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CULVERT SIZE DIAMETER (in.)	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
	Sq. Yds.	Class A1 Cu. Yds.	Class I Cu. Yds.	Class II Cu. Yds.	Sq. Yds.	Class A1 Cu. Yds.	Class I Cu. Yds.	Class II Cu. Yds.
12	1.59	0.79	1.06	1.59	1.50	0.75	1.00	1.50
15	2.49	1.24	1.66	2.49	2.34	1.17	1.56	2.34
18	3.61	1.81	2.41	3.61	3.39	1.69	2.26	3.39
24	6.39	3.19	4.26	6.39	6.00	3.00	4.00	6.00
30	9.97	4.99	6.65	9.97	9.37	4.69	6.25	9.37
36	21.18	10.59	14.12	21.18	19.97	9.98	13.31	19.97
42	28.55	14.27	19.03	28.55	26.91	13.46	17.94	26.91
48	36.93	18.47	24.62	36.93	34.80	17.40	23.20	34.80
54	46.53	23.27	31.02	46.53	43.82	21.91	29.21	43.82
60	57.23	28.61	38.15	57.23	53.24	26.62	35.49	53.24

TABLE D-1 CULVERT OUTLET PROTECTION WITH ST'D. ES-1 END SECTIONS

CULVERT SIZE DIAMETER (in.)	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
	Sq. Yds.	Class A1 Cu. Yds.	Class I Cu. Yds.	Class II Cu. Yds.	Sq. Yds.	Class A1 Cu. Yds.	Class I Cu. Yds.	Class II Cu. Yds.
12	1.78	0.89	1.19	1.78	1.69	0.85	1.13	1.69
15	2.77	1.39	1.85	2.77	2.62	1.31	1.75	2.62
18	3.99	1.99	2.66	3.99	3.76	1.88	2.51	3.76
24	7.05	3.52	4.70	7.05	6.64	3.32	4.43	6.64
30	10.96	5.48	7.31	10.96	10.35	5.17	6.90	10.35
36	22.56	11.28	15.04	22.56	21.33	10.67	14.22	21.33
42	30.69	15.35	20.46	30.69	29.01	14.51	19.34	29.01
48	39.68	19.84	26.45	39.68	37.47	18.74	24.98	37.47
54	49.98	24.99	33.32	49.98	47.21	23.60	31.47	47.21
60	61.53	30.77	41.02	61.53	57.45	28.73	38.30	57.45

TABLE D-2 CULVERT OUTLET PROTECTION WITH ST'D. ES-2 END SECTIONS

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

* Rev. 7/10

PIPE ARCH SPAN RISE (in)	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II		Class A1	Class I	Class II
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
17 x 13	2.73	1.36	1.82	2.73	2.59	1.30	1.73	2.59
21 x 15	3.93	1.96	2.62	3.93	3.67	1.84	2.45	3.67
24 x 18	8.34	4.17	5.56	8.34	4.99	2.50	3.33	4.99
28 x 20	6.97	3.49	4.65	6.97	6.51	3.25	4.34	6.51
35 x 24	10.59	5.29	7.06	10.59	9.88	4.94	6.59	9.88
42 x 29	24.74	12.37	16.49	24.74	23.27	11.63	15.51	23.27
49 x 33	33.14	16.57	22.09	33.14	31.14	15.57	20.76	31.14
57 x 38	44.43	22.22	29.62	44.43	41.73	20.87	27.82	41.73
64 x 43	56.52	28.26	37.68	56.52	53.12	26.56	35.41	53.12
71 x 47	69.42	34.71	46.28	69.42	65.24	32.62	43.49	65.24

TABLE D-3 CULVERT OUTLET PROTECTION WITH ST'D. ES-3 END SECTIONS

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

CULVERT SIZE DIAMETER (in.)	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II		Class A1	Class I	Class II
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
12	1.09	0.55	0.73	1.09	1.03	0.52	0.69	1.03
15	1.71	0.85	1.14	1.71	1.62	0.81	1.08	1.62
18	2.47	1.24	1.65	2.47	2.34	1.17	1.56	2.34
24	4.39	2.20	2.93	4.39	4.17	2.08	2.78	4.17
30	6.88	3.44	4.59	6.88	6.54	3.27	4.36	6.54
36	16.76	8.38	11.17	16.76	15.93	7.97	10.62	15.93

TABLE D-4 CULVERT OUTLET PROTECTION WITH ST'D. EW-1 ENDWALLS

CULVERT SIZE DIAMETER (in.)	Increments For Each Additional Pipe							
	EC-3 Type B		Depth (T) (18") Class A1		Depth (T) (24") Class I		Depth (T) (36") Class II	
	Conc.	C. M.	Conc.	C. M.	Conc.	C. M.	Conc.	C. M.
	Sq. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
12	0.52	0.45	0.26	0.22	0.35	0.30	0.52	0.45
15	0.81	0.70	0.40	0.35	0.54	0.47	0.81	0.70
18	1.18	1.03	0.59	0.51	0.79	0.69	1.18	1.03
24	2.07	1.83	1.03	0.91	1.38	1.22	2.07	1.83
30	3.25	2.88	1.63	1.44	2.17	1.92	3.25	2.88
36	6.74	5.53	3.37	3.43	4.49	4.13	6.74	5.33

TABLE D-5 CULVERT OUTLET PROTECTION WITH ST'D. EW-6 ENDWALLS

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

* Rev. 7/10

ELLIPTICAL PIPE SPAN RISE (in.)	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II		Class A1	Class I	Class II
Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	
23 x 14	2.43	1.21	1.62	2.43	2.31	1.15	1.54	2.31
30 x 19	4.35	2.17	2.90	4.35	4.12	2.06	2.75	4.12
34 x 22	5.71	2.85	3.81	5.71	5.41	2.71	3.61	5.41
38 x 24	6.94	3.47	4.63	6.94	6.60	3.30	4.40	6.60
42 x 27	8.67	4.33	5.78	8.67	8.25	4.12	5.49	8.23
45 x 29	9.97	4.99	6.65	9.97	9.46	4.73	6.31	9.46
49 x 32	12.01	6.00	8.01	12.01	11.40	5.70	7.60	11.40
53 x 34	13.78	6.89	9.19	13.78	13.09	6.55	8.73	13.09

**TABLE D-6 CULVERT OUTLET PROTECTION WITH ST'D. EW-2S AND EW-7S
ENDWALLS (30° SKEW)**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

CULVERT SIZE DIAMETER (in.)	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II		Class A1	Class I	Class II
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
42	25.46	12.73	16.97	25.46	23.91	11.96	15.94	23.91
48	33.29	16.64	22.19	33.29	31.25	15.62	20.83	31.25
54	42.02	21.01	28.01	42.02	39.56	19.78	26.37	39.56
60	52.04	26.02	34.69	52.04	48.20	24.10	32.13	48.20
66	63.29	31.64	42.19	63.29	59.15	29.57	39.43	59.15
72	75.03	37.52	50.02	75.03	70.41	35.21	46.94	70.41
78	88.08	44.04	58.72	88.08	82.67	41.33	55.11	82.67
84	102.17	51.08	68.11	102.17	95.90	47.95	63.93	95.90

TABLE D-7 CULVERT OUTLET PROTECTION WITH ST'D. EW-2 ENDWALLS

CULVERT SIZE DIAMETER (in.)	Increments For Each Additional Pipe			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II
	Conc.	Conc.	Conc.	Conc.
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
42	11.67	5.83	7.78	11.67
48	15.17	7.58	10.11	15.17
54	19.17	9.58	12.78	19.17
60	23.60	11.80	15.73	23.60
66	28.51	14.26	19.01	28.51
72	33.90	16.95	22.60	33.90
78	39.71	19.86	26.48	39.71
84	46.01	23.01	30.68	46.01

TABLE D-8 CULVERT OUTLET PROTECTION WITH ST'D. EW-7 ENDWALLS

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

CULVERT SIZE DIAMETER (in.)	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18") Class A1	Depth (T) (24") Class I	Depth (T) (36") Class II	EC-3 Type B	Depth (T) (18") Class A1	Depth (T) (24") Class I	Depth (T) (36") Class II
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
42	26.09	13.04	17.39	26.09	24.54	12.27	16.36	24.54
48	34.11	17.06	22.74	34.11	32.07	16.04	21.38	32.07
54	43.20	21.60	28.80	43.20	40.61	20.30	27.07	40.61
60	53.34	26.67	35.56	53.34	49.50	24.75	33.00	49.50
66	64.85	32.42	43.23	64.85	60.71	30.35	40.47	60.71
72	76.89	38.45	51.26	76.89	72.27	36.14	48.18	72.27
78	90.27	45.14	60.18	90.27	70.83	35.42	47.22	70.83
84	104.70	52.35	69.80	104.70	98.42	49.21	65.61	98.42

TABLE D-9 CULVERT OUTLET PROTECTION WITH ST'D. EW-2S ENDWALLS (30° SKEW)

CULVERT SIZE DIAMETER (in.)	Increments For Each Additional Pipe			
	EC-3 Type B	Depth (T) (18") Class A1	Depth (T) (24") Class I	Depth (T) (36") Class II
	Conc.	Conc.	Conc.	Conc.
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
42	13.46	6.73	8.98	13.46
48	17.50	8.75	11.66	17.50
54	22.15	11.06	14.76	22.15
60	27.25	13.61	18.17	27.25
66	32.95	16.46	21.96	32.95
72	39.15	19.56	26.10	39.15
78	45.85	22.91	30.57	45.85
84	53.15	26.56	35.43	53.15

TABLE D-10 CULVERT OUTLET PROTECTION WITH ST'D. EW-7S ENDWALLS (30° SKEW)

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

* Rev. 7/10

CULVERT SIZE DIAMETER (in.)	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II		Class A1	Class I	Class II
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
42	28.80	14.40	19.20	28.80	27.65	13.82	18.43	27.65
48	37.64	18.82	25.09	37.64	36.12	18.06	24.08	36.12
54	47.64	23.82	31.76	47.64	45.71	22.85	30.47	45.71
60	58.80	29.40	39.20	58.80	55.77	27.89	37.18	55.77
66	71.12	35.56	47.41	71.12	68.30	34.15	45.53	68.30
72	84.71	42.35	56.47	84.71	81.29	40.64	54.19	81.29
78	99.41	49.70	66.27	99.41	95.39	47.69	63.59	95.39
84	115.29	57.65	76.86	115.29	110.63	55.31	73.75	110.63

**TABLE D-11 CULVERT OUTLET PROTECTION WITH ST'D. EW-2S ENDWALLS
(45° SKEW)**

CULVERT SIZE DIAMETER (in.)	Increments For Each Additional Pipe			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II
	Conc.	Conc.	Conc.	Conc.
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
42	12.63	6.32	8.42	12.63
48	16.44	8.22	10.96	16.44
54	20.78	10.39	13.85	20.78
60	25.58	12.79	17.05	25.58
66	30.92	15.46	20.61	30.92
72	36.75	18.38	24.50	36.75
78	43.10	21.55	28.73	43.10
84	49.94	24.97	33.29	49.94

**TABLE D-12 CULVERT OUTLET PROTECTION WITH ST'D. EW-7S ENDWALLS
(45° SKEW)**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

ELLIPTICAL PIPE SPAN RISE (in.)	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18") Class A1	Depth (T) (24") Class I	Depth (T) (36") Class II	EC-3 Type B	Depth (T) (18") Class A1	Depth (T) (24") Class I	Depth (T) (36") Class II
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
60 x 38	29.10	14.55	19.40	29.10	26.39	13.19	17.59	26.39
68 x 43	37.95	18.98	25.30	37.95	34.52	17.26	23.01	34.52
76 x 48	47.31	23.66	31.54	47.31	42.99	21.50	28.66	42.99
83 x 53	57.03	28.52	38.02	57.03	51.86	25.93	34.57	51.86
91 x 58	68.34	34.17	45.56	68.34	62.07	31.04	41.38	62.07
98 x 63	80.82	40.41	53.88	80.82	72.66	36.33	48.44	72.66
106 x 68	93.35	46.67	62.23	93.35	84.74	42.37	56.49	84.74

TABLE D-13 CULVERT OUTLET PROTECTION WITH ST'D. EW-2A ENDWALLS

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

* Rev. 7/10

PIPE ARCH Span Riser (in.)	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II		Class A1	Class I	Class II
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
17 x 13	1.68	0.84	1.12	1.68	1.59	0.79	1.06	1.59
21 x 15	2.40	1.20	1.60	2.40	2.28	1.14	1.52	2.28
24 x 18	3.30	1.65	2.20	3.30	3.13	1.57	2.09	3.13
28 x 20	4.29	2.14	2.86	4.29	4.06	2.03	2.71	4.06
35 x 24	6.40	3.20	4.27	6.40	6.07	3.04	4.05	6.07
42 x 29	9.30	4.65	6.20	9.30	8.83	4.42	5.89	8.83
49 x 33	12.40	6.20	8.27	12.40	11.77	5.89	7.85	11.77
57 x 38	24.33	12.11	16.15	24.33	23.03	11.51	15.35	23.03

TABLE D-14 CULVERT OUTLET PROTECTION WITH ST'D. EW-9 PIPE ARCHES

PIPE ARCH Span Riser (in.)	Increments For Each Additional Pipe			
	EC-3 Type B	Depth (T) (18") Class A1	Depth (T) (24") Class I	Depth (T) (36") Class II
	Conc. Sq. Yds.	Conc. Cu. Yds.	Conc. Cu. Yds.	Conc. Cu. Yds.
17 x 13	0.78	0.39	0.52	0.78
21 x 15	1.05	0.52	0.70	1.05
24 x 18	1.38	0.69	0.92	1.38
28 x 20	1.71	0.85	1.14	1.71
35 x 24	2.37	1.18	1.58	2.37
42 x 29	3.49	1.75	2.33	3.49
49 x 33	4.65	2.32	3.10	4.65
57 x 38	11.33	5.66	7.55	11.33

TABLE D-15 CULVERT OUTLET PROTECTION WITH ST'D. EW-10 PIPE ARCHES

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

* Rev. 7/10

CULVERT SIZE (FEET) SPAN X RISE	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II		Class A1	Class I	Class II
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
3 x 3	21.12	10.56	14.08	21.12	20.39	10.19	13.59	20.39
3 x 4	28.71	14.36	19.14	28.71	28.26	14.13	18.84	28.26
4 x 3	28.49	14.24	18.99	28.49	26.85	13.43	17.90	26.85
4 x 4	37.61	18.80	25.07	37.61	36.41	18.20	24.27	36.41
4 x 5	47.66	23.83	31.77	47.66	46.86	23.43	31.24	46.86
4 x 6	58.01	29.00	38.67	58.01	58.34	29.17	38.89	58.34
5 x 3	36.62	18.31	24.41	36.62	33.95	16.97	22.63	33.95
5 x 4	47.25	23.63	31.50	47.25	44.78	22.39	29.85	44.78
5 x 5	58.82	29.41	39.21	58.82	56.72	28.36	37.81	56.72
5 x 6	70.86	35.43	47.24	70.86	69.62	34.81	46.41	69.62
5 x 7	84.08	42.04	56.05	84.08	83.45	41.72	55.63	83.45
6 x 4	57.68	28.84	38.45	57.68	53.93	26.96	35.95	53.93
6 x 5	70.74	35.37	47.16	70.74	67.20	33.60	44.80	67.20
6 x 6	84.50	42.25	56.33	84.50	81.54	40.77	54.36	81.54
6 x 7	97.89	48.95	65.26	97.89	96.83	48.41	64.55	96.83
6 x 8	114.17	57.08	76.11	114.17	113.04	56.52	75.36	113.04
7 x 4	68.82	34.41	45.88	68.82	63.77	31.88	42.51	63.77
7 x 6	98.96	49.48	65.97	98.96	94.10	47.05	62.73	94.10
7 x 8	132.47	66.23	88.31	132.47	128.49	64.25	85.66	128.49
7 x 10	167.46	83.73	111.64	167.46	165.53	82.76	110.35	165.53
8 x 4	80.73	40.37	53.82	80.73	74.30	37.15	49.53	74.30
8 x 6	114.09	57.05	76.06	114.09	107.36	53.68	71.57	107.36
8 x 8	150.47	75.23	100.31	150.47	145.11	72.56	96.74	145.11
8 x 10	189.00	94.50	126.00	189.00	174.18	87.09	116.12	174.18
9 x 4	93.39	46.70	62.26	93.39	85.47	42.74	56.98	85.47
9 x 6	130.17	65.09	86.78	130.17	121.41	60.71	80.94	121.41
9 x 8	163.32	81.66	108.88	163.32	161.72	80.86	107.81	161.72
9 x 10	211.31	105.65	140.87	211.31	217.35	108.68	144.90	217.35
9 x 12	256.28	128.14	170.85	256.28	293.36	146.68	195.57	293.36
10 x 4	106.83	53.42	71.22	106.83	97.31	48.65	64.87	97.31
10 x 6	147.00	73.50	98.00	147.00	136.13	68.06	90.75	136.13
10 x 8	189.03	94.52	126.02	189.03	179.00	89.50	119.33	179.00
10 x 10	234.86	117.43	156.57	234.86	226.31	113.15	150.87	226.31
10 x 12	283.50	141.75	189.00	283.50	277.40	138.70	184.93	277.40
12 x 6	182.09	91.04	121.39	182.09	168.32	84.16	112.21	168.32
12 x 8	231.05	115.52	154.03	231.05	215.67	107.84	143.78	215.67
12 x 10	283.01	141.50	188.67	283.01	268.80	134.40	179.20	268.80
12 x 12	338.57	169.28	225.71	338.57	326.13	163.07	217.42	326.13

**TABLE D-16 CULVERT OUTLET PROTECTION FOR BOX CULVERT ST'D BCS-02
THRU BCS-50 (NO SKEW)**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

* Rev. 7/10

CULVERT SIZE (FEET) SPAN X RISE	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II		Class A1	Class I	Class II
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
3 x 3	21.23	10.61	14.15	21.23	20.49	10.25	13.66	20.49
3 x 4	28.86	14.43	19.24	28.86	28.40	14.20	18.93	28.40
4 x 3	28.62	14.31	19.08	28.62	27.00	13.50	18.00	27.00
4 x 4	37.80	18.90	25.20	37.80	36.59	18.29	24.39	36.59
4 x 5	47.90	23.95	31.93	47.90	47.13	23.57	31.42	47.13
4 x 6	58.29	29.15	38.86	58.29	58.62	29.31	39.08	58.62
5 x 3	36.50	18.25	24.33	36.50	34.13	17.06	22.75	34.13
5 x 4	47.48	23.74	31.65	47.48	45.00	22.50	30.00	45.00
5 x 5	59.12	29.56	39.41	59.12	57.02	28.51	38.01	57.02
5 x 6	71.21	35.60	47.47	71.21	69.96	34.98	46.64	69.96
5 x 7	84.50	42.25	56.33	84.50	83.87	41.93	55.91	83.87
6 x 4	57.96	28.98	38.64	57.96	54.21	27.11	36.14	54.21
6 x 5	71.10	35.55	47.40	71.10	67.56	33.78	45.04	67.56
6 x 6	84.93	42.47	56.62	84.93	81.98	40.99	54.65	81.98
6 x 7	98.39	49.19	65.59	98.39	97.32	48.66	64.88	97.32
6 x 8	114.72	57.36	76.48	114.72	113.61	56.81	75.74	113.61
7 x 4	69.17	34.58	46.11	69.17	64.10	32.05	42.73	64.10
7 x 6	99.45	49.73	66.30	99.45	30.18	15.09	20.12	30.18
7 x 8	197.39	98.69	131.59	197.39	129.15	64.58	86.10	129.15
7 x 10	168.27	84.14	112.18	168.27	166.35	83.18	110.90	166.35
8 x 4	81.11	40.55	54.07	81.11	74.67	37.34	49.78	74.67
8 x 6	114.65	57.32	76.43	114.65	107.91	53.96	71.94	107.91
8 x 8	151.22	75.61	100.81	151.22	145.86	72.93	97.24	145.86
8 x 10	189.95	94.97	126.63	189.95	175.11	87.56	116.74	175.11
9 x 4	93.83	46.91	62.55	93.83	85.89	42.95	57.26	85.89
9 x 6	130.80	65.40	87.20	130.80	122.04	61.02	81.36	122.04
9 x 8	164.18	82.09	109.45	164.18	162.57	81.29	108.38	162.57
9 x 10	212.37	106.19	141.58	212.37	218.42	109.21	145.61	218.42
9 x 12	257.54	128.77	171.69	257.54	294.63	147.32	196.42	294.63
10 x 4	107.30	53.65	71.53	107.30	97.77	48.89	65.18	97.77
10 x 6	147.71	73.85	98.47	147.71	136.83	68.42	91.22	136.83
10 x 8	189.98	94.99	126.65	189.98	179.93	89.96	119.95	179.93
10 x 10	236.03	118.01	157.35	236.03	227.48	113.74	151.65	227.48
10 x 12	284.91	142.46	189.94	284.91	278.81	139.40	185.87	278.81
12 x 6	182.94	91.47	121.96	182.94	169.17	84.59	112.78	169.17
12 x 8	232.17	116.09	154.78	232.17	216.80	108.40	144.53	216.80
12 x 10	284.42	142.21	189.61	284.42	270.21	135.11	180.14	270.21
12 x 12	340.26	170.13	226.84	340.26	327.83	163.91	218.55	327.83

**TABLE D-17 CULVERT OUTLET PROTECTION FOR BOX CULVERT ST'D BCS-02
THRU BCS-50 (15° SKEW)**

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

* Rev. 7/10

CULVERT SIZE (FEET)	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II		Class A1	Class I	Class II
	SPAN X RISE	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.
3 x 3	21.69	10.85	14.46	21.69	21.03	10.52	14.02	21.03
3 x 4	29.61	14.81	19.74	29.61	29.40	14.70	19.60	29.40
4 x 3	29.07	14.54	19.38	29.07	27.48	13.74	18.32	27.48
4 x 4	38.67	19.34	25.78	38.67	37.59	18.80	25.06	37.59
4 x 5	49.22	24.61	32.81	49.22	48.87	24.44	32.58	48.87
4 x 6	60.56	30.28	40.37	60.56	61.35	30.68	40.90	61.35
5 x 3	37.22	18.61	24.81	37.22	34.55	17.27	23.03	34.55
5 x 4	48.27	24.14	32.18	48.27	45.90	22.95	30.60	45.90
5 x 5	60.39	30.20	40.26	60.39	62.21	31.10	41.47	62.21
5 x 6	73.35	36.68	48.90	73.35	72.50	36.25	48.33	72.50
5 x 7	87.30	43.65	58.20	87.30	87.38	43.69	58.25	87.38
6 x 4	58.77	29.39	39.18	58.77	55.04	27.52	36.69	55.04
6 x 5	72.35	36.17	48.23	72.35	69.00	34.50	46.00	69.00
6 x 6	86.93	43.46	57.95	86.93	84.30	42.15	56.20	84.30
6 x 7	100.83	50.42	67.22	100.83	100.64	50.32	67.09	100.64
6 x 8	118.52	59.26	79.01	118.52	118.22	59.11	78.81	118.22
7 x 4	84.98	42.49	56.65	84.98	64.86	32.43	43.24	64.86
7 x 6	101.27	50.63	67.51	101.27	96.74	48.37	64.49	96.74
7 x 8	136.32	68.16	90.88	136.32	133.52	66.76	89.01	133.52
7 x 10	174.42	87.21	116.28	174.42	174.21	87.11	116.14	174.21
8 x 4	81.96	40.98	54.64	81.96	75.36	37.68	50.24	75.36
8 x 6	116.39	58.19	77.59	116.39	109.85	54.92	73.23	109.85
8 x 8	154.32	77.16	102.88	154.32	150.05	75.02	100.03	150.05
8 x 10	196.26	98.13	130.84	196.26	182.82	91.41	121.88	182.82
9 x 4	94.68	47.34	63.12	94.68	86.52	43.26	57.68	86.52
9 x 6	132.45	66.23	88.30	132.45	123.81	61.91	82.54	123.81
9 x 8	167.51	83.75	111.67	167.51	166.50	83.25	111.00	166.50
9 x 10	218.42	109.21	145.61	218.42	225.68	112.84	150.45	225.68
9 x 12	266.64	133.32	177.76	266.64	305.79	152.90	203.86	305.79
10 x 4	108.18	54.09	72.12	108.18	98.34	49.17	65.56	98.34
10 x 6	149.27	74.63	99.51	149.27	138.45	69.23	92.30	138.45
10 x 8	193.16	96.58	128.77	193.16	183.66	91.83	122.44	183.66
10 x 10	241.77	120.89	161.18	241.77	234.47	117.23	156.31	234.47
10 x 12	293.69	146.84	195.79	293.69	289.74	144.87	193.16	289.74
12 x 6	184.10	92.05	122.73	184.10	170.30	85.15	113.53	170.30
12 x 8	235.04	117.52	156.69	235.04	219.90	109.95	146.60	219.90
12 x 10	289.53	144.77	193.02	289.53	276.30	138.15	184.20	276.30
12 x 12	348.38	174.19	232.25	348.38	337.88	168.94	225.25	337.88

TABLE D-18 CULVERT OUTLET PROTECTION FOR BOX CULVERT ST'D BCS-02 THRU BCS-50 (30° SKEW)

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

* Rev. 7/10

CULVERT SIZE (FEET) SPAN X RISE	1 ½ : 1 Slope				2 : 1 Slope			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II		Class A1	Class I	Class II
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
3 x 3	22.46	11.23	14.97	22.46	21.80	10.90	14.53	21.80
3 x 4	30.65	15.32	20.43	30.65	30.44	15.22	20.29	30.44
4 x 3	30.11	15.05	20.07	30.11	28.52	14.26	19.01	28.52
4 x 4	40.05	20.03	26.70	40.05	38.97	19.49	25.98	38.97
4 x 5	50.96	25.48	33.97	50.96	50.60	25.30	33.73	50.60
4 x 6	62.64	31.32	41.76	62.64	63.42	31.71	42.28	63.42
5 x 3	38.51	19.25	25.67	38.51	35.85	17.93	23.90	35.85
5 x 4	50.01	25.01	33.34	50.01	47.63	23.81	31.75	47.63
5 x 5	62.57	31.28	41.71	62.57	60.77	30.38	40.51	60.77
5 x 6	75.95	37.97	50.63	75.95	75.09	37.55	50.06	75.09
5 x 7	90.33	45.17	60.22	90.33	90.41	45.20	60.27	90.41
6 x 4	60.86	30.43	40.57	60.86	57.11	28.55	38.07	57.11
6 x 5	74.94	37.47	49.96	74.94	71.60	35.80	47.73	71.60
6 x 6	90.03	45.02	60.02	90.03	87.42	43.71	58.28	87.42
6 x 7	104.73	52.37	69.82	104.73	104.27	52.13	69.51	104.27
6 x 8	122.67	61.34	81.78	122.67	122.37	61.19	81.58	122.37
7 x 4	72.39	36.20	48.26	72.39	67.28	33.64	44.85	67.28
7 x 6	104.90	52.45	69.93	104.90	100.37	50.18	66.91	100.37
7 x 8	141.17	70.58	94.11	141.17	138.36	69.18	92.24	138.36
7 x 10	180.48	90.24	120.32	180.48	180.26	90.13	120.17	180.26
8 x 4	84.72	42.36	56.48	84.72	78.14	39.07	52.09	78.14
8 x 6	120.54	60.27	80.36	120.54	114.00	57.00	76.00	114.00
8 x 8	160.23	80.12	106.82	160.23	155.63	77.81	103.75	155.63
8 x 10	203.22	101.61	135.48	203.22	189.74	94.87	126.49	189.74
9 x 4	97.80	48.90	65.20	97.80	89.64	44.82	59.76	89.64
9 x 6	137.13	68.57	91.42	137.13	128.49	64.25	85.66	128.49
9 x 8	173.73	86.87	115.82	173.73	172.73	86.36	115.15	172.73
9 x 10	226.20	113.10	150.80	226.20	233.46	116.73	155.64	233.46
9 x 12	275.97	137.99	183.98	275.97	315.14	157.57	210.09	315.14
10 x 4	111.65	55.82	74.43	111.65	101.81	50.90	67.87	101.81
10 x 6	154.46	77.23	102.97	154.46	143.64	71.82	95.76	143.64
10 x 8	200.07	100.04	133.38	200.07	190.59	95.30	127.06	190.59
10 x 10	250.41	125.21	166.94	250.41	243.12	121.56	162.08	243.12
10 x 12	304.07	152.03	202.71	304.07	300.12	150.06	200.08	300.12
12 x 6	190.32	95.16	126.88	190.32	176.52	88.26	117.68	176.52
12 x 8	243.35	121.67	162.23	243.35	228.20	114.10	152.13	228.20
12 x 10	299.91	149.96	199.94	299.91	286.68	143.34	191.12	286.68
12 x 12	360.83	180.41	240.55	360.83	350.34	175.17	233.56	350.34

TABLE D-19 CULVERT OUTLET PROTECTION FOR BOX CULVERT ST'D BCS-02 THRU BCS-50 (45° SKEW)

Quantities To Be Used Only For Computations of Dry Rip Rap For Outlet Protection.*

* Rev. 7/10

CULVERT SIZE (FEET) SPAN X RISE	1 ½ : 1 Slope No Skew				1 ½ : 1 Slope 15° Skew			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II		Class A1	Class I	Class II
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
3 x 3	5.84	2.92	3.89	5.84	5.97	2.99	3.98	5.97
3 x 4	7.29	3.65	4.86	7.29	7.47	3.74	4.98	7.47
4 x 3	8.22	4.11	5.48	8.22	8.40	4.20	5.60	8.40
4 x 4	9.78	4.89	6.52	9.78	10.01	5.00	6.67	10.01
4 x 5	11.34	5.67	7.56	11.34	11.61	5.81	7.74	11.61
4 x 6	12.89	6.44	8.59	12.89	13.22	6.61	8.81	13.22
5 x 3	11.22	5.61	7.48	11.22	11.42	5.71	7.61	11.42
5 x 4	13.10	6.55	8.73	13.10	13.38	6.69	8.92	13.38
5 x 5	15.00	7.50	10.00	15.00	15.33	7.67	10.22	15.33
5 x 6	16.89	8.45	11.26	16.89	17.30	8.65	11.53	17.30
5 x 7	18.78	9.39	12.52	18.78	19.23	9.62	12.82	19.23
6 x 4	16.89	8.45	11.26	16.89	17.21	8.60	11.47	17.21
6 x 5	19.23	9.62	12.82	19.23	19.62	9.81	13.08	19.62
6 x 6	21.69	10.85	14.46	21.69	22.16	11.08	14.77	22.16
6 x 7	24.15	12.08	16.10	24.15	24.69	12.35	16.46	24.69
6 x 8	25.77	12.89	17.18	25.77	26.40	13.20	17.60	26.40
7 x 4	21.11	10.55	14.07	21.11	21.47	10.73	14.31	21.47
7 x 6	26.40	13.20	17.60	26.40	26.94	13.47	17.96	26.94
7 x 8	31.98	15.99	21.32	31.98	32.70	16.35	21.80	32.70
7 x 10	37.56	18.78	25.04	37.56	38.46	19.23	25.64	38.46
8 x 4	25.77	12.89	17.18	25.77	26.19	13.10	17.46	26.19
8 x 6	31.55	15.77	21.03	31.55	32.18	16.09	21.45	32.18
8 x 8	37.32	18.66	24.88	37.32	38.15	19.07	25.43	38.15
8 x 10	43.11	21.56	28.74	43.11	44.13	22.07	29.42	44.13
9 x 4	30.90	15.45	20.60	30.90	31.35	15.68	20.90	31.35
9 x 6	37.34	18.67	24.89	37.34	38.03	19.01	25.35	38.03
9 x 8	43.76	21.88	29.17	43.76	44.69	22.34	29.79	44.69
9 x 10	51.00	25.50	34.00	51.00	52.13	26.06	34.75	52.13
9 x 12	57.92	28.96	38.61	57.92	59.28	29.64	39.52	59.28
10 x 4	36.44	18.22	24.29	36.44	36.95	18.47	24.63	36.95
10 x 6	43.56	21.78	29.04	43.56	44.31	22.16	29.54	44.31
10 x 8	50.67	25.34	33.78	50.67	51.68	25.84	34.45	51.68
10 x 10	57.77	28.88	38.51	57.77	59.03	29.51	39.35	59.03
10 x 12	64.88	32.44	43.25	64.88	66.39	33.20	44.26	66.39
12 x 6	57.33	28.67	38.22	57.33	58.22	29.11	38.81	58.22
12 x 8	65.78	32.89	43.85	65.78	66.96	33.48	44.64	66.96
12 x 10	74.22	37.11	49.48	74.22	75.71	37.85	50.47	75.71
12 x 12	82.67	41.33	55.11	82.67	84.45	42.23	56.30	84.45

**TABLE D-20 CULVERT OUTLET PROTECTION FOR MULTIPLE BOX CULVERT
(INCREMENTS FOR EACH ADDITIONAL BARREL)**

Quantities To Be Used Only For Computations Of Dry Rip Rap For Outlet Protection.*

* Rev. 7/10

CULVERT SIZE (FEET) SPAN X RISE	2 : 1 Slope 30° Skew				2 : 1 Slope 45° Skew			
	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")	EC-3 Type B	Depth (T) (18")	Depth (T) (24")	Depth (T) (36")
		Class A1	Class I	Class II		Class A1	Class I	Class II
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
3 x 3	6.45	3.23	4.30	6.45	7.41	3.71	4.94	7.41
3 x 4	7.83	3.92	5.22	7.83	9.42	4.71	6.28	9.42
4 x 3	8.94	4.47	5.96	8.94	10.16	5.08	6.77	10.16
4 x 4	10.74	5.37	7.16	10.74	12.36	6.18	8.24	12.36
4 x 5	12.54	6.27	8.36	12.54	14.57	7.28	9.71	14.57
4 x 6	14.34	7.17	9.56	14.34	16.76	8.38	11.17	16.76
5 x 3	12.09	6.05	8.06	12.09	13.56	6.78	9.04	13.56
5 x 4	14.28	7.14	9.52	14.28	16.23	8.12	10.82	16.23
5 x 5	16.46	8.23	10.97	16.46	18.92	9.46	12.61	18.92
5 x 6	18.65	9.32	12.43	18.65	21.59	10.79	14.39	21.59
5 x 7	20.82	10.41	13.88	20.82	24.24	12.12	16.16	24.24
6 x 4	18.27	9.14	12.18	18.27	20.57	10.28	13.71	20.57
6 x 5	20.99	10.49	13.99	20.99	23.87	11.93	15.91	23.87
6 x 6	23.75	11.87	15.83	23.75	27.21	13.61	18.14	27.21
6 x 7	26.73	13.37	17.82	26.73	30.74	15.37	20.49	30.74
6 x 8	28.53	14.27	19.02	28.53	33.14	16.57	22.09	33.14
7 x 4	22.68	11.34	15.12	22.68	25.34	12.67	16.89	25.34
7 x 6	28.76	14.38	19.17	28.76	32.75	16.37	21.83	32.75
7 x 8	35.30	17.65	23.53	35.30	40.61	20.30	27.07	40.61
7 x 10	41.79	20.90	27.86	41.79	48.44	24.22	32.29	48.44
8 x 4	27.57	13.79	18.38	27.57	30.57	15.29	20.38	30.57
8 x 6	34.25	17.12	22.83	34.25	38.23	19.12	25.82	38.23
8 x 8	40.91	20.45	27.27	40.91	46.91	23.45	31.27	46.91
8 x 10	47.58	23.79	31.72	47.58	55.23	27.62	36.82	55.23
9 x 4	32.90	16.45	21.93	32.90	36.23	18.11	24.15	36.23
9 x 6	40.34	20.17	26.89	40.34	45.33	22.67	30.22	45.33
9 x 8	48.00	24.00	32.00	48.00	54.69	27.35	36.46	54.69
9 x 10	56.18	28.09	37.45	56.18	64.55	32.27	43.03	64.55
9 x 12	64.22	32.11	42.81	64.22	74.24	37.12	49.49	74.24
10 x 4	38.64	19.32	25.76	38.64	42.33	21.17	28.22	42.33
10 x 6	46.85	23.42	31.23	46.85	52.40	26.20	34.93	52.40
10 x 8	55.07	27.53	36.71	55.07	62.45	31.22	41.63	62.45
10 x 10	63.27	31.64	42.18	63.27	72.51	36.26	48.34	72.51
10 x 12	71.49	35.75	47.66	71.49	82.56	41.28	55.04	82.56
12 x 6	61.25	30.62	40.83	61.25	67.83	33.92	45.22	67.83
12 x 8	71.01	35.51	47.34	71.01	79.77	39.89	53.18	79.77
12 x 10	80.76	40.38	53.84	80.76	91.71	45.86	61.14	91.71
12 x 12	90.51	45.26	60.34	90.51	103.65	51.83	69.10	103.65

**TABLE D-21 CULVERT OUTLET PROTECTION FOR MULTIPLE BOX CULVERT
(INCREMENTS FOR EACH ADDITIONAL BARREL)**

Quantities To Be Used Only For Computations Of Dry Rip Rap For Outlet Protection.*

* Rev. 7/10

PROJECT _____ STATION _____

If Line 5 is over 5' 4", use Type A Tower
 If Line 5 is 3' 2" to 5' 4", use Type B Tower
 If Line 5 is 2' 4" to 3' 2", use Type C Tower

Increase above dimensions by 1" for use with 72" pipe.

1. Grade Elevation _____
 2. Minus Inv. Elev. _____
 3. Vertical Difference _____
 4. Minus Pipe Size _____
 5. Difference _____

CHAMBER

6. Type _____ Pipe Size _____ Turn Angle _____

Less: Pipe Openings

7. Size _____ Class _____ Defl. Angle _____
 8. Size _____ Class _____ Defl. Angle _____
 9. Size _____ Class _____ Defl. Angle _____
 10. Size _____ Class _____ Defl. Angle _____

11. Total Deductions (Lines 7-10) _____

12. Quantities for Chamber
 (Subtract Line 11 from Line 6 and Transfer to Line 17)

TOWER

13. Type _____ x Height _____ Min. Height _____
 x 48" Pipe - Line 3 minus 6.33'
 x 54" Pipe - Line 3 minus 6.83'
 x 60" Pipe - Line 3 minus 7.33'
 x 66" Pipe - Line 3 minus 7.83'
 x 72" Pipe - Line 3 minus 9.33'

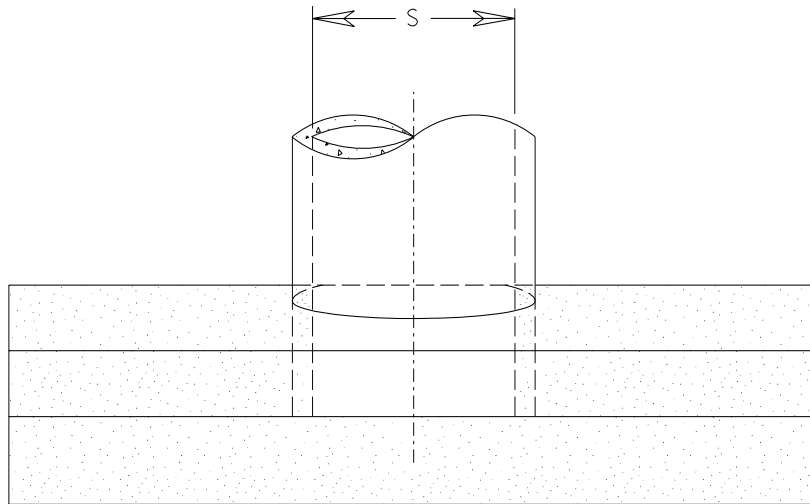
14. Minimum Height Quantities _____
 15. (Line 13 less Min. Height) x increment per foot _____
 16. Quantities for tower (Add Lines 14 & 15) _____
 17. Quantities for Chamber (Line 12) _____
 18. Total Concrete and Reinforcing Steel (Add Lines 16 & 17) _____

CONCRETE CU. YDS. _____
 REINFORCING STEEL LBS. _____

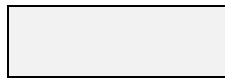
STRUCTURAL STEEL QUANTITY (Lbs.) _____

PIPE SIZE	PIPE CLASS	CONCRETE				REINFORCING STEEL	
		0° CU. YDS.	15° CU. YDS.	30° CU. YDS.	45° CU. YDS.	LBS.	LBS.
12"	III, IV, V C. M.	0.035 0.019	0.036 0.020	0.040 0.022	0.050 0.027	17.67 11.06	
15"	III, IV, V C. M.	0.050 0.030	0.052 0.031	0.058 0.034	0.071 0.042	24.88 15.93	
18"	III, IV, V C. M.	0.069 0.043	0.072 0.044	0.080 0.049	0.099 0.061	33.23 21.68	
24"	III, IV, V C. M.	0.118 0.076	0.122 0.078	0.137 0.087	0.168 0.108	53.53 35.33	
30"	III, IV, V C. M.	0.179 0.118	0.186 0.122	0.209 0.137	0.256 0.168	78.64 53.53	
36"	III, IV, V C. M.	0.254 0.170	0.263 0.176	0.294 0.197	0.362 0.242	108.76 74.76	
42"	III, IV, V C. M.	0.341 0.231	0.353 0.240	0.395 0.268	0.486 0.330	143.33 99.53	
48"	III, IV, V C. M.	0.441 0.302	0.457 0.313	0.511 0.350	0.629 0.431	182.90 127.85	
54"	III & IV V C. M.	0.554 0.580 0.382	0.574 0.600 0.412	0.642 0.672 0.443	0.789 0.826 0.545	227.39 257.42 159.70	
60"	III & IV V C. M.	0.679 0.708 0.472	0.704 0.734 0.481	0.787 0.821 0.551	0.965 1.009 0.673	276.49 287.65 195.09	
66"	III & IV V C. M.	0.818 0.849 0.571	0.847 0.880 0.591	0.948 0.985 0.682	1.166 1.211 0.814	330.50 342.70 234.02	
72"	III & IV V C. M.	0.969 1.003 0.679	1.004 1.040 0.704	1.123 1.163 0.787	1.382 1.431 0.969	389.34 402.58 276.49	

FIGURE D-1 COMPUTATIONS FOR STANDARD JB-1 JUNCTION BOX
 TABLE D-22 ADJUSTMENT QUANTITIES FOR JUNCTION BOX



PLAN VIEW



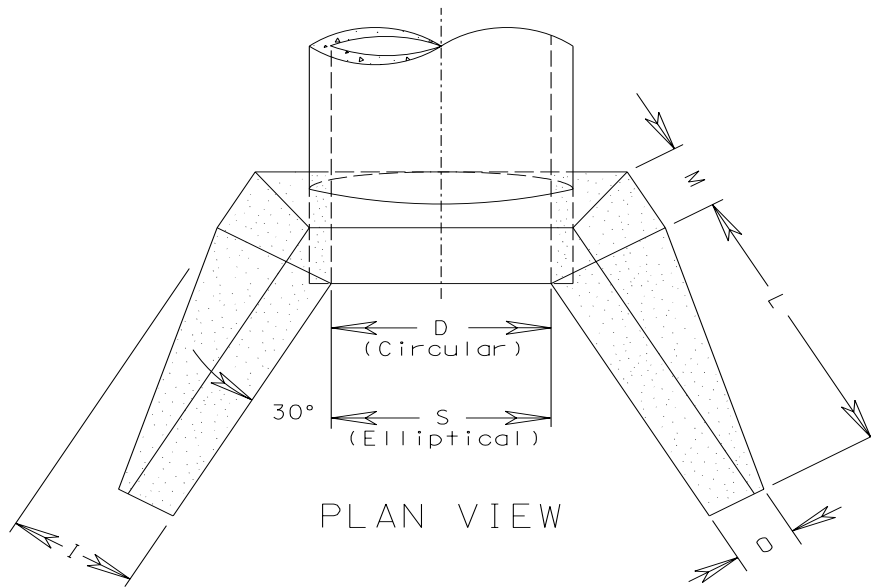
Area for computing ratio

STANDARD	(S) Span of Culvert (inches)	Area (A)
		Conc or C. M. Sq. Ft.
EW-1A	49	24.40
	53	27.06

Area is given for one endwall.
Double area shown if two endwalls are used.

TO DETERMINE RATIO	$\frac{A}{S \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-23 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION
STANDARD EW-1A**



Area for computing ratio

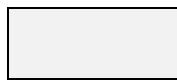
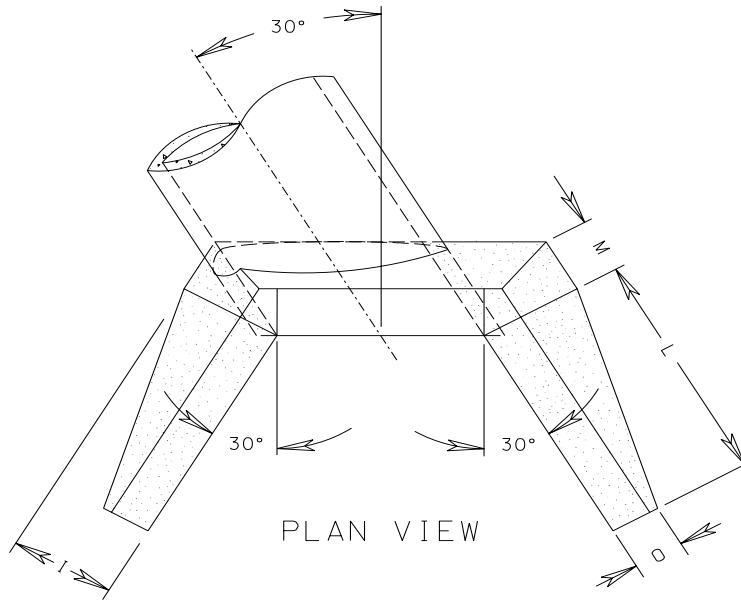
(D) Diameter of Culvert (inches)	Area (A)	
	1 ½ : 1 Slope	2 : 1 Slope
	Sq. Ft.	Sq. Ft.
48	27.31	33.95
54	33.43	41.64
60	40.07	50.05
66	47.38	59.29
72	55.29	69.25
78	63.74	80.00
84	72.80	91.55

(S) Span of Culvert (inches)	Area (A)	
	1 ½ : 1 Slope	2 : 1 Slope
	Sq. Ft.	Sq. Ft.
60	23.31	28.88
68	23.31	28.88
76	27.31	33.95
83	33.43	41.64
91	40.07	50.05
98	47.38	59.29
106	55.29	69.25

Area is given for one endwall.
Double area shown if two endwalls are used.

TO DETERMINE RATIO	$\frac{A}{D \text{ or } S \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

TABLE D-24 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARDS EW-2, EW-2A



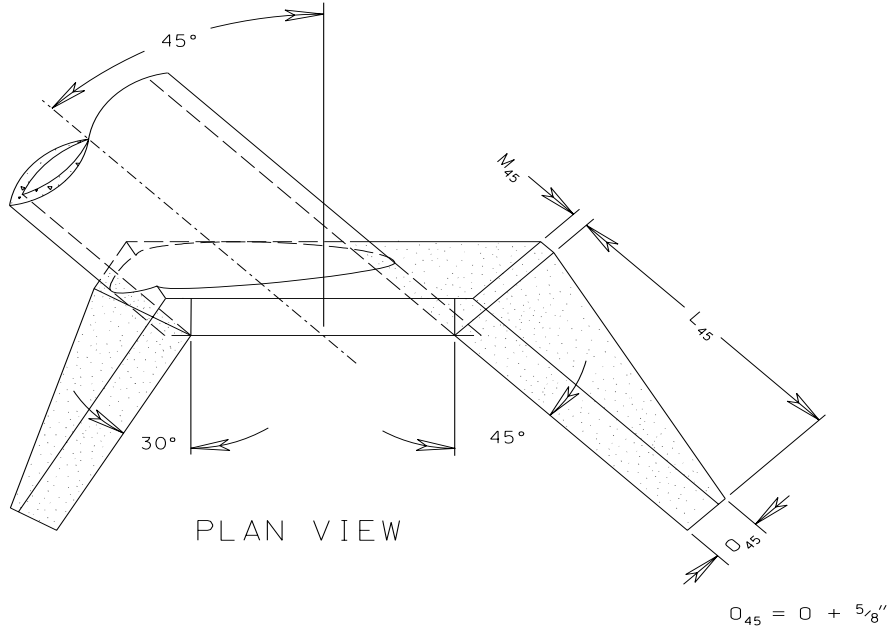
Area for computing ratio

(D) Diameter of Culvert (inches)	Area (A)	
	1 ½ : 1 Slope Sq. Ft.	2 : 1 Slope Sq. Ft.
48	27.31	33.95
54	33.43	41.64
60	40.07	50.05
66	47.38	59.29
72	55.29	69.25
78	63.74	80.00
84	72.80	91.55

Area is given for one endwall.
Double area shown if two endwalls are used.

TO DETERMINE RATIO	$\frac{A}{D \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-25 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION
STANDARD EW-2S (30°)**



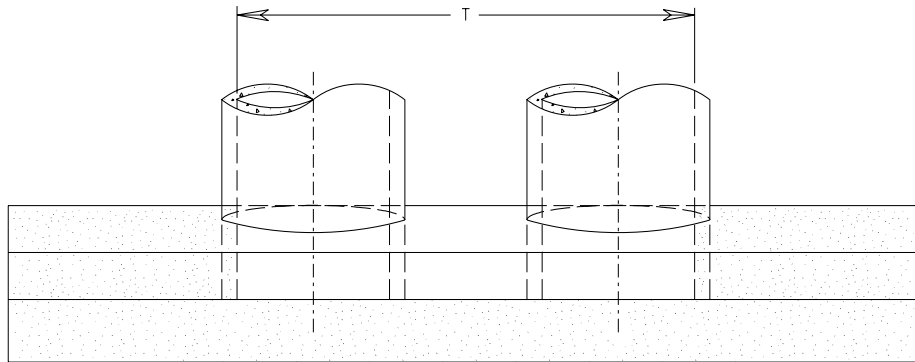
Area for computing ratio

(D) Diameter of Culvert (inches)	Area (A)	
	1 ½ : 1 Slope Sq. Ft.	2 : 1 Slope Sq. Ft.
48	32.23	40.50
54	39.37	49.45
60	47.31	59.51
66	55.90	70.43
72	65.20	82.30
78	75.25	95.11
84	85.96	108.84

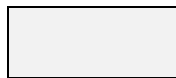
Area is given for one endwall.
Double area shown if two endwalls are used.

TO DETERMINE RATIO	$\frac{A}{D \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-26 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION
STANDARD EW-2S (45°)**



PLAN VIEW



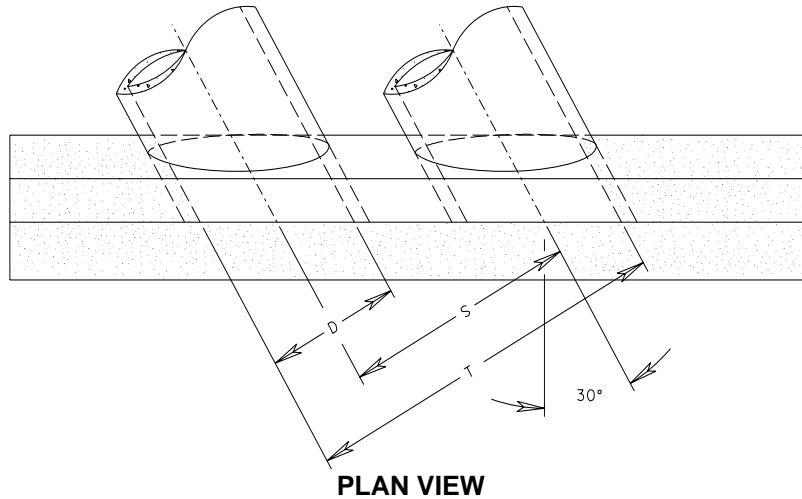
Area for computing ratio

(D) Diameter of Culvert (inches)	Area (A)					
	Double Line		Triple Line		Quadruple Line	
	Conc.	C.M.	Conc.	C.M.	Conc.	C.M.
	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.
15			8.18	8.52	9.94	9.50
18	9.96	9.79	11.29	10.96	12.63	12.13
24	16.67	16.39	19.00	18.44	21.33	20.50
30	23.88	23.50	27.13	26.38	30.38	29.25
36	30.88	30.44	34.75	33.88	38.63	37.31
	Culvert Width (T)					
	Feet	Feet	Feet	Feet	Feet	Feet
15			5.75	5.17	8.00	7.13
18	4.17	3.83	6.83	6.17	9.50	8.50
24	5.50	5.08	9.00	8.17	12.50	11.25
30	6.83	6.33	11.17	10.17	15.50	14.00
36	8.17	7.58	13.33	12.17	18.50	16.75

Area is given for one endwall.
Double area shown if two endwalls are used.

TO DETERMINE RATIO	$\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-27 COMPUTATION OF RATIOS FOR MINOR STRUCTURE
EXCAVATION STANDARD EW-6**



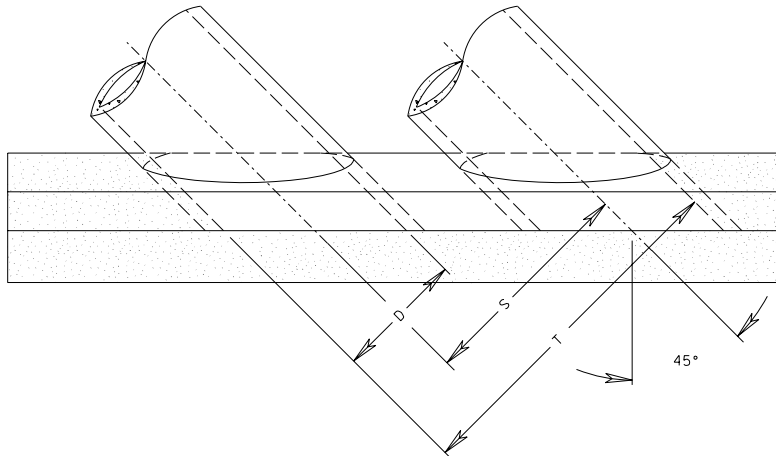
Area for computing ratio

(D) Diameter of Culvert (inches)	Area (A)					
	Double Line		Triple Line		Quadruple Line	
	Conc. Sq. Ft.	C.M. Sq. Ft.	Conc. Sq. Ft.	C.M. Sq. Ft.	Conc. Sq. Ft.	C.M. Sq. Ft.
15			8.94	8.61	10.23	9.74
18	9.88	9.69	11.43	11.04	12.98	12.40
24	16.56	16.25	19.26	18.63	21.95	21.00
30	23.69	23.27	27.44	26.59	31.18	29.91
36	30.44	30.04	34.81	34.01	39.17	37.97
	Culvert Width (T)					
	Feet	Feet	Feet	Feet	Feet	Feet
15			5.75	5.17	8.00	7.13
18	4.17	3.83	6.83	6.17	9.50	8.50
24	5.50	5.08	9.00	8.17	12.50	11.25
30	6.83	6.33	11.17	10.17	15.50	14.00
36	8.17	7.58	13.33	12.17	18.50	16.75

Area is given for one endwall.
Double area shown if two endwalls are used.

TO DETERMINE RATIO	$\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

TABLE D-28 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-6S (30°)



PLAN VIEW



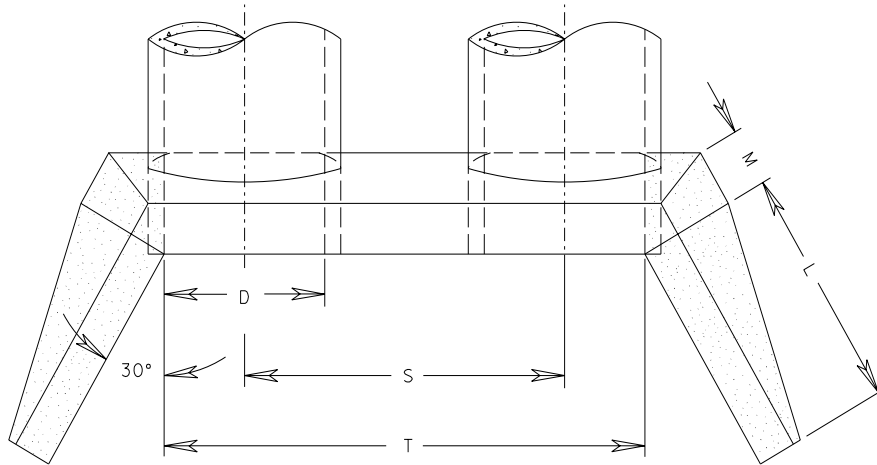
Area for computing ratio

(D) Diameter of Culvert (inches)	Area (A)					
	Double Line		Triple Line		Quadruple Line	
	Conc.	C.M.	Conc.	C.M.	Conc.	C.M.
	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.	Sq. Ft.
15			9.17	8.78	10.75	10.16
18	9.73	9.50	11.62	11.16	13.50	12.81
24	16.39	16.01	19.68	18.92	22.98	21.84
30	23.40	22.87	27.99	26.92	32.58	30.98
36	29.98	29.37	35.45	34.22	40.92	39.08
	Culvert Width (T)					
	Feet	Feet	Feet	Feet	Feet	Feet
15			5.75	5.17	8.00	7.13
18	4.17	3.83	6.83	6.17	9.50	8.50
24	5.50	5.08	9.00	8.17	12.50	11.25
30	6.83	6.33	11.17	10.17	15.50	14.00
36	8.17	7.58	13.33	12.17	18.50	16.75

Area is given for one endwall.
Double area shown if two endwalls are used.

TO DETERMINE RATIO	$\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

TABLE D-29 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-6S (45°)



PLAN VIEW



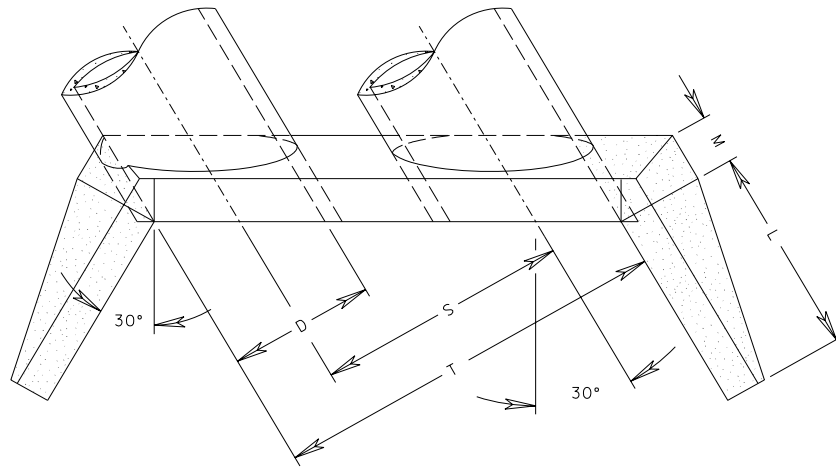
Area for computing ratio

(D) Diameter of Culvert (inches)	Area (A)		Culvert width (T)					
	1 ½ : 1 Slope Sq. Ft.	2 : 1 Slope Sq. Ft.	Double Line		Triple Line		Quadruple Line	
			Conc. Feet	C.M. Feet	Conc. Feet	C.M. Feet	Conc. Feet	C.M. Feet
42	23.31	28.88	9.50	8.79	15.50	14.08	21.50	19.37
48	27.31	33.95	10.83	10.04	17.67	16.08	24.50	22.12
54	33.43	41.64	12.17	11.29	19.83	18.08	27.50	24.87
60	40.07	50.05	13.50	12.54	22.00	20.08	30.50	27.62
66	47.38	59.29	14.83	13.79	24.17	22.08	33.50	30.37
72	55.29	69.25	16.17	15.04	26.33	24.08	36.50	33.12
78	63.74	80.00	17.50	16.29	28.50	26.08	39.50	35.87
84	72.80	91.55	18.83	17.54	30.67	28.08	42.50	38.62

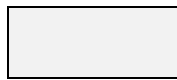
Area is given for one endwall.
Double area shown if two endwalls are used.

TO DETERMINE RATIO	$\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-30 COMPUTATION OF RATIOS FOR MINOR STRUCTURE
EXCAVATION STANDARD EW-7S**



PLAN VIEW



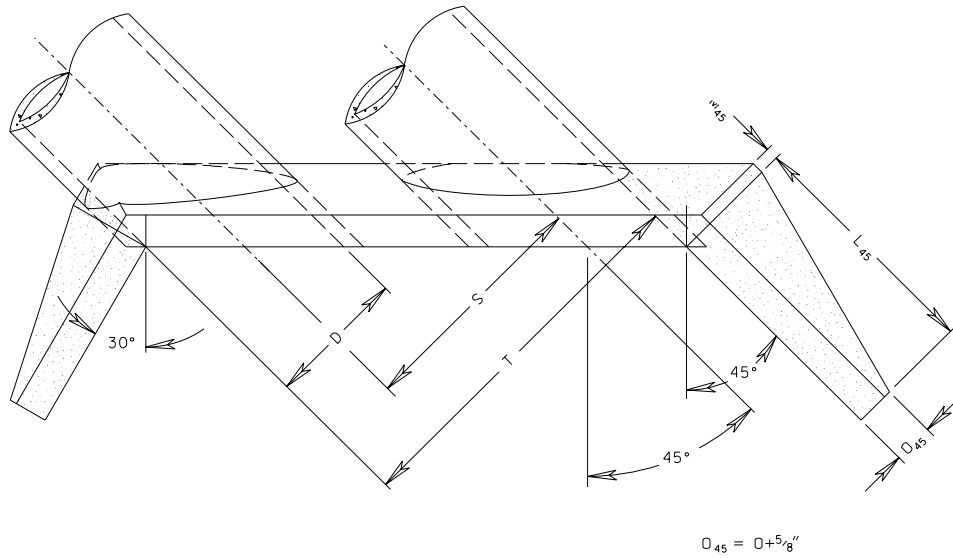
Area for computing ratio

(D) Diameter of Culvert (inches)	Area (A)		Culvert width (T)					
	1 ½ : 1 Slope Sq. Ft.	2 : 1 Slope Sq. Ft.	Double Line		Triple Line		Quadruple Line	
			Conc. Feet	C.M. Feet	Conc. Feet	C.M. Feet	Conc. Feet	C.M. Feet
42	23.31	28.88	9.50	8.79	15.50	14.08	21.50	19.37
48	27.31	33.95	10.83	10.04	17.67	16.08	24.50	22.12
54	33.43	41.64	12.17	11.29	19.83	18.08	27.50	24.87
60	40.07	50.05	13.50	12.54	22.00	20.08	30.50	27.62
66	47.38	59.29	14.83	13.79	24.17	22.08	33.50	30.37
72	55.29	69.25	16.17	15.04	26.33	24.08	36.50	33.12
78	63.74	80.00	17.50	16.29	28.50	26.08	39.50	35.87
84	72.80	91.55	18.83	17.54	30.67	28.08	42.50	38.62

Area is given for one endwall.
Double area shown if two endwalls are used.

TO DETERMINE RATIO	$\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-31 COMPUTATION OF RATIOS FOR MINOR STRUCTURE
EXCAVATION STANDARD EW-7S (30°)**



PLAN VIEW



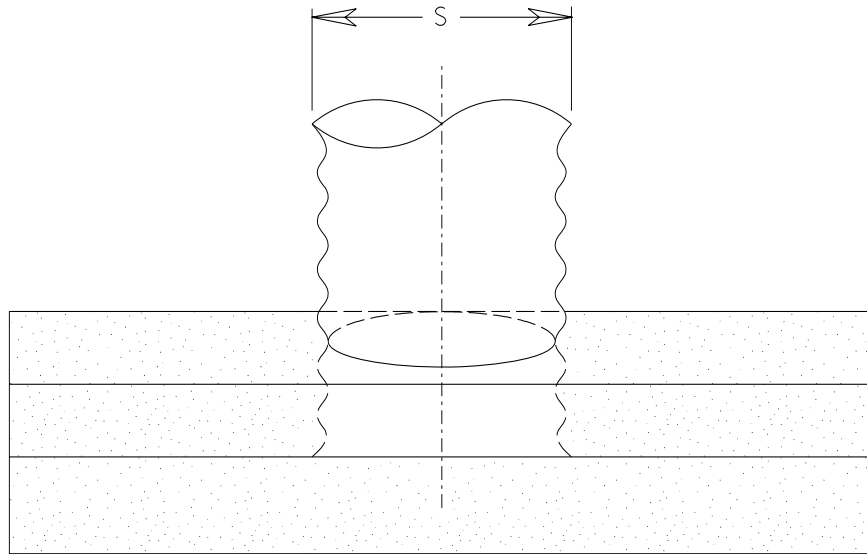
Area for computing ratio

(D) Diameter of Culvert (inches)	Area (A)		Culvert width (T)					
	1 ½ : 1 Slope	2 : 1 Slope	Double Line		Triple Line		Quadruple Line	
	Sq. Ft.	Sq. Ft.	Conc. Feet	C.M. Feet	Conc. Feet	C.M. Feet	Conc. Feet	C.M. Feet
42	27.37	34.10	9.50	8.79	15.50	14.08	21.50	19.37
48	32.23	40.50	10.83	10.04	17.67	16.08	24.50	22.12
54	39.37	49.45	12.17	11.29	19.83	18.08	27.50	24.87
60	47.31	59.51	13.50	12.54	22.00	20.08	30.50	27.62
66	55.90	70.43	14.83	13.79	24.17	22.08	33.50	30.37
72	65.20	82.30	16.17	15.04	26.33	24.08	36.50	33.12
78	75.25	95.11	17.50	16.29	28.50	26.08	39.50	35.87
84	85.96	108.84	18.83	17.54	30.67	28.08	42.50	38.62

Area is given for one endwall.
Double area shown if two endwalls are used.

TO DETERMINE RATIO	$\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-32 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION
STANDARD EW-7S (45°)**



PLAN VIEW



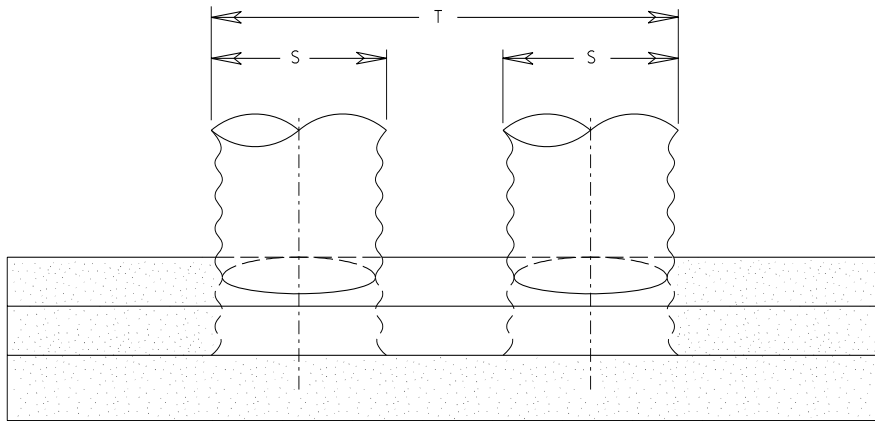
Area for computing ratio

(S) Span of Culvert (inches)	Area (A)
	Sq. Ft.
49	22.65
*46	23.08
57	28.54
*53	29.21

Area is given for one endwall.
 Double area shown if two endwalls are used
 * 3"x1" corrugation dimension.

TO DETERMINE RATIO	$\frac{A}{S \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-33 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION
 STANDARD EW-9**



PLAN VIEW



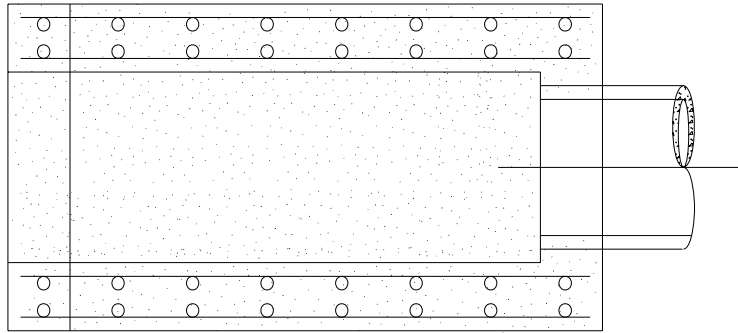
Area for computing ratio

(S) Span of Culvert (inches)	Area (A)			Culvert Width (T)		
	Double Line	Triple Line	Quadruple Line	Double Line	Triple Line	Quadruple Line
	Sq. Ft.	Sq. Ft	Sq. Ft	Feet	Feet	Feet
21	6.47	7.65	8.83	4.58	7.42	10.25
24	8.93	10.34	11.75	5.08	8.17	11.25
28	11.04	12.75	14.46	5.75	9.17	12.58
35	16.71	19.38	22.04	6.92	10.92	14.92
42	23.33	26.96	30.58	8.33	13.17	18.00
*40	23.63	27.25	30.88	8.17	13.00	17.83
49	27.04	31.23	35.42	9.67	15.25	20.83
*46	27.48	31.67	35.85	9.42	15.00	20.58
57	33.42	38.29	43.17	11.25	17.75	24.25
*53	34.08	38.96	43.83	10.92	17.42	23.92

Area is given for one endwall.
 Double area shown if two endwalls are used
 * 3"x1" corrugation dimension.

TO DETERMINE RATIO	$\frac{A}{T \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-34 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION
 STANDARD EW-10**



PLAN VIEW

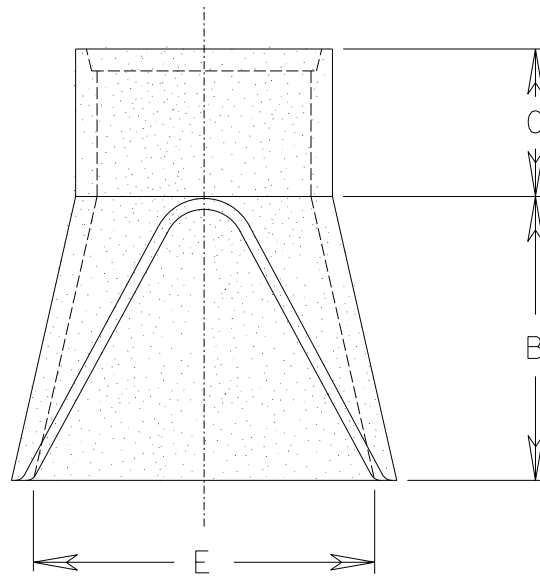


Area for computing ratio

(D) Diameter of Culvert (inches)	Area (A)		
	3:1 Slope	4:1 Slope	6:1 Slope
	Sq. Ft	Sq. Ft.	Sq. Ft
48	114.42	150.00	221.17
54	143.83	188.83	278.83
60	156.33	205.67	304.33

TO DETERMINE RATIO	$\frac{A}{D \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-35 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION
STANDARD EW-11**



PLAN VIEW



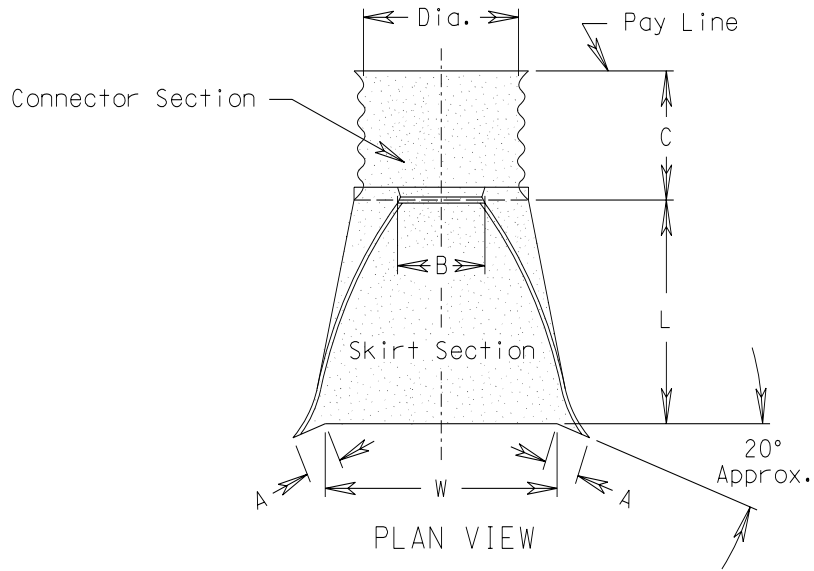
Area for computing ratio

(D) Diameter of Culvert (inches)	Area (A)
	Sq. Ft.
48	48.47
54	52.47
60	57.00

Area is given for one endwall.
Double area shown if two endsections are used

TO DETERMINE RATIO	$\frac{A}{D \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-36 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION
STANDARD ES-1**



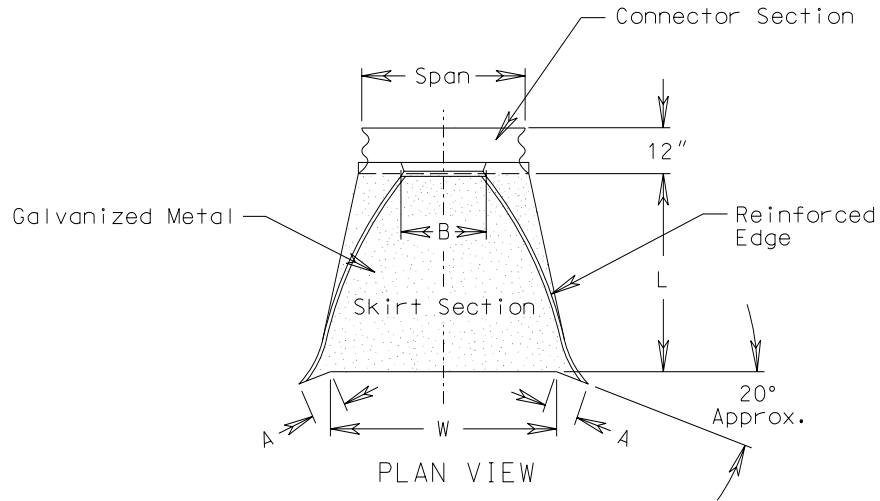
Area for computing ratio

(D) Diameter of Culvert (inches)	Area (A)
	Sq. Ft.
48	53.64
54	67.84
60	76.63

Area is given for one endwall.
Double area shown if two endsections are used

TO DETERMINE RATIO	$\frac{A}{D \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-37 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION
STANDARD ES-2**



Area for computing ratio

(S) Span of Culvert (inches)	Area (A)
	Sq. Ft.
	3" x 1" Corr.
46	28.31
53	37.63
60	48.03
66	59.27

(S) Span of Culvert (inches)	Area (A)
	Sq. Ft
	2 2/3" X 1/2" Corr.
49	28.92
57	38.58
64	49.07
71	60.70

Area is given for one end section.
Double area shown if two end sections are used

TO DETERMINE RATIO	$\frac{A}{S \text{ (in feet)} \times \text{Length of Culvert}}$
-----------------------	---

**TABLE D-38 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION
STANDARD ES-3**

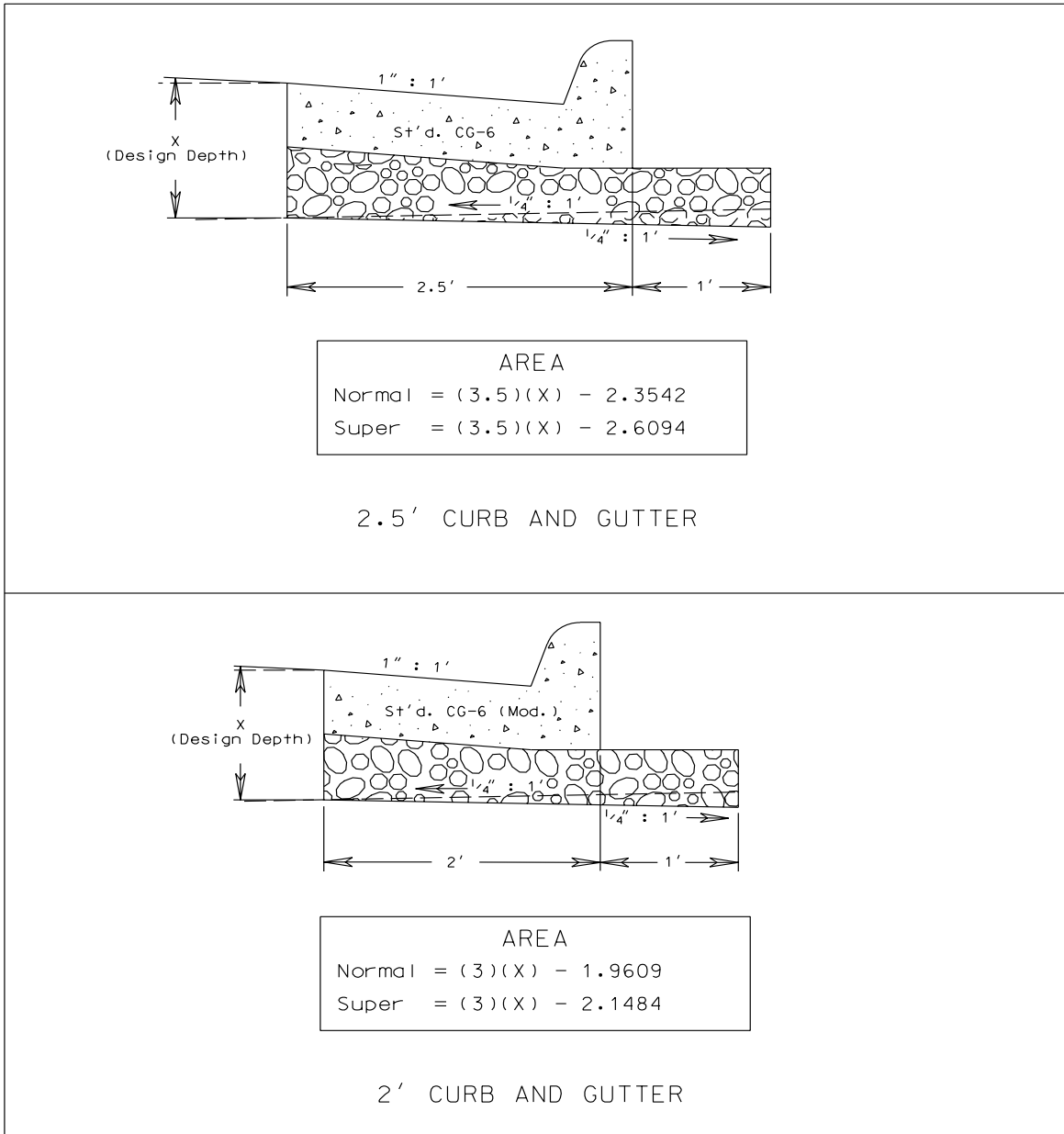
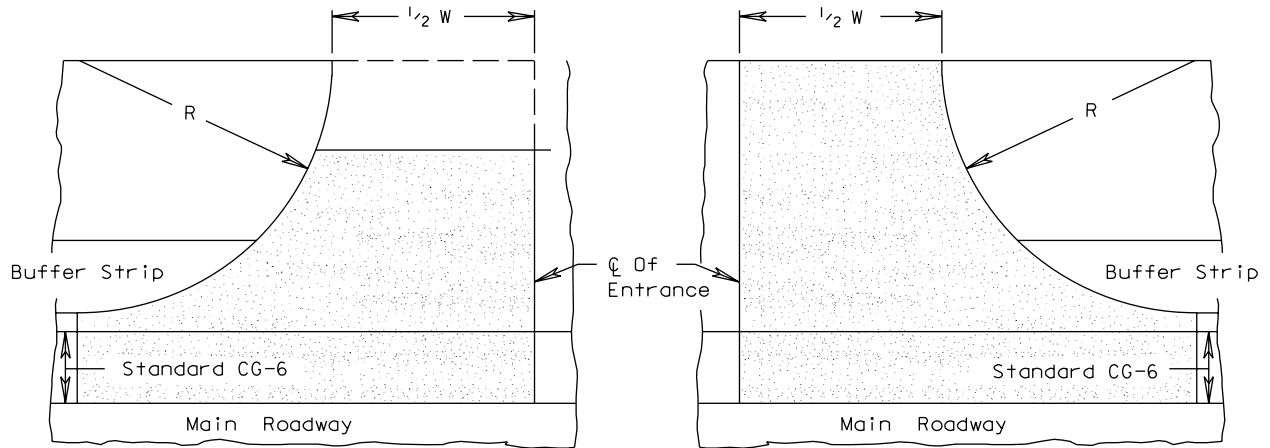


FIGURE D-2 SUBBASE END AREAS AT CURB AND GUTTER LOCATION



**HALF PLAN
AREA WITHOUT SIDEWALK**

**HALF PLAN
AREA WITH SIDEWALK**

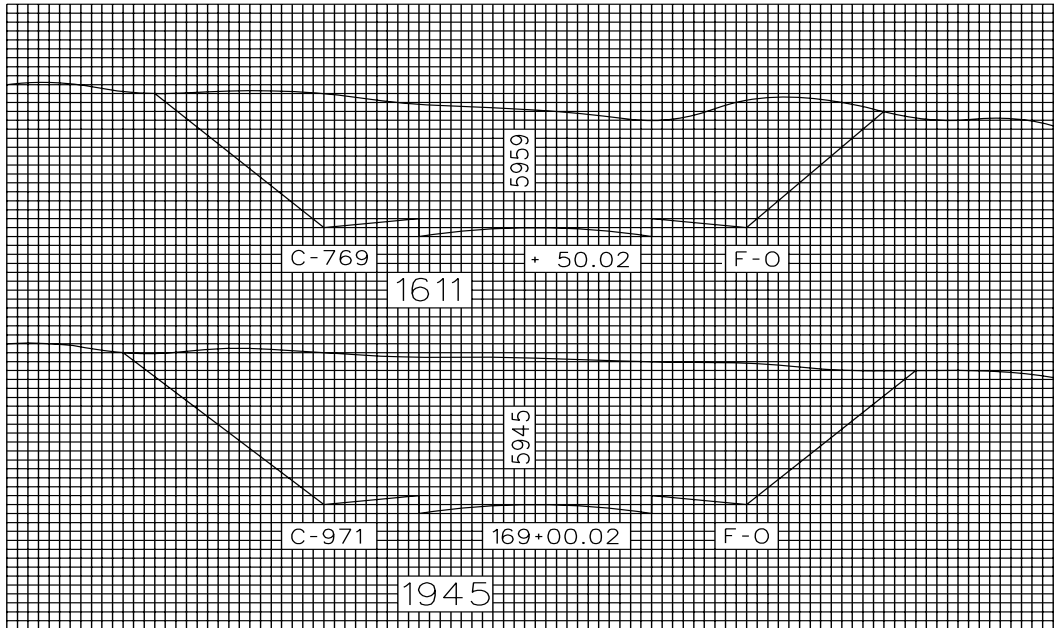
W= Width of Entrance



Area for computing ratio

Width Of Entrance (Feet)	R = 6'		R = 7'		R = 8.5'	
	2' Buffer Strip		2' Buffer Strip		2' Buffer Strip	
	Without Sidewalk	With 4' Sidewalk	Without Sidewalk	With 5' Sidewalk	Without Sidewalk	With 5' Sidewalk
	Sq. Yds.	Sq. Yds.	Sq. Yds.	Sq. Yds.	Sq. Yds.	Sq. Yds.
12	14.36	16.39	15.47	18.90	17.21	22.84
16	17.47	20.16	18.59	23.12	20.32	27.73
20	20.58	23.94	21.70	27.34	23.43	32.62
24	23.70	27.72	24.81	31.56	26.55	37.51
25	24.47	28.66	25.59	32.62	27.32	38.73
26	25.25	29.61	26.36	33.67	28.10	39.95
30	28.36	33.39	29.47	37.89	31.21	44.84
36	33.03	39.05	34.14	44.23	35.88	52.17
40	36.14	42.83	37.25	48.45	38.99	57.06
42	37.70	44.72	38.81	50.56	40.55	59.50
44	39.25	46.61	40.36	52.67	42.10	61.95
48	42.36	50.39	43.47	56.89	45.21	66.84
50	43.92	52.28	45.03	59.01	46.77	69.29
Each Additional Foot	0.778	0.944	0.778	1.056	0.778	1.222

TABLE D-39 AREAS FOR ENTRANCE GUTTER STANDARD CG-9D



The cut area of station 163+00.02 is 971 square feet, and the area of station 169+50.02 is 769 square feet. To find the average area of the two, we would add the two and divide by two.

$$\text{Thus, } \frac{971 + 769}{2} = \frac{1740}{2} = 870 \text{ Sq. Ft. (average)}$$

Now we must find the volume of the area between the two stations. The cross section has an average of 870 square feet and there is 50 feet between stations. Therefore, 870 multiplied by 50 equals 43,500 cubic feet to be removed from between these stations.

In order to arrive at 1611 cubic yards (this is the unit used as a basis of payment in earthwork) we divide the 43,500 cubic feet by 27, since there are twenty-seven cubic feet in one cubic yard.

The formula used to determine the volume of earthwork is called the AVERAGE END AREA METHOD and is noted below. Examine it closely.

$$\text{Volume} = \frac{L (A' + A'')}{2 \times 27}$$

L = distance between stations
 A' = area of one station
 A'' = area of second station
 2 gets the average of A' & A''
 27 converts cubic feet to cubic yards

EXAMPLE

$$\text{Volume} = \frac{50 (971 + 769)}{2 \times 27} = 1611$$

FIGURE D-4 EARTHWORK QUANTITY COMPUTATIONS