NATIONAL EXAMS DECEMBER 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 $8\frac{1}{2}''$ x $11''$ 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.

4. Any five (5) questions constitute a complete paper. Only the first five (5) answers as they appear in your work book(s), will be marked.

5. Each question is worth a total of 20 marks with the section marks indicated in brackets ( ) at the left margin 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.

Problem 1

Provide answers to the following questions related to *hydrologic processes, precipitation and snow melt, infiltration, evaporation and evapotranspiration.*

(i) Define the following hydrologic processes and briefly explain the importance of each component to the hydrologic cycle.

(3) (a) Evapotranspiration

(3) (b) Surface Runoff

(3) (c) Snow melt

(3) (d) Precipitation

(ii) Consider Horton's infiltration equation below.

(4) (a) Explain the meaning of the terms in Horton's equation (below).

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

(4) (b) Explain how to use Horton's equation to calculate the maximum infiltration capacity of a given soil. In your explanation, provide the necessary system information required.

Problem 2

Provide answers to the following questions related to *unit hydrographs (UH), runoff hydrographs* and *conceptual models of runoff.*

(7) (i) Give three important steps to generate a storm runoff hydrograph in a large watershed of approximately 100 km^2.

(7) (ii) Explain why a unit hydrograph (UH) reflects the drainage basin for which it was developed and provie two (2) important factors that influence the form of the hydrograph.

(6) (iii) Explain the main purpose of conceptual runoff models and provide one (1) engineering example of their use.

Problem 3

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

(6) (i) Briefly describe the *Isohyetal Analysis* technique to calculate the areal precipitation. In your answer give two (2) limitations of its use.

(6) (ii) Briefly define *Stream Stage* and *Rating Curve*. In your answer explain how each parameter is measured or developed in the field and give (1) limitation of their use for each.

(iii) Using the equation below, we may compute the amount of runoff flowing into the stream for each land use.

$$Q = \frac{P - 0.2(1000/CN - 10)^2}{P + 0.8(1000/CN - 10)}$$

(4) (a) Define the terms Q, P and CN and provide examples of how the CN values may vary with land use.

(4) (b) Briefly explain how the stream *base flow* may be measured.

Problem 4

Provide answers to the following questions related to and *reservoir and lake routing* and *statistical methods of frequency analysis applied to precipitation.*

(6) (i) Briefly explain the mass-curve method of reservoir routing. Use equations along with an explanation and/or figure to explain the steps in the method. Consider mass inflow and outflow hydrographs, along with the storage and average discharge over a given time.

(5) (ii) Briefly explain how a Type I extreme-value distribution (Gumbel) may be applied to the annual maximum series for a set of rain-gauge stations to estimate the relevant parameters of the IDF model.

(iii) Briefly define and describe the importance of the following terms related to frequency analysis applied to precipitation:

(3) (a) Probable maximum precipitation (PMP)

(3) (b) Gross and net precipitation input

(3) (c) Thiessen weights

Problem 5

Provide answers to the following questions related to *channel conveyance systems* and *basics of hydrologic modelling*.

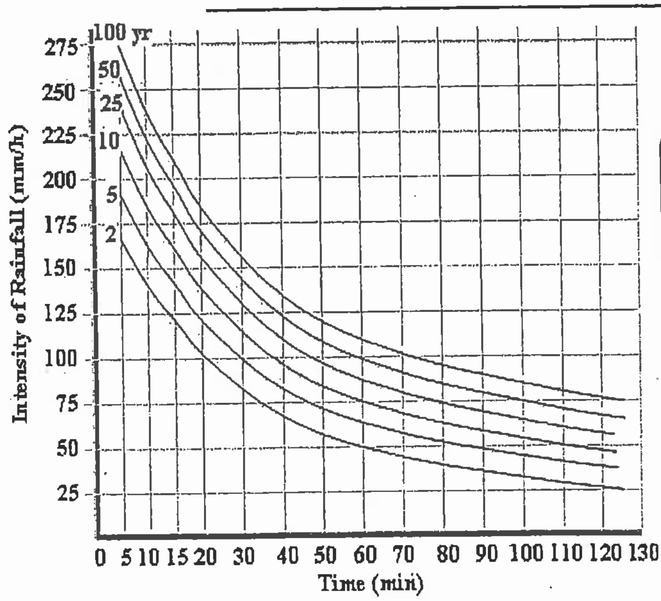
(5) (i) A rectangular channel has a Manning's roughness n of 0.020, width W of 3.0 m, channel slope S of 0.2% and a water depth D of 2.0 m. Calculate the discharge Q in m^3/h, average velocity V in m/s and Froude Number F. Is the flow in the channel subcritical or supercritical?

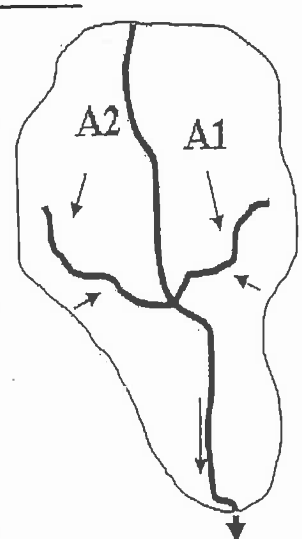
(5) (ii) A hydrologic transport model is commonly used to simulate river flow, expected flooding levels and flood return period. Give an example of a hydrologic transport model and briefly explain how such a model is calibrated.

(5) (iii) Provide three (3) key assumptions related to the rational formula $Q = C \cdot i \cdot A$. Briefly explain under what situation these assumptions are good approximations.

(5) (iv) Use the Rational Formula to determine the 50-year design peak runoff Q50 in 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 and use the following design information.

Area Label	Area (ha)	Runoff Coefficient	Time of Concentration t (min)
A1	2.5	0.6	60
A2	2.0	0.5	50





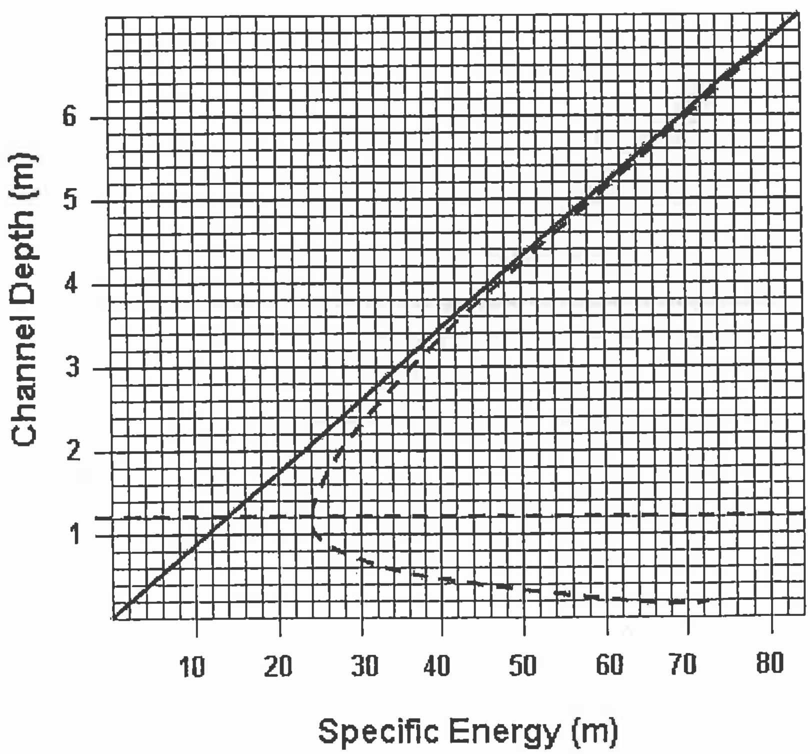
Problem 6

Provide answers to the following questions related to *flood wave behaviour* and *channel routing*.

(7) (i) The Saint-Venant hydrodynamic equations in combination with Manning's open channel equation, play an important role in the study of the flood wave behaviour in natural rivers. Briefly explain the basis of these equations, identify two (2) key parameters of the equations and how these parameters influence the complex phenomenon of flood wave propagation in a river channel.

(7) (ii) Briefly explain the Muskingum Method of river routing. In your answer explain the use of the Muskingum assumptions that $f_1(I)$ and $f_2(I-O)$ are linear. What is the main limitation of these assumptions?

(6) (iii) Using the channel depth versus energy figure below, identify the *critical depth*, the *critical energy*, the *subcritical flow region* and the *supercritical flow region.*



Problem 7

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

(i) A temporary cofferdam is to be built to protect the 10-year construction activity for a major cross valley dam. If the cofferdam is built to withstand the 25-year flood, answer the following questions.

(4) (a) What is the risk that the cofferdam will be overtopped in the first year?

(4) (b) What is the risk that the cofferdam will be overtopped at least once in the 5-year construction period?

(6) (ii) Explain three (3) key steps involved in the derivation of a regional flood index curve or index-flood method proposed by the U.S. Geological Survey or any other governmental agency.

(6) (iii) Explain the application of the *flood frequency method* to determine the peak discharge of a known frequency. For your explanation, you may consider a generally applied simulation model, the meaning of its key parameters and how they are determined. Comment on the validity of the computed peak discharge value.

Marking Scheme

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