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RI (AN)

AGRICULTURAL AND FOOD ENGINEERING DEPARTMENT
INDIAN INSTITUTE OF TECHNOLOGY, KHARAGPUR

End-Autumn Semester Examination 2011-2012

Program: M.Tech. (LWRE) & M.Tech. (WM) **Full Marks: 50**

Subject: Advanced Groundwater Hydrology (AG60044) ***Time: 3 hours***

Date of Examination: 24 November 2011 (AN) ***No. of Students: 24***

Instructions: *Answer **all** questions. Answer different parts of a question at one place. Make reasonable assumptions wherever required.*

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1. (a) A well of diameter 40 cm installed in a confined aquifer discharges water at a rate of 1500 m^3/day. If the transmissivity and storage coefficient of the aquifer are 600 m^2/day and 4 x 10^{-4}, respectively, determine the drawdown after one year of pumping at the well face. What will be the radius of influence after one year of pumping? Check the error involved in your calculation. *(2+2+1)*

(b) Two pumping wells (W1 and W2) are installed in a confined aquifer of transmissivity 300 m^2/day and storage coefficient 0.0006. The well spacing of these two pumping wells is such that the wells interfere with each other. If the wells are pumped simultaneously at rates of 550 m^3/day and 1100 m^3/day, respectively, calculate the drawdown after 200 days of pumping in an observation well located at a distance of 30 m from W1 and at a distance of 40 m from W2. *(5)*

2. (a) An aquifer consists of three different layers having following properties:

Top Layer: thickness = 9.0 m and hydraulic conductivity = 2.4 m/day; *Middle Layer:* thickness = 4.5 m and hydraulic conductivity = 13.5 m/day; and *Bottom Layer:* thickness = 6.6 m and hydraulic conductivity = 5.6 m/day. Assuming each individual layer homogeneous and isotropic, compute 'mean horizontal hydraulic conductivity' and 'mean vertical hydraulic conductivity' of this aquifer. Based on the results obtained, identify whether the aquifer is made of consolidated or unconsolidated geologic formations. *(2+2+1)*

(b) A well installed in an unconfined aquifer is pumped at a rate of 200 m^3/day and drawdown is measured in two monitoring wells which are located at distances 8 and 45 m, respectively from the pumping well. After sufficient time of pumping, the water levels in the monitoring wells attained almost steady-state condition and drawdowns measured in the monitoring wells under this condition were 2.5 and 1.2 m, respectively. If the initial saturated thickness of the aquifer is 10 m, calculate hydraulic conductivity of the unconfined aquifer. *(5)*

3. (a) Classify types of aquifers based on different combinations of homogeneity/heterogeneity and isotropy/anisotropy, and write their hydraulic characteristics based on hydraulic conductivity. Out of these classes, which type of aquifer system has been used widely for deriving analytical solutions to real-world groundwater problems? *(4+1)*

(b) What do you mean by 'direct recharge' and 'indirect recharge'? Name five important (in terms of accuracy in recharge estimate) methods of recharge estimation and briefly describe one of them which you consider the most important. *(2+2.5+1.5)*

4. **(a)** A production well of diameter 30 cm fully penetrates a homogeneous and isotropic unconfined aquifer having a hydraulic conductivity of 15 m/day, specific yield of 15% and an initial saturated thickness of 35 m. If the radius of influence of the well is 600 m, compute discharge of the well which can produce a quasi-steady drawdown of 5.2 m in the well. Assume that the well is 100% efficient. *(5)*

(b) Assuming principal directions of anisotropy to coincide with x, y and z directions of the coordinate axes, write the following expressions and define the variables and parameters used in the equations: *(5+1)*

(i) 3-D form of Darcy's law, **(ii)** Nonlinear Boussinesq equation for homogeneous and isotropic unconfined aquifers with source/sink term, **(iii)** Governing equation for transient groundwater flow to wells in homogeneous and isotropic confined aquifers, **(iv)** Governing equation for transient groundwater flow in heterogeneous and anisotropic leaky confined aquifers, and **(v)** 3-D form of diffusion equation for confined aquifers.

5. With a neat sketch and adequate labeling, clearly depict the following: *(5)*

(i) Capture-zone curve for a pumping well located in the aquifer having its own hydraulic gradient.

(ii) Variation of drawdown in a confined aquifer with time at different radial distances from pumping well.

(iii) Time-drawdown curve of an unconfined aquifer having significant delayed yield.

(iv) Cone of depression in a confined aquifer having high transmissivity.

(v) Cone of depression in a confined aquifer having low transmissivity.

6. Write the reason for the following: *(3)*

(i) Dupuit's water table is always lower than the actual water table.

(ii) Production well is not technically suitable for monitoring drawdowns during pumping test.

(iii) Some unconfined aquifers show delayed yield characteristics during time-drawdown pumping test.

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