The answers to all questions must be given on this question sheet, using the reverse side if you need to. No additional papers handed in by the candidate will be accepted or considered in the grading.

Name:_____ Date:_____

National Exams Dec 2013

98-Civ-A3, Municipal Engineering

3 hours duration

Notes:

1. Four questions should be answered. Candidates **MUST** answer Question 1. Then they may answer any 3 out of the remaining 4 questions.
   DO NOT ANSWER FIVE QUESTIONS.

2. Each question carries a maximum of 25 marks, for a total of 100. Try to arrange your time in accordance with the value of the question (hence slightly less than 2 minutes per mark).

3. If doubt exists as to the interpretation of any question, the candidate is urged to include with their answer a clear statement of any assumptions made.

4. This is an open book exam.

5. Candidates may use one of two calculators, the Casio or Sharp approved models.

6. Please take care to give your answers clearly and logically. State any assumptions which you need to make, as well as any sources of information used which are not in the examination paper (for example, a table or page number in a textbook).

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Marks

Question 1. Short questions. Take note of the number of marks assigned for each question, and answer accordingly. (25 marks total)

2 a) Lake intake structures for water supplies generally need to be able to draw water from different levels. Give 2 reasons why water should not be drawn too close to the bottom of the lake, and 2 reasons why water should not be drawn from too close to the top of the lake. (½ mark for each reason)

Bottom	
Bottom	
Top	
Top	

3 b) Potable water supplied by a municipality may contain chemicals which were not in the source (raw) water. In the table below, give two examples of such chemicals, describe how they entered the water, and their health effects.

Chemical	How entered water	Health effects

2 c) The rational method is widely used to calculate the flow in storm sewers caused by rainfall. It assumes that the maximum flow will occur when the time of concentration of the watershed or sub-basin equals or exceeds the duration of the rainfall. Give 2 cases where this assumption may be incorrect, and explain why.

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Marks

d) Peak flows are experienced both for municipal water demands and for sanitary sewer flows; in fact the two are usually closely related.

2 i. What impact does the size of the population have on the peak flow ratios? Give reasons for your answer.

1 ii. What would cause wastewater peaks to be different from water peaks?

iii. For a town with a population of 150,000, complete the following table:

3

Formula or table used and source	Ratio of max. to ave. day **water** flow, based on information in first column	Ratio of max. to ave. day **wastewater** flow

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Marks

7 e) Water pipe replacement.

Two ageing water main pipes connected in series will be replaced by a single pipe of the same total length. The characteristics of each pipe are given in the table below. Determine the minimum diameter of the new pipe, Hazen-Williams "C" value 130, if the total headloss through this pipe at a flow of 1 m^3/s is to be 20% less than the total headloss in the two pipes. Note that the two old pipes are connected by a conical contraction with a "k" value of 0.06 (with reference to the first pipe) which will obviously no longer be present with the new pipe.

COMPLETE THE TABLE BELOW WITH INFORMATION ON THE NEW PIPE

Pipe	Length (m)	Diameter (m)	C value
First	80	0.5	90
Second	60	0.4	80
New	140		130

Show your calculations below.

1 f) Elevated water storage tanks are commonly used to equalize pressures and to accommodate fluctuating water demands, but there are problems associated with them as well. Describe one such problem.

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Marks

2 g) Separate sewers are generally considered preferable for modern urban communities, but this is not always true. Give 2 advantages and 2 disadvantages of separate sewers (½ mark each).

Advantage	
Advantage	
Dis-advantage	
Dis-advantage	

2 h) When designing a sanitary sewer system, one needs to decide on an appropriate depth of cover for the pipes. Suggest two factors that influence the selection of a depth of cover and explain why they are important.

Factors	Why important

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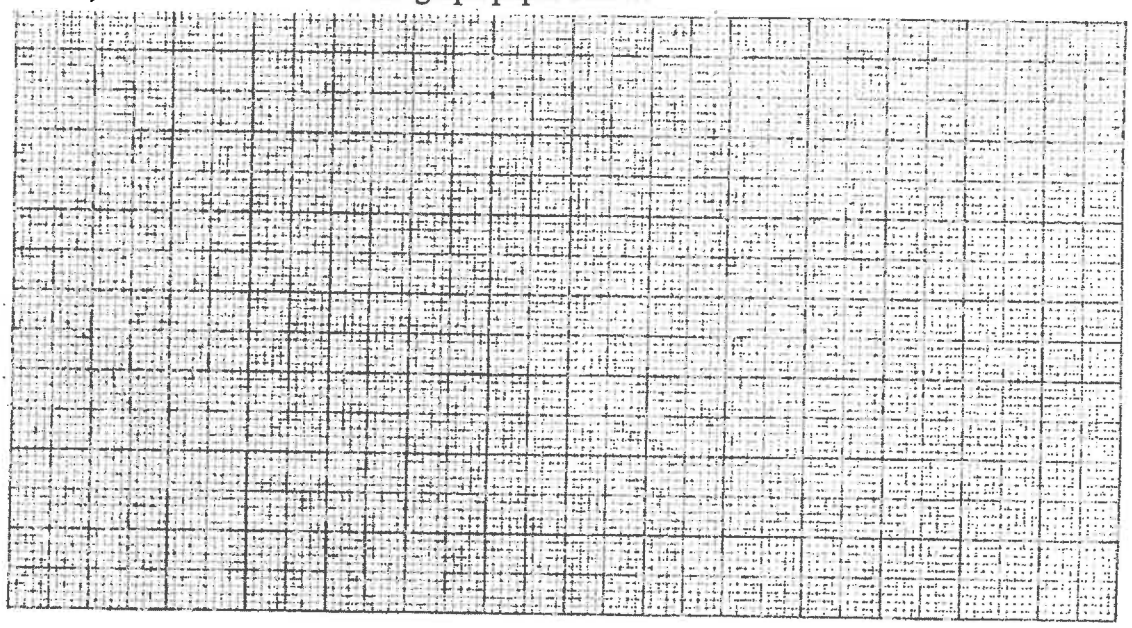
Marks

Question 2. Population projection and water supply (25 marks total)

Population data for a town are presented below.

Year	Population
1988	3,400
1998	18,000
2008	43,300
2013	50,000

3 a) Plot the data on the graph paper below.



b) Predict the population in the year 2023, using the following methods, and show your calculations:

3 i. arithmetic method

Population:_____

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Marks

Question 2, contd.

3 ii. geometric method

Population: _____

2 c) Which estimate would you recommend to be used by the town planners? Justify your answer.

d) The town has decided to build a new intake system in a nearby lake to satisfy the future water demands for the above community. Based on land-use estimates, and other factors beyond the control of the town, the ultimate population of the town was set at 80,000. It is your assignment to design a 500-m long intake conduit (raw water pipe) to transport the water from the river intake to a wet well. The design life is 50 years. To help you in your design, the following data were collected by the Municipal Engineering Department for the community:

- In 2013, the **total** water supplied to the residents and industries of the community was 8.6×10^6 m^3 (i.e. the present average demand).
- The **industrial demand** in 2013 was 5,000 m^3/d and the Urban Planning Office expects it to triple by the year 2063.
- All fire flow and other fluctuating water demands will be handled by storage.
- Minor headlosses through the pipe can be estimated using a "k" value of 3.0.
- From past experience, the velocity in the pipe at the end of the design life is recommended to be 1.5 m/s.

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Marks

Question 2, contd.

Based on the information given, evaluate (for the end of the design life):

7 i) the required capacity of the pipe (m^3/d).

3 ii) the diameter (in mm) of the pipe required to carry the flow.

4 iii) the head loss (in m) through this pipe, including all minor losses. Assume a Hazen-Williams (C) coefficient of 110.

Total 25

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Marks

Question 3. Pumps (25 marks total)

a) A pump located at ground level is used to pump water from a well and into a force main (i.e. a pressure pipe) to a water treatment plant. An engineer notices that when the water level in the well drops to a very low level, the pump efficiency drops significantly and the pump starts making clicking noises. Explain what is probably happening and what can be done to avoid this problem.

1 Cause:

1 Solution:

b) Centrifugal pumps may be configured to operate in parallel or in series. Show, **with the aid of diagrams**, under what conditions it would be desirable to configure two identical pumps:

2 in parallel:

2 in series:

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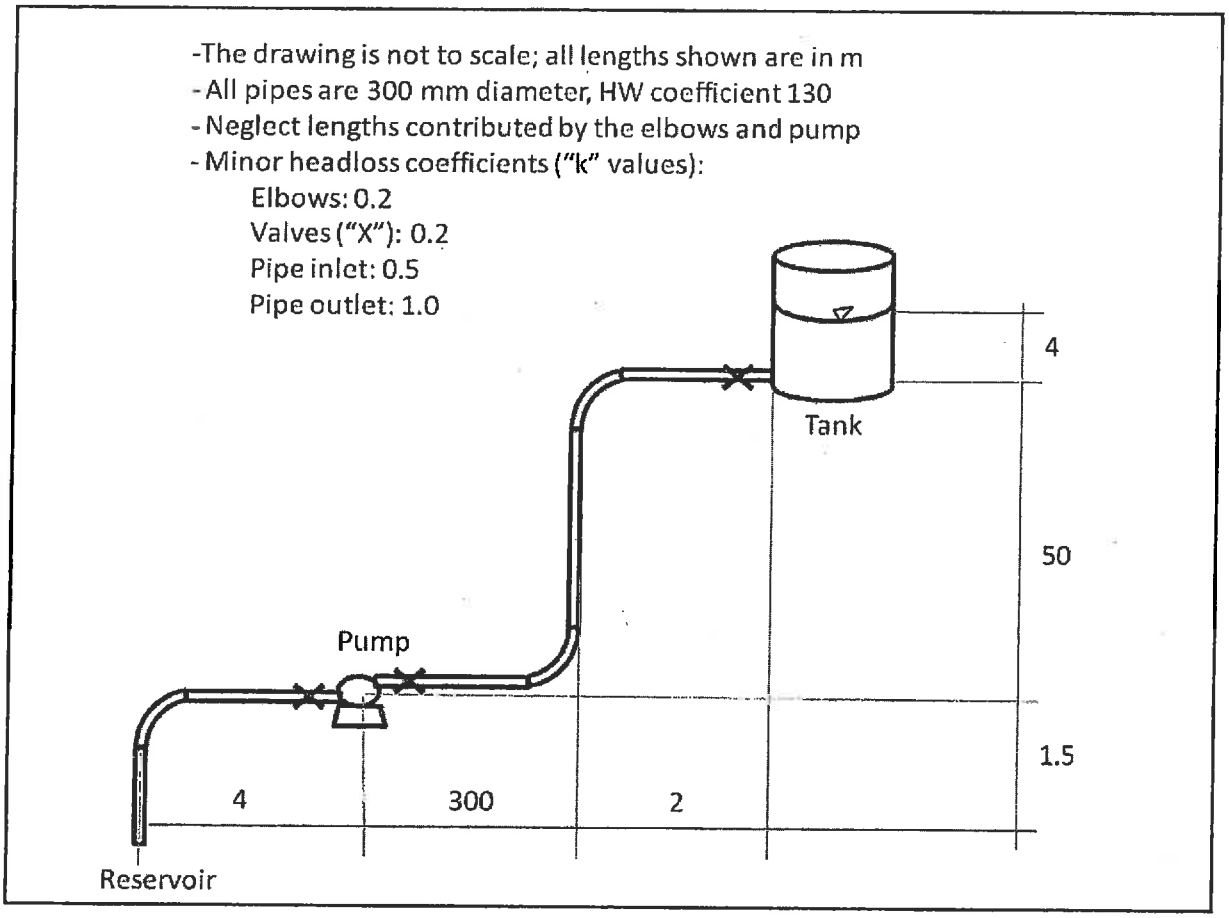
Marks

Question 3, contd.

19 c) The impeller size for a pump is to be selected from the chart on the following page. It will pump water from a reservoir at sea level into a storage tank, as shown in the diagram below. When the level of water in the reservoir is at 4 m, the pump flow should be approximately 0.14 m^3/s.
Vapour pressure of water is 1.2 m; atmospheric pressure is 10.2 m.
All other required information is shown on the diagrams.



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Section 410 Page 422
Dated JUNE 1989

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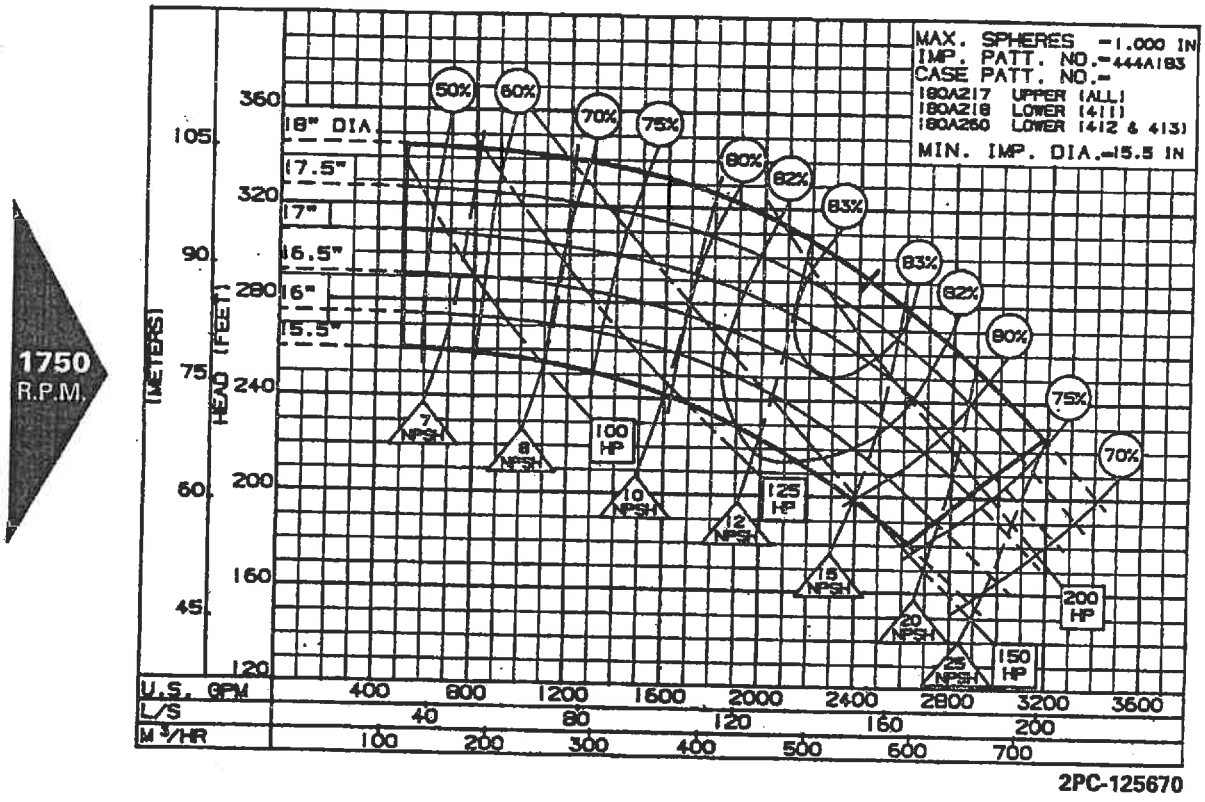
ENCLOSED IMPELLER



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Note: NPSH is in ft.

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Marks

Question 4. Design of sanitary sewers (25 marks total)

6 a) Estimate the maximum hourly, maximum daily, and minimum hourly sewage flow (in m^3/d) in a residential system from a subdivision occupied by 800 people. The total length of the house drain system and sewers (200 mm dia.) within the subdivision is 2.2 km. Include infiltration. Be sure to give sources for all your information and assumptions. **50% of the marks for this question will be deducted if you do not give appropriate sources of information.**

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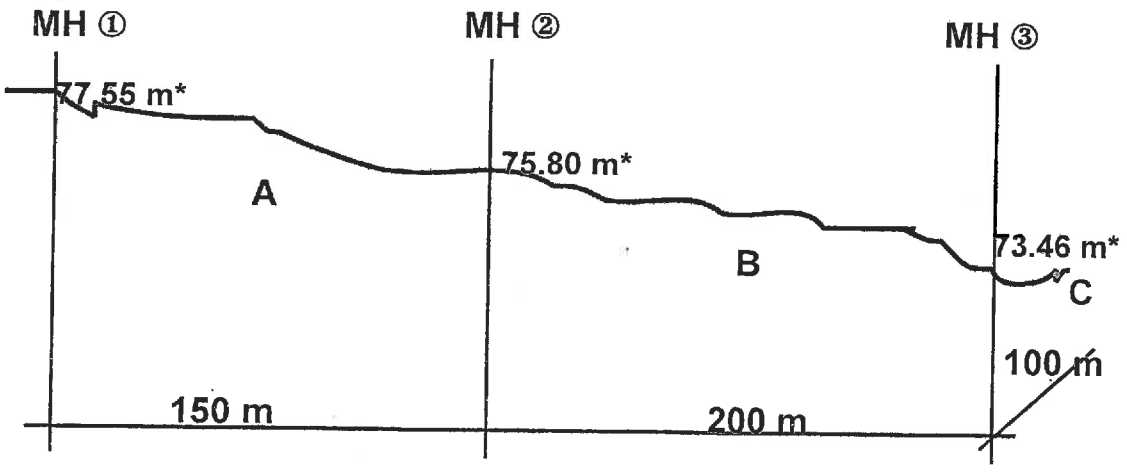
Marks

Question 4. (Contd)

19 b) One solution for maximum daily flow (MDF) in part (a) is 722 m^3/d. Your solution may not be the same, but for ease of grading the problem, use this figure in the following design.

Sewer mains will convey the sewage from the subdivision to an interceptor sewer, (pipes A and B) according to the profile below. Pipe C also flows into MH ③, and intercepts a MDF of 650 m^3/d at its upstream MH. Pipe D (not shown on the diagram) carries the total flow out of MH ③. Determine the depth, diameter and slope of pipes A and B, and the diameter of pipe D, taking into account headlosses in the pipes and the manhole, and complete the **Design Information** table on the next page. Respect the following and/or make the following assumptions:

Infiltration of 15 m^3/d-km into these main sewer pipes (design each pipe for total infiltration along the full length)
Old concrete pipe, Manning "n" = 0.015
Commercial pipe diameters (m): 0.15, 0.20, 0.25, 0.31, 0.38, 0.46, 0.51
Pipe should flow ⅔ full (i.e. d/D = 0.667) or less at MDF, including infiltration (assume variable Manning "n" coefficient)
Max. velocity = 4 m/s
Min. velocity = 0.6 m/s at MDF + infiltration
Minimum depth of cover over the crown (top inside) of the pipe = 2 m
At MH ② , the pipe makes a 45° change in direction
At MH ③ , the two pipes B and C enter at an angle of 45° to each other, to form the top part of a "Y", and pipe D (not shown) exits the MH as the lower arm of the "Y"
* = ground elevation at manhole



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Design information

Pipe	A	B	C	D
Design flow (m^3/s)				
Diameter (m)			0.15	
Length (m)	150	200	100	200
Elevation of upstream crown (m)			72.75	71.00
Elevation of downstream crown (m)				69.40
Slope (decimal fraction)				
Flow full (m^3/s)				
Velocity at design flow (m/s)				

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Working page for Question 4

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Marks

Question 5. Essay: Impact of floods and possible solutions (25 marks total)

Although not everyone is convinced that the cause is global warming, there is no doubt that extreme events, such as flooding, are occurring with increasing frequency and greater magnitude in Canadian cities. Examples in 2013 alone include High River, Calgary, and Toronto. This essay should consist of two parts:

10 (a) Describe the impact which flooding has on municipal infrastructure, specifically that which is below ground (therefore exclude personal property, as well bridges). Including quantitative information, where possible, will assist in obtaining maximum marks.

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Marks

Question 5, contd.

15 (b) For each item or system mentioned in Part (a), suggest a solution. As above, try to include numerical information, design guidelines, etc., to indicate your familiarity with the subject.