

**The answers to all questions must be given on these question sheets, 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 May 2015

98-Civ-A3, Municipal Engineering

3 hours duration

Notes:

1. **Answers to all questions must be given on this question sheet, using the facing (blank) side if necessary. No additional papers handed in by the candidate will be accepted or considered in the grading.**
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. **Candidates MUST answer Question 1, then any 3 out of the 4 remaining questions.** Do not answer five questions. Only the first four questions answered will be graded.
4. 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.
5. This is an open book exam.
6. Candidates may use one of two calculators, the Casio or Sharp approved models.
7. 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).

Question 1. YOU MUST ATTEMPT TO ANSWER THESE SHORT QUESTIONS

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

- (5 marks) a) A town in Ontario (population 100,000 consuming 300 L/cap-d) must decide whether to give a permit to a beverage company which wants to set up a bottling plant nearby. It would produce 45,000 m³ of the beverage per year, requiring 1.7 m³ of water/m³ beverage produced. The benefit to the town will be jobs creation – 1,000 positions. The condition, however, is that the city must supply the company with water from its treatment plant, which will require a renovation amortized at \$350,000 each year for 10 years. The company is willing to pay half the water rate charged to the citizens (\$1.50/m³), but nothing for the wastewater discharged, since it will recycle its wastewater. Citizens are charged \$1.80/m³ for their wastewater discharge. If the town rejects the permit, there will be no population increase, therefore the plant will require a smaller renovation - \$250,000 per year - but it would be subsidized 90% by the Provincial and Federal governments. Based only on the economics of the impact of the permit, would you recommend that it be granted?
- (2 marks) b) i. Give an initial estimate of the flow rate required to put out a fire in a wood-frame warehouse storing low-hazard electronic components which is 25 m long, 9 m wide, 7 m high and has 2 storeys (but no basement). Give the basis for your calculation, and list any assumptions.
- (2 marks) ii. What could the building owner do to drastically reduce this flow requirement? On the other hand, what situation may require the flow rate to be significantly higher?

- (6 marks) 1.c) A water main was laid under a downtown street, and many years later a second main in parallel to carry the increased flow. Details are given below. The street was subsequently converted to a pedestrian mall, and it was decided to replace the two pipes with a single hydraulically-equivalent pipe carrying the same flow. Determine the diameter of this pipe, thereby completing the table (show your calculations below the table).

Pipe	Year installed	Material	Current value of C	Length (m)	Diameter (m)
1	1960	Cast iron	70	300	0.30
2	1970	Asbestos cement	130	300	0.20
3	2015	PVC	150	300	

- (4 marks) 1.d) Modern drinking water treatment plants use various disinfection technologies to produce pathogen-free water, nevertheless Canadian practice aims to provide water to every consumer which contains a small chlorine residual to ensure that the water is pathogen-free at the tap. Describe two cases where the water leaving the treatment plant does contain chlorine, but by the time it reaches the consumer it does not. Without increasing the chlorine dose at the treatment plant, what measures can be put in place in the distribution system to ensure that a chlorine residual is maintained at all times?

Factors causing loss of chlorine residual	
Solutions	

(4 marks) 1.e) Calculations have shown that the load on a 350 mm nominal diameter buried reinforced concrete pipe will not exceed 60 kN/m. With a factor of safety of at least 1.5 for the bearing capacity, give two potential combinations of bedding class and pipe type (ASTM specification) that would be suitable.

(2 marks) 1.f) Gas from the anaerobic decomposition of organic material can create dangerous conditions in sewers which are large enough to be inspected by entering them, as well as in manholes which have been sealed.

- What is the name of the gas?

- How can the design of the sewer system be improved to avoid the production of this gas?

Question 2. Groundwater. (25 marks)

- (16 marks) a) Water is pumped from a test well in a confined aquifer to determine the storage coefficient (S_c dimensionless) and the coefficient of transmissivity, T [gpd/ft]. Data have been plotted on two graphs, which were then overlaid according to the Theis analysis method to determine these coefficients. The graphs are shown on the following page, where:

t = time (days)
 r = distance from the pumped well (ft)
 s = drawdown (ft)

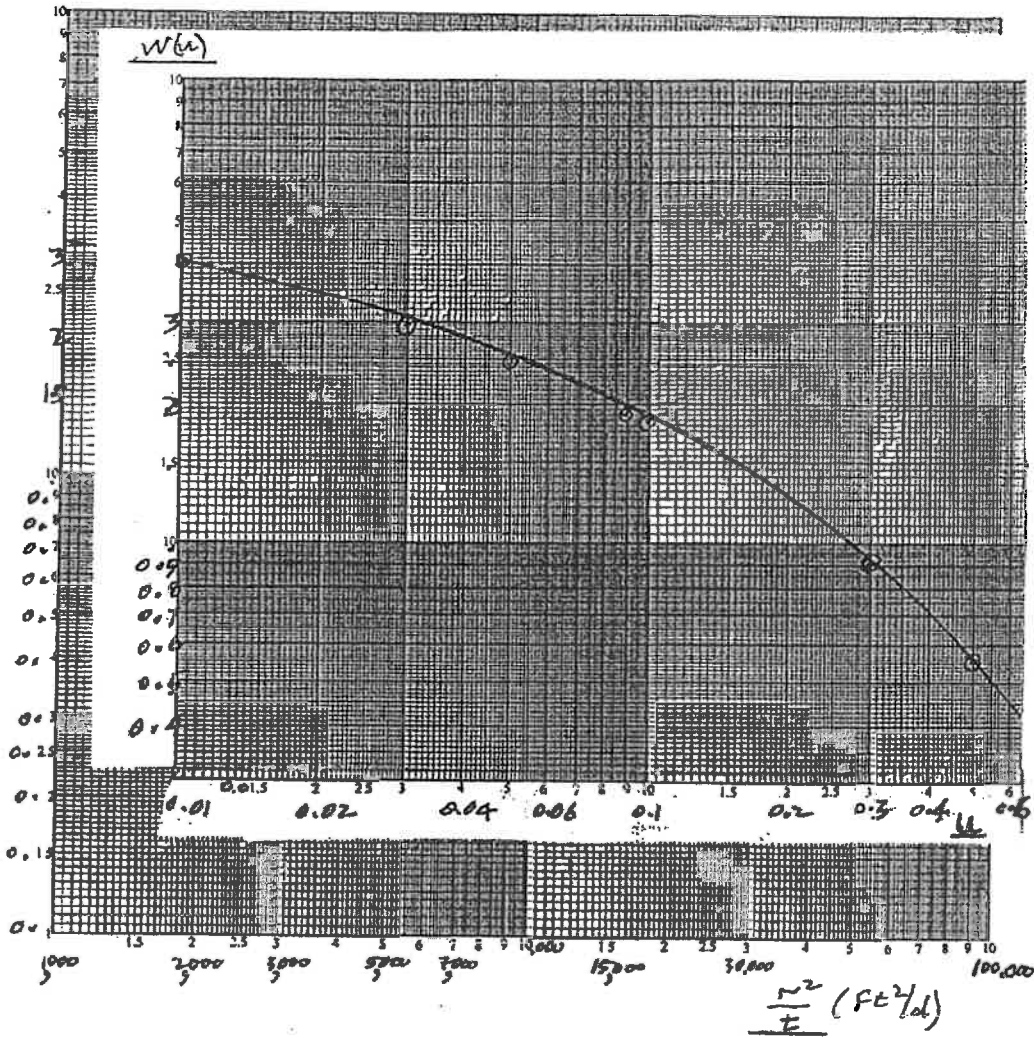
The well was pumped at a rate of 540 gpm.

Clearly show the points on the graphs which you using to determine the values of S_c and T .

- (9 marks) b) The drawdown in part (a) was measured at 125 ft from the pumped well. If the drawdown value at 75 ft after 5 days was considered to be the limiting condition for pumping of that aquifer, and using any other information obtained from part (a), what rate of pumping could be sustained from the well if the drawdown at 300 ft from the well was limited to 6 ft?

Note: 1 gal = 0.1337 ft³

Drawdowns (Ft)



Question 3. Elevated storage and pumps. (25 marks)

(2 marks) a) Explain how elevated storage tanks can lead to a deterioration in water quality.

(2 marks) b) What measure(s) can be taken when designing the tank and its hydraulics to reduce or eliminate the problem described in part (a).

(21 marks) c) The system shown below in Figure 1 for a population of 75,000 should be analysed for two scenarios, and the results given in the table.

In scenario 1, there is no elevated storage tank, and the 12" pump will operate according to the pump curve in Figure 2, depending on the flow demand.

In scenario 2, an elevated storage tank is located at B as shown in the figure, and the 12" pump will also operate according to the pump curve in Figure 2, however at low demands the storage tank will be filling, and at high demands the storage tank will contribute to the load demand. You may neglect headlosses in the vertical pipe feeding the storage tank, as well as minor headlosses.

Further details are given in the table, which you must complete. Note that the comparison of the scenarios is worth 3 marks.

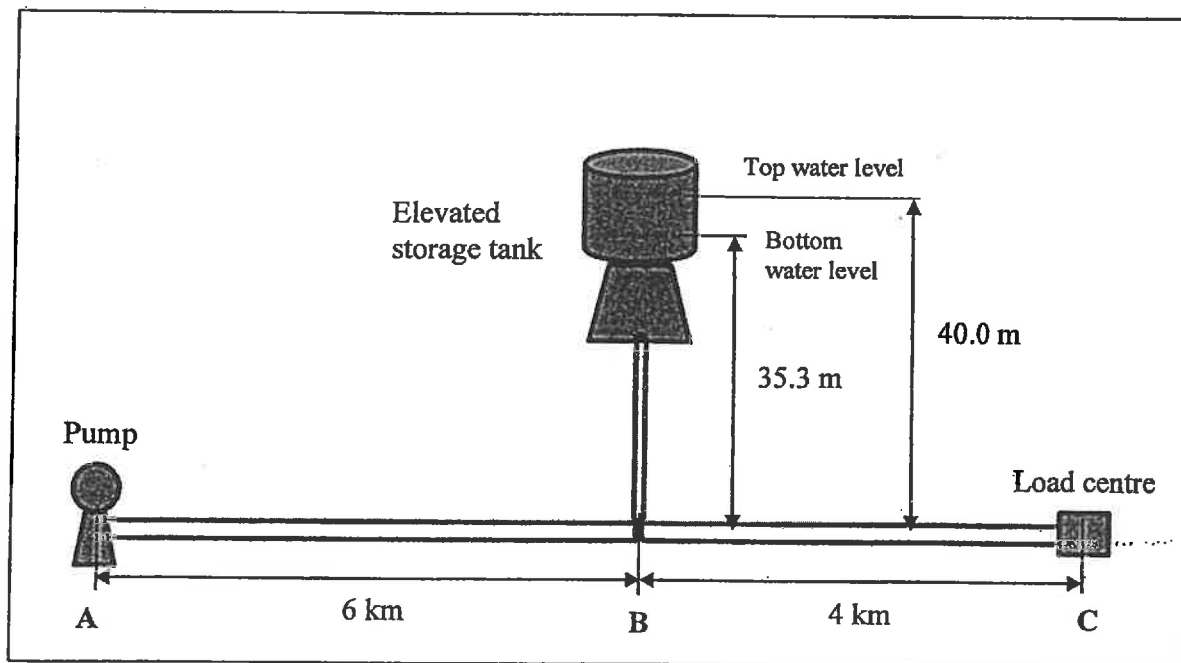


Figure 1. Water distribution system

10 x 12 x 12B
SERIES 410
 ENCLOSED IMPELLER

Section **410** Page **437**
 Date **May 2013**

Supersedes Section 410 Page 437
 Dated March 2007

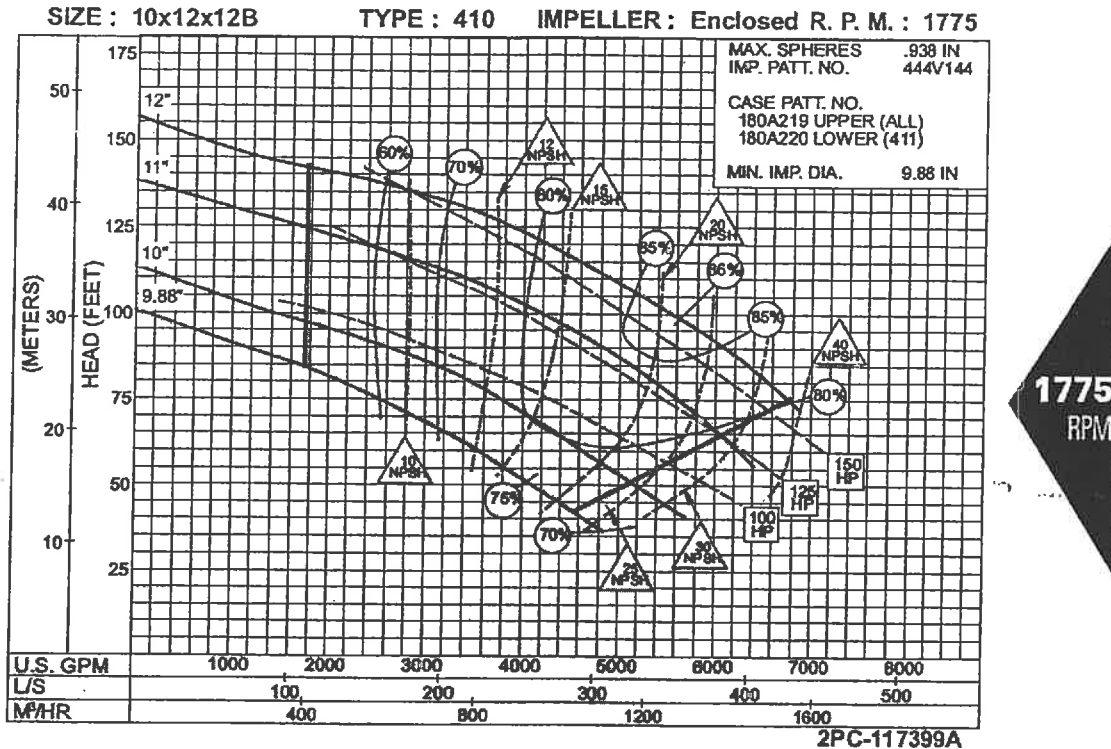


Figure 2. Head vs flow curve (Pump curve) from the Aurora/Pentair catalogue

Table 1. System flow and pressure head data
 Pipes are 0.3 m diameter, C = 100

	Scenario 1		Scenario 2	
	Minimum pressure head at load centre (m)	Minimum pressure head at reservoir (m)	Minimum pressure head at load centre (m)	Minimum pressure head at load centre (m)
Low flow demand at load centre = 167 L/s				
High flow demand at load centre = 333 L/s				
Comparison of scenarios				

Calculation page for Question 3.

Question 4. Stresses in pipes. (25 marks)

A Schedule 40 steel pipeline of inside diameter of 12 inches (300 mm) carries a water flow of 7 ft³/s (0.2 m³/s) at 25°C and 50 psi (350 kN/m² or kPa). The pipe makes a short radius 90° turn.

Information on Schedule 40 steel pipes:

Inside diameter = 11.94" = 0.303 m

Thickness = 0.406" = 0.0103 m

Modulus of elasticity = 2×10^8 kN/m²

Other useful information:

Modulus of elasticity of water = 2.2×10^6 kN/m²

Modulus of elasticity of PVC = 2.9×10^6 kN/m²

- (6 marks) (a) What is the total force (in kN) developed in a buttress at the bend?
- (3 marks) (b) Calculate the longitudinal stress (in kPa) which would be developed in the pipe by this change in direction if no buttress was provided?
- (9 marks) (c) What is the maximum stress (in kPa) which could be produced in the pipe wall as a result of suddenly closing a valve in the line?

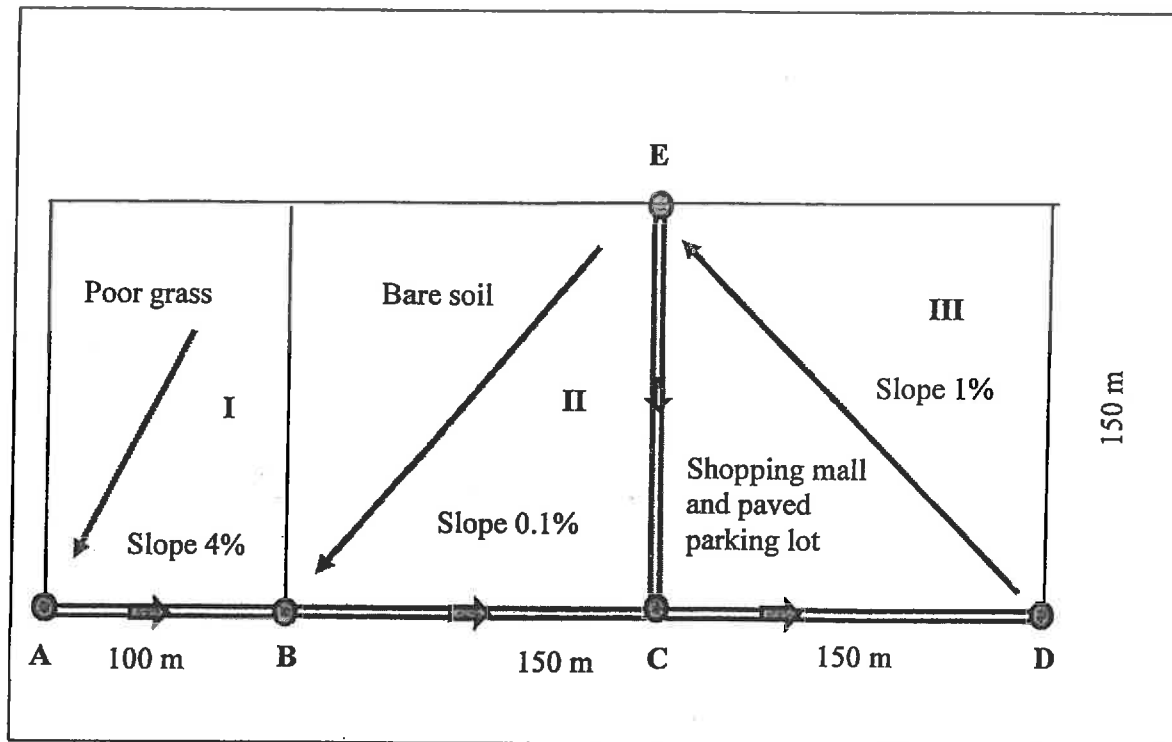
Question 4, contd.

(4 marks) (d) Instead of using steel pipe, the consultant decides to use a 12" Schedule 40 PVC pipe (same thickness as steel). How does changing the pipe material affect the forces and stresses calculated in parts (a - c)?

(3 marks) (e) If the PVC pipe is considered to behave as a flexible pipe, what would be the force (in kN/m) acting on the pipe due to backfill of sand and gravel, under the following conditions:

- load coefficient $C_d = 2.3$
- unit mass of backfill over the pipe = $1,900 \text{ kg/m}^3$
- the transition width of the trench = $2.8 \times$ outside diameter of the pipe

Question 5. Rainfall, runoff and stormwater. (25 marks).



You are required to determine the storm-water flows and the diameters of four storm sewers to handle a critical storm of 10-year return period for the town of Auburn. A sketch of the area to be sewered is shown above. The long arrow lines show the direction of overland flow to the inlets marked A, B etc., and the short arrows show the direction of flow in the sewer. The I-D curves for Auburn are given on the following page; use the HRM3-HadCM3 curve, which is a projection for the future taking into account climate change. An overland flow time curve is also given for various values of the runoff coefficient, "C". Design the sewers to flow full, or close to full (d), using commercial pipe sizes only. You may assume the following:

Slope of sewer ABCD = 0.006 m/m; slope of sewer EC = 0.015 m/m

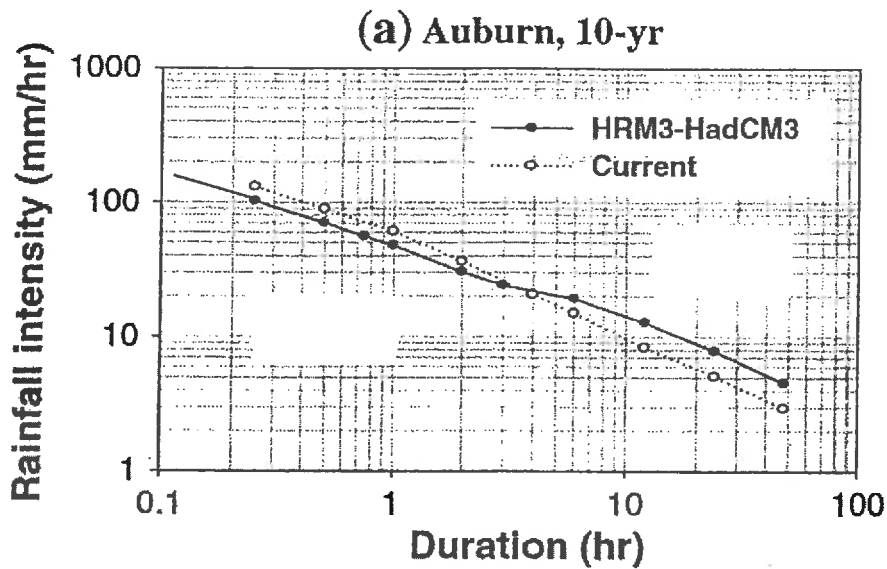
Manning's n = 0.011; assume constant with depth

Commercially available pipe sizes, D (mm): 225, 300, 375, 450, 525, 600.

Note: It is reasonable to choose a pipe diameter up to 5 mm smaller than your calculated value, rather than going to the next size.

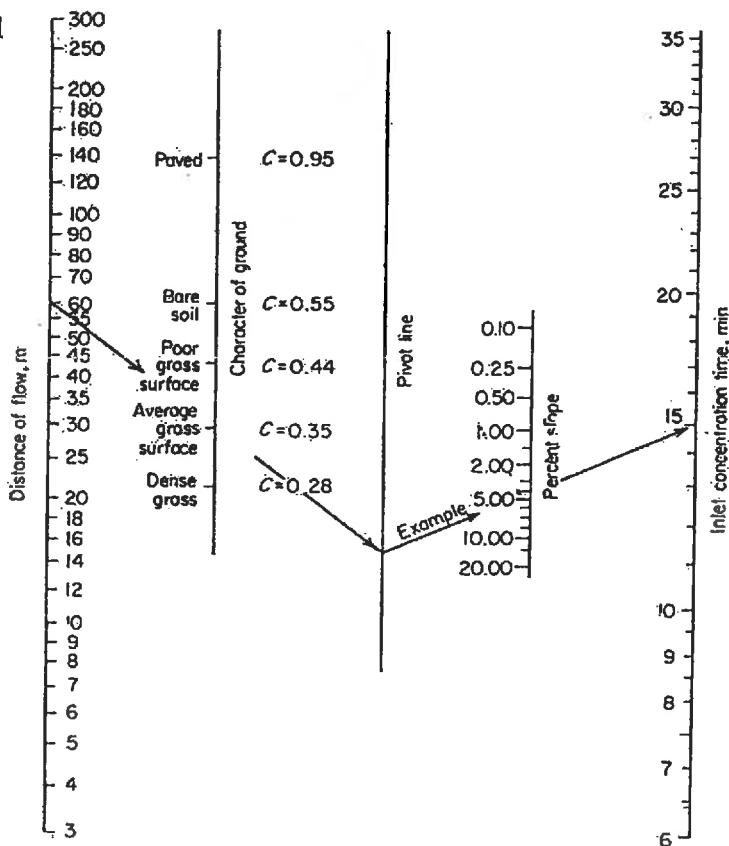
Please complete the following table, and show all your calculations on the calculation page (Page 14):

Pipe	Runoff coefficient C	Rainfall intensity i (mm/h)	Flow (m ³ /s)	Pipe diameter (mm)	Velocity (m/s)	d/D
AB						
BC						
EC						
CD						



Mirhosseini, G; Srivastava, P; Stefanova, L. Regional Environmental Change, 13, 1 (Sup),25-33.

Simplified Overland Flow Time Determination for Urban Drainage



Appendix 18
© John Wiley & Sons, Inc. All rights reserved.

Shamas and Wang, 2011

Calculation page for Question 5.