NATIONAL EXAMS MAY 2014

04-ENV-A2 HYDROLOGY AND MUNICIPAL HYDRAULICS ENGINEERING

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 $8\frac{1}{2}'' \times 11''$ 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 *conceptual models of runoff, hydraulics of closed pipe systems* and *water distribution systems.*

(8) (i) Briefly describe two (2) main differences between a deterministic and stochastic conceptual models. For each model, describe a situation, related to runoff modelling, where one model approach is preferred over the other.

(ii) Consider water flowing though a concrete pipe having length L of 1000 m, diameter d of 500 mm and a full flow rate of 1000 L/s. Calculate the following:

(2) (a) The average fluid velocity V in m/s.

(2) (b) Reynolds number Re and type of flow (i.e., laminar or turbulent).

(2) (c) Pipe friction loss H_f in m.

(6) (iii) Briefly explain how a relief or air and vacuum valves operate within a water distribution network and give two (2) important reason why these valves are necessary.

Problem 2

Provide answers to the following questions related to *components* and *processes* of the *natural hydrologic cycle* and *stormwater collection system design.*

(7) (i) Provide a simple labelled schematic showing the natural hydrologic cycle identifying three (3) key processes and briefly explain how each process may affect the resulting runoff in a stream located in a rural watershed.

(7) (ii) Briefly explain what a drop-structure is, two (2) of its important design considerations and its primary function in a stormwater collection system.

(6) (iii) Storm sewer pipe sizing is commonly based on Manning's Equation (below). Briefly define or explain the significance of all the terms (Q, n, A, R and S) in this equation and give a consistent set of dimensions for each term:

$$Q = \frac{1}{n} \cdot A \cdot R^{\frac{2}{3}} \cdot S^{\frac{1}{2}}$$

Problem 3

Provide answers to the following questions related to *precipitation and snow melt*, *wastewater collection system* and *infiltration storm frequency and duration analysis*.

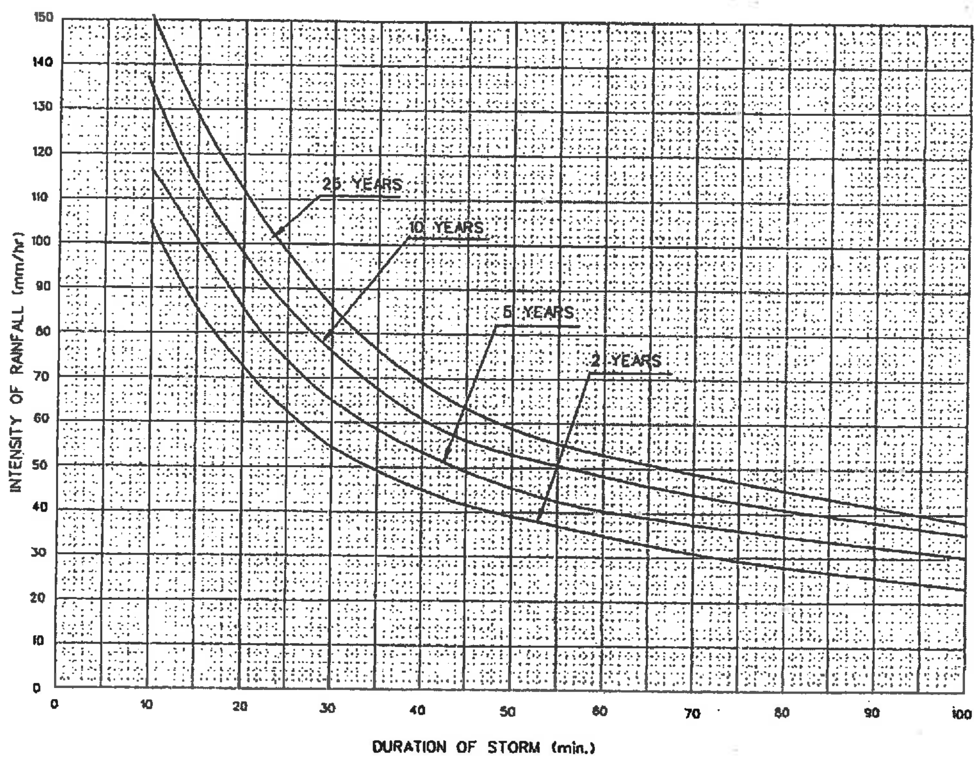
(6) (i) Briefly explain two (2) engineering methods that may be used to incorporate snow melt in the design of hydraulic structures. In your explanation, you may consider the design of a structure used to reduce the impacts of snow melt and Spring flooding in a mountainous region.

(6) (ii) Briefly explain the function or importance of the following components of a wastewater collection system:

(a) Sanitary interceptor; and

(b) Combined sewer system pumping station overflow;

(8) (iii) Give an example of the use of the Intensity Duration Frequency (IDF) curves (below) in the design of a stormwater infiltration system to deal with runoff from a large parking lot during a 25-year return storm event.



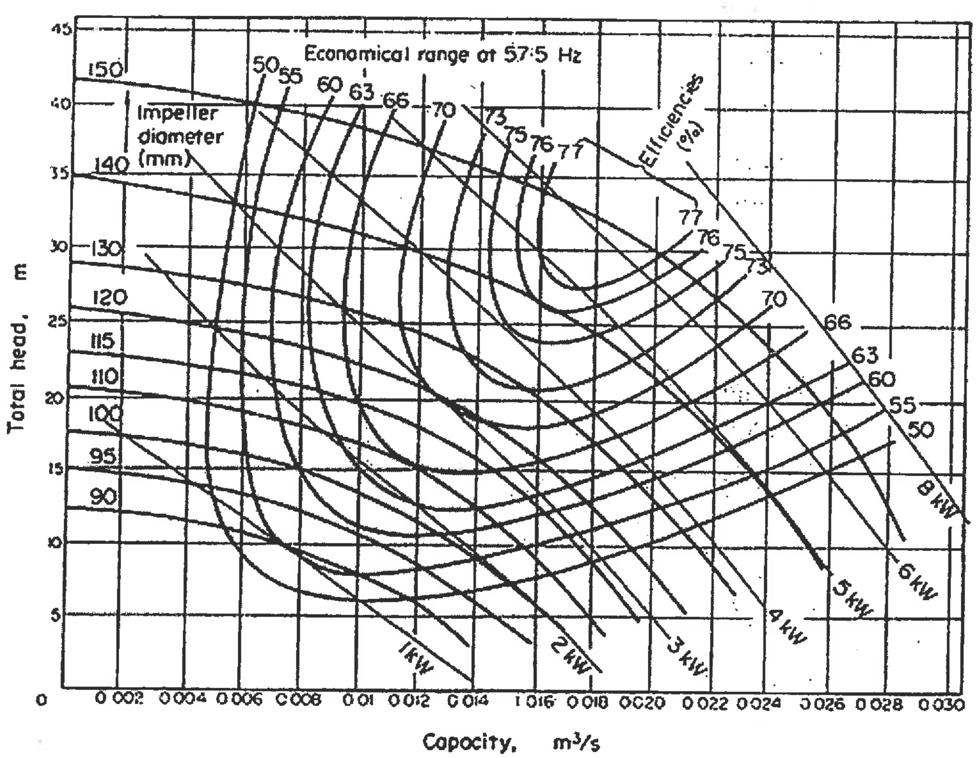
Problem 4

Provide answers to the following questions related to *stream flow and hydrograph analysis* and *basic pumps or prime movers.*

(6) (i) Briefly explain the concepts of recession curve, base flow and direct runoff as it relates to a runoff hydrograph and stream flow. Provide a simple labelled schematic of a typical runoff hydrograph.

(6) (ii) Briefly explain two (2) main factors that affect the hydrograph shape and explain how these factors impact the hydrograph analysis.

(8) (iii) Assume an impeller diameter change from 95 mm to 130 mm. With reference to the pump characteristic curve (below), determine the new optimum capacity (m^3/s), the head (m), the brake horse power (kW), pump efficiency expected and the percent pump capacity improvement (%).

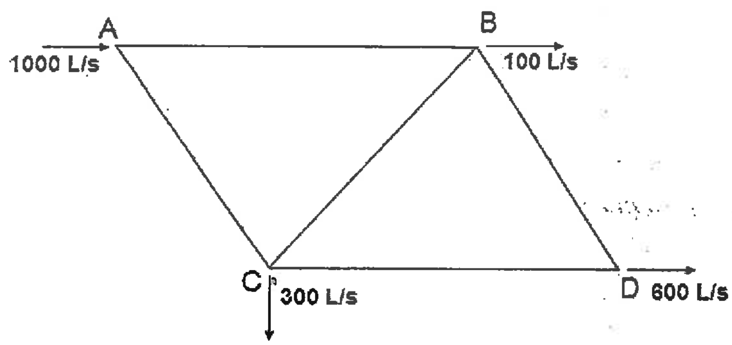


Problem 5

Provide answers to the following questions related to *pipe networks*, *network design* and *sanitary sewers design*.

(10) (i) Solve for the flows in each pipe of the pipe network below (not to scale) using the Hardy-Cross or similar method, given the following pipe lengths (L) and corresponding diameters (d):

Pipe	Length (m)	Diameter (mm)
AB	500	400
BC	700	250
CD	500	200
AC	700	350
BD	500	300



(5) (ii) Briefly provide one (1) condition and an advantage of using gravity, pressure and vacuum sanitary sewers. A total of three (3) conditions and corresponding advantages should be provided.

(5) (iii) Explain the meaning and dimensions of the terms M and p in the Harmon Formula (below).

$$M = 1 + \frac{14}{4 + p^{1/2}}$$

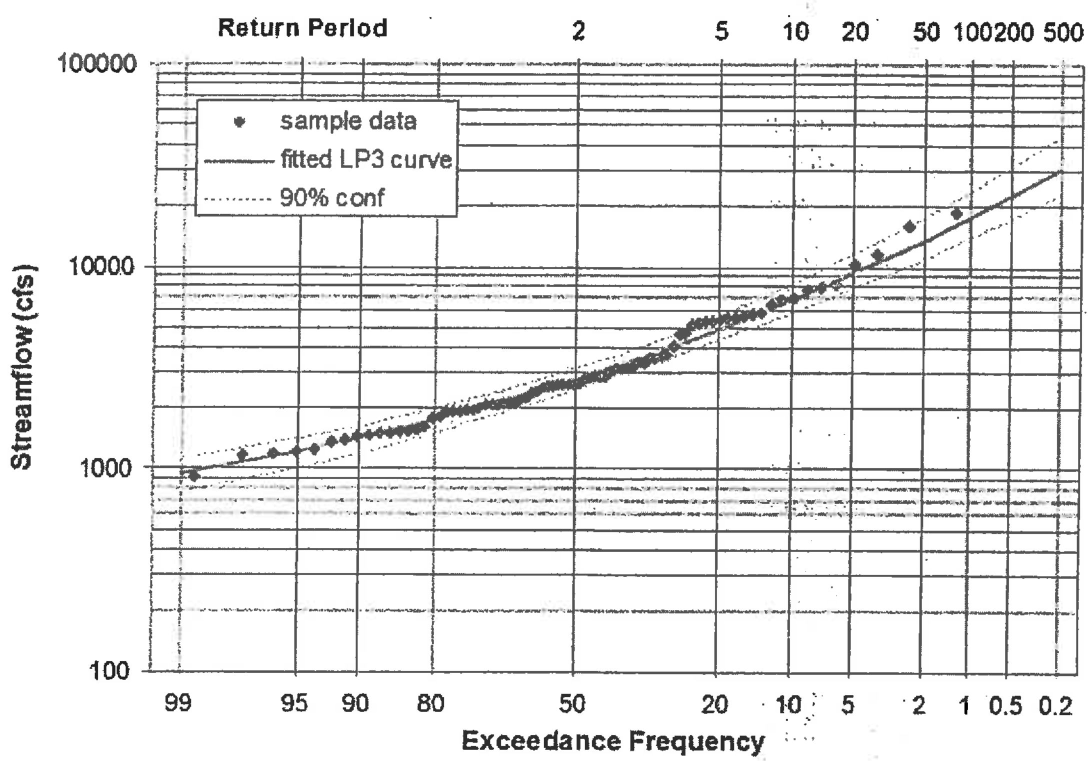
Problem 6

Provide answers to the following questions related to *urban drainage with runoff control system design, frequency and probability analysis related to precipitation, floods and droughts*.

(6) (i) Stormwater best management practices (BMPs) suggest that it a good principle to hold runoff for a period of time. Provide three (3) reasons why the use of stormwater management wet ponds meet this BMP principle.

(6) (ii) Select an on-site and an off-site runoff control system and briefly explain two (2) key design principles necessary to ensure good system performance for each of the two (2) systems.

(8) (iii) Flooding occurs when streams overtop their banks and downstream areas are flooded. These historical events are recorded and flood frequency historical curves (similar the one below) are generated for engineering designs. Briefly explain how these curves are used in the design of hydraulic structures used as flood protection measures.



Problem 7

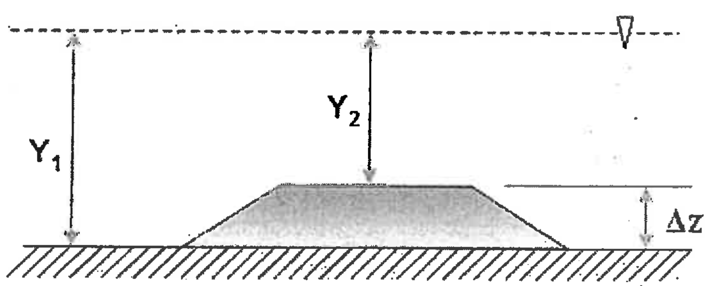
Provide answers to the following questions related to *open channel flows* under *uniform* and *gradually varied flow* conditions and *sediment transport.*

(i) A grass lined trapezoidal channel experiences uniform flow at a normal depth of $5m$. The base width is 10 m and the side slopes are equal at a H:V of 1:5. Using an appropriate Manning's n and a bed slope S_o of 4 % calculate the following:

(3) (a) The discharge flow rate Q in m^3/s; and

(3) (b) Reynolds number Re and type of flow (i.e., laminar or turbulent).

(8) (ii) Assume that the channel has a flowrate of 30 m^3/s at a normal flow depth Y_1 of 4 m. Calculate the depth of flow Y_2 in a section of the channel, 7 m downstream, in which the bed rises ΔZ equal to 1.5 m. Consider the figure below, assume frictional losses are negligible and you may use the *specific energy* equations at the two sections 1 and 2.



(6) (iii) In the study of hydraulics of alluvial channels, the engineers are often interested in finding the quantity of water and the sediment load carried by the stream under given hydraulic conditions. Draw a force diagram to explain how the following equation (below) may be used to determine the incipient sediment motion in a stream. Recall ϕ, W, α, F_D and F_L refer to the angle of repose, the weight of the particles, the inclination of the bed, drag and lift forces, respectively.

$$tan\phi = \frac{W \cdot sin\alpha + F_D}{W \cdot cons\alpha - F_L}$$

Marking Scheme

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