National Exams December 2015

04-Agric-B7 Principles of Hydrology

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.

   Any non-communicating calculator is permitted.

3. FIVE (5) questions constitute a complete exam paper.
   The first five questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. Most questions require an answer involving calculations. Clarity and organization of the answer are important.

1. (20 marks)

In the table below is a 15-minute unit hydrograph based on 1 cm of excess precipitation for a small watershed.

a. Based on this unit hydrograph information, what is the area of the watershed in hectares?

b. For a 45-minute storm in which the excess precipitation is 0.5, 1.0 and 2.0 cm for each 15-minute segment, determine:

   i. The runoff rate expected at 30 minutes after the start of runoff

   ii. The peak runoff rate

   iii. The time of peak runoff

time (min)	Runoff m^3/s
0	0
15	2
30	5
45	2.5
60	1
75	0

2.(20 Marks)

Define the following terms with respect to hydrology. Include equations where appropriate.

a. Curve Number
b. Muskingum Method
c. Saturated hydraulic conductivity
d. Depression storage
e. Storm water management
f. Abstractions
g. Thiessen Polygons
h. Hyetograph
i. Evapotranspiration
j. Distributed vs Lumped hydrologic models

3.(20 Marks)

Instrumentation has been installed on a local stream for the past 8 years with the following results for the peak flows in each year. In three of the eight years the data was not obtained due to a failure of the instrumentation related to the batteries used in the sensor. Although the period of record is short, the past eight years are assumed to be representative of the long term record.

a. What strategies would you propose to deal with years of missing data? You may assume the data are missing due to sensor problems and more than just the peak flows are missing from the record. Justify your answer from a hydrological point of view.

b. Assuming the data are log-normally distributed, what do you estimate the discharges with the 2 and 10-year return periods are?

c. What do you think the chances of the peak flow exceeding 40 m^3/s in 2016 are?

d. What do you think the chances of the peak flow exceeding 40 m^3/s in both 2016 *and* 2017 are?

Year	Peak Discharge (m^3/s)
2014	12
2013	N/A
2012	15
2011	42
2010	N/A
2009	N/A
2008	22
2007	33

4.(20 Marks)

A double ring infiltrometer has been used to determine the infiltration characteristics of a soil. The outer ring has a diameter of 1.0 m while the inner ring has a diameter of 0.5 m. In each ring water is added continuously to keep a depth of no less than 5 mm in it. In the first 5 minutes 1.0 L of water is added, from 45 to 60 minutes 1.8 L are added and from 120 to 135 minutes 1.1 L are added. After 6 hours the amount added every 15 minutes is approximately constant at 0.75 L. All the quantities are for the inner ring only.

a. Sketch the infiltration curve (infiltration rate vs time) for this soil on the Figure for question 4.
b. For any infiltration equation of your choice:
    i. Write out the equation, identifying all variables and parameters with units, and
    ii. Determine the parameters based on the infiltration information given for this soil.
    iii. Predict what the infiltration rate would be at a time 30 minutes after the start of the test.

5.(20 Marks)

A simplified runoff hydrograph from a small watershed is shown in the figure attached. You have been asked to design a small flood management pond that will reduce the flooding downstream by reducing the peak flow to 1 m^3/s from the 2 m^3/s shown in the runoff hydrograph through the use of a stormwater pond whose level is controlled by a broad crested weir. The equation for the weir is given below and you may assume the weir coefficient (C) is 1.70 $m^{0.5}/s$ for all water levels. The maximum water level (H) above the weir crest allowed is 0.25 m.

$$Q\left(m^3/_s\right) = CLH^{3/2}$$

a. What is the length (L) of weir required for this pond?

b. Sketch (without calculation) the outflow from the management pond on the graph, paying attention to the timing of the peak discharge and the time to when the discharge returns to 0. Make sure to submit this graph with your exam booklet.

c. What is the area of the pond required at the maximum water level required?

d. Using a routing method of your choice, estimate what the discharge over the weir at 0.5 hours, assuming the outflow at time equal to 0, was 0 m^3/s.

6.(20 Marks)

A golf course is to be serviced with irrigation requirements from a 30 cm diameter, fully screened, well installed in a local surficial aquifer. At present the water table is approximately 2.5 m below the ground surface and nearly horizontal. The aquifer consists of a sand and gravel material that is 15 m thick and sits atop an impermeable till layer. Upon pumping the well at a constant rate for some time, the water level in the well reaches a constant level 6.5 m below the original water level while at the same time water in a monitoring well some 100 m away reaches a constant level some 0.1 m below its original static level.

a. What is your estimate of the well pumping rate?
b. What assumptions were required to answer part a?
c. If the water being pumped is being returned to the land above the aquifer for irrigation purposes, how would you change your approach to part a? Would evapotranspiration considerations be important to consider?

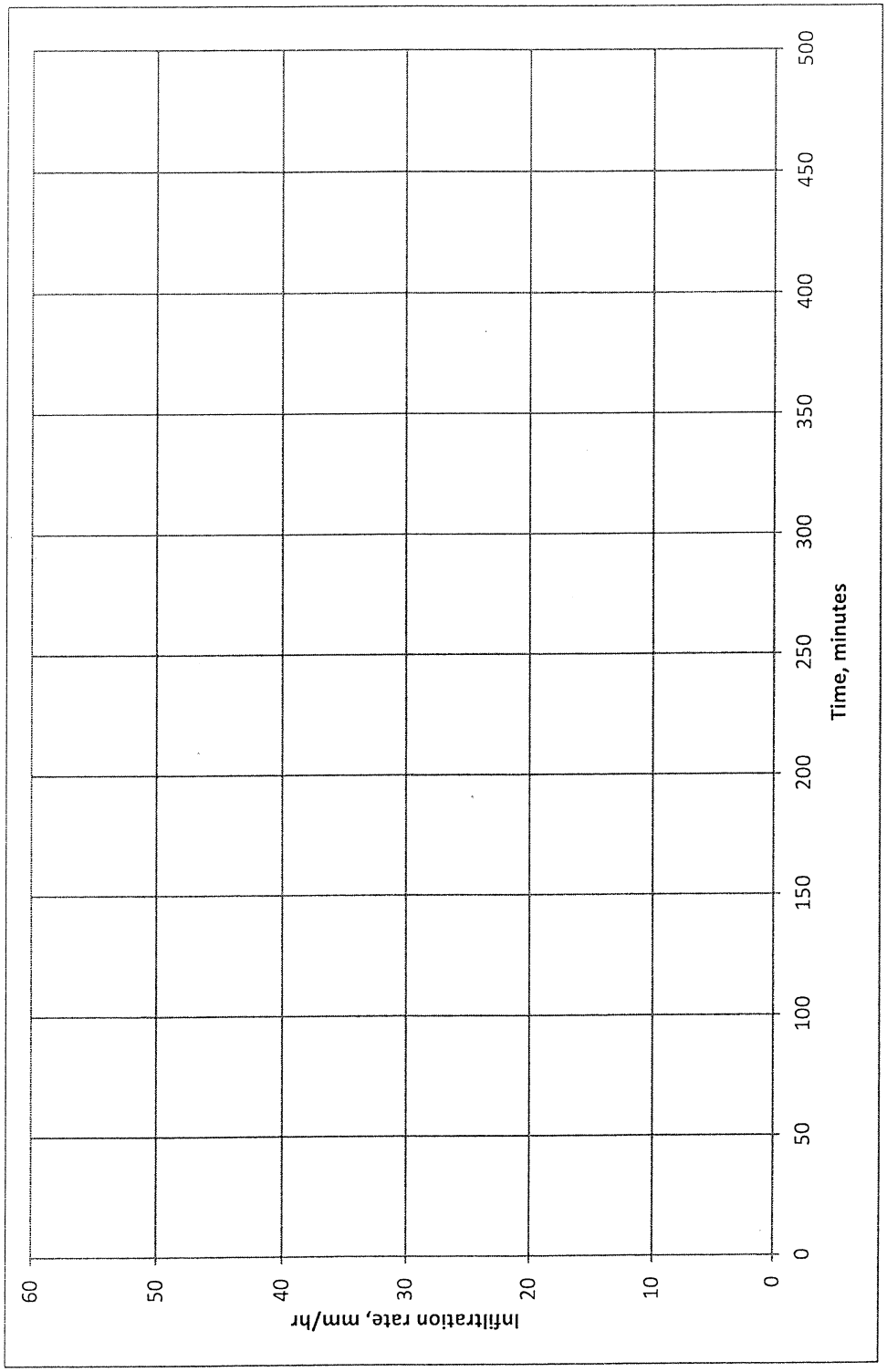

Figure for question 4

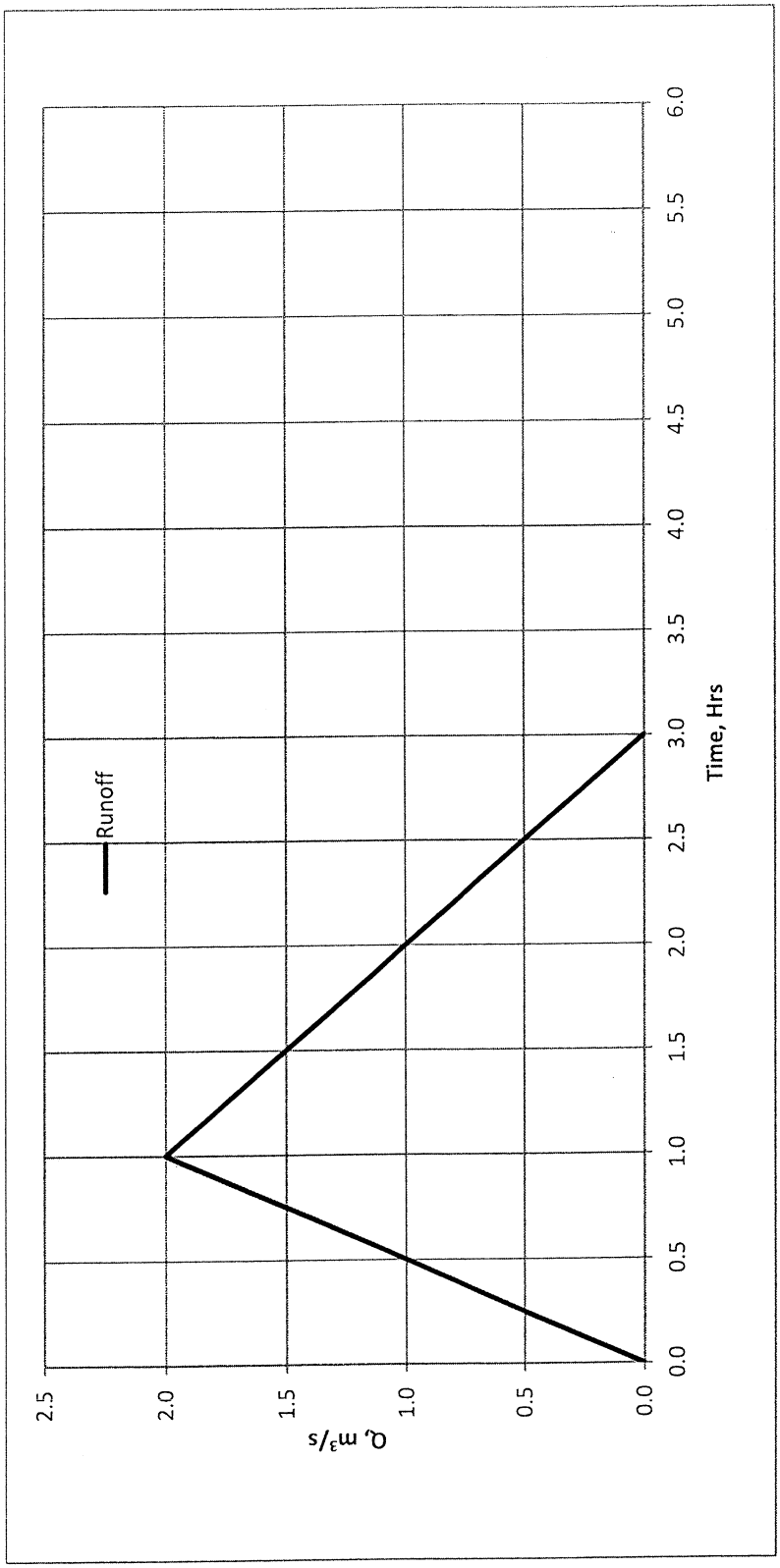

Figure for Question 5 – submit with your book.