NATIONAL EXAMS MAY 2010

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.

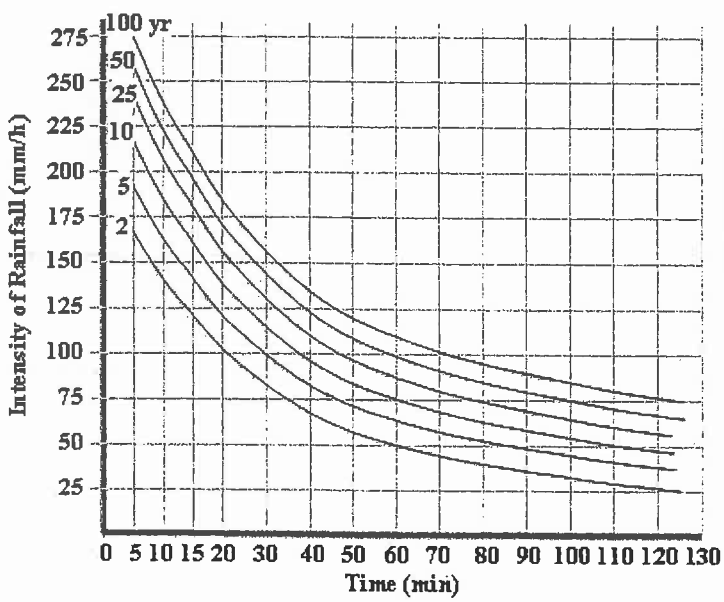
4. Each question is worth a total of 20 marks with the section marks indicated in square brackets [ ] at the end of the question. The complete Marking Scheme is also provided on the final page. A completed exam consists of five (5) answered questions with a possible maximum score of 100 marks.

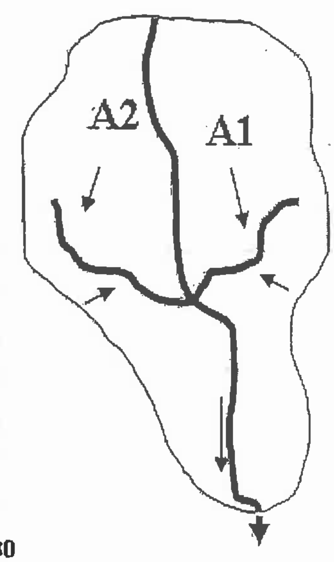
1. Provide answers to the following questions related to components and processes of the *natural hydrologic cycle*, *precipitation*, *runoff*, *storm frequency* and *duration analysis*.

   i. Define the following hydrologic processes and briefly explain the importance of each process in the *hydrologic cycle*:
      a. Water advection **[2]**
      b. Water condensation **[2]**
      c. Evapotranspiration **[2]**

   ii. Use the Rational Formula to determine the 50-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. **[6]**

Area Label	Area (ha)	Runoff Coefficient (C)	Time of Concentration t (min)
A1	100	0.4	150
A2	120	0.6	200





   iii. Provide three (3) underlying assumptions associated with the Rational Formula. For each assumption give an example where each assumption may hold and one example where it would be violated. Use a table to organize your answer. **[8]**

2. Provide answers to the following questions related to *conceptual models of runoff, unit hydrograph* and *flood frequency analysis.*

   i. Briefly describe three (3) important differences between a *conceptual model of runoff* and a *physical model.* Give an example of a useful conceptual model for generating runoff from a large catchment area. **[7]**

   ii. Briefly explain three (3) underlying principles of the *unit hydrograph* method and give one example of how it is used. [7]

   iii. Various methods are commonly used for flood frequency analysis to predict flood frequencies. However the Log-Pearson Type III Distribution method is recommended over the Log-Normal and Gumbel Distribution methods. Give two (2) advantages and one disadvantage of the Log-Pearson Type III Distribution method over *any one* of the other methods. **[6]**

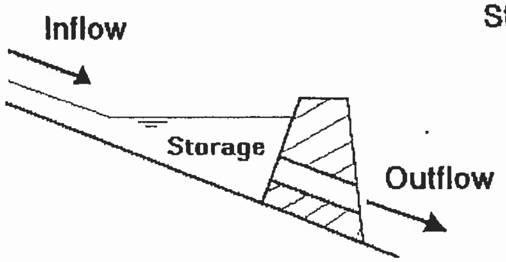
3. Provide answers to the following questions related to basics of *hydrologic modelling, river or channel routing* and *reservoir routing.*

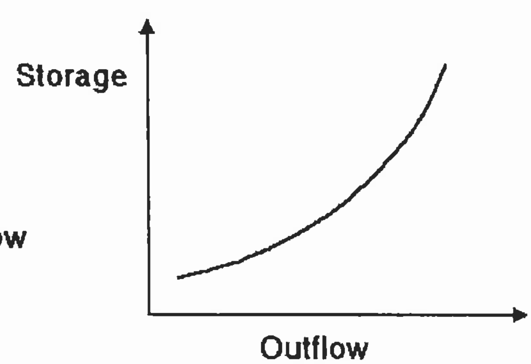
   i. Briefly explain a calibration method for a specific hydrologic model used to predict stream flow. In your calibration explanation, describe the *key* data needs of the model and outline how *calibration* for the given watershed is performed to ensure the reliability of the model stream flow prediction. [7]

   ii. Briefly explain the use of the Muskingum routing equation (below) or other river routing flood hydrograph method. In your explanation provide the fundamental routing equation, explanation of the key terms in the equation and two (2) fundamental assumptions of the method.[7]

$$O_{i+1} = C_o I_{i+1} + C_1 I_i + C_2 O_i$$

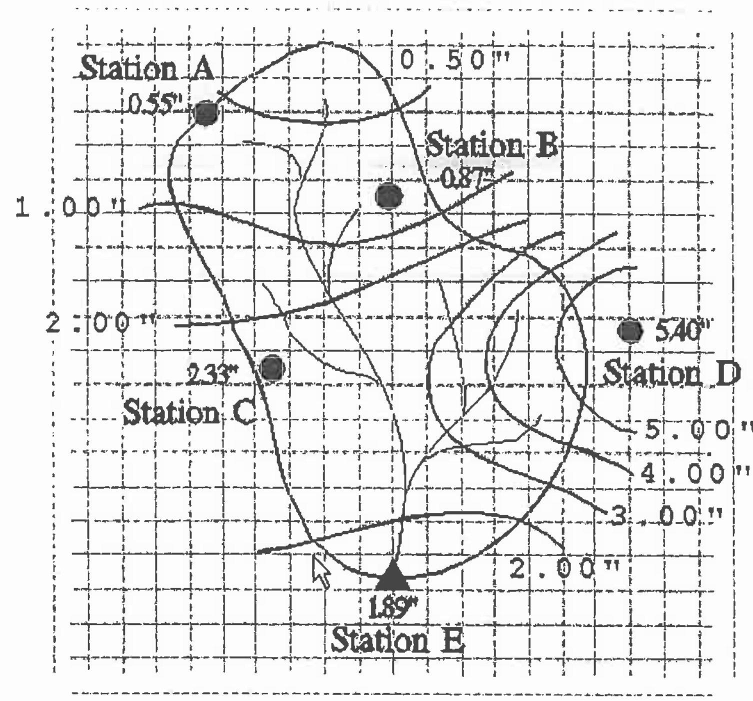
   iii. The figures below show a storage-discharge curve for an unregulated reservoir. Explain, using equations, diagrams or narrative, how the storage-discharge curve is derived. In your explanation also provide one assumption, one limitation and one useful application of this curve. [6]



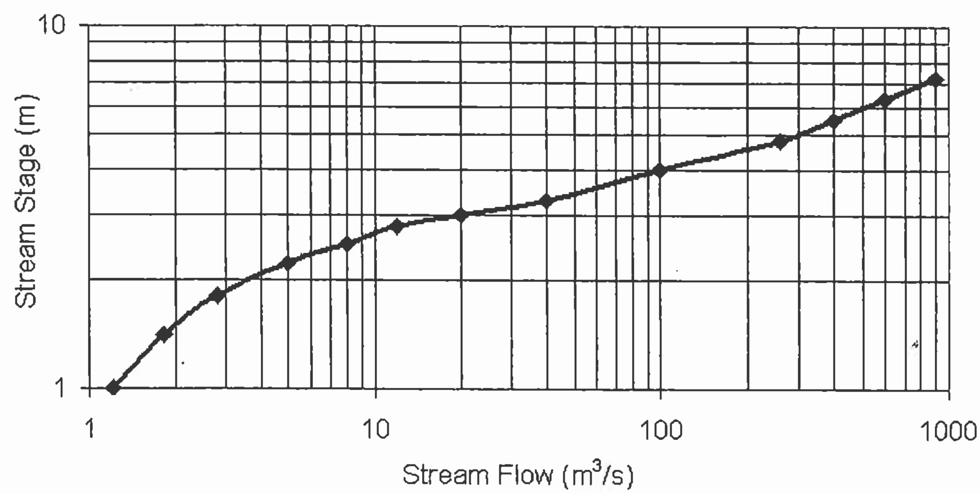


4. Provide answers to the following questions related to *point and areal estimates of precipitation* and *stream flow measurements*.

   i. Use the Isohyetal Method on the figure below to estimate the basin areal precipitation in inches. Give one engineering example of how this information may be used. **[8]**



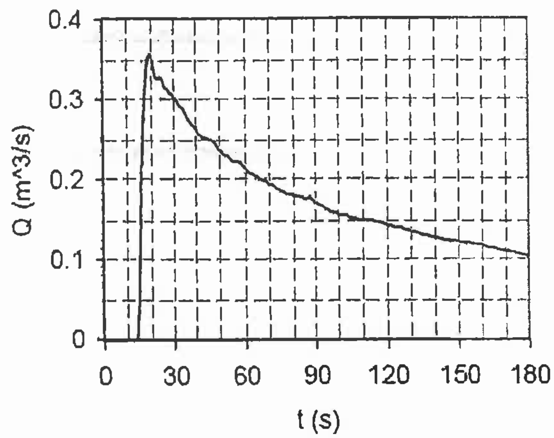
   ii. Below is a typical *stream stage-flow* or rating curve. Explain how this curve is generated and give two (2) reasons why this curve will change over time due to flood events. In your answer, consider two (2) key physical properties of a stream. **[8]**



   iii. Rating curves usually have a "break point". Explain what a break point is and explain how this is indicated in a rating curve. **[4]**

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

    i. A flood wave propagates into a valley due to a dam break resulting in the inflow-discharge hydrograph given below. Briefly explain two possible factors, related to flood wave propagation that caused the sudden decline of the flowrate from 350 to 100 L /s in 160 seconds. **[5]**



    ii. Define and explain the importance of hydrologic synthesis techniques used in hydrologic modeling. Give an example in your explanation. **[5]**

    iii. Briefly outline the procedure used by event simulation models to simulate storm events through a watershed to predict the stream flow hydrograph. **[5]**

    iv. Generate the first three terms (U_1, U_2 and U_3) of a half-hour unit hydrograph in m^3/(min·mm) by using the excess rainfall hyetograph and direct runoff hydrograph (below). **[5]**

Time (min)	30	60	90	120	150	180	210	240
Excess rainfall (mm)	25	50	40	-	-	-	-	-
Direct runoff (m^3/min)	450	1900	5200	9131	10625	7834	3921	1846

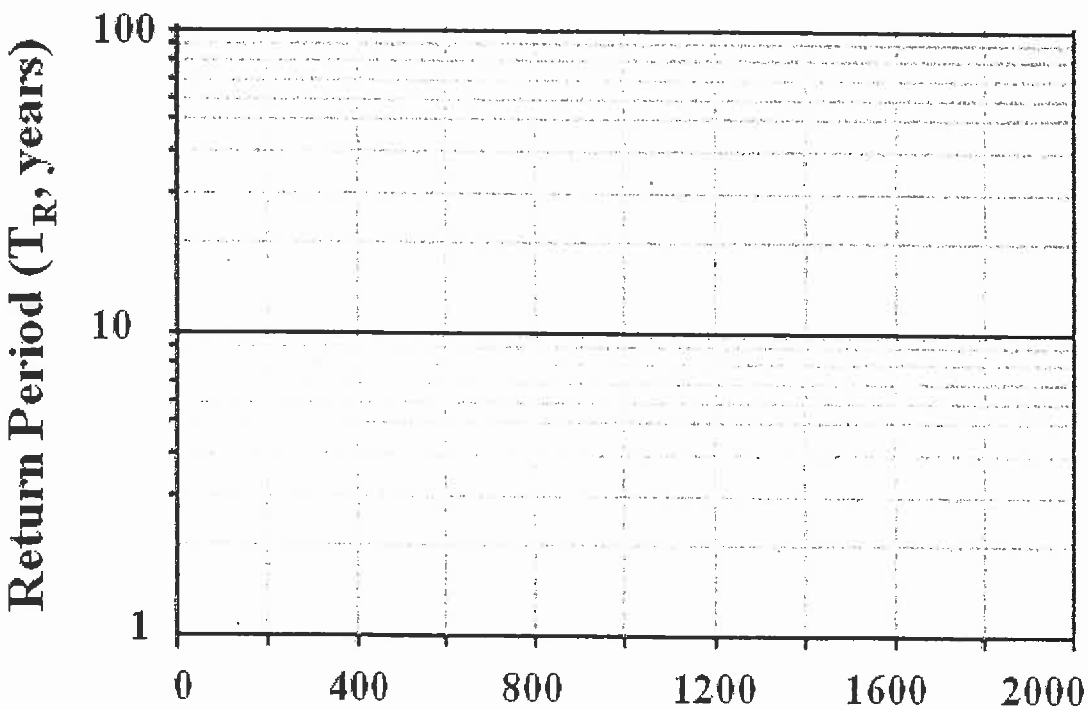
6. Provide answers to the following questions related to *statistical methods of frequency and probability analysis applied to precipitation and floods*.

   i. When local rainfall data is available intensity duration frequency (IDF) curves may be developed using frequency analysis. Provide and briefly explain three key steps for the derivation of IDF curves. **[5]**

   ii. Give two methods by which precipitation is quantified and made useful for predicting runoff and stream flow within a large catchment. **[5]**

   iii. The average annual peak stream flow at a site with a 50 year record is 2000 m^3/s with a standard deviation of 300 m^3/s. Given the extreme-value frequency factor (K) of 4.1 for a 100-year recurrence interval, estimate the magnitude of the 100-year flood. **[5]**

   iv. A river is subject to annual flooding. Based on the observed annual maximum, over the last 50 years, the data plot as a straight line on a semi-log paper (provided below), with a return period plotted on the logarithmic scale. The maximum recorded flood is 1400 m^3/s and the minimum is 200 m^3/s. The design discharge selected was 1600 m^3/s. What is the probability of the design discharge being exceeded during the next 20 years? You may use the semi-log paper provided below and submit with exam workbook. **[5]**



7. Provide answers to the following questions related to the *hydrologic equation, energy budget equation* and *infiltration simulation.*

   i. Consider the hydrologic cycle and develop the general hydrologic equation. Briefly define the terms in the general hydrologic equation you developed and give a quantitative example of its use. [7]

   ii. Consider an inland lake and develop an appropriate energy budget equation where each term is given in Joules per meter squared per day [J/(m^2·d)]. Include the major factors, define them and prioritize them from most important to least important, from a quantitative perspective. [7]

   iii. The infiltration rate for excess rain on a small watershed was observed to be 100 mm/h at the beginning of a rainstorm and it decreased exponentially to an equilibrium rate of 10 mm/h after 10 h. A total of 100 in of water infiltrated during the 10 h interval. Determine the value of k in Horton's equation (below). [6]

$$f = f_c + (f_o - f_c)e^{-kt}$$

Marking Scheme

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