UNIVERSITY OF TORONTO
FACULTY OF APPLIED SCIENCE AND ENGINEERING

FINAL EXAMINATION, APRIL 2001
EDV 250S – HYDRAULICS AND HYDROLOGY

Exam Type: C
Examiner: C.A. Kennedy

Instructions
1. Type C examination. Silent, self-powered, non-programmable electronic calculators permitted.
2. Give your answers to all four questions in this booklet.
3. All four questions are of equal value.
4. If doubt exists as to the interpretation of any question, a clear statement of any assumptions made should be included with the answer.

Question 1

(a) The 1-hour (25-mm) unit hydrograph for a rural watershed has ordinates as follows:

Time (hours)	0	1	2	3	4	5
Effective Runoff (m^3/s)	0	1.5	4.0	2.0	1.0	0

What is the 3-hour (25-mm) unit hydrograph for the same watershed?

(b) A two hour storm occurs in a different watershed to part (a). The intensity of the storm is 1.5 in/hr for the first hour and 1.0 in./hr for the second hour.

The effective runoff from the storm is as follows:

Time (hours)	0	1	2	3	4	5
Effective Runoff (ft^3/s)	0	150	435	730	1126	496

The watershed may be divided into four areas A_1 to A_4, separated by isochrones, where area A_1 is closest to the point of outflow. The loss coefficients for the four areas are as follows:

$\phi_1 =$ 0.5 in./hr.; $\phi_2 =$ 0.3 in./hr.; $\phi_3 =$ 0.2 in./hr.; $\phi_4 =$ 0.2 in./hr.

Use the isochronal method to determine the areas A_1 to A_4 (in acres).

(c) If the peak flow rate for the storm in part (b) has a return period of 20 years, what is the risk that this flow rate will be reached at least once in the next 5 years?

Question 2

(a) Briefly describe how each of the following five components of the hydrological cycle may be *measured in the field*; and for each case, give one example of a practical use of the measurement. (i.e., why do we measure it?)

Rainfall

Groundwater Flow

Streamflow

Evaporation (from a water surface)

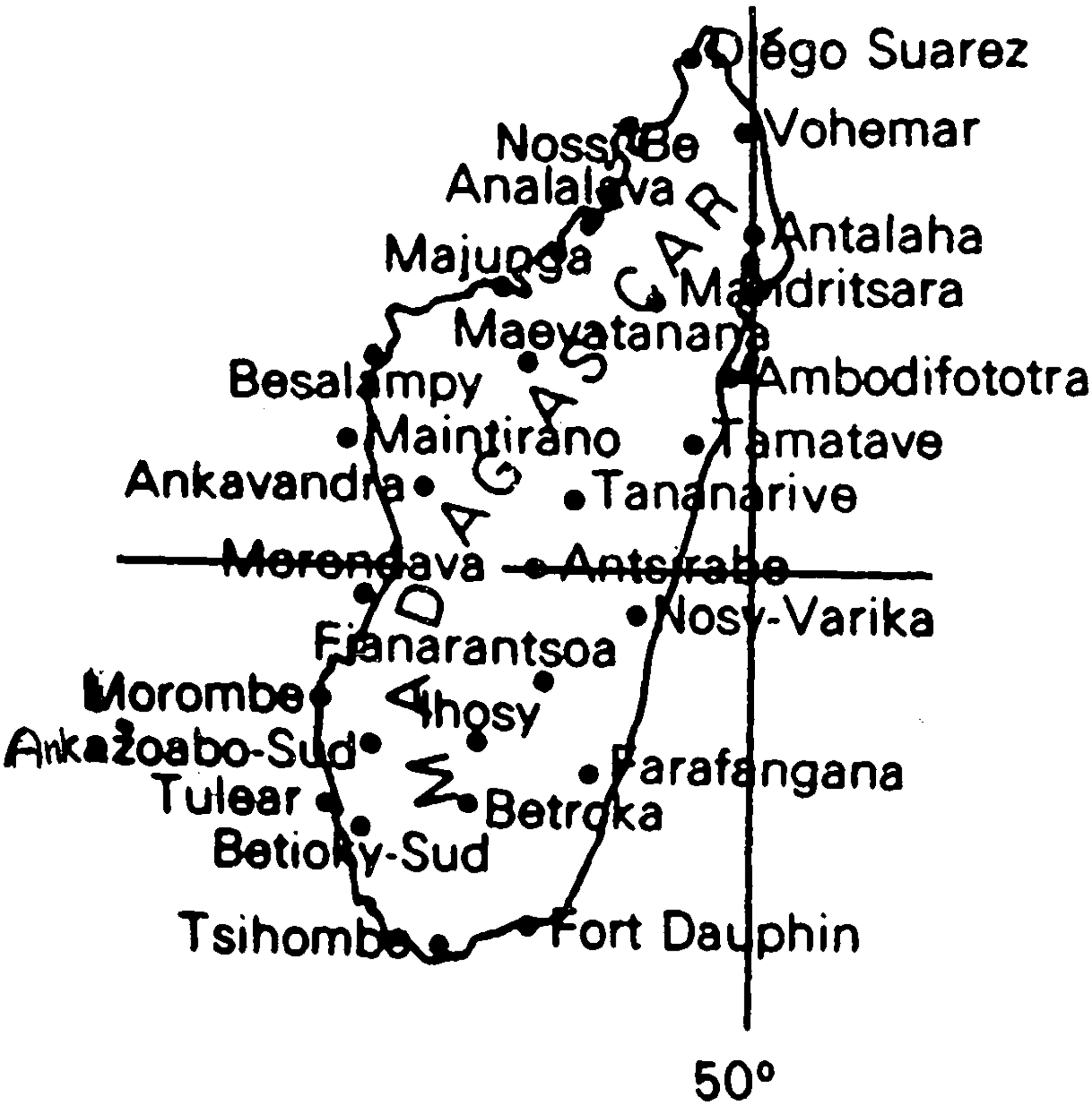
Infiltration

(b) The table below gives average yearly rainfall (in inches) over the African island of Madagascar. Use the data to roughly sketch 50 in. and 100 in. rainfall contours on the map provided over page. Label the contours clearly.

Ambodifototra	128.3
Analalava	75.8
Ankavandra	56.4
Ankazoabo-Sud	28.3
Antalha	82.8
Antsirabe	56.6
Besalampy	47.1
Betioky-Sud	24.2
Betroka	33.3
Diego Suarez	38.7
Dzaoudzi/Comoro Islands	43.1
Farafangana	108.8
Fianarantsoa	48.5
Fort Dauphin	65.2
Ihosy	20

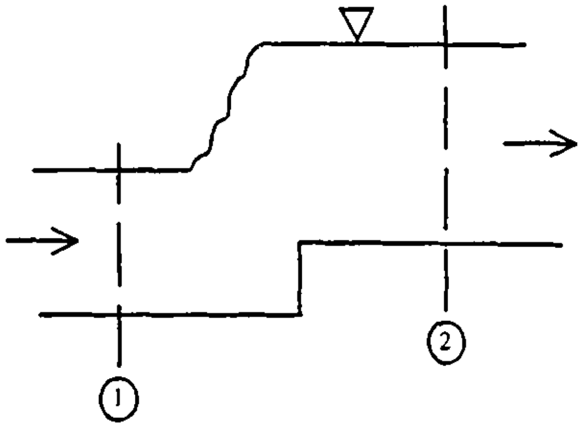
Maevatanana	68.1
Maintirano	30.7
Majunga	61.6
Mandritsara	45.7
Morombe	19.3
Morondava	27.9
Mutsamdu/Comoro Islands	74.8
Nossi Be	92.4
Nosy-Varika	107.9
Tamatave	128.2
Tananarive	53.4
Tsihombe	19.3
Tulear	13.5
Vohemar	56.4

(from Tables of Temperature, Relative Humidity and Precipitation for the World, Part IV, HMSO, 1967)


MADAGASCAR
Diégo Suarez
Vohemar
Nossi-Be
Analalava
Antalaha
Majunga
Mandritsara
Maevatanana
Besalampy
Ambodifototra
Maintirano
Tamatave
Ankavandra
Tananarive
Morondava
Antsirabe
Nosy-Varika
Fianarantsoa
Morombe
Ihosy
Ankazoabo-Sud
Farafangana
Tulear
Betroka
Betioky-Sud
Tsihombe
Fort Dauphin
50°

Question 3

A flow of 80 m^3/s occurs in a rectangular section of width 10-m. A hydraulic jump occurs along the channel immediately before a 0.5-m upward step in the channel bed (see figure below). The upstream depth, y_1, is 1.0 m.



(a) Calculate the critical depth of flow for the channel.

(b) Determine the downstream depth by applying conservation of momentum between sections (1) and (2). Assume that the pressure force on the step is a function of the downstream depth, y_2.

(c) If the normal depth of flow for the channel is 2-m, classify the flow profiles upstream and downstream of the jump (according to gradually varied flow theory).

Question 4

(a) An unlined trapezoidal channel is to be designed to carry a flow of 500 cfs. down a slope of 1 in 500. The following design parameters are given:

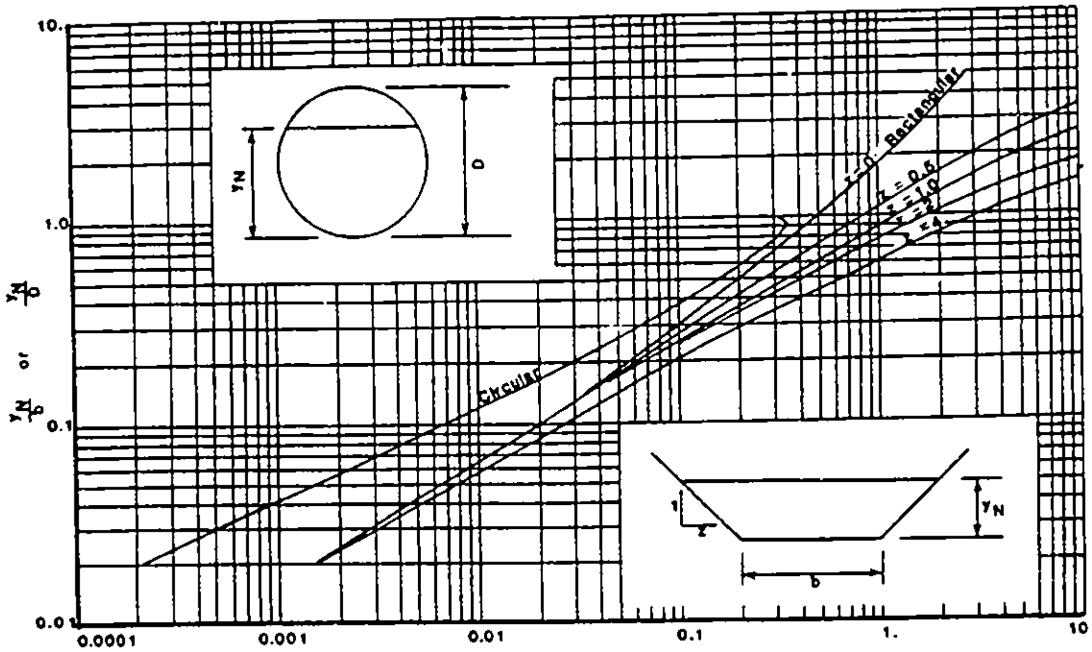
side slope = 25°
angle of repose = 35°
permissible unit tractive force on the channel bed, $\tau_0 = 0.5$ lb/ft^2
Manning roughness coefficient = 0.025

Determine a suitable width, b, for the base of the trapezoidal section.

(b) A rectangular-shaped constriction of width 10-ft is to be built into the channel designed in part (a).
What is the depth of flow in the constriction, assuming that flow is critical?
What is the depth of flow immediately upstream of the constriction, assuming that there are no energy losses?
Is the channel design determined in part (a) suitable for the change in flow depth resulting from the constriction? If not, what is the problem? Qualitatively discuss how the design might be changed.

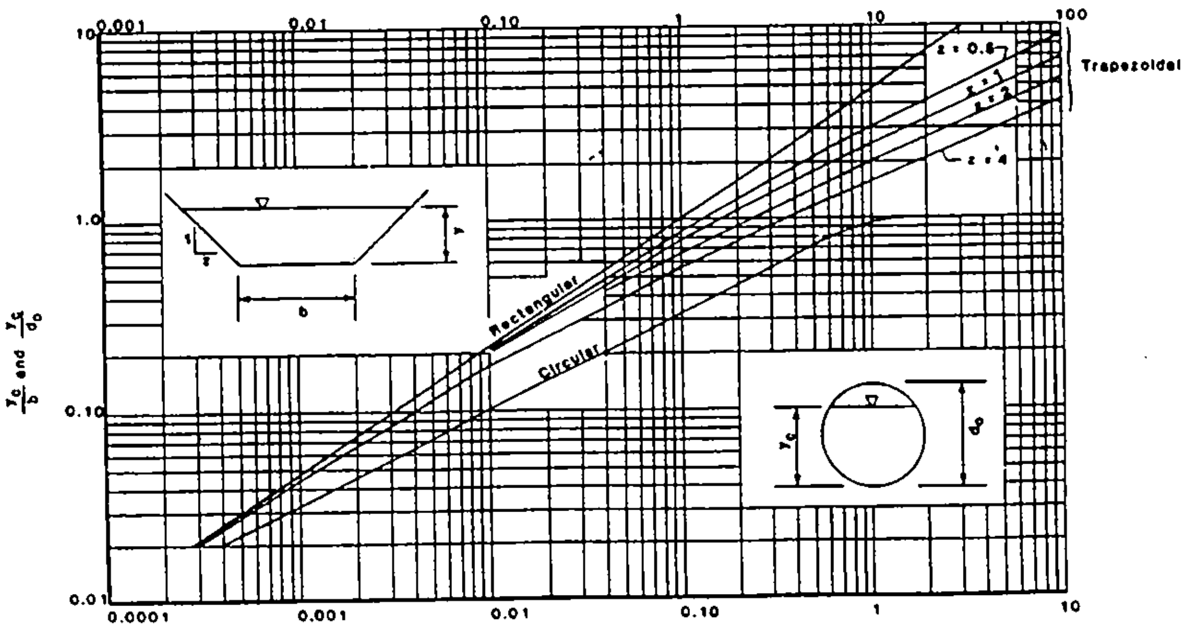
(Note: $\gamma = 62.4$ lb/ft^3, $g = 32.2$ ft/s^2)

Graph for calculation of Normal Depth



$$\frac{AR^{2/3}}{b^{8/3}} \text{ or } \frac{AR^{2/3}}{D_o^{8/3}}$$

Graph for calculation of Critical Depth $\frac{Z_c}{b^{2.5}}$ (rectangular and trapezoidal sections)



$\frac{Z_c}{d_o^{2.5}}$ (Circular Sections)