NATIONAL EXAMS DECEMBER 2009

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 2-sided ($8\frac{1}{2}'' \times 11''$) AID SHEET prepared by the candidate allowed.

3. The candidate may use one of two calculators, the Casio or Sharp approved models. Note that you must indicate the type of calculator being used. 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 equally weighted at twenty (20) points for a total of a possible one-hundred (100) points for a complete paper.

Problem 1

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

(i) Define the following hydrologic components, briefly explaining the importance of each component to the hydrologic cycle.

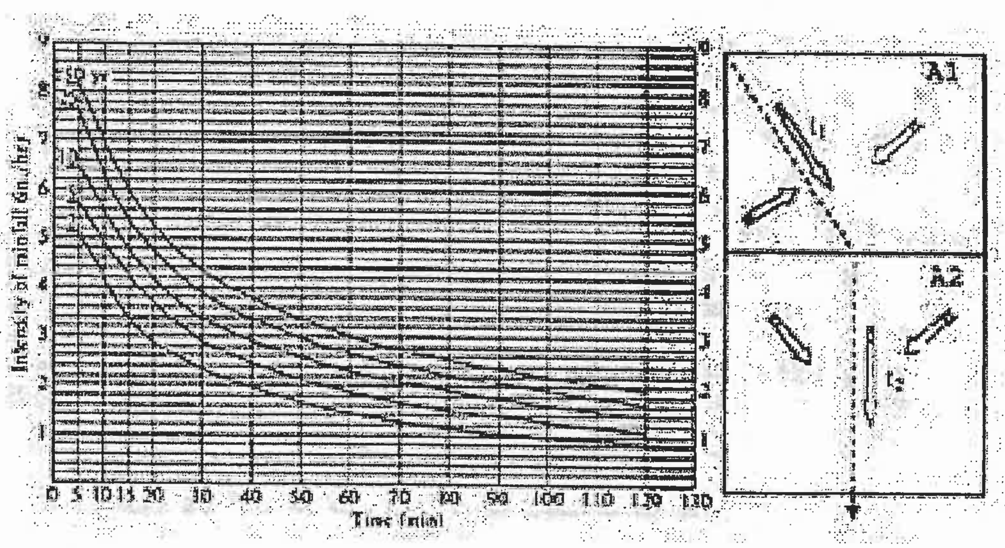
(3) (a) Infiltration;

(3) (b) Precipitation; and

(3) (c) Transpiration

(6) (ii) Use the Rational Formula to determine the 25-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.

Area Label	Area (*ha*)	Runoff Coefficient C	Time of Concentration t (*min*)
A1	15	0.7	70
A2	20	0.5	90



(5) (iii) The Rational Formula is typically used to determine the peak runoff of small watersheds. Provide three (3) assumptions made by the Rational formula and explain how the modified rational formula may improve the estimate of the peak runoff by including a storage coefficient in the formulation.

Problem 2

Provide answers to the following questions related to *conceptual rainfall-runoff models*, *streamflow* and *probability frequency hydrograph analysis* related to *floods*.

(4) (i) Identify two (2) typical components of a conceptual rainfall-runoff model and briefly explain two (2) advantages of a conceptual model over a physical or black-box rainfall-runoff models.

(ii) Briefly describe the importance of the following terms related to *streamflow*:

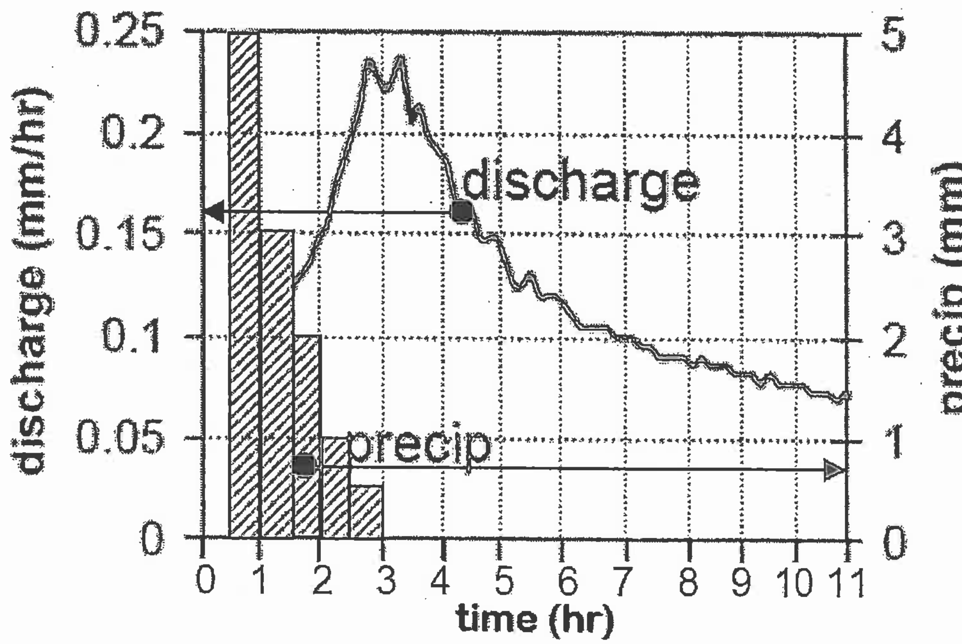
(4) (a) Log recession curve method; and

(4) (b) Stream flow hydrograph.

(iii) Consider the diagram below showing the rainfall (vertical bars) and the streamflow (curve) with respect to the time in hours (hr) and calculate the following:

(4) (a) The approximate *direct runoff* in ft^3 and m^3; and

(4) (b) The approximate *runoff from detention storage* in ft^3 and m^3.



Problem 3

Provide answers to the following questions related to *hydraulics of closed pipe systems* and *open channel flows* under *uniform* and *gradually varied flow* conditions.

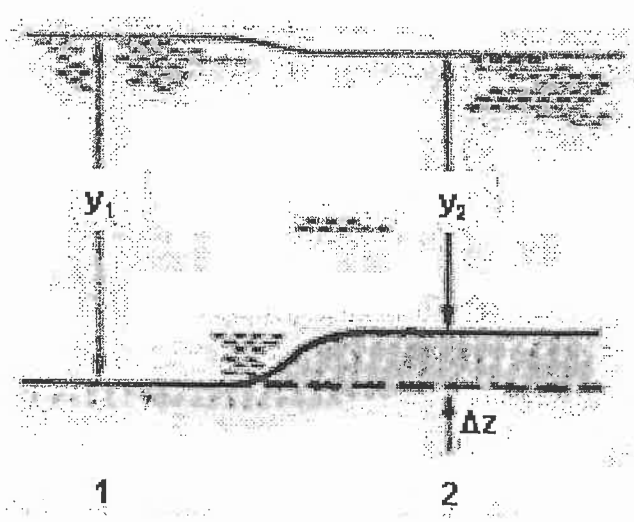
(4) (i) A 1000 m pipeline carries a flow of 50 m^3/h. Explain what effect increasing the pipe diameter and increasing the length of the pipeline will have on the pressure loss. In each case use appropriate equations to justify your answer.

(ii) A clay tile lined rectangular channel with a base width of 5 m experiences uniform flow at a normal depth of 4 m. Using an appropriate Manning's n and a bed slope S_o of 3 % calculate the following:

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

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

(8) (iii) Assume that the channel has a flowrate of 10 m^3/s at a normal flow depth y_1 of 3 m. Calculate the depth of flow y_2 in a section of the channel in which the bed rises Δz equal to 0.7 m. See figure below and assume frictional losses are negligible. You may consider the *specific energy* at the two sections 1 and 2 to assist you in answering the questions.

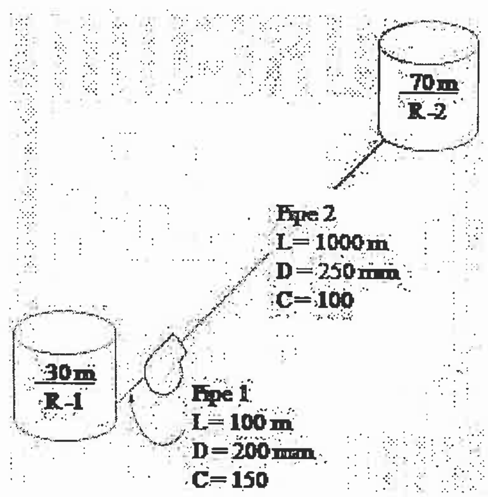


Problem 4

Provide answers to the following questions related to *water distribution systems, storage reservoirs* and the *design of sanitary sewers.*

(5) (i) Water hammer is a common occurrence in water distribution systems. Briefly explain the fundamental cause of water hammer, its effects on pumps and two (2) potential remedies to reduce or eliminate water hammer in a water distribution system.

(5) (ii) Determine the approximate pump head in m needed to deliver water from reservoir R-1 to reservoir R-2 (see figure below) at a rate of 1000 L/s. Compute the friction head losses using the Hazen-Williams equation and pipe characteristics (L, D and C) provided in the figure.



(5) (iii) The demand to reservoir 2 (R-2) is doubled to 2000 L/s during a fire that lasts 4-hours. Briefly describe (no detailed calculations are necessary) two methods that would allow the systems to satisfy this demand and, in your description, provide one advantage and one disadvantage for each method.

(5) (iv) You have been asked by the project manager to design a sanitary sewer to convey a peak flow of 10 m^3/s when flowing 75% full with a bedding slope of 5%. The senior engineer advises that the flow velocity must be greater than 1 m/s and less than 7 m/s and that a concrete pipe with a Manning's n of 0.02 is to be used. Calculate the required diameter d in mm for this sewer.

Problem 5

Provide answers to the following questions related to, *network design* and the *wastewater collection system.*

(10) (i) Briefly explain the Hardy Cross or similar method used in network designs. In your answer, explain how the concept of conservation of mass and energy are used to arrive at a solution.

(10) (ii) Briefly explain the design basis for a typical wastewater force-main as part of a wastewater collection system. In your explanation, describe how cavitation can be avoided by proper design.

Problem 6

Provide answers to the following questions related to *urban stormwater management* and *runoff control system design.*

(10) (i) Briefly explain the difference between wet-ponds and dry-ponds, in stormwater management applications and under what conditions one type of pond is preferred over the other. In your explanation provide the key design objectives for each.

(10) (ii) Describe an effective urban storm runoff control system by giving the design basis and objectives that it needs to comply with. Besides proper design, what is necessary to ensure long term performance to comply with the effluent objectives?

Problem 7

Provide answers to the following questions related to *stormwater collection system design* and *basic pumps or prime movers*.

(i) Briefly answer the following related to *stormwater collection system design*:

(4) (a) Briefly explain why combined sewer overflows (CSOs) occur in a combined sewer system and what can be done to reduce CSOs or minimize their environmental impacts;

(4) (b) Briefly explain how the intensity-duration frequency curves are used in the design of stormwater collection systems; and

(2) (c) Briefly explain one important difference between sanitary and stormwater collection system design.

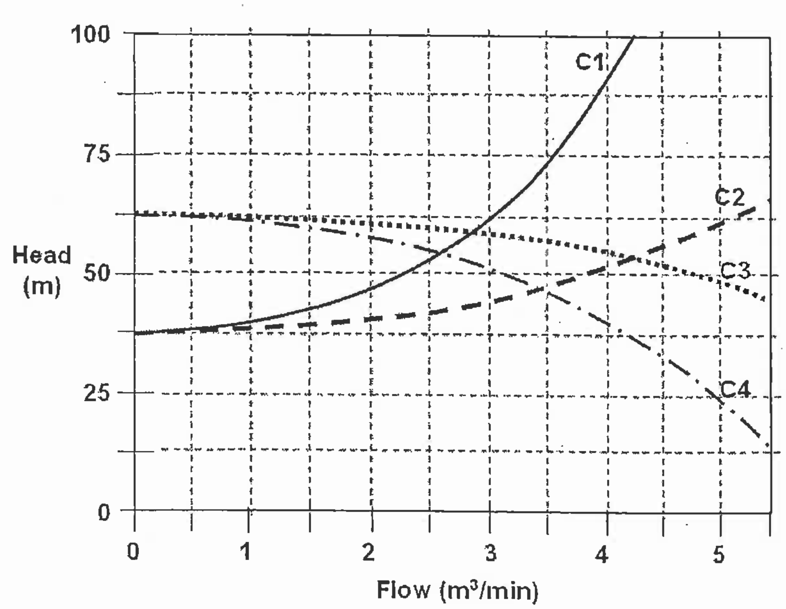
(ii) Answer the following questions, related to *basic pumps*, by considering the figure below:

(2) (a) Identify the one-pump curve with the corresponding system operating points;

(2) (b) Identify the two-pump curve with the corresponding system operating points;

(2) (c) Identify the system curve with ample pipe capacity and the one with limited pipe capacity; and

(4) (d) Briefly explain, when two pumps are operated in parallel, why the combined flow (Q_s in m^3/min) delivered is not simply the flows of the individual pumps added together and why the total flow capacity depends on the system curve.



Marking Scheme

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