NATIONAL EXAMS MAY 2019

18-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 200 m^3/s when flowing 100% full with a bedding slope of 5%. The senior engineer advises that the flow velocity must be greater than 0.6 m/s and less than 8 m/s and that a PVC pipe with a Manning's n of 0.015 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 on-site stormwater runoff control systems. Compare the design, operation and maintenance issues for each system assuming that the systems are to be maintained for a 25-year design life.

(7) (iii) The USGS flood information service recommends the logarithmic Pearson type III distribution for the probability frequency analysis procedure to predict annual maximum (floods) and minimum stream flows. Provide three (3) reasons why the logarithmic Pearson type III distribution is particularly useful and one (1) limitation of its application.

Problem 2

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 three (3) key components and briefly explain two (2) main processes necessary to replenish a natural groundwater aquifer.

(7) (ii) Briefly explain the use of the intensity-duration frequency (IDF) curves in the design of the minor stormwater collection systems used to convey the flow for a storm event. Recall the Rational formula ($Q = C \cdot i \cdot A$).

(6) (iii) Briefly explain two (2) important linkages between the hydrologic cycle and the 'major' stormwater collection systems. Consider that the major stormwater collection system serves an urban watershed with the potential for downstream flooding and erosion unless the stormwater is properly controlled.

Problem 3

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

(8) (i) Compare by providing three (3) main design, operation or maintenance differences between stormwater (major or minor) and wastewater collection system design.

(4) (ii) Briefly explain two (2) important reasons to utilize a sanitary forcemain and pumping station within a sanitary collection system.

(8) (iii) Briefly explain three (3) differences when predicting the runoff associated with rain (precipitation) versus runoff associated with snow melt.

Problem 4

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

(7) (i) Consider water flowing though a steel pipe ($n = 0.015$) having length L of 2000 m, diameter d of 400 mm and a full flow velocity of $4 m/s$. Calculate the following:

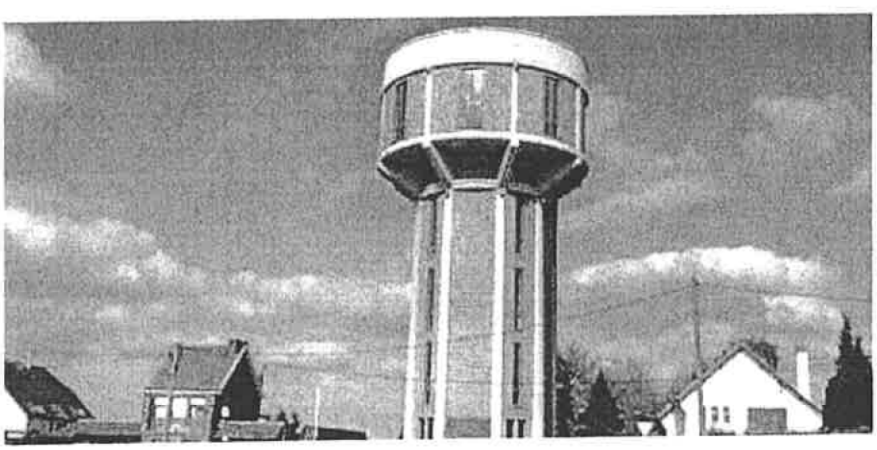
(a) The average flow rate Q in m^3/min.

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

(c) Pipe head loss H_f in m.

(6) (ii) Briefly describe three (3) main functions, operations or design aspects of *distribution storage tanks* within water distribution systems. Note that only three (3) aspects in total need to be described briefly.

(7) (iii) Give an example of a conceptual model of runoff, briefly explain its use and give two (2) limitations of its use in engineering design.



Problem 5

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

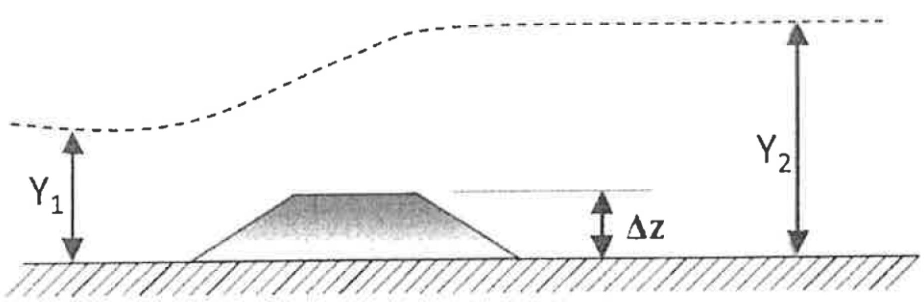
(7) (i) Streamflow measurements involves obtaining a continuous record of stage, making periodic discharge measurements, establishing and maintaining a relationship between the stage and discharge, and applying the stage-discharge relationship to the stage record to obtain a continuous record of discharge. Explain the derivation and use of the stage-discharge approach in predicting streamflow. In your explanation, also discuss two (2) key parameters that affect the long term (25 years into the future) streamflow prediction.

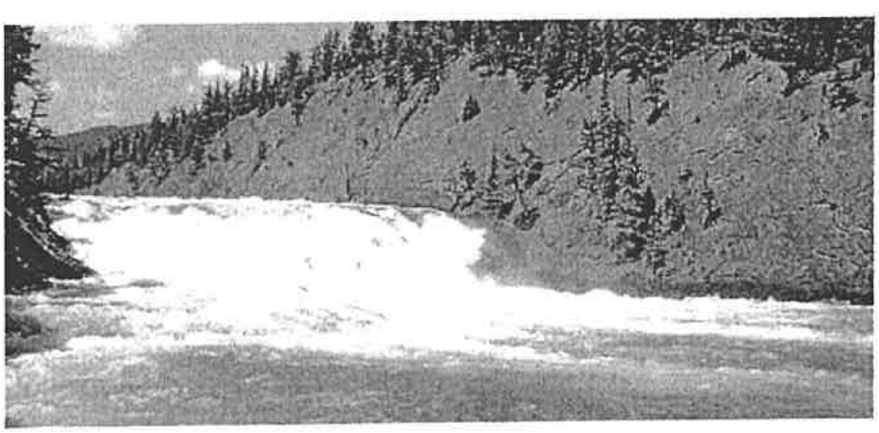
(6) (ii) A concrete lined trapezoidal channel experiences uniform flow at a normal depth of 2.5 m. The base width is 8 m and the side slopes are equal at a H:V of 1:4. Using an appropriate Manning's n and a bed slope S_o of 3 %, calculate the following:

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

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

(7) (iii) Assume that the above mentioned channel has a flowrate of 50 m^3/s at a normal flow depth Y_1 of 2.5 m. Calculate the depth of flow Y_2 in a section of the channel, 30 m downstream, in which the bed rises Δz equal to 0.6 m. Consider the figure below and assume frictional losses are negligible.





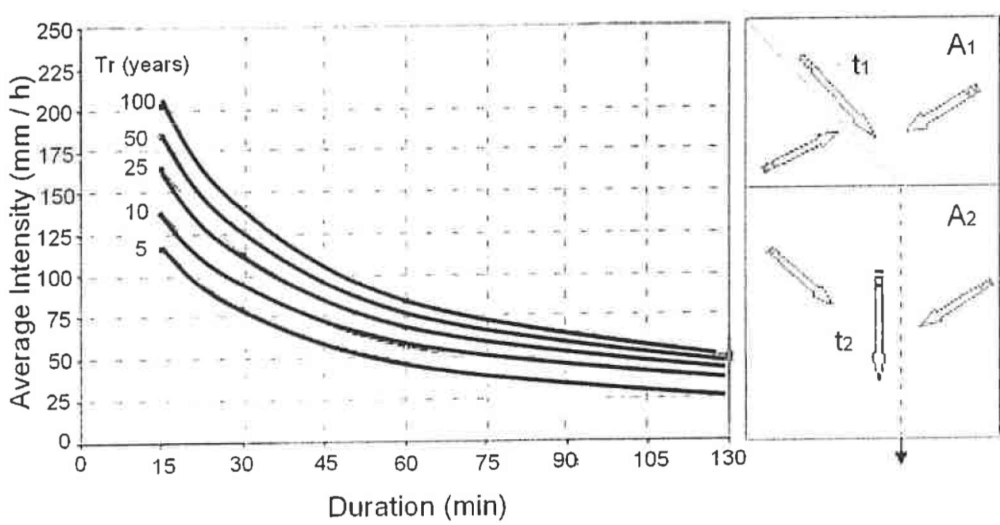
Problem 6

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

(10) (i) Explain the basic design approach for a *stormwater dry pond* for quantity control of surface runoff from an urban watershed. Assume that the primary objectives are downstream erosion control and flooding prevention to a low lying residential development.

(10) (ii) Use the Rational Formula to determine the 100-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	40	0.5	50
A2	60	0.6	80



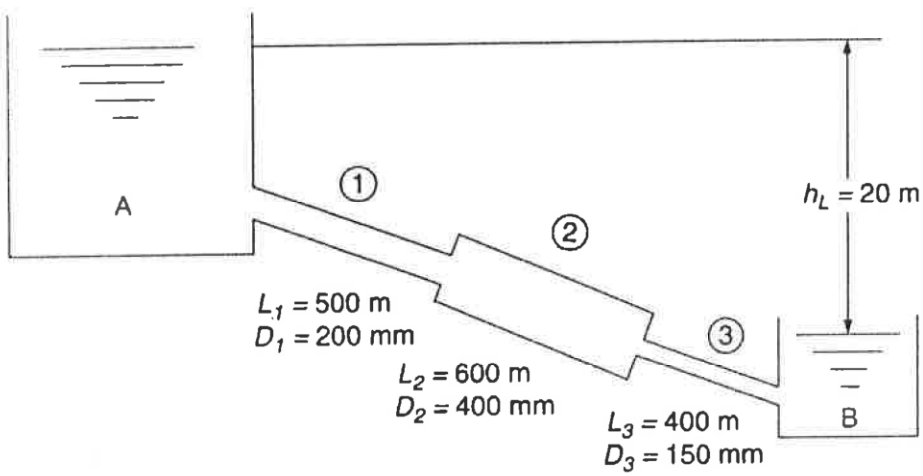
Problem 7

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

(6) (i) Calculate the equivalent pipe diameter (D_e) and the corresponding flow (Q) for the arrangement of three pipes in series between tank A and B in the figure below. Use the information provided in the figure, assume Darcy-Weisbach's friction factor $f = 0.03$ and ignore entry and exit (minor) losses. Recall the following equations:

$$D_e = \left(\frac{\sum_{i=1}^{N} L_i}{\sum_{i=1}^{N} \frac{L_i}{D_i^5}} \right)^{0.2} \qquad K_e = \left[\frac{8fL_e}{\pi^2 g D_e^5} \right] \qquad Q = \left[\frac{h_L}{K_e} \right]^{0.2}$$

where $L_e = \sum L_i$ and K_e is a pipe constant.



(7) (ii) Briefly explain three (3) main steps in solving a branched water network using the Hardy-Cross Method. In you explanation, use equations and figures, as appropriate, to clearly present the main steps.

(7) (iii) Provide a figure showing four (4) key points of an example system-pump curve for two (2) pumps in parallel. The figure should be clearly labelled and should clearly identify the single pump and dual pump characteristic curve, the system curve, the operating point (B) and the shutoff head (H_o)

Marking Scheme

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