UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACHELOR OF ENGINEERING TECHNOLOGY: *ENGINEERING : CIVIL*
SUBJECT	:	**WATER RETICULATION DESIGN 3A**
CODE	:	**WRDCIA3**
ASSESSMENT	:	WINTER EXAMINATION (SUPPLEMENTARY PAPER)
DATE		JULY 2019
DURATION	:	(SESSION 1) 08:30 - 11:30
WEIGHT	:	40:60
TOTAL MARKS	:	90

ASSESSOR	:	G.K. NKHONJERA
MODERATOR	:	DR EDNAH ONYARI
NUMBER OF PAGES:		PAGES: 17 including the cover page and Annexures.

INSTRUCTIONS :

1. This paper contains 5 questions: ANSWER **ALL** QUESTIONS
2. Make sure that you understand what the question requires before attempting it.
3. Any additional material is to be placed in the answer book and must indicate clearly the question number, your name, and Student number.
5. Where necessary, answers without calculations will not be considered.

ANSWER **ALL** QUESTIONS

QUESTION 1 [15]

1.1 Provision of appropriate sanitation to any community in this country should take place under the National Sanitation Policy. Explain any TWO major aims of National Sanitation Policy. (2)

1.2 A 200 mm sewer with a length of 110 m is to be installed on a slope of 0.023. The sewer line carries a flow of 18.7 l/s and runs from manhole A to manhole B. If the invert level of manhole A is 101.17 m, determine the following:

a) Pipe cover at downstream manhole B if the ground level at B is actually 100.07 m. (2)
b) Flow depth in the sewer. (5)
c) Actual flow velocity in the sewer. (2)

1.3 A certain African town, with a daily per capita water consumption of 150 l/c/day, has a population of 50,000. In this town, the non-domestic water use is 1,500,000 m^3/yr. If the unaccounted-for water (UFW) is 12% of total production, determine the daily total water production that is delivered to this town in (m^3). (4)

QUESTION 2 [15]

2.1 It is widely believed that land-use directly affects the quantity of runoff that is generated in a catchment. Describe how the following land-use practices may affect runoff in a catchment.

a) Crop farming. (2)
b) Rural electrification. (2)
c) Tree planting. (2)

2.2 A stormwater pipe in an urban area is to be constructed to carry a peak flow of 600 m^3/min when flowing 100% full with a bedding slope of 0.025. It is further stated that, at all times, the stormwater pipe should have flow velocity more than 0.75 m/s but not greater than 3.0 m/s. A concrete pipe, with sizes in increments of 50 mm, and having a Manning's coefficient, $n = 0.020$ is the only pipe type available. Under these conditions, calculate the pipe size and check whether the design meet the required standards. (9)

QUESTION 3 [20]

You are asked to analyze a proposed water supply pipe network. The initial estimated flow in pipes AB, CG and MN are 120 l/s , 60 and 10 l/s respectively. Inflows into and outflows from various nodes are as indicated in **Fig. 3.1** below. Using the head balance (Hardy Cross) method, determine the discharge in each pipe after performing **<u>only 1 (one) iteration for each loop</u>**. Use the Darcy's friction factor, $f = 0.0184$ for all the pipes. *(Calculation sheets provided in Appendix C may be used).*

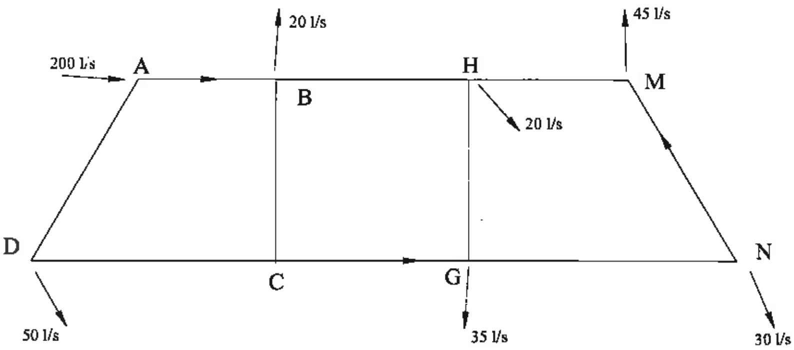


Fig. 3.1

Table 3.2: Pipe lengths and sizes

No.	Pipe name	Pipe length (m)	Pipe diameter (mm)	Estimated flow (l/s)
1	AB	900	350	120
2	BC	1000	250	
3	CD	900	250	
4	AD	1000	300	
5	BH	850	250	
6	HG	1000	200	
7	CG	850	200	60
8	HM	850	250	
9	MN	1000	250	10
10	GN	850	250	

QUESTION 4 [20]

The diagram (**Fig. 4.3**) shows part of a layout of a proposed sewer reticulation system. All the manholes on the layout are indicated as A, B, C, up to L as shown. All other information you may need is provided in **Table 4.4** below. Taking into account 20% for infiltration and inflows, determine the Peak Wet Weather Flow (PWWF) discharging into the existing sewer at manhole L. *Use the calculation sheet in Appendix D.*

Table 4.4: Sewage contribution of each development.

Income group	Lower	Middle	Higher	General residential
Average flow *(L/unit/day)*	500	750	1000	400 *L/100 m^2/day*
No. of people per unit.	7	6	5	10 people *per 100 m^2*

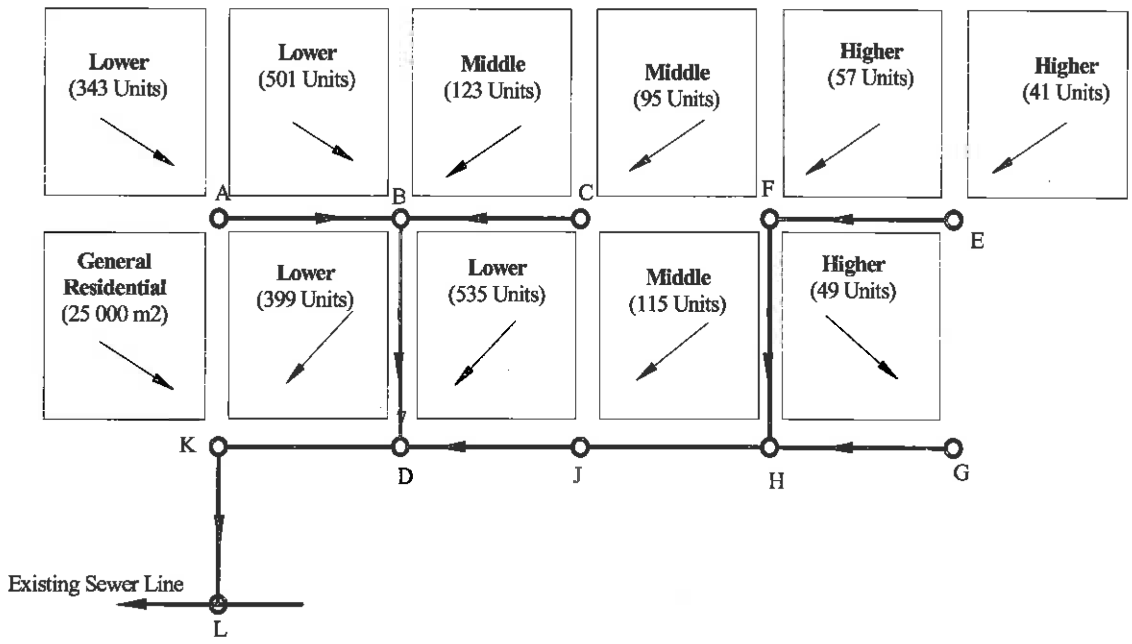


Fig. 4.3: Layout of the sewer lines

QUESTION 5 [20]

A stormwater drain is proposed that will trap the stormwater and drain it into the natural water way (Main Drain) as shown in **Fig. 5.5** in **Appendix B**. This stormwater drain, which should be unlined, is expected to be covered with grass in order to stabilize its banks. Thus, the Manning's coefficient, $n = 0.025$. The total length of the drain, from the inlet point to the outlet point, is 550 m. For economic reasons, the drain should be designed to handle, at most, a 10-year flood from the contributing areas. Now, you have been tasked to design this stormwater drain and to do this you may need information, some of which is given below:

- The drain should be designed so that water enters the drain at the specified inlet points only.
- Between any two inlet points, the bed slope should be taken as uniform. The flow is also uniform.
- Losses such as evaporation or infiltration may not be considered in the design.
- For this channel material, maximum velocity can be taken as 1.25 m/s.
- Assume water flows in well-defined channels before entering the drain.
- The channel side slopes may be taken as 1: 3, where, z = 3 or m = 3.
- The IDF curves from the City Engineer, East London (*Appendix E*) may be used.
- Otherwise all information is provided in the accompanying Table 5.6 below.

For the bed width of the channel, $b = 3.5$ m, with a freeboard of 0.65 m, determine the following:

a) Total depth of stormwater channel. (13)
b) Froude number and therefore, comment on the stability of the channel. (7)

Table 5.6: Stormwater drain information

	Inlet	*Outlet*
Invert Level (m)	214.245	213.570
Contributing area, A, (ha)	70.6	59.8
Runoff Coefficient, C, in the contributing area.	0.44	0.56
Terrain general slope of the contributing area, (%)	2.4	1.8
Hydraulic length of the contributing area, (m)	900	1050

WELCOME BACK TO YOU ALL!!!!

APPENDIX A

FORMULAS

1.0 **Rational Formula:**

$$Q = 0.278CIA, \qquad T_c = 0.0195L^{0.77}S^{-0.385}$$

Where:

I = intensity (mm/hr).
A = catchment area (km^2).
L = hydraulic length of the catchment (m).

2.0 **Pipe Friction:**

General Formula: $h_L = h_f = rQ^m$;

Darcy-Weisbach: $h_f = \dfrac{fLQ^2}{12.1d^5}$

Resistance, $r = \dfrac{fL}{12.1d^5}$

Hazen-William formula: $h_f = 10.67LD^{-4.87}\left(\dfrac{Q}{C}\right)^{1.85}$

3.0 **Pipe capacity:**

$$Q = AV$$

4.0 **Manning's Equation:**

$$V = \frac{1}{n}R^{2/3}S^{1/2}$$

5.0 **Chezy Formula:**

$V = CR^{1/2}S^{1/2}$; where C = Chezy coefficient.

6.0 **Hydraulic radius:**

$R = \dfrac{A}{P}$; where P = Wetted perimeter in the channel.

7.0 **Hydraulic Depth:**

$D = \dfrac{A}{T}$; where T = Top width of the water surface in the channel.

8.0 **Froude Number:**

$$N_F = \frac{V}{\sqrt{gD}}$$

9.0 Darcy-Weisbach Head Balance Method spreadsheet:

Trial No.	Loop No.	Pipe	Diameter	f	L	m	r	Flow rate Q	Friction loss (h_f)	h_f/Q	ΔQ	$\Delta Q'$	Revised flow (Q)	Velocity

Where $\Delta Q = \frac{\sum h_f}{-m\sum \frac{h_f}{Q}}$

$$r = \frac{fL}{3.03d^5}$$

$$NewQ = Q + \Delta Q + \Delta Q'$$

10.0 Harmon's formula

$$PF = 1 + \frac{14}{4 + \sqrt{p}}$$

Where:

P = population per a thousand.

APPENDIX B: STORMWATER DRAINAGE SYSTEM

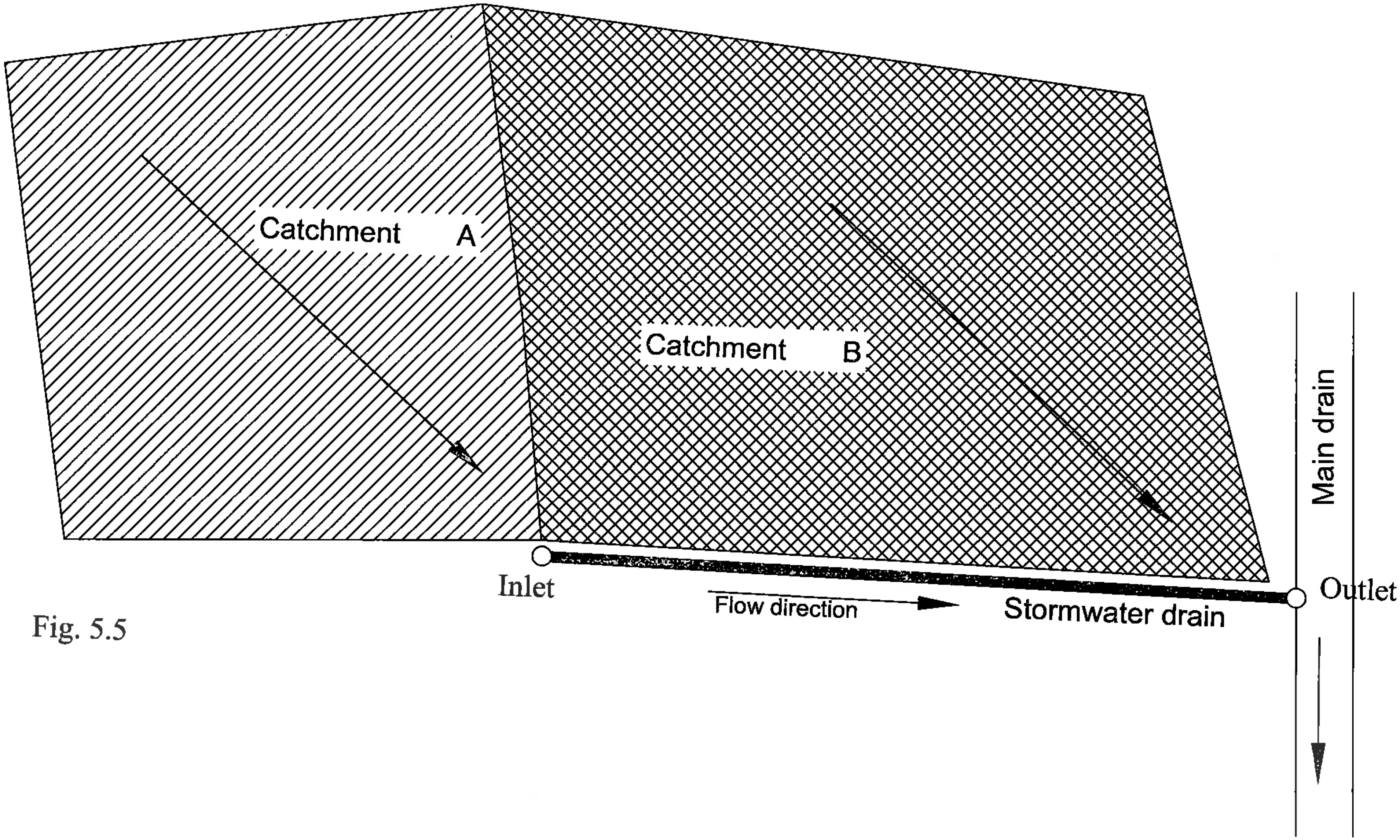


Fig. 5.5

APPENDIX C

DEPARTMENT OF CIVIL ENGINEERING
DOORNFONTEIN CAMPUS

HEAD-BALANCE METHOD ANAYLSIS

UNIVERSITY OF JOHANNESBURG

PROJECT NAME:________________ SHEET No. ________ DESIGNED BY: ________________ DATE: ________

Trial No.	Loop No.	Pipe Name	Diameter (mm)	Length, L (m)	Pipe roughness size, k (mm)	*Friction Coef. "f"*	r **	Flow, Q (L/s)	m	Friction loss, hf (m)	hf/Q	Change in Q, ΔQ	Change in Q', ΔQ'	New Q

* This table is developed for the Darcy-Weisbach formula, but some columns can be added or replaced to suit other formulas

** For Darcy-Weisbach Formula, r = (fL)/(12.1*D^5)

APPENDIX D

DEPARTMENT OF CIVIL ENGINEERING
DOORNFONTEIN CAMPUS

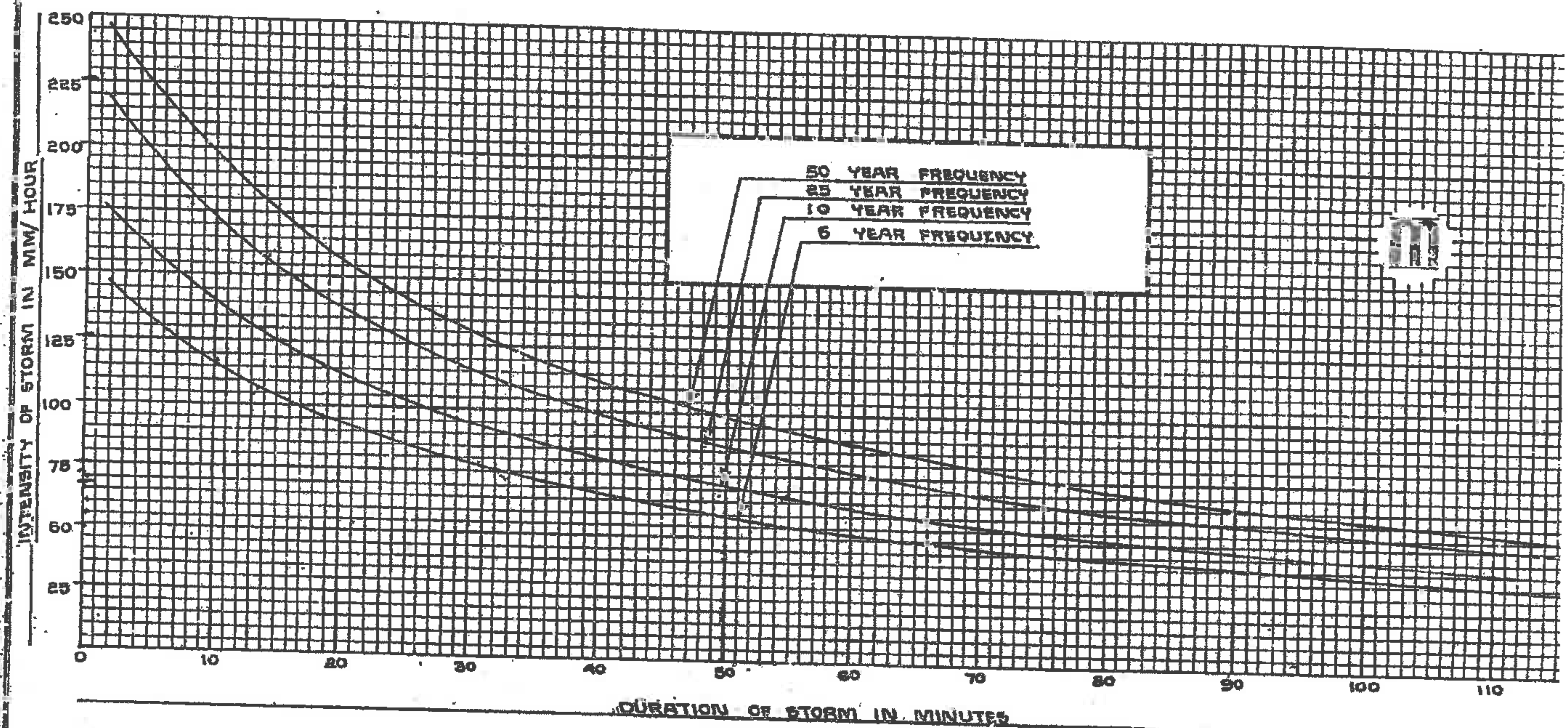
UNIVERSITY OF JOHANNESBURG

SEWAGE FLOW CALCULATION SHEET

PROJECT NAME: ____________ **SHEET No.** ____________ **DESIGNED BY:** ____________________ **DATE:** ____________

Line No.	Line Description	From Manhole	To Manhole	Sub Area Name	Income Level	No. of Units/ Area Size	Average flow (l/unit/day) or (l/area/day)	ADWF (L/s)	Cummulative ADWF (l/s)	No. of people per unit	Total tributary population	PF	PDWF (L/s)	PWWF (L/s)

APPENDIX E



REFERENCE

BASED ON I (25 YEAR FREQUENCY) $= \frac{270(25.4)}{T+20}$
WHERE T = DURATION OF STORM.

FOR A STORM OF 'N' YEARS FREQUENCY
WHERE F = 0.36+0.445 LOG N.

$$I = \frac{F \times 270(25.4)}{T+20}$$

F = 0.36 + 0.445 LOG N

PREPARED	
SENIOR ROADS ENGINEER.	
DEPUTY CITY ENGINEER	

EAST LONDON - CITY ENGINEER'S DEPARTMENT.

STORMWATER DRAINAGE
RAINFALL INTENSITY & DURATION
FREQUENCY CURVES.

BSc (Eng) M.I.C.E., A.M.I.S.A.I.C.E., A.M.I.W.E., A.M.I.W.P.C., M.R.S.H.
CITY ENGINEER.

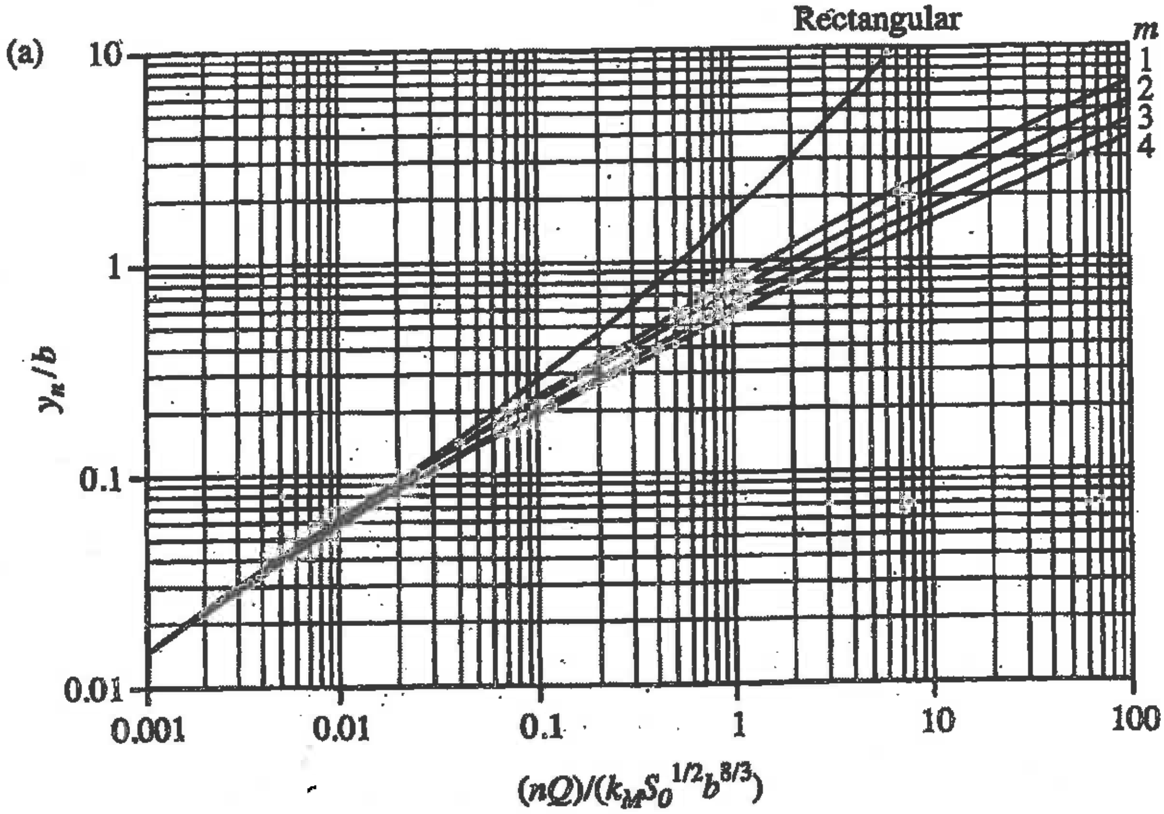
DATE

SCALE N.A.

PLAN

APPENDIX F

OPEN CHANNEL DESIGN, NORMAL DEPTH



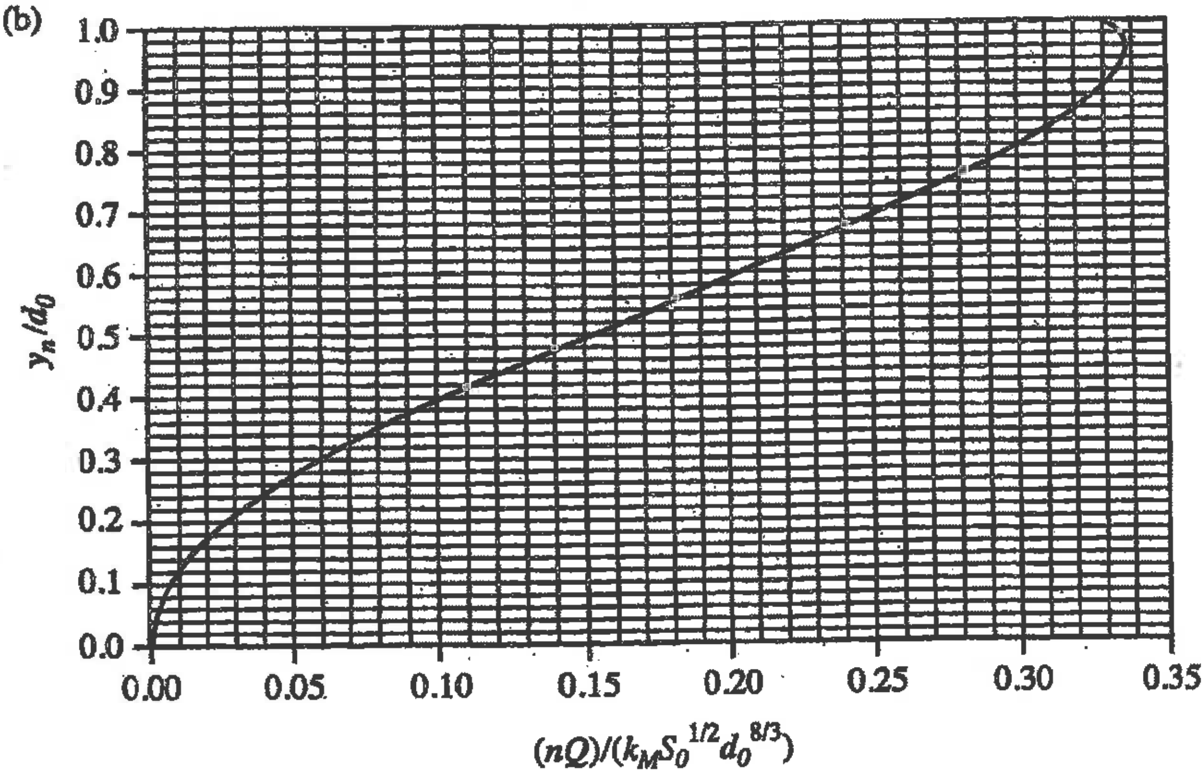
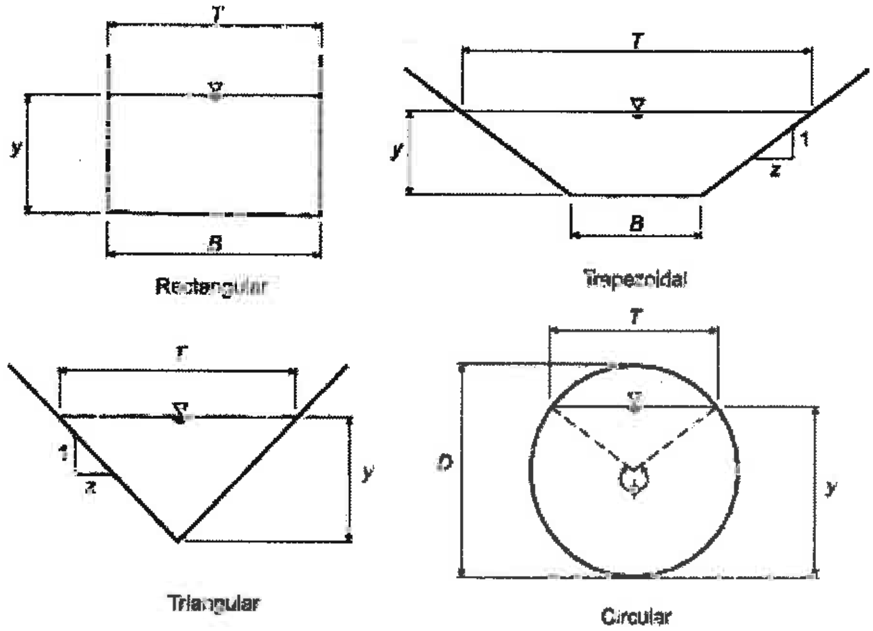


Figure 6.4 Normal depth solution procedure: (a) trapezoidal channels (m = side slope) and (b) circular channels (d_0 = diameter)

APPENDIX G

OPEN CHANNEL CROSS SECTIONS



Channel Shape	***Area, A***	***Wetted Perimeter, P***	***Hydraulic Radius, R***	***Top Width, T***	***Hydraulic depth, D***
Rectangular	By	$B+2y$	$\frac{By}{B+2y}$	B	y
Trapezoidal	$By+zy^2$	$B+2y\sqrt{1+z^2}$	$\frac{By+zy^2}{B+2y\sqrt{1+z^2}}$	$B+2zy$	$\frac{By+zy^2}{B+2zy}$
Triangular	zy^2	$2y\sqrt{1+z^2}$	$\frac{zy}{2\sqrt{1+z^2}}$	$2zy$	$\frac{y}{2}$
Circular *(ϕ in radians)*	$\frac{D^2(\phi-\sin\phi)}{8}$	$\frac{D\phi}{2}$	$\frac{D}{4}\left(1-\frac{\sin\phi}{\phi}\right)$	$D\frac{\sin\phi}{2}$	$\frac{D(\varphi-\sin\varphi)}{4\sin\varphi}$

APPENDIX H

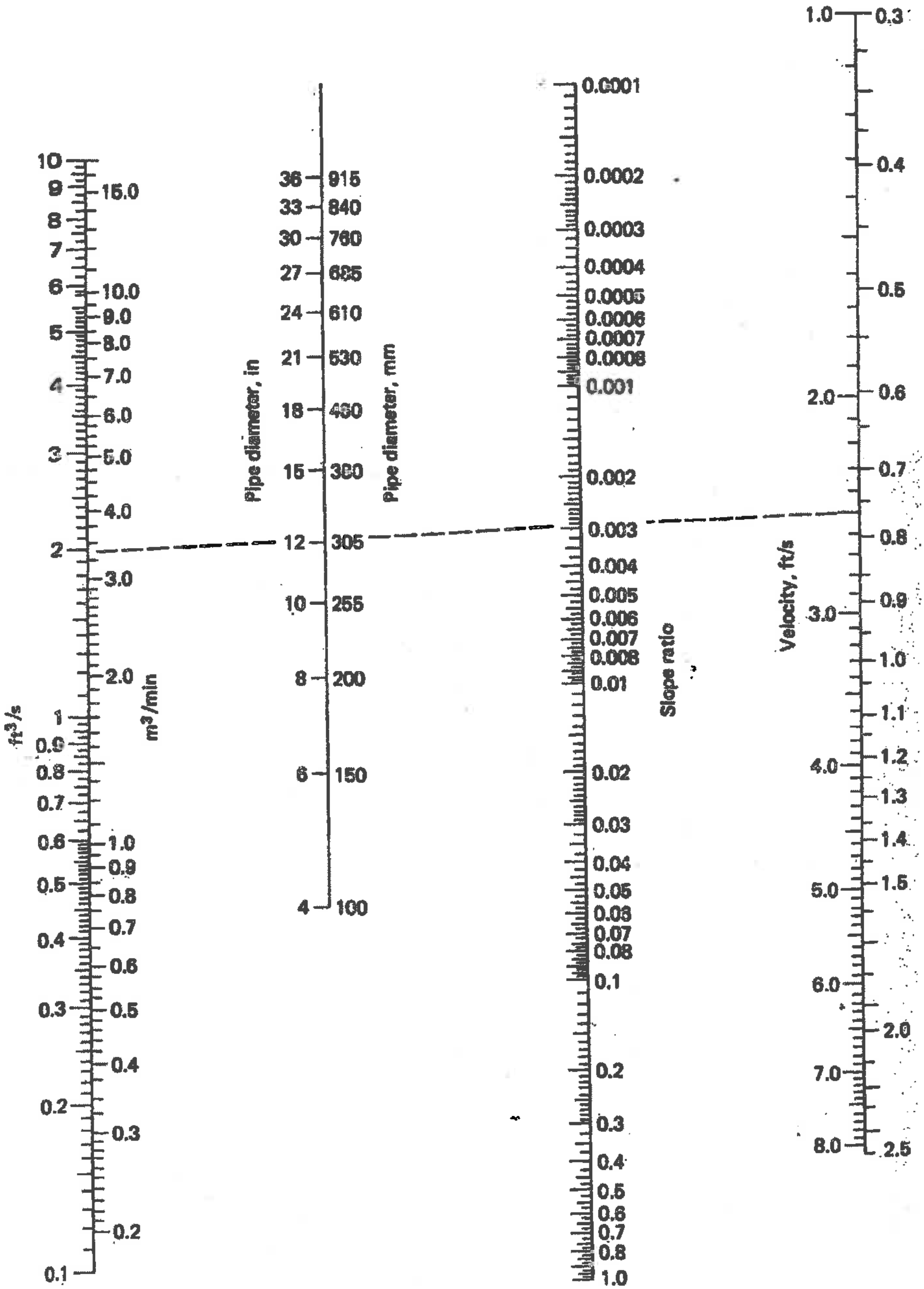
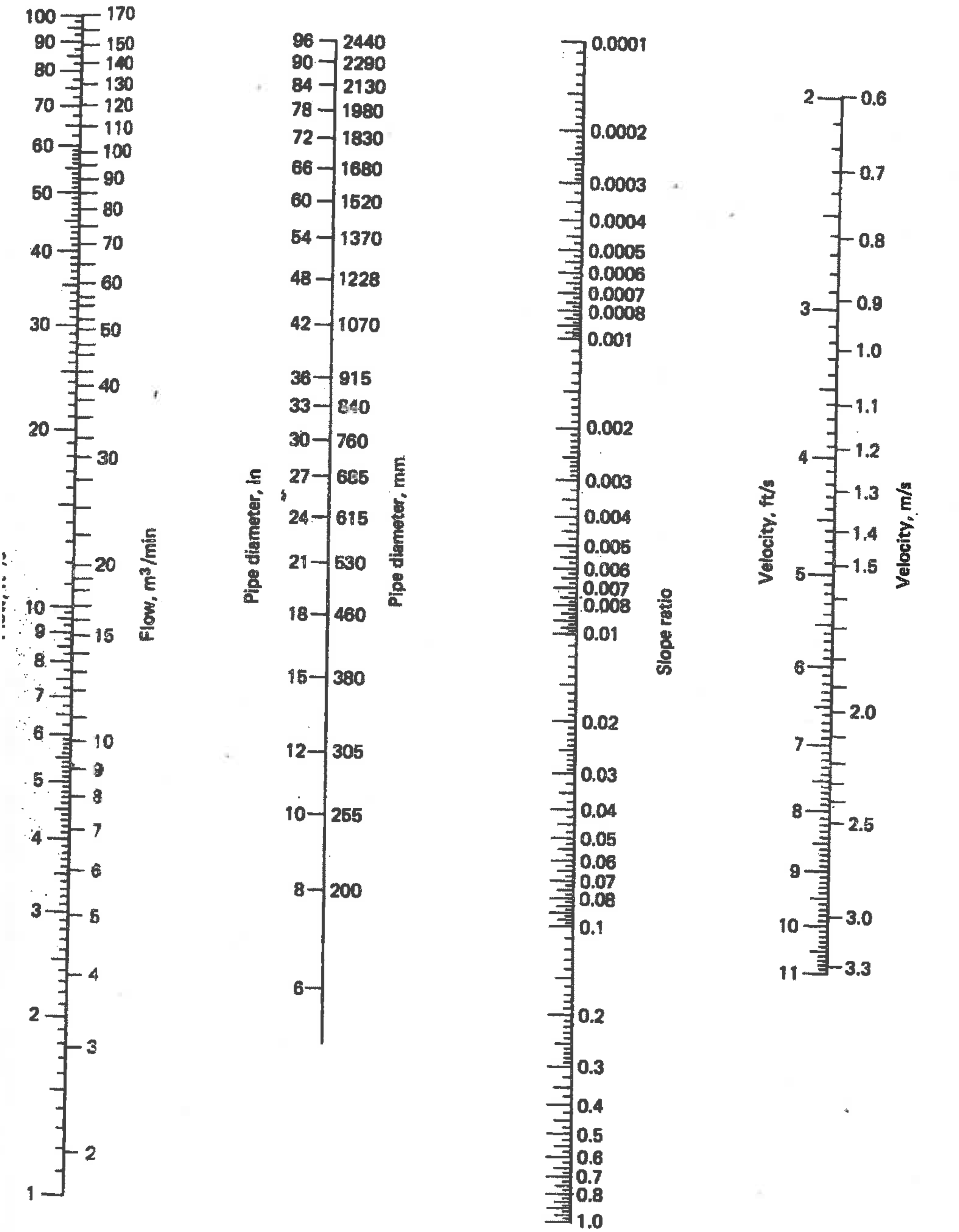


FIGURE 16-2
Nomogram for solution of Manning's equation for circular pipes flowing full (n = 0.013).



IGURE 16-3

lomogram for solution of Manning's equation for circular pipes flowing full (n = 0.013).

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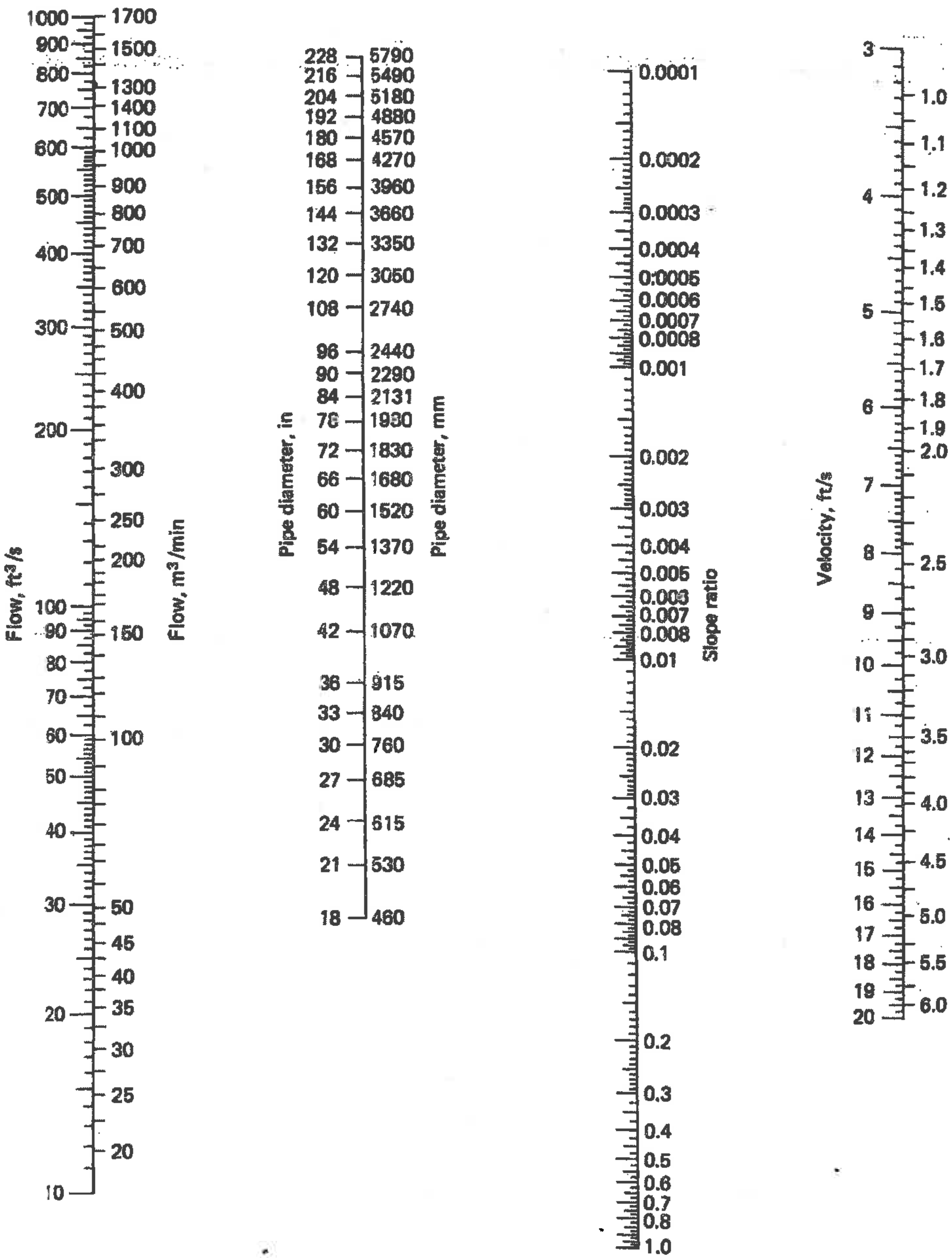

FIGURE 16-4
Nomogram for solution of Manning's equation for circular pipes flowing full (n = 0.013).

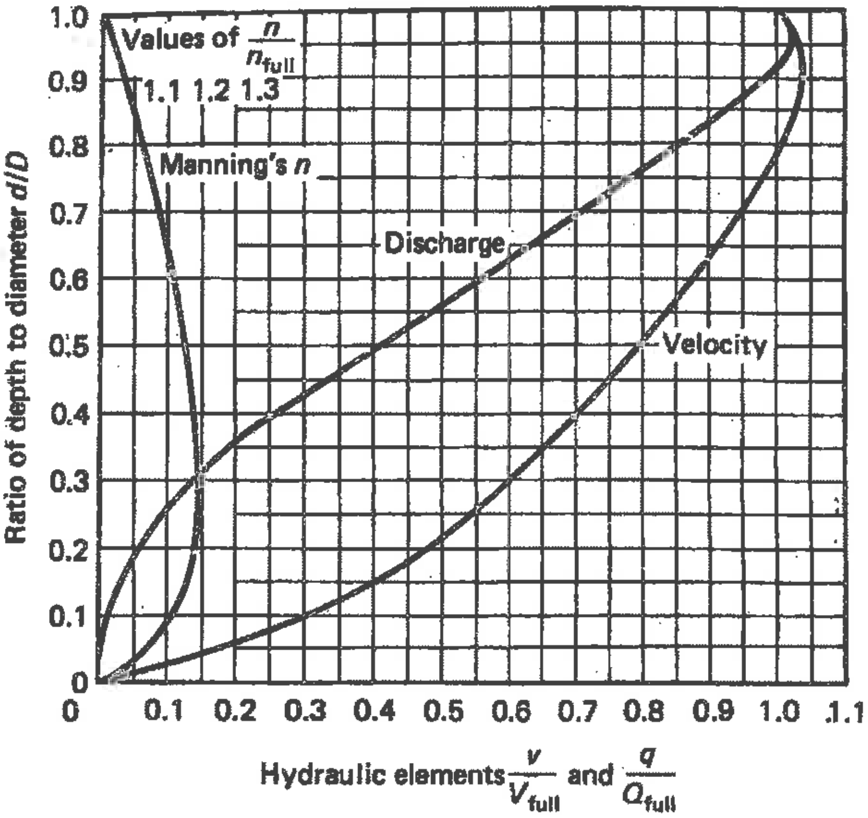

FIGURE 16-6
Variation of flow and velocity with depth in circular pipes.