Figure 6-18

CONVEYANCE FACTORS -- ROUND PIPE

Dia., in.	A Area, sq. ft.	Various Values of n																	
		.010	.012	.013	.014	.016	.017	.018	.019	.020	.021	.023	.024	.025	.031	.032	.033	.034	.035
6	.20	7.29	6.08	5.61	5.21	4.56													
8	.35	15.70	13.10	12.10	11.20	9.82													
10	.55	28.50	23.70	21.90	20.30	17.80													
12	.79	46.30	38.60	35.60	33.10	28.90													
15	1.23	84.00	70.00	64.60	60.00	52.50													
18	1.77	137	114	105	98	85	80	76	72	68	65	59	57	55					
21	2.41	206	172	158	147	129	121	114	108	103	98	90	86	82					
24	3.14	294	245	226		184	173	163	155	147	140	128	123	118					
30	4.91	533	444	410		333	314	296	281	267	254	232	222	213					
36	7.07	867	723	667			510	482	456	434	413	377	361	347					
42	9.62	1310	1090	1010				727	688	654	623	569	545	523					
48	12.57	1870	1560	1440						934	889	812	778	747					
54	15.90	2560	2130	1970						1280	1220	1110	1070	1020					
60	19.63	3390	2820	2600						1690	1610	1470	1410		1090	1060	1030	996	967
66	23.76	4370	3640	3360							2080	1900	1820		1410	1360	1320	1280	1250
72	28.27	5510	4590	4240							2620	2390	2290		1780	1720	1670	1620	1570
78	33.18	6820	5680	5240							3250	2960	2840		2200	2130	2070	2000	1950
84	38.48	8300	6920	6390							3950	3610	3460		2680	2600	2520	2440	2370
90	44.18	9980	8320	7680							4750	4340	4160		3220	3120	3020	2940	2850
96	50.27	11900	9880	9120							5650	5160	4940		3820	3710	3590	3490	3390
102	56.75	13900	11600	10700							6640	6060	5810		4500	4360	4220	4100	3980
108	63.62	16200	13500	12500							7730	7060	6760		5240	5070	4920	4770	4640
114	70.88	18700	15600	14400							8930	8150	7810		6050	5860	5680	5510	5360
120	78.54	21500	17900	16500							10200	9350	8960		6930	6720	6510	6320	6140
126	86.59	24500	20400	18800											7900	7650	7420	7200	7000
132	95.03	27700	23100	21300											8940	8660	8400	8150	7920
138	103.87	31200	26000	24000											10100	9750	9460	9180	8920
144	113.10	35000	29100	26900											11300	10900	10600	10300	9990
150	122.72	39000	32500	30000											12600	12200	11800	11500	11100
156	132.73	43300	36100	33300											14000	13500	13100	12700	12400
162	143.14	47900	39900	36800											15400	15000	14500	14100	13700
168	153.94	52700	43900	40600											17000	16500	16000	15500	15100
174	165.13	57900	48300	44500											18700	18100	17500	17000	16500
180	176.71	63400	52800	48800											20400	19800	19200	18600	18100

Figure 6-19

CONVEYANCE FACTORS -- CMP ARCH PIPE

Size, In.		A Area, sq. ft.	R Hydraulic Radius, ft.	Values of n									
Span	Rise			.012	.014	.016	.017	.018	.019	.020	.021	.024	.025
17	13	1.2	.311	69	59	52	49	46	44	42	40	35	33
21	15	1.7	.357	105	90	78	74	70	66	63	60	52	50
24	18	2.3	.415	157	135	118	111	105	99	94	90	79	75
28	20	2.9	.458	212	182	159	150	141	134	127	121	106	102
35	24	4.4	.563	373	320	280	263	249	236	224	213	187	179
42	29	6.5	.689	627	537	470	442	418	396	376	358	313	301
49	33	8.4	.766	873	748	655	616	582	551	524	499	436	419
57	38	11.3	.896	1300	1110	972	915	864	819	778	741	648	622
64	43	14.4	1.021	1810	1550	1360	1280	1210	1150	1090	1040	907	871
71	47	17.4	1.109	2310	1980	1730	1630	1540	1460	1390	1320	1160	1110
77	52	21.3	1.232	3030	2600	2270	2140	2020	1910	1820	1730	1520	1450
83	57	25.6	1.359	3890	3340	2920	2750	2600	2460	2340	2220	1950	1870

Figure 6-20

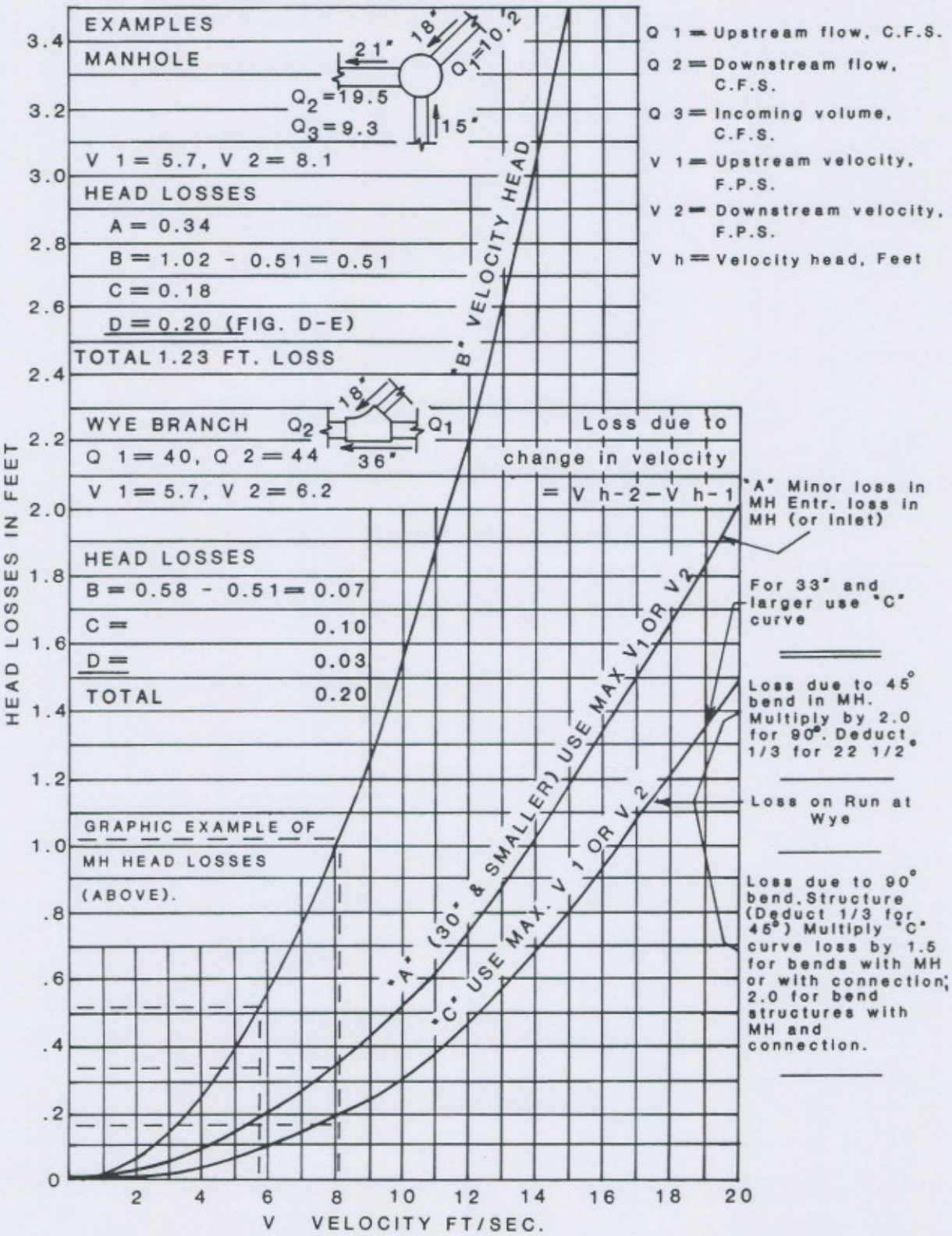
VALUES OF $S^{1/2}$ FOR USE IN MANNING'S EQUATION

S	0	1	2	3	4	5	6	7	8	9
.00	-	.0316	.0447	.0548	.0632	.0707	.0775	.0837	.0894	.0949
.01	.10	.1049	.1095	.1140	.1183	.1225	.1265	.1304	.1342	.1378
.02	.1414	.1449	.1483	.1517	.1549	.1581	.1612	.1643	.1673	.1703
.03	.1732	.1761	.1789	.1817	.1844	.1871	1.897	.1924	.1949	.1975
.04	.20	.2025	.2049	.2074	.2098	.2121	.2145	.2168	.2191	.2214
.05	.2236	.2258	.2280	.2302	.2324	.2345	.2366	.2387	.2408	.2429
.06	.2449	.2470	.2490	.2510	.2530	.2550	.2569	.2588	.2608	.2627
.07	.2646	.2665	.2683	.2702	.2720	.2739	.2757	.2775	.2793	.2811
.08	.2828	.2846	.2864	.2881	.2898	.2915	.2933	.2950	.2966	.2983
.09	.30	.3017	.3033	.3050	.3066	.3082	.3098	.3114	.3130	.3146
.10	.3162	.3178	.3194	.3209	.3225	.3240	.3256	.3271	.3286	.3302

Note: Numbers across top represent third decimal place, e.g. if given slopes are .002 ft./ft. and .034 ft./ft. then respective $S^{1/2}$ values are .0447 and .1844.

Figure 6-21

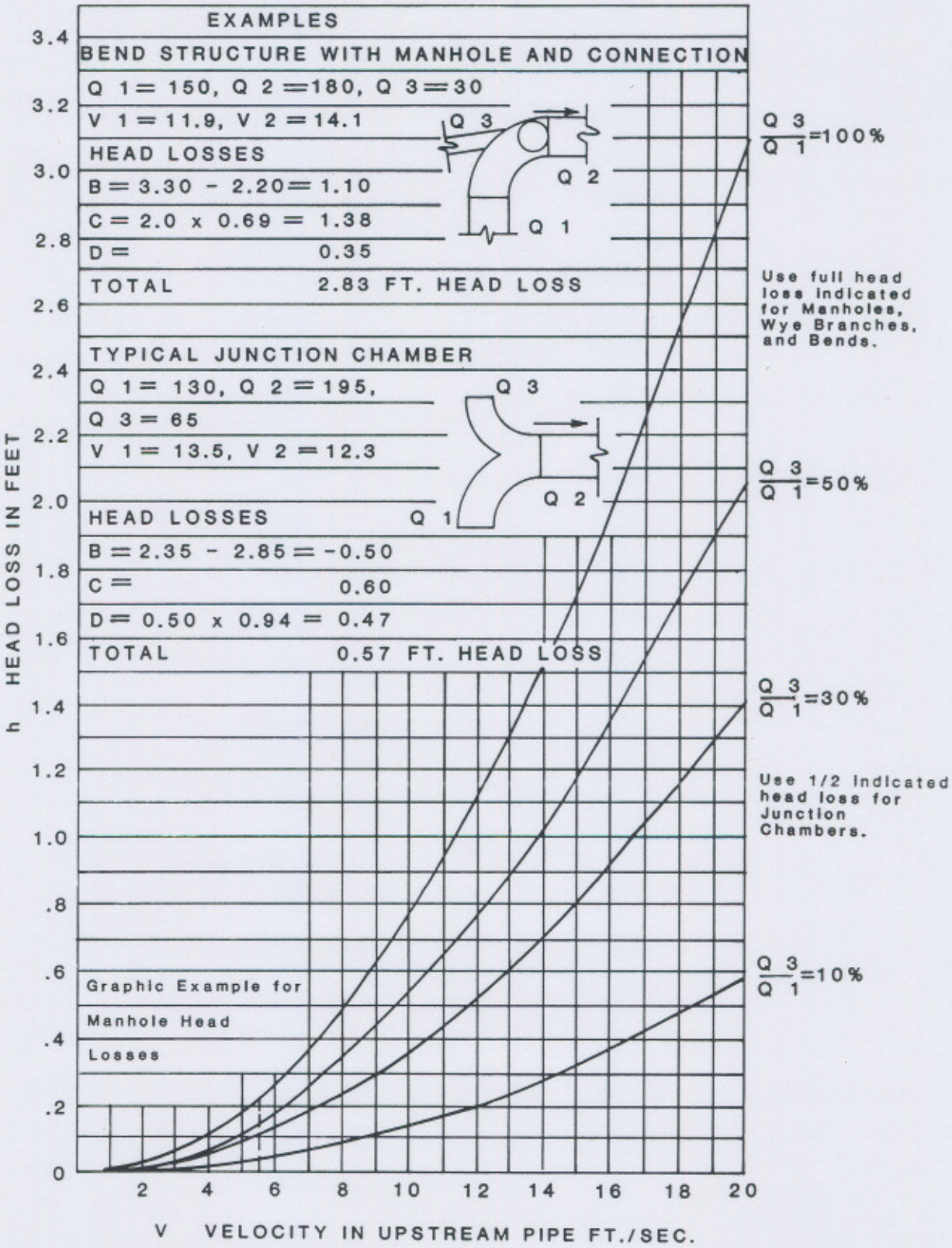
HEAD LOSSES IN STRUCTURES-"A", "B", & "C" LOSSES



Source: Baltimore County Department of Public Works

Figure 6-22

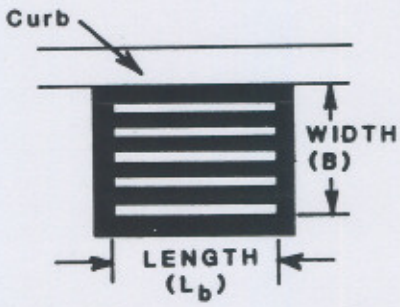
HEAD LOSSES IN STRUCTURE "D" LOSS



Source: Baltimore County Department of Public Works

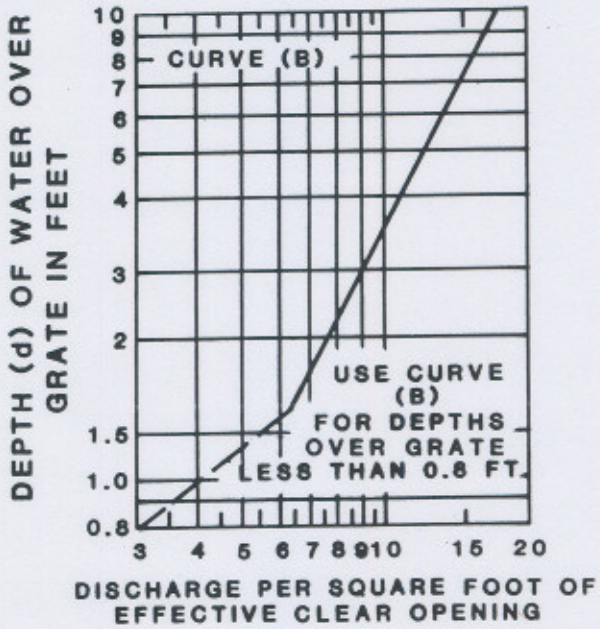
Figure 6-23

HYDRAULIC CAPACITY OF GRATE INLET IN SUMP



$P = 2B + L_b$

A AREA OF CLEAR OPENING IN GRATE TO ALLOW FOR CLOGGING DIVIDE P OR A BY 2 BEFORE OBTAINING d. WITHOUT CURB $P = 2(B + L_b)$



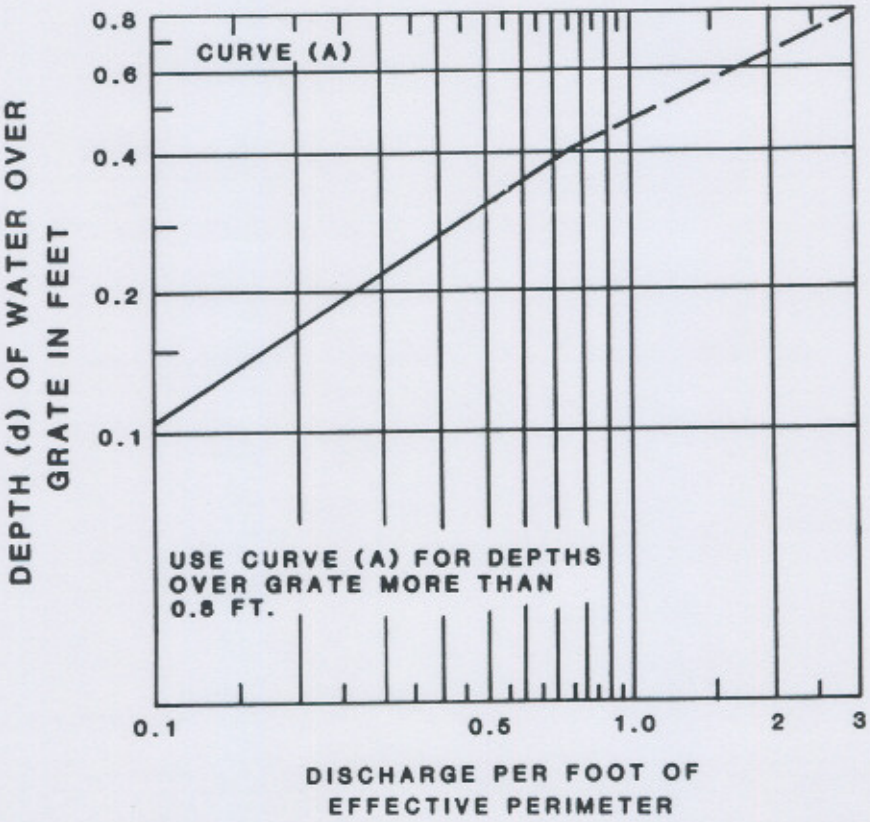
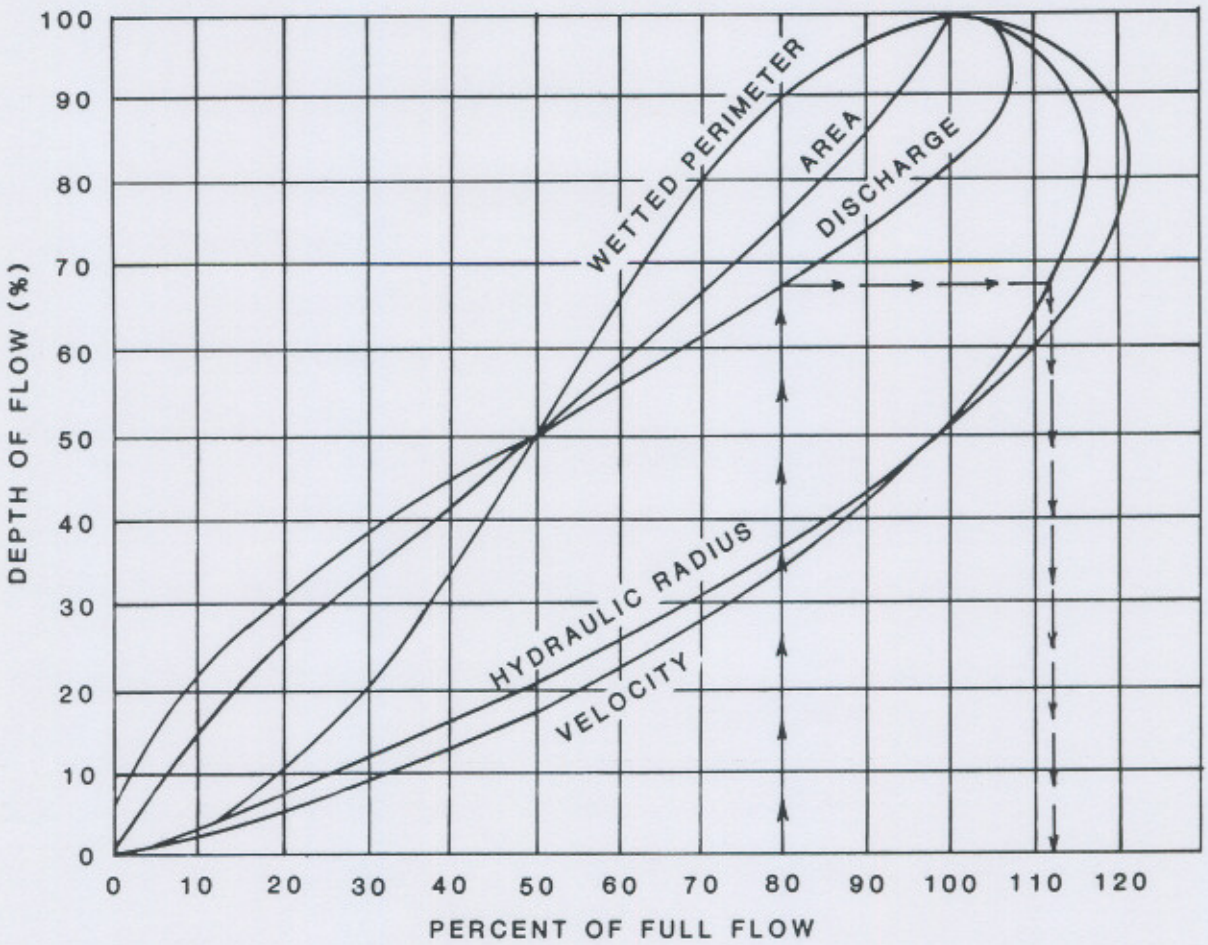


Figure 6-24

HYDRAULIC ELEMENTS OF CIRCULAR SECTIONS



EXAMPLE:

Given- Discharge flowing full 15 c.f.s., velocity = 7 f.p.s.

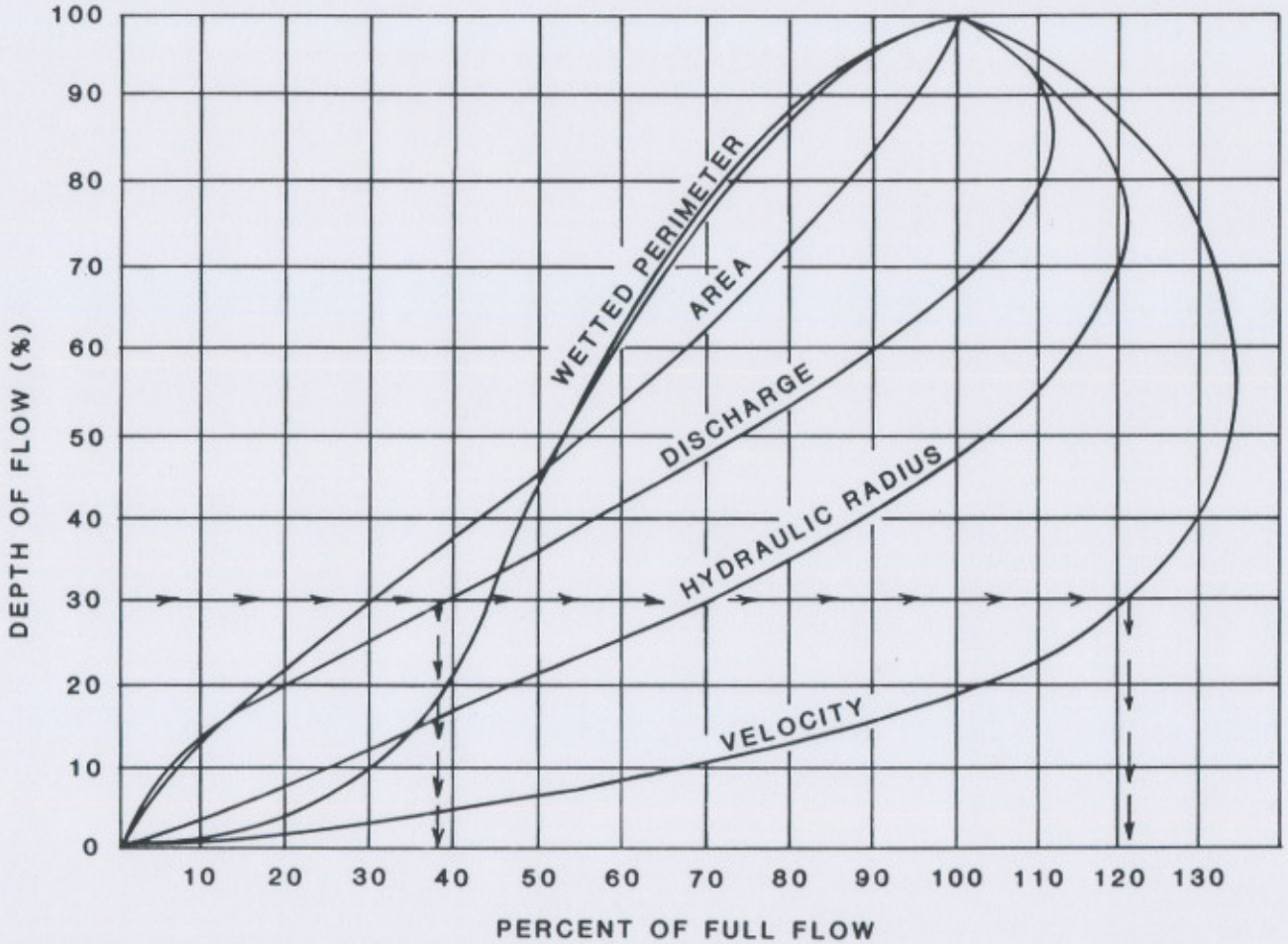
Determine- Velocity and depth of flow when discharge is 12 c.f.s.

Solution- Enter chart at 80% of value for full section of Hydraulic Elements. Obtain depth of flow 68% of full flow depth and velocity = 112.5% x 7 = 7.9 f.p.s.

Source: Baltimore County Department of Public Works

Figure 6-25

HYDRAULIC ELEMENTS OF ARCH PIPE SECTIONS



EXAMPLE: Given- Discharge flowing full 20 cfs ; velocity = 10 fps
Determine- Discharge & velocity when depth of flow is 30% of depth flowing full
Solution- Q = 38% of 20 cfs = 7.6 cfs V = 122% of 10 fps = 12.2 fps

Source: Baltimore County Department of Public Works

Figure 6-26

GRATE INLET DESIGN CURVES - STANDARD GRATES

45° Tilt Bar Grate

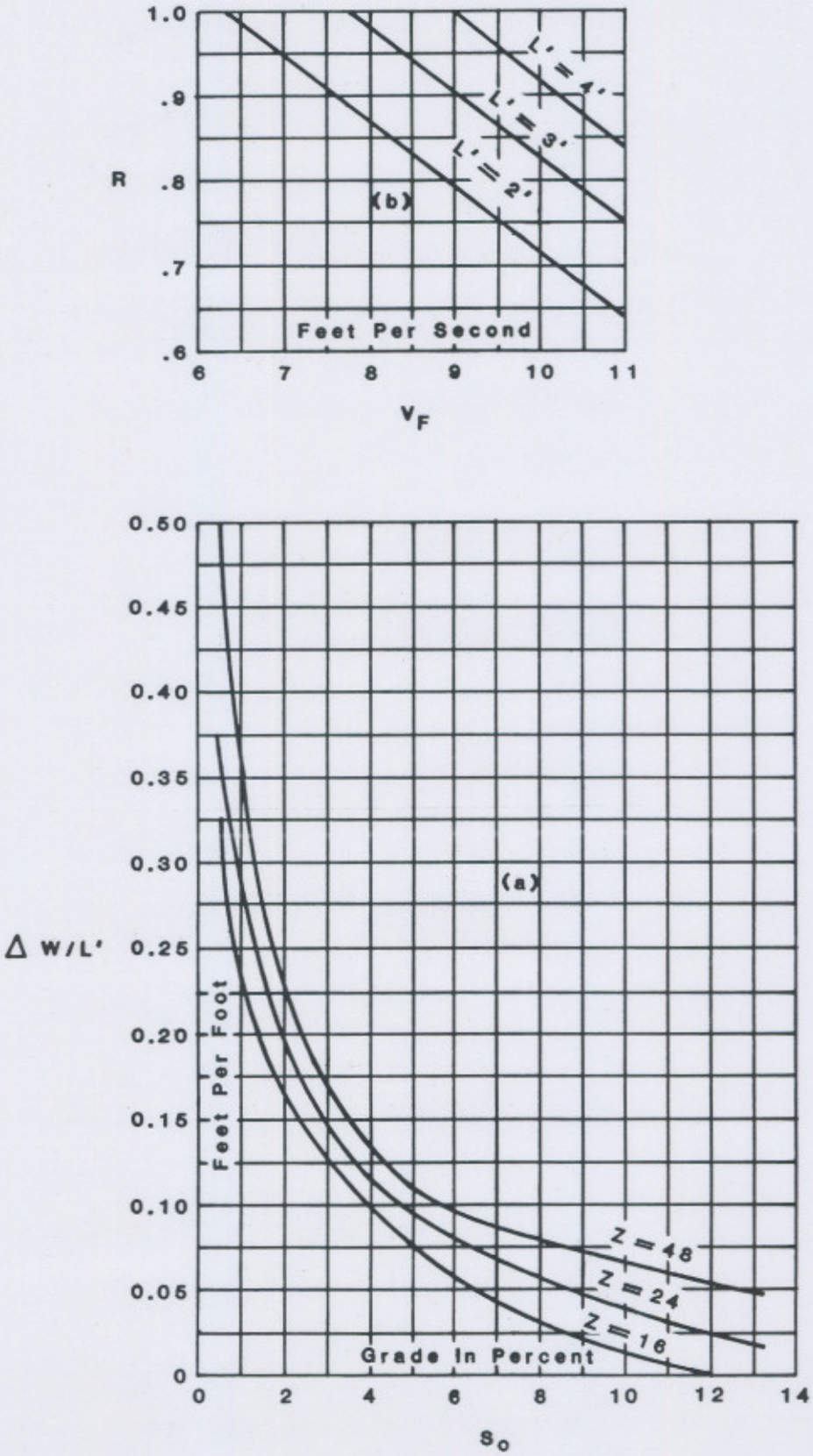
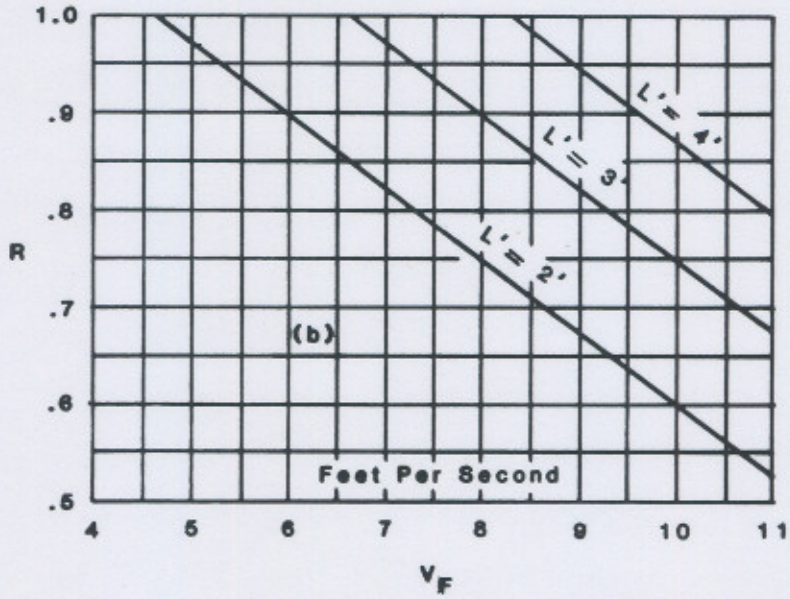


Figure 6-27

GRATE INLET DESIGN CURVES - PWBD GRATES



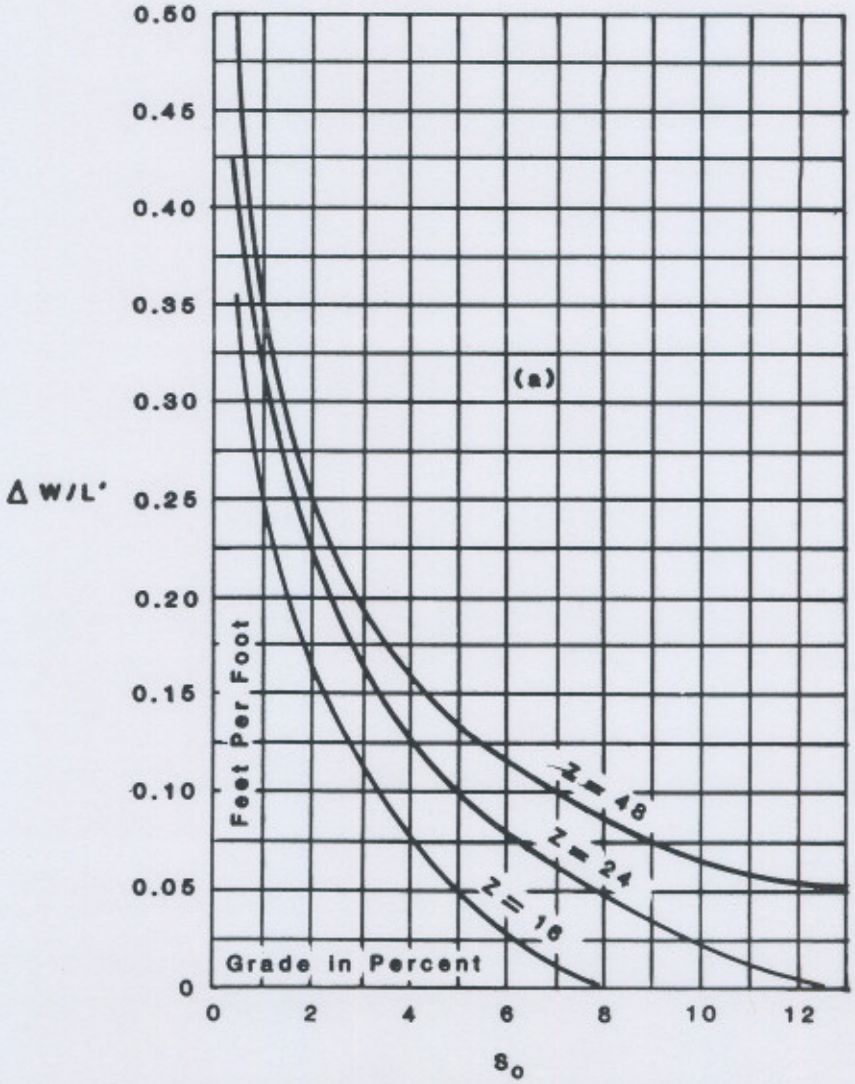
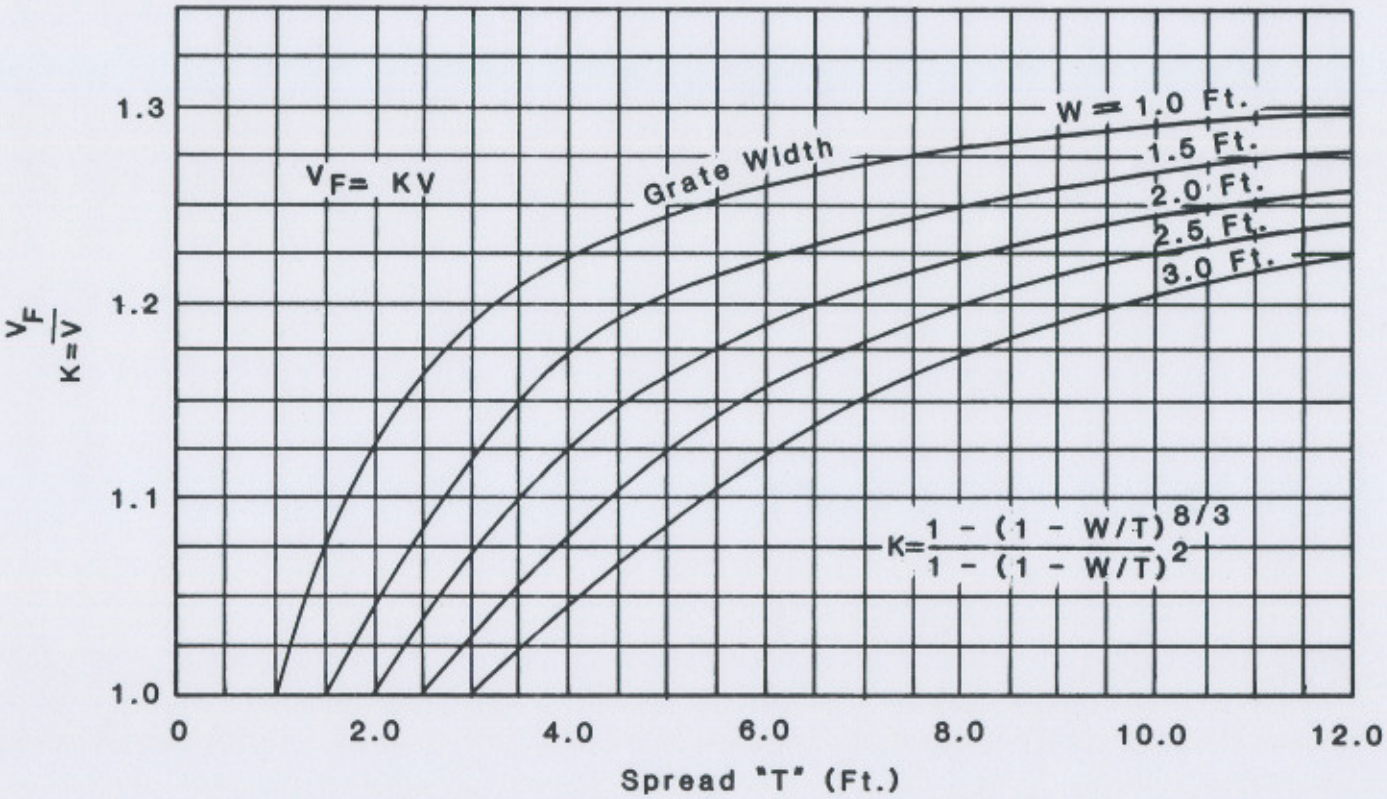


Figure 6-28

FRONTAL FLOW VELOCITY COEFFICIENTS



Spread vs. K (Frontal Flow Velocity Coefficients).

Figure 6-29

PIPE SELECTION CRITERIA

O - ROUND - CORRUGATED STEEL PIPE

Pipe Diameter (In.)	Area (Ft^2)	Minimum Cover (Ft.)	Minimum Metal Thickness (In.)	Minimum Metal Thickness (Gage)	Maximum Fill Heights (Ft.)
2 2/3" x 1/2" Corrugations					
12	0.8	1.0	0.064	16	124
15	1.2				100
18	1.8				83
24	3.1				62
30	4.9		0.079	14	62
36	7.1				51
42	9.6				44
48	12.6		0.019	12	54
54	15.9				46
60	19.6		0.138	10	51
66	23.8				43
72	28.3		0.168	8	44
78	33.2				50
84	38.5				41
90	44.2				33
96	50.3				27
3" x 1" and 5" x 1" Corrugations					
36	7.1	1.0	0.079	14	60
42	9.6				51
48	12.6				45
54	15.9				40
60	19.6				36
66	23.8				33
72	28.3				30
78	33.2		0.109	12	38
84	38.5				35
90	44.2				33
96	50.3				31

Note: The gages shown above are the industry standard. Only the gage shown for each pipe size may be used.

Figure 6-30

PIPE SELECTION CRITERIA

- PIPE ARCH - CORRUGATED STEEL - PLAIN GALVANIZED

Equivalent Round Pipe Diameter (In.)	Span and Rise (In.)	Area (Ft^2)	Minimum Cover (Ft.)	Minimum Metal Thickness (In.)	Minimum Metal Thickness (Gage)	Maximum Fill Heights (Ft.)
2 2/3" x 1/2" Corrugations						
15	17 x 13	1.2	1.0	0.079	14	22
18	21 x 15	1.7				21
21	24 x 18	2.3				19
24	28 x 20	2.9				18
30	35 x 24	4.4				18
36	42 x 29	6.5				15
42	49 x 33	8.4		0.109	12	14
48	57 x 38	11.3		0.138	10	14
54	64 x 43	14.4				14
60	71 x 47	17.4		0.168	8	14
66	77 x 52	21.3				14
72	83 x 57	25.6				15
3" x 1" and 5" x 1" Corrugations						
36	40 x 31	7.0	1.0	0.079	14	23
42	46 x 31	9.4				22
54	53 x 41	12.3		0.109	12	21
60	60 x 46	15.6				21
66	66 x 51	19.3				28
72	73 x 55	23.2				26
78	81 x 59	27.4				24
84	87 x 63	32.1				22
90	95 x 67	37.0				20
96	103 x 71	42.4	1.5			18

Note: The gages shown above are the industry standard. Only the gage shown for each pipe size may be used.

Figure 6-31

PIPE SELECTION CRITERIA

○ - ROUND - CORRUGATED ALUMINUM PIPE

Pipe Diameter (In.)	Area (Ft^2)	Minimum Cover (Ft.)	Minimum Metal Thickness (In.)	Minimum Metal Thickness (Gage)	Maximum Fill Heights (Ft.)
2 2/3" x 1/2" Corrugations					
12	0.8	1.0	0.075	14	116
15	1.2				90
18	1.8				75
24	3.1				56
30	4.8		0.105	12	63
36	7.1				52
42	9.6		0.135	10	58
48	12.6				50
54	15.9	1.5			45
60	19.6		0.164	8	49
66	23.8				44
72	28.3				40
78	33.2	2.0			37
84	38.5				34
90	44.2				N.A.
96	50.3				N.A.
3" x 1" and 5" x 1" Corrugations					
36	7.1	1.0	0.075	14	42
42	9.6				36
48	12.6				31
54	15.9	1.5	0.105	12	39
60	19.6				35
66	23.8				32
72	28.3		0.135	10	38
78	33.2				35
84	38.5				32
90	44.2	2.0			30
96	50.3		0.164	8	34

Note: The gages shown above are the industry standard. Only the gage shown for each pipe size may be used.

Figure 6-32

PIPE SELECTION CRITERIA

- PIPE ARCH - CORRUGATED ALUMINUM

Equivalent Round Pipe Diameter (In.)	Span and Rise (In.)	Area (Ft^2)	Minimum Cover (Ft.)	Minimum Metal Thickness (In.)	Minimum Metal Thickness (Gage)	Maximum Fill Heights (Ft.)
2 2/3" x 1/2" Corrugations						
15	17 x 13	1.2	1.25	0.105	12	15
18	21 x 15	1.7				15
21	24 x 18	2.3				14
24	28 x 20	2.9		0.134	10	14
30	35 x 24	4.4	1.50			13
36	42 x 29	6.5				13
42	49 x 33	8.4				12
48	57 x 38	11.3				8
54	64 x 43	14.4		0.164	8	7
60	71 x 47	17.4	2.00			7
66	77 x 52	21.3				7
72	83 x 57	25.6				7
3" x 1" and 5" x 1" Corrugations						
36	40 x 31	7.0	1.50	0.105	12	29
42	46 x 31	9.4				25
54	53 x 41	12.3				29
60	60 x 46	15.6				29
66	66 x 51	19.3	1.75			25
72	73 x 55	23.2				22
78	81 x 59	27.4		0.135	10	29
84	87 x 63	32.1	2.00			26
90	95 x 67	37.0				24
96	103 x 71	42.4	2.25			34

Note: The gages shown above are the industry standard. Only the gage shown for each pipe size may be used.

Figure 6-33

PIPE SELECTION CRITERIA

REINFORCED CONCRETE PIPE

Inside Pipe Diameter (In.)	Area (Sq. Ft.)	Maximum Fill Heights (Feet) Above Top of Pipe		
		Class III	Class IV	Class V
12	0.8	8	20	No Limit
15	1.2	9	18	No Limit
18	1.8	10	19	No Limit
21	2.4	11	20	No Limit
24	3.1	12	21	No Limit
27	3.5	12	22	No Limit
30	4.9	12	22	57
33	5.9	13	22	62
36	7.1	11	17	33
42	9.6	11	17	34
48	12.6	12	19	34
54	15.9	12	19	34
60	19.6	12	19	34
66	23.8	12	20	34
72	28.3	13	20	34
78	33.2	13	20	
84	38.5	13	20	
90	44.2	13		
96	50.3	13		
102	56.7	14		
108	63.6	14		

Note: Based on Class C bedding and soil of 130# per cubic foot.

Figure 6-34

CHANNEL LINING CRITERIA

VELOCITY (FT/S)	CHANNEL LINING	COMMENTS
Under 8.0	Grass	Design may require a study of the velocity vs. organic lining charts due to the possibility of eroding the underlying soil.
8.0 - 12.5	Rip-Rap	Maximum permissible velocity depends on the side slope of the proposed channel and size of rip-rap used. For slopes of: 12:1 = 12:5 ft/s, 4:1 = 11.75 ft/s, 3:1 = 11.0 ft/s, and 2:1 = 10.5 ft/s.
Over 12.5	Gabions or Concrete	A great range of velocities may be handled here. All designs lead to a reduction of flow time in the facility and high erosive capability at the outfall.

Note: All drainage facilities shall be evaluated for outfall erosion and service life (flexible vs. nonflexible lining).