

## APPENDIX D IMPERIAL LIST OF TABLES

	Page
TABLE D-1 CULVERT OUTLET PROTECTION W/ ST'D. ES-1 END SECTIONS...	D-1
TABLE D-2 CULVERT OUTLET PROTECTION W/ ST'D. ES-2 END SECTIONS...	D-1
TABLE D-3 CULVERT OUTLET PROTECTION W/ ST'D. ES-3 END SECTIONS...	D-2
TABLE D-4 CULVERT OUTLET PROTECTION W/ ST'D. EW-1 ENDWALLS .....	D-3
TABLE D-5 CULVERT OUTLET PROTECTION W/ ST'D. EW-6 ENDWALLS .....	D-3
TABLE D-6 CULVERT OUTLET PROTECTION WITH ST'D. EW-2S AND EW-7S ENDWALLS (30° SKEW) .....	D-4
TABLE D-7 CULVERT OUTLET PROTECTION WITH ST'D. EW-2 ENDWALLS 5 (30° SKEW) .....	D-5
TABLE D-8 CULVERT OUTLET PROTECTION WITH ST'D. EW-7 ENDWALLS 5 (30° SKEW) .....	D-5
TABLE D-9 CULVERT OUTLET PROTECTION WITH ST'D. EW-2S ENDWALLS 6 (30° SKEW) .....	D-6
TABLE D-10 CULVERT OUTLET PROTECTION WITH ST'D. EW-7S ENDWALLS 6 (30° SKEW) .....	D-6
TABLE D-11 CULVERT OUTLET PROTECTION WITH ST'D. EW-2S ENDWALLS 7 (45° SKEW) .....	D-7
TABLE D-12 CULVERT OUTLET PROTECTION WITH ST'D. EW-7S ENDWALLS 7 (45° SKEW) .....	D-7
TABLE D-13 CULVERT OUTLET PROTECTION W/ ST'D. EW-2A ENDWALLS....	D-8
TABLE D-14 CULVERT OUTLET PROTECTION W/ ST'D. EW-9 PIPE ARCHES..	D-9
TABLE D-15 CULVERT OUTLET PROTECTION W/ ST'D. EW-10 PIPE ARCHES	D-9
TABLE D-16 CULVERT OUTLET PROTECTION FOR BOX CULVERT ST'D BCS-02 THRU BCS-50 (NO SKEW) .....	D-10
TABLE D-17 CULVERT OUTLET PROTECTION FOR BOX CULVERT ST'D BCS-02 THRU BCS-50 (15° SKEW) .....	D-11
TABLE D-18 CULVERT OUTLET PROTECTION FOR BOX CULVERT ST'D BCS-02 THRU BCS-50 (30° SKEW) .....	D-12
TABLE D-19 CULVERT OUTLET PROTECTION FOR BOX CULVERT ST'D BCS-02 THRU BCS-50 (45° SKEW) .....	D-13
TABLE D-20 CULVERT OUTLET PROTECTION FOR MULTIPLE BOX CULVERT (INCREMENTS FOR EACH ADDITIONAL BARREL) .....	D-14
TABLE D-21 CULVERT OUTLET PROTECTION FOR MULTIPLE BOX CULVERT (INCREMENTS FOR EACH ADDITIONAL BARREL) .....	D-15
FIGURE D-1 COMPUTATIONS FOR STANDARD JB-1 JUNCTION BOX	
TABLE D-22 ADJUSTMENT QUANTITIES FOR JUNCTION BOX.....	D-16
TABLE D-23 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-1A .....	D-17
TABLE D-24 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARDS EW-2, EW-2A .....	D-18
TABLE D-25 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-2S (30° ) .....	D-19

TABLE D-26 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-2S (45° ) .....	D-20
TABLE D-27 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-6.....	D-21
TABLE D-28 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-6S (30° ) .....	D-22
TABLE D-29 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-6S (45°) .....	D-23
TABLE D-30 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-7S .....	D-24
TABLE D-31 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-7S (30°) .....	D-25
TABLE D-32 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-7S (45°) .....	D-26
TABLE D-33 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-9.....	D-27
TABLE D-34 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-10.....	D-28
TABLE D-35 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD EW-11.....	D-29
TABLE D-36 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD ES-1 .....	D-30
TABLE D-37 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD ES-2 .....	D-31
TABLE D-38 COMPUTATION OF RATIOS FOR MINOR STRUCTURE EXCAVATION STANDARD ES-3 .....	D-32
FIGURE D-2 SUBBASE END AREAS AT CURB AND GUTTER LOCATION .....	D-33
TABLE D-39 AREAS FOR ENTRANCE GUTTER STANDARD CG-9D .....	D-34
FIGURE D-4 EARTHWORK QUANTITY COMPUTATIONS .....	D-35

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	1.59	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	14.38	7.19	9.59	14.38	13.51	6.76	9.01	13.51
42	19.29	9.64	12.86	19.29	18.10	9.05	12.07	18.10
48	24.82	12.41	16.55	24.82	23.29	11.65	15.53	23.95
54	31.21	15.61	20.81	31.21	29.26	14.63	19.51	29.26
60	38.34	19.17	25.56	38.34	35.92	17.96	23.95	35.92

**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")
		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	1.78	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	15.76	7.88	10.51	15.76	14.86	7.43	9.91	14.86
42	21.43	10.72	14.29	21.43	20.20	10.10	13.47	20.20
48	27.57	13.78	18.38	27.57	25.96	12.98	17.31	25.96
54	34.66	17.33	23.11	34.66	32.65	16.33	21.77	32.65
60	42.64	21.32	28.43	42.64	40.14	20.07	26.76	40.14

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

\* Rev. 7/08

PIPE ARCH 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.
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	15.48	7.74	10.32	15.48	14.46	7.23	9.64	14.46
49 x 33	20.53	10.27	13.69	20.53	19.15	9.58	12.77	19.15
57 x 38	27.36	13.68	18.24	27.36	25.51	12.76	17.01	25.51
64 x 43	35.02	17.51	23.35	35.02	32.68	16.68	21.79	32.68
71 x 47	42.94	21.47	28.63	42.94	40.05	20.05	26.70	40.05

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

\* Rev. 7/08

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	9.96	4.98	6.64	9.96	9.46	4.73	6.31	9.46

**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	4.74	4.20	2.37	2.10	3.16	2.80	4.74	4.20

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

\* Rev. 7/08

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.
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)\***

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\* Rev. 7/08

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	16.20	8.10	10.80	16.20	15.10	7.55	10.07	15.10
48	21.18	10.59	14.12	21.18	19.74	9.87	13.16	19.74
54	26.83	13.42	17.89	26.83	25.00	12.50	16.67	25.00
60	33.15	16.57	22.10	33.15	30.88	15.44	20.59	30.88
66	40.41	20.20	26.94	40.41	37.39	18.70	24.93	37.39
72	47.80	23.90	31.87	47.80	44.52	22.26	29.68	44.52
78	56.13	28.06	37.42	56.13	52.13	26.14	34.85	52.27
84	65.11	32.56	43.41	65.11	60.64	32.32	40.43	60.64

**TABLE D-7 CULVERT OUTLET PROTECTION WITH ST'D. EW-2 ENDWALLS  
(30° 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	7.00	3.50	4.67	7.00
48	9.10	4.55	6.07	9.10
54	11.50	5.75	7.67	11.50
60	14.16	7.08	9.44	14.16
66	17.11	8.56	11.41	17.11
72	20.34	10.17	13.56	20.34
78	23.83	11.92	15.89	23.83
84	27.61	13.81	18.41	27.61

**TABLE D-8 CULVERT OUTLET PROTECTION WITH ST'D. EW-7 ENDWALLS  
(30° SKEW)\***

\* Rev. 7/08

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	16.83	8.41	11.22	16.83	15.73	7.87	10.49	15.73
48	22.00	11.00	14.67	22.00	20.56	10.28	13.71	20.56
54	27.88	13.94	18.59	27.88	26.05	13.03	17.37	26.05
60	34.45	17.23	22.97	34.45	32.19	16.09	21.46	32.19
66	41.97	20.98	27.98	41.97	38.95	19.48	25.97	38.95
72	49.66	24.83	33.11	49.66	46.38	23.19	30.92	46.38
78	58.32	29.16	38.88	58.32	54.46	27.23	36.31	54.46
84	67.65	33.82	45.10	67.65	63.16	31.58	42.11	63.16

**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	8.08	4.04	5.39	8.08
48	10.50	5.25	7.00	10.50
54	13.29	6.64	8.86	13.29
60	16.35	8.17	10.90	16.35
66	19.77	9.88	13.18	19.77
72	23.49	11.74	15.66	23.49
78	27.51	13.75	18.34	27.51
84	31.89	15.94	21.26	31.89

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

\* Rev. 7/08



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	19.54	9.77	13.03	19.54	18.84	9.42	12.56	18.84
48	25.53	12.76	17.02	25.53	24.61	12.31	16.41	24.61
54	32.32	16.16	21.55	32.32	31.15	15.58	20.77	31.15
60	39.91	19.96	26.61	39.91	38.46	19.23	25.64	38.46
66	48.24	24.12	32.16	48.24	46.54	23.27	31.03	46.54
72	57.48	28.74	38.32	57.48	55.39	27.70	36.93	55.39
78	67.45	33.73	44.97	67.45	64.99	32.50	43.33	64.99
84	78.24	39.12	52.16	78.24	75.37	37.69	50.25	75.37

**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	9.91	4.96	6.61	9.91
48	12.88	6.44	8.59	12.88
54	16.27	8.14	10.85	16.27
60	20.02	10.01	13.35	20.02
66	24.19	12.10	16.13	24.19
72	28.75	14.38	19.17	28.75
78	33.70	16.85	22.47	33.70
84	39.06	19.53	26.04	39.06

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

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	21.54	10.77	14.36	21.54	19.18	9.59	12.79	19.18
68 x 43	28.26	14.13	18.84	28.26	25.30	12.65	16.87	25.30
76 x 48	35.20	17.60	23.47	35.20	31.48	15.74	20.99	31.48
83 x 53	42.53	42.30	28.20	42.30	37.83	18.91	25.22	37.83
91 x 58	50.71	25.36	33.81	50.71	45.30	22.65	30.20	45.30
98 x 63	59.97	29.98	39.98	59.97	52.84	26.42	35.23	52.84
106 x 68	69.04	34.52	46.03	69.04	61.63	30.32	41.09	61.63

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

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\* Rev. 7/08

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	16.66	8.33	11.11	16.66	15.82	7.91	10.55	15.82

**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.	Conc.	Conc.	Conc.
	Sq. Yds.	Cu. Yds.	Cu. Yds.	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	6.31	3.16	4.21	6.31

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

\* Rev. 7/08

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	14.32	7.16	9.55	14.32	13.92	6.96	9.28	13.92
3 x 4	19.65	9.82	13.10	19.65	19.63	9.82	13.09	19.63
4 x 3	19.42	9.71	12.95	19.42	18.21	9.10	12.14	18.21
4 x 4	25.51	12.76	17.01	25.51	24.90	12.45	16.60	24.90
4 x 5	32.55	16.27	21.70	32.55	32.49	16.24	21.66	32.49
4 x 6	39.87	19.93	26.58	39.87	41.08	20.54	27.39	41.08
5 x 3	25.29	12.64	16.86	25.29	23.16	11.58	15.44	23.16
5 x 4	32.14	16.07	21.43	32.14	30.40	15.20	50.27	30.40
5 x 5	39.93	19.96	26.62	39.93	38.74	19.37	25.83	38.74
5 x 6	48.19	24.10	32.13	48.19	48.04	24.02	32.03	48.04
5 x 7	57.63	28.81	38.42	57.63	58.27	29.14	38.85	58.27
6 x 4	39.51	19.75	26.34	39.51	36.66	18.33	24.44	36.66
6 x 5	48.06	24.03	32.04	48.06	45.63	22.81	30.42	45.63
6 x 6	57.27	28.63	38.18	57.27	55.65	27.82	37.10	55.65
6 x 7	67.47	33.73	44.98	67.47	66.61	33.31	44.41	66.61
6 x 8	77.86	38.93	51.91	77.86	78.52	39.26	52.35	78.52
7 x 4	47.65	23.83	31.77	47.65	43.65	21.82	29.10	43.65
7 x 6	67.20	33.60	44.80	67.20	63.91	31.96	42.61	63.91
7 x 8	89.97	44.98	59.98	89.97	88.24	44.12	58.83	88.24
7 x 10	114.52	57.26	76.35	114.52	115.21	57.61	76.81	115.21
8 x 4	56.53	28.27	37.69	56.53	51.30	25.65	34.20	51.30
8 x 6	77.80	38.90	51.87	77.80	72.85	36.43	48.57	72.85
8 x 8	102.07	51.04	68.05	102.07	99.10	49.55	66.07	99.10
8 x 10	128.52	64.26	85.68	128.52	128.17	64.09	85.45	128.17
9 x 4	66.18	33.09	44.12	66.18	59.59	29.80	39.73	59.59
9 x 6	89.34	44.67	59.56	89.34	82.59	41.29	55.06	82.59
9 x 8	114.93	57.46	76.62	114.93	109.95	54.97	73.30	109.95
9 x 10	143.26	71.63	95.51	143.26	140.65	70.33	93.77	140.65
9 x 12	174.63	83.31	116.42	174.63	175.42	87.71	116.95	175.42
10 x 4	76.59	38.29	51.06	76.59	68.55	34.27	45.70	68.55
10 x 6	101.64	50.82	67.76	101.64	92.98	46.49	61.99	92.98
10 x 8	128.55	64.27	85.70	128.55	121.47	60.73	80.98	121.47
10 x 10	159.25	79.63	106.17	159.25	154.39	77.20	102.93	154.39
10 x 12	192.78	96.39	128.52	192.78	191.11	95.55	127.40	191.11
12 x 6	127.63	63.82	85.09	127.63	115.06	57.53	76.71	115.06
12 x 8	158.44	79.22	105.63	158.44	146.67	73.33	97.78	146.67
12 x 10	192.25	96.13	128.17	192.25	182.53	91.27	121.69	182.53
12 x 12	229.66	114.83	153.11	229.66	222.61	111.31	148.41	222.61

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

\* Rev. 7/08

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
	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.	Sq. Yds.	Cu. Yds.	Cu. Yds.	Cu. Yds.
3 x 3	14.43	7.21	9.62	14.43	14.02	7.01	9.35	14.02
3 x 4	19.80	9.90	13.20	19.80	19.77	9.88	13.18	19.77
4 x 3	19.56	9.78	13.04	19.56	18.36	9.18	12.24	18.36
4 x 4	25.71	12.85	17.14	25.71	25.08	12.54	16.72	25.08
4 x 5	32.79	16.39	21.86	32.79	32.76	16.38	21.84	32.76
4 x 6	40.15	20.08	26.77	40.15	41.37	20.68	27.58	41.37
5 x 3	25.47	12.73	16.98	25.47	23.34	11.67	15.56	23.34
5 x 4	32.37	16.18	21.58	32.37	30.63	15.31	20.42	30.63
5 x 5	40.23	20.11	26.82	40.23	39.04	19.52	26.03	39.04
5 x 6	48.54	24.27	32.36	48.54	48.39	24.19	32.26	48.39
5 x 7	58.05	29.02	38.70	58.05	58.69	29.35	39.13	58.69
6 x 4	39.79	19.90	26.53	39.79	36.94	18.47	24.63	36.94
6 x 5	48.42	24.21	32.28	48.42	45.99	22.99	30.66	45.99
6 x 6	57.70	28.85	38.47	57.50	56.08	28.04	37.39	56.08
6 x 7	67.96	33.98	45.31	67.96	67.11	33.55	44.74	67.11
6 x 8	78.42	39.21	52.28	78.42	79.09	39.55	52.73	79.09
7 x 4	47.98	23.99	31.99	47.98	43.98	21.99	29.32	43.98
7 x 6	67.69	33.85	45.13	67.69	64.41	32.20	42.94	64.41
7 x 8	90.63	45.31	60.42	90.63	88.90	44.45	59.27	88.90
7 x 10	115.33	57.67	76.89	115.33	116.04	58.02	77.36	116.04
8 x 4	56.91	28.45	37.94	56.91	51.67	25.84	34.45	51.67
8 x 6	78.36	39.18	52.24	78.36	73.41	36.70	48.94	73.41
8 x 8	102.82	51.41	68.55	102.82	99.85	49.93	66.57	99.85
8 x 10	129.46	64.73	86.31	129.46	129.10	64.55	86.07	129.10
9 x 4	66.61	33.31	44.41	66.61	60.01	30.01	40.01	60.01
9 x 6	89.97	44.98	59.98	89.97	83.22	41.61	55.48	83.22
9 x 8	115.78	57.89	77.19	115.78	110.80	55.40	73.87	110.80
9 x 10	144.33	72.16	96.22	144.33	142.20	70.86	94.48	142.20
9 x 12	175.89	87.94	117.26	175.89	176.70	88.35	117.80	176.70
10 x 4	77.05	38.53	51.37	77.05	69.01	34.51	46.01	69.01
10 x 6	102.34	51.17	68.23	102.34	93.69	46.84	62.46	93.69
10 x 8	129.49	64.75	86.33	129.49	122.40	61.20	81.60	122.40
10 x 10	160.42	80.21	106.95	160.42	155.56	77.78	103.71	155.56
10 x 12	194.19	97.09	129.46	194.19	192.51	96.25	128.34	192.51
12 x 6	128.49	64.24	85.66	125.49	115.92	57.96	77.28	115.92
12 x 8	159.57	79.78	106.38	159.57	147.79	73.90	98.53	147.79
12 x 10	193.66	96.83	129.11	193.66	183.94	91.97	122.63	183.94
12 x 12	231.36	115.68	154.24	231.36	224.31	112.15	149.54	224.31

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

\* Rev. 7/08

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	14.89	7.45	9.93	14.89	14.56	7.28	9.71	14.56
3 x 4	20.55	10.27	13.70	20.55	20.77	10.39	13.85	20.77
4 x 3	20.01	10.00	13.34	20.01	18.84	9.42	12.56	18.84
4 x 4	26.58	13.29	17.72	26.58	26.08	13.04	17.39	26.08
4 x 5	34.11	17.05	22.74	34.11	34.50	17.25	23.00	34.50
4 x 6	42.42	21.21	28.28	42.42	44.10	22.05	29.40	44.10
5 x 3	25.89	12.94	17.26	25.89	23.76	11.88	15.84	23.76
5 x 4	33.16	16.58	22.11	33.16	31.53	15.76	21.02	31.53
5 x 5	41.50	20.75	27.67	41.50	40.63	20.32	27.09	40.63
5 x 6	50.68	25.34	33.79	50.68	50.92	25.46	33.95	50.92
5 x 7	60.85	30.43	40.57	60.85	62.20	31.10	41.47	62.20
6 x 4	40.60	20.30	27.07	40.60	37.77	18.88	25.18	37.77
6 x 5	49.66	24.83	33.11	49.66	47.43	23.71	31.62	47.43
6 x 6	59.70	29.85	39.80	59.70	58.41	29.20	38.94	58.41
6 x 7	70.41	35.20	46.94	70.41	70.42	35.21	46.95	70.42
6 x 8	82.21	41.11	54.81	82.21	83.70	41.85	55.80	83.70
7 x 4	48.81	24.40	32.54	48.81	44.74	22.37	29.83	44.74
7 x 6	69.51	34.75	46.34	69.51	66.55	33.28	44.37	66.55
7 x 8	93.97	46.99	62.65	93.97	93.27	46.63	62.18	93.27
7 x 10	121.48	60.74	80.99	121.48	123.90	61.95	82.60	123.90
8 x 4	57.76	28.88	38.51	57.76	52.36	26.18	34.91	52.36
8 x 6	80.10	40.05	53.40	80.10	75.34	37.67	50.23	75.34
8 x 8	105.93	52.96	70.62	105.93	104.08	52.04	69.39	104.08
8 x 10	135.78	67.89	90.52	135.78	136.81	68.41	91.21	136.81
9 x 4	67.47	33.73	44.98	67.47	60.64	30.32	40.43	60.64
9 x 6	91.62	45.81	61.08	91.62	84.99	42.49	56.66	84.99
9 x 8	119.11	59.56	79.41	119.11	114.73	57.37	76.49	114.73
9 x 10	150.37	75.19	100.25	150.37	148.98	74.49	99.32	148.98
9 x 12	184.99	92.50	123.33	184.99	187.86	93.93	125.24	187.86
10 x 4	77.94	38.97	51.96	77.94	69.58	34.79	46.39	69.58
10 x 6	103.90	51.95	69.27	103.90	95.31	47.65	63.54	95.31
10 x 8	132.67	66.34	88.45	132.67	126.13	60.07	84.09	126.13
10 x 10	166.17	83.03	110.78	166.17	162.55	81.28	108.37	162.55
10 x 12	202.96	101.48	135.31	202.96	203.44	101.72	135.63	203.44
12 x 6	129.64	64.82	86.43	129.64	117.04	58.52	78.03	117.04
12 x 8	162.43	81.22	108.29	162.43	150.90	75.45	100.60	150.90
12 x 10	198.78	99.39	132.52	198.78	190.03	95.02	126.69	190.03
12 x 12	239.47	119.74	159.65	239.47	234.36	117.18	156.24	234.36

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

\* Rev. 7/08

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	15.66	7.83	10.44	15.66	15.33	7.66	10.22	15.33
3 x 4	21.58	10.79	14.39	21.58	21.81	10.90	14.54	21.81
4 x 3	21.04	10.52	14.03	21.04	19.87	9.94	13.25	19.87
4 x 4	27.96	13.98	18.64	27.96	27.46	13.73	18.31	27.46
4 x 5	35.85	17.92	23.90	35.85	36.22	18.11	24.15	36.22
4 x 6	44.50	22.25	29.67	44.50	46.17	23.08	30.78	46.17
5 x 3	27.18	13.59	18.12	27.18	20.06	12.53	16.71	20.06
5 x 4	34.90	17.45	23.27	34.90	33.25	16.63	22.17	33.25
5 x 5	43.68	21.84	29.12	43.68	42.79	21.40	28.53	42.79
5 x 6	53.28	26.64	35.52	53.28	53.52	26.76	35.68	53.52
5 x 7	63.88	31.94	42.59	63.88	65.23	32.62	43.49	65.23
6 x 4	42.69	21.34	28.46	42.69	39.84	19.92	26.56	39.84
6 x 5	52.26	26.13	34.84	52.26	50.02	25.01	33.35	50.02
6 x 6	62.80	31.40	41.87	62.80	61.53	30.76	41.02	61.53
6 x 7	74.31	37.15	49.54	74.31	74.06	37.03	49.37	74.05
6 x 8	86.37	43.18	57.58	86.37	87.85	43.93	58.57	87.85
7 x 4	51.22	25.61	34.15	51.22	47.16	23.58	31.44	47.16
7 x 6	73.14	36.57	48.76	73.14	70.18	35.09	46.79	70.18
7 x 8	98.82	49.41	65.88	98.82	98.11	49.06	65.41	98.11
7 x 10	127.54	63.77	85.03	127.54	129.94	64.97	86.63	129.94
8 x 4	60.52	30.26	40.35	60.52	55.14	27.57	36.76	55.14
8 x 6	84.25	42.13	56.17	84.25	79.50	39.75	53.00	79.50
8 x 8	11.84	55.92	74.56	11.84	109.62	54.81	73.08	109.62
8 x 10	142.74	71.37	95.16	142.74	143.73	71.86	95.82	143.73
9 x 4	70.59	35.29	47.06	70.59	63.76	31.88	42.51	63.76
9 x 6	96.30	48.15	64.20	96.30	89.67	44.83	59.78	89.67
9 x 8	125.34	62.67	83.56	125.34	120.96	60.48	80.64	120.96
9 x 10	158.16	79.08	105.44	158.16	156.76	78.38	104.51	156.76
9 x 12	194.32	97.16	129.55	194.32	197.20	98.60	131.47	197.20
10 x 4	81.40	40.70	54.27	81.40	73.05	36.52	48.70	73.05
10 x 6	109.09	54.55	72.73	109.09	100.50	50.25	67.00	100.50
10 x 8	139.59	69.79	93.06	139.59	133.06	66.53	88.71	133.06
10 x 10	174.81	87.40	116.54	174.81	171.21	85.60	114.14	171.21
10 x 12	213.34	106.67	142.23	213.34	213.82	106.91	142.55	213.82
12 x 6	135.87	67.93	90.58	135.87	123.27	61.63	82.18	123.27
12 x 8	170.74	85.37	113.83	170.74	159.19	79.60	106.13	159.19
12 x 10	209.16	104.58	139.44	209.16	200.41	100.21	133.61	200.41
12 x 12	251.92	125.96	167.95	251.92	246.82	123.41	164.55	246.82

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

\* Rev. 7/08

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	3.84	1.92	2.56	3.84	3.97	1.99	2.65	3.97
3 x 4	5.29	2.65	3.53	5.29	5.47	2.74	3.65	5.47
4 x 3	4.66	2.33	3.11	4.66	4.84	2.42	3.23	4.84
4 x 4	6.22	3.11	4.15	6.22	6.45	3.22	4.30	6.45
4 x 5	7.78	3.89	5.19	7.78	8.05	4.03	5.37	8.05
4 x 6	9.33	4.66	6.22	9.33	9.66	4.83	6.44	9.66
5 x 3	5.67	2.83	3.78	5.67	5.86	2.93	3.91	5.86
5 x 4	7.54	3.77	5.03	7.54	7.83	3.91	5.22	7.83
5 x 5	9.45	4.72	6.30	9.45	9.78	4.89	6.52	9.78
5 x 6	11.34	5.67	7.56	11.34	11.74	5.87	7.83	11.74
5 x 7	13.23	6.61	8.82	13.23	13.68	6.84	9.12	13.68
6 x 4	8.89	4.45	5.93	8.89	9.21	4.60	6.14	9.21
6 x 5	11.23	5.62	7.49	11.23	11.62	5.81	7.75	11.62
6 x 6	13.69	6.85	9.13	13.69	14.16	7.08	9.44	14.16
6 x 7	16.15	8.08	10.77	16.15	16.69	8.35	11.13	16.69
6 x 8	17.77	8.89	11.85	17.77	18.40	9.20	12.27	18.40
7 x 4	10.23	5.11	6.82	10.23	10.59	5.29	7.06	10.59
7 x 6	15.52	7.76	10.35	15.52	16.06	8.03	10.71	16.06
7 x 8	21.10	10.55	14.07	21.10	21.82	10.91	14.55	21.82
7 x 10	26.68	13.34	17.79	26.68	27.58	13.79	18.39	27.58
8 x 4	11.55	5.77	7.70	11.55	11.97	5.98	7.98	11.97
8 x 6	17.32	8.66	11.55	17.32	17.95	8.98	11.97	17.95
8 x 8	23.10	11.55	15.40	23.10	23.92	11.96	15.95	23.92
8 x 10	28.89	14.44	19.26	28.89	29.91	14.96	19.94	29.91
9 x 4	12.90	6.45	8.60	12.90	13.35	6.67	8.90	13.35
9 x 6	19.33	9.67	12.89	19.33	20.02	10.01	13.35	20.02
9 x 8	25.78	12.89	17.19	25.78	26.68	13.34	17.79	26.68
9 x 10	33.00	16.50	22.00	33.00	34.12	17.06	22.75	34.12
9 x 12	39.91	19.96	26.61	39.91	41.28	20.64	27.52	41.28
10 x 4	14.22	7.11	9.48	14.22	14.73	7.36	9.82	14.73
10 x 6	21.34	10.67	14.23	21.34	22.09	11.05	14.73	22.09
10 x 8	28.45	14.23	18.97	28.45	29.46	14.73	19.64	29.46
10 x 10	35.55	17.77	23.70	35.55	36.81	18.41	24.54	36.81
10 x 12	42.66	21.33	28.44	42.66	44.17	22.09	29.45	44.17
12 x 6	25.33	12.67	16.89	25.33	26.22	13.11	17.48	26.22
12 x 8	33.78	16.89	22.52	33.78	34.96	17.48	23.31	34.96
12 x 10	42.22	21.11	28.15	42.22	43.71	21.85	29.14	43.71
12 x 12	50.67	25.33	33.78	50.67	52.45	26.23	34.97	52.45

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

\* Rev. 7/08



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	4.45	2.23	2.97	4.45	5.41	2.71	3.61	5.41
3 x 4	5.83	2.92	3.89	5.83	7.42	3.71	4.95	7.42
4 x 3	5.38	2.69	3.59	5.38	6.60	3.30	4.40	6.60
4 x 4	7.18	3.59	4.79	7.18	8.80	4.40	5.87	8.80
4 x 5	8.98	4.49	5.99	8.98	11.01	5.50	7.34	11.01
4 x 6	10.78	5.39	7.19	10.78	13.20	6.60	8.80	13.20
5 x 3	6.54	3.27	4.36	6.54	8.01	4.00	5.34	8.01
5 x 4	8.73	4.36	5.82	8.73	10.68	5.34	7.12	10.68
5 x 5	10.90	5.45	7.27	10.90	13.36	6.68	8.91	13.36
5 x 6	13.09	6.55	8.73	13.09	16.03	8.02	10.69	16.03
5 x 7	15.27	7.63	10.18	15.27	18.69	9.34	12.46	18.69
6 x 4	10.27	5.14	6.85	10.27	12.57	6.28	8.38	12.57
6 x 5	12.99	6.49	8.66	12.99	15.87	7.93	10.58	15.87
6 x 6	15.75	7.87	10.50	15.75	19.21	9.61	12.81	19.21
6 x 7	18.73	9.37	12.49	18.73	22.74	11.37	15.16	22.74
6 x 8	20.53	10.27	13.69	20.53	25.14	12.57	16.76	24.14
7 x 4	11.80	5.90	7.87	11.80	14.46	7.23	9.64	14.46
7 x 6	17.88	8.94	11.92	17.88	21.87	10.93	14.58	21.87
7 x 8	24.42	12.21	16.28	24.42	29.73	14.86	19.82	29.73
7 x 10	30.91	15.46	20.61	30.91	37.56	18.78	25.04	37.56
8 x 4	13.35	6.67	8.90	13.35	16.35	8.17	10.90	16.35
8 x 6	20.02	10.01	13.35	20.02	24.51	12.25	16.34	24.51
8 x 8	26.68	13.34	17.79	26.68	32.68	16.34	21.79	32.68
8 x 10	33.36	16.68	22.24	33.36	40.86	20.43	27.24	40.86
9 x 4	14.89	7.45	9.93	14.89	18.22	9.11	12.15	18.22
9 x 6	22.33	11.17	14.89	22.33	27.33	13.66	18.22	27.33
9 x 8	30.00	15.00	20.00	30.00	36.69	18.34	24.46	36.69
9 x 10	38.17	19.09	25.45	38.17	46.54	23.27	31.03	46.54
9 x 12	46.21	23.11	30.81	46.21	56.23	28.12	37.49	56.23
10 x 4	16.42	8.21	10.95	16.42	20.11	10.05	13.41	20.11
10 x 6	24.63	12.31	16.42	24.63	30.18	15.09	20.12	30.18
10 x 8	32.85	16.42	21.90	32.85	40.23	20.11	26.82	40.23
10 x 10	41.05	20.53	27.37	41.05	50.29	25.15	33.53	50.29
10 x 12	49.27	24.64	32.85	49.27	60.34	30.17	40.23	60.34
12 x 6	29.25	14.62	19.50	29.25	35.83	17.92	23.89	35.83
12 x 8	39.01	19.51	26.01	39.01	47.77	23.89	31.85	47.77
12 x 10	48.76	24.38	32.51	48.76	59.71	29.86	39.81	59.71
12 x 12	58.51	29.26	39.01	58.51	71.65	35.83	47.77	71.65

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

\* Rev. 7/08

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 6.83'  
 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'

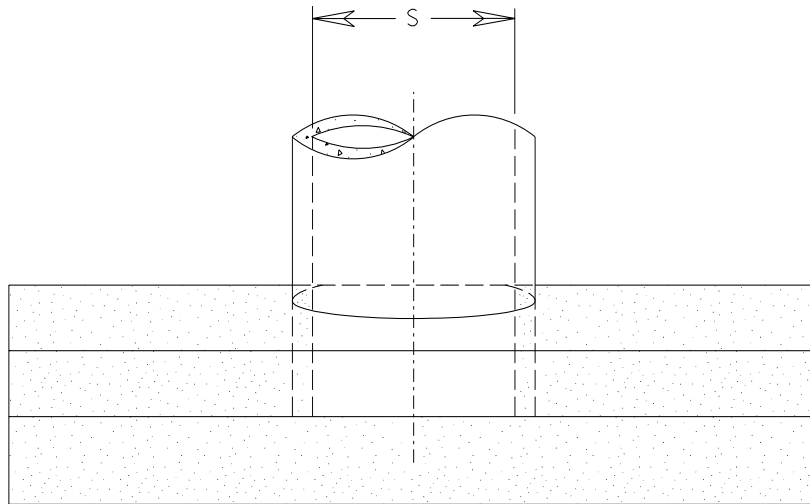
14. Minimum Height Quantities \_\_\_\_\_  
 15. (Line 13 less Min. Height) x increment per foot \_\_\_\_\_  
 16. Quantities for tower (Add Lines 14 & 15) \_\_\_\_\_  
 17. Quantities for Chamber (Line 12) \_\_\_\_\_  
 18. Total Concrete and Reinforcing Steel (Add Lines 16 & 17) \_\_\_\_\_

CONCRETE CU. YDS. \_\_\_\_\_  
 REINFORCING STEEL LBS. \_\_\_\_\_

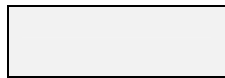
STRUCTURAL STEEL QUANTITY (Lbs.) \_\_\_\_\_

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	227.29 257.42 159.70	
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**



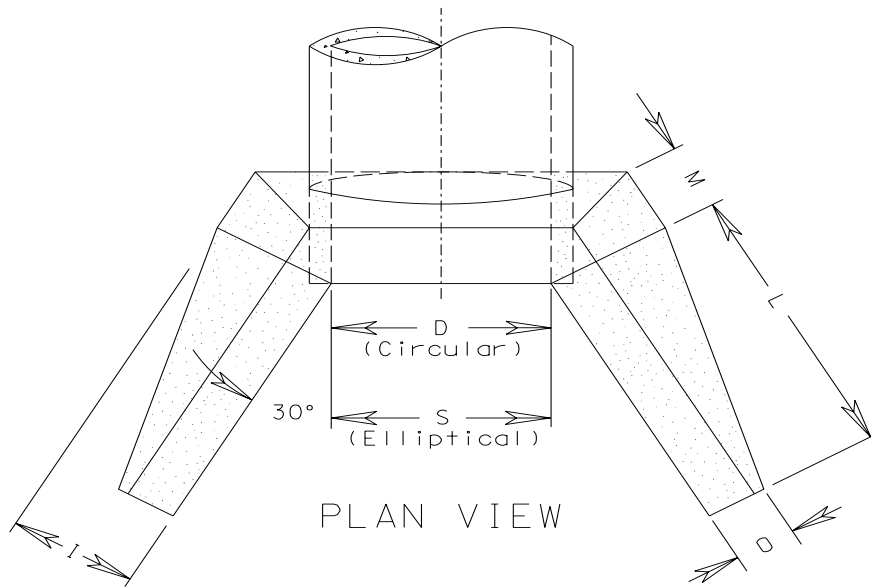
Area for computing ratio

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

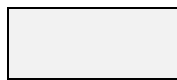
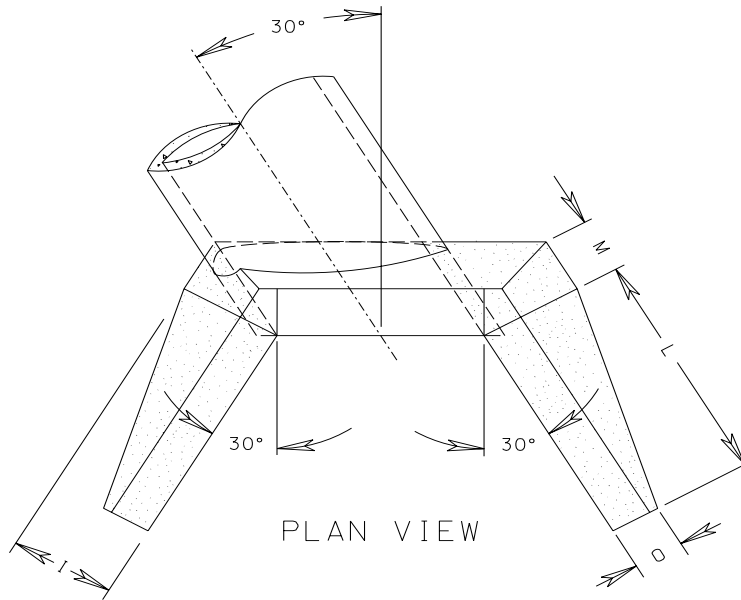
(D) Diameter of Culvert (inches)	Area (A)	
	1 ½ : 1 Slope	2 : 1 Slope
	Sq. Ft.	Sq. Ft.
48	27.31	33.95
54	33.43	41.64
60	40.07	50.05
66	47.38	59.29
72	55.29	69.25
78	63.74	80.00
84	72.80	91.55

(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**



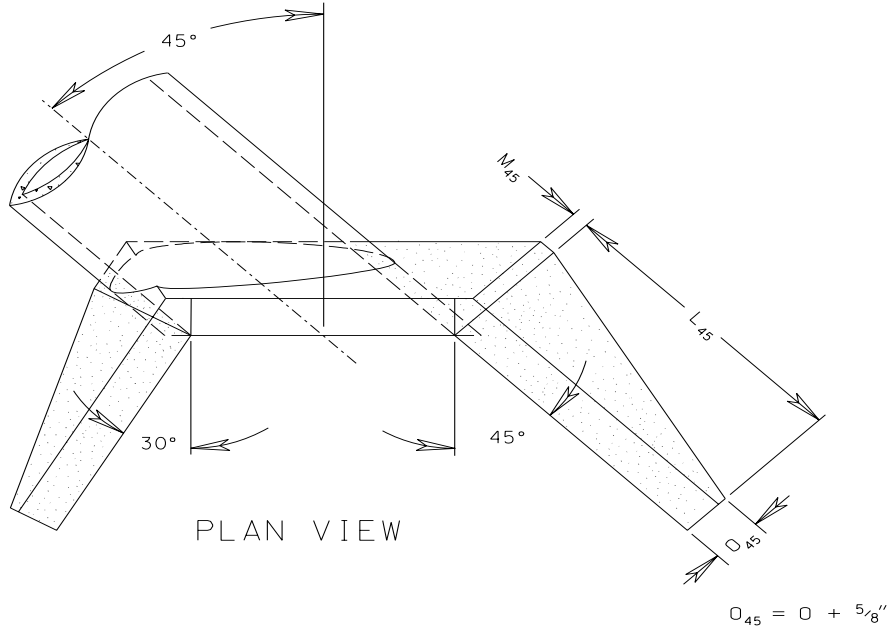
Area for computing ratio

(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°)**



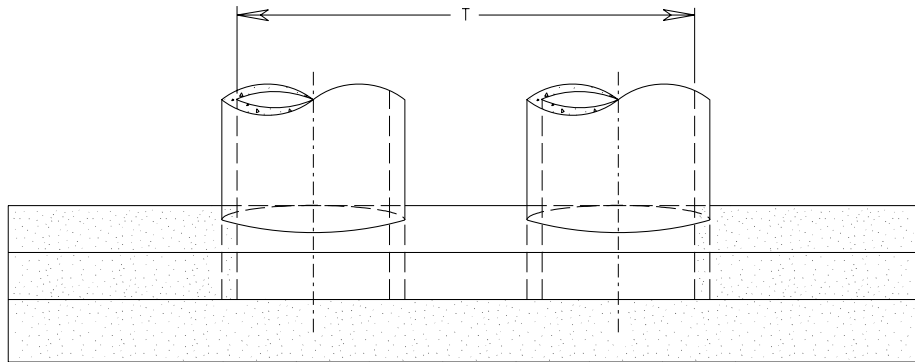
Area for computing ratio

(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**



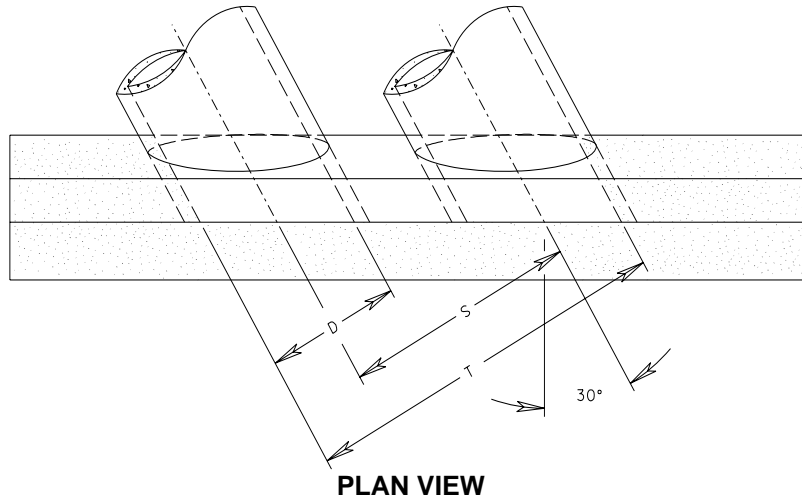
Area for computing ratio

(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

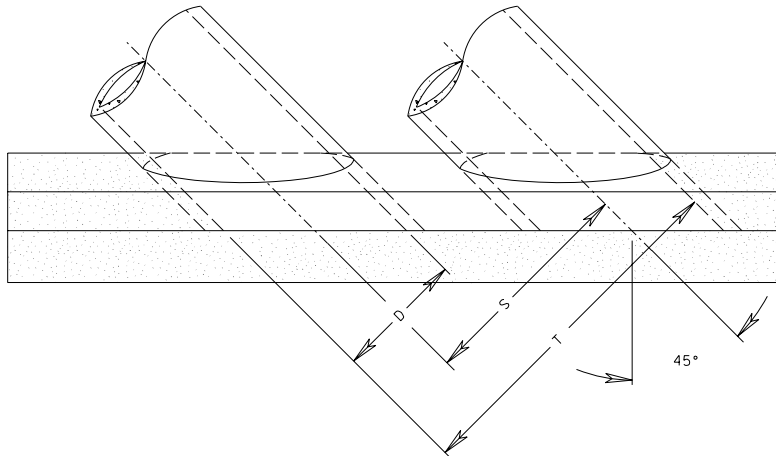
(D) Diameter of Culvert (inches)	Area (A)					
	Double Line		Triple Line		Quadruple Line	
	Conc. Sq. Ft.	C.M. Sq. Ft.	Conc. Sq. Ft.	C.M. Sq. Ft.	Conc. Sq. Ft.	C.M. Sq. Ft.
15			8.94	8.61	10.23	9.74
18	9.88	9.69	11.43	11.04	12.98	12.40
24	16.56	16.25	19.26	18.63	21.95	21.00
30	23.69	23.27	27.44	26.59	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**



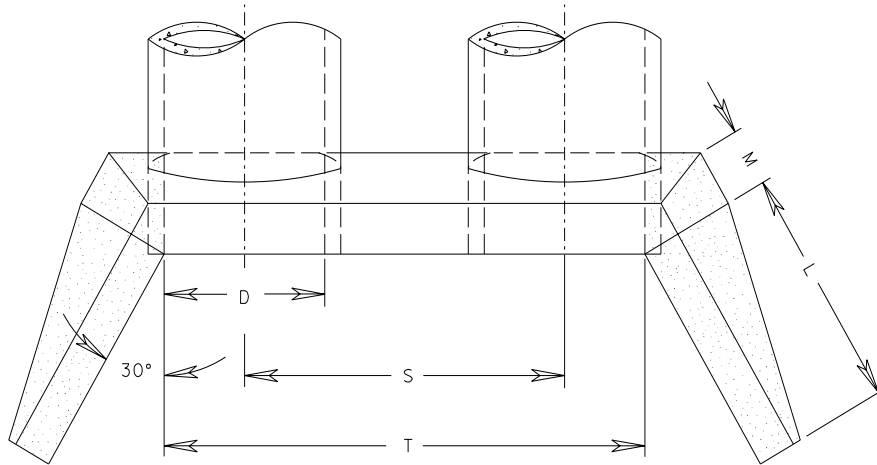
Area for computing ratio

(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**



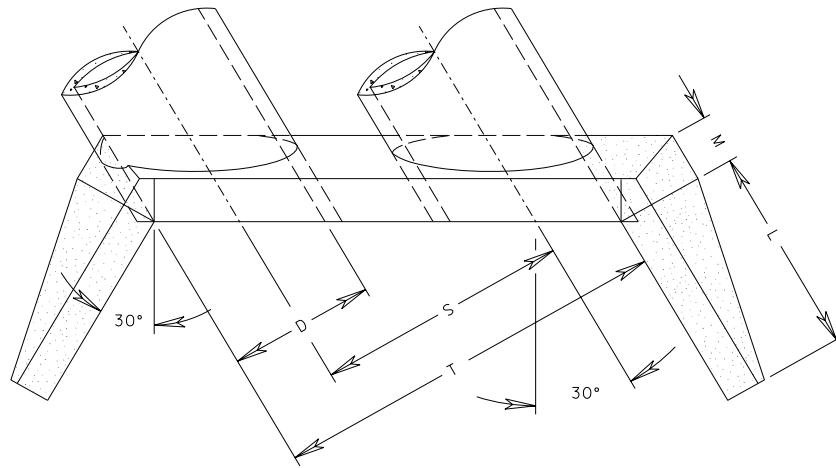
Area for computing ratio

(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

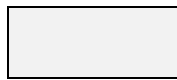
Area is given for one endwall.  
Double area shown if two endwalls are used.

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**



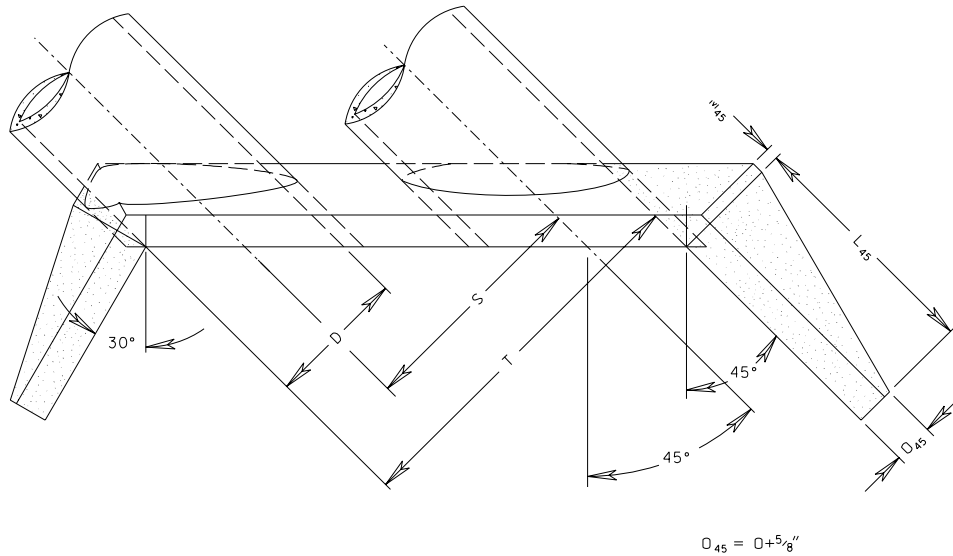
Area for computing ratio

(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**



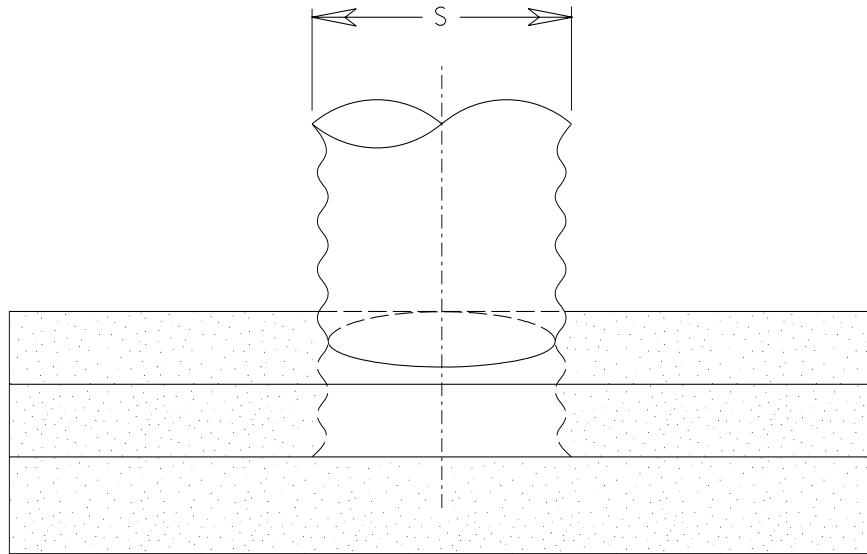
Area for computing ratio

(D) Diameter of Culvert (inches)	Area (A)		Culvert width (T)					
	1 ½ : 1 Slope 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	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**



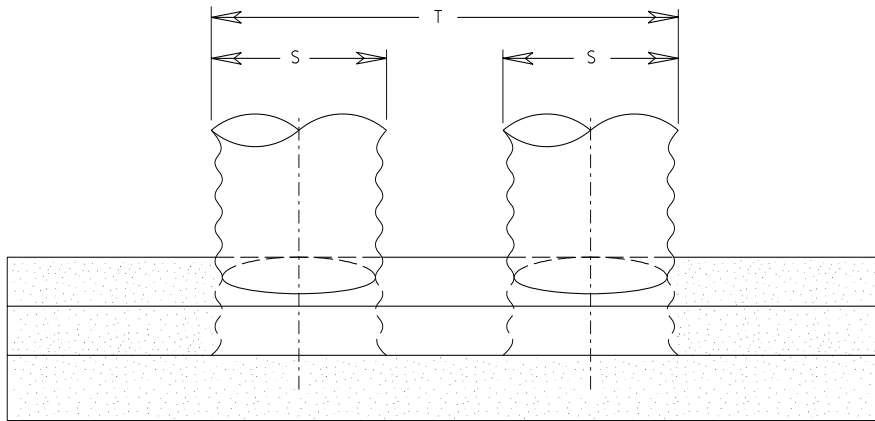
Area for computing ratio

(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**



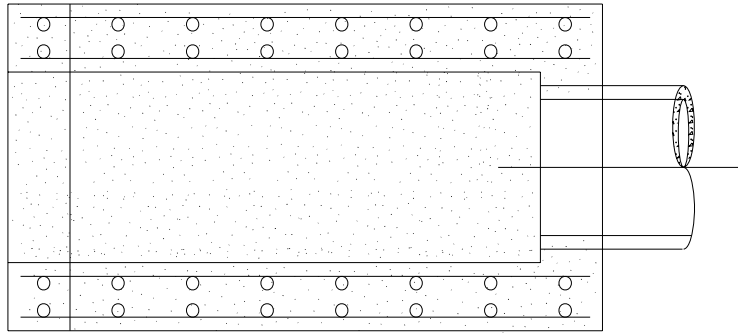
Area for computing ratio

(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

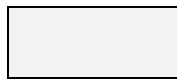
Area is given for one endwall.  
 Double area shown if two endwalls are used  
 \* 3"x1" corrugation dimension.

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**

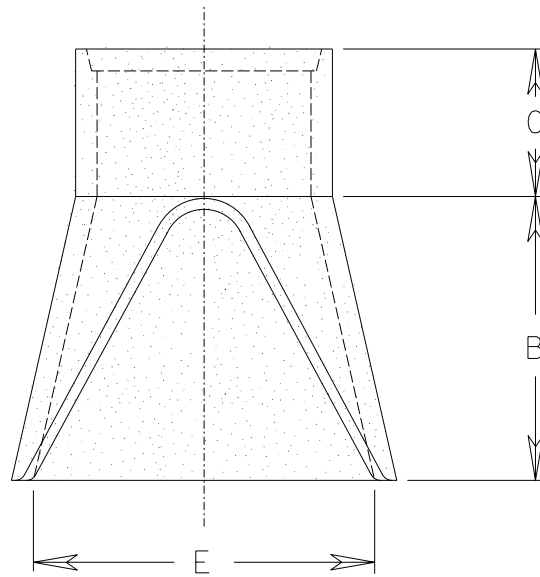


Area for computing ratio

(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

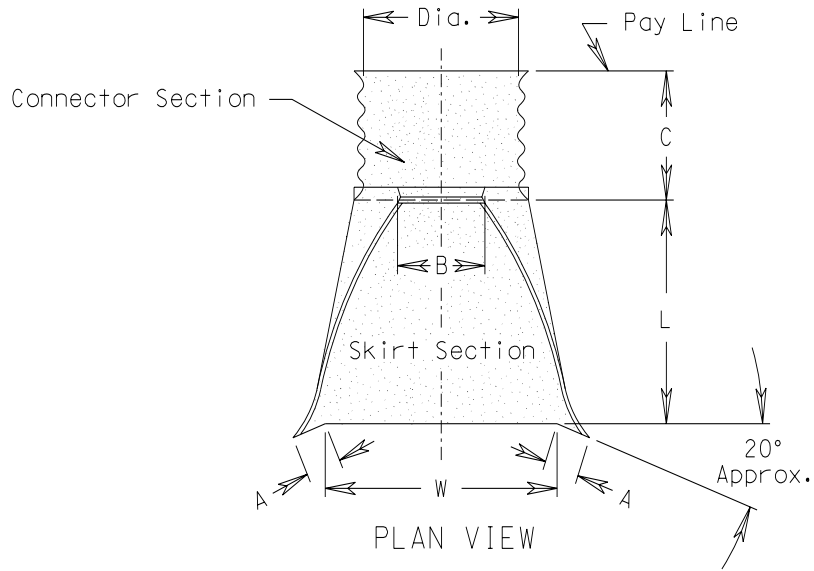
(D) Diameter of Culvert (inches)	Area (A)
	Sq. Ft.
48	48.47
54	52.47
60	57.00

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**





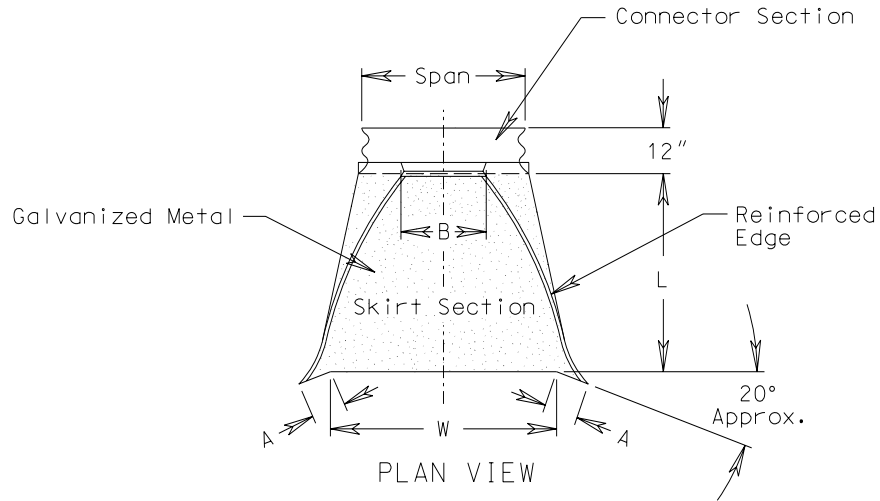
Area for computing ratio

(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

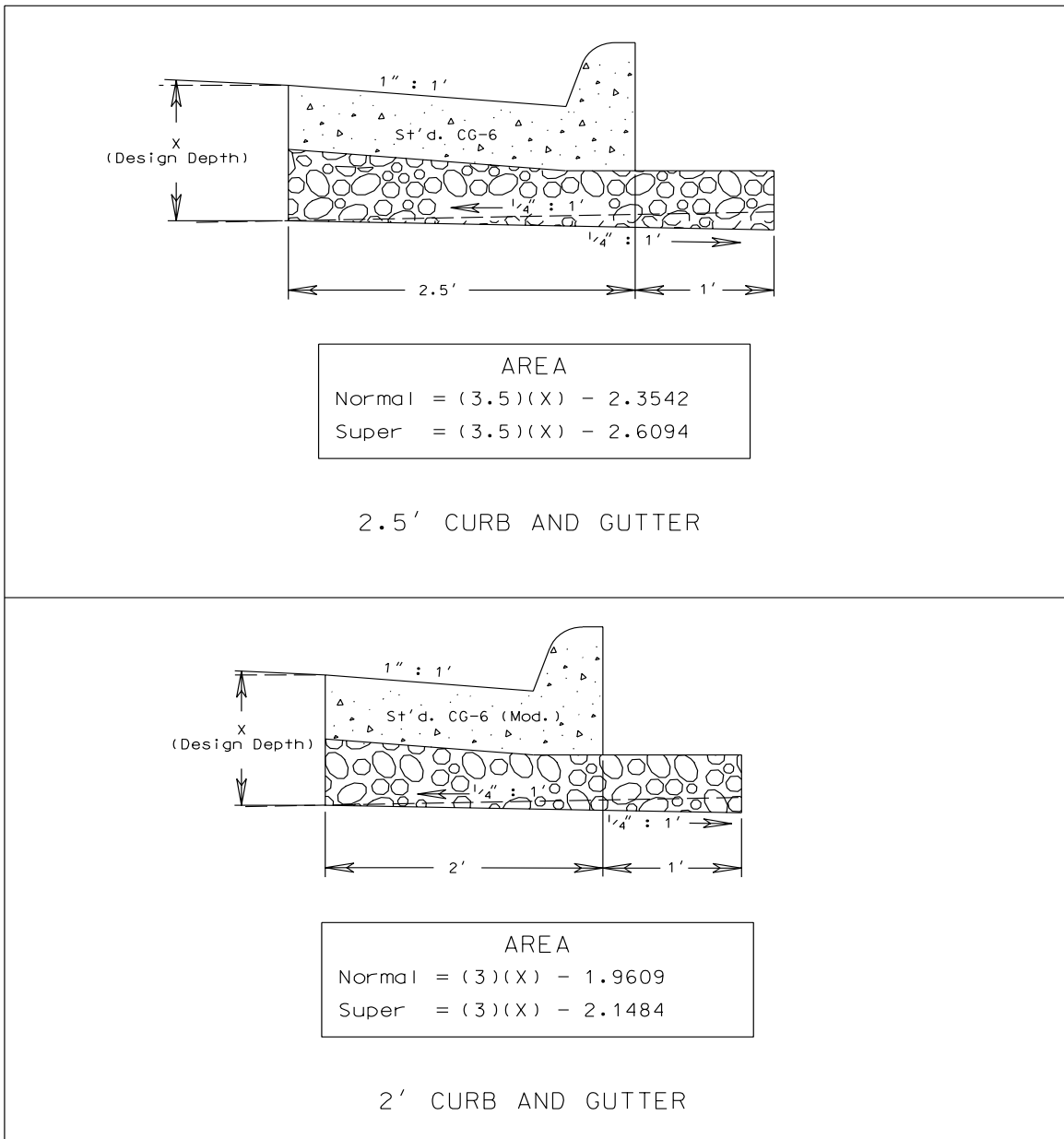
(S) Span of Culvert (inches)	Area (A)
	Sq. Ft.
	3" x 1" Corr.
46	28.31
53	37.63
60	48.03
66	59.27

(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

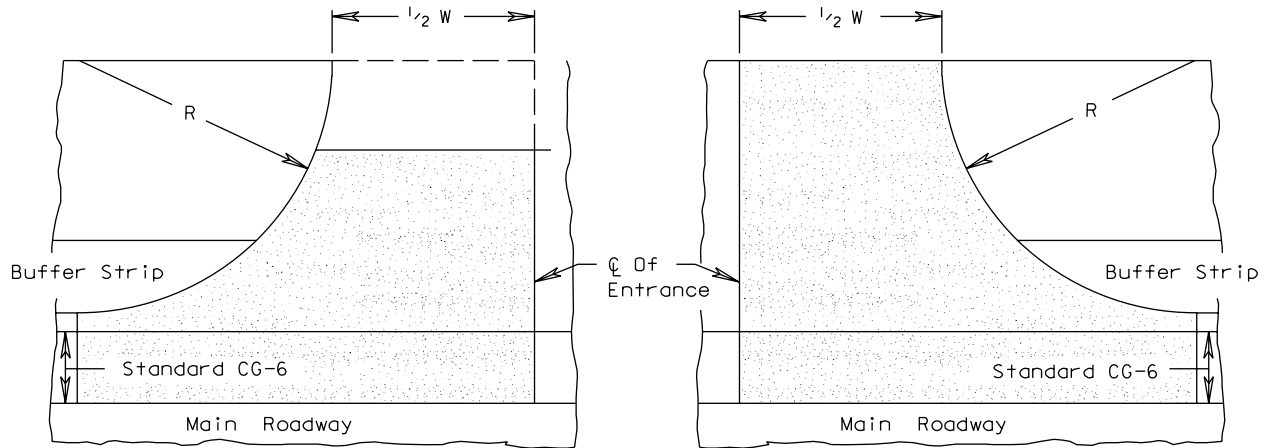
Area is given for one end section.  
Double area shown if two end sections are used

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**

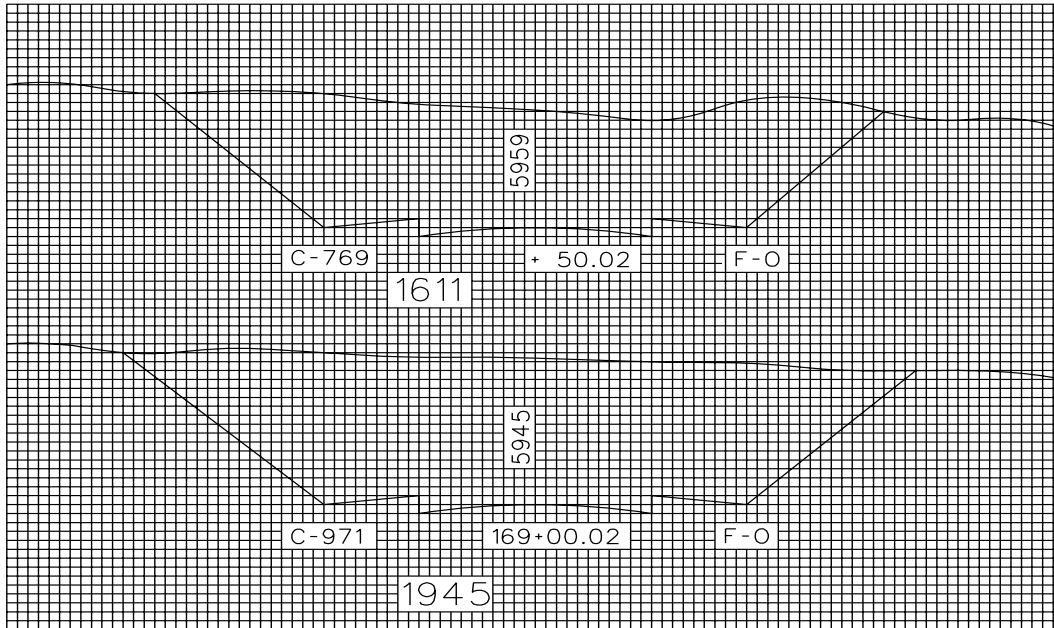
W= Width of Entrance



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**