GOLF COURSE ROAD

STORMDRAIN SYSTEM DESIGN
AND
HYDRAULIC GRADE LINE COMPUTATIONS

RIO RANCHO, NEW MEXICO

PREPARED FOR:

CITY OF RIO RANCHO
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PREPARED BY:

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ALBUQUERQUE, NEW MEXICO 87114

JULY 1986

I, Charles M. Easterling, do hereby certify that this report was prepared by me or under my direction and that I am a duly registered Professional Engineer under the laws of the State of New Mexico.

Charles M. Easterling, P.E.
N.M.P.E. No. 6411

GOLF COURSE ROAD

STORMDRAIN SYSTEM DESIGN

The system is designed basically in accordance with the Preliminary Stormdrain System Design (June 1986) report previously submitted.

Mid-block inlet locations have been adjusted slightly to place the inlets at lot lines or in the center of lots as the least likely locations for future driveways.

The inlets at 22nd Avenue and 23rd Avenue were changed from the Preliminary Report. These streets do not yet have curbs and gutters. A Type A inlet with double grate was placed at the downhill curb return on Golf Course Road at each street. Inlets may be constructed on 22nd Avenue and 23rd Avenue with future improvements on these streets, and connected then to the Golf Course Road inlets.

The inlet connector pipes are conservatively sized. However, the added cost for these still small diameter pipes is not really significant, and the larger sizes will substantially ease maintenance requirements. There will be silt and blowsand problems all along Golf Course Road until the majority of the adjacent land is developed. The larger size connector pipes will be slower to plug up and will be a lot easier to clean when they do plug. Also, headlosses are reduced, particularly at the inlet exits, which will help realize the full capacity of the system in a larger than 10-year event.

The stormdrain mainline is designed to keep the hydraulic grade line at least two feet below the top of pavement, which should be adequate to allow the inlets to function. An "n-

factor" of 0.013 as specified by the City of Albuquerque Development Process Manual was used throughout, even for the larger sized pipe towards the south end of the project, which provides a degree of conservatism.

It would be possible to neck down a pipe size approximately between Stations 43+00 to 48+50 and 54+00 to 57+50. However, the price difference between 30 inch and 33 inch diameter pipe is not great and would be largely offset by the cost of the special fittings required. These complexities were therefore not pursued further.

Headlosses were calculated as follows:

Pipe friction : $h_f = S_f \times L \quad ; \quad S_f = (Q/k)^2$

Curves : $h_b = 0.002 \times \Delta \times h_v$

Bends : $h_b = 0.20 \sqrt{\Delta/90^\circ} \times h_v$

Manholes * : $h_{mh} = 0.05 \times h_{v\ outlet}$

Transitions : $h_t = K_2 \times h_v$ (sudden expansion)

$h_t = K_3 \times h_v$ (sudden contraction)

(K_2; K_3 from King; Brater tables)

Junctions : $\Delta y = \dfrac{Q_2 V_2 - Q_1 V_1 - Q_3 V_3 \cos\theta}{\frac{1}{2}(A_1 + A_2)g} + \left(\dfrac{S_{f1} + S_{f2}}{2}\right) \times L$

$h_J = \Delta y + h_{v1} - h_{v2}$

("Thompson equation")

* Manhole headlosses were calculated only for the smaller lines with conventional manholes. Prefabricated manhole tees as used on lines 36"Ø and larger do not cause a significant disturbance in the flow.

TABLE III: Circular Concrete and Corrugated Metal Pipe

Pipe Dia. (Inch)	A Area (Square Feet)	R Hydraulic Radius (Feet)	Values of $1.486/n \times A \times R^{2/3}$					
			Concrete Pipe			Corrugated Metal Pipe		
			n = 0.011	n = 0.012	n = 0.013	2-2/3" x 1/2" n = 0.024	3" x 1" n = 0.027	6" x 2" n = 0.033
8	0.349	0.167	14.3	13.1	12.1	6.5		
10	0.545	0.208	25.8	23.6	21.8	11.8		
12	0.785	0.250	42.1	38.6	35.7	19.3		
15	1.227	0.312	76.5	70.1	64.7	35.0		
18	1.767	0.375	124.2	113.8	105.1	56.9		
21	2.405	0.437	187.1	171.5	158.3	85.7		
24	3.142	0.500	267.4	245.1	226.2	122.5		
27	3.976	0.562	365.8	335.3	309.6	167.7		
30	4.909	0.625	484.7	444.3	410.1	222.2		
33	5.940	0.688	623.6	573.7	529.6	286.9		
36	7.069	0.750	788	722	666	361	321	
42	9.621	0.875	1189	1090	1006	545	484	
48	12.566	1.000	1698	1556	1436	778	692	
54	15.904	1.125	2325	2131	1967	1065	947	
60	19.635	1.250	3077	2821	2604	1410	1254	1026
66	23.758	1.375	3967	3636	3357	1818	1616	1323
72	28.274	1.500	5004	4587	4234	2293	2039	1668
78	33.183	1.625	6195	5679	5242	2839	2524	2065
84	38.485	1.750	7549	6920	6388	3460	3075	2517
90	44.179	1.875	9078	8321	7681		3698	3026
96	50.266	2.000	10776	9878	9119		4390	3592
102	56.745	2.125	12671	11615	10722			4224
108	63.617	2.250	14756	13526	12486			4919
114	70.882	2.375	17044	15624	14422			5682
120	78.540	2.500	19544	17915	16537			6515
126	86.590	2.625	22255	20397	18829			7417
132	95.030	2.750	25200	23104	21327			8401
138	103.870	2.875	28372	26009	24011			9459
144	113.100	3.000	31780	29133	26894			10594
150	122.720	3.125						11810
156	132.730	3.250						13115
162	143.140	3.375						14504
168	153.940	3.500						16160
174	165.130	3.625						17551
180	176.710	3.750						19212

Table 6-5. Circumferences of Circles by Hundredths (*Concluded*)

Diam.	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09
5.0	15.71	15.74	15.77	15.80	15.83	15.87	15.90	15.93	15.96	15.99
.1	16.02	16.05	16.08	16.12	16.15	16.18	16.21	16.24	16.27	16.30
.2	16.34	16.37	16.40	16.43	16.46	16.49	16.52	16.56	16.59	16.62
.3	16.65	16.68	16.71	16.74	16.78	16.81	16.84	16.87	16.90	16.93
.4	16.96	17.00	17.03	17.06	17.09	17.12	17.15	17.18	17.22	17.25
5.5	17.28	17.31	17.34	17.37	17.40	17.44	17.47	17.50	17.53	17.56
.6	17.59	17.62	17.66	17.69	17.72	17.75	17.78	17.81	17.84	17.88
.7	17.91	17.94	17.97	18.00	18.03	18.06	18.10	18.13	18.16	18.19
.8	18.22	18.25	18.28	18.32	18.35	18.38	18.41	18.44	18.47	18.50
.9	18.54	18.57	18.60	18.63	18.66	18.69	18.72	18.76	18.79	18.82
6.0	18.85	18.88	18.91	18.94	18.98	19.01	19.04	19.07	19.10	19.13
.1	19.16	19.20	19.23	19.26	19.29	19.32	19.35	19.38	19.42	19.45
.2	19.48	19.51	19.54	19.57	19.60	19.63	19.67	19.70	19.73	19.76
.3	19.79	19.82	19.85	19.89	19.92	19.95	19.98	20.01	20.04	20.07
.4	20.11	20.14	20.17	20.20	20.23	20.26	20.29	20.33	20.36	20.39
6.5	20.42	20.45	20.48	20.51	20.55	20.58	20.61	20.64	20.67	20.70
.6	20.73	20.77	20.80	20.83	20.86	20.89	20.92	20.95	20.99	21.02
.7	21.05	21.08	21.11	21.14	21.17	21.21	21.24	21.27	21.30	21.33
.8	21.36	21.39	21.43	21.46	21.49	21.52	21.55	21.58	21.61	21.65
.9	21.68	21.71	21.74	21.77	21.80	21.83	21.87	21.90	21.93	21.96
7.0	21.99	22.02	22.05	22.09	22.12	22.15	22.18	22.21	22.24	22.27
.1	22.31	22.34	22.37	22.40	22.43	22.46	22.49	22.53	22.56	22.59
.2	22.62	22.65	22.68	22.71	22.75	22.78	22.81	22.84	22.87	22.90
.3	22.93	22.97	23.00	23.03	23.06	23.09	23.12	23.15	23.18	23.22
.4	23.25	23.28	23.31	23.34	23.37	23.40	23.44	23.47	23.50	23.53
7.5	23.56	23.59	23.62	23.66	23.69	23.72	23.75	23.78	23.81	23.84
.6	23.88	23.91	23.94	23.97	24.00	24.03	24.06	24.10	24.13	24.16
.7	24.19	24.22	24.25	24.28	24.32	24.35	24.38	24.41	24.44	24.47
.8	24.50	24.54	24.57	24.60	24.63	24.66	24.69	24.72	24.76	24.79
.9	24.82	24.85	24.88	24.91	24.94	24.98	25.01	25.04	25.07	25.10
8.0	25.13	25.16	25.20	25.23	25.26	25.29	25.32	25.35	25.38	25.42
.1	25.45	25.48	25.51	25.54	25.57	25.60	25.64	25.67	25.70	25.73
.2	25.76	25.79	25.82	25.86	25.89	25.92	25.95	25.98	26.01	26.04
.3	26.08	26.11	26.14	26.17	26.20	26.23	26.26	26.30	26.33	26.36
.4	26.39	26.42	26.45	26.48	26.52	26.55	26.58	26.61	26.64	26.67
8.5	26.70	26.73	26.77	26.80	26.83	26.86	26.89	26.92	26.95	26.99
.6	27.02	27.05	27.08	27.11	27.14	27.17	27.21	27.24	27.27	27.30
.7	27.33	27.36	27.39	27.43	27.46	27.49	27.52	27.55	27.58	27.61
.8	27.65	27.68	27.71	27.74	27.77	27.80	27.83	27.87	27.90	27.93
.9	27.96	27.99	28.02	28.05	28.09	28.12	28.15	28.18	28.21	28.24
9.0	28.27	28.31	28.34	28.37	28.40	28.43	28.46	28.49	28.53	28.56
.1	28.59	28.62	28.65	28.68	28.71	28.75	28.78	28.81	28.84	28.87
.2	28.90	28.93	28.97	29.00	29.03	29.06	29.09	29.12	29.15	29.19
.3	29.22	29.25	29.28	29.31	29.34	29.37	29.41	29.44	29.47	29.50
.4	29.53	29.56	29.59	29.63	29.66	29.69	29.72	29.75	29.78	29.81
9.5	29.85	29.88	29.91	29.94	29.97	30.00	30.03	30.07	30.10	30.13
.6	30.16	30.19	30.22	30.25	30.28	30.32	30.35	30.38	30.41	30.44
.7	30.47	30.50	30.54	30.57	30.60	30.63	30.66	30.69	30.72	30.76
.8	30.79	30.82	30.85	30.88	30.91	30.94	30.98	31.01	31.04	31.07
.9	31.10	31.13	31.16	31.20	31.23	31.26	31.29	31.32	31.35	31.38

Table 6-6. Loss of Head H_2 Due to Sudden Enlargement in Pipes

d_2/d_1 = ratio of diameter of larger pipe to diameter of smaller pipe

V_1 = velocity in smaller pipe

$\frac{d_2}{d_1}$	Velocity, V_1, in feet per second												
	2	3	4	5	6	7	8	10	12	15	20	30	40
1.2	.01	.01	.02	.04	.06	.07	.10	.14	.21	.32	.55	1.20	2.08
1.4	.02	.04	.06	.10	.14	.18	.23	.36	.51	.78	1.36	2.96	5.14
1.6	.02	.05	.09	.14	.20	.28	.36	.55	.78	1.19	2.07	4.50	7.82
1.8	.03	.07	.12	.18	.26	.35	.45	.70	.99	1.52	2.64	5.74	9.97
2.0	.04	.08	.14	.22	.31	.41	.53	.81	1.16	1.77	3.08	6.71	11.65
2.5	.05	.10	.17	.27	.38	.51	.66	1.01	1.44	2.20	3.83	8.34	14.48
3.0	.05	.11	.19	.30	.42	.57	.74	1.13	1.60	2.46	4.27	9.29	16.14
4.0	.06	.12	.22	.33	.47	.63	.82	1.25	1.78	2.76	4.73	10.30	17.90
5.0	.06	.13	.23	.35	.49	.66	.85	1.31	1.86	2.85	4.95	10.79	18.73
10.0	.06	.14	.24	.37	.52	.70	.91	1.39	1.97	2.96	5.25	11.44	19.87
∞	.06	.14	.24	.37	.53	.71	.92	1.42	2.01	3.09	5.36	11.66	20.26

Table 6-7. Values of K_2 for Determining Loss of Head Due to Sudden Enlargement in Pipes, from the Formula

$$H_2 = K_2(V_1^2/2g)$$

d_2/d_1 = ratio of larger pipe to smaller pipe V_1 = velocity in smaller pipe

$\frac{d_2}{d_1}$	Velocity, V_1, in feet per second												
	2	3	4	5	6	7	8	10	12	15	20	30	40
1.2	.11	.10	.10	.10	.10	.10	.10	.09	.09	.09	.09	.09	.08
1.4	.26	.26	.25	.24	.24	.24	.24	.23	.23	.22	.22	.21	.20
1.6	.40	.39	.38	.37	.37	.36	.36	.35	.35	.34	.33	.32	.32
1.8	.51	.49	.48	.47	.47	.46	.46	.45	.44	.43	.42	.41	.40
2.0	.60	.58	.56	.55	.55	.54	.53	.52	.52	.51	.50	.48	.47
2.5	.74	.72	.70	.69	.68	.67	.66	.65	.64	.63	.62	.60	.58
3.0	.83	.80	.78	.77	.76	.75	.74	.73	.72	.70	.69	.67	.65
4.0	.92	.89	.87	.85	.84	.83	.82	.80	.79	.78	.76	.74	.72
5.0	.96	.93	.91	.89	.88	.87	.86	.84	.83	.82	.80	.77	.75
10.0	1.00	.99	.96	.95	.93	.92	.91	.89	.88	.86	.84	.82	.80
∞	1.00	1.00	.98	.96	.95	.94	.93	.91	.90	.88	.86	.83	.81

Table 6-8. Values of K_2 for Determining Loss of Head Due to Gradual Enlargements in Pipes, from the Formula $H_2 = K_2(V_1^2/2g)$

d_2/d_1 = ratio of diameter of larger pipe to diameter of smaller pipe. Angle of cone is twice the angle between the axis of the cone and its side.

$\frac{d_2}{d_1}$	Angle of cone													
	2°	4°	6°	8°	10°	15°	20°	25°	30°	35°	40°	45°	50°	60°
1.1	.01	.01	.01	.02	.03	.05	.10	.13	.16	.18	.19	.20	.21	.23
1.2	.02	.02	.02	.03	.04	.09	.16	.21	.25	.29	.31	.33	.35	.37
1.4	.02	.03	.03	.04	.06	.12	.23	.30	.36	.41	.44	.47	.50	.53
1.6	.03	.03	.04	.05	.07	.14	.26	.35	.42	.47	.51	.54	.57	.61
1.8	.03	.04	.04	.05	.07	.15	.28	.37	.44	.50	.54	.58	.61	.65
2.0	.03	.04	.04	.05	.07	.16	.29	.38	.46	.52	.56	.60	.63	.68
2.5	.03	.04	.04	.05	.08	.16	.30	.39	.48	.54	.58	.62	.65	.70
3.0	.03	.04	.04	.05	.08	.16	.31	.40	.48	.55	.59	.63	.66	.71
∞	.03	.04	.05	.06	.08	.16	.31	.40	.49	.56	.60	.64	.67	.72

Table 6-9. Loss of Head H_2 Due to Sudden Contraction

d_2/d_1 = ratio of larger to smaller diameter V_2 = velocity in smaller pipe

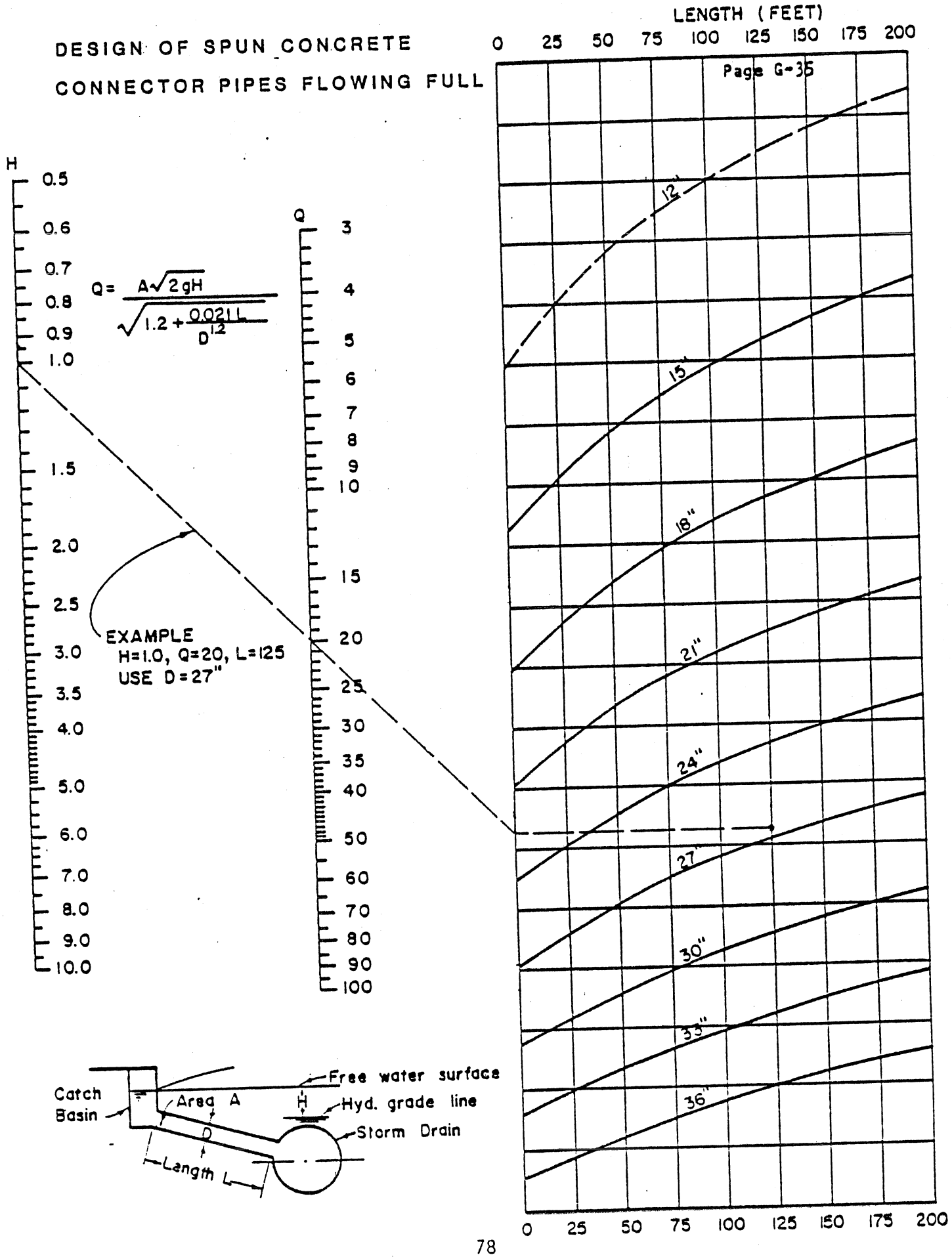
$\frac{d_2}{d_1}$	Velocity, V_2, in feet per second												
	2	3	4	5	6	7	8	10	12	15	20	30	40
1.1	.00	.00	.01	.01	.02	.03	.04	.06	.09	.15	.20	.75	1.49
1.2	.00	.01	.02	.03	.04	.06	.07	.12	.18	.28	.54	1.38	2.74
1.4	.01	.02	.04	.07	.10	.13	.17	.27	.40	.65	1.14	2.68	4.98
1.6	.02	.04	.06	.10	.14	.20	.26	.40	.67	.89	1.56	3.44	5.97
1.8	.02	.05	.08	.13	.19	.25	.33	.51	.73	1.12	1.92	4.05	6.72
2.0	.02	.05	.09	.14	.21	.28	.36	.55	.79	1.19	2.06	4.28	7.09
2.2	.02	.06	.10	.15	.22	.30	.38	.59	.84	1.28	2.20	4.56	7.41
2.5	.03	.06	.10	.16	.23	.31	.40	.62	.88	1.34	2.30	4.76	7.71
3.0	.03	.06	.11	.17	.24	.32	.42	.65	.92	1.40	2.41	4.98	8.11
4.0	.03	.06	.12	.18	.25	.34	.44	.69	.97	1.48	2.53	5.24	8.48
5.0	.03	.07	.12	.18	.26	.35	.46	.70	1.00	1.52	2.60	5.36	8.67
10.0	.03	.07	.12	.19	.27	.36	.47	.72	1.02	1.56	2.68	5.56	9.06
∞	.03	.07	.12	.19	.27	.36	.47	.72	1.03	1.58	2.71	5.68	9.36

Table 6-10. Values of K_3 for Determining Loss of Head Due to Sudden Contraction, from the Formula $H_3 = K_3(V_2^2/2g)$

d_2/d_1 = ratio of larger to smaller diameter V_2 = velocity in smaller pipe

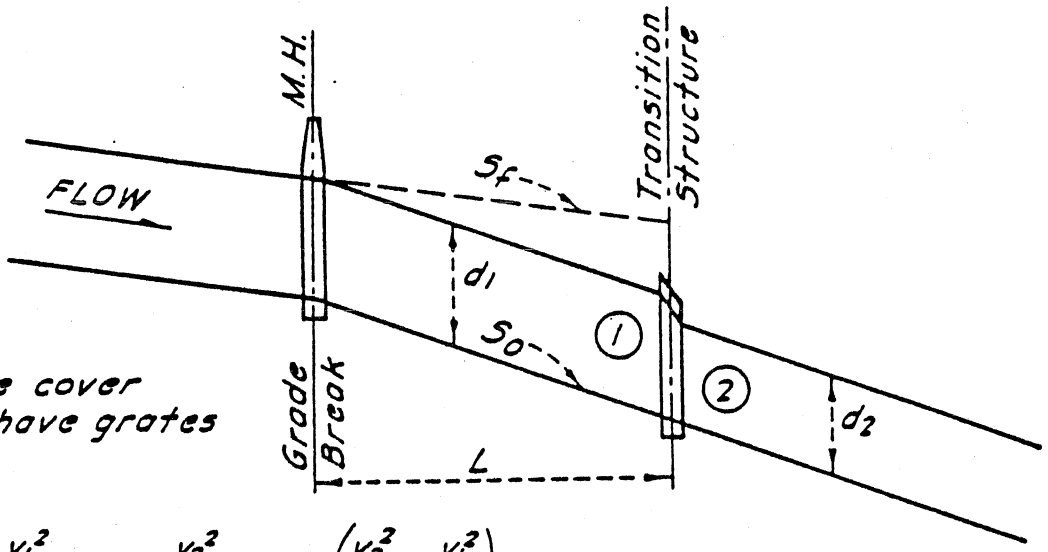
$\frac{d_2}{d_1}$	Velocity, V_2, in feet per second												
	2	3	4	5	6	7	8	10	12	15	20	30	40
1.1	.03	.04	.04	.04	.04	.04	.04	.04	.04	.04	.05	.05	.06
1.2	.07	.07	.07	.07	.07	.07	.07	.08	.08	.08	.09	.10	.11
1.4	.17	.17	.17	.17	.17	.17	.17	.18	.18	.18	.18	.19	.20
1.6	.26	.26	.26	.26	.26	.26	.26	.26	.26	.25	.25	.25	.24
1.8	.34	.34	.34	.34	.34	.34	.33	.33	.32	.32	.31	.29	.27
2.0	.38	.38	.37	.37	.37	.37	.36	.36	.35	.34	.33	.31	.29
2.2	.40	.40	.40	.39	.39	.39	.39	.38	.37	.37	.35	.33	.30
2.5	.42	.42	.42	.41	.41	.41	.40	.40	.39	.38	.37	.34	.31
3.0	.44	.44	.44	.43	.43	.43	.42	.42	.41	.40	.39	.36	.33
4.0	.47	.46	.46	.46	.45	.45	.45	.44	.43	.42	.41	.37	.34
5.0	.48	.48	.47	.47	.47	.46	.46	.45	.45	.44	.42	.38	.35
10.0	.49	.48	.48	.48	.48	.47	.47	.46	.46	.45	.43	.40	.36
∞	.49	.49	.48	.48	.48	.47	.47	.47	.46	.45	.44	.41	.38

DESIGN OF SPUN CONCRETE CONNECTOR PIPES FLOWING FULL



LOCATION OF TRANSITION

Large to Small Conduit



NOTE:
Manhole cover should have grates

$$s_o L + d_1 + \frac{v_1^2}{2g} = d_2 + \frac{v_2^2}{2g} + 0.1\left(\frac{v_2^2}{2g} - \frac{v_1^2}{2g}\right) + s_f L + hm, \text{ and}$$

$$s_o L - s_f L = d_2 - d_1 + 1.1\left(\frac{v_2^2}{2g} - \frac{v_1^2}{2g}\right) + hm \ldots\ldots \text{therefore:}$$

$$L = \frac{d_2 - d_1 + 1.1\left(\frac{v_2^2}{2g} - \frac{v_1^2}{2g}\right) + hm}{s_o - s_f}$$

where s_o = slope of conduit

s_f = friction slope of larger conduit

d_1 = diameter or depth of larger conduit

v_1 = velocity in larger conduit flowing full

d_2 = diameter or depth of smaller conduit

V_2 = velocity in smaller conduit flowing full

h_m = other losses occuring between the transition and the grade break such as bend and confluence losses

EXAMPLE PROBLEM

$Q = 400$ cfs

$d_1 = 84" = 7'$ $\quad d_2 = 78" = 6.5'$

$A_1 = 38.49$ sq. ft. $\quad A_2 = 33.18$ sq. ft.

$v_1 = 10.4$ fps $\quad v_2 = 12.0$ fps

$\frac{v_1^2}{2g} = 1.68'$ $\quad \frac{v_2^2}{2g} = 2.24'$

$S_o = .00474$

$S_f = .00395$

$$L = \frac{6.5 - 7.0 + 1.1(2.24 - 1.68)}{.00474 - .00395} \approx 147$$

C. M. EASTERLING
& ASSOCIATES
ALBUQUERQUE, N.M.

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: Fe-a
DATE: 7-18-86
SHEET: 1 OF 4

PROJECT: GOLF COURSE ROAD LINE:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
STATION	STRUCT.	INV.	D	Q	A	V	K	S_F	L	Δ	LOSSES							E.G.	h_v	H.G.
											H_F	H_B	H_J	H_{MH}	H_T	$H_{MISC.}$	ΣH_L			
			42"	151.7	9.621	15.77	1006	0.0227										85.17	3.86	81.31 *
9+53	42x42 WYE	77.81	— CONTROL —										0.87				0.87	86.04		
9+60	36x42 EXP	~~78.08~~ 78.56	— CONTROL —												0.47		0.47	87.81	6.23	81.58*
			36"	141.6	7.069	20.03	666	0.0452	23		1.04						1.04	88.85	6.23	82.62
9+83	36x18 WYE	79.45											0.26				0.26	89.11	5.95	83.16
			36"	138.4	7.069	19.58	666	0.0432	190		8.21						8.21	97.32	5.95	91.37
11+73	36x24 WYE	86.67											0.94				0.94	98.26	4.83	93.43
			36"	124.7	7.069	17.64	666	0.0351	115		4.04						4.04	02.30	4.83	97.47
12+88	36x18 WYE	91.04											0.28				0.28	02.58	4.53	98.05
			36"	120.7	7.069	17.07	666	0.0328	12'		0.39						0.39	02.97	4.53	98.44
13+00	UPI	91.50															—			
			36"	120.7	7.069	17.07	666	0.0328	350'		11.48	PART FULL					11.48	14.45		
16+50	UPI	16.00																		
			36"	120.7	7.069	17.07	666	0.0328	100'		3.28	PART FULL						26.53	4.53	22.00
17+50	42x36 RED	19.00	— CONTROL —												0.32		0.32	26.85	2.44	24.41
			42"	120.7	9.621	12.55	1006	0.0144	18'		0.26						0.26	27.11	2.44	24.67
17+68	42x18 WYE	21.04											0.16				0.16	27.27	2.28	24.99
			42"	116.5	9.621	12.11	1006	0.0134	80'		1.07						1.07	28.34	2.28	26.06
18+48	42x18 WYE	21.94											C 13				0.13	28.47	2.13	26.34
			42"	112.6	9.621	11.70	1006	0.0125	52'		0.65	PART FULL (0.01)						29.13	2.13	27.00
19+00	UPI	23.50															—			
			42"	112.6	9.621	11.70	1006	0.0125	562		7.03						7.03	36.16	2.13	34.03
24+62	42x18 WYE	30.24											0.04				0.04	36.20	2.08	34.12
			42"	111.3	9.621	11.57	1006	0.0122	26		0.32						0.32	36.52	2.08	34.44

REMARKS: * = CONTROL; HGL = INV. + D

C. M. EASTERLING
& ASSOCIATES
ALBUQUERQUE, N.M.

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: JC-a
DATE: 7-21-86
PROJECT: GOLF COURSE ROAD
LINE:
SHEET: 2 OF 4

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
STATION	STRUCT.	INV.	D	Q	A	V	K	S_F	L	Δ	LOSSES							E.G.	h_v	H.G.
											H_F	H_B	H_J	H_{MH}	H_T	$H_{MISC.}$	ΣH_L			
24+88	42"X18 WYE	30.56																36.52	2.08	34.44
													0.10				0.10	36.62	1.97	34.65
			42"	108.3	9.621	11.26	1006	0.0116	400'		4.64						4.64	41.26	1.97	39.29
28+88	42X18 WYE	35.36																41.36	1.85	39.51
													0.10				0.10	43.20	1.85	41.35
			42"	105.1	9.621	10.92	1006	0.0109	169		1.84						1.84	43.28	1.77	41.51
30+57	42X18 WYE	37.38																45.68	1.77	43.91
													0.08				0.08	45.77	1.65	44.12
			42"	102.7	9.621	10.67	1006	0.0104	231		2.40						2.40	45.84	1.65	44.19
32+88	42X18 WYE	40.16																46.80	3.06	43.74*
													0.09				0.09	54.84	3.06	51.78
			42"	99.3	9.621	10.32	1006	0.097	7'		0.07						0.07	55.00	2.90	52.10
32+95	36X42 EXP	40.24/40.74	-CONTROL-								-PART FULL				0.23		0.23	55.17	2.90	52.27
			36"	99.3	7.069	14.05	666	0.0222	362'		8.04						8.04	55.46	2.57	52.89
36+57	36X18 WYE	46.53											0.16				0.16	55.59	2.57	53.02
			36"	96.6	7.069	13.67	666	0.0210	8'		0.17						0.17	55.74	3.64	52.10
36+65	36X21 WYE	46.66											0.29				0.29	56.42	3.64	52.78
			36"	91.0	7.069	12.87	666	0.0187	7'		0.13						0.13	56.65	3.39	53.26
36+72	33X36 EXP	46.77/47.02													0.15		0.15	71.12	3.39	67.73
			33"	91.0	5.940	15.32	529.6	0.0295	23'		0.68						0.68	71.54	3.12	68.42
36+95	33X18 WYE	47.66											0.23				0.23	71.74	3.12	68.62
			33"	87.8	5.940	14.78	529.6	0.0275	526'		14.47						14.47	72.02	2.81	69+21
42+21	33X18 WYE	62.39											0.25	0.17			0.42	73.09	2.81	70.28
			33"	84.2	5.940	14.18	529.6	0.0253	8		0.20						0.20	73.32	2.56	70.76
42+29	33X18 WYE	62.61											0.28				0.28	73.82	2.56	71.26
			33"	79.9	5.940	13.45	529.6	0.0228	47		1.07						1.07			
42+76	33X18 WYE	63.93											0.23				0.23			
			33"	76.2	5.940	12.83	529.6	0.0207	24		0.50						0.50			

REMARKS: * = CONTROL; HGL = INV. + D

C. M. EASTERLING
& ASSOCIATES
ALBUQUERQUE, N.M.

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: TE-G
DATE: 7-21-86
SHEET: 3 OF 4

PROJECT: GOLF COURSE ROAD LINE:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
STATION	STRUCT.	INV.	D	Q	A	V	K	S_F	L	Δ	LOSSES							E.G.	h_V	H.G.
											H_F	H_B	H_J	H_{MH}	H_T	$H_{MISC.}$	ΣH_L			
43+00	VPI	64.60															—	73.82	2.56	71.26
			33"	76.2	5.940	12.83	529.6	0.0207	583'		12.07	—	PART FULL							
48+83	33x18 WYE	93.75	— CONTROL —															99.06	2.56	96.50*
													0.19	0.13			0.32	99.38	2.33	97.05
			33"	72.8	5.940	12.26	529.6	0.0189	67		1.27	—	PART FULL							
49+50	VPI	97.10	— CONTROL —														—	02.18	2.33	99.85*
			33"	72.8	5.940	12.26	529.6	0.0189	391		7.39						7.39			
53+41	33x18 WYE	01.79											0.17				0.17	09.57	2.33	07.24
			33"	69.8	5.940	11.75	529.6	0.0174	40		0.70						0.70	09.74	2.14	07.60
53+81	33x18 WYE	02.27																10.44	2.14	08.30
													0.11	0.11			0.22	10.66	2.03	08.63
			33"	67.9	5.940	11.43	529.6	0.0164	19		0.31						0.31			
54+00	VPI	02.50																10.97	2.03	08.94
			33"	67.9	5.940	11.43	529.6	0.0164	341		5.59	—	PART FULL							
57+41	33x18 WYE	14.78	— CONTROL —															19.56	2.03	17.53*
													0.18	0.11			0.29	19.85	1.82	18.03
			33"	64.3	5.940	10.82	529.6	0.0147	109		1.60	—	PART FULL							
58+50	VPI	18.70	— CONTROL —														—			
			33"	64.3	5.940	10.82	529.6	0.0147	283		4.16						4.16	23.27	1.82	21.45*
61+33	33x18 WYE	22.66											0.11	0.10			0.21	27.43	1.82	25.61
			33"	62.1	5.940	10.45	529.6	0.0137	8		0.11						0.11	27.64	1.70	25.94
61+41	33x18 WYE	22.77											0.15				0.15	27.75	1.70	26.05
			33"	58.9	5.940	9.92	529.6	0.0124	9		0.11						0.11	27.90	1.53	26.37
61+50	VPI	22.90																28.01	1.53	26.48
			33"	58.9	5.940	9.92	529.6	0.0124	352		4.36						4.36			
65+02	33x18 WYE	26.42											0.15	0.09			0.24	32.37	1.53	30.84
			33"	55.4	5.940	9.33	529.6	0.0109	308		3.36						3.36	32.61	1.35	31.26
																		35.97	1.35	34.62

REMARKS: * = CONTROL; HGL = INV.+D

C. M. EASTERLING
& ASSOCIATES
ALBUQUERQUE, N.M.

SUMMARY OF HYDRAULIC CALCULATIONS

CLOSED CONDUIT

BY: TC-9
DATE: 7-22-86
SHEET: 4 OF 4

PROJECT: GOLF COURSE ROAD
LINE:

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
											LOSSES									
STATION	STRUCT.	INV.	D	Q	A	V	K	S_F	L	Δ	H_F	H_B	H_J	H_{MH}	H_T	$H_{MISC.}$	ΣH_L	E.G.	h_v	H.G.
68+10	JCT MH EXP	29.50/29.80											-0.06	0.08	0.08		0.10	35.97	1.35	34.62
			30"	50.5	4.909	10.29	410.1	0.0152	51		0.78						0.78	36.07	1.64	34.43
68+61	30X18 WYE	30.82											0.19				0.19	36.85	1.64	35.21
			30"	47.1	4.909	9.59	410.1	0.0132	473		6.24	- PART FULL					6.24	37.04	1.43	35.61
73+34	30X18 WYE	40.28	- CONTROL -										0.16				0.16	44.21	1.43	42.78*
			30"	43.9	4.909	8.94	410.1	0.0115	47		0.54	- PART FULL					0.54	44.37	1.24	43.13
73+81	JCT. MH EXP	41.22/41.53	- CONTROL -										0.09	0.09	0.09		0.27	44.91	1.24	43.67
			27"	42.6	3.976	10.71	309.6	0.0189	332		6.27						6.27	45.56	1.78	43.78*
77+13	27X18 WYE	46.18											0.22				0.22	51.83	1.78	50.05
			27"	39.5	3.976	9.93	309.6	0.0163	233		3.80						3.80	52.05	1.53	50.52
79+46	JCT MH 27X18	49.38/49.54											0.13	0.08			0.21	55.85	1.53	54.32
			27"	37.7	3.976	9.48	309.6	0.0148	167		2.47						2.47	56.06	1.40	54.66
81+13	27X18 WYE	51.88											0.18				0.18	58.53	1.40	57.13
			27"	34.8	3.976	8.75	309.6	0.0125	360		4.50						4.50	58.71	1.19	57.52
84+73	27X18 WYE	56.92											0.15				0.15	63.21	1.19	62.02
			27"	32.1	3.976	8.07	309.6	0.0107	28		0.30						0.30	63.36	1.01	62.35
85+01	JCT MH 27X18	57.31/57.41											0.13	0.05			0.18	63.36	1.01	62.65
			27"	29.6	3.976	7.44	309.6	0.0091	164		1.49						1.49	63.54	0.86	62.68
86+65	27X18 WYE	59.72											0.19				0.19	65.03	0.86	64.17
			27"	24.5	3.976	6.16	309.6	0.0063	45		0.28						0.28	65.22	0.59	64.63
87+10	JCT MH 27X24	60.34/60.64											0.21	0.03	0.04		0.28	65.50	0.59	64.91
			24"	10.5	3.142	3.34	226.2	0.0022	55		0.12						0.12	65.78	0.17	65.61
87+65	24X18 WYE	61.41											0.07				0.07	65.90	0.17	65.73
			24"	7.4	3.142	2.36	226.2	0.0011	277		0.30	PART FULL					0.30	65.97	0.17	65.80
																		66.27	0.09	66.18

REMARKS: * = CONTROL ; HGL = INV + D

GOLF COURSE ROAD STORMDRAIN

HYDRAULIC GRADE LINE CALCULATIONS

STORMDRAIN IS NOT DESIGNED YET SOUTH OF THE COUNTY LINE SINCE THE ALIGNMENT, ETC. HAS NOT BEEN SETTLED WITH THE CITY OF ALBUQUERQUE.

BEGIN @ FIRST JUNCTION FROM RIO RANCHO INLET.

$n = 0.013$; $D = 42"$, $S = 3.80\%$, $K = 1{,}006$, $S_f = 2.27\%$

$Q = 196.1$ cfs , $q = 151.7$ cfs , $q/Q = 0.77$ (PART FULL)

42"X24" WYE, STA 9+53
36"X42" EXPANDER, STA 9+60

$Q = 141.6$ cfs	$Q_2 = 151.7$ cfs	$Q_3 = 10.1$ cfs
$D_1 = 3.00'$	$D_2 = 3.50'$	$D_3 = 2.00'$
$S_1 = 0.0380$ ft/ft	$S_2 = 0.0380$ ft/ft	$S_3 =$
$A_1 = 7.069$ ft^2	$A_2 = 9.621$ ft^2	$A_3 = 3.142$ ft^2
$V_1 = 20.03$ fps	$V_2 = 15.77$ fps	$V_3 = 3.21$ fps
$S_{f_1} = 0.0452$ ft/ft	$S_{f_2} = 0.0227$ ft/ft	$\theta = 45°$
$h_{v_1} = 6.23'$	$h_{v_2} = 3.86'$	

$$\Delta y = \frac{151.7 \times 15.77 - 141.6 \times 20.03 - 10.1 \times 3.21 \cos 45}{\frac{1}{2}(9.621 + 7.069)\,32.2} + \left(\frac{0.0452 + 0.0227}{2}\right) 7$$

$$= -1.74 + 0.24 = \underline{-1.50'}$$

$$h_J = -1.50 + 6.23 - 3.86 = \underline{0.87'}$$

$$h_t = 0.075 \times 6.23 = \underline{0.47'}$$

36"X18" WYE, STA. 9+83

$Q_1 = 138.4$	$Q_2 = 141.6$	$Q_3 = 3.2$
$D_1 = 3.00$	$D_2 = 3.00$	$D_3 = 1.50$
$S_1 = 0.0380$	$S_2 = 0.0380$	$S_3 =$
$A_1 = 7.069$	$A_2 = 7.069$	$A_3 = 1.767$
$V_1 = 19.58$	$V_2 = 20.03$	$V_3 = 1.81$
$S_{f1} = 0.0432$	$S_{f2} = 0.0452$	$\Theta = 45°$
$h_{v1} = 5.95$	$h_{v2} = 6.23$	

$$\Delta y = \frac{141.6 \times 20.03 - 138.4 \times 19.58 - 3.2 \times 1.81 \cos 45°}{\frac{1}{2}(7.069 + 7.069)\, 32.2} = 0.54'$$

$$h_J = 0.54 + 5.95 - 6.23 = \underline{0.26'}$$

36"X24" WYE, STA 11+73

$Q_1 = 124.7$	$Q_2 = 138.4$	$Q_3 = 13.7$
$D_1 = 3.00$	$D_2 = 3.00$	$D_3 = 2.00$
$S_1 = 0.0380$	$S_2 = 0.0380$	$S_3 =$
$A_1 = 7.069$	$A_2 = 7.069$	$A_3 = 3.142$
$V_1 = 17.64$	$V_2 = 19.58$	$V_3 = 4.36$
$S_{f1} = 0.0351$	$S_{f2} = 0.0432$	$\Theta = 45°$
$h_{v1} = 4.83$	$h_{v2} = 5.95$	

$$\Delta y = \frac{138.4 \times 19.58 - 124.7 \times 17.64 - 13.7 \times 4.36 \cos 45°}{\frac{1}{2}(7.069 + 7.069)\, 32.2} = 2.06'$$

$$h_J = 2.06 + 4.83 - 5.95 = \underline{0.94'}$$

36"X18" WYE, STA 12+88

$Q_1 = 120.7$	$Q_2 = 124.7$	$Q_3 = 4.0$
$D_1 = 3.00$	$D_2 = 3.00$	$D_3 = 1.50$
$S_1 = 0.0380$	$S_2 = 0.0380$	$S_3 =$
$A_1 = 7.069$	$A_2 = 7.069$	$A_3 = 1.767$
$V_1 = 17.07$	$V_2 = 17.64$	$V_3 = 2.26$
$S_{f1} = 0.0328$	$S_{f2} = 0.0351$	$\Theta = 45°$
$h_{v1} = 4.53$	$h_{v2} = 4.83$	

$$\Delta y = \frac{124.7 \times 17.64 - 120.7 \times 17.07 - 4.0 \times 2.26 \cos 45°}{\frac{1}{2}(7.069 + 7.069)\, 32.2} = 0.58'$$

$$h_J = 0.58 + 4.53 - 4.83 = \underline{0.28'}$$

42" X 36" REDUCER, STA 17+50

$h_L = 0.07 \times 4.53 = \underline{0.32'}$

42"X21" WYE, STA 17+68

$Q_1 = 116.5$	$Q_2 = 120.7$	$Q_3 = 4.2$
$D_1 = 3.50'$	$D_2 = 3.50$	$D_3 = 1.75$
$S_1 = 0.0600$	$S_2 = 0.0600$	$S_3 =$
$A_1 = 9.621$	$A_2 = 9.621$	$A_3 = 2.405$
$V_1 = 12.11$	$V_2 = 12.55$	$V_3 = 1.75$
$S_{f1} = 0.0134$	$S_{f2} = 0.0144$	$\theta = 45°$
$h_{v1} = 2.28$	$h_{v2} = 2.44$	

$$\Delta y = \frac{120.7 \times 12.55 - 116.5 \times 12.11 - 4.2 \times 1.75 \cos 45°}{\frac{1}{2}(9.621+9.621)32.2} = 0.32'$$

$h_J = 0.32 + 2.28 - 2.44 = \underline{0.16'}$

42"X18" WYE, STA. 18+48

$Q_1 = 112.6$	$Q_2 = 116.5$	$Q_3 = 3.9$
$D_1 = 3.50$	$D_2 = 3.50$	$D_3 = 1.50$
$S_1 = 0.0130$	$S_2 = 0.0130$	S_3
$A_1 = 9.621$	$A_2 = 9.621$	$A_3 = 1.767$
$V_1 = 11.70$	$V_2 = 12.11$	$V_3 = 2.21$
$S_{f1} = 0.0125$	$S_{f2} = 0.0134$	$\theta = 45°$
$h_{v1} = 2.13$	$h_{v2} = 2.28$	

$$\Delta y = \frac{116.5 \times 12.11 - 112.6 \times 11.70 - 3.9 \times 2.21 \cos 45}{\frac{1}{2}(9.621+9.621)32.2} = 0.28'$$

$h_J = 0.28 + 2.13 - 2.28 = \underline{0.13'}$

42"X18" WYE, STA. 24+62

$Q_1 = 111.3$	$Q_2 = 112.6$	$Q_3 = 1.3$
$D_1 = 3.50$	$D_2 = 3.50$	$D_3 = 1.50$
$S_1 = 0.0130$	$S_2 = 0.0130$	$S_3 =$
$A_1 = 9.621$	$A_2 = 9.621$	$A_3 = 1.767$
$V_1 = 11.57$	$V_2 = 11.70$	$V_3 = 0.7$
$S_{f1} = 0.0122$	$S_{f2} = 0.01225$	$\theta = 45^\circ$
$h_{v1} = 2.08$	$h_{v2} = 2.13$	

$$\Delta y = \frac{112.6 \times 11.70 - 111.3 \times 11.57 - 1.3 \times 0.7 \cos 45^\circ}{\frac{1}{2}(9.621 + 9.621)\,32.2} = 0.09'$$

$$h_J = 0.09 + 2.08 - 2.13 = 0.04'$$

42"X18" WYE, STA. 24+88

$Q_1 = 108.3$	$Q_2 = 111.3$	$Q_3 = 3.0$
$D_1 = 3.50$	$D_2 = 3.50$	$D_3 = 1.50$
$S_1 = 0.0130$	$S_2 = 0.0130$	$S_3 =$
$A_1 = 9.621$	$A_2 = 9.621$	$A_3 = 1.767$
$V_1 = 11.26$	$V_2 = 11.57$	$V_3 = 1.7$
$S_{f1} = 0.0116$	$S_{f2} = 0.0122$	$\theta = 45^\circ$
$h_{v1} = 1.97$	$h_{v2} = 2.08$	

$$\Delta y = \frac{111.3 \times 11.57 - 108.3 \times 11.26 - 3.0 \times 1.7 \cos 45^\circ}{\frac{1}{2}(9.621 + 9.621)\,32.2} = 0.21'$$

$$h_J = 0.21 + 1.97 - 2.08 = 0.10'$$

42"x18" WYE, STA. 28+88

$Q_1 = 105.1$ $Q_2 = 108.3$ $Q_3 = 3.2$

$D_1 = 3.50$ $D_2 = 3.50$ $D_3 = 1.50$

$S_1 = 0.0120$ $S_2 = 0.0120$ $S_3 =$

$A_1 = 9.621$ $A_2 = 9.621$ $A_3 = 1.767$

$V_1 = 10.92$ $V_2 = 11.26$ $V_3 = 1.81$

$S_{f1} = 0.0109$ $S_{f2} = 0.0116$ $\theta = 45°$

$h_{v1} = 1.85$ $h_{v2} = 1.97$

$$\Delta y = \frac{108.3 \times 11.26 - 105.1 \times 10.92 - 3.2 \times 1.81 \cos 45°}{\frac{1}{2}(9.621 + 9.621)32.2} = 0.22'$$

$h_j = 0.22 + 1.85 - 1.97 = \underline{0.10'}$

42"x18" WYE, STA. 30+57

$Q_1 = 102.7$ $Q_2 = 105.1$ $Q_3 = 2.4$

$D_1 = 3.50$ $D_2 = 3.50$ $D_3 = 1.50$

$S_1 = 0.0120$ $S_2 = 0.0120$ $S_3 =$

$A_1 = 9.621$ $A_2 = 9.621$ $A_3 = 1.767$

$V_1 = 10.67$ $V_2 = 10.92$ $V_3 = 1.4$

$S_{f1} = 0.0104$ $S_{f2} = 0.0109$ $\theta = 45°$

$h_{v1} = 1.77$ $h_{v2} = 1.85$

$$\Delta y = \frac{105.1 \times 10.92 - 102.7 \times 10.67 - 2.4 \times 1.4 \cos 45°}{\frac{1}{2}(9.621 + 9.621)32.2} = 0.16'$$

$h_j = 0.16 + 1.77 - 1.85 = 0.08'$

42"x18" WYE, STA 32+88

$Q_1 = 99.3$ $Q_2 = 102.7$ $Q_3 = 3.4$

$D_1 = 3.50$ $D_2 = 3.50$ $D_3 = 1.50$

$S_1 = 0.0120$ $S_2 = 0.0120$ $S_3 =$

$A_1 = 9.621$ $A_2 = 9.621$ $A_3 = 1.767$

$V_1 = 10.32$ $V_2 = 10.67$ $V_3 = 1.9$

$S_{f1} = 0.0097$ $S_{f1} = 0.0104$ $\theta = 45°$

$h_{v1} = 1.65$ $h_{v1} = 1.77$

$$\Delta y = \frac{102.7 \times 10.67 - 99.3 \times 10.32 - 3.4 \times 1.9 \cos 45°}{\frac{1}{2}(9.621 + 9.621)32.2} = 0.21'$$

$h_j = 0.21 + 1.65 - 1.77 = 0.09'$

36"X42" EXPANDER, STA 32+95

$h_t = 0.075 \times 3.06 = 0.23'$

36"X18" WYE, STA. 36+57

$Q_1 = 96.6$	$Q_2 = 99.3$	$Q_3 = 2.7$
$D_1 = 3.00$	$D_2 = 3.00$	$D_3 = 1.50$
$S_1 = 0.0160$	$S_2 = 0.0160$	$S_3 =$
$A_1 = 7.069$	$A_2 = 7.069$	$A_3 = 1.767$
$V_1 = 13.67$	$V_2 = 14.05$	$V_3 = 1.53$
$S_{f_1} = 0.210$	$S_{f_2} = 0.0222$	$\Theta = 45°$
$h_{v_1} = 2.90$	$h_{v_2} = 3.06$	

$$\Delta y = \frac{99.3 \times 14.05 - 96.6 \times 13.67 - 2.7 \times 1.53 \cos 45°}{\frac{1}{2}(7.069 + 7.069)\, 32.2} = 0.32'$$

$h_j = 0.32 + 2.90 - 3.06 = \underline{0.16'}$

36"X21" WYE, STA 36+65

$Q_1 = 91.0$	$Q_2 = 96.6$	$Q_3 = 5.6$
$D_1 = 3.00$	$D_2 = 3.00$	$D_3 = 1.75$
$S_1 = 0.0160$	$S_2 = 0.0160$	$S_3 =$
$A_1 = 7.069$	$A_2 = 7.069$	$A_3 = 2.405$
$V_1 = 12.87$	$V_2 = 13.67$	$V_3 = 2.33$
$S_{f_1} = 0.0187$	$S_{f_2} = 0.210$	$\Theta = 45°$
$h_{v_1} = 2.57$	$h_{v_2} = 2.90$	

$$\Delta y = \frac{96.6 \times 13.67 - 91.0 \times 12.87 - 5.6 \times 2.33 \cos 45°}{\frac{1}{2}(7.069 + 7.069)\, 32.2} = 0.62'$$

$h_j = 0.62 + 2.57 - 2.90 = \underline{0.29'}$

33"X36" EXPANDER, STA. 36+72

$h_t = 0.04 \times 3.64 = \underline{0.15'}$

33"X18" WYE, STA 36+95

$Q_1 = 87.8$	$Q_2 = 91.0$	$Q_3 = 3.2$
$D_1 = 2.75$	$D_2 = 2.75$	$D_3 = 1.50$
$S_1 = 0.0280$	$S_2 = 0.0280$	$S_3 =$
$A_1 = 5.940$	$A_2 = 5.940$	$A_3 = 1.767$
$V_1 = 14.78$	$V_2 = 15.32$	$V_3 = 1.81$
$S_{f1} = 0.0275$	$S_{f2} = 0.0295$	$\Theta = 45^\circ$
$h_{v1} = 3.39$	$h_{v2} = 3.64$	

$$\Delta y = \frac{91.0 \times 15.32 - 87.8 \times 14.78 - 3.2 \times 1.81 \cos 45^\circ}{\frac{1}{2}(5.940 + 5.940)32.2} = 0.48'$$

$h_j = 0.48 + 3.39 - 3.64 = 0.23'$

SDMH, STA 42+15 ; $h_{mh} = 0.05 \times 3.39 = 0.17'$

33"X18" WYE, STA 42+21

$Q_1 = 84.2$	$Q_2 = 87.8$	$Q_3 = 3.6$
$D_1 = 2.75$	$D_2 = 2.75$	$D_3 = 1.50$
$S_1 = 0.0280$	$S_2 = 0.0280$	$S_3 =$
$A_1 = 5.940$	$A_2 = 5.940$	$A_3 = 1.767$
$V_1 = 14.18$	$V_2 = 14.78$	$V_3 = 2.04$
$S_{f1} = 0.0253$	$S_{f2} = 0.0275$	$\Theta = 45^\circ$
$h_{v1} = 3.12$	$h_{v2} = 3.39$	

$$\Delta y = \frac{87.8 \times 14.78 - 84.2 \times 14.18 - 3.6 \times 2.04 \cos 45^\circ}{\frac{1}{2}(5.940 + 5.940)32.2} = 0.52'$$

$h_j = 0.52 + 3.12 - 3.39 = 0.25'$

33"X18" WYE, STA. 42+29

$Q_1 = 79.9$	$Q_2 = 84.2$	$Q_3 = 4.3$
$D_1 = 2.75$	$D_2 = 2.75$	$D_3 = 1.50$
$S_1 = 0.0280$	$S_2 = 0.0280$	$S_3 =$
$A_1 = 5.940$	$A_2 = 5.940$	$A_3 = 1.767$
$V_1 = 13.45$	$V_2 = 14.18$	$V_3 = 2.43$
$S_{f1} = 0.0228$	$S_{f2} = 0.0253$	$\Theta = 45^\circ$
$h_{v1} = 2.81$	$h_{v2} = 3.12$	

$$\Delta y = \frac{84.2 \times 14.18 - 79.9 \times 13.45 - 4.3 \times 2.43 \cos 45^\circ}{\frac{1}{2}(5.940 + 5.940)32.2} = 0.59'$$

$h_j = 0.59 + 2.81 - 3.12 = \underline{0.28'}$

33x18" WYE, STA. 42+76

$Q_1 = 76.2$	$Q_2 = 79.9$	$Q_3 = 3.7$
$D_1 = 2.75$	$D_2 = 2.75$	$D_3 = 1.50$
$S_1 = 0.0280$	$S_2 = 0.0280$	$S_3 =$
$A_1 = 5.940$	$A_2 = 5.940$	$A_3 = 1.767$
$V_1 = 12.83$	$V_2 = 13.45$	$V_3 = 2.09$
$S_{f1} = 0.0207$	$S_{f2} = 0.0253$	$\theta = 45^\circ$
$h_{v1} = 2.56$	$h_{v2} = 2.81$	

$$\Delta y = \frac{79.9 \times 13.45 - 76.2 \times 12.83 - 3.7 \times 2.09 \cos 45}{\frac{1}{2}(5.940 + 5.940)32.2} = 0.48'$$

$h_j = 0.48 + 2.56 - 2.81 = \underline{0.23'}$

SDMH, STA. 48+77 ; $h_{mh} = 0.05 \times 2.56 = 0.13$

33"x18" WYE, STA. 48+83

$Q_1 = 72.80$	$Q_2 = 76.2$	$Q_3 = 3.4$
$D_1 = 2.75$	$D_2 = 2.75$	$D_3 = 1.50$
$S_1 = 0.0500$	$S_2 = 0.0500$	$S_3 =$
$A_1 = 5.940$	$A_2 = 5.940$	$A_3 = 1.767$
$V_1 = 12.26$	$V_2 = 12.83$	$V_3 = 1.92$
$S_{f1} = 0.0189$	$S_{f2} = 0.0207$	$\theta = 45^\circ$
$h_{v1} = 2.33$	$h_{v2} = 2.56$	

$$\Delta y = \frac{76.2 \times 12.83 - 72.80 \times 12.26 - 3.4 \times 1.92 \cos 45^\circ}{\frac{1}{2}(5.940 + 5.940)32.2} = 0.42'$$

$h_j = 0.42' + 2.33 - 2.56 = \underline{0.19'}$,

33"x18" WYE, STA 53+41

$Q_1 = 69.8$	$Q_2 = 72.8$	$Q_3 = 3.0$
$D_1 = 2.75$	$D_2 = 2.75$	$D_3 = 1.50$
$S_1 = 0.0120$	$S_2 = 0.0120$	$S_3 =$
$A_1 = 5.940$	$A_2 = 5.940$	$A_3 = 1.767$
$V_1 = 11.75$	$V_2 = 12.26$	$V_3 = 1.70$
$S_{f1} = 0.0174$	$S_{f2} = 0.0189$	$\theta = 45^\circ$
$h_{v1} = 2.14$	$h_{v2} = 2.33$	

$$\Delta y = \frac{72.8 \times 12.26 - 69.8 \times 11.75 - 3.0 \times 1.70 \cos 45}{\frac{1}{2}(5.940 + 5.940)32.2} = 0.36'$$

$h_j = 0.36' + 2.14 - 2.33 = \underline{0.17'}$

SDMH, STA. 53+75 ; $h_{mh} = 0.05 \times 2.14 = 0.11$

33"X18" WYE, STA 53+81

$Q_1 = 67.9$	$Q_2 = 69.8$	$Q_3 = 1.9$
$D_1 = 2.75$	$D_2 = 2.75$	$D_3 = 1.50$
$S_1 = 0.0120$	$S_2 = 0.0120$	$S_3 =$
$A_1 = 5.940$	$A_2 = 5.940$	$A_3 = 1.767$
$V_1 = 11.43$	$V_2 = 11.75$	$V_3 = 1.08$
$S_{f1} = 0.0164$	$S_{f2} = 0.0174$	$\theta = 45^\circ$
$h_{v1} = 2.03$	$h_{v2} = 2.14$	

$$\Delta y = \frac{69.8 \times 11.75 - 67.9 \times 11.43 - 1.9 \times 1.08 \cos 45}{\frac{1}{2}(5.940 + 5.940)\,32.2} = 0.22'$$

$h_J = 0.22 + 2.03 - 2.14 = 0.11'$,

SDMH, STA. 57+35 ; $h_{mh} = 0.05 \times 2.14 = 0.11'$

33"X18" WYE, STA 57+41

$Q_1 = 64.3$	$Q_2 = 67.9$	$Q_3 = 3.6$
$D_1 = 2.75$	$D_2 = 2.75$	$D_3 = 1.50$
$S_1 = 0.0360$	$S_2 = 0.0360$	$S_3 =$
$A_1 = 5.940$	$A_2 = 5.940$	$A_3 = 1.767$
$V_1 = 10.82$	$V_2 = 11.43$	$V_3 = 2.04$
$S_{f1} = 0.0147$	$S_{f2} = 0.0164$	$\theta = 45^\circ$
$h_{v1} = 1.82$	$h_{v2} = 2.03$	

$$\Delta y = \frac{67.9 \times 11.43 - 64.3 \times 10.82 - 3.6 \times 2.04 \cos 45}{\frac{1}{2}(5.940 + 5.940)\,32.2} = 0.39'$$

$h_J = 0.39 + 1.82 - 2.03 = 0.18'$

SDMH, STA 61+27 ; $h_{mh} = 0.05 \times 2.03 = 0.10$

33"X18" WYE, STA. 61+33

$Q_1 = 62.1$	$Q_2 = 64.3$	$Q_3 = 2.2$
$D_1 = 2.75$	$D_2 = 2.75$	$D_3 = 1.50$
$S_1 = 0.0140$	$S_2 = 0.0140$	$S_3 =$
$A_1 = 5.940$	$A_2 = 5.940$	$A_3 = 1.767$
$V_1 = 10.45$	$V_2 = 10.82$	$V_3 = 1.25$
$S_{f1} = 0.0137$	$S_{f2} = 0.0147$	$\theta = 45^\circ$
$h_{v1} = 1.70$	$h_{v2} = 1.82$	

$$\Delta y = \frac{64.3 \times 10.82 - 62.1 \times 10.45 - 2.2 \times 1.25 \cos 45}{\frac{1}{2}(5.940 + 5.940)\,32.2} = 0.23$$

$h_J = 0.23 + 1.70 - 1.82 = 0.11'$

33"X18" WYE, STA 61+41

$Q_1 = 58.9$	$Q_2 = 62.1$	$Q_3 = 3.2$
$D_1 = 2.75$	$D_2 = 2.75$	$D_3 = 1.50$
$S_1 = 0.0140$	$S_2 = 0.0140$	$S_3 =$
$A_1 = 5.940$	$A_2 = 5.940$	$A_3 = 1.767$
$V_1 = 9.92$	$V_2 = 10.45$	$V_3 = 1.81$
$S_{f1} = 0.0124$	$S_{f2} = 0.0137$	$\theta = 45°$
$h_{v1} = 1.53$	$h_{v2} = 1.70$	

$$\Delta y = \frac{62.1 \times 10.45 - 58.9 \times 9.92 - 3.2 \times 1.81 \cos 45°}{\frac{1}{2}(5.940 + 5.940)\,32.2} = 0.32$$

$h_1 = 0.32 + 1.53 - 1.70 = \underline{0.15'}$

SDMH, STA 64+96 ; $h_{mh} = 0.05 \times 1.70 = \underline{0.09'}$

33"X18" WYE, STA 65+02

$Q_1 = 55.4$	$Q_2 = 58.9$	$Q_3 = 3.5$
$D_1 = 2.75$	$D_2 = 2.75$	$D_3 = 1.50$
$S_1 = 0.0100$	$S_2 = 0.0100$	$S_3 =$
$A_1 = 5.940$	$A_2 = 5.940$	$A_3 = 1.767$
$V_1 = 9.33$	$V_2 = 9.92$	$V_3 = 1.98$
$S_{f1} = 0.0109$	$S_{f2} = 0.0124$	$\theta = 45°$
$h_{v1} = 1.35$	$h_{v2} = 1.53$	

$$\Delta y = \frac{58.9 \times 9.92 - 55.4 \times 9.33 - 3.5 \times 1.98 \cos 45°}{\frac{1}{2}(5.940 + 5.940)\,32.2} = 0.33'$$

$h_3 = 0.33 + 1.35 - 1.53 = 0.15'$

MANHOLE JCT, VB1, EXPANSION ; STA 68+10

$Q_1 = 50.5$	$Q_2 = 55.4$	$Q_3 = 4.9$
$D_1 = 2.50$	$D_2 = 2.75$	$D_3 = 1.75$
$S_1 = 0.0200$	$S_2 = 0.0100$	$S_3 =$
$A_1 = 4.909$	$A_2 = 5.940$	$A_3 = 2.405$
$V_1 = 10.29$	$V_2 = 9.33$	$V_3 = 2.04$
$S_{f1} = 0.0152$	$S_{f2} = 0.0109$	$\theta = 45°$
$h_{v1} = 1.64$	$h_{v2} = 1.35$	

$$\Delta y = \frac{55.4 \times 9.33 - 50.5 \times 10.29 - 4.9 \times 2.04 \cos 45°}{\frac{1}{2}(4.909 + 5.940)\,32.2} = -0.06'$$

$h_E = 0.05 \times 1.64 = \underline{0.08'}$

$h_3 = -0.06 + 1.64 - 1.35 = \underline{0.23'}$, $h_{mh} = 0.05 \times 1.64 = \underline{0.08'}$

30"X18" WYE, STA 68+61

$Q_1 = 47.1$	$Q_2 = 50.5$	$Q_3 = 3.4$
$D_1 = 2.50$	$D_2 = 2.50$	$D_3 = 1.50$
$S_1 = 0.0200$	$S_2 = 0.0200$	$S_3 =$
$A_1 = 4.909$	$A_2 = 4.909$	$A_3 = 1.767$
$V_1 = 9.59$	$V_2 = 10.29$	$V_3 = 1.92$
$S_{f1} = 0.0132$	$S_{f2} = 0.0152$	$\Theta = 45°$
$h_{v1} = 1.43$	$h_{v2} = 1.64$	

$$\Delta y = \frac{50.5 \times 10.29 - 47.1 \times 9.59 - 3.4 \times 1.92 \cos 45°}{\frac{1}{2}(4.909 + 4.909)\,32.2} = 0.40'$$

$$h_j = 0.40 + 1.43 - 1.64 = \underline{0.19'}$$

30"X18" WYE, STA 73+34

$Q_1 = 43.9$	$Q_2 = 47.1$	$Q_3 = 3.2$
$D_1 = 2.5$	$D_2 = 2.5$	$D_3 = 1.50$
$S_1 = 0.0200$	$S_2 = 0.0200$	$S_3 =$
$A_1 = 4.909$	$A_2 = 4.909$	$A_3 = 1.767$
$V_1 = 8.94$	$V_2 = 9.59$	$V_3 = 1.81$
$S_{f1} = 0.0115$	$S_{f2} = 0.0132$	$\Theta = 45°$
$h_{v1} = 1.24$	$h_{v2} = 1.43$	

$$\Delta y = \frac{47.1 \times 9.59 - 43.9 \times 8.94 - 3.2 \times 1.81 \cos 45°}{\frac{1}{2}(4.909 + 4.909)\,32.2} = 0.35'$$

$$h_j = 0.35 + 1.24 - 1.43 = \underline{0.16'}$$

MANHOLE JUNCTION, UPI, EXPANSION, STA 73+81

$Q_1 = 42.6$	$Q_2 = 43.9$	$Q_3 = 1.3$
$D_1 = 2.25$	$D_2 = 2.5$	$D_3 = 1.50$
$S_1 = 0.0140$	$S_2 = 0.0200$	$S_3 =$
$A_1 = 3.976$	$A_2 = 4.909$	$A_3 = 1.767$
$V_1 = 10.71$	$V_2 = 8.94$	$V_3 = 0.74$
$S_{f1} = 0.0189$	$S_{f2} = 0.0115$	$\theta = 45^\circ$
$h_{v1} = 1.78$	$h_{v2} = 1.24$	

$$\Delta y = \frac{43.9 \times 8.94 - 42.6 \times 10.71 - 1.3 \times 0.74 \cos 45}{\frac{1}{2}(3.976 + 4.909)\,32.2} = -0.45'$$

$h_J = -0.45 + 1.78 - 1.24 = \underline{0.09'}$ $\quad h_t = 0.05 \times 1.78 = 0.09$

$h_{mh} = 0.05 \times 1.78 = \underline{0.09'}$

27" X 18" WYE, STA 77+13

$Q_1 = 39.5$	$Q_2 = 42.6$	$Q_3 = 3.1$
$D_1 = 2.25$	$D_2 = 2.25$	$D_3 = 1.5$
$S_1 = 0.0140$	$S_2 = 0.0140$	$S_3 =$
$A_1 = 3.976$	$A_2 = 3.976$	$A_3 = 1.767$
$V_1 = 9.93$	$V_2 = 10.71$	$V_3 = 1.75$
$S_{f1} = 0.0163$	$S_{f2} = 0.0189$	$\theta = 45^\circ$
$h_{v1} = 1.53$	$h_{v2} = 1.78$	

$$\Delta y = \frac{42.6 \times 10.71 - 39.5 \times 9.93 - 3.1 \times 1.75 \cos 45}{\frac{1}{2}(3.976 + 3.976)\,32.2} = 0.47'$$

$h_J = 0.47 + 1.53 - 1.78 = 0.22'$

MANHOLE JUNCTION, STA 79+46

$Q_1 = 37.7$	$Q_2 = 39.5$	$Q_3 = 1.8$
$D_1 = 2.25$	$D_2 = 2.25$	$D_3 = 1.5$
$S_1 = 0.0140$	$S_2 = 0.0140$	$S_3 =$
$A_1 = 3.976$	$A_2 = 3.976$	$A_3 = 1.767$
$V_1 = 9.48$	$V_2 = 9.93$	$V_3 = 1.02$
$S_{f1} = 0.0148$	$S_{f2} = 0.0163$	$\theta = 45^\circ$
$h_{v1} = 1.40$	$h_{v2} = 1.53$	

$$\Delta y = \frac{39.5 \times 9.93 - 37.7 \times 9.48 - 1.8 \times 1.02 \cos 45}{\frac{1}{2}(3.976 + 3.976)32.2} = 0.26'$$

$$h_J = 0.26 + 1.40 - 1.53 = 0.13'$$

$$h_{ML} = 0.05 \times 1.53 = 0.08'$$

27X18" WYE, STA. 81+13

$Q_1 = 34.8$	$Q_2 = 37.7$	$Q_3 = 2.9$
$D_1 = 2.25$	$D_2 = 2.25$	$D_3 = 1.50$
$S_1 = 0.0140$	$S_2 = 0.0140$	$S_3 =$
$A_1 = 3.976$	$A_2 = 3.976$	$A_3 = 1.767$
$V_1 = 8.75$	$V_2 = 9.48$	$V_3 = 1.64$
$S_{f1} = 0.0125$	$S_{f2} = 0.0148$	$\theta = 45^\circ$
$h_{v1} = 1.19$	$h_{v2} = 1.40$	

$$\Delta y = \frac{37.7 \times 9.48 - 34.8 \times 8.75 - 2.9 \times 1.64 \cos 45}{\frac{1}{2}(3.976 + 3.976)32.2} = 0.39'$$

$$h_J = 0.39 + 1.19 - 1.40 = 0.18'$$

27"X18" WYE, STA 84+73

$Q_1 = 32.1$	$Q_2 = 34.8$	$Q_3 = 2.7$
$D_1 = 2.25$	$D_2 = 2.25$	$D_3 = 1.50$
$S_1 = 0.0140$	$S_2 = 0.0140$	$S_3 =$
$A_1 = 3.976$	$A_2 = 3.976$	$A_3 = 1.767$
$V_1 = 8.07$	$V_2 = 8.75$	$V_3 = 1.53$
$S_{f1} = 0.0107$	$S_{f2} = 0.0125$	$\theta = 45^\circ$
$h_{v1} = 1.01$	$h_{v2} = 1.19$	

$$\Delta y = \frac{34.8 \times 8.75 - 32.1 \times 8.07 - 2.7 \times 1.53 \cos 45}{\frac{1}{2}(3.976 + 3.976)32.2} = 0.33'$$

$$h_J = 0.33 + 1.01 - 1.19 = 0.15'$$

MANHOLE JUNCTION, STA 85+01

$Q_1 = 29.6$	$Q_2 = 32.1$	$Q_3 = 2.5$
$D_1 = 2.25$	$D_2 = 2.25$	$D_3 = 1.5$
$S_1 = 0.014$	$S_2 = 0.0140$	$S_3 =$
$A_1 = 3.976$	$A_2 = 3.976$	$A_3 = 1.767$
$V_1 = 7.44$	$V_2 = 8.07$	$V_3 = 1.41$
$S_{f1} = 0.0091$	$S_{f2} = 0.0107$	$\Theta = 45°$
$h_{v1} = 0.86$	$h_{v2} = 1.01$	

$$\Delta y = \frac{32.1 \times 8.07 - 29.6 \times 7.44 - 2.5 \times 1.41 \cos 45°}{\frac{1}{2}(3.976 + 3.976)32.2} = 0.28'$$

$$h_j = 0.28 + 0.86 - 1.01 = 0.13'$$

$$h_{mh} = 0.05 \times 1.01 = 0.05'$$

27"X18" WYE, STA 86+65

$Q_1 = 24.5$	$Q_2 = 29.6$	$Q_3 = 5.1$
$D_1 = 2.25$	$D_2 = 2.25$	$D_3 = 1.5$
$S_1 = 0.0140$	$S_2 = 0.0140$	$S_3 =$
$A_1 = 3.976$	$A_2 = 3.976$	$A_3 = 1.767$
$V_1 = 6.16$	$V_2 = 7.44$	$V_3 = 2.89$
$S_{f1} = 0.0063$	$S_{f2} = 0.0091$	$\Theta = 45°$
$h_{v1} = 0.59$	$h_{v2} = 0.86$	

$$\Delta y = \frac{29.6 \times 7.44 - 24.5 \times 6.16 - 5.1 \times 2.89 \cos 45}{\frac{1}{2}(3.976 + 3.976)32.2} = 0.46$$

$$h_j = 0.46 + 0.59 - 0.86 = \underline{0.19}$$

MANHOLE JUNCTION, EXPANSION, STA 87+10

$Q_1 = 10.5$	$Q_2 = 24.5$	$Q_3 = 14.0$
$D_1 = 2.0$	$D_2 = 2.25$	$D_3 = 2.0$
$S_1 = 0.0140$	$S_2 = 0.0140$	$S_3 =$
$A_1 = 3.142$	$A_2 = 3.976$	$A_3 = 3.142$
$V_1 = 3.34$	$V_2 = 6.16$	$V_3 = 4.46$
$S_{f1} = 0.0022$	$S_{f2} = 0.0063$	$\theta = 45^\circ$
$h_{v1} = 0.17$	$h_{v2} = 0.59$	

$$\Delta_J = \frac{24.5 \times 6.16 - 10.5 \times 3.34 - 14.0 \times 4.46 \cos 45^\circ}{\frac{1}{2}(3.976 + 3.142)\,32.2} = 0.63'$$

$$h_J = 0.63 + 0.17 - 0.59 = 0.21'$$

$$h_{mh} = 0.05 \times 0.59 = 0.03' \qquad h_t = 0.06 \times 0.59 = 0.04'$$

24"X18" WYE, STA 87+65

$Q_1 = 7.4$	$Q_2 = 10.5$	$Q_3 = 3.1$
$D_1 = 2.0$	$D_2 = 2.0$	$D_3 = 1.5$
$S_1 = 0.0140$	$S_2 = 0.0140$	$S_3 =$
$A_1 = 3.142$	$A_2 = 3.142$	$A_3 = 1.767$
$V_1 = 2.36$	$V_2 = 3.44$	$V_3 = 1.75$
$S_{f1} = 0.0011$	$S_{f2} = 0.0022$	$\theta = 45^\circ$
$h_{v1} = 0.09$	$h_{v2} = 0.17$	

$$\Delta_J = \frac{10.5 \times 3.44 - 7.4 \times 2.36 - 3.1 \times 1.75 \cos 45^\circ}{\frac{1}{2}(3.142 + 3.142)\,32.2} = 0.15'$$

$$h_J = 0.15 + 0.09 - 0.17 = 0.07'$$