National Exams December 2019

04-Agric-B7 Principles of Hydrology

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. Any THREE (3) questions constitute a complete exam paper.
   The first three questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. Three questions require answers involving calculations. Clarity and organization of the answers are important.

Question 1

1.1 Fill in the blanks in the following questions

a) What is the long-term annual average precipitation in Ontario?
b) What percentage of annual precipitation changes to annual evapotranspiration on long-term basis in Ontario?
c) Name the months when most of the evapotranspiration occurs in Ontario.
d) Describe briefly the difference between actual evapotranspiration and potential evapotranspiration.
e) Give the characteristics of rainfall data collected by a recording rain and a non-recording gauge.
f) Name three components of the interception process.
g) Name two major components of stream flow.
h) Describe briefly the difference between storage indication method reservoir routing and Muskingum method of channel routing.

1.2 Consider southern Ontario Great Lakes basin and describe briefly (**in point form**) the spatial and temporal variations of the following watershed hydrologic abstractions on a scale (high, moderate and low) and the factors affecting these abstractions.

a) Infiltration
b) Evapotranspiration
c) Interception
d) Depression Storage

1.3. Consider a typical agricultural watershed and **describe briefly** the effect of four watershed characteristics on storm hydrograph (peak, volume and duration)

Question 2

2.1 A 1250 ha watershed has a small pond (20 m long, 10 m wide and 1.6 m deep). Measurements of rainfall and evaporation over the pond, and water levels in the pond for a period of 10 days are given in Table 1.

Table 1. Daily rainfall, evaporation and water level in the pond.

Day	1	2	3	4	5	6	7	9	9	10
Evaporation (mm)	12.5	0	12.5	0	12,5	12.5	0	12.5	12.5	12.5
Rainfall (mm)	0	25	0	95	0	0	50	0	0	0
Water depth (m)	1.5									1.2

Determine the average daily losses due to seepage to groundwater from the pond. Assume that the water in the pond is 1.5 m deep on day 1.

2.2. **Calculate** average daily evaporation rate (mm/day) from this pond using the combination method with the following average weather conditions during the month of January.

Net radiation	= 40 W/m^2
Air temperature	= 14 °C
Relative humidity	= 65%
Wind run per day (2m height)	= 172.8 km/day
Standard atmospheric pressure	= 101.3 kPa
Roughness height for water	= 0.03 cm
Density of water at 14°C	= 999.2 kg/m^3
Density of air at 14°C	= 1.23 kg/m^3
Specific heat of water	= 1005 J/kg °K

2.3. A rainfall event given in Table 2, falling over this watershed (1250 ha) results a direct runoff hydrograph given in Figure 1. **Determine** the amount of infiltration. Assume that the evaporation for the event day is 5 mm, and is equally distributed over 24 hours period. Make necessary assumptions, if required.

Table 2. Cumulative rainfall during a rainfall even over a 1250 ha watershed

Time (min)	0	15	30	45	60	75	90	105	120	135
P (mm)	0	2.5	11	25	38	46	50	56	58	61

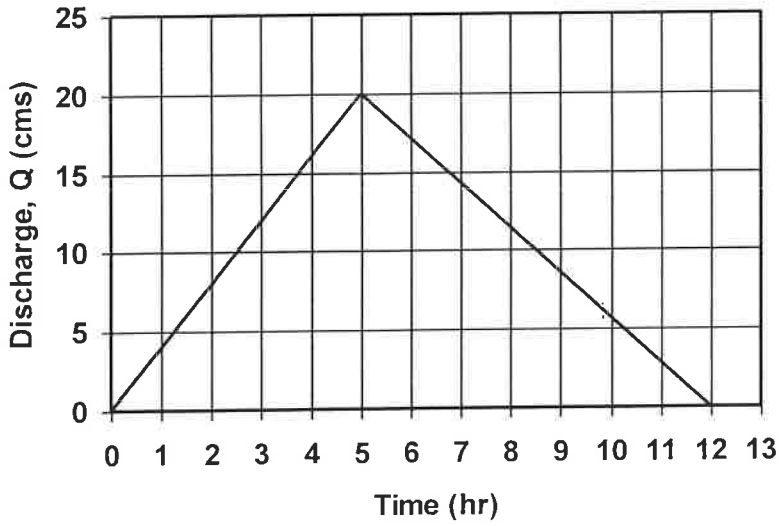

Figure 1. Direct runoff hydrograph generated by rainfall storm given in Table 2.

Question 3

3.1 Storm data (rainfall and runoff) given in Figure 2 was recorded for a storm over a 83 ha basin on April 17, 2003. The direct runoff hydrograph generated by this storm at the outlet of watershed is shown in Figure 3. and the ordinate of this hydrograph are given in Table 2.

a) **Compute** the duration and the average intensity of the rainfall for this storm.
b) **Compute** the time to peak for this storm.
c) **Find** the Φ index for this storm using the rainfall and runoff data.
d) Develop a unit hydrograph (UH) for this watershed for the duration computed in part (a). Prepare a table similar to Table 2 to record the ordinates of the computed UH.

Table 2. The ordinates of the hydrograph given in Figure 3.

Time (hr)	Q (m^3/s)	Time (hr)	Q (m^3/s)	Time (hr)	Q (m^3/s)	Time (hr)	Q (m^3/s)
16	0	17.5	3.40	19	0.79	20.5	0.08
16.25	0.85	17.75	2.92	19.25	0.57	20.75	0.08
16.5	1.70	18	2.55	19.5	0.40	21	0.06
16.75	3.40	18.25	2.18	19.75	0.23	21.25	0.04
17	3.82	18.5	1.70	20	0.17	21.5	0.02
17.25	3.96	18.75	1.27	20.25	0.11	21.75	0

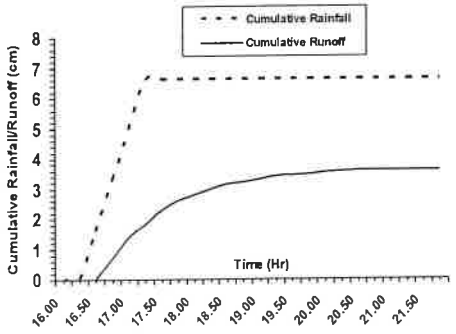

Figure 2. Rainfall and runoff record for the storm

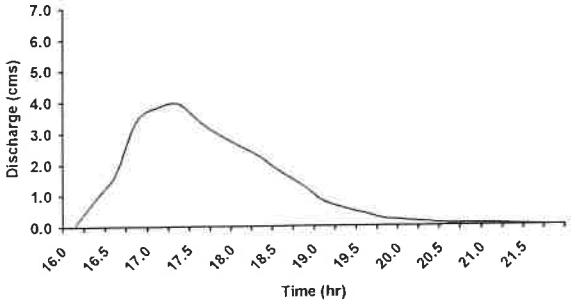

Figure 3. The direct runoff hydrograph generated by storm event given in Figure 1.

3.2. A 12-hour rainfall storm over a 393 km^2 watershed results in an excess rainfall of 5 cm for the first six hours and 15 cm for the second six hours. **Compute** the peak flow rate and the time at which occurs from this storm assuming a constant base flow of 100 m^3/s. The six hours unit hydrograph for this watershed is given in the following table.

Time (hr)	0	6	12	18	24	30	36	42
UH (m^3/s.cm)	0	1.8	30.9	85.6	41.8	14.6	5.5	1.8

Question 4

4.1 The numbers below are the maximum monthly precipitation values for the past 12 years at a location in Ontario. Maximum monthly precipitation values are known to follow a log-normal distribution for this area.

a) **Perform** a check to confirm that the data may indeed be described by a 2-parameter lognormal distribution.
b) **What** is the probability that the maximum monthly precipitation for 2008 will equal or less than 66 mm?

Monthly Precipitation (mm)
68.6
54.1
65.9
64.9
77.5
77.8
76.6
90.5
101.3
92.1
76.5
67.1

Percentiles of the Normal Distribution

z	F(z)
-3.000	0.0013
-2.326	0.0100
-2.000	0.0228
-1.645	0.0500
-1.282	0.1000
-1.000	0.1587
-0.500	0.3085
0.000	0.5000
0.500	0.6915
1.000	0.8413
1.282	0.9000
1.645	0.9500
2.000	0.9772
2.326	0.9900
3.000	0.9987

4.2. **Determine** the monthly precipitation for a 50 year return period for a station if the log (base 10) distribution of the precipitation (y= logQ) has the following characteristics. State all assumptions.

Mean, $\bar{y}^{\omega} = 1.875$
Standard Deviation, $S_y = 0.1$
Skew Coefficient, $C_s = -0.25$

4.3 **Determine** the monthly precipitation for the 100 year return period for a station if the precipitation data fits a two parameter gamma distribution and has the following characteristics. State all assumptions.

Mean, $\bar{x} = 76.1\,mm$
Standard Deviation, $S_x = 14.8$ mm