
NATIONAL EXAMS MAY 2009

98-Civ-B4
Engineering Hydrology

3 hours duration

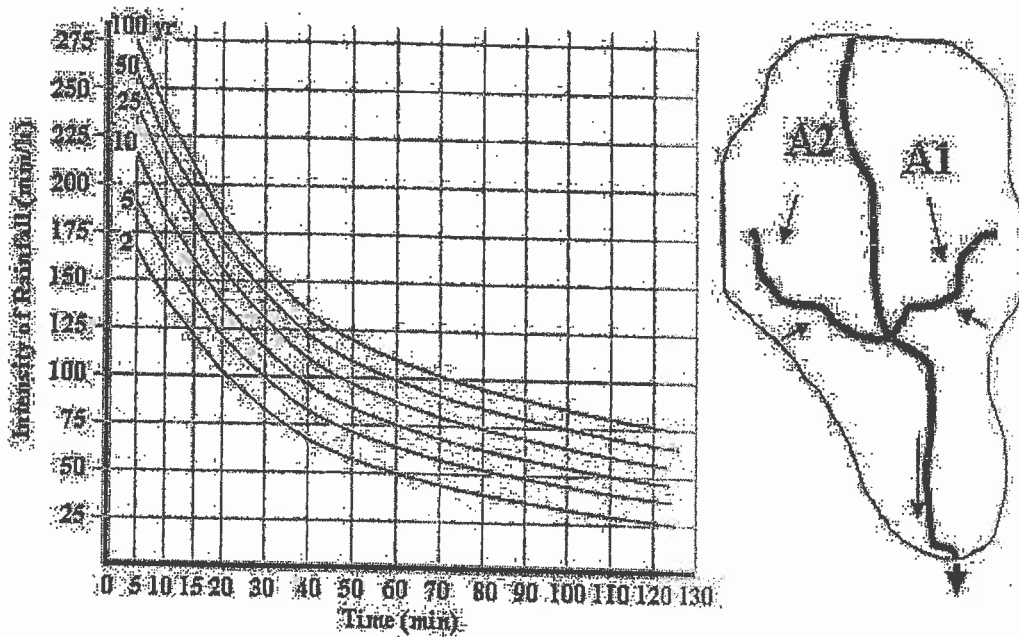
NOTES:

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 a Closed Book exam with a candidate prepared 8.5 x 11 inches double sided Aid-Sheet allowed.
3. Candidates may use one of two calculators, the Casio or Sharp approved models. Write the name and model designation of the calculator, on the first inside left hand sheet, of the exam work book.
3. Any five questions constitute a complete paper. Only the first five answers, to the seven questions, as they appear in your answer book(s) will be marked.
4. Each question is worth a total of 20 marks with the section marks indicated in square brackets [] at the end of the question. The complete Marking Scheme is also provided on the final page. A completed exam consists of five (5) answered questions with a possible maximum score of 100 marks.

1. Provide answers to the following questions related to components and processes of the *natural hydrologic cycle, precipitation, runoff, storm frequency and duration analysis.*

- i. Define the following hydrologic components and briefly explain the importance of each component to the *hydrologic cycle*:
 - a. Infiltration [3]
 - b. Precipitation [3]
 - c. Water Table [3]
- ii. Use the Rational Formula to determine the 100-year design peak runoff (m^3/min) for the catchment areas (A1 and A2) shown below. Assume that the intensity duration frequency (IDF) curves given below are applicable for this area. Use the following design information. [5]

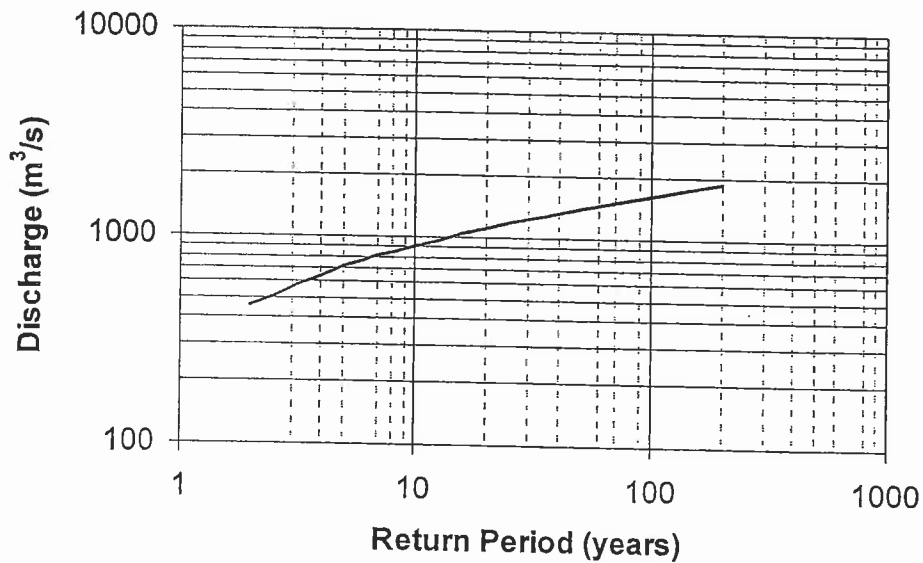
Area Label	Area (ha)	Runoff Coefficient (C)	Time of Concentration t (min)
A1	40	0.5	70
A2	45	0.7	90



- iii. Briefly identify three (3) underlying assumptions made when using the Rational Formula and indicate how each assumption may result in an increase or decrease of the calculated peak design runoff in part (ii) above. [6]

2. Provide answers to the following questions related to *conceptual models of runoff, unit hydrograph and flood frequency analysis*.
 - i. Briefly describe two (2) important properties of *conceptual models of runoff*, provide two (2) examples of how such models can be used and two (2) limitations of such models. [7]
 - ii. Briefly define the *unit hydrograph* and provide two (2) important underlying assumptions associated with the unit hydrograph linear model. [5]
 - iii. The annual flood level (Q_{Peak}) of the French River at a station in Ontario was measured over a ten year period (1990 – 1999) (tabulated below). This data was used to generate the flood-frequency curve using the Log-Pearson Type III distribution method.
 - a. Briefly explain the important steps in generating the flood-frequency curve using the Log-Pearson Type III distribution method *or* any other similar statistical method. [5]
 - b. Give two (2) short examples that demonstrate *how* the flood-frequency curve can be used for practical engineering purposes. [3]

Q_{Peak} (m^3/s)	920	909	798	657	470	331	294	289	286	243
Date	1998	1996	1996	1999	1995	1992	1994	1997	1993	1990



3. Provide answers to the following questions related to basics of *hydrologic modelling, river or channel routing and reservoir routing*.
- i. Adequate hydrologic modelling requires a substantial data inventory and calibration for the specific watershed we are trying to model. Identify *one* major hydrologic simulation model, briefly describe the *key* data needs of the model and outline how *calibration* for the given watershed is performed to ensure the reliability of the model prediction. Assume that the model predicts the streamflow. [8]
 - ii. Briefly explain one (1) method (e.g., Muskingum, Linear Channel, Kalinin-Miljukov) used for river routing a flood hydrograph. In your explanation, provide the fundamental equation and the assumptions of the method.[6]
 - iii. Explain the process of reservoir and lake routing and how it is used in predicting reservoir levels. In your explanation you may consider a flood wave passing through a storage reservoir. [6]
4. Provide answers to the following questions related to *point and areal estimates of precipitation and stream flow measurements*.
- i. When catchments have several separated gauges, the need to determine the average precipitation over the whole catchment is typically necessary. Briefly describe one (1) commonly used method. In your description, consider key details of the method, the required data, accuracy and effort required to apply the method. Recall that the three (3) popular methods are the Arithmetic Mean Method, Thiessen's Polygon Method and the Isohyetal Method. [10]
 - ii. Briefly explain how the relationship between *stream stage* and *streamflow* is constantly changing due to flood events. In your answer consider three (3) key physical properties of a stream. [10]

5. Provide answers to the following questions related to *flood wave behaviour statistical methods and basics of hydrologic modelling*.

- i. A 30-mile long finger lake is subject to wave action with given heights and return periods (as shown below). A hydro station is located downstream of the lake and can accept a 20% risk that its protective barrier will be overtopped by waves at least once in a 20-year period. Determine the minimum height of the barrier. Assume that the risk (R), return period (T) and number of events during a time period (n), are related by the following equation:[4]

$$R = 1 - \left(1 - \frac{1}{T}\right)^n$$

Wave Height (m)	4	3	2.5	2	1.5
Return Period (years)	100	50	30	15	10

- ii. Briefly outline the procedure used by event simulation models to simulate storm events through a watershed to predict the total streamflow hydrograph. In your description, include the typical modelled components of the hydrologic processes. [8]
- iii. Describe a methodology or a flood model that can be used to simulate *downstream wave effects* and potential dam breaching due to the movement of a flood wave. In your description, state the principles or basis for the model. You may use a schematic and diagrams to describe the methodology. [8]
6. Provide answers to the following questions related to *statistical methods of frequency and probability analysis applied to precipitation and floods*.

- i. Explain how the *flood frequency method* deals with runoff directly and determines the peak discharge of a specified frequency.[5]
- ii. Explain how the *extreme-value frequency factors* influence the flood magnitude and recurrence period.[5]
- iii. The average annual peak streamflows at a site with a 25 year record is 1000 m³/s with a standard deviation of 400 m³/s. Given an extreme-value frequency factor (K) of 3.088 for a 50-year recurrence interval, estimate the magnitude of the 50-year flood. [3]
- iv. Explain the justification for using *frequency and probability distributions* in characterizing and describing hydrologic variables. Identify two (2) hydrologic variables and their commonly applied distributions. [7]

7. Provide answers to the following questions related to the *hydrologic equation*, *energy budget equation* and *infiltration simulation*.
- i. Estimate the amount of evapotranspiration ($E + T$) for the year (mm) from a watershed with a $10,000 \text{ km}^2$ surface area. Consider that the drainage area receives 50 mm of rain over the year and the river draining the area has an annual flowrate of $200 \text{ m}^3/\text{s}$. Justify any assumptions you make and use the basic equation of hydrology (BEH). Recall that the BEH may be written as: [6]

$$P - R - G - E - T = \Delta S$$

Where

- P = Precipitation
- R = Surface runoff
- G = Groundwater flow
- E = Evaporation
- T = Transpiration
- ΔS = Change in Storage

- ii. Briefly compare the Energy and Water Budget equations for their similarities and differences. [6]
- iii. Briefly explain why the infiltration capacity of soil tends to decrease in an exponential manner. You may consider the typical infiltration process or a known model that simulates the physical process in your explanation. [8]

Marking Scheme

1. (i) (a) 3 (b) 3 (c) 3 (ii) 5 (iii) 6 marks; 20 marks total
2. (i) 7 (ii) 5 (iii) (a) 5 (b) 3 marks; 20 marks total
3. (i) 8 (ii) 6 (iii) 6 marks; 20 marks total
4. (i) 10 (ii) 10 marks; 20 marks total
5. (i) 4 (ii) 8 (iii) 8 marks; 20 marks total
6. (i) 5 (ii) 5 (iii) 3 (iv) 7 marks; 20 marks total
7. (i) 6 (ii) 6 (iii) 8 marks; 20 marks total