NATIONAL EXAMS - May 2017

16-Civ-B4, Engineering Hydrology

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.

Marking Scheme

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

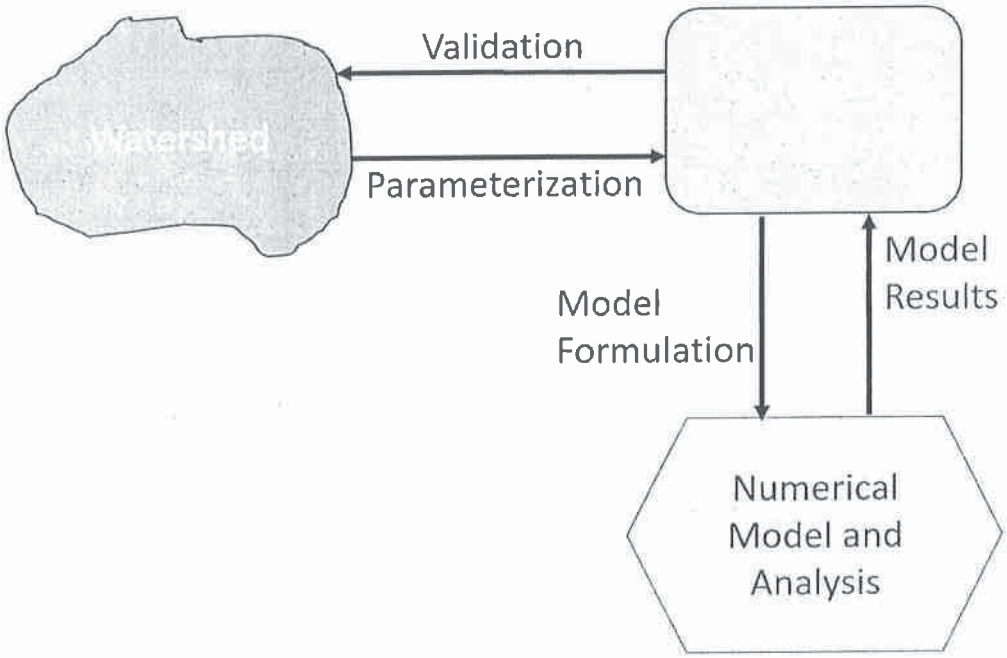
Problem 1

Provide answers to the following questions related to *runoff hydrographs*, *unit hydrographs* and *conceptual models of runoff*.

(6) (i) Briefly explain two (2) main assumptions in the use of a runoff hydrograph for a large watershed and explain two (2) main properties of a watershed that significantly influence a runoff hydrograph.

(6) (ii) Briefly give two (2) underlying assumptions in the development of a unit hydrograph to determine the surface runoff from a gauged watershed.

(8) (iii) A watershed conceptual model for runoff was used to develop a numerical model based on the iterative framework provided in the figure below. Considering the figure below, describe how the conceptual model can be used to address the issues of: (1) Reliability and (2) Vulnerability related to the performance of engineered systems (e.g., retention pond to mitigate downstream flooding).



Problem 2

Provide answers to the following questions related to *hydrologic cycle processes*, *groundwater flow* and *surface runoff*.

(10) (i) Describe how precipitation, groundwater infiltration and surface runoff are interrelated within the hydrologic processes and briefly explain the importance of each component to the hydrologic cycle. Use a clearly labelled schematic to show the important inter-relationships.

(10) (ii) A new 10 ha suburban development is to be drained by a storm sewer that connects to a municipal drainage system. The time of concentration for the sub-watershed is 90 minutes and the local IDF relationship can be approximated as $i = 7.0 - 0.2t_d$, where t_d is the rainfall duration in hours. Estimate the peak surface runoff using the Rational Method. State clearly your assumptions and the reasons for them.

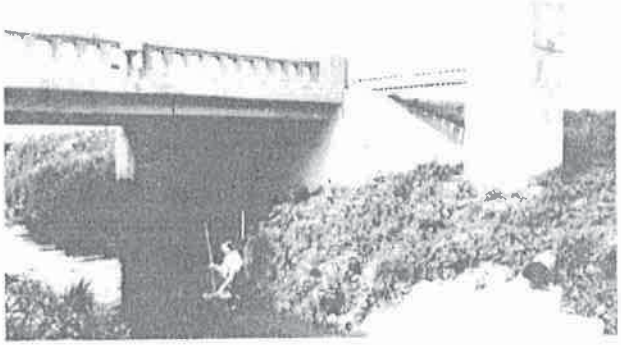
Problem 3

Provide answers to the following questions related to *point* and *areal estimates of precipitation* and *stream flow measurements*.

(7) (i) Briefly describe two (2) main differences between the Theissen Polygons and Isohyetal Method techniques used to calculate the average watershed precipitation. As part of your description, provide a clearly labelled schematic for each technique showing how each technique is different.

(5) (ii) Briefly explain how *convolution adding* and *lagging procedures* can be used to derive design storm hydrographs for a 100-year return period design storm event.

(8) (iii) Briefly explain how a stage-discharge rating curve is generated and used to determine the stream flow. In your explanation, discuss issues of instrumentation used for field measurements and the degree of predictability over time of the stream flow determined by the stage-discharge rating curve.



Problem 4

Provide answers to the following questions related to *basics of hydrologic modelling* and *reservoir* and *lake routing*.

(8) (i) Briefly explain two (2) main similarities and two (2) main differences between Deterministic Models and Stochastic Models and under what conditions each model type is preferred.

(6) (ii) Briefly describe three (3) key steps and two (2) assumptions in the application of the lumped Muskingum reservoir or Lake routing method.

(6) (iii) Give two (2) main factors that influence reservoir or lake flood routing and how each factor is considered in the design of engineered flood control systems (e.g., height of flood gates).

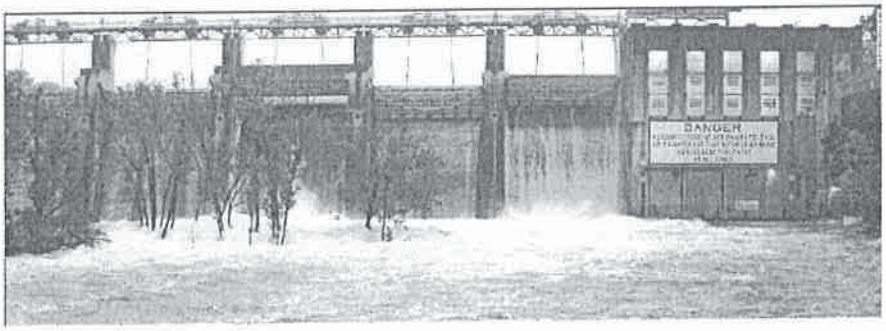
Problem 5

Provide answers to the following questions related to *channel* or *river routing* and *flood wave behavior*.

(7) (i) Briefly explain how channel or river routing (i.e., analysis of a hydrograph travelling along the channel or river) is used to determine the effects of a channel or river crest peak flow and travel time. Identify the fundamental equation(s) that would be used in the analysis.

(7) (ii) The routing method accuracy and application depend on basic assumptions inherent in the method. Briefly explain two (2) assumptions in a typical river or channel routing method and how these assumptions will influence the design decisions of the engineer in his work.

(6) (iii) Briefly explain the Muskingum-Cunge Method of flood propagation. In your explanation, provide the main equation used in the computational part and two (2) key assumptions made in the general method.



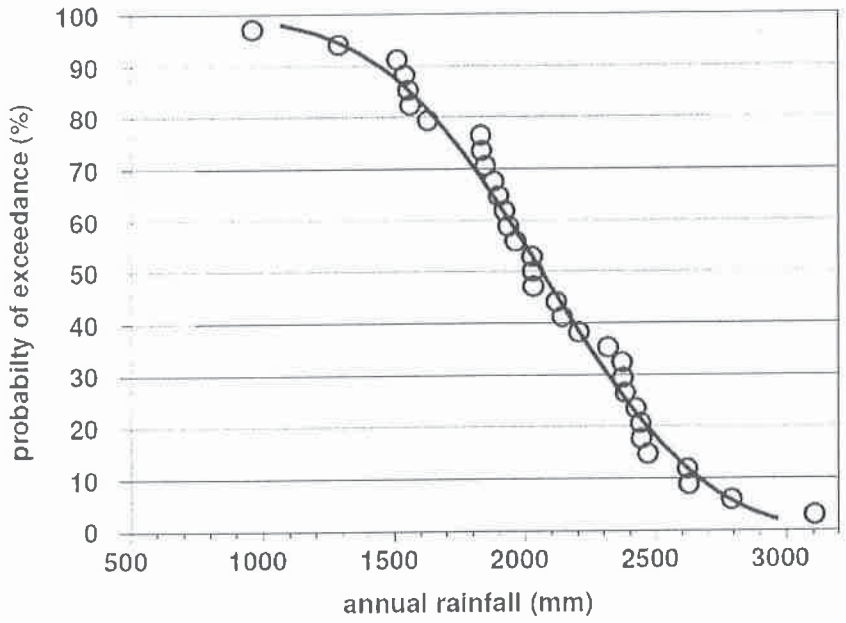
Problem 6

Provide answers to the following questions related to *statistical methods of frequency* and *probability analysis applied to precipitation* and *floods*.

(7) (i) Briefly explain how to use the intensity-duration frequency (IDF) curve to predict the peak runoff (Q) of a watershed for a design storm with a 50-year return period. Clearly state two (2) qualifications or recommendations for the design engineer using your derived peak flow for the design of a culvert under a major highway.

(7) (ii) The local insurance agent is in charge of settling flood claims but is not clear about the concept of "50-year flood". He says, "On the river near me, we have had two 50-year floods in the last 5 years. I'm really confused about this 50-year flood stuff". Provide a clear explanation about how a 50-year flood can occur twice in the last 5 years.

(6) (iii) With reference to the probability plot (below), briefly explain how it can be used to determine the probability distribution and statistics (e.g., log-normal distribution, mean, standard deviation) of the annual rainfall events. You may provide diagrams and equations as part of your explanation.



Problem 7

Provide answers to the following questions related to the *hydrologic equation*, *energy budget equation* and *infiltration simulation.*

(6) (i) Estimate the amount of evapotranspiration (ET) for the year (mm) from a watershed with a 10,000 km^2 surface area. Consider the drainage area receives 60 mm of rain over the year and the river draining the area has an annual flowrate of 2200 m^3/s. Justify any assumptions you make and use the basic equation of hydrology (BEH). Recall that the BEH may be written as:

$$P - R - G - E - T = \Delta S$$

Where P = Precipitation, R = Surface runoff G = Groundwater flow
E = Evaporation, T = Transpiration, ΔS = Change in Storage

(6) (ii) Taking into account the energy budget equation with latent heat exchanges and differential solar heating, briefly explain the reason for the global radiative balance and the greenhouse effect.

(8) (iii) With respect to infiltration simulation and the infiltration process under ponded conditions, briefly describe a potential infiltration simulation approach and two (2) characteristics of the Saturated Zone and Transition Zone shown in the soil profile identified below.