NATIONAL EXAMS MAY 2018

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.

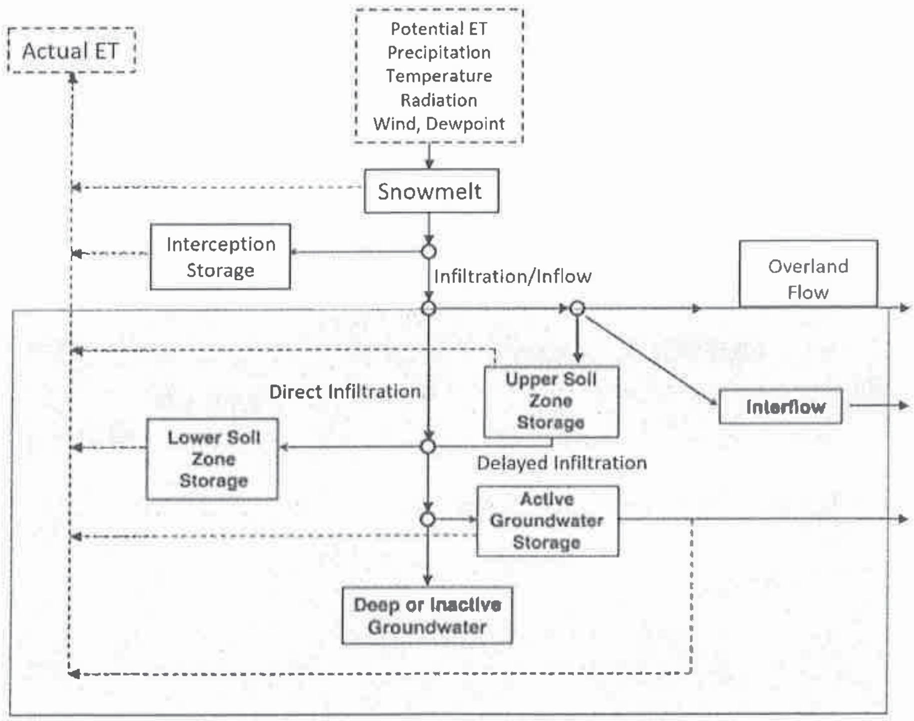
4. Any five (5) questions constitute a complete paper. Only the first five (5) answers as they appear in your work book(s), will be marked.

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 *conceptual models of runoff*, *hydraulics of closed pipe systems* and *water distribution systems*.

(8) (i) The figure below shows a conceptual model schematic used to model pervious land flow with multiple storage processes. State the water balance equation and briefly explain how the water balance equation is integrated into this conceptual model.



(ii) Consider water flowing though a PVC pipe having length L of 100 m , diameter d of 200 mm and a full flow rate of 50 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 three (3) functions of a low-lift pumping station located within a water treatment plant.

Problem 2

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

(6) (i) Briefly explain two (2) important insights that understanding the hydrological cycle may provide to design a warning system to notify a municipality of potential flooding. Consider that the municipality is located in a valley of a mountainous region with potential flooding associated with heavy precipitation and snow melt.

(6) (ii) Briefly explain the function or importance of the following components/concepts of a stormwater collection system design:

- (a) Stormwater catch basin;
- (b) Minor system; and
- (c) Inlet control device (ICD)

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

- (a) Sanitary vacuum sewer;
- (b) Inverted syphon; and
- (c) Sanitary forcemain

Problem 3

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

(8) (i) Provide a schematic showing the natural hydrologic cycle identifying three (3) key components and processes that influence the amount of surface runoff during a major storm event.

(6) (ii) Briefly explain two (2) different ways in which soil moisture affects the total surface runoff during a sequence of storm events that occur within hours of each other. State clearly any assumptions made and you may provide a schematic and/or equations to support your answer.

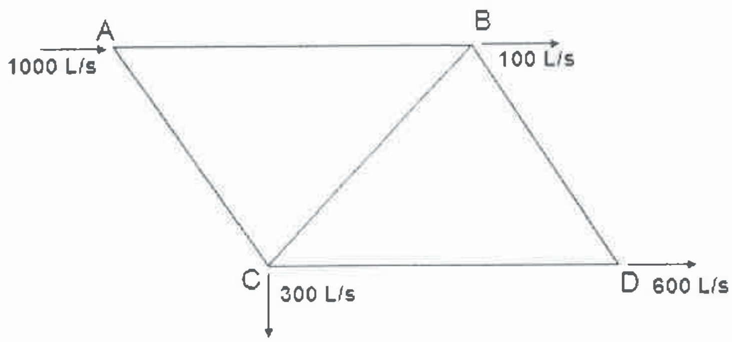
(6) (iii) Briefly explain two (2) causes of sediment transport and two (2) ways to reduce sediment transport to a river system located downstream from an urbanized area.

Problem 4

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

(8) (i) Solve for the flows in each pipe of the pipe network below using the Hardy-Cross or similar method, given the following pipe lengths (L) and corresponding diameters (d):

Pipe	Length (m)	Diameter (mm)
AB	400	300
BC	600	350
CD	500	300
AC	600	350
BD	500	300



(4) (ii) Define pressure head and explain why the theoretical pump lift is generally less than what is possible due to cavitation.

(4) (iii) Describe the principle of a positive displacement pump and how it is able to deliver a constant volume of fluid in a cycle.

(4) (iv) Provide a schematic of a typical system head curve for two (2) pumps in series. Label the head/flow curve, the system curve and the operating point.

Problem 5

Provide answers to the following questions related to *sanitary sewers design*, *runoff control system design* and *probability frequency hydrograph analysis* related to *floods*.

(8) (i) You have been asked by the project manager to design a sanitary sewer to convey a peak flow of 5 m^3/s when flowing 85% 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 8 m/s and that a plastic pipe with a Manning's n of 0.014 is to be used. Calculate the required diameter in mm for this sewer.

(6) (ii) Briefly describe three (3) important design features of an off-site stormwater runoff quantity or quality control system (select only one type). Provide one (1) advantage and one (1) disadvantage of using an off-site system compared to an on-site stormwater control system.

(6) (iii) Given the maximum annual instantaneous flood flow levels from the French River, Ontario over a 15-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 100 years. Note that you only need to explain the method.

Water Year	Discharge (m^3/s)	Water Year	Discharge (m^3/s)	Water Year	Discharge (m^3/s)
1930	300	1935	450	1940	600
1931	400	1936	350	1941	500
1932	500	1937	500	1942	500
1933	600	1938	600	1943	400
1934	450	1939	800	1944	250

Problem 6

Provide answers to the following questions related to *urban drainage* and *stream flow*.

(7) (i) Urban drainage may be controlled through a *combined* or *separated collection system*. Briefly describe two (2) main differences between the two (2) systems and explain under what conditions each system is preferred over the other.

(7) (ii) Explain two (2) key design measures of a *stormwater pond* designed to improve the quality of stormwater runoff detained and treated prior to being discharged to the nearby lake used for swimming. Assume that the main objective of the treatment was to effectively reduce total suspended solids (TSS) that may include microbial contaminants. Clearly state any assumptions made and provide diagrams or equations to support your answer.

(6) (iii) Briefly describe two (2) quantitative techniques to predict the future stream flow from the contributing watershed and provide one (1) advantage of using one technique compared to the other.

Problem 7

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

(i) A concrete lined trapezoidal channel experiences uniform flow at a normal depth of 3 m. The base width is 12 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 2 % calculate the following:

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

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

(2) (c) The hydraulic radius R_h in m.

(6) (ii) Briefly explain supercritical, critical and subcritical flow in relation to open channel flow and how each type of flow is explained by the Froude number (F_r) value. Give an expression of F_r as part of your explanation.

(6) (iii) Water flows under a sluice gate in a horizontal ($z = 0$) rectangular channel that is 3 m wide. If the depths of the flow before and after the gate are 5 m and 1 m, respectively, what is the discharge Q in m^3/s. Recall the energy equation between two sections (below) and assume $\alpha_1 = \alpha_2 = 1$ for a sluice gate:

$$z_1 + y_1 + \alpha_1 \frac{V_1^2}{2g} = z_2 + y_2 + \alpha_2 \frac{V_2^2}{2g}$$

Marking Scheme

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