FOREST LAKES WEST ADDITION

CUMULATIVE AREA = 0.08 SQ MI

*** *** *** *** ***

HYDROGRAPH AT STATION POND4
FOR PLAN 1, RATIO = 1.00

PEAK FLOW (CFS)	TIME (HR)		MAXIMUM AVERAGE FLOW 6-HR	24-HR	72-HR	24.00-HR
106.	12.50	(CFS)	34.	10.	10.	10.
		(INCHES)	3.966	4.764	4.764	4.764
		(AC-FT)	17.	20.	20.	20.

PEAK STORAGE (AC-FT)	TIME (HR)	MAXIMUM AVERAGE STORAGE 6-HR	24-HR	72-HR	24.00-HR
5.	12.50	2.	1.	1.	1.

PEAK STAGE (FEET)	TIME (HR)	MAXIMUM AVERAGE STAGE 6-HR	24-HR	72-HR	24.00-HR
154.85	12.50	153.57	152.88	152.88	152.88

CUMULATIVE AREA = 0.08 SQ MI

FOREST LAKES WEST ADDITION

PEAK FLOW AND STAGE (END-OF-PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND, AREA IN SQUARE MILES
TIME TO PEAK IN HOURS

OPERATION	STATION	AREA	PLAN		RATIOS APPLIED TO PRECIPITATION RATIO 1 0.45	RATIO 2 0.68	RATIO 3 0.90	RATIO 4 1.00	
HYDROGRAPH AT	EAST	0.04	1	FLOW	25.	56.	87.	102.	- PREDEVELOPED FLW E
				TIME	12.17	12.17	12.17	12.17	
HYDROGRAPH AT	WEST	0.08	1	FLOW	23.	55.	89.	106.	- PREDEVELOPED FLW W
				TIME	12.75	12.67	12.67	12.67	
HYDROGRAPH AT	100	0.04	1	FLOW	35.	71.	108.	125.	- POST-DEVELOPED FLW 100
				TIME	12.08	12.08	12.08	12.08	
HYDROGRAPH AT	NBFL	0.11	1	FLOW	58.	118.	178.	207.	- DEVELOPED FL N.
				TIME	12.42	12.42	12.42	12.33	
2 COMBINED AT	QN2#1	0.15	1	FLOW	79.	162.	246.	286.	- Total Qin POND #1
				TIME	12.25	12.25	12.17	12.17	
ROUTED TO	POND1	0.15	1	FLOW	37.	82.	143.	172.	- Routed Flow out of POND #1
				TIME	13.00	12.92	12.75	12.75	< 198cfs OK✓✓ (BEFORE REVISION)
			** PEAK STAGES IN FEET **						
			1	STAGE	139.50	140.29	140.93	141.22	- HW POND #1 (-2.4' from original FL)
				TIME	13.00	12.92	12.75	12.75	
HYDROGRAPH AT	MDBFL	0.09	1	FLOW	98.	173.	247.	282.	- DEVELOPED FL M
				TIME	12.08	12.08	12.08	12.08	
2 COMBINED AT	QN2FL2	0.24	1	FLOW	109.	201.	295.	340.	- Total Qin POND #2 F.L.
				TIME	12.08	12.08	12.08	12.08	
ROUTED TO	FLPD2	0.24	1	FLOW	6.	39.	90.	119.	- Routed flow out of POND #2 FL
				TIME	23.83	15.25	14.00	13.75	< 192 cfs OK✓✓ (Before Revision)
			** PEAK STAGES IN FEET **						
			1	STAGE	138.05	138.71	139.38	139.72	- HW POND #2 FL (-0.7 from F.L. original)
				TIME	23.92	15.25	14.00	13.75	
HYDROGRAPH AT	SBFL	0.09	1	FLOW	75.	140.	207.	239.	- Developed FL S
				TIME	12.08	12.08	12.08	12.08	
2 COMBINED AT	QN2FL3	0.33	1	FLOW	75.	140.	207.	239.	- Total Qin POND #3 F.L.
				TIME	12.08	12.08	12.08	12.08	
ROUTED TO	FLPD3	0.33	1	FLOW	32.	58.	101.	135.	- Routed flow out of POND #3 FL
				TIME	12.50	12.50	14.33	14.08	< 216 cfs OK✓✓ (Before Revision)
			** PEAK STAGES IN FEET **						
			1	STAGE	135.40	135.89	136.45	136.77	- HW POND #3 F.L. (-0.9 from F.L. original
				TIME	12.50	12.50	14.33	14.08	
HYDROGRAPH AT	200	0.01	1	FLOW	10.	22.	34.	39.	- Post-Developed FLW 200
				TIME	12.08	12.08	12.08	12.08	
ROUTED TO	POND2	0.01	1	FLOW	5.	14.	23.	28.	- Routed flow out of POND #2 FLW
				TIME	12.42	12.33	12.25	12.25	
			** PEAK STAGES IN FEET **						
			1	STAGE	153.35	153.65	153.91	154.04	- HW POND #2 FLW
				TIME	12.42	12.33	12.25	12.25	
HYDROGRAPH AT	300	0.03	1	FLOW	17.	37.	59.	70.	- Post-Developed FLW 300
				TIME	12.17	12.08	12.08	12.08	
2 COMBINED AT	QN2#3	0.04	1	FLOW	20.	49.	80.	94.	- Total Qin POND #3 FLW
				TIME	12.17	12.17	12.17	12.17	
ROUTED TO	POND3	0.04	1	FLOW	18.	43.	65.	74.	- Routed flow out of POND #3 FLW
				TIME	12.25	12.33	12.33	12.33	

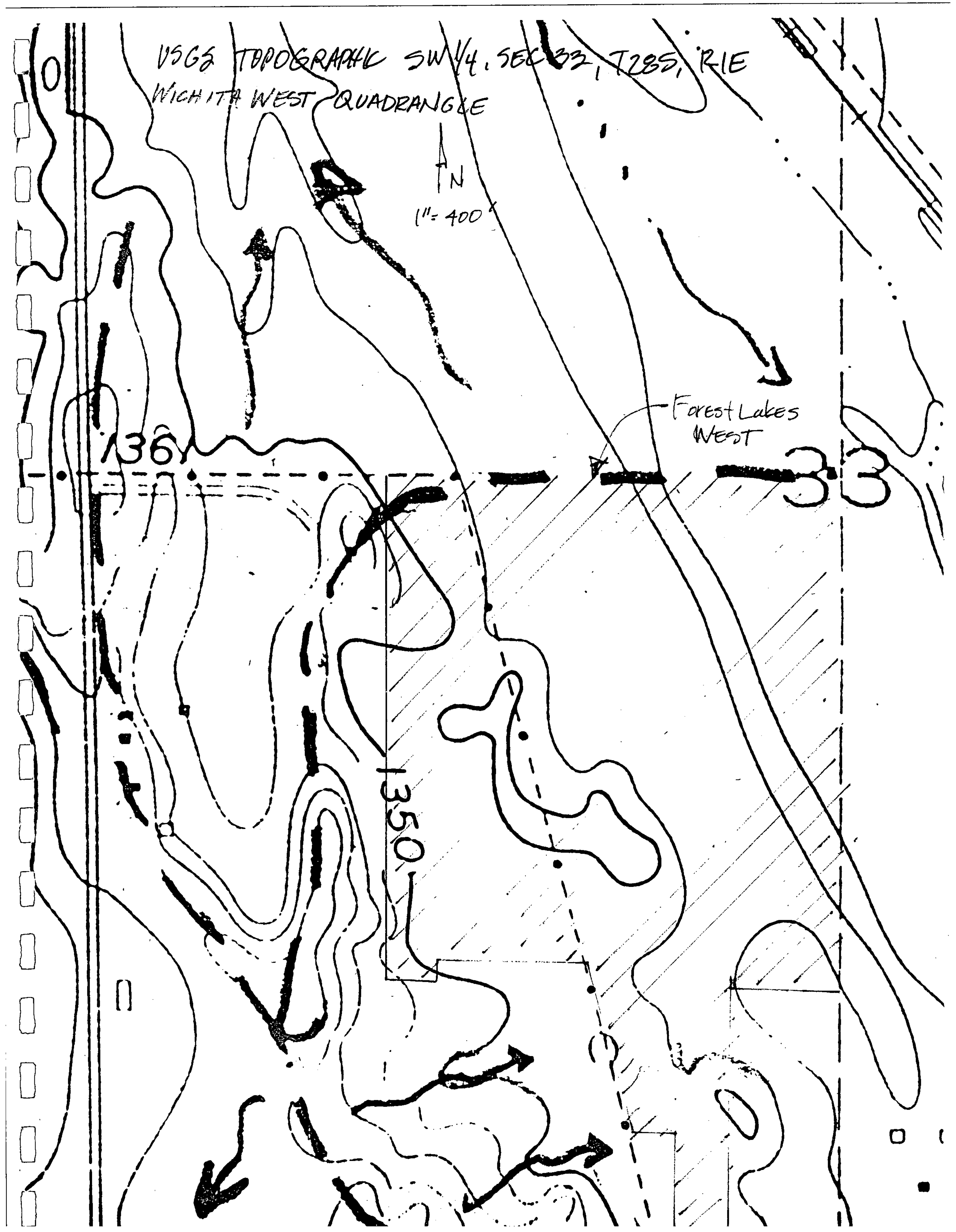
FOREST LAKES WEST ADDITION

			** PEAK STAGES IN FEET **						
			1	STAGE	153.11	153.57	154.31	154.72	- HW POND #3 FLW
				TIME	12.25	12.33	12.33	12.33	
YDROGRAPH AT	400	0.04	1	FLOW	27.	56.	85.	99.	- Post-Developed FLW 400
				TIME	12.08	12.08	12.08	12.08	
2 COMBINED AT	QN2#4	0.08	1	FLOW	43.	94.	141.	162.	- TOTAL Q in POND #4 FLW
				TIME	12.17	12.17	12.17	12.17	
OUTED TO	POND4	0.08	1	FLOW	18.	48.	87.	106.	- Routed flow out of POND #4 FLW
				TIME	12.75	12.67	12.58	12.50	≤ 106 cfs (Pre-Developed for W Basin)
			** PEAK STAGES IN FEET **						
			1	STAGE	153.25	154.01	154.61	154.85	- H.W. POND POND #4 FLW
				TIME	12.75	12.67	12.58	12.50	

*** NORMAL END OF HEC-1 ***

FOR PONDS #2 & #3, BACKWATER FROM POND #4

WILL GOVERN H.W. ∴ PONDS #2, #3, & #4 HW = 154.9



USGS TOPOGRAPHIC SW 1/4, SEC 33, T28S, R1E
WICHITA WEST QUADRANGLE
N
1" = 400'
Forest Lakes West
136
33
1350

ATTACHMENT A
DRAINAGE CRITERIA MANUAL

CITY OF WICHITA, KANSAS

RAINFALL INTENSITY TABLE FOR SEDGWICK COUNTY, KANSAS

The following tabulation contains rainfall intensity in inches per hour as derived from ESSA Weather Bureau Technical Paper 40 Modified to NWS Hydro-35, 1977 During First Hour

DURATION IN MINUTES	RETURN PERIODS OF 1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
5	4.18	5.57	6.53	7.41	8.52	9.48	10.32
6	3.99	5.32	6.25	7.09	8.16	9.09	9.89
7	3.81	5.09	5.99	6.81	7.84	8.74	9.50
8	3.66	4.89	5.75	6.55	7.55	8.42	9.15
9	3.52	4.70	5.54	6.31	7.28	8.13	8.83
10	3.39	4.52	5.34	6.09	7.04	7.86	8.54
11	3.27	4.36	5.16	5.89	6.81	7.61	8.27
12	3.18	4.21	4.99	5.71	6.60	7.38	8.02
13	3.05	4.08	4.84	5.53	6.41	7.17	7.79
14	2.96	3.95	4.69	5.37	6.23	6.97	7.57
15	2.87	3.83	4.56	5.22	6.06	6.78	7.37
16	2.78	3.72	4.43	5.08	5.90	6.60	7.18
17	2.71	3.61	4.31	4.95	5.75	6.44	7.00
18	2.63	3.51	4.20	4.83	5.61	6.29	6.84
19	2.56	3.42	4.10	4.71	5.47	6.14	6.68
20	2.50	3.33	4.00	4.60	5.35	6.00	6.53
21	2.44	3.25	3.90	4.50	5.23	5.87	6.39
22	2.38	3.17	3.81	4.40	5.12	5.75	6.26
23	2.32	3.10	3.73	4.31	5.01	5.63	6.13
24	2.27	3.03	3.65	4.22	4.91	5.52	6.01
25	2.22	2.96	3.57	4.13	4.81	5.41	5.90
26	2.20	2.90	3.50	4.05	4.72	5.31	5.79
27	2.16	2.84	3.43	3.98	4.63	5.21	5.69
28	2.14	2.78	3.37	3.90	4.55	5.12	5.59
29	2.11	2.72	3.30	3.83	4.47	5.03	5.49
30	2.08	2.67	3.24	3.76	4.39	4.94	5.40
31	2.05	2.62	3.19	3.70	4.32	4.86	5.32
32	2.02	2.57	3.10	3.63	4.25	4.79	5.22
33	1.99	2.52	3.05	3.57	4.18	4.71	5.14
34	1.96	2.48	3.01	3.51	4.11	4.63	5.07
35	1.93	2.44	2.98	3.46	4.05	4.56	5.00
36	1.91	2.39	2.93	3.41	3.99	4.50	4.93
37	1.89	2.35	2.88	3.36	3.93	4.43	4.86
38	1.87	2.32	2.84	3.31	3.87	4.37	4.79
39	1.85	2.28	2.80	3.26	3.82	4.31	4.73
40	1.83	2.24	2.76	3.22	3.76	4.25	4.66
41	1.81	2.21	2.72	3.17	3.71	4.19	4.60
42	1.79	2.18	2.68	3.13	3.66	4.13	4.54
43	1.77	2.14	2.64	3.09	3.61	4.08	4.49
44	1.75	2.11	2.61	3.05	3.57	4.03	4.43
45	1.73	2.08	2.57	3.01	3.52	3.98	4.38

ATTACHMENT A CONTINUED
Page 2

DURATION IN MINUTES	RETURN PERIODS OF 1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
46	1.70	2.05	2.54	2.97	3.48	3.93	4.33
47	1.67	2.02	2.50	2.93	3.44	3.88	4.28
48	1.66	2.00	2.47	2.90	3.39	3.84	4.23
49	1.64	1.97	2.44	2.86	3.35	3.79	4.18
50	1.61	1.95	2.41	2.83	3.32	3.75	4.13
51	1.59	1.92	2.38	2.79	3.28	3.71	4.09
52	1.56	1.89	2.35	2.76	3.24	3.67	4.05
53	1.54	1.86	2.33	2.73	3.20	3.63	4.00
54	1.52	1.84	2.30	2.70	3.17	3.59	3.96
55	1.50	1.81	2.27	2.67	3.14	3.55	3.92
56	1.47	1.79	2.25	2.64	3.10	3.51	3.88
57	1.45	1.76	2.22	2.61	3.07	3.48	3.84
58	1.43	1.74	2.20	2.59	3.04	3.44	3.81
59	1.42	1.72	2.18	2.56	3.01	3.41	3.77
60	1.40	1.69	2.15	2.53	2.98	3.37	3.73
61	1.38	1.67	2.13	2.51	2.95	3.34	3.70
62	1.36	1.65	2.11	2.48	2.92	3.31	3.67
63	1.34	1.63	2.09	2.46	2.89	3.28	3.63
64	1.33	1.61	2.07	2.44	2.86	3.25	3.60
65	1.31	1.59	2.05	2.41	2.84	3.22	3.57
66	1.30	1.57	2.03	2.39	2.81	3.19	3.54
67	1.28	1.56	2.01	2.37	2.79	3.16	3.51
68	1.26	1.54	1.99	2.35	2.76	3.13	3.48
69	1.25	1.52	1.97	2.33	2.74	3.10	3.45
70	1.24	1.50	1.95	2.31	2.71	3.08	3.42
71	1.22	1.49	1.93	2.28	2.69	3.05	3.39
72	1.21	1.47	1.92	2.26	2.67	3.02	3.36
73	1.20	1.46	1.90	2.25	2.64	3.00	3.34
74	1.18	1.44	1.88	2.23	2.63	2.98	3.31
75	1.17	1.43	1.86	2.21	2.61	2.95	3.29
76	1.16	1.41	1.85	2.19	2.58	2.93	3.26
77	1.15	1.40	1.83	2.17	2.55	2.90	3.24
78	1.13	1.38	1.82	2.15	2.53	2.88	3.22
79	1.12	1.37	1.80	2.14	2.50	2.86	3.19
80	1.11	1.36	1.79	2.12	2.48	2.84	3.16
81	1.10	1.34	1.77	2.10	2.46	2.82	3.13
82	1.09	1.33	1.76	2.08	2.43	2.79	3.10
83	1.08	1.32	1.74	2.06	2.41	2.76	3.07
84	1.07	1.31	1.73	2.04	2.39	2.74	3.04
85	1.06	1.30	1.72	2.02	2.37	2.71	3.01
86	1.05	1.28	1.70	2.00	2.34	2.69	2.99
87	1.04	1.27	1.69	1.99	2.32	2.66	2.96
88	1.03	1.26	1.68	1.97	2.30	2.64	2.93
89	1.02	1.25	1.68	1.95	2.28	2.62	2.91
90	1.01	1.24	1.66	1.93	2.26	2.59	2.88

ATTACHMENT A CONTINUED
Page 3

DURATION IN MINUTES	RETURN PERIODS OF 1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
91	1.00	1.23	1.65	1.92	2.24	2.57	2.86
92	1.00	1.22	1.63	1.90	2.22	2.55	2.83
93	0.99	1.21	1.62	1.89	2.20	2.53	2.81
94	0.98	1.20	1.61	1.87	2.19	2.51	2.79
95	0.97	1.19	1.59	1.85	2.17	2.49	2.76
96	0.96	1.18	1.58	1.84	2.15	2.46	2.74
97	0.96	1.17	1.57	1.82	2.13	2.44	2.72
98	0.95	1.16	1.56	1.81	2.12	2.42	2.70
99	0.94	1.15	1.54	1.80	2.10	2.41	2.67
100	0.93	1.14	1.53	1.78	2.08	2.39	2.65
101	0.93	1.13	1.52	1.77	2.07	2.39	2.65
102	0.92	1.13	1.51	1.75	2.05	2.35	2.61
103	0.91	1.12	1.50	1.74	2.04	2.33	2.59
104	0.90	1.11	1.49	1.73	2.02	2.31	2.57
105	0.90	1.10	1.47	1.72	2.01	2.30	2.55
106	0.89	1.09	1.46	1.70	1.99	2.28	2.54
107	0.88	1.09	1.45	1.69	1.98	2.26	2.52
108	0.88	1.08	1.44	1.68	1.96	2.25	2.50
109	0.87	1.07	1.43	1.67	1.95	2.23	2.48
110	0.87	1.06	1.42	1.65	1.93	2.21	2.46
111	0.86	1.06	1.41	1.64	1.92	2.20	2.45
112	0.85	1.05	1.40	1.63	1.91	2.18	2.43
113	0.85	1.04	1.39	1.62	1.89	2.17	2.41
114	0.84	1.03	1.38	1.61	1.88	2.15	2.40
115	0.84	1.03	1.37	1.60	1.87	2.14	2.38
116	0.83	1.02	1.36	1.59	1.86	2.12	2.36
117	0.82	1.01	1.36	1.58	1.84	2.11	2.35
118	0.82	1.01	1.35	1.57	1.83	2.09	2.33
119	0.81	1.00	1.34	1.56	1.82	2.08	2.32
120	0.81	0.99	1.33	1.55	1.81	2.07	2.30

DURATION IN HOURS	RETURN PERIODS OF 1-YR	2-YR	5-YR	10-YR	25-YR	50-YR	100-YR
2	0.81	0.99	1.33	1.55	1.81	2.07	2.30
3	0.59	0.72	0.97	1.13	1.32	1.51	1.68
4	0.47	0.58	0.78	0.91	1.06	1.21	1.35
5	0.40	0.49	0.66	0.77	0.89	1.02	1.14
6	0.35	0.42	0.57	0.67	0.78	0.89	0.99
8	0.28	0.34	0.46	0.53	0.62	0.71	0.79
10	0.23	0.29	0.39	0.45	0.52	0.60	0.67
12	0.20	0.25	0.33	0.39	0.45	0.52	0.58
18	0.15	0.18	0.24	0.28	0.33	0.38	0.42
24	0.12	0.15	0.20	0.23	0.27	0.31	0.34

0014S

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COUNTY, KANSAS — SHEET NUMBER 25

SOIL SURVEY OF SEDGWICK CO.; KS. USDA (SCS) 1979 (9)

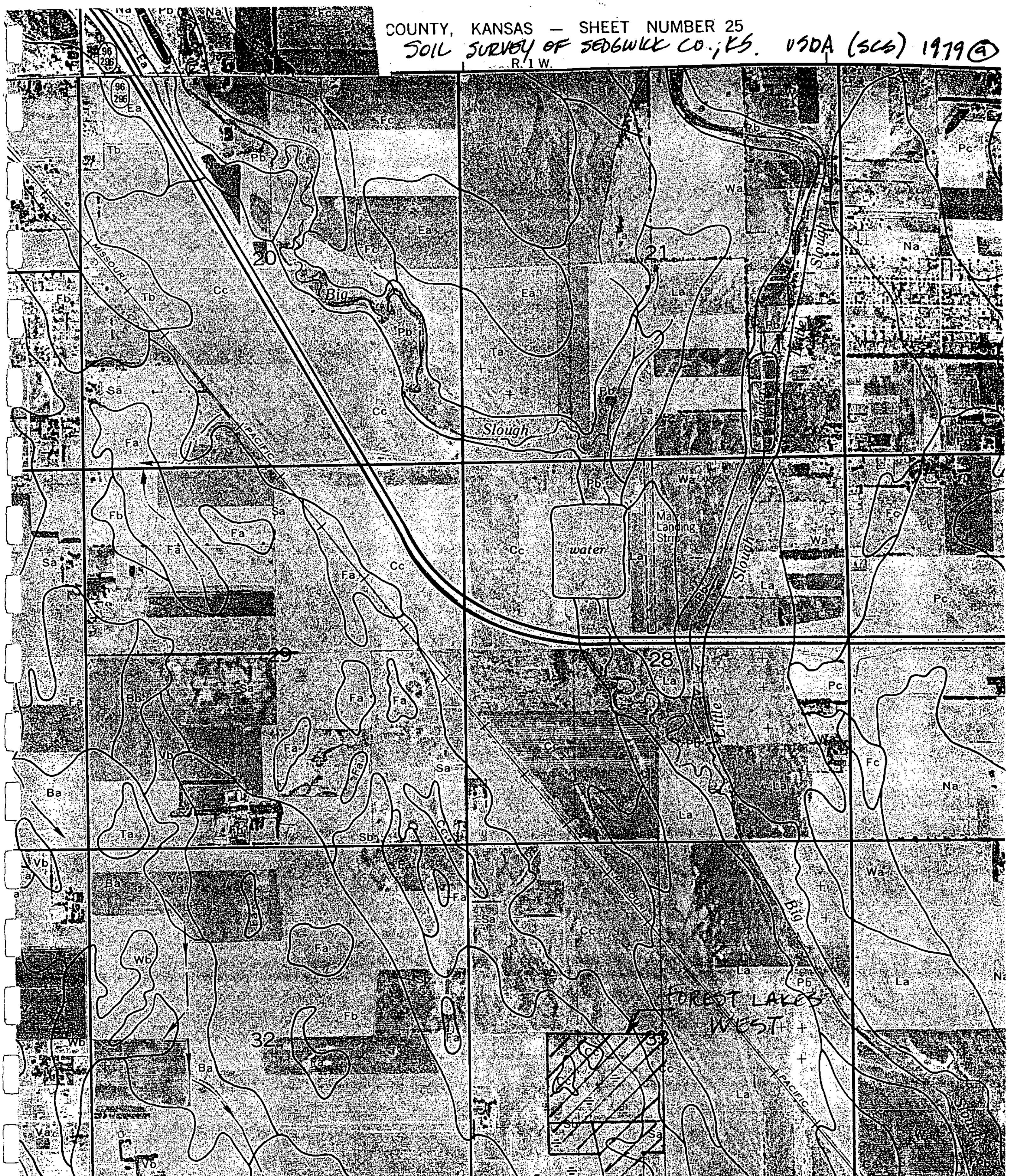


EXHIBIT VII-7
11-4-81

SOIL LEGEND

SYMBOL	HYDROLOGIC GROUP	NAME
Aa	B	Albion–Shellabarger sandy loams, 1 to 4 percent slopes
Ab	B	Albion and Shellabarger sandy loams, 7 to 15 percent slopes
Ba	C	Blanket silt loam, 0 to 1 percent slopes
Bb	C	Blanket silt loam, 1 to 3 percent slopes
Ca	B	Canadian fine sandy loam
Cb	B	Canadian–Waldeck fine sandy loams
Cc	D	Carwile fine sandy loam
Cd	B	Clark–Ost clay loams, 1 to 4 percent slopes
Ce	C	Clime silty clay, 3 to 6 percent slopes
Ea	B	Elandco silt loam
Eb	B	Elandco silt loam, occasionally flooded
Ec	B	Elandco silt loam, frequently flooded
Fa	B	Farnum loam, 0 to 1 percent slopes
Fb	B	Farnum loam, 1 to 3 percent slopes
Fc	B	Farnum loam, sandy substratum, 0 to 1 percent slopes
Ga	D	Goessel silty clay, 0 to 1 percent slopes
Gb	D	Goessel silty clay, 1 to 2 percent slopes
Ia	D	Irwin silty clay loam, 1 to 3 percent slopes
Ib	D	Irwin silty clay loam, 3 to 6 percent slopes
Ic	D	Irwin silty clay loam, 2 to 6 percent slopes, eroded
La	C	Lesho loam
Lb	A	Lincoln soils
Ma	B	Milan loam, 1 to 3 percent slopes
Mb	B	Milan loam, 3 to 6 percent slopes
Mc	B	Milan clay loam, 2 to 6 percent slopes, eroded
Na	B	Naron fine sandy loam
Oc	D	Owens clay loam, 1 to 3 percent slopes
Od	D	Owens–Rock outcrop complex, 3 to 10 percent slopes
Pa		Pits
Pb	D	Plevna fine sandy loam
Pc	A	Pratt loamy fine sand, undulating
Pd	A	Pratt–Tivoli complex, rolling
Ra	D	Renfrow silty clay loam, 1 to 3 percent slopes
Rb	D	Renfrow silty clay loam, 3 to 6 percent slopes
Rc	D	Renfrow–Owens clay loams, 1 to 4 percent slopes
Rd	D.	Rosehill silty clay, 1 to 3 percent slopes
Sa	B	Shellabarger sandy loam, 1 to 3 percent slopes
Sb	B	Shellabarger sandy loam, 3 to 6 percent slopes
Sc	B	Shellabarger sandy loam, 3 to 6 percent slopes, eroded
Ta	D	Tabler silty clay loam
Tb	D	Tabler–Drummond complex
Ua	B	Urban land–Canadian complex
Ub	B	Urban land–Elandco complex
Uc	B	Urban land–Farnum complex, 0 to 3 percent slopes
Ud	D	Urban land–Irwin complex, 1 to 3 percent slopes
Ue	D	Urban land–Tabler complex
Va	B	Vanoss silt loam, 0 to 1 percent slopes
Vb	B	Vanoss silt loam, 1 to 3 percent slopes
Vc	B	Vanoss silt loam, 3 to 6 percent slopes
Vd	B	Vanoss silt loam, 3 to 6 percent slopes, eroded
Ve	D	Vernon sandy loam, 1 to 3 percent slopes
Vf	D	Vernon sandy loam, 3 to 6 percent slopes
Wa	C	Waldeck sandy loam
Wb	D	Waurika silt loam

Table I. Runoff Curve Numbers for Selected Areas For Antecedent Moisture Condition II
(for Ia = 0.2*S) *Selected Conditions Only -- Reproduced from USDA, SCS (1986)*

Fully developed urban areas (vegetation established)

Cover Description Cover Type Hydrologic Condition	Average % Impervious Area	Curve numbers for hydrologic soil group -- A	B	C	D
Open space (lawns, parks,golf courses, cemeteries, etc)					
Poor condition (grass cover < 50%)		68	79	86	89
Fair condition (grass cover 50 to 75%)		49	69	79	84
Good condition (grass cover > 75%)		39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)		98	98	98	98
Streets and roads:					
Paved: curbs and storm sewers (excluding right-of-way)		98	98	98	98
Paved: open ditches (including right-of-way)		83	89	92	93
Gravel (including right-of-way)		76	85	89	91
Dirt (including right-of-way)		72	82	87	89
Urban districts:					
Commercial and business	85	96	96	96	96
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8-acre or less (townhouses)	65	77	85	90	92
1/4-acre	38	61	75	83	87
1/3-acre	30	57	72	81	86
1/2-acre	25	54	70	80	85
1-acre	20	51	68	79	84
2-acre	12	46	65	77	82

Rural areas

Land Use	Cover Treatment or Practice	Hydrologic Condition	Hydrologic Soil Group A	B	C	D
Fallow	Straight row	-----	77	86	91	94
Row crops	Straight row	poor	72	81	88	91
	Straight row	good	67	78	85	89
	Contoured	poor	70	79	84	88
	Contoured	good	65	75	82	86
	Contoured and terraced	poor	66	74	80	82
	Contoured and terraced	good	62	71	78	81
Small grain	Straight row	poor	65	76	84	88
	Straight row	good	63	75	83	87
	Contoured	poor	63	74	82	85
	Contoured	good	61	73	81	84
	Contoured and terraced	poor	61	72	79	82
	Contoured and terraced	good	59	70	78	81
Pasture or range		poor	68	79	86	89
		fair	49	69	79	84
		good	39	61	74	80
Meadow		good	30	58	71	78
Woods		poor	45	66	77	83
		fair	46	60	73	79
		good	25	55	70	77
Farmsteads			59	74	82	86
Roads (dirt, including right-of-way)		----	72	82	87	89
(hard surface, including right of way)		----	74	84	90	92

(3 pages)

ATTACHMENT D

DRAINAGE CRITERIA

CITY OF WICHITA, KANSAS

RECOMMENDED RUNOFF COEFFICIENTS FOR RATIONAL METHOD AND PERCENT IMPERVIOUS FOR UNIT HYDROGRAPH METHOD

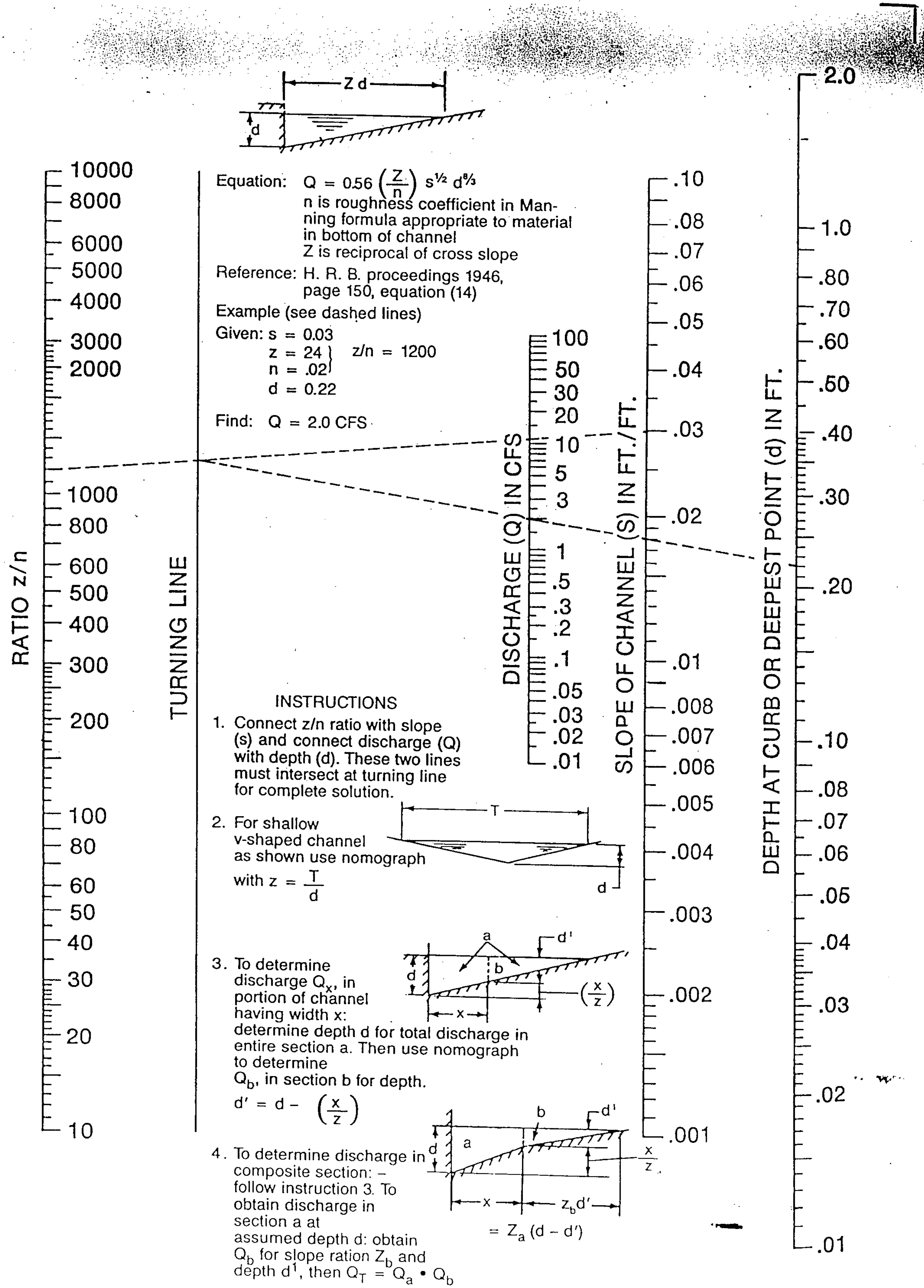
Land Use or Surface Characteristics	Percent Impervious	Frequency			
		2	5	10	100
1. Business:					
Downtown Areas	95	0.84	0.85	0.87	0.91
Neighborhood Areas	70	0.68	0.69	0.73	0.80
2. Residential:					
Single Family (Soil Group D)					
1/8 Acre	50	0.57	0.61	0.66	0.79
1/4 Acre	38	0.50	0.54	0.62	0.76
1/3 Acre	30	0.46	0.50	0.59	0.73
1/2 Acre	25	0.42	0.48	0.56	0.72
3/4 Acre	22	0.42	0.46	0.55	0.71
1 Acre	20	0.41	0.45	0.54	0.71
Multi-Family (Soil Group D)					
Multi-Unit (detached)	60	0.62	0.66	0.72	0.82
Multi-Unit (attached)	65	0.64	0.68	0.73	0.83
Apartments	75	0.70	0.73	0.79	0.86
Single Family (Soil Group C)					
1/8 Acre	50	0.55	0.58	0.64	0.73
1/4 Acre	38	0.48	0.51	0.57	0.68
1/3 Acre	30	0.43	0.46	0.53	0.65
1/2 Acre	25	0.40	0.43	0.50	0.63
3/4 Acre	22	0.39	0.42	0.49	0.62
1 Acre	20	0.37	0.40	0.48	0.61
Multi-Family (Soil Group C)					
Multi-Unit (detached)	60	0.60	0.63	0.69	0.77
Multi-Unit (attached)	65	0.63	0.66	0.71	0.79
Apartments	75	0.68	0.72	0.77	0.83
Single-Family (Soil Group B)					
1/8 Acre	50	0.52	0.54	0.59	0.67
1/4 Acre	38	0.44	0.46	0.52	0.61
1/3 Acre	30	0.39	0.41	0.47	0.57
1/2 Acre	25	0.36	0.38	0.44	0.54
3/4 Acre	22	0.34	0.36	0.42	0.52
1 Acre	20	0.33	0.35	0.40	0.51
Multi-Family (Soil Group B)					
Multi-Unit (detached)	60	0.58	0.60	0.65	0.72
Multi-Unit (attached)	65	0.61	0.64	0.68	0.75
Apartments	75	0.67	0.70	0.74	0.80

Land Use or ace Characteristics	Percent Impervious	Frequency 2	5	10	100
Single Family (Soil Group A)					
1/8 Acre	50	0.47	0.50	0.54	0.60
1/4 Acre	38	0.39	0.41	0.45	0.52
1/3 Acre	30	0.33	0.35	0.39	0.47
1/2 Acre	25	0.30	0.31	0.35	0.44
3/4 Acre	22	0.28	0.29	0.33	0.42
1 Acre	20	0.26	0.28	0.32	0.40
Multi-Family (Soil Group A)					
Multi-Unit (detached)	60	0.55	0.57	0.61	0.67
Multi-Unit (attached)	65	0.58	0.60	0.64	0.70
Apartments	75	0.65	0.68	0.72	0.77
3. Industrial:					
Light Areas	70	0.68	0.69	0.73	0.80
Heavy Areas	80	0.74	0.76	0.79	0.84
4. Playgrounds:	15	0.33	0.35	0.42	0.55
5. Schools:	40	0.49	0.51	0.56	0.66
6. Railroad Yard Areas:	30	0.43	0.45	0.50	0.62
Undeveloped Urban Areas:					
Offsite Flow Analysis (when land use not defined)	45	0.52	0.54	0.59	0.68
8. Streets:					
Paved	99	0.87	0.88	0.90	0.93
Gravel	00	0.24	0.26	0.33	0.48
9. Drive, Parking Lots and Walks:	96	0.87	0.87	0.88	0.89
10. Roofs:	90	0.80	0.85	0.90	0.93
11. Urban Lawn Areas (See Note No. 1 below):					
Soil Group A					
Slope less than 1%	00	0.08	0.09	0.13	0.23
Slope 1% to 4%	00	0.12	0.13	0.17	0.27
Slope more than 4%	00	0.16	0.17	0.21	0.31
Soil Group B					
Slope less than 1%	00	0.16	0.18	0.24	0.37
Slope 1% to 4%	00	0.20	0.22	0.28	0.41
Slope more than 4%	00	0.24	0.26	0.32	0.45
Soil Group C					
Slope less than 1%	00	0.24	0.27	0.35	0.51
Slope 1% to 4%	00	0.26	0.29	0.~~37~~	0.53
Slope more than 4%	00	0.28	0.31	0.39	0.55

Land Use or ace Characteristics	Percent Impervious	Frequency 2	5	10	100
Soil Group D					
Slope less than 1%	00	0.28	0.33	0.43	0.63
Slope 1% to 4%	00	0.30	0.35	0.45	0.65
Slope more than 4%	00	0.32	0.37	0.47	0.67

Note No. 1: Coefficients shown in the above table are for pervious open space areas with thick turf which includes pervious areas in parks and cemeteries. Coefficients shown above must be increased 0.02 for use with agricultural pasture areas. Coefficients shown above must be reduced by 0.04 for use with agricultural cultivated areas. Group A soils are well-drained, coarse textured sands with high infiltration rates. Group B soils are moderately well-drained, moderately coarse textured soils with moderate infiltration rates. Group C soils are moderately poor-drained, moderately fine textured soils with slow infiltration rates. Group D soils are poor-drained, fine textured soils with very slow infiltration rates.

GENERAL NOTE: These Rational Formula Coefficients may not be valid for basins 320 acres or larger.



Equation: $Q = 0.56 \left(\frac{Z}{n}\right) s^{1/2} d^{8/3}$

n is roughness coefficient in Manning formula appropriate to material in bottom of channel

Z is reciprocal of cross slope

Reference: H. R. B. proceedings 1946, page 150, equation (14)

Example (see dashed lines)

Given: s = 0.03

z = 24 } z/n = 1200

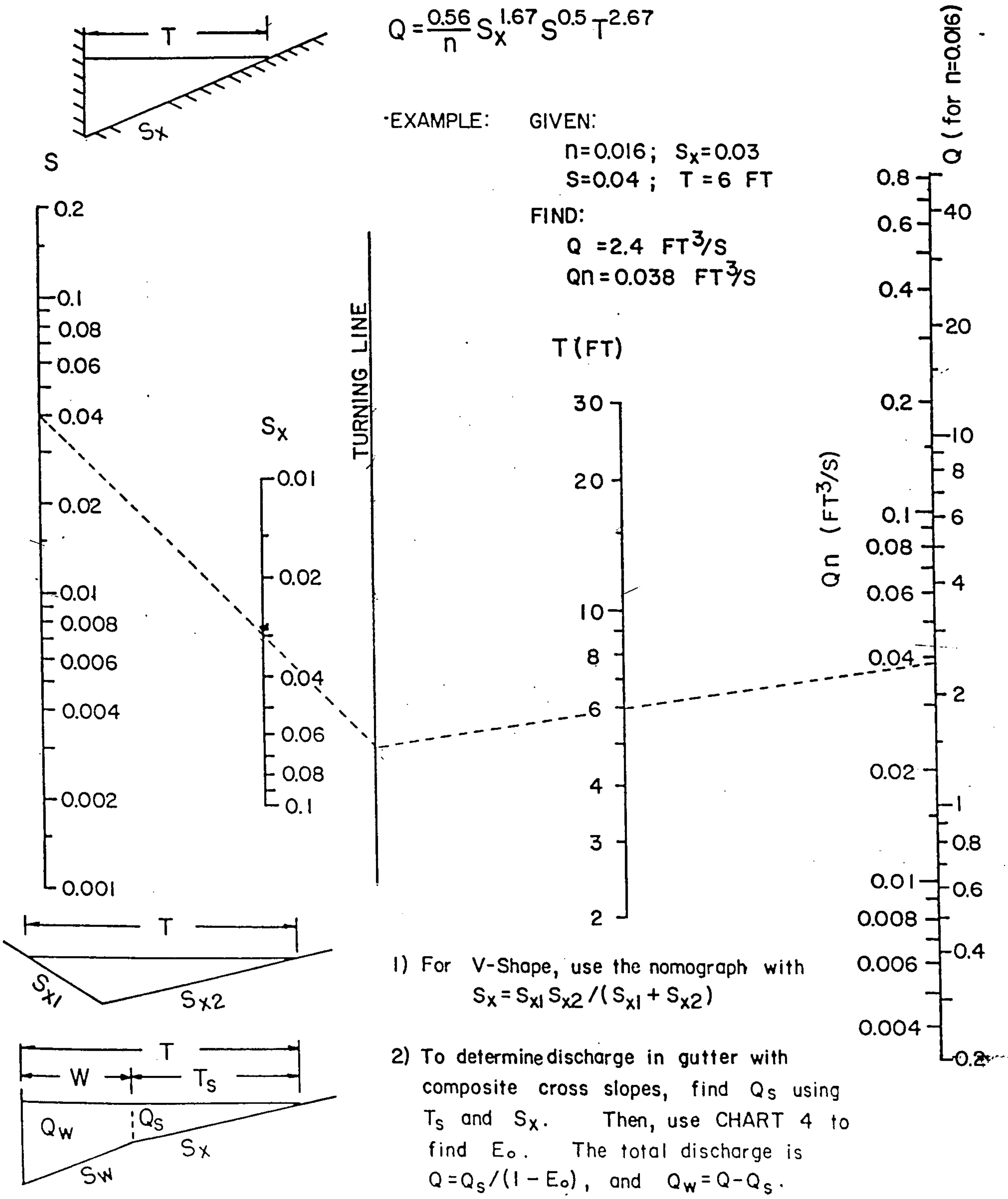
n = .02

d = 0.22

Find: Q = 2.0 CFS

INSTRUCTIONS

1. Connect z/n ratio with slope (s) and connect discharge (Q) with depth (d). These two lines must intersect at turning line for complete solution.
2. For shallow v-shaped channel as shown use nomograph with $z = \frac{T}{d}$
3. To determine discharge Q_x, in portion of channel having width x: determine depth d for total discharge in entire section a. Then use nomograph to determine Q_b, in section b for depth. $d' = d - \left(\frac{x}{z}\right)$
4. To determine discharge in composite section: – follow instruction 3. To obtain discharge in section a at assumed depth d: obtain Q_b for slope ration Z_b and depth d^1, then $Q_T = Q_a \bullet Q_b$



$$Q = \frac{0.56}{n} S_x^{1.67} S^{0.5} T^{2.67}$$

EXAMPLE: GIVEN:

$n = 0.016$; $S_x = 0.03$

$S = 0.04$; $T = 6$ FT

FIND:

$Q = 2.4\ FT^3/S$

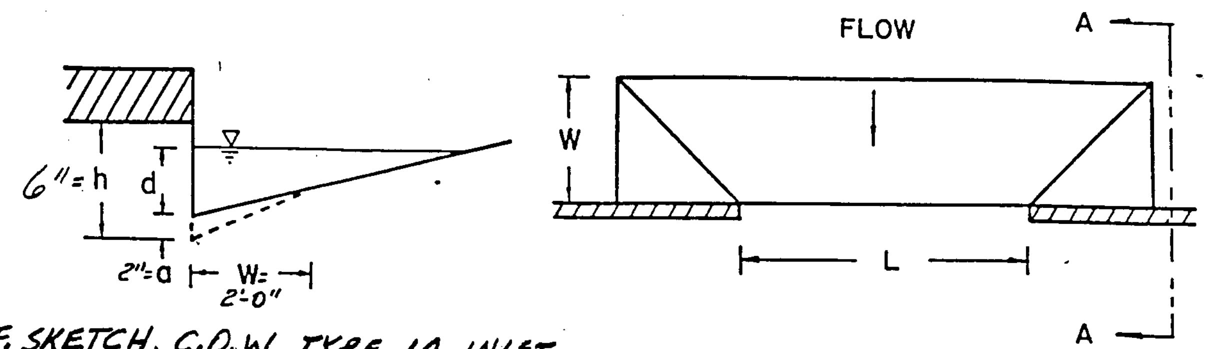
$Qn = 0.038\ FT^3/S$

1) For V-Shape, use the nomograph with $S_x = S_{x1} S_{x2} / (S_{x1} + S_{x2})$

2) To determine discharge in gutter with composite cross slopes, find Q_s using T_s and S_x. Then, use CHART 4 to find E_o. The total discharge is $Q = Q_s / (1 - E_o)$, and $Q_w = Q - Q_s$.

CHART 3. Flow in triangular gutter sections.

From: HEC-12: Drainage of Highway Pavements, F.H.W.A., Mar. 1984



DEF. SKETCH, C.D.W. TYPE 1A INLET

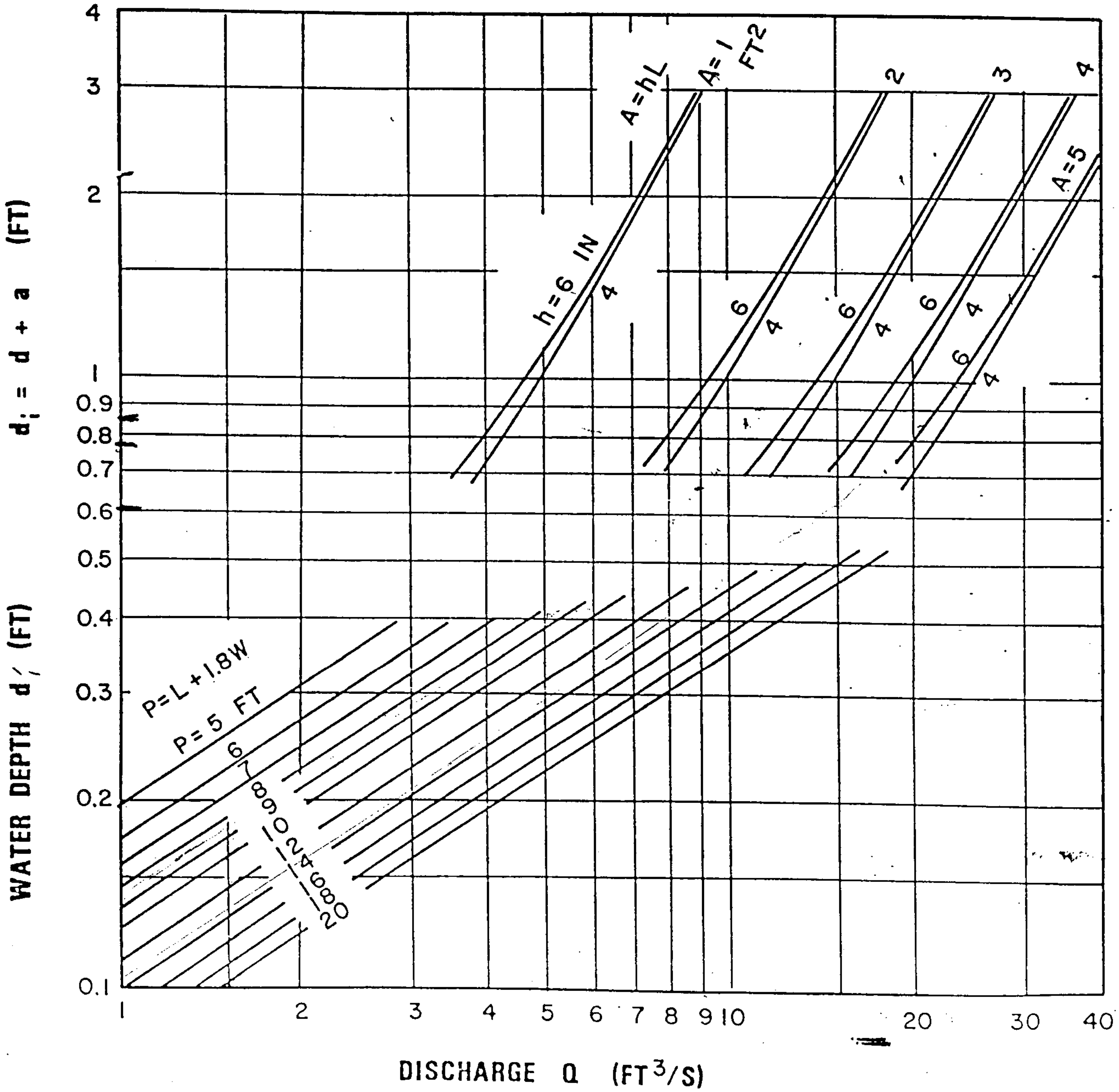


CHART 12. Depressed curb–opening inlet capacity in sump locations.

FROM: HEC-12, DRAINAGE OF HIGHWAY PAVEMENTS, F.H.W.A., MAR., 1984

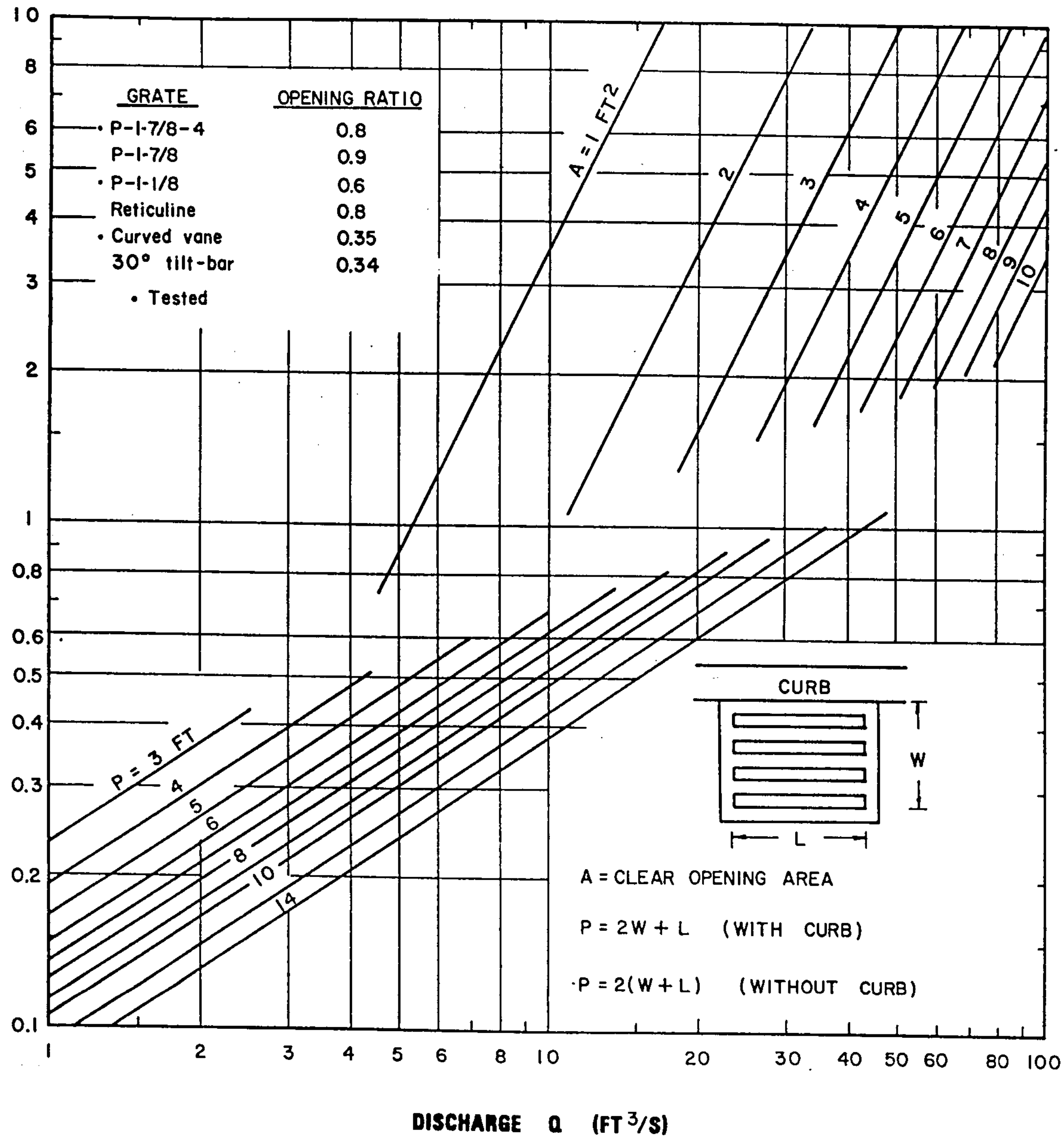


CHART 11. Grate inlet capacity in sump conditions.

TABLE 3

$S = ft/ft$ .03 ft/ft cfs

$S = Q^2/K^2$

$Q = K\sqrt{S}$

$K = Q/\sqrt{S}$

FULL FLOW COEFFICIENT VALUES CIRCULAR CONCRETE PIPE

D Pipe Diameter (inches)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{2/3} = K$ n=0.010	n=0.011	n=0.012	n=0.013
8	0.349	0.167	15.8	14.3	13.1	12.1
10	0.545	0.208	28.4	25.8	23.6	21.8
12	0.785	0.250	46.4	42.1	38.6	35.7
15	1.227	0.312	84.1	76.5	70.1	64.7
18	1.767	0.375	137	124	114	105
21	2.405	0.437	206	187	172	158
24	3.142	0.500	294	267	245	226
27	3.976	0.562	402	366	335	310
30	4.909	0.625	533	485	444	410
33	5.940	0.688	686	624	574	530
36	7.069	0.750	867	788	722	666
42	9.621	0.875	1308	1189	1090	1006
48	12.566	1.000	1867	1698	1556	1436
54	15.904	1.125	2557	2325	2131	1967
60	19.635	1.250	3385	3077	2821	2604
66	23.758	1.375	4364	3967	3636	3357
72	28.274	1.500	5504	5004	4587	4234
78	33.183	1.625	6815	6195	5679	5242
84	38.485	1.750	8304	7549	6920	6388
90	44.170	1.875	9985	9078	8321	7681
96	50.266	2.000	11850	10780	9878	9119
102	56.745	2.125	13940	12670	11620	10720
108	63.617	2.250	16230	14760	13530	12490
114	70.882	2.375	18750	17040	15620	14420
120	78.540	2.500	21500	19540	17920	16540
126	86.590	2.625	24480	22260	20400	18830
132	95.033	2.750	27720	25200	23100	21330
138	103.870	2.875	31210	28370	26010	24010
144	113.100	3.000	34960	31780	29130	26890

TABLE 4

FULL FLOW COEFFICIENT VALUES ELLIPTICAL CONCRETE PIPE

Pipe Size R x S (HE) S x R (VE) (Inches)	Approximate Equivalent Circular Diameter (Inches)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{2/3} = K$ n = 0.010	n = 0.011	n = 0.012	n = 0.013
14 x 23	18	1.8	0.367	138	125	116	108
19 x 30	24	3.3	0.490	301	274	252	232
22 x 34	27	4.1	0.546	405	368	339	313
24 x 38	30	5.1	0.613	547	497	456	421
27 x 42	33	6.3	0.686	728	662	607	560
29 x 45	36	7.4	0.736	891	810	746	686
32 x 49	39	8.8	0.812	1140	1036	948	875
34 x 53	42	10.2	0.875	1386	1260	1156	1067
38 x 60	48	12.9	0.969	1878	1707	1565	1445
43 x 68	54	16.6	1.106	2635	2395	2196	2027
48 x 76	60	20.5	1.229	3491	3174	2910	2686
53 x 83	66	24.8	1.352	4503	4094	3753	3464
58 x 91	72	29.5	1.475	5680	5164	4734	4370
63 x 98	78	34.6	1.598	7027	6388	5856	5406
68 x 106	84	40.1	1.721	8560	7790	7140	6590
72 x 113	90	46.1	1.845	10300	9365	8584	7925
77 x 121	96	52.4	1.967	12220	11110	10190	9403
82 x 128	102	59.2	2.091	14380	13070	11980	11060
87 x 136	108	66.4	2.215	16770	15240	13970	12900
92 x 143	114	74.0	2.340	19380	17620	16150	14910
97 x 151	120	82.0	2.461	22190	20180	18490	17070
106 x 166	132	99.2	2.707	28630	26020	23860	22020
116 x 180	144	118.6	2.968	36400	33100	30340	28000

TABLE 5

FULL FLOW COEFFICIENT VALUES CONCRETE ARCH PIPE

Pipe Size R x S (Inches)	Approximate Equivalent Circular Diameter (Inches)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Value of $C_1 = \frac{1.486}{n} \times A \times R^{2/3} = K$ n = 0.010	n = 0.011	n = 0.012	n = 0.013
11 x 18	15	1.1	0.25	65	59	54	50
13½ x 22	18	1.6	0.30	110	100	91	84
15½ x 26	21	2.2	0.36	165	150	137	127
18 x 28½	24	2.8	0.45	243	221	203	187
22½ x 36¼	30	4.4	0.56	441	401	368	339
26⅝ x 43¾	36	6.4	0.68	736	669	613	566
31 5/16 x 51⅛	42	8.8	0.80	1125	1023	938	866
36 x 58½	48	11.4	0.90	1579	1435	1315	1214
40 x 65	54	14.3	1.01	2140	1945	1783	1646
45 x 73	60	17.7	1.13	2851	2592	2376	2193
54 x 88	72	25.6	1.35	4641	4219	3867	3569
62 x 102	84	34.6	1.57	6941	6310	5784	5339
72 x 115	90	44.5	1.77	9668	8789	8056	7436
77¼ x 122	96	51.7	1.92	11850	10770	9872	9112
87⅛ x 138	108	66.0	2.17	16430	14940	13690	12640
96⅞ x 154	120	81.8	2.42	21975	19977	18312	16904
106½ x 168¾	132	99.1	2.65	28292	25720	23577	21763

TABLE 6

FULL FLOW COEFFICIENT VALUES PRECAST CONCRETE BOX SECTIONS

Box Size Span x Rise (Feet)	A Area (Square Feet)	R Hydraulic Radius (Feet)	$C = 1.486/n(A \times R^{2/3})$ n = 0.012	n = 0.013	Box Size Span x Rise (Feet)	A Area (Square Feet)	R Hydraulic Radius (Feet)	$C = 1.486/n(A \times R^{2/3})$ n = 0.012	n = 0.013
3 X 2	5.78	0.63	524	484	9 X 5	43.88	1.67	7060	7070
3 X 3	8.78	0.78	923	852	9 X 6	52.88	1.87	9950	9180
4 X 2	7.65	0.69	743	686	9 X 7	61.88	2.05	12400	11400
4 X 3	11.65	0.90	1340	1240	9 X 8	70.88	2.20	14800	13700
4 X 4	15.65	1.04	1990	1840	9 X 9	79.88	2.33	17400	16100
5 X 3	14.50	0.98	1770	1630	10 X 5	48.61	1.73	8690	8020
5 X 4	19.50	1.16	2660	2460	10 X 6	58.61	1.95	11300	10462
5 X 5	24.50	1.30	3620	3340	10 X 7	68.61	2.14	14100	13000
6 X 3	17.32	1.04	2200	2030	10 X 8	78.61	2.31	17000	15700
6 X 4	23.32	1.25	3350	3100	10 X 9	88.61	2.46	20000	18500
6 X 5	29.32	1.42	4590	4240	10 X 10	98.61	2.59	23000	21300
6 X 6	35.32	1.56	5880	5430	11 X 4	42.32	1.52	6930	6390
7 X 4	27.11	1.33	4050	3740	11 X 6	64.32	2.02	12730	11700
7 X 5	34.11	1.52	5590	5160	11 X 8	86.32	2.41	19200	17700
7 X 6	41.11	1.68	7200	6650	11 X 10	108.32	2.72	26100	24100
7 X 7	48.11	1.82	8880	8200	11 X 11	119.32	2.85	29700	27400
8 X 4	31.11	1.39	4790	4420	12 X 4	46.00	1.55	7630	7050
8 X 5	39.11	1.60	6630	6120	12 X 6	70.00	2.08	14100	13000
8 X 6	47.11	1.78	8760	7920	12 X 8	94.00	2.50	21400	19800
8 X 7	55.11	1.94	10600	9790	12 X 10	118.00	2.83	29300	27000
8 X 8	63.11	2.07	12700	11700	12 X 12	142.00	3.11	37500	34600

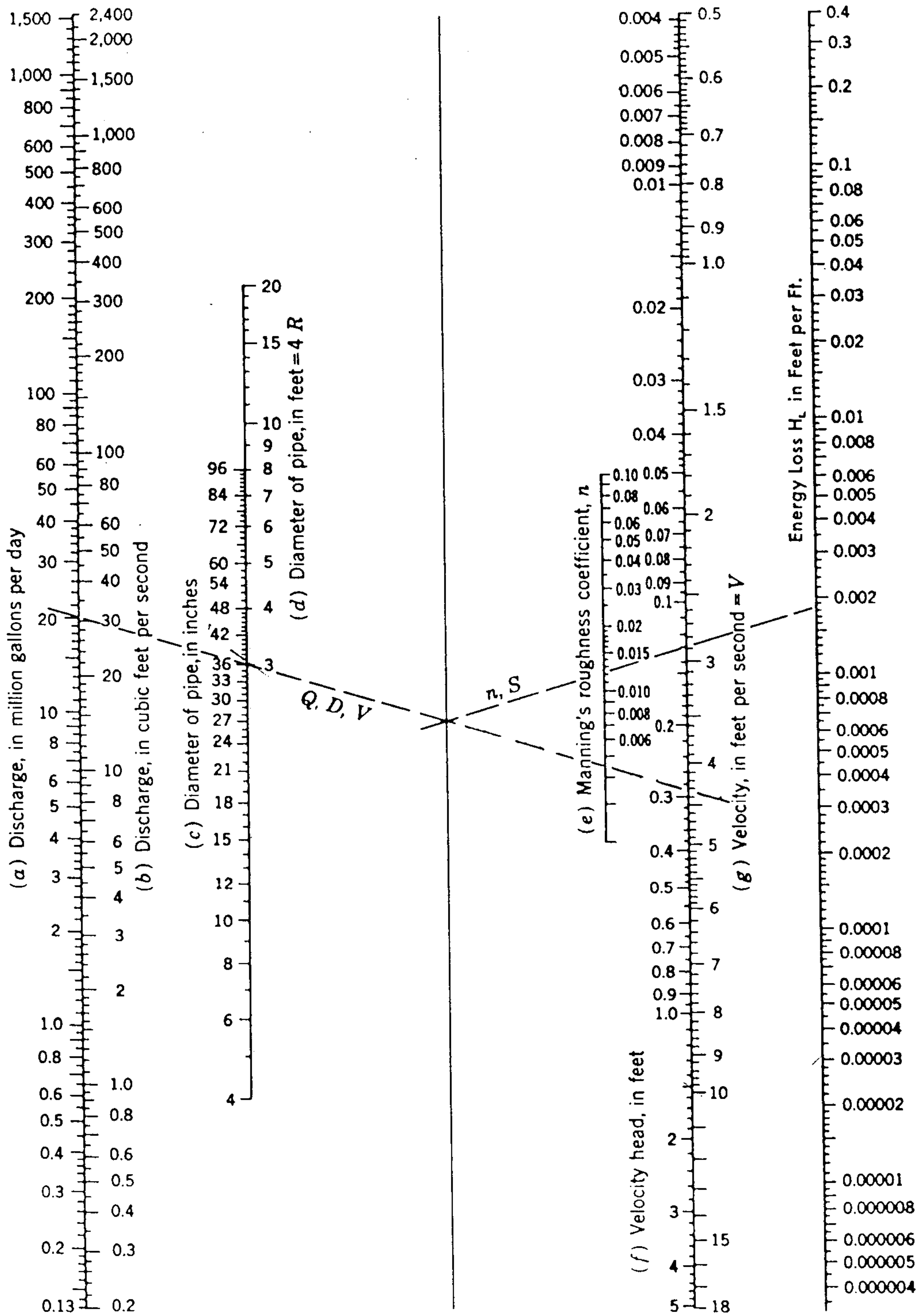
TABLE 7

SLOPES REQUIRED FOR V = 2fps AT FULL AND HALF FULL FLOW

Pipe Diameter (Inches)	Slope in % n = 0.010	n = 0.011	n = 0.012	n = 0.013
8	0.197	0.238	0.284	0.332
10	0.147	0.178	0.213	0.248
12	0.115	0.139	0.166	0.194
15	0.086	0.104	0.123	0.145
18	0.067	0.081	0.097	0.114
21	0.055	0.066	0.079	0.092
24	0.046	0.055	0.066	0.077
27	0.039	0.047	0.056	0.065
30	0.034	0.041	0.049	0.057
33	0.030	0.036	0.043	0.051
36	0.027	0.032	0.038	0.045
42	0.022	0.026	0.031	0.036
48	0.018	0.022	0.026	0.031
54	0.015	0.019	0.022	0.027
60	0.013	0.016	0.019	0.023
66	0.012	0.014	0.017	0.020
72	0.011	0.013	0.015	0.018
78	0.010	0.011	0.014	0.016
84	0.009	0.010	0.012	0.015
90	0.008	0.010	0.011	0.013
96	0.007	0.009	0.010	0.012
102	0.007	0.008	0.010	0.011
108	0.006	0.007	0.009	0.010
114	0.006	0.007	0.008	0.010
120	0.005	0.006	0.008	0.009
126	0.005	0.006	0.007	0.008
132	0.004	0.006	0.007	0.008
138	0.004	0.005	0.006	0.007
144	0.004	0.005	0.006	0.007

Note: For a velocity V other than 2fps, multiple the above by $\frac{V^2}{4}$.

Although the friction slope S_f appears as a second order term in the expression for 'C' the resulting discharge is not sensitive to this term. Table 4.11 shows the difference (%) in discharge computed using the Kutter equation compared with that obtained by Manning. The table gives the relationship between the diameter (D) and the hydraulic radius (R) assuming full flow in a circular pipe. The values in Table 4.11 are also valid for noncircular pipes flowing partially full.



Alignment chart for energy loss in pipes, for Manning's formula.
Note: Use chart for flow computations, $H_L = S$

Figure 4.8 Nomograph for solution of Manning's formula.

PROFESSIONAL ENGINEERING CONSULTANTS
1440 EAST ENGLISH
WICHITA, KANSAS
ZIP CODE / 67211

Date June 17, 1982

Project

Item Minimum Storm Drain Slopes

For Reinf. Conc. Pipe w/ n = 0.013 find Smin for 2fps @ 0.2d

do (in.)	Smin (%)	do (in.)	Smin. (%)
12	0.51	39	0.11
15	0.38	42	0.10
18	0.30	48	0.08
21	0.24	54	0.07
24	0.20	60	0.06
27	0.17	66	0.05
30	0.15	72	0.05
33	0.13	84	0.04
36	0.12	96	0.03

Pipe thickness
$= \frac{d}{12''} + 1'' = t$ (in)

.75

.0006

For CMP w/ n as shown find Smin. for 3 & 2 fps @ 0.2d

	do (in.)	Corrugations*	Manning's n (3)	Smin (%) 3 f.p.s.	Smin. (%) 2 f.p.s.
(1)	12	H & C	~~0.014~~ 0.024	~~1.34~~ 3.94	~~0.60~~ 1.75
	15	H & C	~~0.014~~ 0.024	~~1.00~~ 2.93	~~0.44~~ 1.30
	18	H & C	~~0.015~~ 0.024	~~0.90~~ 2.29	~~0.40~~ 1.02
	21	H & C	0.024	1.87	0.83
	24	H & C	0.024	1.56	0.70
	30	H & C	0.024	1.16	0.52
	36	H & C	0.024	0.91	0.40
	42	H & C	0.024	0.74	0.33
	48	H & C	0.024	0.62	0.28
	54	H & C	0.024	0.53	0.24
	60	C	~~0.027~~ 0.024	~~0.58~~ 0.46	~~0.26~~ 0.20
	66	C	~~0.027~~ 0.024	~~0.57~~ 0.41	~~0.23~~ 0.18
(2)	72	C	0.027	0.46	0.20
	78	C	0.027	0.41	0.18
	84	C	0.027	0.37	0.17
	90	C	0.027	0.34	0.15
	96	C	0.027	0.31	0.14

* C = Circumferential
H = Helical

(1) 2⅔ x ½ corrugations } from Specifications
(2) 3 x 1 Corrugations }
(3) "N" from Section III.2.a p. 11 "Interim Drainage & Stm. Sew. Policy

Appendix A.—TABLES

Table 1.—Manning roughness coefficients, n [1]

	Manning's n range [2]
I. Closed conduits:	
A. Concrete pipe	0.011–0.013
B. Corrugated-metal pipe or pipe-arch:	
1. 2⅔ by ½-in. corrugation (riveted pipe): [3]	
a. Plain or fully coated	0.024
b. Paved invert (range values are for 25 and 50 percent of circumference paved):	
(1) Flow full depth	0.021–0.018
(2) Flow 0.8 depth	0.021–0.016
(3) Flow 0.6 depth	0.019–0.013
2. 6 by 2-in. corrugation (field bolted)	0.03
C. Vitrified clay pipe	0.012–0.014
D. Cast-iron pipe, uncoated	0.013
E. Steel pipe	0.009–0.011
F. Brick	0.014–0.017
G. Monolithic concrete:	
1. Wood forms, rough	0.015–0.017
2. Wood forms, smooth	0.012–0.014
3. Steel forms	0.012–0.013
H. Cemented rubble masonry walls:	
1. Concrete floor and top	0.017–0.022
2. Natural floor	0.019–0.025
I. Laminated treated wood	0.015–0.017
J. Vitrified clay liner plates	0.015
II. Open channels, lined [4] (straight alinement): [5]	
A. Concrete, with surfaces as indicated:	
1. Formed, no finish	0.013–0.017
2. Trowel finish	0.012–0.014
3. Float finish	0.013–0.015
4. Float finish, some gravel on bottom	0.015–0.017
5. Gunite, good section	0.016–0.019
6. Gunite, wavy section	0.018–0.022
B. Concrete, bottom float finished, sides as indicated:	
1. Dressed stone in mortar	0.015–0.017
2. Random stone in mortar	0.017–0.020
3. Cement rubble masonry	0.020–0.025
4. Cement rubble masonry, plastered	0.016–0.020
5. Dry rubble (riprap)	0.020–0.030
C. Gravel bottom, sides as indicated:	
1. Formed concrete	0.017–0.020
2. Random stone in mortar	0.020–0.023
3. Dry rubble (riprap)	0.023–0.033
D. Brick	0.014–0.017
E. Asphalt:	
1. Smooth	0.013
2. Rough	0.016
F. Wood, planed, clean	0.011–0.013
G. Concrete-lined excavated rock:	
1. Good section	0.017–0.020
2. Irregular section	0.022–0.027
III. Open channels, excavated [4] (straight alinement, [5] natural lining):	
A. Earth, uniform section:	
1. Clean, recently completed	0.016–0.018
2. Clean, after weathering	0.018–0.020
3. With short grass, few weeds	0.022–0.027
4. In gravelly soil, uniform section, clean	0.022–0.025
B. Earth, fairly uniform section:	
1. No vegetation	0.022–0.025
2. Grass, some weeds	0.025–0.030
3. Dense weeds or aquatic plants in deep channels	0.030–0.035
4. Sides clean, gravel bottom	0.025–0.030
5. Sides clean, cobble bottom	0.030–0.040
C. Dragline excavated or dredged:	
1. No vegetation	0.028–0.033
2. Light brush on banks	0.035–0.050
D. Rock:	
1. Based on design section	0.035
2. Based on actual mean section:	
a. Smooth and uniform	0.035–0.040
b. Jagged and irregular	0.040–0.045
E. Channels not maintained, weeds and brush uncut:	
1. Dense weeds, high as flow depth	0.08–0.12
2. Clean bottom, brush on sides	0.05–0.08
3. Clean bottom, brush on sides, highest stage of flow	0.07–0.11
4. Dense brush, high stage	0.10–0.14
IV. Highway channels and swales with maintained vegetation [6, 7] (values shown are for velocities of 2 and 6 f.p.s.):	
A. Depth of flow up to 0.7 foot:	
1. Bermudagrass, Kentucky bluegrass, buffalograss:	
a. Mowed to 2 inches	0.07–0.045
b. Length 4–6 inches	0.09–0.05
2. Good stand, any grass:	
a. Length about 12 inches	0.18–0.09
b. Length about 24 inches	0.30–0.15
3. Fair stand, any grass:	
a. Length about 12 inches	0.14–0.08
b. Length about 24 inches	0.25–0.13
B. Depth of flow 0.7–1.5 feet:	
1. Bermudagrass, Kentucky bluegrass, buffalograss:	
a. Mowed to 2 inches	0.05–0.035
b. Length 4 to 6 inches	0.06–0.04
2. Good stand, any grass:	
a. Length about 12 inches	0.12–0.07
b. Length about 24 inches	0.20–0.10
3. Fair stand, any grass:	
a. Length about 12 inches	0.10–0.06
b. Length about 24 inches	0.17–0.09
V. Street and expressway gutters:	
A. Concrete gutter, troweled finish	0.012
B. Asphalt pavement:	
1. Smooth texture	0.013
2. Rough texture	0.016
C. Concrete gutter with asphalt pavement:	
1. Smooth	0.013
2. Rough	0.015
D. Concrete pavement:	
1. Float finish	0.014
2. Broom finish	0.016
E. For gutters with small slope, where sediment may accumulate, increase above values of n by	*0.002*
VI. Natural stream channels: [8]	
A. Minor streams [9] (surface width at flood stage less than 100 ft.):	
1. Fairly regular section:	
a. Some grass and weeds, little or no brush	0.030–0.035
b. Dense growth of weeds, depth of flow materially greater than weed height	0.035–0.05
c. Some weeds, light brush on banks	0.035–0.05
d. Some weeds, heavy brush on banks	0.05–0.07
e. Some weeds, dense willows on banks	0.06–0.08
f. For trees within channel, with branches submerged at high stage, increase all above values by	*0.01–0.02*
2. Irregular sections, with pools, slight channel meander; increase values given in 1a–e about	*0.01–0.02*
3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage:	
a. Bottom of gravel, cobbles, and few boulders	0.04–0.05
b. Bottom of cobbles, with large boulders	0.05–0.07
B. Flood plains (adjacent to natural streams):	
1. Pasture, no brush:	
a. Short grass	0.030–0.035
b. High grass	0.035–0.05
2. Cultivated areas:	
a. No crop	0.03–0.04
b. Mature row crops	0.035–0.045
c. Mature field crops	0.04–0.05
3. Heavy weeds, scattered brush	0.05–0.07
4. Light brush and trees: [10]	
a. Winter	0.05–0.06
b. Summer	0.06–0.08
5. Medium to dense brush: [10]	
a. Winter	0.07–0.11
b. Summer	0.10–0.16
6. Dense willows, summer, not bent over by current	0.15–0.20
7. Cleared land with tree stumps, 100–150 per acre:	
a. No sprouts	0.04–0.05
b. With heavy growth of sprouts	0.06–0.08
8. Heavy stand of timber, a few down trees, little undergrowth:	
a. Flood depth below branches	0.10–0.12
b. Flood depth reaches branches	0.12–0.16
C. Major streams (surface width at flood stage more than 100 ft.): Roughness coefficient is usually less than for minor streams of similar description on account of less effective resistance offered by irregular banks or vegetation on banks. Values of n may be somewhat reduced. Follow recommendation in publication cited [8] if possible. The value of n for larger streams of most regular section, with no boulders or brush, may be in the range of	0.028–0.033

Footnotes to table 1 appear at the top of page 101.

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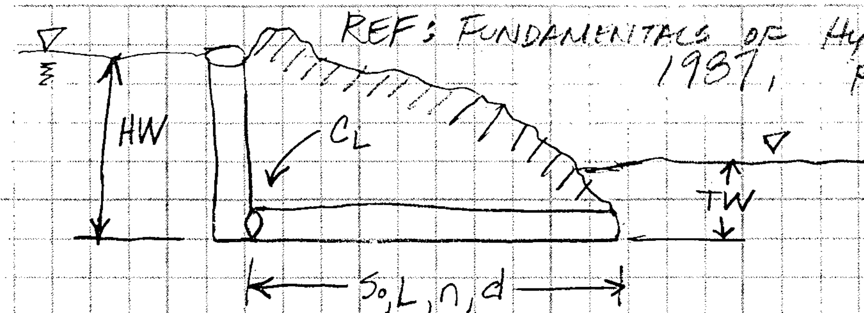
Date 5/24/97 PDM Page ______ of ______

Project Outlet Control for CULVERT ANALYSIS

Item for PNDRTING.XLS

REF: FUNDAMENTALS OF Hydraulic Engineering, A.L. Prasuhn 1987, p. 432-457



I Outlet Control is based on ENERGY Balance between inflow & outflow configuration.

$$HW + S_oL + \frac{V_o^2}{2g} = TW + H_L$$

$$HW + S_oL + \frac{\left(\frac{Q_1}{A_1}\right)^2}{2g} = TW + \left(C_L + 1 + \frac{gn^2L}{1.11R^{4/3}}\right)\frac{8Q_2^2}{\pi^2 g D^4}$$

II Solve for Q_2

$$\frac{HW - TW + S_oL + \frac{\left(\frac{Q_1}{A_1}\right)^2}{2g}}{\left(C_L + 1 + \frac{gn^2L}{1.11R^{4/3}}\right)\frac{8}{\pi^2 g D^4}} = Q_2^2$$

$R = \frac{D}{4}$ for ϕ pipe

$$\therefore Q_2 = \sqrt{\frac{HW - TW + S_oL + \left(\frac{Q_1}{A}\right)^2/2g}{\left(C_L + 1 + \frac{gn^2L}{1.11\left(\frac{D}{4}\right)^{4/3}}\right)\frac{8}{\pi^2 g D^4}}}$$

$$\frac{(A21 - G\$9) - (G\$12 - G\$13) + \left(\frac{G\$15}{100} \times G\$14\right) + \frac{\left[\frac{D21}{(PI()*((G\$8/12/2)^2))}\right]^2}{64.4}}{\left[1 + G\$17 + \frac{32.2(G\$16)^2(G\$14)}{\ldots}\right]\frac{8}{\ldots}}$$

[illegible]

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6/1/97 PDM REVISED FOR FOREST LAKES WEST

Date 10/20/92 MWB Page ______ of ______

Project FOREST LAKES & FOREST LAKES WEST

Item TYPICAL SECTION THRU LOT (VIEW OUT)

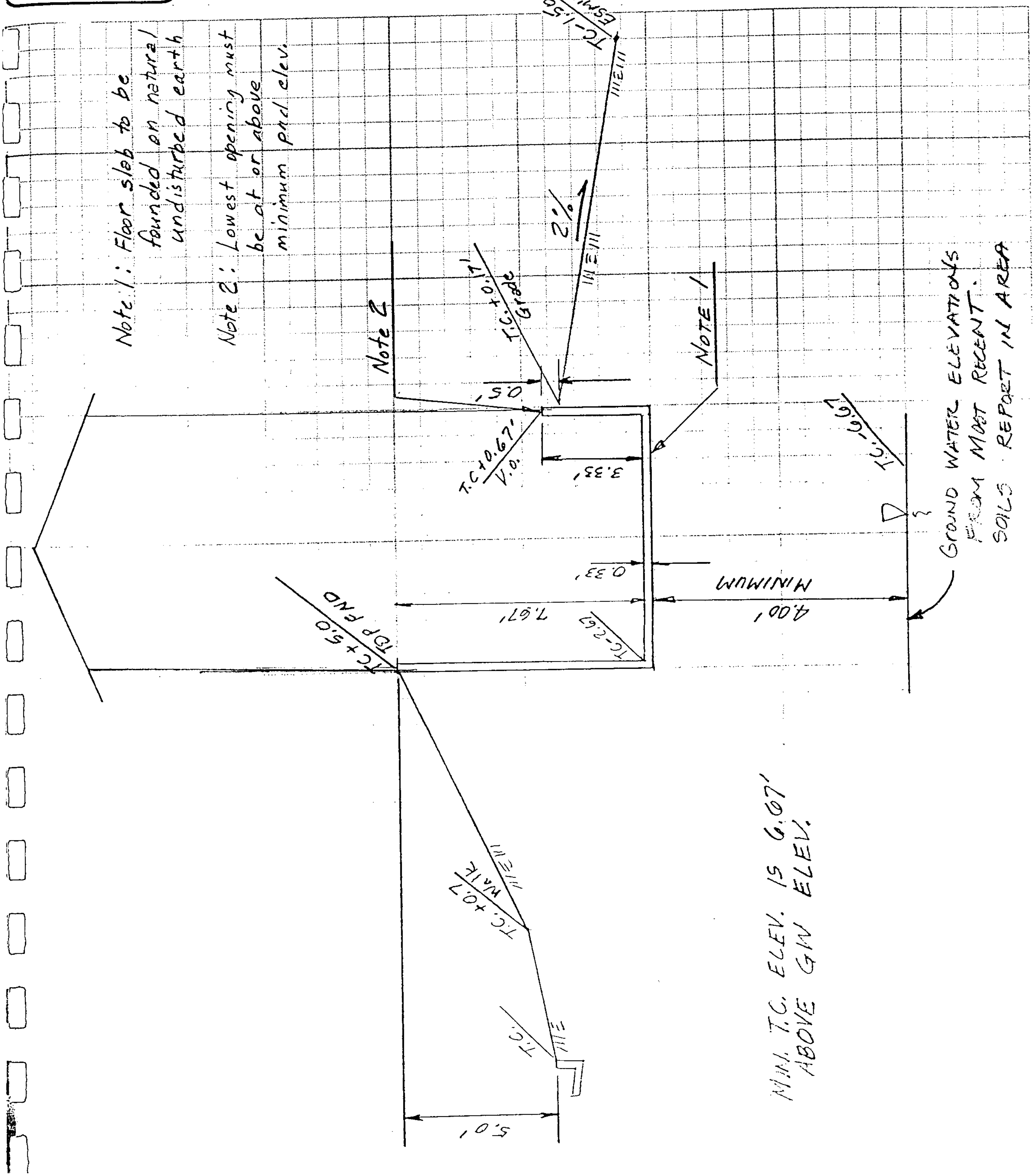
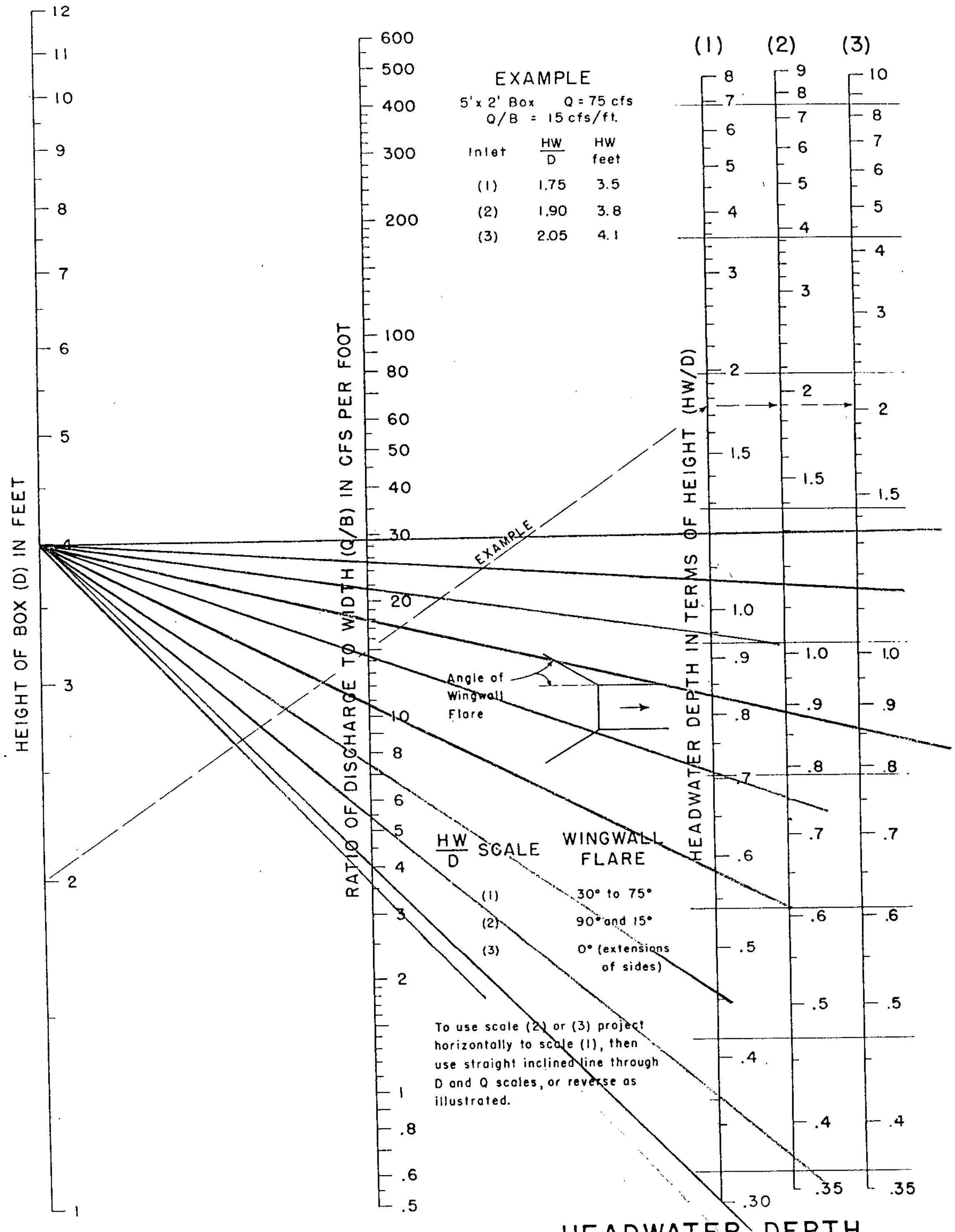


CHART I



HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1963

orifice

Pond Outflow Rating Curve Calculations

Project : Forest Lakes West

Pond ID: #3

Target Flow at HW_{100} (cfs)= 38

Standpipe Characteristics

Weir Control	$Q=CLH^{1.5}$
Weir Coefficient =	0
Inlet Perimeter (ft) =	0
Inlet Top Elev. (D.W.S) =	152.5
Orifice Control	$Q=CA(2gH)^{0.5}$
Orifice Coefficient =	0.00
Orifice Area (ft^2) =	0
(Assumes 60% Grate Opening)	
pprox. Standpipe Size =	0

Pipe Characteristics

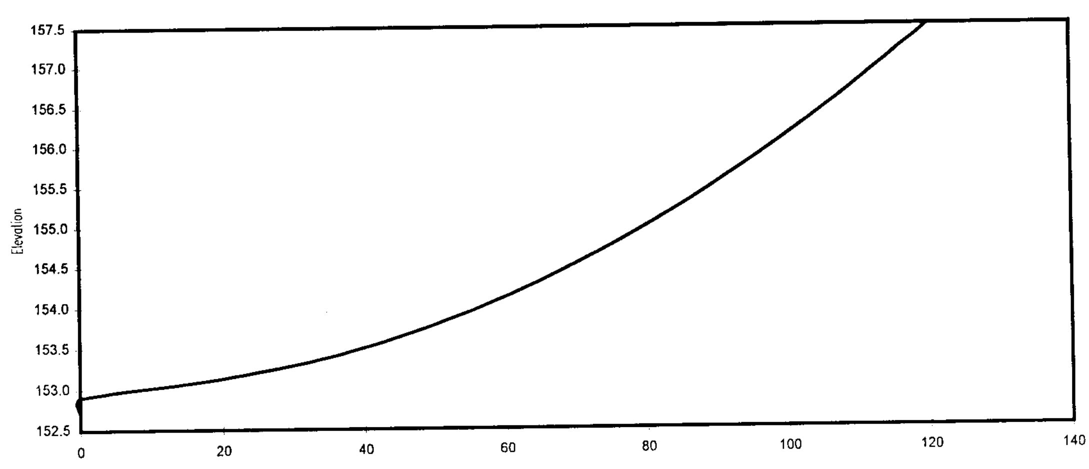
Inlet Control	$Q=CA(2gH)^{0.5}$
Orifice Coefficient =	0.67
Pipe Diameter (in) =	48
Invert Elevation =	147.5
Outlet Control	**Energy Equation**
Est. T.W. Elev. =	153
Outlet Flowline Elev. =	144.5
Pipe Length (ft) =	300
Avg. Pipe Slope (%) =	1
Manning 'n' for pipe =	0.013
Entrance Loss Coef. =	0.7

Overflow Characteristics

Weir Control	$Q=CLH^{1.5}$
Weir Coefficient =	0
Overflow Length (ft) =	0
Overflow Elevation =	0

ELEV	Weir	Orifice	Standpipe Control	Inlet	Outlet	Pipe Control	Overflow	Pond Outflow
152.5	0.0	0.0	0.0	117.0	#NUM!	#NUM!	0.0	#NUM!
152.7	0.0	0.0	0.0	120.9	#NUM!	#NUM!	0.0	#NUM!
152.9	0.0	0.0	0.0	124.6	#NUM!	#NUM!	0.0	#NUM!
153.1	0.0	0.0	0.0	128.2	17.9	17.9	0.0	17.9
153.3	0.0	0.0	0.0	131.7	31.0	31.0	0.0	31.0
153.5	0.0	0.0	0.0	135.1	40.0	40.0	0.0	40.0
153.7	0.0	0.0	0.0	138.5	47.4	47.4	0.0	47.4
153.9	0.0	0.0	0.0	141.7	53.7	53.7	0.0	53.7
154.1	0.0	0.0	0.0	144.9	59.4	59.4	0.0	59.4
154.3	0.0	0.0	0.0	148.0	64.6	64.6	0.0	64.6
154.5	0.0	0.0	0.0	151.1	69.4	69.4	0.0	69.4
154.7	0.0	0.0	0.0	154.1	73.8	73.8	0.0	73.8
154.9	0.0	0.0	0.0	157.0	78.1	78.1	0.0	78.1
155.1	0.0	0.0	0.0	159.9	82.1	82.1	0.0	82.1
155.3	0.0	0.0	0.0	162.7	85.9	85.9	0.0	85.9
155.5	0.0	0.0	0.0	165.5	89.5	89.5	0.0	89.5
155.7	0.0	0.0	0.0	168.2	93.1	93.1	0.0	93.1
155.9	0.0	0.0	0.0	170.9	96.4	96.4	0.0	96.4
156.1	0.0	0.0	0.0	173.6	99.7	99.7	0.0	99.7
156.3	0.0	0.0	0.0	176.2	102.9	102.9	0.0	102.9
156.5	0.0	0.0	0.0	178.8	106.0	106.0	0.0	106.0
156.7	0.0	0.0	0.0	181.3	108.9	108.9	0.0	108.9
156.9	0.0	0.0	0.0	183.8	111.8	111.8	0.0	111.8
157.1	0.0	0.0	0.0	186.3	114.7	114.7	0.0	114.7
157.3	0.0	0.0	0.0	188.7	117.4	117.4	0.0	117.4
157.5	0.0	0.0	0.0	191.1	120.1	120.1	0.0	120.1

Pond Rating Curve



Pond Outflow Rating Curve Calculations

Project : Forest Lakes West

Pond ID: #4

Target Flow at HW_{100} (cfs)= 106

Trapezoidal Control Channel

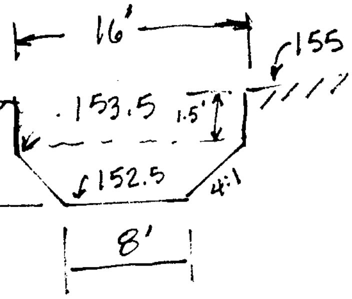
$Q=(1.49AR^{2/3}S^{1/2})/n$

Bottom Width =	8		
Design Depth =	1		
Side Slope X:1 =	4	Q(max) (cfs) =	30.6
Channel Slope (%) =	0.7	A (ft^2) =	12
Manning 'n' =	0.04	R (ft) =	0.74
Design Static Elev. =	152.5		

Overflow Characteristics

Weir Control $Q=CLH^{1.5}$

Weir Coefficient =	3
Overflow Length (ft) =	16
Overflow Elevation =	153.5



ELEV	Area	Hyd. Radius	Channel Control	Overflow	Pond Outflow
152.5	0.0	0.0	0.0	0.0	0.0
152.7	1.8	0.2	1.8	0.0	1.8
152.9	3.8	0.3	5.8	0.0	5.8
153.1	6.2	0.5	11.9	0.0	11.9
153.3	9.0	0.6	20.1	0.0	20.1
153.5	12.0	0.7	30.5	0.0	30.5
153.7	15.4	0.9	30.6	4.3	34.9
153.9	19.0	1.0	30.6	12.1	42.7
154.1	23.0	1.1	30.6	22.3	52.9
154.3	27.4	1.2	30.6	34.3	64.9
154.5	32.0	1.3	30.6	48.0	78.6
154.7	37.0	1.4	30.6	63.1	93.7
154.9	42.2	1.5	30.6	79.5	110.1
155.1	47.8	1.6	30.6	97.1	127.7
155.3	53.8	1.7	30.6	115.9	146.5
155.5	60.0	1.8	30.6	135.8	166.3
155.7	66.6	1.9	30.6	156.6	187.2
155.9	73.4	2.0	30.6	178.5	209.0
156.1	80.6	2.1	30.6	201.2	231.8
156.3	88.2	2.2	30.6	224.9	255.5
156.5	96.0	2.3	30.6	249.4	280.0
156.7	104.2	2.4	30.6	274.8	305.3
156.9	112.6	2.5	30.6	300.9	331.5
157.1	121.4	2.6	30.6	327.9	358.4
157.3	130.6	2.7	30.6	355.6	386.1
157.5	140.0	2.8	30.6	384.0	414.6

Pond Rating Curve
Channel Control