

OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

Semester II Examinations 2005

M. Appl. Sc. Examination

EH 866 – Applied Hydrology III (Groundwater)

Examiners: Professor K.J. Beven
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Time Allowed: Three hours.

Attempt five questions.

1. (a) Explain/define the following terms
- Hydraulic conductivity
 - Specific yield
 - Specific storativity
 - Aquitard
 - Potentiometric surface
 - Permeability

Explain why the value of storativity S in a confined aquifer is of a different order of magnitude to that in an unconfined aquifer.

Comment on the relationship between specific storativity and storativity on the one hand and between hydraulic conductivity and transmissivity on the other. *[12 marks]*

- (b) Explain the term effective stress, σ_e , in an aquifer and why $d\sigma_e + dP = 0$, where P = water pressure.

A confined aquifer consolidates when the water pressure is lowered by 19000 Pa. If the original aquifer thickness was 45 m and compressibility of the aquifer is $\alpha = 2 \times 10^{-8} \text{ m}^2/\text{N}$ calculate the amount of vertical consolidation.

Give two examples of occurrence of permanent consolidation occurring as a result of excessive water withdrawal from aquifers by pumping. *[8 marks]*

- (c) The flow per unit width in an unconfined aquifer is

$$q' = -K h \frac{dh}{dx}$$

where h is the saturated thickness of the aquifer and K is the hydraulic conductivity. Show how the Dupuit equation is derived from this starting point.

Explain how the Dupuit equation for flow through an unconfined aquifer can be converted into a form which is analogous to the Darcy equation for flow through a confined aquifer. [8 marks]

4. (a) Explain
(i) the circumstances in which the Theis well drawdown solution is valid and
(ii) how the Theim equation

$$h_2^2 - h_1^2 = \frac{Q}{\pi K} \ln \left[\frac{r_2}{r_1} \right]$$

for flow towards a well in an unconfined aquifer can be converted into a form which is analogous to the Theis equation for flow towards a well in a confined aquifer.

A 50 m thick confined aquifer has hydraulic conductivity of 1.5 m/day specific storativity of 0.000007. What is the maximum allowable pumping rate which would ensure that drawdown would not exceed 3 m at a distance of 100 m from the well after 2 days of continuous pumping? [10 marks]

- (b) A pumping test conducted on a well involved pumping at a rate of 350 m³/day. After 2 days the drawdown in four wells located at different radial distances from the test well were as follows:

Distance	25	50	100	200
Drawdown	6	5	3.8	2

Determine the values of transmissivity and storativity of the aquifer. [6 marks]

- (c) Starting with the Theis well drawdown equation and the approximation $W(u) \approx 0.5772 - \ln u$, show that drawdown, s , as a function of distance r from the well can be expressed as
 $s = A + B \log_{10} r$

Hence deduce the expressions for T and S for use with the Cooper Jacob distance drawdown method of analysis. [8 marks]

5. (a) Outline five of practices or kinds of enterprises legal or illegal, which may contribute to groundwater contamination in contemporary Ireland. [5 marks]
- (b) Outline a number of different options which might be considered in order to mitigate the contamination of an unconfined aquifer over which an unlined landfill site exists. [7 marks]
- (c) Outline the main steps involved in the remediation of an industrial site [a superfund site in USA] which had become contaminated by 1,4 dioxane [8 marks]
6. (a) Explain what is meant by the terms *capture zone* and *well-head protection zones*. Use a sketch to illustrate your answer. How are these related to the cone of depression of a pumping well?
- What is the significance of the stagnation point in this context?
- In what way are these concepts included in the current Irish Groundwater Protection schemes. [10 marks]
- (b) Groundwater Protection Response Matrices are a major component of the current Irish Groundwater Protection Schemes. State which circumstances these are currently available for and explain the main features of any one of them. [10 marks]
7. (a) In the context of Groundwater Rights outline briefly
- (i) the English rule
 - (ii) the American rule
 - (iii) the mutual prescription doctrine. [6 marks]
- (b) In the context of *Surface Water Rights* outline briefly the following
- (i) the riparian doctrine
 - (ii) the prior appropriation doctrine
 - (iii) the public trust doctrine
 - (iv) the Winters doctrine. [6 marks]
- (c) Discuss what has sometimes been referred to as the *Paradox of Safe Yield* of a groundwater resource. [8 marks]

