UNIVERSITY OF TORONTO

Department of Civil Engineering

CIV 340F MUNICIPAL ENGINEERING

Final Examination 2001 | **Type C Exam**

Examiner: B.W. Karney | Date: April 2001

INSTRUCTIONS

- Permitted aides are a silent, self-powered electronic calculator a single 8.5 × 11 inch reference sheet.
- Answer **both questions** in Part A; Answer any **2 of the 3 questions** in Part B. All questions of equal value.
- In questions involving iteration, approximately 75% of the mark will be assigned to a correct first iteration including application of the corrections.
- If doubt exists as to the interpretation of a question, a clear statement of any assumptions made should be included with the answer.
- The following relations and values may be useful:
  - $\rho = 1000$ kg/m^3; cms = m^3/s.
  - Hazen-Williams: $Q = 0.278 C D^{2.63} S^{0.54}$, $S = \Delta h / L$
  - Darcy-Weisbach: $\Delta h = \dfrac{fL}{D} \cdot \dfrac{V^2}{2g}$
  - Hardy Cross: $q_l = -\dfrac{0.54 \sum_{\text{loop}} \Delta h_i}{\sum_{\text{loop}} |\Delta h_i / Q_i|}$
  - Hardy Cross: $\Delta H_j = \dfrac{\sum_{\text{node}} Q_i}{0.54 \sum_{\text{node}} |Q_i / \Delta h_i|}$
  - Manning: $V = \dfrac{1}{n} R^{2/3} S^{1/2}$ $\qquad Q = \dfrac{0.312}{n} D^{8/3} S^{1/2}$

- Assume that the following pipe sizes are commercially available:

Actual Diameter (inches)	Actual Diameter (mm)	Nominal Diameter (mm)	Actual Diameter (inches)	Actual Diameter (mm)	Nominal Diameter (mm)
6	152	150	42	1067	1100
8	203	200	48	1219	1200
10	254	250	54	1372	1400
12	305	300	60	1524	1500
15	381	400	66	1676	1700
18	457	450	72	1829	1800
21	533	500	78	1981	2000
24	610	600	84	2134	2100
27	686	700	90	2286	2300
30	762	800	96	2438	2400
36	914	900	102	2591	2600

Part A: Answer Both Questions

1. Provide short (about 1/2 to 1 page) answers/explanations to the following questions:

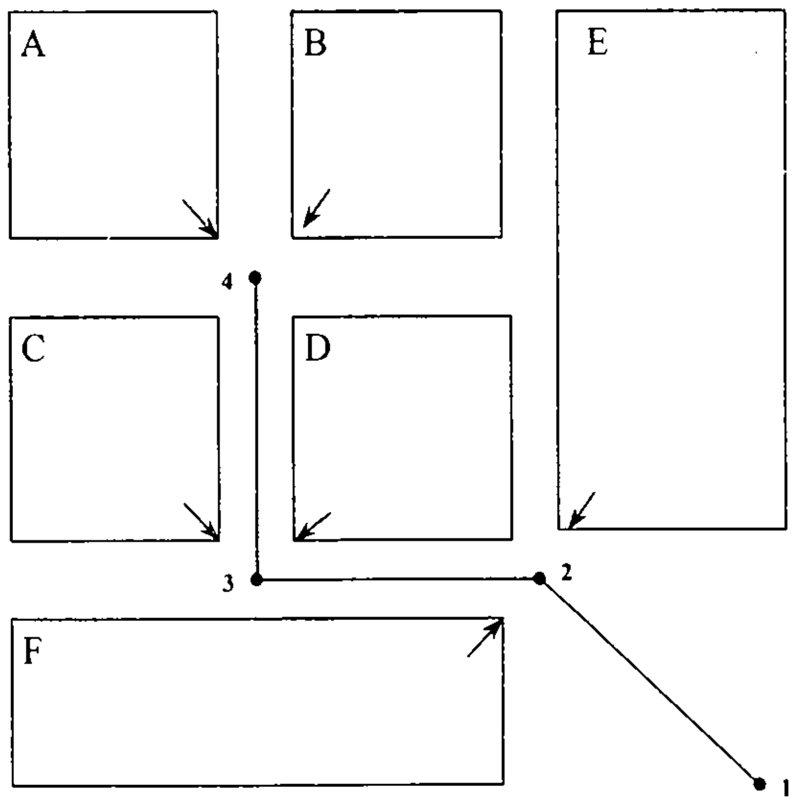
   (a) Sewer separation has been suggested as a means of reducing both the pollution of receiving water bodies and also reducing the impact of upstream flooding. What is the basis for this argument? However, in practice, the positive impact of sewer separation has often been disappointing, having fewer benefits than anticipated. What are some of the reasons for this less-than-expected performance?

   (b) Water distribution systems are almost always design with extra or redundant pipes that are used to form "loops" within the pipe system. What are the key benefits of a looped system over an apparently more efficient "tree" system (i.e., a system without loops)?

   (c) "Storm sewers are designed to fail. The question is not whether they will fail, but how often." Explain what this quote means, and how such a design approach can be justified.

2. The areas shown below are to be drained by a storm sewer system. The sizes of the areas, inlet times and runoff coefficients are given in the table. The distance between manholes is 400 m and the ground slope is 0.75% in the direction of flow. Sewer pipes are concrete with $n = 0.013$. The design storm intensity-duration rainfall data is given in tabular form below (i.e., "Precipitation" column). (a) Calculate the design flows and size the sewers with commercially available pipe. Calculate actual flow depth and velocities. Comment on the design. (b) Briefly explain how the design storm rainfall intensities would have been obtained, and what the basis is for using these values for a storm sewer design.

Label	Area (ha)	Inlet Time (min)	Runoff C	Time (min)	Precip. (mm/hr)
A	16	12	0.4	5	90
B	16	15	0.8	10	82
C	16	10	0.7	15	78
D	16	9	0.6	20	75
E	28	25	0.3	30	70
F	32	17	0.7	40	67



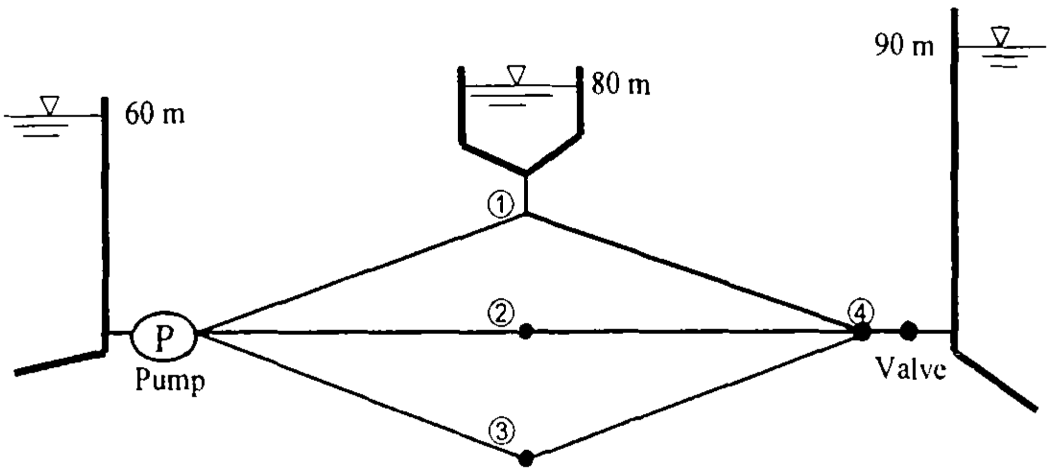
Part B: Answer Two of the following Three Questions

3. Three reservoirs are connected by the six pipe system shown in the sketch (not to scale). The left-hand reservoir at 60 m elevation is boosted through the pump to supply water for the other parts of the system. Each of the six main pipes is 15 inches in diameter, 2500 m long and has a Hazen-Williams C of 125; the short pipes that connect the reservoirs to the main system have high capacity and negligible loss, and thus can be neglected from the analysis. The pump curve for a single pump can be approximated by the equation

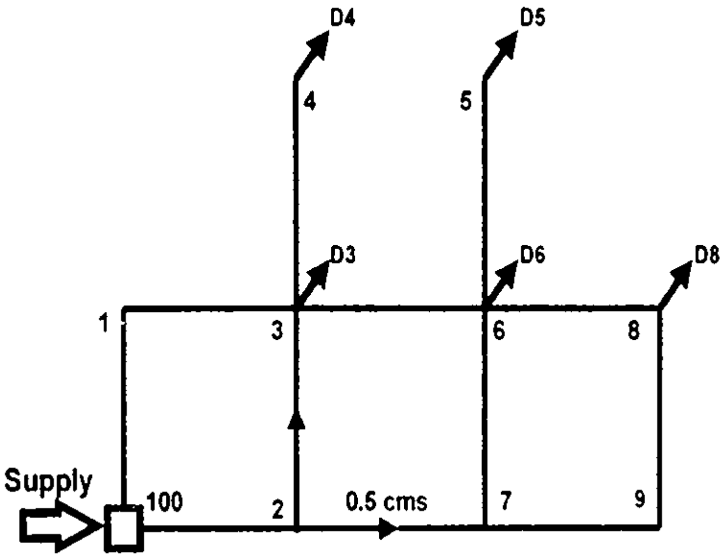
$$H_p = 50 - 950Q_p^{1.9}$$

where H_p is the total dynamic head (m) and Q_p is the discharge through a single pump (m^3/s). There are three pumps in parallel in the actual system.

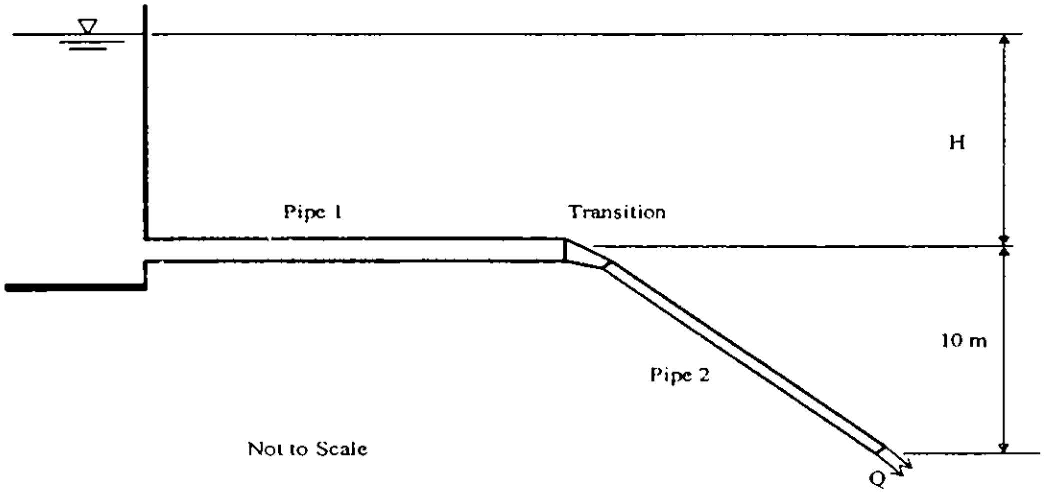
Determine the flow in each pipe in the system, and the flow either from or to each reservoir, (a) assuming the valve near node 4 is completely closed and permits no flow and (b) assuming this same valve is fully open with negligible loss.



4. Solve the 12 pipe system shown below. All pipe—except for the one carrying the known flow—are 30 inches in diameter, have a $C = 130$, are 500 m long and constructed at a 100 m elevation. The pipe connecting nodes 2 and 7 is carrying a known flow of 0.5 m^3/s; this pipe has the same length and diameter as the others, but has an unknown C factor. The total head at the source node (node 100) is 200 m. The demands at all five indicated nodes (D3, D4, D5, D6 and D8) are each 0.70 m^3/s. Determine: (a) the flow in each pipe, (b) the minimum pressure head in the system and (c) the C value for the pipe connecting nodes 2 to 7.



5. In the system shown below, each pipe is 1000 m long, pipe 1 is 15 inches in diameter and pipe 2 is 8 inches in diameter. The transition section is known to have a loss of three velocity heads (of pipe 2) and the entrance loss (pipe 1) is 0.5 velocity heads. Both pipes are believed to have the same relative roughness. When the value of H is 50 m, the flow in the system is known to be 0.110 m^3/s. Determine, as accurately you can, the discharge in the system when H is 2 m.



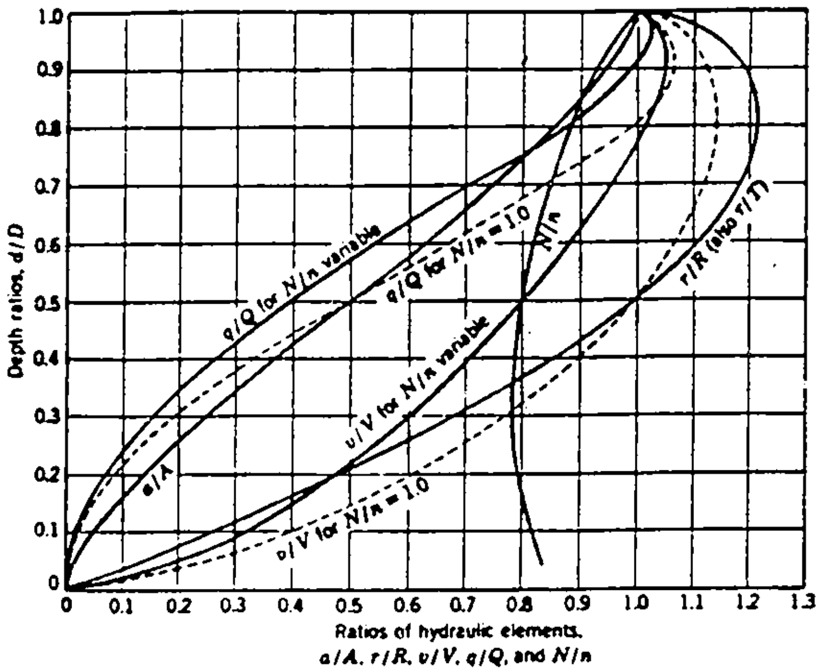


Fig. 14-2. Basic hydraulic elements of circular sewers for all values of roughness and slope.

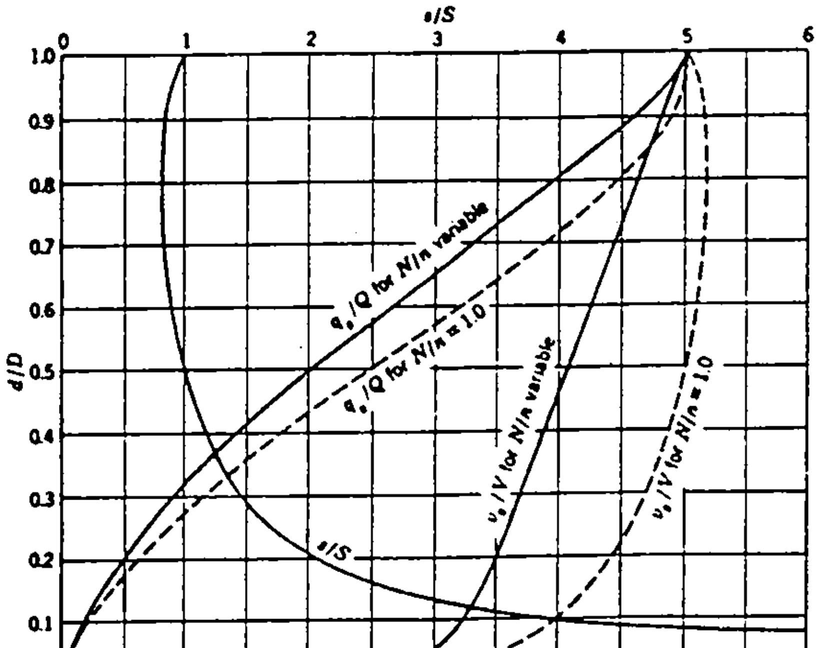


Fig. 14-3. Hydraulic elements of circular sewers with equal self-cleansing properties at all depths.

from WATER AND WASTEWATER ENGINEERING, VOL. 1 WATER SUPPLY AND WASTEWATER REMOVAL, G.M. Fair, J.C. Geyer & D.A. Okun
John Wiley & Sons, Inc. New York. 1966.

Critical Flow and Critical Velocity in Circular Conduits