UNIVERSITY
OF
JOHANNESBURG

PROGRAM	:	BACCALAUREUS TECHNOLOGIAE: *ENGINEERING : CIVIL*
SUBJECT	:	**RETICULATION DESIGN AND MANAGEMENT IV**
CODE	:	**CRD411**
ASSESSMENT	:	SUMMER EXAMINATION (MAIN PAPER)
DATE		15th NOVEMBER 2017
DURATION	:	(SESSION 2) 12:30 - 15:30
WEIGHT	:	40:60
TOTAL MARKS	:	110

ASSESSOR	:	G.K. NKHONJERA
MODERATOR	:	PROF. F.M. ILUNGA
NUMBER OF PAGES:		PAGES: 20 including the cover page and Annexures.

INSTRUCTIONS :

1. This paper contains 3 questions in Section A and 3 questions in Section B
2. Section A: ANSWER **ALL** QUESTIONS
3. Section B: ANSWER **TWO** QUESTIONS ONLY
4. Make sure that you understand what the question requires before attempting it.
5. 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.

SECTION A
ANSWER ALL QUESTIONS

QUESTION 1 [10]

1.1 In a typical water reticulation system, state any two locations where the fire hydrant, if located there, may serve as a scour valve as well. (2)

1.2 Discuss why the following impact assessment exercises may be important in planning and designing of sustainable stormwater systems:

a) Policy impact assessment. (2)
b) Strategic impact assessment. (2)

1.3 Type of soil where the sewer pipe is laid may have direct influence on infiltration of water into the sewer pipe. Discuss any TWO ways soil type may affect infiltration in sewer pipes. (4)

QUESTION 2 [15]

2.1 The "RED BOOK" recommends minimum and maximum residual pressures in water supply pipes. In your understanding of water engineering, explain why there should be such limitations in residual pressure? (4)

2.2 Consider a residential location somewhere in Mogale City Municipality that has a population of 4100 people. The municipality supplies this location with an annual water supply of 65200 m^3, which includes unaccounted-for water (UFW) estimated at 35% of the total supply. In this location, the UFW is largely due to leakages and illegal connections. The leakages in the distribution system constitute 15% of this UFW, otherwise the rest of the loss is due to illegal connections. If, during the same period, the maximum flow registered by the municipality flow meter were 24.2 m^3/hr, determine the following:

a) Total amount of water lost due to illegal connections. (3)
b) Per capita water consumption in litres per day. (4)
c) Maximum instantaneous peak factor. (4)

QUESTION 3 [15]

3.1 The local insurance agent is in charge of settling flood claims in Bram Fischer area in Soweto but is not clear about the concept of "50-year flood". The agent says, "On the river near my area, we have had two 50-year floods in just 15 years. I'm really confused about this 50-year flood 'stuff'". As a water engineering professional, demonstrate your understanding of the subject by providing a clear explanation about how a 50-year flood can occur twice in the last 15 years. (3)

3.2 For truly sustainable stormwater systems, best management practices (BMPs) must be adopted as technologies for designing stormwater systems in South Africa. Briefly, discuss how the following may be used as BMPs:

a) Grassed stormwater drain. (2)
b) Rainwater harvesting. (2)
c) Natural wetlands. (2)

3.3 Urbanization is generally referred to as the opening up of land for the establishment of an urban development such as towns and cities. With respect to stormwater management, discuss how this urbanization may impact on the following:

a) Natural wetlands. (2)
b) Riparian ecosystem of an urban stream like the Jukskei River. (2)
c) Groundwater recharge. (2)

QUESTION 4 [20]

You are the Civil Engineer in charge of designing a municipal sewer line project. You are presented with a section of a sewer line already designed by a junior colleague as shown in *(***Fig. 4.1, Appendix B***)*. This is essentially a longitudinal section of the sewer line. The sewer will be laid in a road reserve for easy accessibility and maintenance. Your duty is just to check the design whether it conforms with design guidelines as set out in the 'RED BOOK' and other design guidelines, *(i.e, Minimum cover is 1.4m, Maximum distance between two adjacent manholes is 100m, Minimum gradient is 0.5%, Maximum gradient is 10%, Drops needed where difference in height between two connecting pipes is more than 0.6 m)*. Now, evaluate the design and list down all the errors and short falls associated with this design and therefore, provide recommendations where necessary.

SECTION B
ANSWER TWO QUESTIONS ONLY

QUESTION 5 [25]

You are presented with a proposed main line sewer (as outlined in **Fig 5.2** in **Appendix D**) that you need to design. The layout of this main sewer line runs along the *Mathonsi Street* which collects sewage flow from the sub-mains in the smaller streets as shown. The main sewer line drains into the existing sewer along *Chiloane Street*. Design information on pipes, manholes and sewer discharge is given in **Table 5.3** below. With this information, the sewer is expected to run partially full. The minimum pipe size available is 300 mm and all the other sizes are in increment of 50 mm. Assuming that the minimum and maximum velocities in the sewer pipes are to be within the recommended range of 0.7 m/s and 2.5 m/s respectively, design the sewer line by determining the minimum pipe sizes for the main sewer line along *Mathonsi Street*, starting from manhole MH78M all the way to manhole MH237E on *Chiloane Street*.

Table 5.3: Information on pipes, manholes and pipe discharge

Pipe name	Length, L (m)	Sewer flow, Q (m^3/min)	Invert levels (m)	
			Upstream manhole	Downstream manhole
MH78M – MH77M	61	15.24	301.99	301.08
MH77M – MH76M	43	18.81	299.69	299.30
MH76M – MH75M	55	28.10	298.49	297.74
MH75M – MH74M	50	40.64	297.14	296.54
MH74M – MH237E	57	40.64	295.69	294.99

QUESTION 6 [25]

Fig 6.4 presents a simplified skeleton of part of a bigger distribution network of a water supply project. The initial estimated pressure heads and demands in the network are presented in **Table 6.5**. Pipe information is presented in **Table 6.6**. It is agreed that for the whole network, the friction coefficient *($f = 0.018$)* can be assumed to be the same for all the pipes. Inflows into and outflows from various pipe nodes are as indicated in the network. Using the Flow-Balance Method, determine the new pressure heads at each node after performing **only 1 (one) iteration**. *(Calculation sheet provided may be used).*

Tabe 6.6: Pipe information

Pipe name	Diameter (mm)	Length (m)
KU	200	1215
KS	350	1580
ST	250	1300
TU	200	1300
BK	300	1400
AB	400	1395
AS	450	1550

Table 6.5: Node information

Node name	Pressure Head (m)	Demand (l/s)
K	595.78	24
S	594.16	13
T	629.12	18
U	596.91	31
B	561.42	14
A	560.63	-100

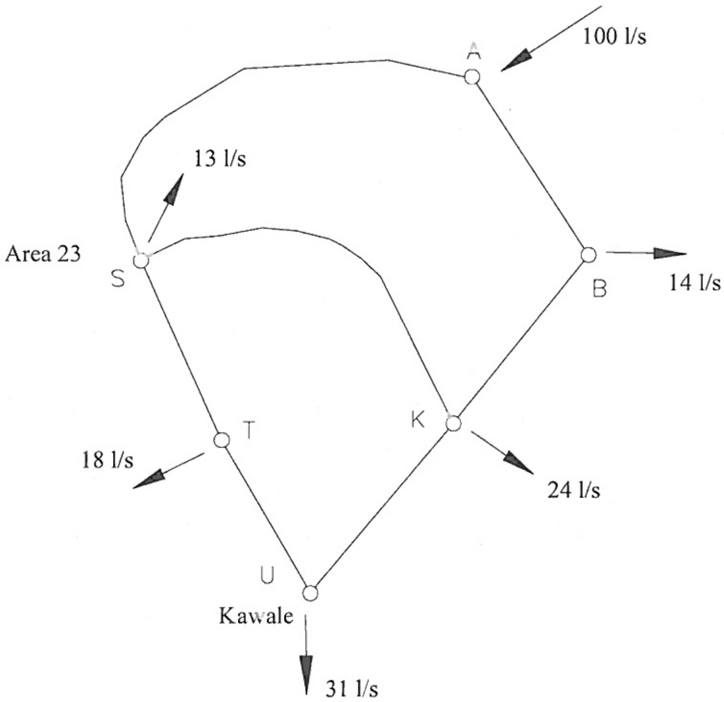


Fig 6.4

QUESTION 7 [25]

As the engineer responsible, you are presented with a planned subdivision of a location as sketched in **Fig. 7.7** in **Appendix F**. The stormwater pipes are laid along the *Sere* and *Makhado Avenues* in such a way that the stormwater collected drain into the main pipe located along the *Mmolawa Street* which eventually drains out at P as shown. The shaded areas between the *Makhado* and *Linda Avenues*, then between *Sere* and *Makhado Avenues*, and between *Kume* and *Molibeli Streets*, will not be served now but later in future, hence, not part of the design. For the served areas, the plan is to let the water run along the street gutters and only enter the pipe drain at the specified inlet points. In this area, the Municipal regulations specify a 5-year return period for the design of all stormwater facilities. Again, in this part of the area, the local IDF curves can be approximated functionally as:

$$i = \frac{a}{b + t_c}$$

Where:

i = Rainfall intensity (*mm/hr*).
t_c = Time of concentration (minutes).
a, b = constants for different return periods.
And, for this hypothetical location, $a = 2500$ and $b = 20$, for a return period of 5 years.

Now, with all this information duly available to you and:

a) Using the stormwater calculation sheet and the nomogram provided in the Appendices G and H respectively, calculate the quantity of stormwater in (m^3/min) that will drain out at P. Also, determine the slopes and sizes of all the stormwater pipes in the layout. (23)

b) If the design philosophy in this Municipality is that the post-development runoff from the area must NOT be more than the pre-development runoff, and that from feasibility studies, it is established that the runoff drained from the proposed area before development is 64.5 m^3/min, do you think this stormwater system is environmentally viable? Explain your answer. (2)

Table 7.8: Specified velocities in pipes (m/s)

Pipe	Length (m)	V (m/s)
AB	70	1.5
BC	70	1.5
CD	70	1.5
DE	70	1.5
FG	70	1.5
GH	70	1.5
HJ	70	1.5
JK	70	1.5
RQ	70	1.5
QP	70	1.5
PE	70	1.5
EK	75	1.5
KL	75	1.5
LP	55	1.5

Table 7.9: Catchment characteristics of the area.

Catch-ment Name	Catch-ment Area, A, (ha)	Runoff Coeff. C	Time of entry (minutes)
6	1.25	0.40	12
7	1.25	0.40	12
8	1.25	0.40	12
9	1.25	0.40	12
10	1.25	0.40	12
11	1.25	0.40	12
12	1.25	0.40	12
13	1.25	0.40	12
14	1.25	0.40	12
15	1.25	0.40	12
20	1.25	0.40	12
51	1.25	0.40	12
52	1.25	0.40	12
54	1.25	0.40	12
57	1.25	0.40	12
58	1.25	0.40	12

Table 7.10: Suggested minimum slopes for standard pipe sizes

Pipe Diameter (mm)	Minimum gradient (1 in ….)
300	80
375	110
450	140
525	170
600	200
675	240
750	280
825	320
900	350
1050	440
1200	520
1375	610

MERRY CHRISTMAS AND HAPPY NEW YEAR !!!!!!!

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: $h_f = \dfrac{fLQ^2}{3.03d^5}$

Resistance, $r = \dfrac{fL}{3.03d^5}$

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

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

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

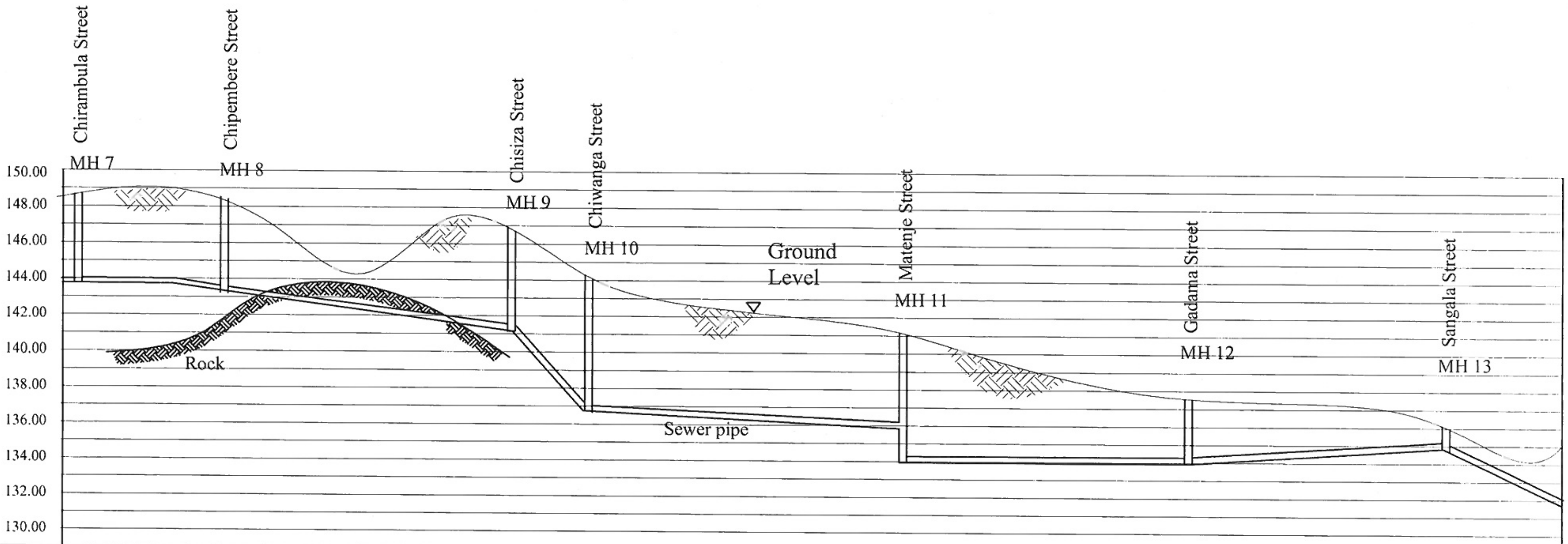
10.0 Harmon's formula

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

Where:

P = population per a thousand.

APPENDIX B: Longitudinal profile of a sewer pipe



Manhole Name	MH 7		MH 8		MH 9		MH 10		MH 11		MH 12		MH 13	
Chainage (m)	0.00		50.00		160.00		180.00		300.00		450.00		480.00	
Groung Level (m)	148.70		148.50		146.90		144.00		141.00		137.50		136.00	
Invert Level (m)	143.30		143.15		141.15		137.05		136.00 134.03 Drop		134.03		135.00	
Pipe Cover (m)	5.40		5.35		5.75		6.95		5.00 6.97		3.47		1.00	
Pipe Size (mm)		150mm		150mm		150mm		150mm		150mm		150mm		150mm
Sewer Gradient (%)		0.30		1.82		20.50		0.88		0.00		-3.23		9.30

Fig. 4.1

APPENDIX C

UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF CIVIL ENGINEERING
DOORNFONTEIN CAMPUS

HEAD BALANCE METHOD

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

For this problem,

$$r = \frac{fL}{12.1d^5}$$

$$h_f = rQ^m$$

$$\Delta Q = -\frac{\sum h_f}{m\sum\left(h_f/Q\right)}$$

$$New Q = Q + \Delta Q + \Delta Q'$$

APPENDIX D: Layout of the Main Sewer

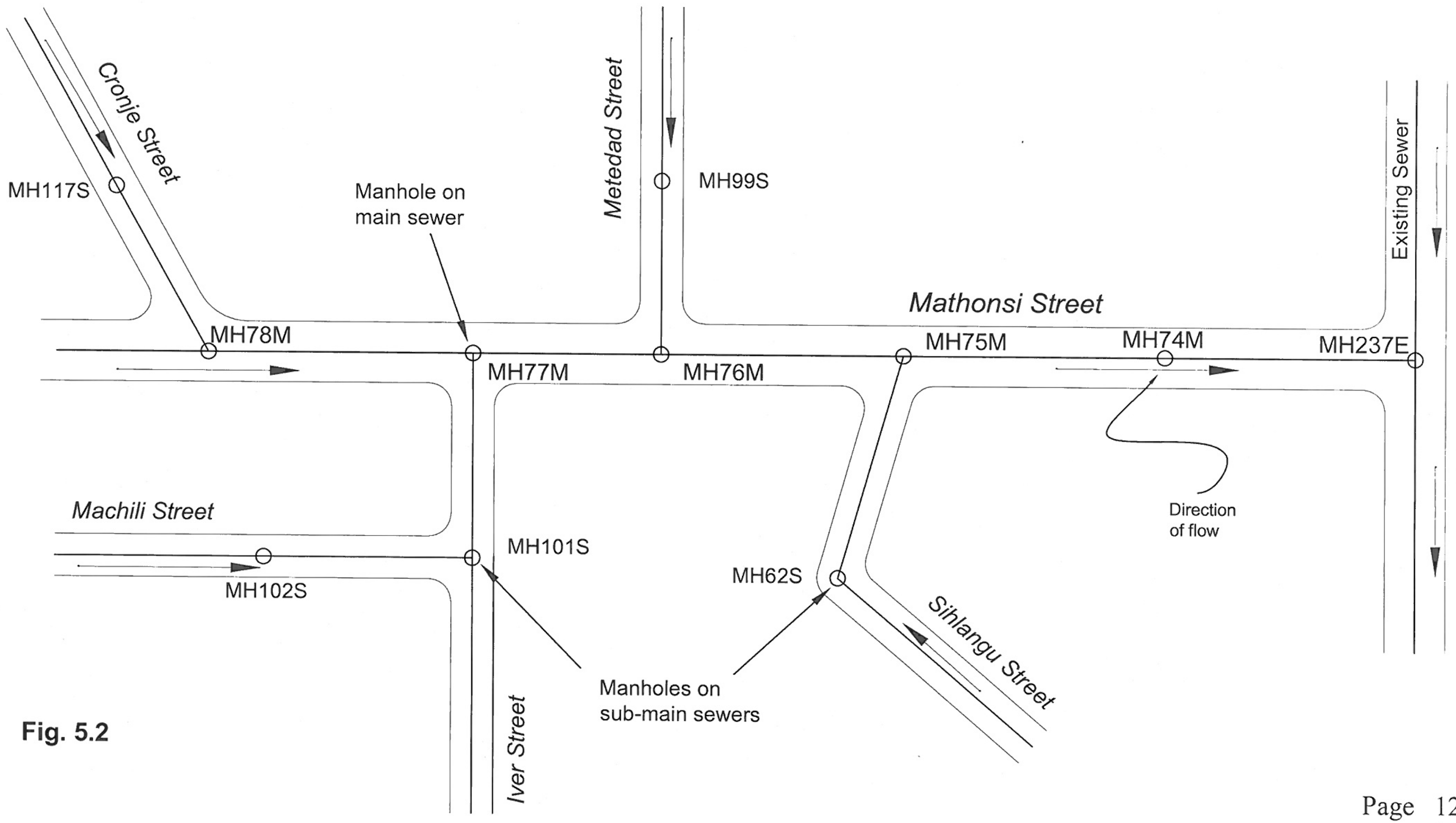


Fig. 5.2

APPENDIX E

UNIVERSITY OF JOHANNESBURG

DEPARTMENT OF CIVIL ENGINEERING
DOORNFONTEIN CAMPUS

FLOW-BALANCE METHOD ANAYLSIS

PROJECT NAME: ____________ SHEET No. ______ DESIGNED BY: ____________ DATE: ________

Trial No.	Node Name.	Piezometric Head, H_o (m)	Node Name up/ downstream	Piezometric head at node up/ downstream, H (m)	Pipe Name	Pipe diameter (mm)	Pipe length, L (m)	Pipe roughness size, k (mm)	*Friction Coef. "f"*	r **	Piezometric head difference, ΔH (m)	m	Flow, Q (L/s)	Q/ΔH	Change in H, ΔH (m)	New H (m)

* 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)

For this problem,

$$r = \frac{fL}{12.1d^5}$$

$$h_f = rQ^m$$

$$\Delta H = \frac{m \sum \Delta Q}{\sum \left(Q/h_f \right)}$$

$$NewH = H + \Delta H$$

APPENDIX F: DRAINAGE AREA IN A LOCATION

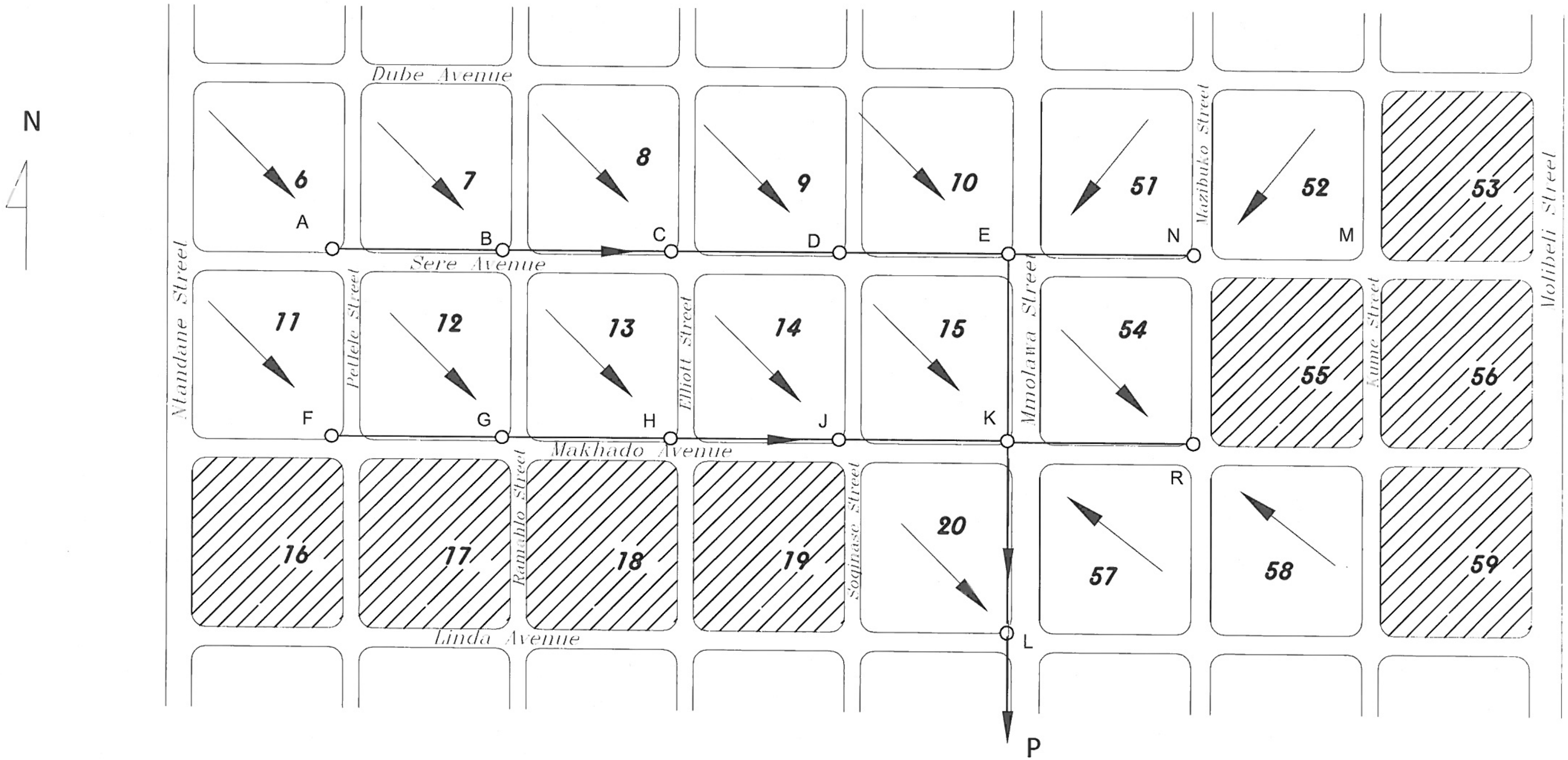


Fig. 7.7

APPENDIX G

DEPARTMENT OF CIVIL ENGINEERING
DOORNFONTEIN CAMPUS

STORMWATER DRAINAGE CALCULATION SHEET

UNIVERSITY OF JOHANNESBURG

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

Line No.	Area Name	Area, A (ha)	Runoff Coefficient, *C*	Imp Area (*C*x*A*)	Cummulative Imp Area $\Sigma(CA)$	Time of concentration, *Tc* (min)	Rainfall Intensity, *I* (mm/hr)	Runoff, Q, (m^3/min)	Slope/ Grade	Pipe Dia. (mm)	Velocity Flowing full, (m/s)	Length, *L*, (m)	Time of flow, *t*, (min)	Capacity of Pipe, (m^3/min)	Ground Elevation		Invert Elevation	
															Upper End, (m)	Lower End, (m)	Upper End, (m)	Lower End, (m)

APPENDIX H

 (T. J. McGhee, 1996)

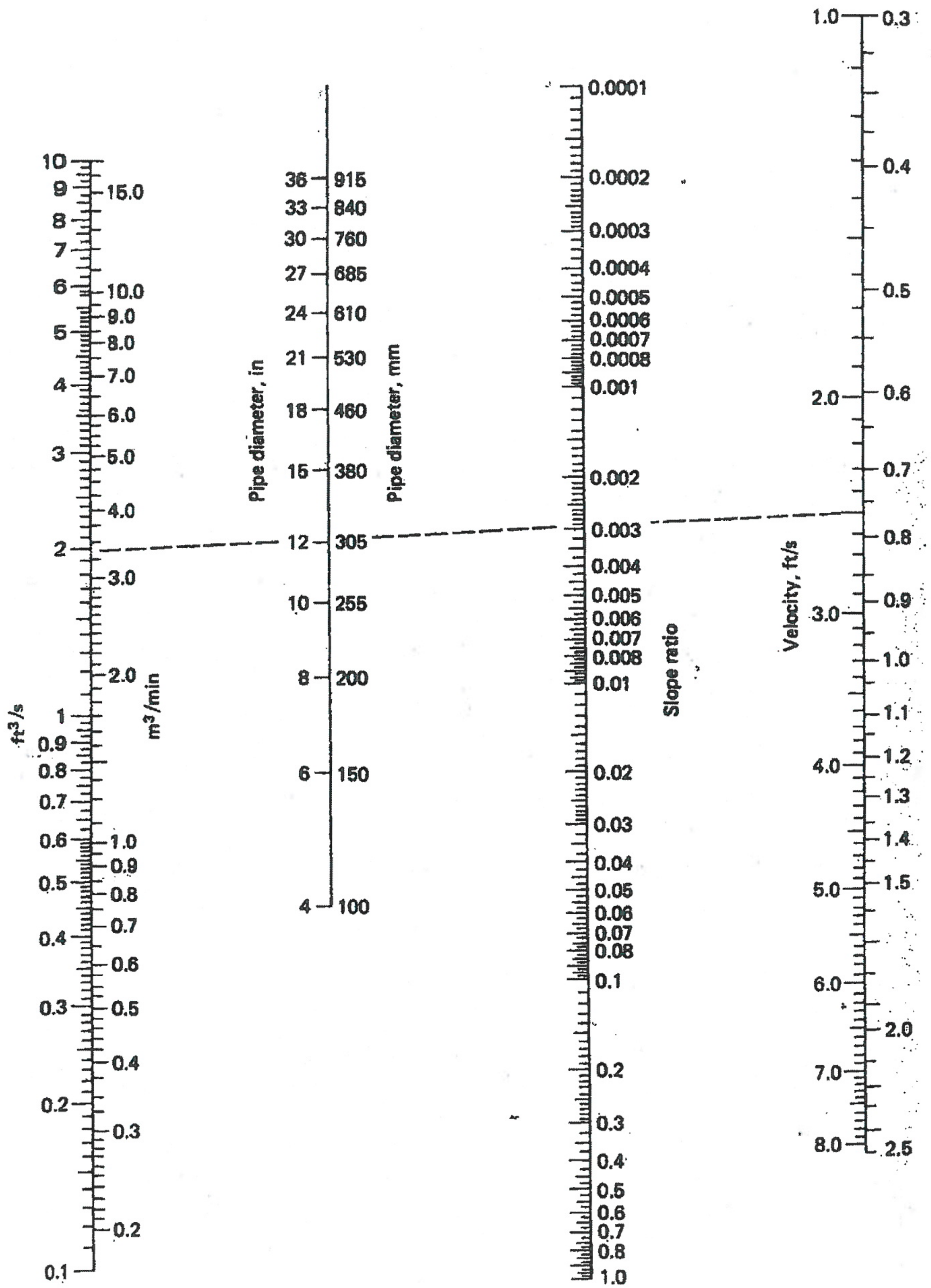


FIGURE 16-2
Nomogram for solution of Manning's equation for circular pipes flowing full ($n = 0.013$).

17

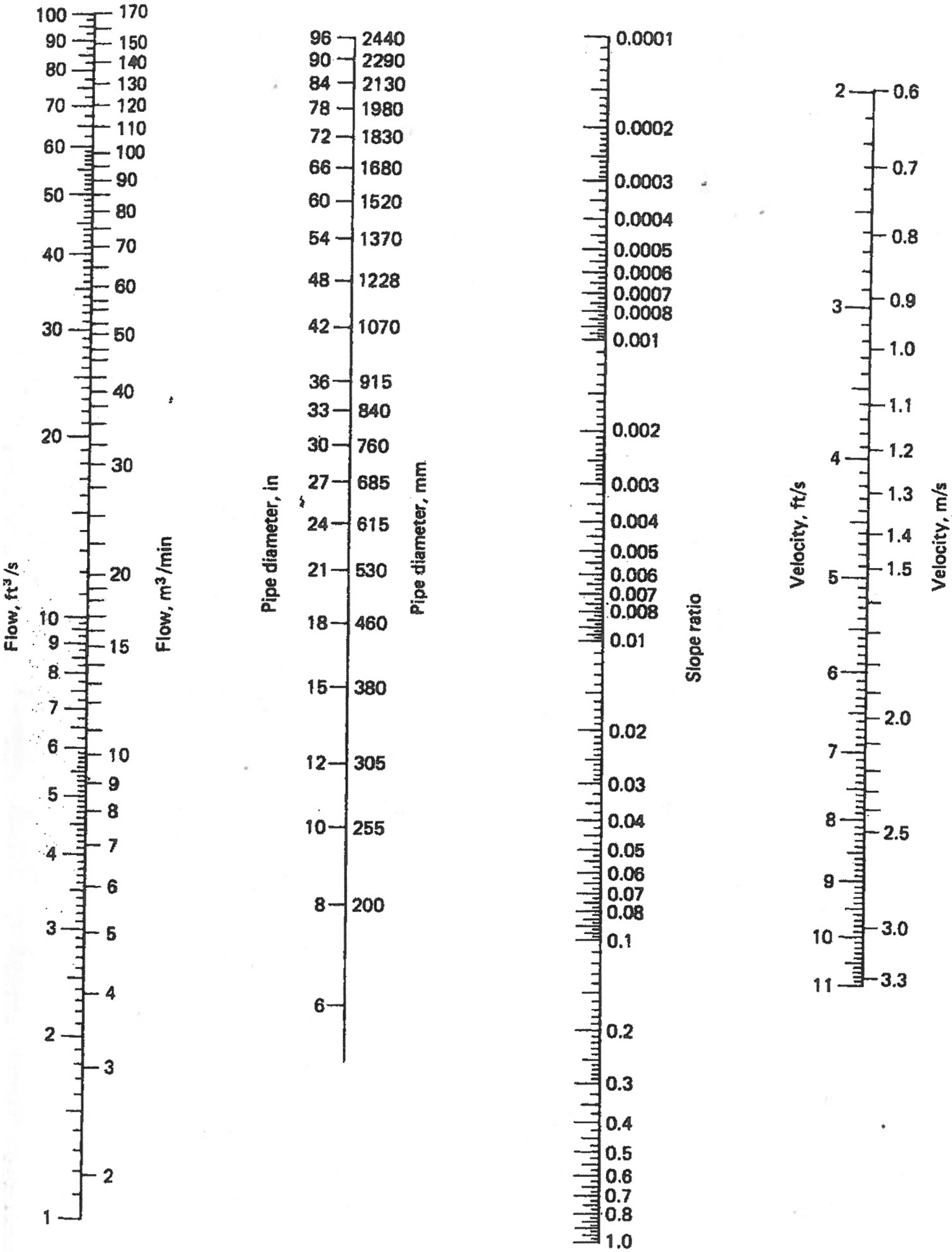


FIGURE 16-3
Nomogram for solution of Manning's equation for circular pipes flowing full ($n = 0.013$).

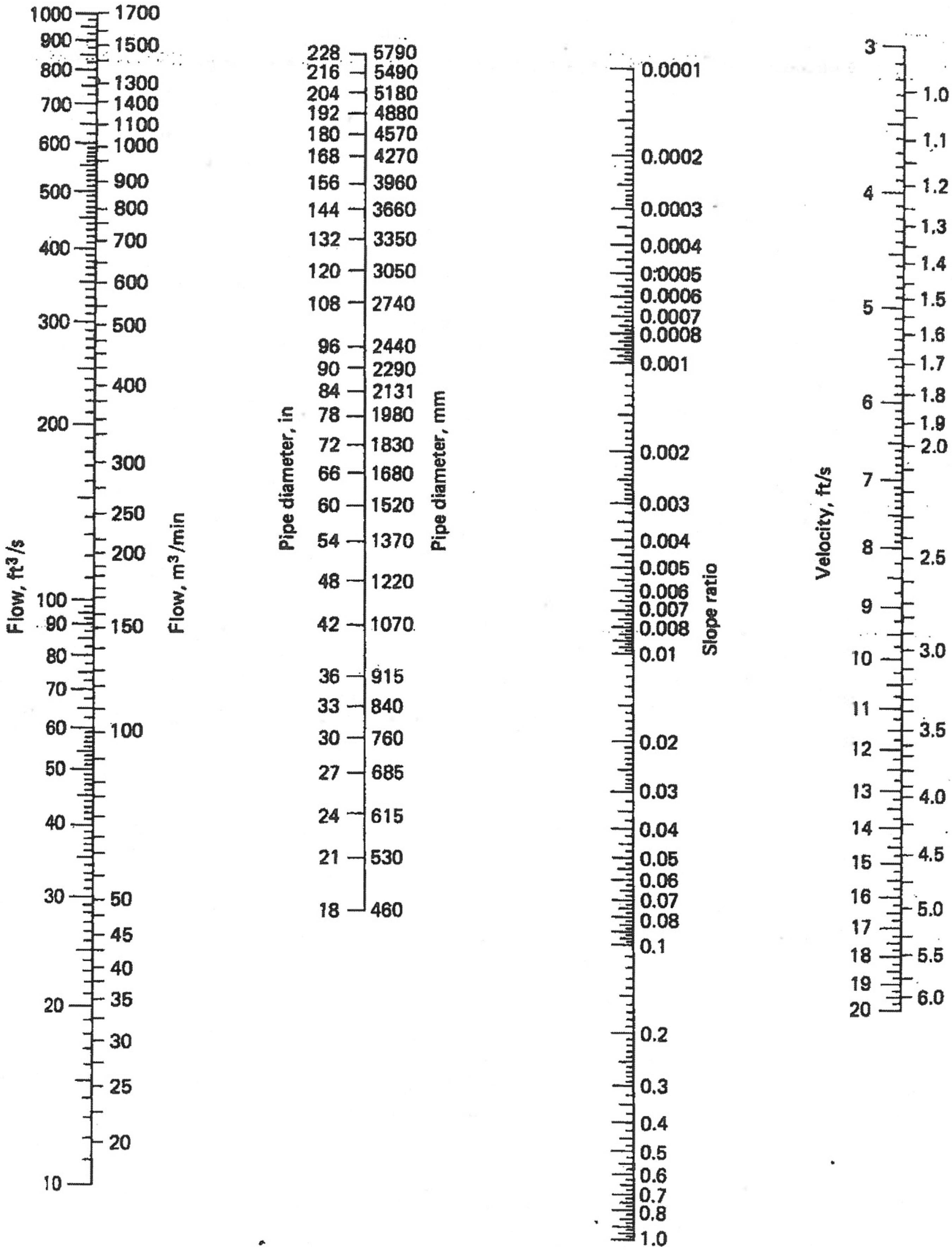


FIGURE 16-4
Nomogram for solution of Manning's equation for circular pipes flowing full (n = 0.013).

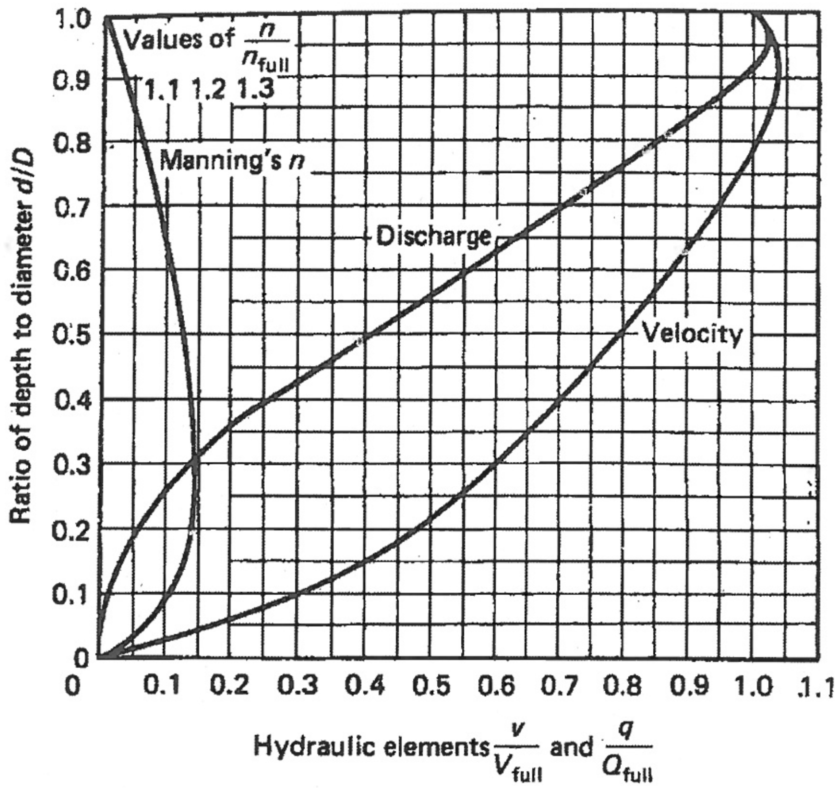


FIGURE 16-6
Variation of flow and velocity with depth in circular pipes.