OLLSCOIL NA hÉIREANN, GAILLIMH
NATIONAL UNIVERSITY OF IRELAND, GALWAY

SUMMER EXAMINATIONS 2001

THIRD SCIENCE EXAMINATION – EH305 HYDROLOGY AND HYDROGEOLOGY

Examiners: Professor P.E. O'Connell
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Mr. T. Henry

Time allowed is *three* hours.

Attempt *five* questions with at least two from each section.
Use separate answer books for each section.

SECTION A

1. Write notes on any *four* of the following:

   (a) Chemical composition of precipitation.

   (b) The role of water vapour in the Earth's hydrological and energy cycles.

   (c) Adsorption of water in clay soils.

   (d) Leaching of nutrients from soils.

   (e) Climate change.

   (f) The role of interception in the hydrological cycle.

   (5 marks each)

2. Answer all parts of the question.

   (a) Explain any *one* method of measuring a discharge (i.e. flowrate) in a river.

   (5 marks)

   (b) The relationship between water level, H, in m, and discharge, Q, in m^3/s, for a given river is:

   $$Q = 2.34 + 39.41(H - 55) + 1.78(H - 55)^2, \text{ where } H \geq 55m$$

   During a 24-hour period when the river flow was receding gradually the following water levels were recorded.

Time	00.00	06.00	12.00	18.00	24.00
H (m)	56.65	56.20	55.80	55.50	55.30

Question 2 continued overleaf

Calculate:

(i) the discharges at these times;

(ii) estimate the total volume of flow during the 24-hour period; and, *(4 marks)*

(iii) the mean daily flow. *(5 marks)*

(6 marks)

3. Answer all parts of the question.

(a) Define:

(i) Field Capacity.

(ii) Soil Moisture Deficit (SMD).

(2 marks each)

(b) If a soil moisture deficit exists what effect, if any, does this have on actual evaporation?

(2 marks)

(c) The following monthly data were measured in millimetres for two successive years. In each case calculate the actual evaporation from grassland for the months of July and August.

Year	Month	Pot. Evap.	Rain	
One	July	80	30	*At the end of June, Potential SMD = 100mm*
	August	75	15	
Two	July	85	45	*At the end of June, Potential SMD = 40mm*
	August	60	48	

(14 marks)

4. A quarry is being developed in Co. Tipperary. You are hired to carry out the hydrology and hydrogeology components of the Environmental Impact Statement (EIS).

The Average Annual Rainfall (AAR) in the area is determined to be 1035mm/year. The Average Potential Evaporation is determined to be 459mm/year. The surface area of the catchment up-gradient of the proposed quarry (including the quarry site itself) is 40km^2.

(a) What is the Effective Rainfall (ER) for the area in which the quarry will be sited? (Assume Actual Evaporation = 0.95PE)

(4 marks)

(b) Assuming that 30 percent of rainfall in the area recharges directly to groundwater, and assuming that the quarry will be entirely above the water table; what volume of water would be available as runoff to the quarry each year?

(4 marks)

Question 4 continued overleaf

(c) The quarry will employ 30 people. Effluent will be collected and treated in a proprietary treatment unit on site before being discharged to a local stream. Assuming that effluent production is 100 litres/person/day how much effluent will be produced on a daily and yearly basis?

(4 marks)

(d) The lowest recorded flow in the stream into which the effluent will be discharged is $0.005m^3$/second. Tipperary County Council require that the effluent be diluted to an 8:1 standard in the stream. Given the effluent discharge calculated above and the recorded low flow, will the stream be suitable to receive the treated water?

(4 marks)

(e) The quarry site is located in the catchment of the River Suir that has an area of $1830km^2$ in the vicinity of the quarry. What is the total volume of water available for runoff or groundwater recharge in the entire catchment? (Assume that ER and PE are as above.)

(4 marks)

SECTION B

5. Answer *eight* of the following. Please keep your answers brief.

(a) What is the difference between the *moisture content* and the *saturation* of a rock sample?

(b) The water table is an imaginary, undulating surface. How is it defined in terms of hydraulic pressure?

(c) Porosity is a function of *sorting, shape and size*. True or False? Explain your answer *briefly*.

(d) What is Hubbert's definition of potential?

(e) Define Hydraulic Conductivity in terms of medium *and* fluid properties.

(f) What is the difference between isotropy and heterogeneity?

(g) Define Specific Storage in terms of aquifer and fluid compressibility.

(h) The equation below describes three-dimensional transient flow through an aquifer. What are the aquifer properties (*i.e.* is it heterogeneous or homogenous, isotropic of non-isotropic)?

$$\frac{\partial^2 h}{\partial x^2}+\frac{\partial^2 h}{\partial y^2}+\frac{\partial^2 h}{\partial z^2}=\frac{S_s \partial h}{K \partial t}$$

(i) The Theis solution assumes three *aquifer* properties. List them.

(j) The development of groundwater resources is a sequential process with three major phases. What are these phases?

(2.5 marks each)

6. Answer (a) *or* (b); not both.

(a) Write an essay on the Karst hydrogeology of the west of Ireland, using specific examples from south Galway and north Clare. Include an explanation of the karstification process in your answer.

(20 marks)

or

(b) Write an essay on the importance of groundwater as a resource, using global and Irish examples.

(20 marks)

7. Answer *all* parts of the question.

(a) What is an aquifer? There are three broad classes of aquifer; list them and write a *brief* note about each.

(6 marks)

(b) What are the Dupuit assumptions in relation to steady flow in unconfined aquifers?

(3 marks)

(c) Two rivers run parallel to each other, at a distance of 800 metres. The rivers fully penetrate an unconfined (water-table) aquifer. The hydraulic conductivity of the aquifer is 0.6 m/day. Rainfall in the area averages 25 cm/year and evaporation averages 10 cm/year. The elevation of the water in River One is 15 metres above datum, and the elevation of the water in River Two is 13 metres above datum.

(i) Determine the *location* of the water table divide.

(2 marks)

(ii) Determine the *elevation* of the water table divide (the maximum water table elevation).

(4 marks)

(iii) Determine the daily discharge per metre width into River One.

(5 marks)

8. Answer (a) *and* (b). Both sections carry equal marks.

(a) A well penetrating a confined aquifer is pumped at a constant rate of 0.02 m^3/second. Drawdowns are measured in an observation well located 50 metres away. The results of the test are plotted on the attached graph.

(i) Identify Δs and t_0 on the graph.

(*2 marks*)

(ii) Calculate T and S, reporting T in m^2/second.

(*6 marks*)

(iii) Give two assumptions regarding the pumping well that are required for the analysis used in (i) and (ii) above.

(*2 marks*)

Remember to write your name and examination number on the graph, and to enclose the graph with your answer script.

(b) (i) There are two types of boundaries found in real aquifers. What are they? Briefly explain how they affect drawdowns in a well?

[*4 marks*]

(ii) A well is installed in a sand aquifer and pumped at a rate of 1500 m^3/day. The transmissivity of the aquifer is reported to be 95 m^2/day and the storativity is 1×10^{-3}. A fault is located 400 metres from the pumping well. What would the drawdown be at a monitoring well located at the midpoint between the fault and the pumping well after 10 days of pumping?

[*6 marks*]