UNIVERSITY OF SWAZILAND
Faculty of Health Sciences

DEGREE IN ENVIRONMENTAL HEALTH

FINAL EXAMINATION PAPER 2007/2008

TITLE OF PAPER	:	**HYDROLOGY**
COURSE CODE	:	**EHS 545**
DURATION	:	**2 HOURS**
MARKS	:	**100**
INSTRUCTIONS	:	**READ THE QUESTIONS & INSTRUCTIONS CAREFULLY**
	:	**ANSWER ANY FOUR QUESTIONS**
	:	**EACH QUESTION CARRIES 25 MARKS**
	:	**WRITE NEATLY & CLEARLY**
	:	**NO PAPER SHOULD BE BROUGHT INTO NOR OUT OF THE EXAMINATION ROOM**
	:	**BEGIN EACH QUESTION ON A SEPARATE SHEET OF PAPER**

DO NOT OPEN THIS QUESTION PAPER UNTIL PERMISSION IS GRANTED BY THE INVIGILATOR.

QUESTION 1

I.

Multiple choice: Write True or False against each letter corresponding to the following statements as they apply to hydrology.

(a) For precipitation to occur there must be some mechanism to cool the vapor, there must be a condensation nuclei and lifting of air to achieve large scale precipitation.

(b) Cyclonic rainfall is velocity difference induced precipitation

(c) Frontal precipitation is when one air mass lifts over another.

(d) In cold front precipitation warm air advances over cold air

(e) Rainfall is measured by rain gauges

(f) Double mass analysis checks the consistency of rainfall data to see if there had been changes in gauge location, exposure conditions, instrumentation and observational procedure

(g) Permeability is the ability of a porous medium to transmit water.

(h) Mass curves are not useful in reservoir design studies since they do not provide a ready means of determining storage capacity.

(16 marks)

II.

Describe the siting of a rain gauge

(9 marks)

QUESTION 2

a) During the water-year 1994/95, a catchment area of 2500km^2 received 1300mm of precipitation. The average discharge at the catchment outlet was 30m^3/s. Estimate the amount of water lost due to the combined effects of evaporation, transpiration and percolation to ground water. Compute the volumetric run off coefficient for the catchment in the water-year.

(9 marks)

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b) A small industrial well 0.2m diameter continuously pumps 500m^3/d from a confined aquifer with T = 100m^2/d (coefficient of transmissibility). The equilibrium water level in the well is 6.778m below the steady piezometric surface. Assuming steady state calculate the radius of influence of the well.

A new well is constructed 400m from the existing well. The new well has a diameter of 0.3m and will pump continuously at 2000m^3/d. Assuming that the area of influence is proportional to well discharge, calculate the radius of influence of the new well as if it was alone in the aquifer.

Using superposition, calculate the depth of the water level in the old well below the static piezometric surface after the new well has been pumped sufficiently for steady state conditions to be reached. By how much has the pumping depth in the old well increased.

(16 marks)

QUESTION 3

SHORT RECORD SITE			**12 CONTROL SITES**	
YEAR	(MM) MEAN ANNUAL	CUMULATIVE (MM)	MEAN ANNUAL	CUMULATIVE (MM)
1940	-		-	
1954	-		-	
1955	542		311	
1956	429		683	
1957	440		737	
1958	528		795	
1959	774		601	
1960	443		829	
1961	527		653	
1962	529		852	
1963	390		829	
1964	293		708	
1965	518		552	
1966	384		565	
1967	325		846	
1968	462		550	
1969	309		485	
1970	529		644	
1971	723		676	
1972	428		546	
1973	480		524	
1974	505		760	
1975	585		617	

Using the information provided in the above table:

(a) Calculate the accumulative precipitation

(15 marks)

(b) Adjustment factors for 1955 to 1966, 1965 to 1975.

(4 marks)

(c) Adjusted accumulative precipitation for the periods; 1955 to 1964, 1965 to 1975.

(4 marks)

(d) Calculate the average annual precipitation.

(2 marks)

QUESTION 4

(a) A river discharge measurement made during a flood indicated Q_a = 3160 m^3/s. During the measurement, which took 2h, the gauge height increased from 50.40 to 50.52. Level readings taken at water surface 400m upstream and 300m downstream of the observation site differed by 100mm. The river was 500m wide with an average depth of 4m at the time of measurement. At what co-ordinate should the measurement be plotted on the rating curve?

(9 marks)

(b) Using the data provided, calculate the storage capacity required. The water demand (D) is 0.305 x $10^6 m^3$/month and the available water flows at a flow rate, Q, of $10^6 m^3$/month. Use the arithmetic method.

Arithmetic Method and Storage

Month	**Q ($10^6 m^3$)**	**D ($10^6 m^3$)**
January	0.18	0.305
February	1.02	0.305
March	1.32	0.305
April	0.51	0.305
May	0.87	0.305
June	0.67	0.305
July	0.19	0.305
August	0.08	0.305
September	0.07	0.305
October	0.04	0.305
November	0.10	0.305
December	0.26	0.305
January	0.20	0.305
February	1.10	0.305
March	1.01	0.305

(16 marks)

QUESTION 5

(a) An evaporation pan is maintained near a small lake in order to determine daily evaporation. The water level in the pan is observed every day, and water is added if the water level falls below about 17.5 cm. Estimate the daily pan evaporation for the 14-day period for which readings are summarized in the following table.

Day	Rainfall, mm during the day	Water level, mm during the day
1.	4.1	199.0
2.	3.8	198.0
3.	4.2	196.7
4.	1.3	196.2
5.	0.2	193.9
6.	0	189.3
7.	0.5	185.5
8.	0.2	182.7
9.	0	180.9
10.	0	179.4
11.	0	176.6
12.	0.2	197.7
13.	0	196.4
14.	0.5	194.9

NB: The pan was filled to a depth of 200mm at the beginning of both day 1 and day 12.

(6 marks)

(b) A ~~cathcment~~ catchment area is divided into two tributaries that are identical in area shape, slope and channel length, and whose channels converge to the same point. A previous analysis has shown that the one-hour unit hydrograph for each sub-area can be approximated by an isosceles triangle of base length 8h with a peak flow rate of 4 $m^3/s/mm$ of effective rainfall. Should the catchment become fully urbanized at some time in the future, the shape of the one-hour unit hydrograph is expected to change to an isosceles triangle with a base length of 4h and a peak flow rate of 12 $m^3/s/mm$ of effective rainfall.

(i) Assuming existing conditions for both sub-areas, estimate the peak flow rate corresponding to an average intensity of 31.25 mm/h for a period of 2h. Assume a total loss of 25 mm over the duration of the storm.

(ii) Assuming one sub-area is fully developed and the other remains in its present state, estimate the peak flow rate caused by a rainfall excess of 25mm over 2h.

(iii) What would the peak flow rate be in response to the storm of part (ii) if both areas were urbanized?

(19 marks)

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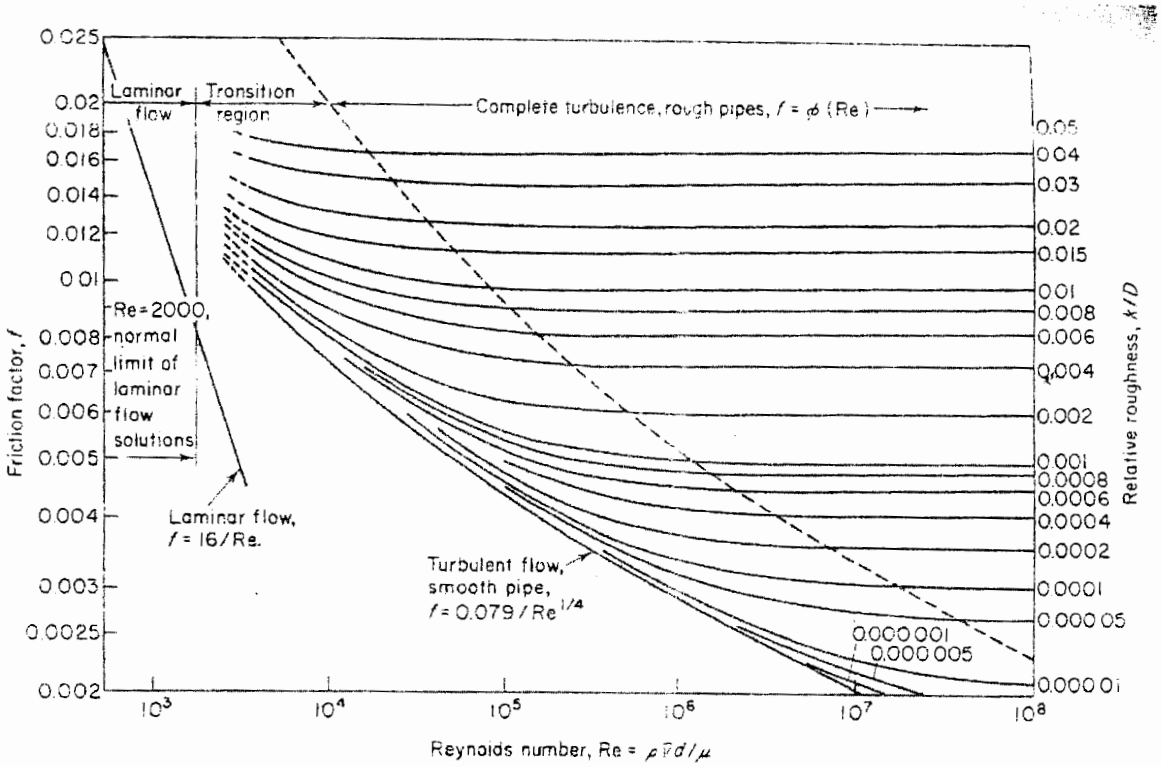

Variation of friction factor f with Reynolds number and pipe wall roughness for ducts of circular cross-section

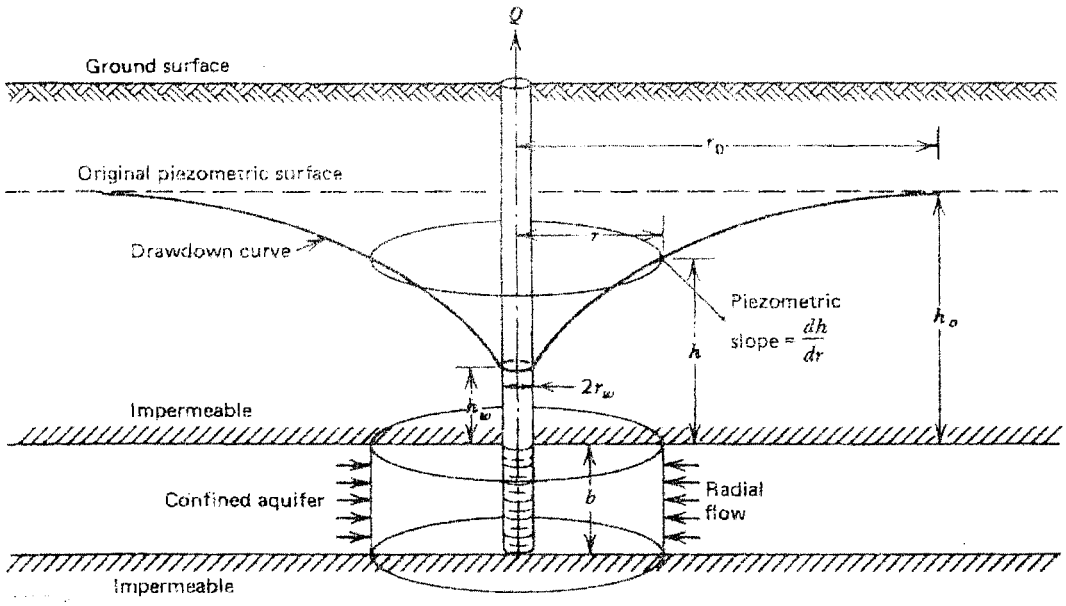
Q
Ground surface
r_0
Original piezometric surface
Drawdown curve
r
Piezometric
slope = $\frac{dh}{dr}$
h
h_o
$2r_w$
h_w
Impermeable
Confined aquifer
b
Radial
flow
Impermeable

Figure 1.

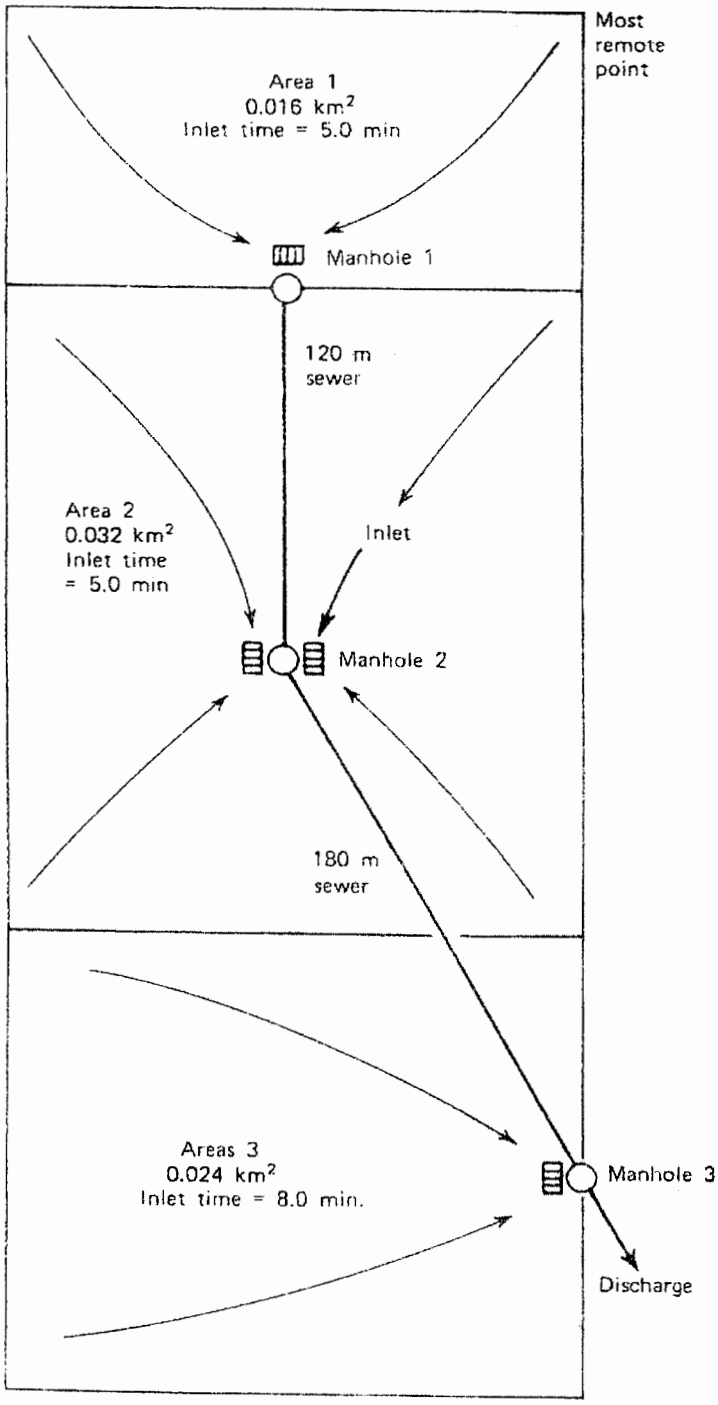
Most
remote
point
Area 1
0.016 km²
Inlet time = 5.0 min
Manhole 1
120 m
sewer
Area 2
0.032 km²
Inlet time
= 5.0 min
Inlet
Manhole 2
180 m
sewer
Areas 3
0.024 km²
Inlet time = 8.0 min.
Manhole 3
Discharge

FIGURE 3

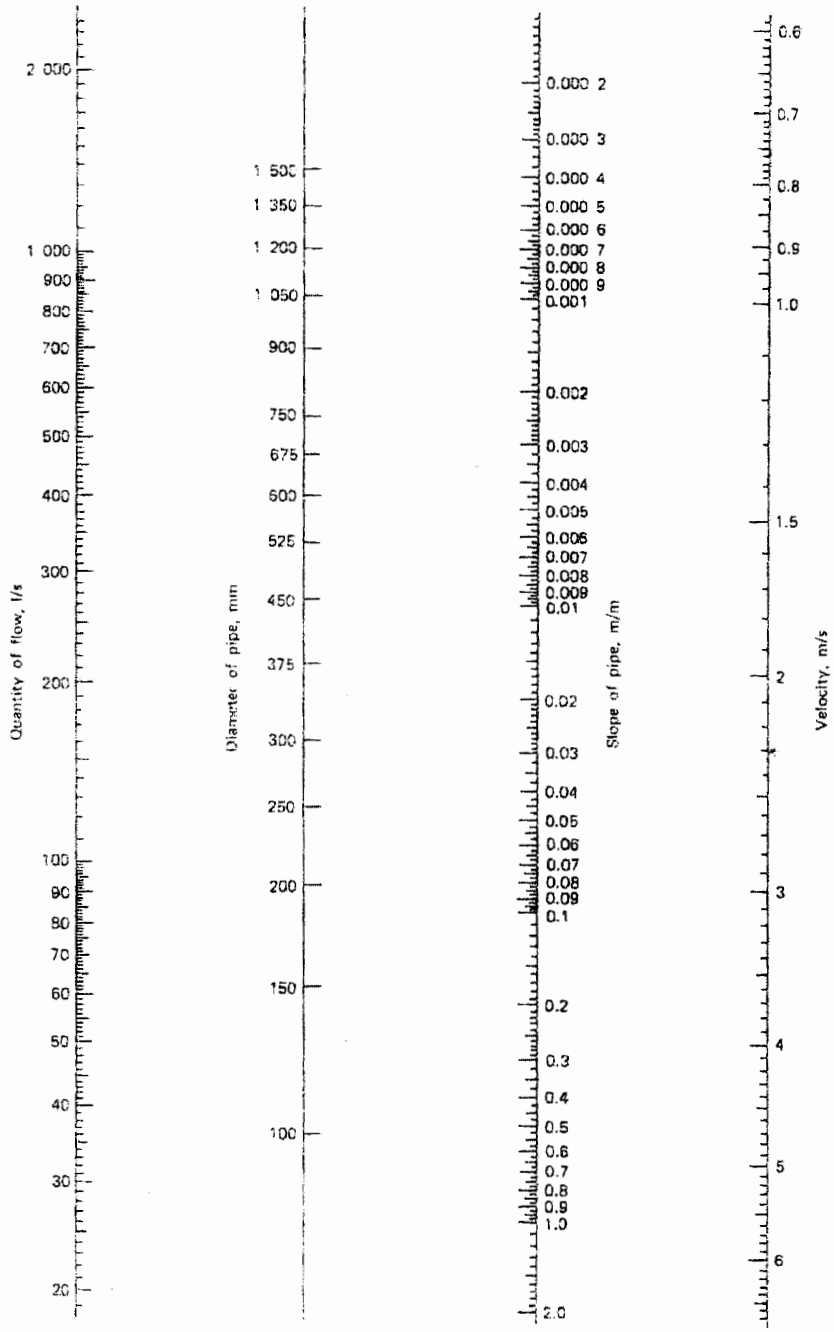
Quantity of flow, l/s
2 000
1 000
900
800
700
600
500
400
300
200
100
90
80
70
60
50
40
30
20
Diameter of pipe, mm
1 500
1 350
1 200
1 050
900
750
675
600
525
450
375
300
250
200
150
100
Slope of pipe, m/m
0.000 2
0.000 3
0.000 4
0.000 5
0.000 6
0.000 7
0.000 8
0.000 9
0.001
0.002
0.003
0.004
0.005
0.006
0.007
0.008
0.009
0.01
0.02
0.03
0.04
0.05
0.06
0.07
0.08
0.09
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
2.0
Velocity, m/s
0.6
0.7
0.8
0.9
1.0
1.5
2
3
4
5
6

FIGURE 6

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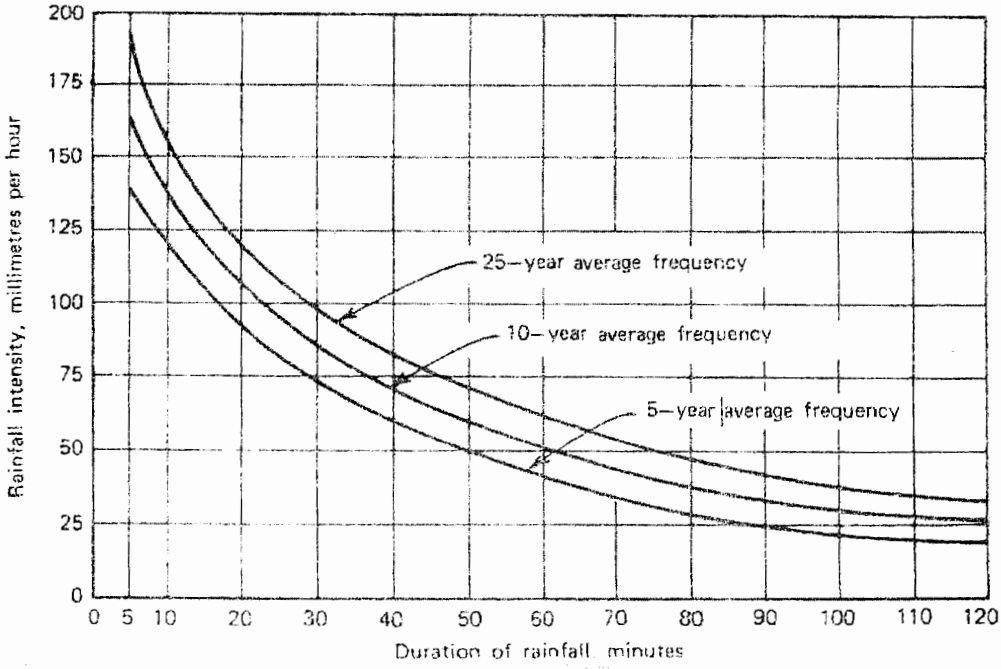

FIGURE 4

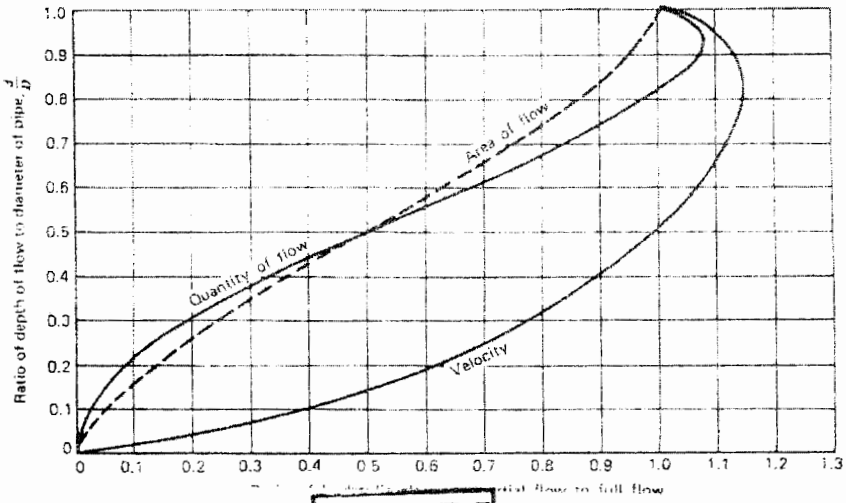

FIGURE 7

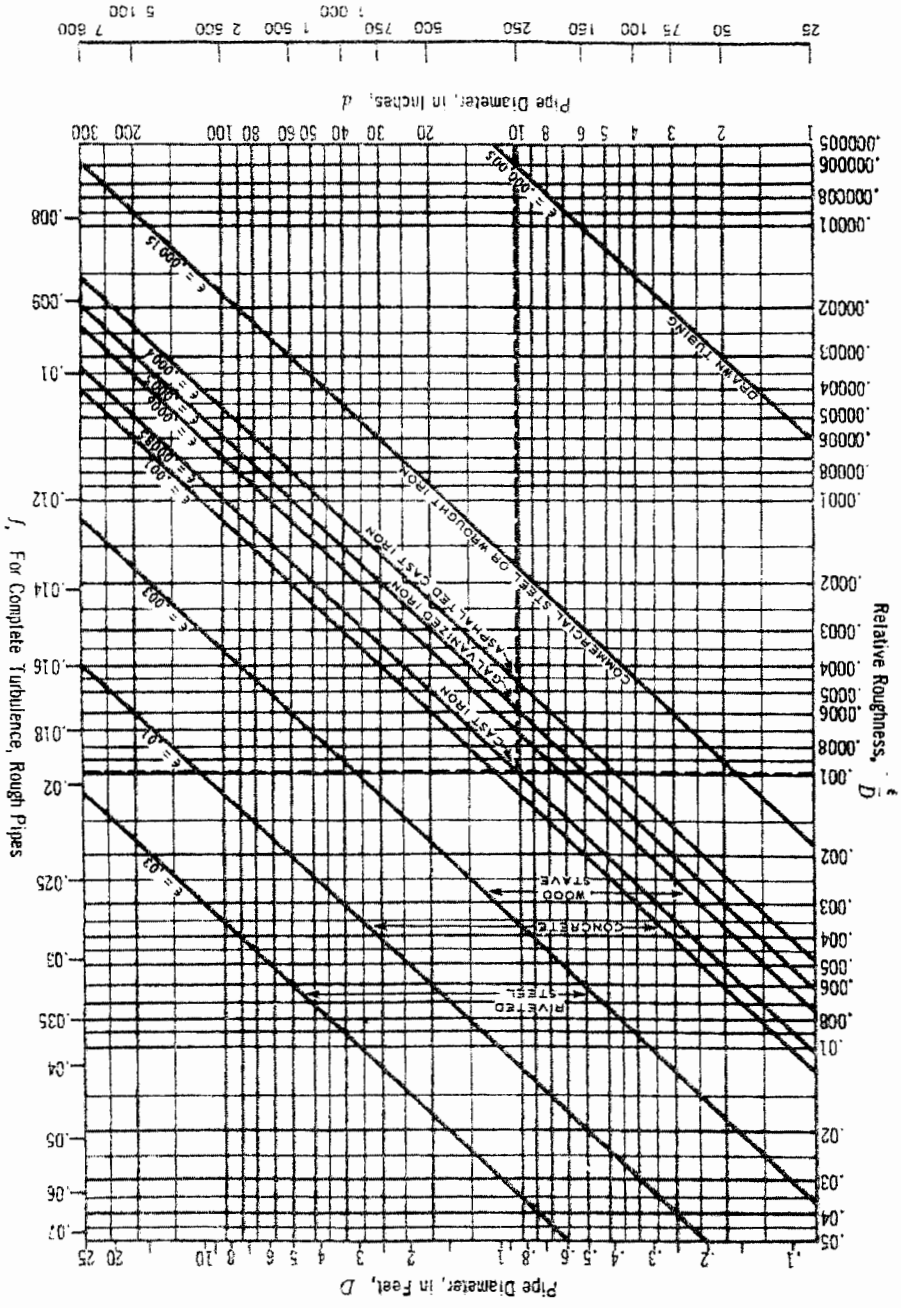
Pipe Diameter, in Feet, D
Pipe Diameter, in Inches, d
Relative Roughness, ε/D
f, For Complete Turbulence, Rough Pipes
DRAWN TUBING
COMMERCIAL STEEL, OR WROUGHT IRON
ASPHALTED CAST IRON
GALVANIZED IRON
CAST IRON
RIVETED STEEL
CONCRETE
WOOD STAVE

FIGURE 8

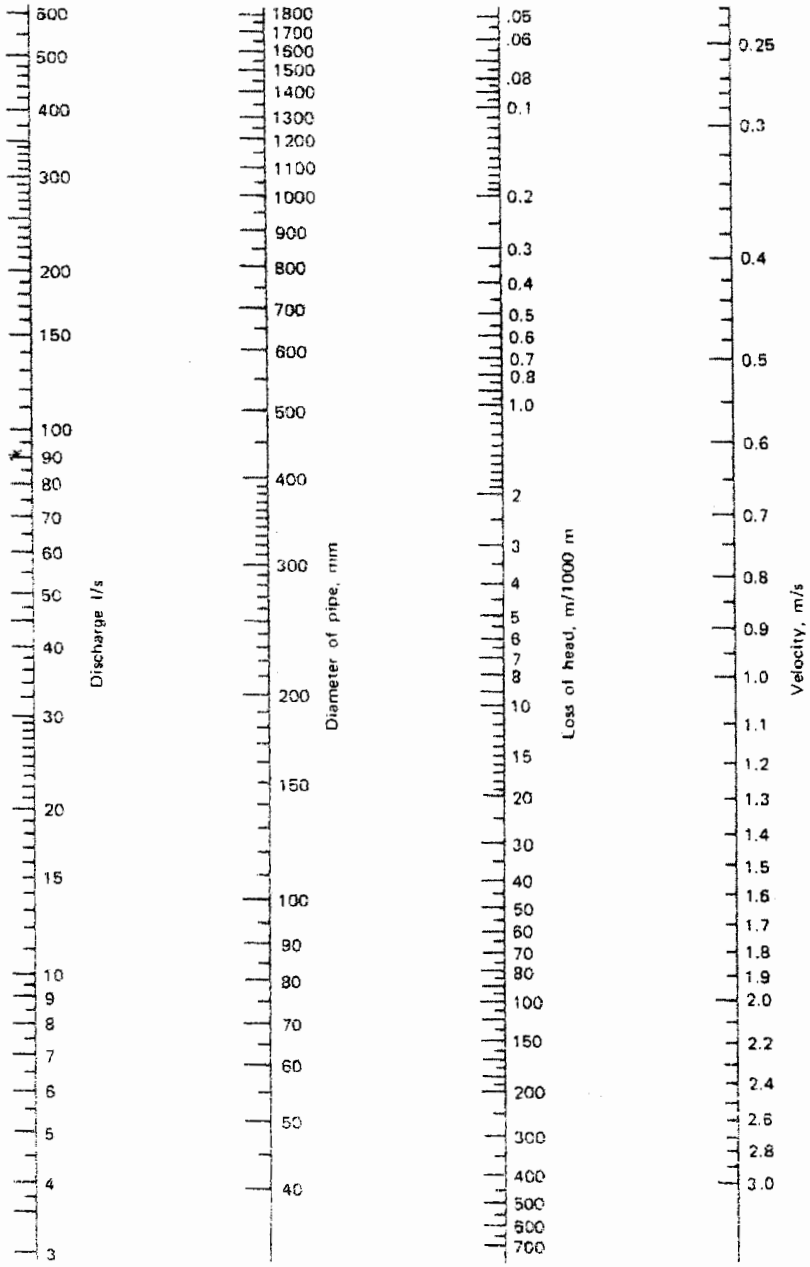
Discharge l/s
600
500
400
300
200
150
100
90
80
70
60
50
40
30
20
15
10
9
8
7
6
5
4
3
Diameter of pipe, mm
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
150
100
90
80
70
60
50
40
Loss of head, m/1000 m
.05
.06
.08
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
1.0
2
3
4
5
6
7
8
10
15
20
30
40
50
60
70
80
100
150
200
300
400
500
600
700
Velocity, m/s
0.25
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
2.2
2.4
2.6
2.8
3.0

FIGURE 9