NATIONAL EXAMS MAY 2013

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 $8\frac{1}{2}''$ 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 *sanitary sewers design*, *runoff control system design* and *probability frequency hydrograph analysis* related to *floods*.

(7) (i) You have been asked by the project manager to design a sanitary sewer to convey a peak flow of 100 m^3/s when flowing 100% full with a bedding slope of 6%. The senior engineer advises that the flow velocity must be greater than 0.7 m/s and less than 10 m/s and that a concrete pipe with a Manning's n of 0.020 is to be used. Calculate the required sewer diameter in m under the stipulated conditions and check that all the conditions are met.

(6) *(ii) Briefly describe* two (2) different off-site stormwater runoff control systems. Compare the design, operation and maintenance issues for each system, from the perspective of a municipality that is expected to operate and maintain these systems for a 25-year design life. Provide two (2) key recommendations as to a strategy that the municipality should adopt to ensure the long term viability of the systems.

(7) *(iii) Given the maximum* annual instantaneous flows form the French River in Quebec, Canada over a 12-year period (below), *explain the method* of fitting this data to a curve of best fit to determine the magnitude of the flood equaled or exceeded once in 25, 50 or 100 years .

Year	River (m^3/s)	Year	River (m^3/s)	Year	River (m^3/s)
1940	430	1944	480	1948	750
1941	500	1945	350	1949	600
1942	650	1946	650	1950	550
1943	750	1947	750	1951	500

Problem 2

Provide answers to the following questions related to *stormwater collection system design* and *wastewater collection system design* and *precipitation and snow melt*.

(8) (i) Considering that all piped collections systems leak and are susceptible to inflow and infiltration over time. Assuming that you are a municipal engineer in charge of the design of the storm and sanitary sewer collection systems, provide one (1) environmental issue and one (1) potential solution for each of the the four (4) conditions identified in the matrix below. Complete the matrix by providing answers to the four conditions. **Note that you should provide four (4) different issues and four (4) different potential solutions; both 'hard' or 'soft' engineering solutions are acceptable.**

"Design Implications and Environmental Protection Issues and Solutions"	Surface Water Inflow	Ground Water Inflow
Storm Sewers		
Sanitary Sewers		

(8) (ii) Briefly explain the function or importance of the following components/concepts as related to precipitation and snow melt:

(a) Major versus minor surface runoff control systems in dealing with precipitation; and

(b) A method to predict runoff associated with snow melt

(4) (iii) Briefly explain the function or importance of the following components of a wastewater or stormwater collection system from a design and operational point of view:

(a) Sanitary emergency overflow at a pumping station; and

(b) Storm cyclone grit chamber

Problem 3

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

(7) (i) Provide a schematic showing the natural hydrologic cycle identifying four (4) key components and briefly explain four (4) main interactions.

(7) (ii) Briefly explain the interaction of the intensity-duration frequency analysis and the hydrologic cycle in the design of the 'major' stormwater collection systems.

(6) (iii) Briefly explain two (2) important linkages between the hydrologic cycle and 'minor' stormwater collection systems.

Problem 4

Provide answers to the following questions related to *hydraulics of closed pipe systems*, *water distribution systems* and *conceptual models of runoff*.

(6) (i) Consider water flowing though a PVC pipe having length L of 1000 m , diameter d of 500 mm and a full flow velocity of 2 m/s. Calculate the following:

(a) The average flow rate Q in m^3/min.

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

(c) Pipe head loss H_f in m.

(8) (ii) Calculate or explain the process to calculate the high lift pump(s) rated capacity (i.e., located at the water treatment plant) to service a community of 10,000 population equivalent. Consider both average day and peak day demands.

(6) (iii) Briefly describe two (2) important properties of conceptual models of runoff and how they differ (in the two (2) important properties that you mention) from analytical models of runoff.

Problem 5

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

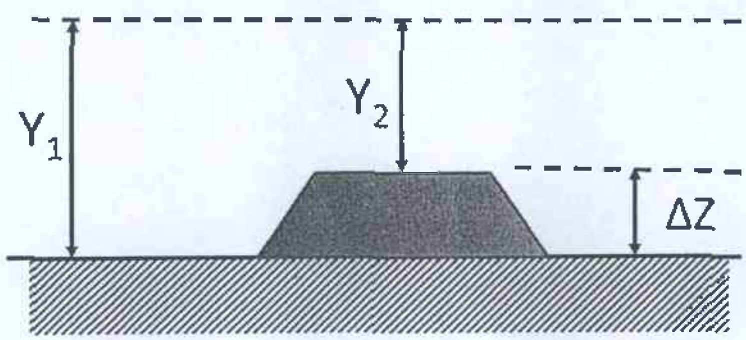
(8) (i) Explain the derivation and use of the stage-discharge approach in predicting streamflow. In your explanation, discuss two (2) key parameters that affect the confidence level of the predicted streamflow over a 25-year period.

(6) (ii) A rock lined trapezoidal channel experiences uniform flow at a normal depth of 2 *m*. The base width is 10 *m* and the side slopes are equal at a H:V of 1:3. Using an appropriate Manning's n and a bed slope S_o of 4 % calculate the following:

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

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

(8) (iii) Assume that the above mentioned channel has a flowrate of 25 m^3/s at a normal flow depth Y_1 of 2 *m*. Calculate the depth of flow Y_2 in a section of the channel, 20 *m* downstream, in which the bed rises Δz equal to 0.5 *m*. Consider the figure below and assume frictional losses are negligible.



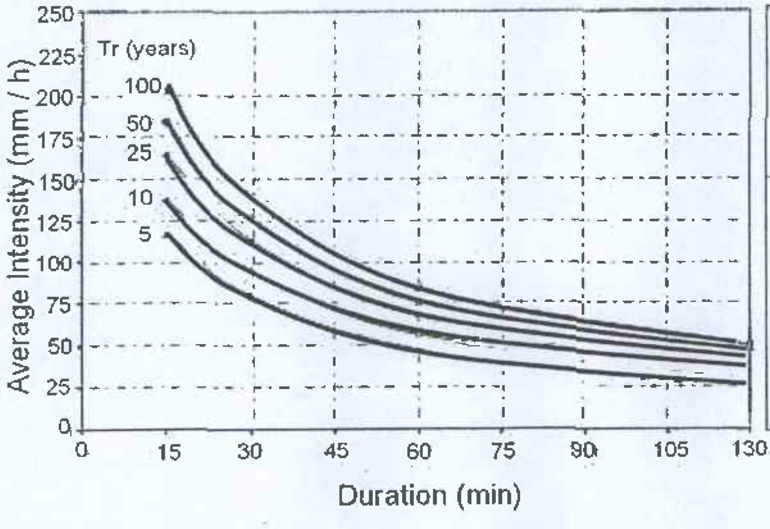
Problem 6

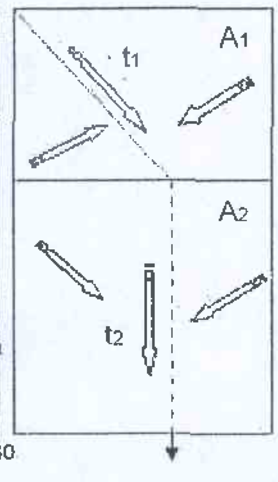
Provide answers to the following questions related to *urban stormwater management* and *intenisty-duration frequency (IDF) analysis curves*.

(10) (i) Explain the basic design approach for a *stormwater wet pond* for the quantity and quality control of surface runoff from an urban watershed. Assume that the primary objective is quality control (i.e., both solids, temperature, dissolved organic contaminants and nutrients) to the downstream sensitive water body known to have a valuable cold-water fish habitat.

(10) (ii) Use the Rational Formula to determine the 50-year design peak runoff (m^3/s) 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	30	0.7	60
A2	40	0.8	70





Problem 7

Provide answers to the following questions related to *pipe networks* and *basic pumps or prime movers*.

(5) (i) Analysis of water distribution systems includes determining quantities of flow and head losses in the various pipe lines and the resulting residual pressures. In any pipe network explain what two (2) important conditions must be satisfied and why.

(5) (ii) Briefly explain two (2) fundamental steps in the use of the Hardy-Cross Method to design water pipe networks, one (1) key assumption and one (1) practical step to consider in full scale applications.

(10) (iii) Explain four (4) key steps in the selection and design of a centrifugal pump system used for the distribution of treated water from a water treatment plant. The water treatment plant is located at a lake shore and needs to pump to a small town over a maximum static head of 100 m and maximum distribution length of 5 km. As part of your explanation provide a sample system pump-head curve, appropriately labeled, with the key design parameters clearly identified.

Marking Scheme

04-Env-A2

Hydrology and Municipal Hydraulics Engineering

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