21.40 | 21.55 | 21.69 | 21.78 |
| 21.64 | 21.59 | 21.51 | 21.42 | 21.33 | 21.28 | 21.28 | 21.33 | 21.42 | 21.52 | 21.60 | 21.65 |
| 21.57 | 21.54 | 21.49 | 21.43 | 21.38 | 21.35 | 21.35 | 21.38 | 21.43 | 21.49 | 21.54 | 21.57 |
| 21.52 | 21.50 | 21.47 | 21.43 | 21.40 | 21.38 | 21.39 | 21.41 | 21.44 | 21.48 | 21.51 | 21.53 |
| 21.49 | 21.48 | 21.46 | 21.44 | 21.42 | 21.40 | 21.41 | 21.42 | 21.44 | 21.47 | 21.49 | 21.50 |
| 21.48 | 21.47 | 21.46 | 21.44 | 21.42 | 21.41 | 21.41 | 21.42 | 21.44 | 21.46 | 21.48 | 21.49 |

Index No.

Description

Contours (m)

(20.30, 20.60, 20.90, 21.20, 21.50, 21.80, 22.10, 22.40, 22.70)

Groundwater Divide

Flow Paths

Figure 1.2. Hydraulic Head Distribution