ATB-193-11.140 (122339)
Design Criteria
LGT Submittal

Location

Location ID: 12304
Located On: SR-193 SR193 N OF C10 AYERS RD, NW OF ANDOVER
Direction: 2-WAY
AADT: 850 (2024)
NB AADT: 404 (2024)
SB AADT: 445 (2024)

View Detail in a New Search

Record 1 of 1 Goto Record go

Location ID	12304	MPO ID	
Type	SPOT	HPMS ID	
On NHS	Non-NHS	On HPMS	
LRS ID	SATBSR00193**C	LRS Loc Pt.	9.996
SF Group	Rural Major Collector;Minor Collector; Local (2024	Route Type	SR
AF Group	RURAL_MAJOR_COLLECTOR (2024)	Route	00193
GF Group	RURAL_MAJOR_COLLECTOR (2024)	Active	Yes
Class Dist Grp		Category	State Program
Seas Clss Grp	Rural Major Collector;Minor Collector; Local (2024		
WIM Group			
QC Group	Default		
Fnct'l Class	5 - Major Collector	Milepost	
Located On	SR-193		
Loc On Alias			
	SR193 N OF C10 AYERS RD, NW OF ANDOVER		

More Detail

STATION DATA

Directions: 2-WAY NB SB

Note, ADT < 2,000 can refer to AASHTO Low-Volume manual

AADT

	Year	AADT	DHV-30	K %	D %	PA	BC	Src
	2024	850				798 (94%)	51 (6%)	
	2023	915[3]		10	55	867 (95%)	48 (5%)	Grown from 2022
	2022	894[3]		10	55	847 (95%)	47 (5%)	Grown from 2021
	2021	894	89	10	55	847 (95%)	47 (5%)	
	2020	864[3]		11	56	787 (91%)	77 (9%)	Grown from 2019

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design exceptions when they are not met or exceeded are set forth in **Section 105.2** and Figure 105-1. The designer should call attention to any design features that require a design exception as soon as possible, but no later than the first stage review submittal as defined in the Location & Design Manual, Volume Three.

Other design values, policies, practices, etc. that are mentioned in this Manual are guidelines intended to promote uniformity and good design. Deviation from these guidelines does not require a formal design exception; however, it may still be necessary to justify or otherwise seek approval from ODOT of the proposed design when deviations are necessary. This should be accomplished through the normal review process.

Ramps do not have continuous design speeds throughout their lengths. However, design exceptions are required for not meeting the lower range for speed related items (see Section 503.2 for directional and loop ramps). In addition, design exceptions for non-speed related items (e.g., lane width, shoulder width, bridge width, and lateral clearance) are required.

A design exception should be reevaluated if the project has not sold within five years of the approved design exception.

Design exceptions will not be required for projects that do not change or provide the opportunity to change the basic highway cross-section or geometry due to the scope of work; e.g. resurfacing, bridge deck overlays, rest areas, lighting, signing, signalization, fencing, guardrail, slide corrections, etc. A change in the basic highway cross section would include any change to the lane width, shoulder width, pavement cross slope or additional earthwork beyond the graded shoulder. Design Exceptions are required for major rehabilitation projects such as full depth pavement replacement even if they do not change the basic highway geometry; however, full-depth pavement reclamation projects will not require a design exception unless an applicable safety study for the project area or the ODOT Safety Integrated Project (SIP) Maps, document historical crash trends. See **Section 106** for additional information.

Side roads with more than 600’ of approach work do require design exceptions.

105.2 Design Controlling Criteria that Require a Design Exception

Exceptions must be processed for the following design controlling criteria when they will not be attained:

High Speed Roadways (Interstate highways, other freeways and roadways with a design speed ≥50 mph)

1. Lane Width
2. Shoulder Width - See Note (A)
3. Horizontal Curve Radius

Review once further into design

4. Maximum Grade
5. Stopping Sight Distance (Horizontal and Crest Vertical Curves)
6. Superelevation Rate
7. Vertical Clearance
8. Pavement Cross Slope
9. Design Loading Structural Capacity

Low Speed Roadways (design speed <50 mph)

1. Design Loading Structural Capacity
2. Lane Width (only if required for the National Network, see **Section 105.3** below)

Note (A) - The Design Exception should focus on the Treated Shoulder Width for Interstate, Freeways, Expressways or other Multilane Divided Facilities. All other facilities should focus on the Graded Shoulder Width.

In addition to the above geometric design features, design exceptions are also required when existing non-standard bridge parapets and curb configurations are to be retained. For details on non-standard bridge parapets see ODOT Bridge Design Manual or contact the Office of Structural Engineering.

See Section 503.2 for design exception requirements for ramps.

105.3 National Network (or National Truck Network)

The National Network was established by Congress in 1982 with the Surface Transportation Assistance Act as the network of highways designated for use by large trucks. In Ohio, the National Network consists of all Interstate Routes and the old Federal Aid Primary (FAP) Routes. One of the criteria for the National Network is, "The route consists of lanes designed to be a width of 12 feet or more or is otherwise consistent with highway safety."

In lieu of providing 12' lane widths for all lanes on the National Network, a single 12' lane in each direction can be provided. For low speed facilities (45 mph design speed or lower) a lane width design exception shall be required only if a single 12' lane in each direction cannot be provided. For high speed facilities (50 mph design speeds or higher) a lane width design exception shall be required if a single 12' lane in each direction cannot be provided and if the proposed widths for all lanes doesn't meet the criteria shown in Fig. 301-2, Fig. 301-4 or Fig. 303-1. The emphasis of the lane width design exception should focus on the impacts of the truck traffic such as truck involved crashes (existing and expected), truck off-tracking, etc. Design exceptions

STOPPING SIGHT DISTANCE

201-1
REFERENCE SECTION
201.2 & 201.2.1

HEIGHT OF EYE 3.50′

HEIGHT OF OBJECT 2.00′

$$SSD = 1.47Vt + 1.075\frac{V^2}{a}$$

SSD = stopping sight distance, ft;
t = brake reaction time, 2.5s;
V = design speed, mph;
a = deceleration rate, 11.2ft/s^2

DESIGN SPEED (mph)	DESIGN SSD (feet)	DESIGN SPEED (mph)	DESIGN SSD (feet)
20	115	48	400
21	120	49	415
22	130	50	425
23	140	51	440
24	145	52	455
25	155	53	465
26	165	54	480
27	170	55	495
28	180	56	510
29	190	57	525
30	200	58	540
31	210	59	555
32	220	60	570
33	230	61	585
34	240	62	600
35	250	63	615
36	260	64	630
37	270	65	645
38	280	66	665
39	290	67	680
40	305	68	695
41	315	69	715
42	325	70	730
43	340	71	745
44	350	72	765
45	360	73	780
46	375	74	800
47	385	75	820

Table 4-7 presents recommended design stopping sight distance criteria for new construction on roads with design volumes of 400 vehicles per day or less based on the models discussed above. These criteria may be used in design of both horizontal and crest vertical curves for new construction.

Table 4-7. Design Stopping Sight Distance Guidelines for New Construction of Low-Volume Roads with Design Volumes of 2,000 Vehicles per Day or Less

U.S. Customary					
	Minimum Sight Distance (ft) for Specified Design Traffic Volumes and Location Types				
	0–100 veh/day	101–250 veh/day		251–400 veh/day	401–2,000 veh/day
Design Speed (mph)	All Locations	"Lower Risk" Locations[1]	"Higher Risk" Locations[2]	All Locations	All Locations
15	65	65	65	65	80
20	90	90	95	95	115
25	115	115	125	125	155
30	135	135	165	165	200
35	170	170	205	205	250
40	215	215	250	250	305
45	260	260	300	300	360
50	310	310	350	350	425
55	365	365	405	405	495
60	435	435	470	470	570

MAXIMUM CENTERLINE DEFLECTION WITHOUT HORIZONTAL CURVE

	DESIGN SPEED	MAX. DEFLECTION *
LOW SPEED	25	5° 30'
	30	3° 45'
	35	2° 45'
	40	2° 05'
	45	1° 40'
HIGH SPEED	50	1° 05'
	55	1° 00'
	60	0° 55'
	65	0° 50'
	70	0° 45'
	75	0° 45'

* ROUNDED TO NEAREST 5'

Based on the Allowable Pavement Transition formulae (301.1.4):
High Speed: Tan $\triangle$= 1.0/V
Low Speed: Tan $\triangle$= $60/V^2$
Where: V = Design Speed
$\triangle$ = Deflection Angle

Note:
The recommended minimum distances between consecutive horizontal deflections is:
High Speed - 200'
Low Speed - 100'

MAXIMUM DEGREE OF CURVE

202-2

REFERENCE SECTION 202.3

DESIGN SPEED (mph)	MAXIMUM DEGREE OF CURVE (A)			
	RURAL	HIGH-SPEED URBAN	LOW-SPEED URBAN RAMPS/ INTERCHANGE	LOW-SPEED URBAN
	MAXIMUM SUPERELEVATION RATE			
	.08	.06	.06	.04
20	--	--	--	66°30'
21	--	--	--	58°15'
22	--	--	--	51°15'
23	--	--	--	45°15'
24	--	--	--	40°15'
25	42°30'	--	39°45'	37°00'
26	38°00'	--	36°00'	33°00'
27	34°00'	--	32°45'	29°30'
28	31°15'	--	29°45'	26°45'
29	28°30'	--	27°15'	24°30'
30	26°45'	--	24°45'	22°45'
31	24°30'	--	23°00'	21°00'
32	22°30'	--	21°15'	19°15'
33	21°15'	--	19°30'	18°00'
34	19°45'	--	18°15'	16°45'
35	18°15'	--	16°45'	15°30'
36	16°45'	--	15°45'	14°15'
37	15°45'	--	14°30'	13°15'
38	14°45'	--	13°30'	12°30'
39	13°45'	--	12°45'	11°30'
40	12°45'	--	11°45'	10°45'
41	12°15'	--	11°15'	10°15'
42	11°45'	--	10°30'	9°45'
43	11°00'	--	10°00'	9°00'
44	10°30'	--	9°30'	8°45'

DESIGN SPEED (mph)	MAXIMUM DEGREE OF CURVE (A)			
	RURAL	HIGH-SPEED URBAN	LOW-SPEED URBAN RAMPS/ INTERCHANGE	LOW-SPEED URBAN
	MAXIMUM SUPERELEVATION RATE			
	.08	.06	.06	.04
45	9°45'	--	9°00'	8°00'
46	9°15'	--	--	--
47	8°45'	--	--	--
48	8°15'	--	--	--
49	8°00'	--	--	--
50	7°30'	6°45'	--	--
51	7°15'	6°30'	--	--
52	6°45'	6°15'	--	--
53	6°30'	6°00'	--	--
54	6°15'	5°45'	--	--
55	6°00'	5°30'	--	--
56	5°45'	5°15'	--	--
57	5°30'	5°00'	--	--
58	5°15'	4°45'	--	--
59	5°00'	4°30'	--	--
60	4°45'	4°15'	--	--
61	4°30'	4°00'	--	--
62	4°15'	4°00'	--	--
63	4°15'	3°45'	--	--
64	4°00'	3°30'	--	--
65	3°45'	3°30'	--	--
66	3°45'	3°15'	--	--
67	3°30'	3°15'	--	--
68	3°30'	3°00'	--	--
69	3°15'	3°00'	--	--
70	3°15'	2°45'	--	--
71	3°00'	2°45'	--	--
72	3°00'	2°30'	--	--
73	2°45'	2°30'	--	--
74	2°45'	2°15'	--	--
75	2°30'	2°15'	--	--

(A) See Superelevation Tables 202-7, 8, 9, and 10 for corresponding radii values.

MAXIMUM DEGREE OF CURVE WITHOUT SUPERELEVATION

202-3

REFERENCE SECTION 202.4.3

	DESIGN SPEED (mph)	DEGREE OF CURVE: RURAL HIGHWAYS		DEGREE OF CURVE: URBAN STREETS & HIGHWAYS	
LOW SPEED	20	--	FIGURE 202-7	54°23′	FIGURE 202-9
	25	2°35′		29°20′	
	30	1°53′		17°30′	
	35	1°26′		11°28′	
	40	1°08′		7°42′	
	45	0°55′		5°40′	
HIGH SPEED	50	0°45′		0°47′	FIGURE 202-8
	55	0°38′		0°39′	
	60	0°32′		0°33′	
	65	0°28′		0°29′	
	70	0°25′		0°26′	
	75	0°23′		0°23′	

SUPERELEVATION TRANSITIONS

202-4

REFERENCE SECTION 202.4.5 & 202.4.8

Maximum Relative Gradient for Profiles Between the Edge of Traveled Way and the Centerline or Reference Line (Axis of Rotation)		
Design Speed (mph)	Maximum Relative Gradient (Percent) "$\triangle$"	Equivalent Maximum Relative Slope "G"
20	0.74	135:1
25	0.70	143:1
30	0.66	152:1
35	0.62	161:1
40	0.58	172:1
45	0.54	185:1
50	0.50	200:1
55	0.47	213:1
60	0.45	222:1
65	0.43	233:1
70	0.40	250:1
75	0.38	263:1

Adjustment Factors, b_w		
Number of Lanes, Rotated n_1	Divided * Roadways b_w	Undivided Roadways b_w
1	1.00	1.00
1.5	1.00	0.83
2	1.00	0.75
2.5	1.00	0.70
3	1.00	0.67
3.5	1.00	0.64

* Interstates, Freeways, Expressways and Ramps

In Figures 202-7, 202-8 and 202-10, the table values for the Minimum Length of Superelevation Runoff, L_r, were determined by the following equation:

$$L_r = \frac{(w \times n_1)\, e_d}{\triangle} (b_w) \times 100 \qquad \text{or} \qquad L_r = (w \times n_1)(e_d)(G)(b_w)$$

The equation can also be used to determine L_r, when more than one lane is rotated about the centerline or the edge or if the lane width is other than 12 feet for Figures 202-7 and 202-8 or 16 feet for Figure 202-10.

Once L_r has been determined, the Minimumum Length of Tangent Runout, L_t,should be determined by the following equation:

$$L_t = (e_{NC} \div e_d)\, L_r$$

The equation for L_t can be used by Figures 202-7, 202-8, 202-9 and 202-10.

Where:
- L_r = minimum length of superelevation runoff, ft
- L_t = minimum length of tangent runout, ft
- $\triangle$ = maximum relative gradient, percent
- n_1 = number of lanes rotated
- w = width of one traffic lane, ft (typically 12 ft)
- e_d = design superelevation rate
- e_{NC} = normal cross slope rate, (0.016)
- G = equivalent maximum relative slope, (the reciprocal of $\triangle$)
- b_w = adjustment factor for number of lanes rotated

SUPERELEVATION AND RUNOFF LENGTHS FOR HORIZONTAL CURVES ON RURAL HIGHWAYS - Based on Max. S.E. of 0.08 ft/ft -

202-7

REFERENCE SECTION
202.4.1, 202.4.3, & 202.4.5

		DESIGN SPEED															
Dc	RADIUS	25		30		35		40		45		50		55		60	
		e_d	L_r	e_d	L_r	e_d	L_r	e_d	L_r	e_d	L_r	e_d	L_r	e_d	L_r	e_d	L_r
0°15′	22918	NC	--	NC	--	NC	--	NC	--	NC	--	NC	--	NC	--	NC	--
0°30′	11459	NC	--	NC	--	NC	--	NC	--	NC	--	NC	--	NC	--	NC	--
0°45′	7639	NC	--	NC	--	NC	--	NC	--	NC	--	.016	39	.019	49	.022	59
1°00′	5730	NC	--	NC	--	NC	--	NC	--	.017	38	.021	51	.025	64	.029	78
1°30′	3820	NC	--	NC	--	.017	33	.021	44	.025	56	.030	72	.035	90	.041	110
2°00′	2865	NC	--	.017	32	.022	43	.027	56	.032	72	.038	92	.045	116	.051	136
2°30′	2292	NC	--	.021	39	.026	51	.033	69	.039	87	.046	111	.053	136	.061	163
3°00′	1910	.018	31	.024	44	.031	60	.038	79	.045	100	.053	128	.060	154	.068	182
3°30′	1637	.021	37	.028	52	.035	68	.043	89	.050	111	.058	140	.066	169	.074	198
4°00′	1432	.024	42	.031	57	.039	76	.047	98	.055	123	.063	152	.071	182	.078	208
4°30′	1273	.026	45	.034	63	.042	82	.051	106	.059	131	.068	164	.075	192	.080	214
5°00′	1146	.029	50	.037	68	.046	89	.055	114	.063	140	.071	171	.078	200	△=4°46′30″	
5°30′	1042	.031	54	.040	73	.049	95	.058	120	.066	147	.074	178	.080	205	▲=0°32′	
6°00′	955	.033	57	.042	77	.051	99	.061	126	.070	156	.077	185	△=5°58′05″			
6°30′	881	.035	61	.045	83	.054	105	.063	131	.072	160	.079	190	▲=0°38′			
7°00′	819	.037	64	.047	86	.056	109	.066	137	.074	165	.080	192				
7°30′	764	.039	67	.049	90	.058	113	.068	141	.076	169	.080	192				
8°00′	716	.041	71	.051	94	.060	116	.070	145	.078	174	△=7°33′30″					
8°30′	674	.042	73	.052	95	.062	120	.072	149	.079	176	▲=0°45′					
9°00′	637	.044	76	.054	99	.064	124	.074	153	.080	178						
9°30′	603	.046	79	.055	101	.066	128	.075	155	.080	178						
10°00′	573	.047	81	.057	104	.067	130	.077	159	△=9°45′40″							
10°30′	546	.048	83	.058	106	.069	134	.078	161	▲=0°55′							
11°00′	521	.049	85	.059	108	.070	136	.079	164								
11°30′	498	.050	86	.061	112	.071	138	.079	164								
12°00′	477	.051	88	.062	114	.073	142	.080	166								
12°30′	458	.052	90	.063	115	.074	143	.080	166								
13°00′	441	.053	91	.064	117	.075	145	△=12°54′15″									
13°30′	424	.054	93	.066	121	.076	147	▲= 1°08′									
14°00′	409	.055	95	.067	123	.077	149										
14°30′	395	.056	97	.068	125	.077	149										
15°00′	382	.057	98	.069	126	.078	151										
16°30′	347	.059	102	.071	130	.079	153										
18°00′	318	.062	107	.074	135	.080	155										
20°00′	286	.064	110	.076	139	△=18°14′50″											
22°00′	260	.067	115	.078	143	▲= 1°26′											
23°00′	249	.068	117	.079	145												
25°00′	229	.071	122	.080	146												
26°30′	216	.072	124	.080	146												
28°00′	205	.074	127	△=26°46′25″													
31°00′	185	.076	131	▲= 1°53′													
34°00′	169	.078	134														
36°00′	159	.079	136														
38°00′	151	.079	136														
40°00′	143	.080	138	△=42°45′30″													
42°00′	136	.080	138	▲= 2°35′													

NC = Normal Crown

△ = Max. Dc for the Design Speed
▲ = Max. Dc Without Superelevation

		DESIGN SPEED					
Dc	RADIUS	65		70		75	
		e_d	L_r	e_d	L_r	e_d	L_r
0°15′	22918	NC	--	NC	--	NC	--
0°30′	11459	.017	48	.019	57	.021	67
0°45′	7639	.025	70	.028	84	.031	98
1°00′	5730	.032	90	.036	108	.040	127
1°15′	4584	.039	110	.044	132	.049	155
1°30′	3820	.046	129	.051	153	.058	184
1°45′	3274	.052	146	.058	174	.066	209
2°00′	2865	.058	163	.065	195	.073	231
2°15′	2546	.063	177	.071	213	.078	247
2°30′	2292	.068	191	.075	225	.080	253
2°45′	2083	.072	202	.078	234	△=2°35′35″	
3°00′	1910	.075	210	.080	240	▲=0°23′	
3°15′	1763	.078	219	△=3°09′55″			
3°30′	1637	.079	221	▲=0°25′			
3°45′	1528	.080	224				
		△=3°52′15″					
		▲=0°28′					

e_d= Design Superelevation Rate
L_r= Min. Runoff Length, 2-Lane Highway Rotated About the Centerline, Lane Width of 12 feet

MAXIMUM GRADES (PERCENT)

203-1

REFERENCE SECTION 203.2.3

	FUNCTIONAL CLASSIFICATION	TERRAIN	DESIGN SPEED (mph)										
			25	30	35	40	45	50	55	60	65	70	75
URBAN	Interstate, Other Freeways and Expressways (A)	LEVEL						4	4	3	3	3	3
		ROLLING						5	5	4	4	4	4
		HILLY						6	6	6	5	5	
	ARTERIAL STREET	LEVEL	7	7	7	7	6	6	5	5			
		ROLLING	10	9	8	8	7	7	6	6			
		HILLY	12	11	10	10	9	9	8	8			
	COLLECTOR STREETS (B)	LEVEL	9	9	9	9	8	7	7	6			
		ROLLING	12	11	10	10	9	8	8	7			
		HILLY	13	12	12	12	11	10	10	9			
	LOCAL STREETS	LEVEL	10	9	9	9	9	8	8	7			
		ROLLING	13	12	12	11	11	10	10	8			
		HILLY	15	15	15	14	14	12	12	10			
RURAL	Interstate, Other Freeways and Expressways (A)	LEVEL						4	4	3	3	3	3
		ROLLING						5	5	4	4	4	4
		HILLY						6	6	6	5	5	
	ARTERIAL STREET	LEVEL	5	5	5	5	5	4	4	3	3	3	
		ROLLING	8	7	7	6	6	5	5	4	4	4	
		HILLY	9	8	8	8	7	7	6	6	5	5	
	COLLECTOR STREETS (B)	LEVEL	7	7	7	7	7	6	6	5			
		ROLLING	10	9	9	8	8	7	7	6			
		HILLY	11	10	10	10	10	9	9	8			
	LOCAL STREETS	LEVEL	7	7	7	7	7	6	6	5			
		ROLLING	11	10	10	10	9	8	7	6			
		HILLY	15	14	14	13	12	10	10				

(A) Grades 1% steeper may be used where development in urban areas precludes the use of flatter grades. Grades 1% steeper may also be used for one-way down-grades, except in hilly terrain.

(B) Grades 2% steeper may be used for short lengths (less than 500 ft.), on one-way down-grades, and on low-volume rural collectors with current AADT less than 2,000 veh/day.

MAXIMUM CHANGE IN VERTICAL ALIGNMENT WITHOUT VERTICAL CURVE

203-2

REFERENCE SECTION
203.3.2

DESIGN SPEED (mph)	MAX. GRADE CHANGE △
25	1.85%
30	1.30%
35	0.95%
40	0.75%
45	0.55%
50	0.45%
55	0.40%
60	0.30%
65	0.30%
70	0.25%
75	0.20%

Based on the AASHTO comfort formula for sag vertical curves:

$$A = 46.5\ L / V^2 = 1162.5 / V^2$$

Where:

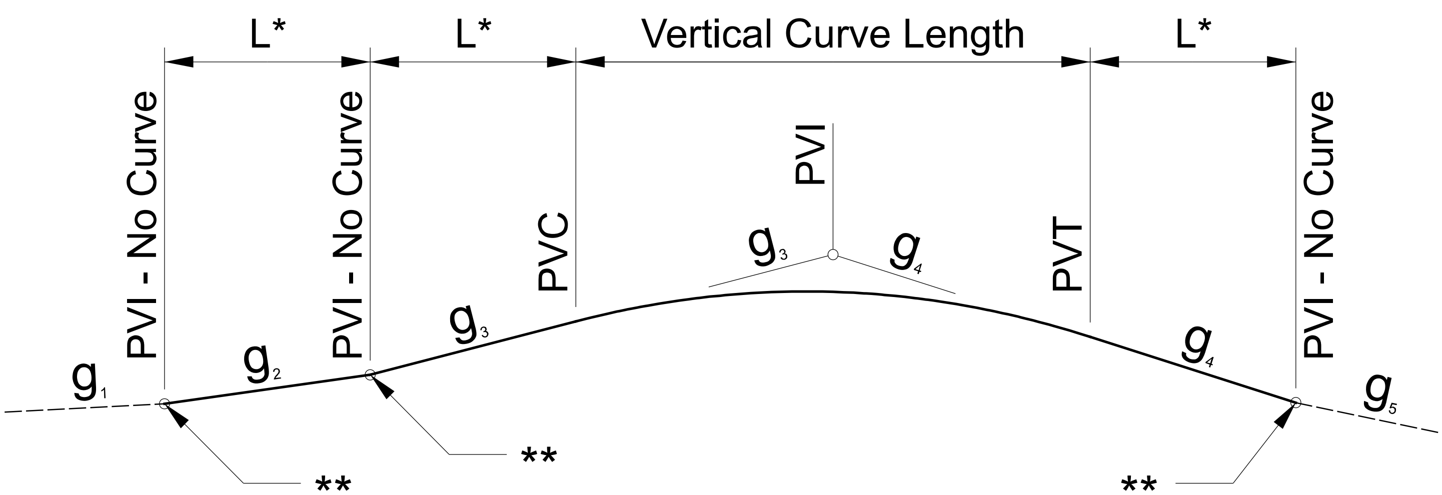
A = Maximum Grade Change (%)

L = Length of Vertical Curve (assume 25')

V = Design Speed (mph)

△ ROUNDED TO NEAREST 0.05%

RELATIONSHIP BETWEEN VERTICAL CURVES AND GRADE BREAKS



* The minimum distance between consecutive deflections is:
100' where design speed is 50 mph or greater
50' where design speed is less than 50 mph

** Allowable grade break location.

CREST VERTICAL CURVES

HEIGHT OF EYE 3.50′ - HEIGHT OF OBJECT 2.00′

DESIGN SPEED	DESIGN SSD	DESIGN K
20	115	7
21	120	7
22	130	8
23	140	10
24	145	10
25	155	12
26	165	13
27	170	14
28	180	15
29	190	17
30	200	19
31	210	21
32	220	23
33	230	25
34	240	27
35	250	29
36	260	32
37	270	34
38	280	37
39	290	39
40	305	44
41	315	46
42	325	49
43	340	54
44	350	57
45	360	61
46	375	66
47	385	69

DESIGN SPEED	DESIGN SSD	DESIGN K
48	400	75
49	415	80
50	425	84
51	440	90
52	455	96
53	465	101
54	480	107
55	495	114
56	510	121
57	525	128
58	540	136
59	555	143
60	570	151
61	585	159
62	600	167
63	615	176
64	630	184
65	645	193
66	665	205
67	680	215
68	695	224
69	715	237
70	730	247
71	745	257
72	765	271
73	780	282
74	800	297
75	820	312

Using: S = Stopping Sight Distance, ft.
L = Length of Crest Vertical Curve, ft.
A = Algebraic Difference in Grades (%), Absolute Value
K = Rate of Vertical Curvature

- For a given design speed and an "A" value, the calculated length "L" = K x A
- To determine "S" with a given "L" and "A", use the following:

For S<L: $S = 46.45 \sqrt{K}$, where K = L/A

For S>L: $S = 1079/A + L/2$

SAG VERTICAL CURVES

203-6

REFERENCE SECTION

201.2.2 & 203.3.4

HEIGHT OF HEADLIGHT = 2.00'

DESIGN SPEED	DESIGN SSD	DESIGN K
20	115	17
21	120	18
22	130	20
23	140	22
24	145	24
25	155	26
26	165	28
27	170	29
28	180	32
29	190	34
30	200	37
31	210	39
32	220	42
33	230	44
34	240	47
35	250	49
36	260	52
37	270	55
38	280	57
39	290	60
40	305	64
41	315	66
42	325	69
43	340	73
44	350	76
45	360	79
46	375	83
47	385	85

UPWARD LIGHT BEAM DIVERGENCE = 1° 00'

DESIGN SPEED	DESIGN SSD	DESIGN K
48	400	89
49	415	93
50	425	96
51	440	100
52	455	104
53	465	107
54	480	111
55	495	115
56	510	119
57	525	123
58	540	128
59	555	132
60	570	136
61	585	140
62	600	144
63	615	148
64	630	153
65	645	157
66	665	162
67	680	167
68	695	171
69	715	176
70	730	181
71	745	185
72	765	190
73	780	194
74	800	200
75	820	206

Using: S = Stopping Sight Distance
L = Length of Sag Vertical Curve
A = Algebraic Difference in Grades (%), Absolute Value
K = Rate of Vertical Curvature

- For a given design speed and an "A" value, the calculated length "L" = K x A
- To determine "S" with a given "L" and "A", use the following:

For S<L: $$S = \frac{3.5L + \sqrt{12.25L^2 + 1600AL}}{2A}$$

For S>L: $$S = (AL + 400)/(2A - 3.5)$$

Note: When the algebraic difference, A, is 1.75% or less, SSD is not restricted by the vertical curve.

Table 4-9. Guidelines for Minimum Rate of Vertical Curvature to Provide Design Stopping Sight Distance on Crest Vertical Curves for New Construction of Low-Volume Roads

U.S. Customary

	All Locations for 0–100 veh/day and "Lower Risk" Locations for 101–250 veh/day[1]			"Higher Risk" Locations for 101–250 veh/day and All Locations for 251–400 veh/day[2]			All Locations for 401–2,000 veh/day		
		Rate of Vertical Curvature, K[3]			Rate of Vertical Curvature, K[3]			Rate of Vertical Curvature, K[3]	
Design Speed (mph)	Stopping Sight Distance (ft)	Calculated	Design	Stopping Sight Distance (ft)	Calculated	Design	Stopping Sight Distance (ft)	Calculated	Design
15	65	2.0	2	65	2.0	2	80	3.0	3
20	90	3.8	4	95	4.2	5	115	6.1	7
25	115	6.1	7	125	7.2	8	200	11.1	12
30	135	8.4	9	165	12.6	13	250	18.5	19
35	170	13.4	14	205	19.5	20	305	29.0	29
40	215	21.4	22	250	29.0	29	360	43.1	44
45	260	31.3	32	300	41.7	42	425	60.1	61
50	310	44.5	45	350	56.8	57	495	83.7	84
55	365	61.7	62	405	76.0	76	570	113.5	114
60	435	87.7	88	470	102.4	103	—	150.6	151

Metric

	All Locations for 0–100 veh/day and "Lower Risk" Locations for 101–250 veh/day[1]			"Higher Risk" Locations for 101–250 veh/day and All Locations for 251–400 veh/day[2]			All Locations for 401–2,000 veh/day		
		Rate of Vertical Curvature, K[3]			Rate of Vertical Curvature, K[3]			Rate of Vertical Curvature, K[3]	
Design Speed (km/h)	Stopping Sight Distance (m)	Calculated	Design	Stopping Sight Distance (m)	Calculated	Design	Stopping Sight Distance (m)	Calculated	Design
20	15	0.3	0.5	15	0.3	0.5	20	0.6	1
30	25	0.9	1	30	1.4	2	35	1.9	2
40	35	1.9	2	40	2.4	4	50	3.8	4
50	45	3.1	4	55	4.6	5	65	6.4	7
60	60	5.5	6	70	7.4	8	85	11.0	11
70	75	8.5	9	90	12.3	13	105	16.8	17
80	95	13.7	14	110	18.4	19	130	25.7	26
90	120	21.9	22	130	25.7	26	160	38.9	39
100	140	29.8	30	155	36.5	37	185	52.0	52

[1] "Lower risk" locations are locations not in close proximity to intersections, narrow bridges, railroad–highway grade crossings, sharp curves, or steep downgrades.
[2] "Higher risk" locations are locations near intersections, narrow bridges, or railroad–highway grade crossings, or in advance of sharp curves or steep downgrades.
[3] The rate of vertical curvature, K, is the length of curve (L) per percent algebraic difference in intersecting grades (A); i.e., $K = L/A$.

4.5.1.4 Sag Vertical Curves

There are no special guidelines for design of sag vertical curves on low-volume roads. Sag vertical curves should generally be designed in accordance with Chapters 5 and 6 of the AASHTO Green Book (5).

4.5.2 Existing Roads

Given the geometry of stopping sight distance on horizontal and crest vertical curves, the costs for even marginal or incremental improvements make reconstruction of low-volume roads to increase stopping sight distance not cost-effective except in unusual cases. NCHRP Report 400 (7) found that, even on higher volume roadways, crashes associated with limited sight distance are extremely rare events. Furthermore, there was no indication that lengthening the sight distance of a crest vertical curve has any demonstrable effect on reducing the number of collisions. Collisions related to limited sight distance are even less likely on low-volume roads than on the higher volume roads studied in NCHRP Report 400 (7).

Because sight distance improvements are unlikely to be cost-effective under most circumstances, the existing sight distance on a low-volume road may be allowed to remain in place unless there is evidence of a site-specific crash pattern attributable to inadequate sight distance. If a site-specific crash pattern is identified, and if the designer finds after investigation that the crash pattern is attributable to limited sight distance, then the sight distance of the specific horizontal or vertical curve(s) at which the problem is present should be upgraded to at least the sight distance levels shown in Table 4-7 as part of any reconstruction project undertaken. Sight distance could be increased to the full criteria presented in the AASHTO Green Book (5) where the judgment of the designer indicates that this is appropriate. This approach is intended to provide maximum flexibility to the designer in assessing site-specific conditions and exercising informed judgment to decide whether a correctable problem is present or not. Guidance concerning identification of site-specific crash patterns is found in Section 3.5 of these guidelines.

4.6 INTERSECTION SIGHT DISTANCE

4.6.1 General Considerations

Each intersection has the potential for several different types of vehicle–vehicle conflicts. The possibility of these conflicts actually occurring can be greatly reduced through the provision of proper sight distances and appropriate traffic controls. The avoidance of crashes and the efficiency of traffic operations still depend on the judgment, capabilities, and response of each individual driver.

The driver of a vehicle approaching an at-grade intersection should have an unobstructed view of the entire intersection, including any intersection traffic-control devices, and sufficient lengths of the intersecting road to permit the driver to anticipate and avoid potential collisions. The sight distance that should be used for design under various assumptions of physical conditions and driver behavior is

RURAL LANE WIDTHS [(A)]

301-2

REFERENCE SECTIONS
301.1.2

Functional Classifcation	Traffic	Minimum Lane Widths (ft.)										
	Design Year ADT	Design Speed (mph)										
		20	25	30	35	40	45	50	55	60	65	70 or >
Interstate, Other Freeways, and Expressways	ALL	--	--	--	--	--	--	12	12	12	12	12
Arterial	> 2000	--	--	--	--	12	12	12	12	12	12	12
	400 to 2000	--	--	--	--	11	11	11	12	12	12	12
	< 400	--	--	--	--	10	10	11	11	11	11	11
Collector	> 2000	11	11	11	11	11	11	11	11 [(C)]	11 [(C)]	--	--
	400 to 2000	10	10	10	11	11	11	11	11	11	11	--
	< 400	10	10	10	10	10	10	10	11	11	11	--
Local	> 2000	11	11	11	11	11	11	11	11 [(C)]	11 [(C)]	--	--
	400 to 2000	10	10	10	10	10	11	11	11	11	--	--
	< 400	9	9	9	9	9	10	10	11	11	--	--

NOTES:

(A) There may be some rural locations that are urban in character. An example would be a village where adjacent development and other conditions resemble and urban area. In such cases, urban design criteria (Figure 301-4) may be used.
(B) The number of lanes should be determined by a capacity analysis.
(C) Consider using a 12' lane width where substantial truck volumes are present or agricultural equipment frequently use the road.
(D) For National Network lane width requirements, see Section 105.3

Note: For the design criteria pertaining to Collectors and Local Roads with ADT's of 2000 or less, refer to the **AASHTO publication Guidelines for Geometric Design of Low-Volume Roads (2nd Edition 2019)**

Table 4-1. Guidelines for Total Roadway Width for New Construction of Low-Volume Roads in Rural Areas

U.S. Customary

Design Speed (mph)	Total Roadway Width (ft) by Functional Subclass[1]: Major Access Road by Design Volume Level (veh/day): 400 or Less	401 to 2,000	Minor Access Road	Recreational and Scenic Road	Industrial/ Commercial Access Road	Resource Recovery Road	Agricultural Access Road
15	18.0	23.0[2]	18.0	18.0	20.0	20.0	22.0
20	18.0	23.0[2]	18.0	18.0	20.0	20.0	24.0
25	18.0	23.0[2]	18.0	18.0	21.0	21.0	24.0
30	18.0	23.0[2]	18.0	18.0	22.5	22.5	24.0
35	18.0	23.0[2]	18.0	18.0	22.5	22.5	24.0
40	18.0	23.0[2]	18.0	20.0	22.5	—	24.0
45	20.0	25.0	20.0	20.0	23.0	—	26.0
50	20.0	25.0	20.0	20.0	24.5	—	—
55	22.0	25.0	—	22.0	—	—	—
60	22.0	25.0	—	—	—	—	—

Metric

Design Speed (km/h)	Total Roadway Width (m) by Functional Subclass[1]: Major Access Road by Design Volume Level (veh/day): 400 or Less	401 to 2,000	Minor Access Road	Recreational and Scenic Road	Industrial/ Commercial Access Road	Resource Recovery Road	Agricultural Access Road
20	5.4	7.0[2]	5.4	5.4	6.0	6.0	6.6
30	5.4	7.0[2]	5.4	5.4	6.0	6.0	7.2
40	5.4	7.0[2]	5.4	5.4	6.4	6.4	7.2
50	5.4	7.0[2]	5.4	5.4	6.8	6.8	7.2
60	5.4	7.0[2]	5.4	5.4	6.8	6.8	7.2
70	6.0	7.6	6.0	6.0	7.0	—	8.0
80	6.0	7.6	6.0	6.0	7.4	—	—
90	6.6	7.6	—	6.6	—	—	—
100	6.6	7.6	—	—	—	—	—

Note: Total roadway width includes the width of both traveled way and usable shoulders.

[1] All low-volume roads with design volumes greater than 400 veh/day should be treated as major access roads

[2] For roads in mountainous terrain with design volumes up to 600 veh/day, use 20.0-ft [6.0-m] total roadway width.

Small differences in the existing or proposed dimensions from those shown in Table 4-1 may be completely acceptable. For example, on roads used by trucks or wider agricultural equipment, designers should have the discretion to consider the actual widths of vehicles expected to use a particular road and modify the width guidelines in Table 4-1 accordingly.

RURAL SHOULDER CRITERIA

Functional Classifcation	Traffic	Graded Width			Treated Width	Type (I)	Rounding (K)		Guardrail Offset (From Traveled Way)
	Design Year ADT	With Barrier	Without Barrier and Foreslope Steeper than 6:1	Without Barrier 6:1 or Flatter Foreslope			Design Speed		
							≥ 50	< 50	
Interstate, Other Freeways, & Expressways (Q)	ALL	15' Rt. 9' Med. (B)(P)	15' Rt. 9' Med. (B)	10' Rt. 4' Med. (D)	10' Rt. (C) (R) 4' Med. (D)	Paved	10'	--	(L) (G)
Arterial (N)	>2000	13' (P)	12'	8'	8'	PVD (O)	8'	4'	10' (G)
	1501 to 2000	11' (P)	10'	6'	6'	PVD (O)	8'	4'	8' (G)
	400 to 1500	11' (P)	10'	6'	6'	PVD (O)	4'	4'	8' (G)
	< 400	9' (P)	8'	4'	4'	PVD (O)	4'	4'	6' (G)
Collector (N)	>2000	11' (P)	10'	8'	6'	SRF. TRT. (J)	8'	4'	8' (M)
	1501 to 2000	9' (P)	8'	6' (E)	4'	AGG. BASE	8'	4'	6' (M)
	400 to 1500	7' (P)	6'	5'	4'	AGG. BASE	4'	4'	4'
	< 400	7' (P)	6'	(F)	(F)	AGG. BASE	4'	4'	4'
Local	>2000	11' (P)(H)	10' (H)	8' (H)	4'	SRF. TRT. (J)	8'	4'	8' (M)
	1501 to 2000	9' (P)	8'	6' (E)	4'	AGG. BASE	8'	4'	6' (M)
	400 to 1500	7' (P)	6'	5'	4'	AGG. BASE	4'	4'	4'
	< 400	7' (P)	6'	(F)	(F)	AGG. BASE	4'	4'	4'

See the following sheet for corresponding notes.

Notes to Figure 301-3: Rural Shoulder Criteria

(A) There may be rural locations that are urban in character. An example would be a village where adjacent development and other conditions resemble an urban area. In such cases, urban design criteria (**Figure 301-4**) may be used.

(B) If 6 or more lanes, use 15 ft.

(C) Where truck traffic exceeds 250 DDHV, additional shoulder width may be beneficial. IF the treated shoulder width is increased then the graded shoulder width should be increased by the same amount.

(D) If 6 or more lanes, use 10 ft. See note (R).

(E) A 6-ft. turf shoulder may be used with a 4:1 or flatter foreslope.

(F) See AASHTO's 2019 Guidelines for Geometric Design Low-Volume Roads 2nd Edition for values.

(G) Concrete barrier may be placed at the edge of treated shoulder when used in lieu of guardrail.

(H) An 8-ft. graded shoulder may be used with a 4:1 or flatter foreslope.

(I) Turf shoulders may be used on non-state maintained roads at option of local government if current year ADT includes less than 250 B and C truck units. Turf shoulders are not to be used on State maintained roads.

(J) On state maintained roads, the treatment is based on the number of B and C unit trucks in the design year ADT. Refer to PDM Figures 303-1 & 403-1 for aggregate and surface treated shoulder build ups. Less than 250 trucks, aggregate base may be used. 250 to 500 trucks, surface treated aggregate base (single layer) may be used. Greater than 500 to 1000 trucks, surface treated on two layers of aggregate base may be used. Over 1000 trucks, paved shoulders are recommended.

(K) Rounding should be 4-ft. where the foreslope begins beyond the clear zone or where guardrail is installed and foreslope is steeper than 6:1. No rounding is required when the foreslope is 6:1 or flatter.

(L) Guardrail offset is treated width plus 2-ft.

(M) Whenever a design exception is approved for graded shoulder width, the guardrail offset may be reduced but shall not be less than 4-ft.

(N) The median and right shoulder width criteria for Interstates, other freeways, and expressways shall apply to the shoulders of divided arterials and divided collectors.

(O) A fully paved shoulder is preferred, but may not be economically feasible. Therefore, a minimum 2-ft. of the treated shoulder should be paved. The remainder of the treated shoulder may be either aggregate shoulder or surface treated according to the criteria stipulated in Note (J). If pedestrians or bicyclists are known to be frequent users, a fully paved shoulder should be provided.

(P) Total Graded Width may be reduced as much as 3-ft. where MGS guardrail with the longer posts is used. See Section 603.1.2 and SCD MGS-1.1 for post length and position details.

(Q) Paved shoulder width reductions of less than 2-ft. at sign or luminaire foundations or bridge piers will not require a design exception. The 4-ft. minimum lateral clearance must still be provided.

(R) Prior to the January 2017 update of L&D Manual Vol. 1, a 12-ft. shoulder width was the standard. A 12-ft. shoulder width may be retained or perpetuated, if desired.

Note: For the design criteria pertaining to Collectors and Local Roads with ADT's of 2000 or less, refer to the **AASHTO publication Guidelines for Geometric Design of Low-Volume Roads (2nd Edition 2019)**

CLEAR ZONE WIDTHS

Design Speed	Design ADT	Foreslope		Backslope		
		6:1 or Flatter	Steeper than 6:1 to 4:1	6:1 or Flatter	Steeper than 6:1 to 4:1	Steeper than 4:1
40 mph or less	<750	8 ft	8 ft	8 ft	8 ft	8 ft
	750-1500	11	13	11	11	11
	1501-6000	13	15	13	13	13
	>6000	15	17	15	15	15
45-50 mph	<750	11	13	11	9	9
	750-1500	13	18	15	13	11
	1501-6000	17	23	17	15	13
	>6000	19	26	21	19	15
55 mph	<750	13	16	11	11	9
	750-1500	17	22	17	15	11
	1501-6000	21	27	21	17	15
	>6000	23	29	23	21	17
60 mph	<750	17	22	15	13	11
	750-1500	22	29	21	17	13
	1501-6000	28	36*	25	21	16
	>6000	31*	40*	27	25	21
65-70 mph	<750	19	23	15	15	11
	750-1500	25	32*	21	19	14
	1501-6000	30	38*	27	23	18
	>6000	32*	42*	28	28	23

* Use a **maximum clear zone** of 30 feet unless a site-specific investigation or accident history indicates a high potential of continuing accidents. When the potential for continuing accidents is high, the widths in the above chart should be multiplied by the following curve correction factors to extend the clear zone on the outside of curves having a Degree of Curvature of 2 degrees or sharper.

Degree of Curvature	HORIZONTAL CURVE CORRECTION FACTORS						
	Design Speed (mph)						
	40	45	50	55	60	65	70
2.0	1.1	1.1	1.1	1.2	1.2	1.2	1.3
2.5	1.1	1.1	1.2	1.2	1.2	1.3	1.3
3.0	1.1	1.2	1.2	1.2	1.3	1.3	1.4
3.5	1.1	1.2	1.2	1.3	1.3	1.4	1.5
4.0	1.2	1.2	1.2	1.3	1.4	1.4	
4.5	1.2	1.2	1.3	1.3	1.4	1.5	
5.0	1.2	1.2	1.3	1.4	1.5		
6.0	1.2	1.3	1.4	1.4	1.5		
7.0	1.3	1.3	1.4	1.5			
8.0	1.3	1.4	1.5				
9.0	1.3	1.4	1.5				
10.0	1.4	1.5					
15.0	1.5						

guidelines for low-volume roads provide great flexibility to the designer in exercising engineering judgment to decide where it is appropriate to provide improved roadsides.

4.7.1 New Construction

Roadside design guidelines applicable to new construction of low-volume roads are presented below. The guidelines address both clear zone width and traffic barrier warrants and are appropriate for all functional subclasses of low-volume roads.

4.7.1.1. Clear Zone Width

The risk assessment discussed in Section 3.4 of this guide found that it is not generally cost-effective to provide clear zones, also known as clear recovery areas, on low-volume roads. Nevertheless, a clear zone of any width should provide some contribution to crash reduction. Thus, where clear zones can be provided on low-volume roads at little or no additional cost, their incorporation in designs should be considered. Clear zones may also be appropriate on horizontal curves where the minimum radius of curvature is not provided. However, major expenditures to provide clear zones will generally have only limited crash reduction benefits and are unlikely to be cost-effective. The design guidelines for roadside clear zone width on low-volume rural roads with design volumes of 400 vehicles per day or less are as follows:

1. At locations where a clear recovery area of 6 ft [2 m] or more in width can be provided at low cost and with minimum social or environmental impacts, provision of such a clear recovery area should be considered.
2. Where constraints of cost, terrain, right-of-way, or potential social or environmental impacts make the provision of a 6-ft [2-m] clear recovery area impractical, clear recovery areas less than 6 ft [2 m] in width may be used, including designs with 0 ft [0 m] clear recovery areas.
3. In all cases, designers should be encouraged to tailor the roadside design to site-specific conditions, considering cost-effectiveness and crash risk tradeoffs. For example, the use of adjustable clear zone widths may be appropriate in some cases, such as providing wider clear zone dimensions at sharp horizontal curves where there is a history of run-off-road crashes or where scarring of trees or utility poles may indicate possible vehicle encroachments. Lesser values of clear zone width may be appropriate on tangent sections of the same roadway.
4. Other factors for consideration in analyzing the need for providing clear zones include the crash history, the expectation for future traffic volume growth on the facility, and the presence of vehicles wider than 8.5 ft [2.6 m] and vehicles with wide loads, such as farm equipment.

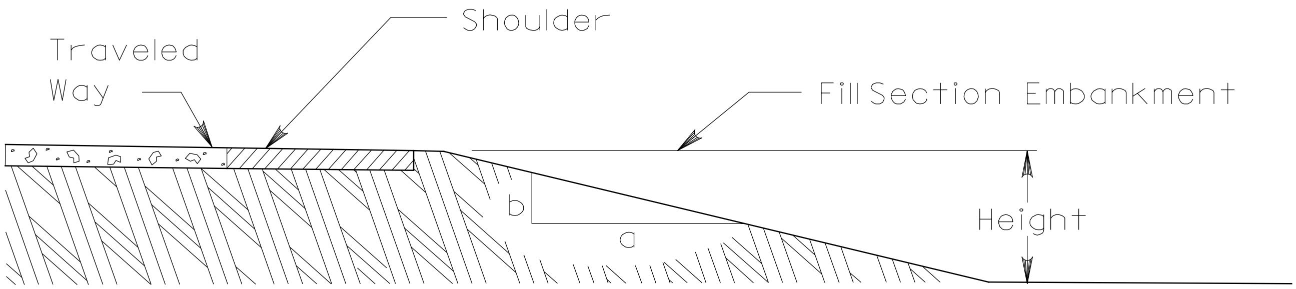
On low-volume rural roads with design volumes from 401 to 2,000 vehicles per day, clear zones with widths of 7 to 10 ft [2 to 3 m] are desirable.

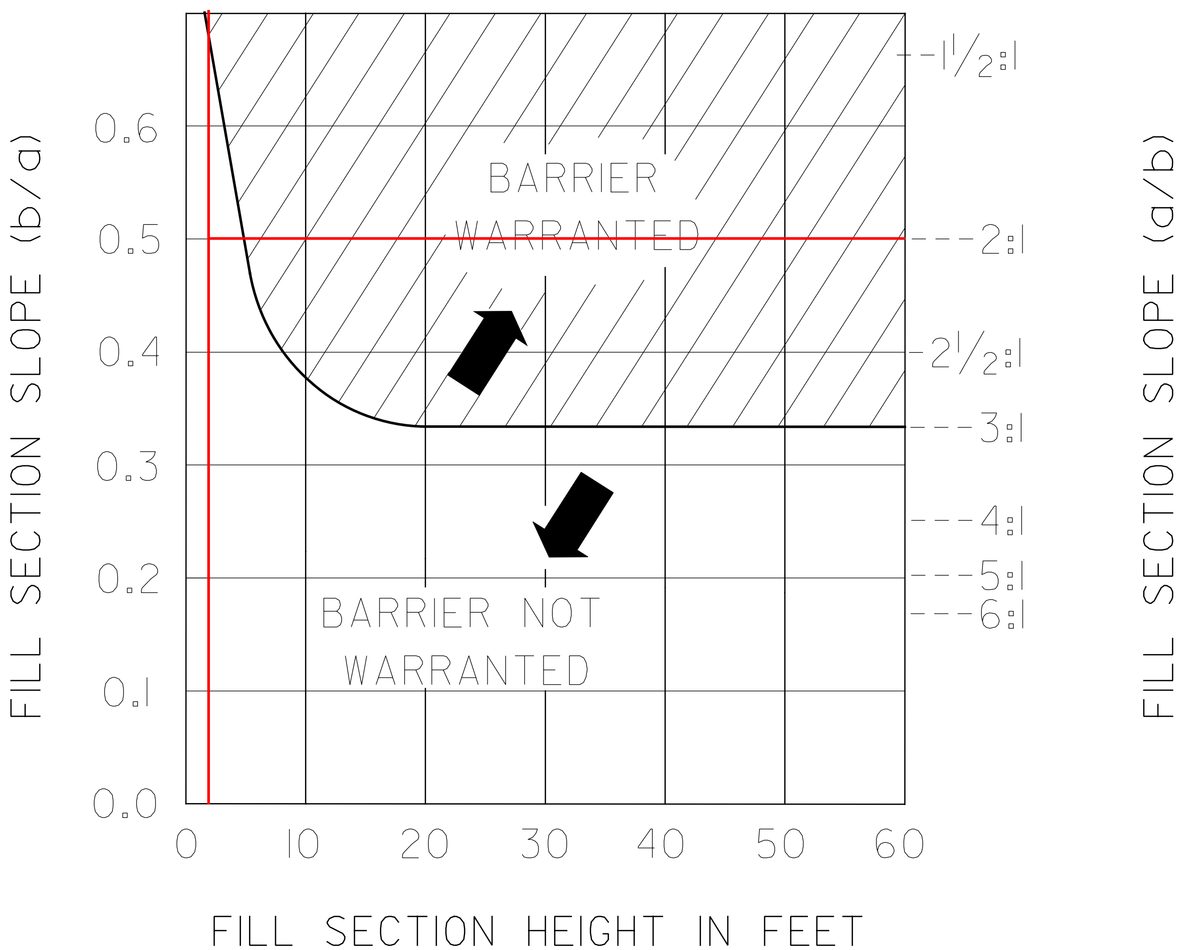
Provision of clear zones is often not practical for urban low-volume streets. On urban local streets, clear zones are not generally provided. On urban minor collector streets, designs with reduced clear zones or designs incorporating as many roadside safety features as practical may be considered.

BARRIER WARRANTS FOR EMBANKMENTS

601-1

REFERENCE SECTIONS 601.1.2



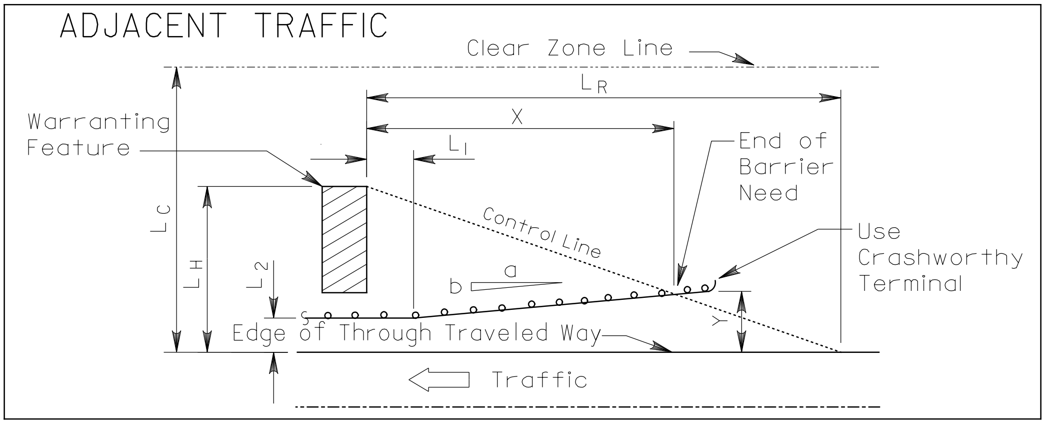


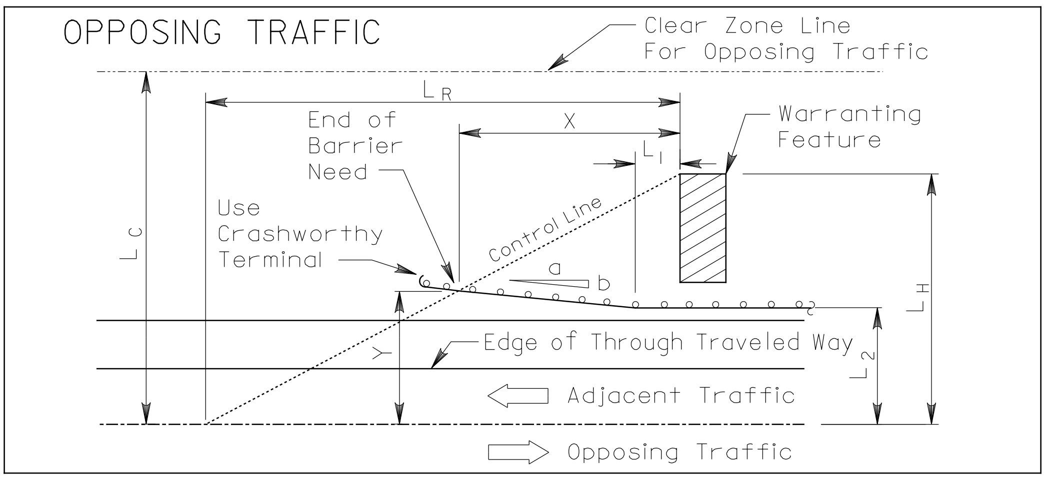
On or below the curve barrier is not warranted for embankment. However, check barrier need for other roadside hazards within the clear zone.

BARRIER LENGTH OF NEED (TANGENT ALIGNMENT)

602-1

REFERENCE SECTIONS 602.1.2, 602.5.1, & 603.6





Design Speed (mph)	Flare Rate (a:b)		Runout Length, L_R (ft) Per Design Year ADT			
	Concrete Barrier	MGS Guardrail	Over 10,000 veh/day	5,000-10,000 veh/day	1,000-5,000 veh/day	Under 1,000 veh/day
75	20:1	7:1	415	380	335	290
70	20:1	7:1	360	330	290	250
65	19:1	7:1	330	290	250	225
60	18:1	7:1	300	250	210	200
55	16:1	7:1	265	220	185	175
50	14:1	7:1	230	190	160	150
45	12:1	7:1	195	160	135	130
40	10:1	7:1	160	130	110	100
35	9:1	7:1	135	110	95	85
30	8:1	7:1	110	90	80	70

Formulas

X = Length of Need
L_R = Runout Length
L_C = Required Clear Zone
L_H = Lateral Offset to Back of Warranting Feature
L_2 = Lateral Offset to Face of Barrier (see Figure 301-3)
L_1 = Varies (Typically measured to the end of a full panel of guardrail)

If $L_H < L_C$: $X = \dfrac{L_H + (b/a)L_1 - L_2}{(b/a) + L_H/L_R}$

$Y = L_H - X(L_H/L_R)$

If $L_H > L_C$: Substitute L_C in the above formulas.

LON Calculations
N/A

Simplified Pavement Designs for Short* Projects

Pavement Composition	Pavement Course Thicknesses Number of Trucks in Opening Day ADT (ADT x T24)														
	<=10		11-25		26-50		51-100		101-200		201-400		401-800		>800
	in	mm	**in**	mm	**in**	mm	**in**	mm	**in**	mm	**in**	mm	**in**	mm	
Flexible Design															
441 AC Surface, Type 1, (449), PG64-22**	**1.25**	32	**3**	75	**3**	75	**3**	75	**3**	75	**3**	75	**3**	75	n/a
301 Asphalt Concrete Base, (449), PG64-22	**4**	100	**4**	100	**5**	125	**6**	150	**7**	180	**8**	200	**9**	230	n/a
304 Aggregate Base	**6**	150	**6**	150	**6**	150	**6**	150	**6**	150	**6**	150	**6**	150	n/a
Alternate Flexible Design															
441 AC Surface, Type 1, (449), PG64-22**	**3**	75	-	-	-	-	-	-	-	-	-	-	-	-	n/a
304 Aggregate Base	**12**	300	-	-	-	-	-	-	-	-	-	-	-	-	n/a
Rigid Design															
452 Non-Reinforced Concrete Pavement, Class QC 1P	**7*** **	180	**7*** **	180	**7*** **	180	**7*** **	180	**8**	210	**9**	230	**10**	260	n/a
304 Aggregate Base	**6**	150	**6**	150	**6**	150	**6**	150	**6**	150	**6**	150	**6**	150	n/a

* Less than 300 linear feet (100 m) of total pavement replacement.
** Include a plan note restricting the 441 to 2-inch (50 mm) maximum lift thickness.
*** 7-inch (180 mm) concrete is allowed for short projects only. All other projects require 8-inch (200 mm) minimum in accordance with Section 302.

# Asphalt Concrete Quick Reference Guide **Page 1**	**406-1** January 2024 **Reference Section** **406**

Item	Minimum Lift	Maximum Lift	Taper to 0"*	Uniform Thickness Required
301 Asphalt Concrete Base (449)	3"	6"	No	No
302 Asphalt Concrete Base (449)	4"	7.75"	No	No
424 Fine Graded Polymer Asphalt Concrete, Type A (449)	0.625" (5/8")	1"	No	Yes
424 Fine Graded Polymer Asphalt Concrete, Type B (448 & 449)	0.75"	1.25"	No	Yes
441 AC Surface Course, Type 1 (446)	1.25"	1.5"	No	Yes
441 AC Surface Course, Type 1 (448)	1.25"	1.5"	No	Yes
441 AC Surface Course, Type 1 (449) [Two Lifts]	1.25"	1.5"	No	No
441 AC Intermediate Course, Type 1 (448)	1"	1.5"	No	Yes
441 AC Intermediate Course, Type 1 (449)	1"	1.5"	Yes	No
441 AC Intermediate Course, Type 2 (446 & 448)	1.75"	3"	No	Yes
441 AC Intermediate Course, Type 2 (449)	1.75"	3"	Yes	No
442 AC Surface Course, 9.5mm, Type A or B (446 & 447)	1.25"	1.5"	No	Yes
442 AC Surface Course, 9.5mm, Type A or B (448)	1.25"	1.5"	No	Yes
442 AC Surface Course, 9.5mm, Type A or B (449)	1.25"	1.5"	No	No
442 AC Surface Course, 12.5mm, Type A or B (446, **447** & 448)	1.5"	2.5"	No	Yes
442 AC Surface Course, 12.5mm, Type A or B (449)	1.5"	2.5"	No	No
442 AC Intermediate Course, 19mm, Type A or B (**446** & 448)	2.25"	3.75"	No	Yes
442 AC Intermediate Course, 19mm, Type A or B (449)	2.25"	3.75"	Yes	No
442 AC Intermediate Course, 12.5mm, Type A or B (**446** & 448)	1.5"	2.5"	No	Yes
442 AC Intermediate Course, 12.5mm, Type A or B (449)	1.5"	2.5"	Yes	No
442 AC Intermediate Course, 9.5mm, Type A or B (448)	1"	1.5"	No	Yes
442 AC Intermediate Course, 9.5mm, Type A or B (449)	1"	1.5"	Yes	No
443 Stone Matrix Asphalt Concrete, 12.5mm (446)	1.5"	2"	No	Yes

Items in **bold** indicate the most commonly used surface and intermediate courses.

low chord clear the water surface profile of the flood produced by the design AEP storm discharge. These clearances may be reduced where a cost comparison of alternatives shows that a reduction in clearance will result in significant savings. Consider future flood related costs relative to highway operation, maintenance, and repair; highway-aggravated flood damage to other property; and for additional or interrupted highway travel.

Flood clearances may also be reduced to protect important ecological resources as identified in the environmental documentation.

Equivalence between the two can be seen below.

AEP	Recurrence Interval
50%	2 year
20%	5 year
10%	10 year
4%	25 year
2%	50 year
1%	100 year
0.2%	500 year

See Glossary of Terms for the definition of AEP.

1004.2 Design AEP Storm

Use the AEP storm for the design as specified below:

- Interstates, Freeways & Expressways...2% AEP
- Other Highways (3000 ADT and over) and Freeway Ramps...4% AEP
- Other Highways (under 3000 ADT)....10% AEP
- *Bicycle Pathway...................................20% AEP

* Unless otherwise approved by OHE.

C1004.2

Code of Federal Regulations 23 CFR 650.115(a)(2) requires interstate highways to be provided with protection from the 2% AEP flood event.

Other roadway design AEP floods are based on the class of highway, or the level of urbanization and development.

1005 Highway Encroachments on Floodplains

1005.1 General

Design all highways that encroach on floodplains, bodies of water or streams to allow conveyance of the 1% AEP storm discharge without causing significant damage to the highway, watercourse, body of water or other property.

Hydraulically design structures and/or channels to carry the design AEP storm discharge. Confirm the structure and/or channel will carry the 1% AEP check storm discharge without causing property damage. Inundation of the highway is acceptable for the 1% AEP discharge, but it is not permitted for the design AEP discharge. Water surface elevations caused by existing structures do not have to be lowered to meet the 1% AEP discharge.

1005.1.1 Flood Data and Flood Insurance Study

Special consideration must be given when designing a structure located within a reach of channel that is part of an FIS. Perform a step

C1005.1.1

The floodway is the channel of a watercourse and the adjacent land areas that must be reserved in order to discharge the 1% AEP flood, or base flood,

1005.2 Type of Studies

1005.2.1 Hazard Evaluation for Watercourses W/O A Defined FEMA SFHA

A Flood Hazard Evaluation is required for all watercourse involvements except for FEMA Zones A, AE and A1-A30, or where roadway culverts are provided to satisfy minimum size requirements. Perform the following for a flood hazard evaluation:

1. Determine the water surface elevation of the design AEP and 1% AEP flood.
2. Delineate the inundation area for the peak water surface elevation for the design AEP and 1% AEP flood on a topographic map or a digital map.
3. Evaluate the impacts of any increase in the flooding limits.

C1005.2.1

A Flood Hazard Evaluation is a condition statement regarding the nature of the upstream area, the extent of upstream flooding, and whether buildings are in the 1% AEP floodplain.

1005.2.2 Detailed Study

If the Hazard Evaluation indicates a significant increase in the flooding of upstream property, a Detailed Study is required. Furnish a Detailed Study in highly urbanized areas where the potential for flooding cannot be accurately assessed without an analysis of the entire floodplain. For prefabricated structures, the Detailed Study, including a step-backwater analysis, will be authorized after review of the Hazard Evaluation by OHE.

1006 Allowable Headwater

1006.1 Design AEP Storm

Use the design AEP storm as shown in Section 1004.2.

1006.2 Culvert Headwater Controls

1006.2.1 Design Storm Controls

Headwater depth for all culverts (Type A Conduits) must not exceed any of the following controls for the design storm:

A. 2 feet below the near, low edge of the pavement for drainage areas 1000 acres or greater and 1 foot below for culverts draining less than 1000 acres.
B. 2 feet above the inlet crown of the culvert or

above a tailwater elevation that submerges the inlet crown in flat terrain.

C. 4 feet above the inlet crown of a culvert in a deep ravine.

D. 1 foot below the near edge of pavement for bicycle pathways.

1006.2.2 Check Storm Controls

Headwater depth for all culverts (Type A Conduits) must not exceed any of the following controls for the applicable check storm.

A. 2 feet below the lowest ground elevation adjacent to an occupied building for a 2% AEP storm. This is not intended to lower existing high-water elevations around buildings.

B. Limit the maximum 1% AEP storm headwater depth to twice the diameter or rise of the culvert.

C. Size a replacement structure to prevent overtopping by the 1% AEP storm where overtopping would not occur with the existing structure.

D. Size a replacement structure so that flooding of upstream land is not increased for the 1% AEP storm when compared to the existing structure. Before implementing this criteria consider the type of upstream property and land use.

E. Controls Specific to an FIS. See section 1006.4.

1006.2.3 Limitations

1006.2.1 A is typically the primary headwater control. 1006.2.1 B and C are secondary headwater controls.

The near low edge of the traveled way is the lowest edge of the traveled way elevation located within the drainage divide. This may or may not be located directly over the culvert. If the overtopping elevation point on the roadway is outside the drainage divide, use the ditch break elevation as a headwater control in lieu of 1006.2.1 A.

Use smooth pipe when 1006.2.1 B is applicable to establish the allowable headwater. Use corrugated pipe when 1006.2.1 C is applicable to establish the allowable headwater. Use these established headwater elevations in the design of conduit alternates.

Provide a free water surface through structures

C1006.2.3

In general, a reduction in waterway opening from existing to proposed is discouraged. Consideration can be given to reducing the waterway opening if it does not cause flooding damage upstream or excessive outlet velocity. There are times the hydrology can be questionable so maintaining the same waterway opening as the existing is recommended.

A culvert on a flat grade or one that acts as an equalizer pipe that experiences frequent tailwater conditions may fit the criteria of 1006.2.1 C for determining allowable headwaters.

with a span greater than or equal to 10 feet for the design storm, unless tailwater controls.

1006.3 Bridge Headwater Control

Evaluate the headwater generated by a bridge in accordance to a flood hazard evaluation. Meet the following:

A. Match the existing headwater for a bridge replacement for the design storm and the 1% AEP check storm to the maximum extent practicable. If there is an increase in headwater, determine the upstream impacts.

B. The design storm does not contact the low chord for new structures on new alignment.

C. Regulations from the local Conservancy Districts apply if they are more restrictive than the Department's.

D. Controls specific to an FIS. See section 1006.4.

1006.4 Controls Specific to Flood Insurance Studies

When making an encroachment on a NFIP designated floodplain in the floodway fringe, the rise in the water surface above the natural 1% AEP flood elevation is limited by the community. Contact the Local Floodplain Coordinator early in the design process to determine the allowable headwater increase. A current list of Floodplain Coordinators may be found here: Floodplain Coordinator List

No increase in the Base Flood Elevation is preferred when encroaching on a NFIP designated floodway. When an increase is necessary, approval from the Department, coordination with the Locals/FEMA and a NFIP FIRM revision are required.

C1006.4

Initiate the flood map revision process as soon as possible if changes to the NFIP FIRM will occur because of an encroachment on the floodway or floodway fringe. Submit a CLOMR to FEMA for approval. After construction, a LOMR officially revises the FIRM. The most common cause of change is an increase in the BFE from fill or obstructions added to the floodplain.

FEMA provides guidance on the Flood Map Revision Process.

1007 Pipe Removal Criteria

1007.1 General

Use the following guidelines to determine whether an existing pipe, regardless of type, being taken out of service is to be abandoned, filled and plugged, or removed.

A. Pipes less than 4 inches in diameter may be abandoned in place when below the pavement subgrade.

B. Remove or fill and plug pipes 4 inches through

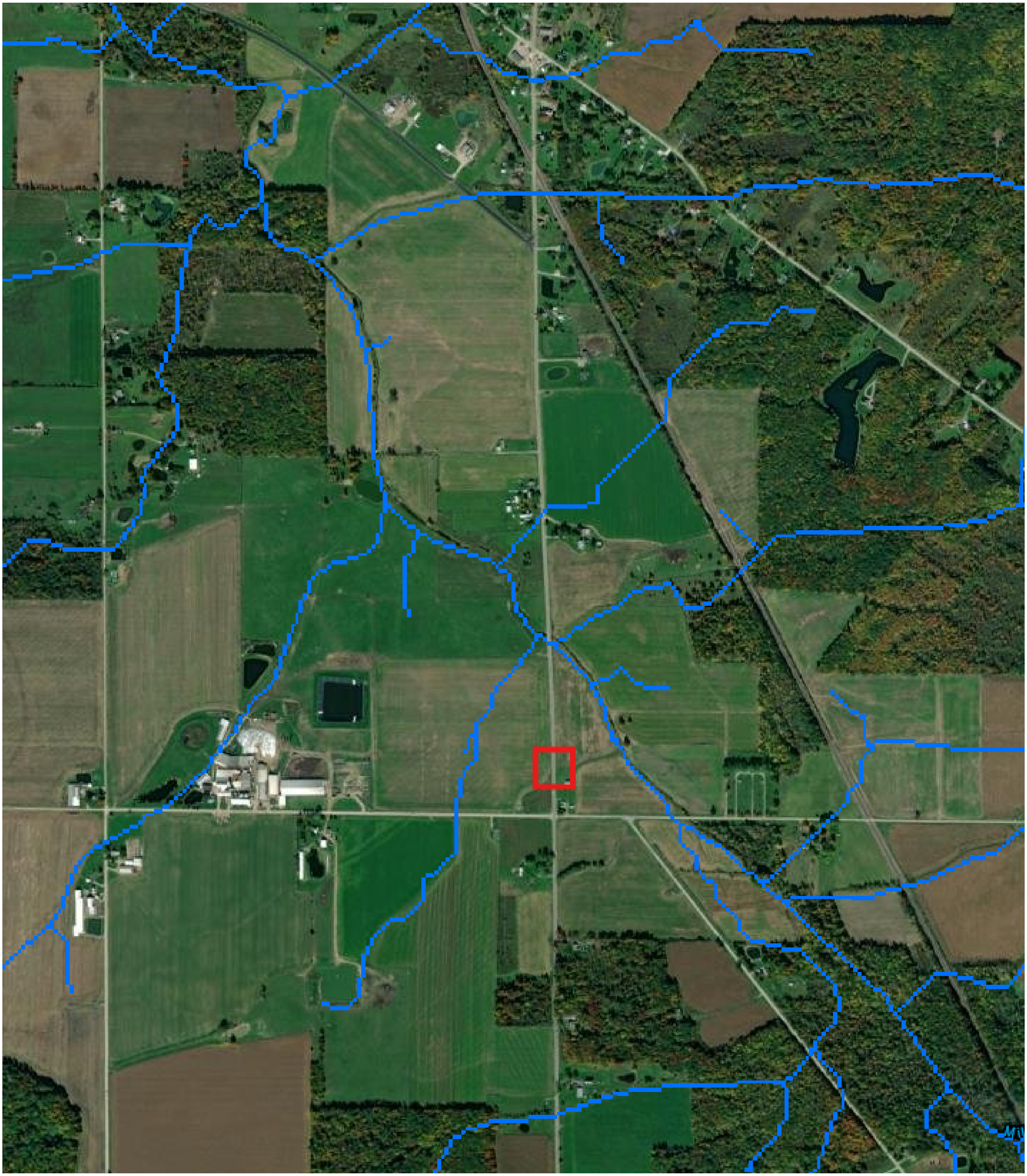
C1007.1

Use discretion in removing:

- Small pipes based on roadway importance, pipe material longevity and if the pipe is under existing rigid pavement or base which is to remain in place.
- Any size pipe with more than 10 feet of cover.

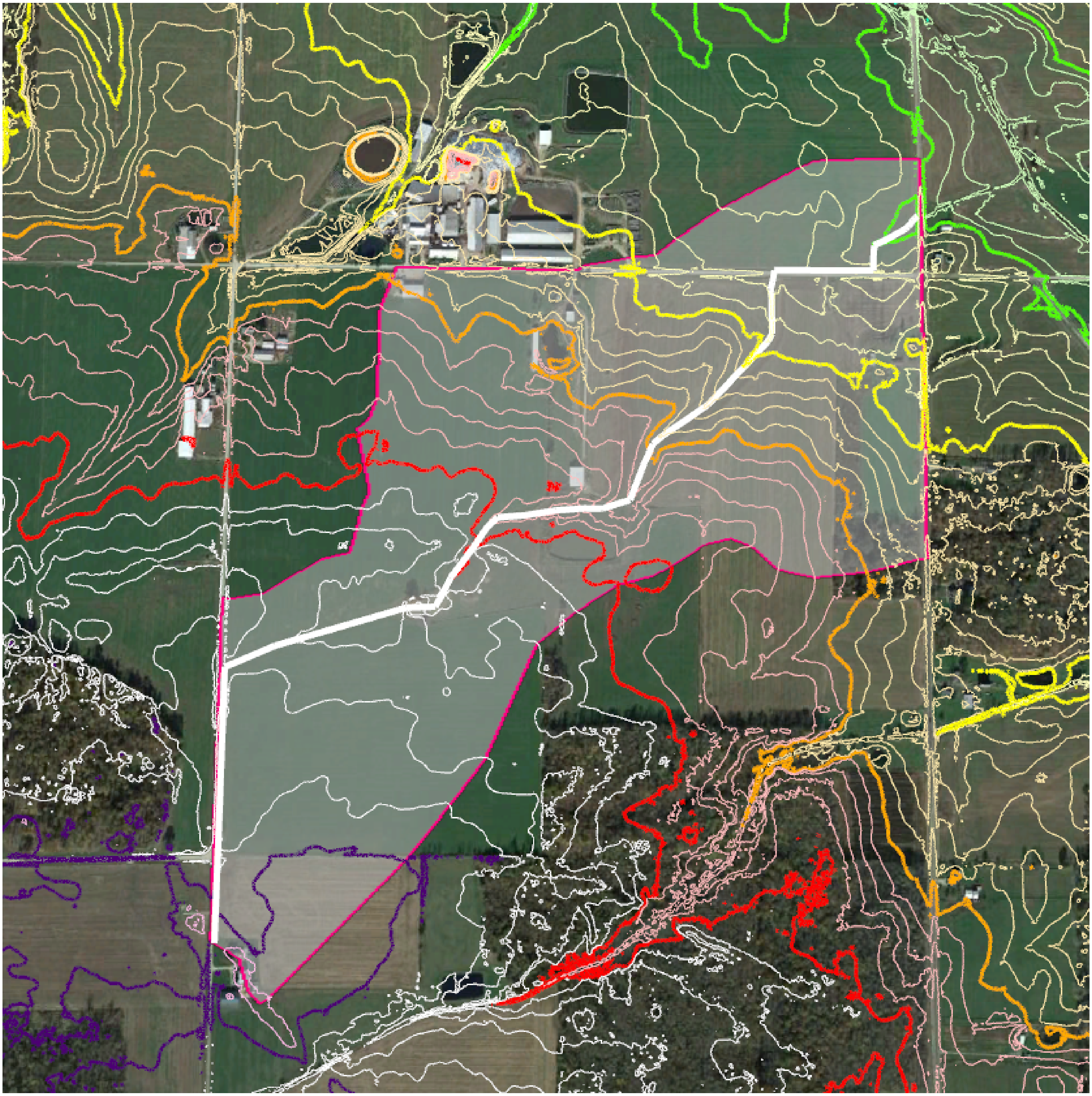
ATB-193-11.140

StreamStats not available



ATB-193-11.140
Google Earth Watershed Delineation

Watershed = 0.29 SQ MI
Contributing Channel = 1.19 MI



Calculation of Flood Peak Discharges in Accordance with USGS Report 89-4126

Project Number: ATB-193-11.140 (PID 122339)

Stream Name: Tributary of Mill Creek

Location: Dorset Twp, Ashtabula County, Ohio

Directions: User input required for numbers in **red**, Output numbers in **blue.** If the Main Channel Slope is known, enter the value directly in the (SLOPE) line. If Main Channel Slope is not known, enter values for (CONTDA) and channel elevations to calculate.

(CONTDA)- Contributing Drainage Area (Sq Miles) = **0.29**

Length of Contributing Channel (Mile) = **1.190**

Distance 85% from Point of Study (Mile) = 1.0 Channel Elevation (feet) = **1008** ft.

Distance 10% from Point of Study (Mile) = 0.1 Channel Elevation (feet) = **970** ft.

(SLOPE)- Main Channel Slope (Feet/Mile) = **42.58**

(STORAGE)- Percentage of Storage Area in Contributing Area = **0.00** %

Enter Region (A, B, or C) = **A** (See Geographic Region Map)

Computation of Peak Flows

Q2 = (RC)*(CONTDA)^0.782 * (SLOPE)^0.172 * (STORAGE+1)^ -0.297 = **40.62 CFS**

Q5 = (RC)*(CONTDA)^0.769 * (SLOPE)^0.221 * (STORAGE+1)^ -0.322 = **74.73 CFS**

Q10 = (RC)*(CONTDA)^0.764 * (SLOPE)^0.244 * (STORAGE+1)^ -0.335 = **100.88 CFS**

Q25 = (RC)*(CONTDA)^0.760 * (SLOPE)^0.264 * (STORAGE+1)^ -0.347 = **135.55 CFS**

Q50 = (RC)*(CONTDA)^0.757 * (SLOPE)^0.276 * (STORAGE+1)^ -0.355 = **163.29 CFS**

Q100 = (RC)*(CONTDA)^0.756 * (SLOPE)^0.285 * (STORAGE+1)^ -0.363 = **190.81 CFS**

Regression Constant (RC) Table

Region	Q2	Q5	Q10	Q25	Q50	Q100
A	56.1	84.5	104	129	148	167
B	40.2	58.4	69.3	82.2	91.2	99.7
C	93.5	133	159	191	214	236

Figure 1.--Location of streamflow-gaging stations and region boundaries (stations outside of Ohio used in the regression analysis are not shown).

☆U.S. GOVERNMENT PRINTING OFFICE: 1990-0-758-159

2 and use the larger of the two as the duration for the new value of rainfall intensity for computing the design flow from MH No. 2 to MH No. 3.

1104.5 Combined Sanitary Sewer Separation

When the Combined Sanitary Authority is under court order to address frequent overflow of the sanitary system due to storm sewer impacts, when feasible, provide an exclusive outfall for the storm sewer. Coordination with the Local is required. While adherence to Local drainage standards is not applicable for ODOT owned and maintained drainage assets it may be possible for the Department to incorporate the needs of the local entity subject to review and approval of OHE.

The Department will fund storm sewer conduit and drainage structures to provide positive drainage of the roadway when a separation is feasible. Conduit and structures required for sanitary sewer are funded by the Local. All conduit located outside of the Department owned right-of-way is also funded by the Local.

1104.6 Sanitary Sewers

Specify joints in accordance with C&MS 706.11 for circular concrete pipe or 706.12 for clay pipe. Permissible thermoplastic pipe may also be specified.

Discharges of treated sanitary flow from abutting property into highway drainage systems are only permitted if the discharge is authorized by the Local Health Department and has a R/W permit.

C1104.6

Obtain and follow local sanitary sewer building codes.

1104.6.1 Manholes

Specify all new manholes for sanitary sewer lines per the Hydraulic SCDs.

1105 Roadway Culverts

1105.1 General

Check the design with a single cell round pipe as a first choice. In cases where the required cover or discharge rules out a round pipe, select a shape that reduces the vertical requirements while maintaining the hydraulic capacity. Consider the following shapes in order of minimum cost to increasing cost: single-cell elliptical concrete, metal pipe-arch, prefabricated box culvert or three-sided structure. For justification of multiple cell culverts,

C1105.1

A culvert generally carries a natural stream under the highway embankment. The culvert horizontal and vertical alignment should approximate that of the natural channel.

Culvert design with the best hydraulic performance and least environmental impacts occurs when the roadway alignment is normal to the flow in the channel and is located on a relatively

MINIMUM CULVERT SIZES	1002-1 REFERENCE SECTION 1002.3.1

	Roadway Types	
	Interstates, Freeways, & Expressways	Other
Fill Depth (ft)	Minimum Size (inches)	Minimum Size (inches)
< 8	24	15
8 to < 16	30	24
16 to 32	36	30
> 32	42	36

REINFORCED CONCRETE ELLIPTICAL PIPE	1008-13
	REFERENCE SECTION 1008.2

706.04 Reinforced Concrete Elliptical Pipe

Equivalent Round Diameter (inches)	Pipe Rise X Span (inches)	Wall Thickness (inches)	Equivalent Round Diameter (inches)	Pipe Rise X Span (inches)	Wall Thickness (inches)
18	14x23	2.75	36	45x29	4.5
24	19x30	3.25	42	53x34	5
27	22x34	3.5	48	60x38	5.5
30	24x38	3.75	54	68x43	6
36	29x45	4.50	60	76x48	6.5
42	34x53	5	66	83x53	7
48	38x60	5.5	72	91x58	7.5
54	43x68	6	78	98x63	8
60	48x76	6.5	84	106x68	8.5
66	53x83	7	90	113x72	9
72	58x91	7.5	96	121x77	9.5
78	63x98	8	102	128x82	9.75
84	68x106	8.5	108	136x87	10
90	72x113	9	114	143x92	10.5
96	77x121	9.5	120	151x97	11
102	82x128	9.75	132	166x106	12
108	87x136	10	144	180x116	13
114	92x143	10.5			
120	97x151	11			
132	106x166	12			
144	116x180	13			

CULVERT ANALYSIS

PID : 122339 **Date :** 12/12/2024 **Project :** ATB/TRU-CULVERTS-FY26 **Location :** ATB-193-11.140

Description : Ex. 84"x36" Slab Top OHWM **Designer :** MEP

HEADWATER CONTROL CODES:
INLET - Inlet Control.
OUTLET - Outlet Control.
OUTLET* - Outlet Control with backwater curve used to compute headwater. See Figure III - 7E in HDS 5 for type flow.
OUTLET** - Outlet Control - See Figure III - 7D in HDS 5 for type flow.
N/A - Flow is supercritical with low headwater and low tailwater. Control Section is at the inlet.

Pipe Number : 1 **Use HW :** 0 **Inlet Invert Elevation (ft.) :** 966.07 **Outlet Invert Elevation (ft.) :** 966.03

Pipe Quantity : 1

Culvert Type : Box **Pipe Length (ft.) :** 35.00 **Culvert Slope (ft./ft.) :** 0.0011

Corrugation Type :

Pipe Size : 7.0 x 3.0 ft.

Design Manning 'n' : (default)

Entrance Type : 0 degree (Extension of sides) **Loss Coef. Ke :** 0.5000

FLOW (cfs.)	HEAD LOSS (ft.)	HWI (ft.)	HWO (ft.)	FLOW TYPE	VELOCITY (fps.)	DN (ft.)	DC (ft.)	MANNING N	HEADWATER CONTROL	BURIED DEPTH (ft.)	TAILWATER ELEVATION (ft.)
41.00	0.77	967.59	967.82	1 - A	5.73	1.40	1.02	0.0120	OUTLET*	0.00	966.50

CULVERT ANALYSIS

PID : 122339 **Date :** 12/12/2024 **Project :** ATB/TRU-CULVERTS-FY26 **Location :** ATB-193-11.140

Description : Ex. 84"x36" Slab Top **Designer :** MEP

HEADWATER CONTROL CODES:

INLET - Inlet Control.
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OUTLET* - Outlet Control with backwater curve used to compute headwater. See Figure III - 7E in HDS 5 for type flow.
OUTLET** - Outlet Control - See Figure III - 7D in HDS 5 for type flow.
N/A - Flow is supercritical with low headwater and low tailwater. Control Section is at the inlet.

Pipe Number : 1 **Use HW :** 0 **Inlet Invert Elevation (ft.) :** 966.07 **Outlet Invert Elevation (ft.) :** 966.03

Pipe Quantity : 1

Culvert Type : Box **Pipe Length (ft.) :** 35.00 **Culvert Slope (ft./ft.) :** 0.0011

Corrugation Type :

Pipe Size : 7.0 x 3.0 ft.

Design Manning 'n' : (default)

Entrance Type : 0 degree (Extension of sides) **Loss Coef. Ke :** 0.5000

FLOW (cfs.)	HEAD LOSS (ft.)	HWI (ft.)	HWO (ft.)	FLOW TYPE	VELOCITY (fps.)	DN (ft.)	DC (ft.)	MANNING N	HEADWATER CONTROL	BURIED DEPTH (ft.)	TAILWATER ELEVATION (ft.)
101.00	1.37	969.21	969.27	1 - A	7.75	3.00	1.86	0.0120	OUTLET*	0.00	966.50
111.00	1.50	969.52	969.47	1 - C	5.29	3.00	1.98	0.0120	INLET	0.00	966.50
121.00	1.68	969.82	969.67	2 - E	5.76	3.00	2.10	0.0120	INLET	0.00	966.50
131.00	1.87	970.11	969.87	2 - E	6.24	3.00	2.22	0.0120	INLET	0.00	966.50
141.00	2.06	970.41	970.06	2 - E	6.71	3.00	2.33	0.0120	INLET	0.00	966.50
151.00	2.25	970.71	970.25	2 - E	7.19	3.00	2.44	0.0120	INLET	0.00	966.50
161.00	2.44	971.01	970.43	2 - E	7.67	3.00	2.54	0.0120	INLET	0.00	966.50
171.00	2.82	971.49	970.61	2 - E	8.14	3.00	2.65	0.0120	INLET	0.00	966.50

CULVERT ANALYSIS

FLOW (cfs.)	HEAD LOSS (ft.)	HWI (ft.)	HWO (ft.)	FLOW TYPE	VELOCITY (fps.)	DN (ft.)	DC (ft.)	MANNING N	HEADWATER CONTROL	BURIED DEPTH (ft.)	TAILWATER ELEVATION (ft.)
181.00	3.03	971.80	970.79	2 - E	8.62	3.00	2.75	0.0120	INLET	0.00	966.50
191.00	3.20	972.16	971.06	2 - E	9.10	3.00	2.85	0.0120	INLET	0.00	966.50

CULVERT ANALYSIS

PID : 122339 **Date :** 12/13/2024 **Project :** ATB/TRU-CULVERTS-FY26 **Location :** ATB-193-11.140

Description : Proposed Culvert Design - Smooth **Designer :** MEP

HEADWATER CONTROL CODES:
INLET - Inlet Control.
OUTLET - Outlet Control.
OUTLET* - Outlet Control with backwater curve used to compute headwater. See Figure III - 7E in HDS 5 for type flow.
OUTLET** - Outlet Control - See Figure III - 7D in HDS 5 for type flow.
N/A - Flow is supercritical with low headwater and low tailwater. Control Section is at the inlet.

Pipe Number : 1 **Use HW :** 0 **Inlet Invert Elevation (ft.) :** 966.30 **Outlet Invert Elevation (ft.) :** 966.00
Pipe Quantity : 1

Culvert Type : Circular Smooth **Pipe Length (ft.) :** 40.00 **Culvert Slope (ft./ft.) :** 0.0075
Corrugation Type :
Pipe Size : 60 in.
Design Manning 'n' : (default)

Entrance Type : Full Headwall **Loss Coef. Ke :** 0.2000

FLOW (cfs.)	HEAD LOSS (ft.)	HWI (ft.)	HWO (ft.)	FLOW TYPE	VELOCITY (fps.)	DN (ft.)	DC (ft.)	MANNING N	HEADWATER CONTROL	BURIED DEPTH (ft.)	TAILWATER ELEVATION (ft.)
101.00	0.54	970.42	N/A	1 - C	8.70	2.24	2.86	0.0120	INLET	0.00	966.50
111.00	0.66	970.65	N/A	1 - C	9.00	2.36	3.01	0.0120	INLET	0.00	966.50
121.00	0.81	970.88	N/A	1 - C	12.41	2.49	3.14	0.0120	INLET	0.00	966.50
131.00	0.98	971.12	N/A	1 - C	12.66	2.61	3.28	0.0120	INLET	0.00	966.50
141.00	1.15	971.35	N/A	1 - C	12.89	2.73	3.40	0.0120	INLET	0.00	966.50
151.00	1.34	971.60	N/A	1 - C	13.10	2.84	3.52	0.0120	INLET	0.00	966.50
161.00	1.53	971.85	N/A	1 - C	13.29	2.96	3.64	0.0120	INLET	0.00	966.50
171.00	1.74	972.12	N/A	1 - C	13.47	3.08	3.75	0.0120	INLET	0.00	966.50

CULVERT ANALYSIS

FLOW (cfs.)	HEAD LOSS (ft.)	HWI (ft.)	HWO (ft.)	FLOW TYPE	VELOCITY (fps.)	DN (ft.)	DC (ft.)	MANNING N	HEADWATER CONTROL	BURIED DEPTH (ft.)	TAILWATER ELEVATION (ft.)
181.00	1.97	972.40	972.17	2 - E	13.63	3.20	3.85	0.0120	INLET	0.00	966.50
191.00	2.21	972.69	972.42	2 - E	13.76	3.33	3.95	0.0120	INLET	0.00	966.50

CULVERT ANALYSIS

PID : 122339 **Date :** 12/13/2024 **Project :** ATB/TRU-CULVERTS-FY26 **Location :** ATB-193-11.140

Description : Proposed Culvert Design - Elliptical **Designer :** MEP

HEADWATER CONTROL CODES:

INLET - Inlet Control.
OUTLET - Outlet Control.
OUTLET* - Outlet Control with backwater curve used to compute headwater. See Figure III - 7E in HDS 5 for type flow.
OUTLET** - Outlet Control - See Figure III - 7D in HDS 5 for type flow.
N/A - Flow is supercritical with low headwater and low tailwater. Control Section is at the inlet.

Pipe Number : 1 **Use HW :** 0 **Inlet Invert Elevation (ft.) :** 966.30 **Outlet Invert Elevation (ft.) :** 966.00
Pipe Quantity : 1

Culvert Type : Elliptical **Pipe Length (ft.) :** 40.00 **Culvert Slope (ft./ft.) :** 0.0075
Corrugation Type :
Pipe Size : 48 x 76 in.
Design Manning 'n' : (default)

Entrance Type : Full Headwall **Loss Coef. Ke :** 0.2000

FLOW (cfs.)	HEAD LOSS (ft.)	HWI (ft.)	HWO (ft.)	FLOW TYPE	VELOCITY (fps.)	DN (ft.)	DC (ft.)	MANNING N	HEADWATER CONTROL	BURIED DEPTH (ft.)	TAILWATER ELEVATION (ft.)
101.00	0.51	969.70	N/A	1 - C	11.51	1.76	2.36	0.0120	INLET	0.00	966.50
111.00	0.67	969.91	N/A	1 - C	11.85	1.86	2.49	0.0120	INLET	0.00	966.50
121.00	0.82	970.12	N/A	1 - C	12.15	1.95	2.61	0.0120	INLET	0.00	966.50
131.00	0.98	970.34	N/A	1 - C	12.43	2.04	2.72	0.0120	INLET	0.00	966.50
141.00	1.14	970.56	N/A	1 - C	12.69	2.13	2.83	0.0120	INLET	0.00	966.50
151.00	1.32	970.78	N/A	1 - C	12.94	2.22	2.93	0.0120	INLET	0.00	966.50
161.00	1.50	971.01	N/A	1 - C	13.16	2.31	3.03	0.0120	INLET	0.00	966.50
171.00	1.69	971.25	971.00	2 - E	13.38	2.40	3.12	0.0120	INLET	0.00	966.50

CULVERT ANALYSIS

FLOW (cfs.)	HEAD LOSS (ft.)	HWI (ft.)	HWO (ft.)	FLOW TYPE	VELOCITY (fps.)	DN (ft.)	DC (ft.)	MANNING N	HEADWATER CONTROL	BURIED DEPTH (ft.)	TAILWATER ELEVATION (ft.)
181.00	1.89	971.50	971.21	2 - E	13.58	2.49	3.21	0.0120	INLET	0.00	966.50
191.00	2.11	971.75	971.44	2 - E	13.77	2.58	3.30	0.0120	INLET	0.00	966.50

CULVERT ANALYSIS

PID : 122339 **Date :** 12/13/2024 **Project :** ATB/TRU-CULVERTS-FY26 **Location :** ATB-193-11.140

Description : Proposed Culvert Design - Arch **Designer :** MEP

HEADWATER CONTROL CODES:

INLET - Inlet Control.
OUTLET - Outlet Control.
OUTLET* - Outlet Control with backwater curve used to compute headwater. See Figure III - 7E in HDS 5 for type flow.
OUTLET** - Outlet Control - See Figure III - 7D in HDS 5 for type flow.
N/A - Flow is supercritical with low headwater and low tailwater. Control Section is at the inlet.

Pipe Number : 1 **Use HW :** 0 **Inlet Invert Elevation (ft.) :** 966.30 **Outlet Invert Elevation (ft.) :** 966.00
Pipe Quantity : 1

Culvert Type : Pipe Arch **Pipe Length (ft.) :** 40.00 **Culvert Slope (ft./ft.) :** 0.0075
Corrugation Type : Corrugated Metal Arch Pipe (2 2/3 x 1/2 in. corrugations)
Pipe Size : 77 x 52 in.
Design Manning 'n' : (default)

Entrance Type : Full Headwall **Loss Coef. Ke :** 0.2500

FLOW (cfs.)	HEAD LOSS (ft.)	HWI (ft.)	HWO (ft.)	FLOW TYPE	VELOCITY (fps.)	DN (ft.)	DC (ft.)	MANNING N	HEADWATER CONTROL	BURIED DEPTH (ft.)	TAILWATER ELEVATION (ft.)
101.00	1.66	969.83	969.74	1 - C	6.82	2.52	2.16	0.0231	INLET	0.00	966.50
111.00	1.77	970.05	969.96	1 - C	6.98	2.72	2.29	0.0231	INLET	0.00	966.50
121.00	1.87	970.28	970.19	1 - C	7.12	2.92	2.41	0.0231	INLET	0.00	966.50
131.00	1.99	970.52	970.41	1 - C	7.23	3.14	2.53	0.0231	INLET	0.00	966.50
141.00	2.12	970.76	970.63	1 - C	7.30	3.39	2.64	0.0231	INLET	0.00	966.50
151.00	2.26	971.01	970.84	1 - C	7.23	3.77	2.75	0.0231	INLET	0.00	966.50
161.00	2.41	971.26	971.07	1 - C	7.70	3.78	2.85	0.0231	INLET	0.00	966.50
171.00	2.58	971.54	971.29	2 - E	7.71	4.33	2.95	0.0231	INLET	0.00	966.50

CULVERT ANALYSIS

FLOW (cfs.)	HEAD LOSS (ft.)	HWI (ft.)	HWO (ft.)	FLOW TYPE	VELOCITY (fps.)	DN (ft.)	DC (ft.)	MANNING N	HEADWATER CONTROL	BURIED DEPTH (ft.)	TAILWATER ELEVATION (ft.)
181.00	2.77	971.82	971.51	2 - E	8.16	4.33	3.05	0.0231	INLET	0.00	966.50
191.00	2.38	972.12	971.76	2 - E	8.61	4.33	3.14	0.0231	INLET	0.00	966.50

CULVERT ANALYSIS

PID : 122339 **Date :** 12/13/2024 **Project :** ATB/TRU-CULVERTS-FY26 **Location :** ATB-193-11.140

Description : Proposed Culvert Design - Box **Designer :** MEP

HEADWATER CONTROL CODES:

INLET - Inlet Control.
OUTLET - Outlet Control.
OUTLET* - Outlet Control with backwater curve used to compute headwater. See Figure III - 7E in HDS 5 for type flow.
OUTLET** - Outlet Control - See Figure III - 7D in HDS 5 for type flow.
N/A - Flow is supercritical with low headwater and low tailwater. Control Section is at the inlet.

Pipe Number : 1 **Use HW :** 0 **Inlet Invert Elevation (ft.) :** 966.30 **Outlet Invert Elevation (ft.) :** 966.00

Pipe Quantity : 1

Culvert Type : Box **Pipe Length (ft.) :** 40.00 **Culvert Slope (ft./ft.) :** 0.0075

Corrugation Type :

Pipe Size : 6.0 x 4.0 ft.

Design Manning 'n' : (default)

Entrance Type : 90 and 15 degrees Wingwalls **Loss Coef. Ke :** 0.2000

FLOW (cfs.)	HEAD LOSS (ft.)	HWI (ft.)	HWO (ft.)	FLOW TYPE	VELOCITY (fps.)	DN (ft.)	DC (ft.)	MANNING N	HEADWATER CONTROL	BURIED DEPTH (ft.)	TAILWATER ELEVATION (ft.)
101.00	0.76	969.79	N/A	1 - C	10.88	1.55	2.07	0.0120	INLET	0.00	966.50
111.00	0.91	970.01	N/A	1 - C	11.19	1.65	2.20	0.0120	INLET	0.00	966.50
121.00	1.06	970.23	N/A	1 - C	11.48	1.76	2.33	0.0120	INLET	0.00	966.50
131.00	1.23	970.46	N/A	1 - C	11.75	1.86	2.46	0.0120	INLET	0.00	966.50
141.00	1.43	970.72	N/A	1 - C	12.00	1.96	2.58	0.0120	INLET	0.00	966.50
151.00	1.64	970.99	N/A	1 - C	12.24	2.06	2.70	0.0120	INLET	0.00	966.50
161.00	1.84	971.25	970.34	2 - E	12.46	2.15	2.82	0.0120	INLET	0.00	966.50
171.00	2.05	971.51	970.52	2 - E	12.67	2.25	2.93	0.0120	INLET	0.00	966.50

CULVERT ANALYSIS

FLOW (cfs.)	HEAD LOSS (ft.)	HWI (ft.)	HWO (ft.)	FLOW TYPE	VELOCITY (fps.)	DN (ft.)	DC (ft.)	MANNING N	HEADWATER CONTROL	BURIED DEPTH (ft.)	TAILWATER ELEVATION (ft.)
181.00	2.26	971.78	970.70	2 - E	12.88	2.34	3.05	0.0120	INLET	0.00	966.50
191.00	2.46	972.04	970.89	2 - E	13.07	2.44	3.16	0.0120	INLET	0.00	966.50

ATB/TRU-CULVERTS-FY2026 (PID 122339)
Proposed Culvert Replacement @ ATB-193-11.140

Culvert Geometry	Existing	~~Design Smooth~~	~~Design Corr.~~	~~Design Ellip.~~	Design Ellip.	~~Design Arch~~	Design Arch	Design Box
Existing Drainage Area (acres) ~ for reference only ~	N/A	~~N/A~~	~~N/A~~	~~N/A~~	N/A	~~N/A~~	N/A	N/A
Existing Q 50-year (cfs) ~ for reference only ~	N/A	~~N/A~~	~~N/A~~	~~N/A~~	N/A	~~N/A~~	N/A	N/A
Drainage Area (acres)	186	~~186~~	~~186~~	~~186~~	186	~~186~~	186	186
Roadway Elevation (feet)	972.0	~~972.0~~	~~972.0~~	~~972.0~~	972.0	~~972.0~~	972.0	972.0
Inside Width (inches)	84	~~60~~		~~68~~	76	~~71~~	77	72
Inside Height (inches)	36	~~60~~		~~43~~	48	~~47~~	52	48
Pipe Material	Slab Top	~~RCP | HDPE~~	~~CMP~~	~~RCP~~	RCP	~~1/2" Corr.~~	1/2" Corr.	Reinf. Conc.
Manning's n	0.0150	~~0.0120~~		~~0.0120~~	0.0120	~~0.0232~~	0.0232	0.0120
Length (feet)	35	~~40~~	~~40~~	~~40~~	40	~~40~~	40	40
Inlet Invert (feet)	966.3	~~966.3~~	~~966.3~~	~~966.3~~	966.3	~~966.3~~	966.3	966.3
Outlet Invert (feet)	966.0	~~966.0~~	~~966.0~~	~~966.0~~	966.0	~~966.0~~	966.0	966.0
Slope	0.0086	~~0.0075~~	~~0.0075~~	~~0.0075~~	0.0075	~~0.0075~~	0.0075	0.0075
Pipe Crown (feet)	969.3	~~971.3~~	~~966.3~~	~~969.9~~	970.3	~~970.2~~	970.6	970.3
Wall Thickness (inches)	12.0	~~6.0~~		~~6.0~~	6.5	~~0.5~~	0.5	12.0
Height of Cover (feet)	1.7	~~0.2~~	~~5.7~~	~~1.6~~	1.2	~~1.7~~	1.3	0.7

Notes:
1. Culvert is a replacement to an existing 84"x36" Slab Top.
2. Fill depth < 8' --> 15" minimum culvert size.
3. Design options that are struck through: Required culvert size exceeds site constraints or requires multiple barrels.
4. In accordance with L&D Volume 2 1105.1, a single-cell elliptical concrete culvert is proposed at this location.

Tailwater Data	Existing	~~Design Smooth~~	~~Design Corr.~~	~~Design Ellip.~~	Design Ellip.	~~Design Arch~~	Design Arch	Design Box
10-year TW (feet)	966.5	~~966.5~~	~~966.5~~	~~966.5~~	966.5	~~966.5~~	966.5	966.5
50-year TW (feet)	966.5	~~966.5~~	~~966.5~~	~~966.5~~	966.5	~~966.5~~	966.5	966.5
100-year TW (feet)	966.5	~~966.5~~	~~966.5~~	~~966.5~~	966.5	~~966.5~~	966.5	966.5

Hydraulic Data (Rational Method Flows & HY-8)	Existing	~~Design Smooth~~	~~Design Corr.~~	~~Design Ellip.~~	Design Ellip.	~~Design Arch~~	Design Arch	Design Box
Q 50-percent AEP (cfs)	41	~~41~~	~~41~~	~~41~~	41	~~41~~	41	41
OHWM (feet)	967.8	~~968.8~~			968.3		968.3	968.3
Q 10-percent AEP (cfs)	101	~~101~~	~~101~~	~~101~~	101	~~101~~	101	101
HW 10-percent AEP (feet)	969.3	~~970.4~~		~~970.0~~	969.7	~~970.0~~	969.8	969.8
V 10-percent AEP (fps)	7.8	~~8.7~~		~~11.7~~	11.5	~~6.8~~	6.8	10.9
Q 2-percent AEP (cfs)	163	~~163~~	~~163~~	~~163~~	163	~~163~~	163	163
HW 2-percent AEP (feet)	971.1	~~971.9~~		~~971.7~~	971.0	~~971.9~~	971.3	971.3
V 2-percent AEP (fps)	7.8	~~13.3~~		~~13.2~~	13.2	~~8.8~~	7.7	12.5
Q 1-percent AEP (cfs)	191	~~191~~	~~191~~	~~191~~	191	~~191~~	191	191
HW 1-percent AEP (feet)	972.2	~~972.7~~		~~972.8~~	971.8	~~973.1~~	972.1	972.0
V 1-percent AEP (fps)	9.1	~~13.8~~		~~13.6~~	13.8	~~10.4~~	8.6	13.1

ATB/TRU-CULVERTS-FY2026 (PID 122339)
Proposed Culvert Replacement @ ATB-193-11.140

Design Storm Controls - HW (L&D 1006.2.1)

A. 2 feet below the near, low edge of the pavement for drainage areas 1000 acres or greater and 1 foot below for culverts draining less than 1000 acres.	✓	✓	~~N/A~~	✓	✓	✓	✓	✓
Pavement Overtopping, Allen-Comp Road @ Upstream Culvert	972.0	~~972.0~~	~~972.0~~	~~972.0~~	972.0	~~972.0~~	972.0	972.0
Difference = (Pavement - HW 10-percent AEP)	2.7	~~1.6~~	~~N/A~~	~~2.0~~	2.3	~~2.0~~	2.2	2.2

Note: The near low edge of pavement is the location where roadway overtopping will occur. This may or may not be located directly over the culvert. Where the overtopping point on the roadway is outside the watershed break, the ditch break overflow elevation should be utilized as a headwater control in lieu of 1006.2.1 A.

B. 2 feet above the inlet crown of the culvert or above a tailwater elevation that submerges the inlet crown in flat terrain.	✓	✓	~~N/A~~	✓	✓	✓	✓	✓
Difference = (Pipe Crown - HW 10-percent AEP)	0.0	~~0.9~~	~~N/A~~	~~-0.1~~	0.6	~~0.2~~	0.8	0.5

Note: Arbitrary control which generally applies to small culverts. Where large structures (greater than or equal to 10 feet in span) are involved, the structure should be sized to pass the design storm while maintaining a free water surface through the structure, unless tail water controls. If applicable, use smooth pipe to establish HW.

C. 4 feet above the inlet crown of a culvert in a deep ravine.	N/A	~~N/A~~	~~N/A~~	~~N/A~~	N/A	~~N/A~~	N/A	N/A

Note: Arbitrary control which generally applies to small culverts. Where large structures (greater than or equal to 10 feet in span) are involved, the structure should be sized to pass the design storm while maintaining a free water surface through the structure, unless tail water controls. If applicable, use corrugated pipe to establish HW.

D. 1 foot below the near edge of pavement for bicycle pathways.	N/A	~~N/A~~	~~N/A~~	~~N/A~~	N/A	~~N/A~~	N/A	N/A

Check Storm Controls - HW (L&D 1006.2.2)

A. 2 feet below the lowest ground elevation adjacent to an occupied building for a 2-percent AEP storm (it is not intended, however, to lower existing high water elevations around buildings).	N/A	~~N/A~~	~~N/A~~	~~N/A~~	N/A	~~N/A~~	N/A	N/A
Lowest Ground Elevation Adjacent to Occupied Building	982.0	~~982.0~~	~~982.0~~	~~982.0~~	982.0	~~982.0~~	982.0	982.0
Difference = (Lowest Ground - HW 2-percent AEP)	N/A	~~N/A~~	~~N/A~~	~~N/A~~	N/A	~~N/A~~	N/A	N/A
B. Limit the maximum 1-percent AEP HW depth to twice the diameter or rise of the culvert.	✓	✓	~~N/A~~	✓	✓	✓	✓	✓
HW 1-percent AEP	972.2	~~972.7~~	~~N/A~~	~~972.8~~	971.8	~~973.1~~	972.1	972.0
Inlet Invert + 2 * (Diameter or Rise)	972.3	~~976.3~~	~~N/A~~	~~973.5~~	974.3	~~974.1~~	975.0	974.3
C. Size a replacement structure to prevent overtopping by the 1-percent AEP storm where overtopping would not occur with the existing structure.	N/A	~~N/A~~	~~N/A~~	~~N/A~~	N/A	~~N/A~~	N/A	N/A
D. Size a replacement structure so that flooding of upstream land is not increased for the 1-percent AEP storm when compared to the existing structure. Before implementing this criteria consider the type of upstream property and land use.	✓	✗	~~N/A~~	✗	✓	✗	✓	✓
E. Controls specific to an FIS. See section 1006.4.	N/A	~~N/A~~	~~N/A~~	~~N/A~~	N/A	~~N/A~~	N/A	N/A

ODOT Conduit Durability Design July 2021

County	Ashtabula	Route	193	Section	11.14	PID	122339	Shape	Elliptical
Station	191+99	Station						Span x Rise	

Span and Rise not Required for Elliptical Shape

User Input	
pH_w	Abrasion Level
8.1	1.0

Constants and Calculated Values			
pHs	Sediment/Rise	End of Service Life GA	Service Life Required
7.6	0	4	75

Metal Conduit Durability Results

Material		707.01 , 707.02, or 707.03 Metallic coated (galvanized)	707.01 or 707.02 or 707.03 Metallic coated (galvanized) with Concrete Field Paving	707.01 or 707.02 Metallic coated (Aluminized)	***707.01 or 707.02 Metallic coated (aluminized) with Concrete Field Paving	707.04 Polymeric Coated over galvanized steel	***707.04 Polymeric Coated with Concrete Field Paving	707.05 or 707.07 (707.01 or 707.02 galvanized) 1/2 Bituminous coated with Bituminous paved invert	***707.05 or 707.07 (707.01 or 707.02 aluminized) 1/2 Bituminous coated with Bituminous paved invert	**707.11 Polymer Precoated spiral rib steel	**707.12 or 707.17 Aluminum coated spiral rib steel	707.13 or 707.14 (707.01 or 707.02 galvanized) Bituminous lined galvanized steel
Conduit Use and Shape		Culvert or Liner Pipe - Round or Pipe Arch	Culvert-Round, Pipe Arch, and Arch	Culvert or Liner Pipe -Round or Pipe Arch	Culvert -Round or Pipe Arch	Culvert or Liner Pipe - Round or Pipe Arch	Culvert-Round or Pipe Arch	Culvert -Round or Pipe Arch	Culvert -Round or Pipe Arch	Storm Sewer or Liner Pipe- Round	Liner Pipe- Round or Pipe Arch	Storm Sewer - Round or Pipe Arch
	Corr. Depth (inches)											
min gauge or thickness	1/4 or 1/2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3/4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
max gauge or thickness	1/4 or 1/2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	3/4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Gauge	Thickness (inches)											
16	0.064											
14	0.079											
12	0.109											
10	0.138											
8	0.168											
7	0.188											
5	0.218											
3	0.249											
1	0.28											
Casing	0.5											

Material		707.13 or 707.14 (707.01 or 707.02 aluminized) Bituminous lined aluminized steel	707.15 Galvanized steel box	**707.18 Polymer Precoated, Galvanized Steel Conduits with precoated galvanized smooth steel interior liner	**707.19 Aluminum coated Steel Conduits with precoated galvanized smooth steel interior liner	**707.20 Galvanized Coated Steel Conduits with precoated galvanized smooth steel interior liner	**748.06 Steel Casing Pipe non-galvanized	707.21 or 707.22 Aluminum	707.23 Aluminum Structural Plate	707.24 Aluminum Spiral Rib	707.25 Aluminum Box	707.21, 707.22, or 707.23 Aluminum Alloy or Aluminum Alloy Structural Plate with Concrete Invert Paving
Conduit Use and Shape		Storm Sewer -Round or Pipe Arch	Culvert -Box	Liner Pipe -Round	Liner Pipe -Round	Liner Pipe - Round	Culvert or Liner Pipe- Round, Pipe Arch, or Box	Culvert or Liner Pipe- Round or Pipe Arch	Culvert or Liner Pipe - Round, Pipe Arch, and Arch	Storm Sewer or Liner Pipe -Round	Culvert -Box	Culvert - Round or Pipe Arch
	Corr. Depth (inches)											
min gauge or thickness	1/4 or 1/2	N/A	N/A	N/A	N/A	N/A	0.5	N/A	N/A	N/A	N/A	N/A
	1	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A
	2	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A
	3/4	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A
max gauge or thickness	1/4 or 1/2	N/A	N/A	N/A	N/A	N/A	0.5	N/A	N/A	N/A	N/A	N/A
	1	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A
	2	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A
	3/4	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A
Gauge	Thickness (inches)											
16	0.064											
14	0.079											
12	0.109											
10	0.138											
8	0.168											
7	0.188											
5	0.218											
3	0.249											
1	0.28											
Casing	0.5											

Concrete Conduit Durability Results

Material	**706.01 Non-reinforced Concrete Pipe	**706.02 Reinforced Concrete Circular Pipe	**706.03 Reinforced Concrete Pipe, Epoxy Coated	**706.04 Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe	**706.05 Precast Reinforced Concrete Box Sections	706.08 Clay Drain Tile
Conduit Use and Shape	Culvert or Storm Sewer - Round	Culvet or Storm Sewer -Round	Culvert or Storm Sewer - Round or Elliptical	Culvert or Storm Sewer -Elliptical	Culvert or Storm Sewer - Box	Culvert or Storm Sewer - Round

Plastic Conduit Durability Results

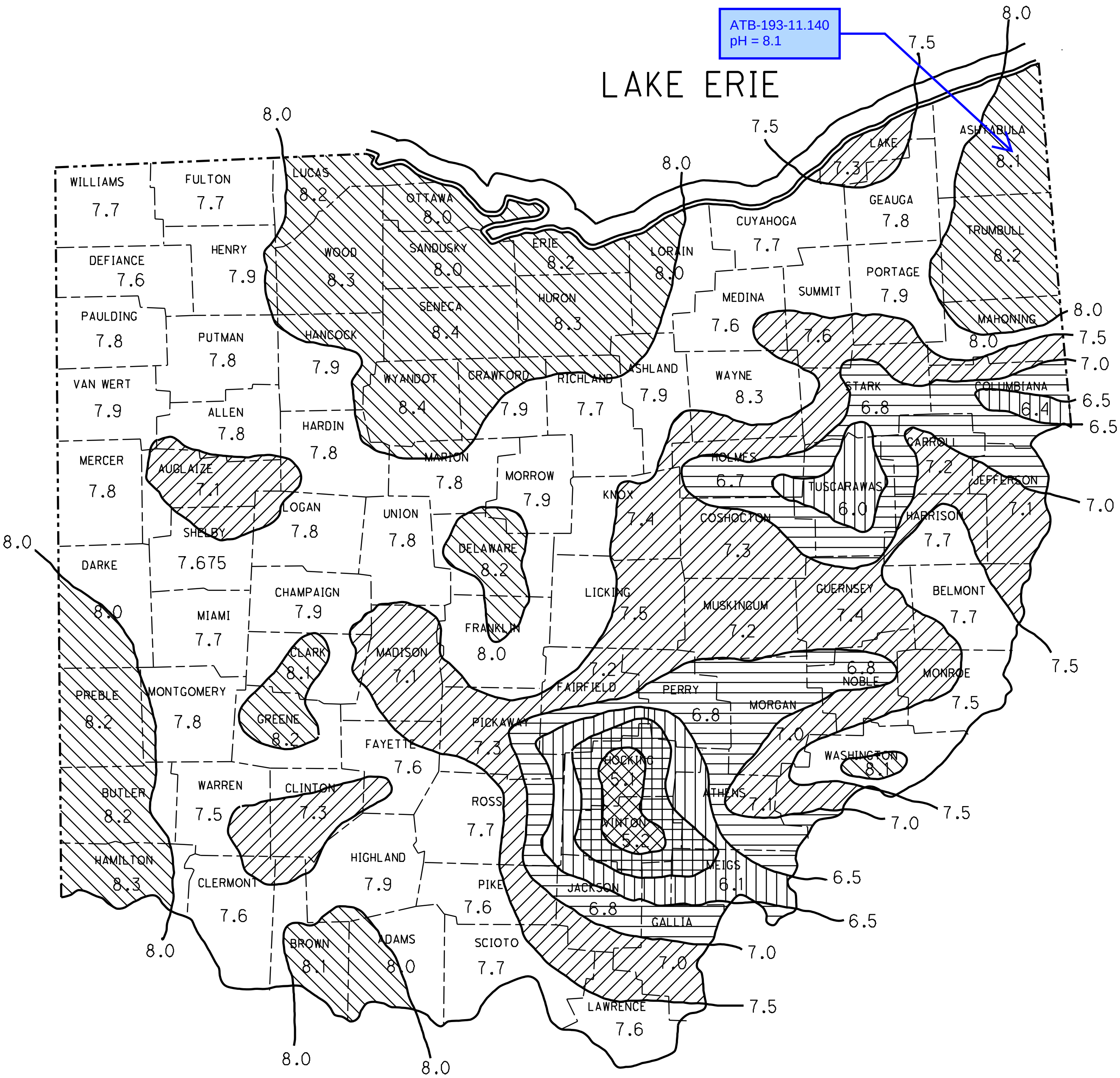
Material	707.33 Corrugated Polyethylene Smooth Lined Pipe	707.34 Polyethylene Plastic Pipe Based on Outside Diameter (OD)	707.35 Polyethylene Profile Wall Pipe	707.42 Polyvinyl Chloride Corrugated Smooth Interior Pipe	707.43 Polyvinyl Chloride Profile Wall Pipe	707.45 Polyvinyl Chloride Solid Wall Pipe	707.46 Polyvinyl Chloride Drain Waste and Vent Pipe	707.47 ABS and Polyvinyl Chloride Composite Pipe	707.48 Polyvinyl Chloride Large-Diameter Solid Wall Pipe	707.65 Corrugated Polypropylene Smooth Lined Pipe	707.75 Glass-Fiber-Reinforced Polymer Mortar Pipe	707.85 Steel Reinforced Thermoplastic Ribbed Pipe	748.02 Polyvinyl Chloride (PVC) Pipe, Joints, and Fittings
Conduit Use and Shape	Culvert, Storm Sewer, or Liner Pipe - Round	Culvert, Storm Sewer, or Liner Pipe - Round	Culvert, Storm Sewer, or Liner Pipe - Round	Storm Sewer or Liner Pipe - Round	Storm Sewer or Liner Pipe - Round	Storm Sewer - Round	Storm Sewer - Round	Storm Sewer - Round	Storm Sewer - Round	Culvert or Storm Sewer - Round	Culvert, Storm Sewer, or Liner Pipe - Round	Culvert or Liner Pipe - Round	Storm Sewer - Round

Notes:

- Many metal options are eliminated when abrasion level equals 4 or greater
- Aluminum is only available between pH levels ranging from 5.0 to less than 9.0
- Alumized protective coating is 0 years when pH levels are outside of allowable for Aluminum
- Polymeric coated is only available for pH ranges greater than 5.0 and less than 9.0
- Options were emiminated when the NCSPA online Service Life Calculator did not recommend option; typically due to abrasive conditions or pH limitations
- Epoxy is required on all concrete surfaces when pH<5
- ** Smooth lined conduit
- ***Minimum gauges set per industry comments; see Reference Data
- Provide concrete field paving on corrugated metal conduits 60" or larger where the invert is always submerged due to tail water conditions from a body of water
- Designer is responsible to ensure the required gage thickness is available for the given pipe size

Constants	
Protective Coating Constants-Initial Service Life (years)	
Concrete Invert Paving=	20
Aluminized=	35
Aluminized Spiral Rib=	35
Polymeric=	50
Bituminous coated w/ bitum. paved invert=	10
Bituminous lined =	25
Galvanized=	0

WATER pH CONTOURS BASED ON AVE. pH FOR COUNTIES	1002-2
	REFERENCE SECTION 1002.3.1

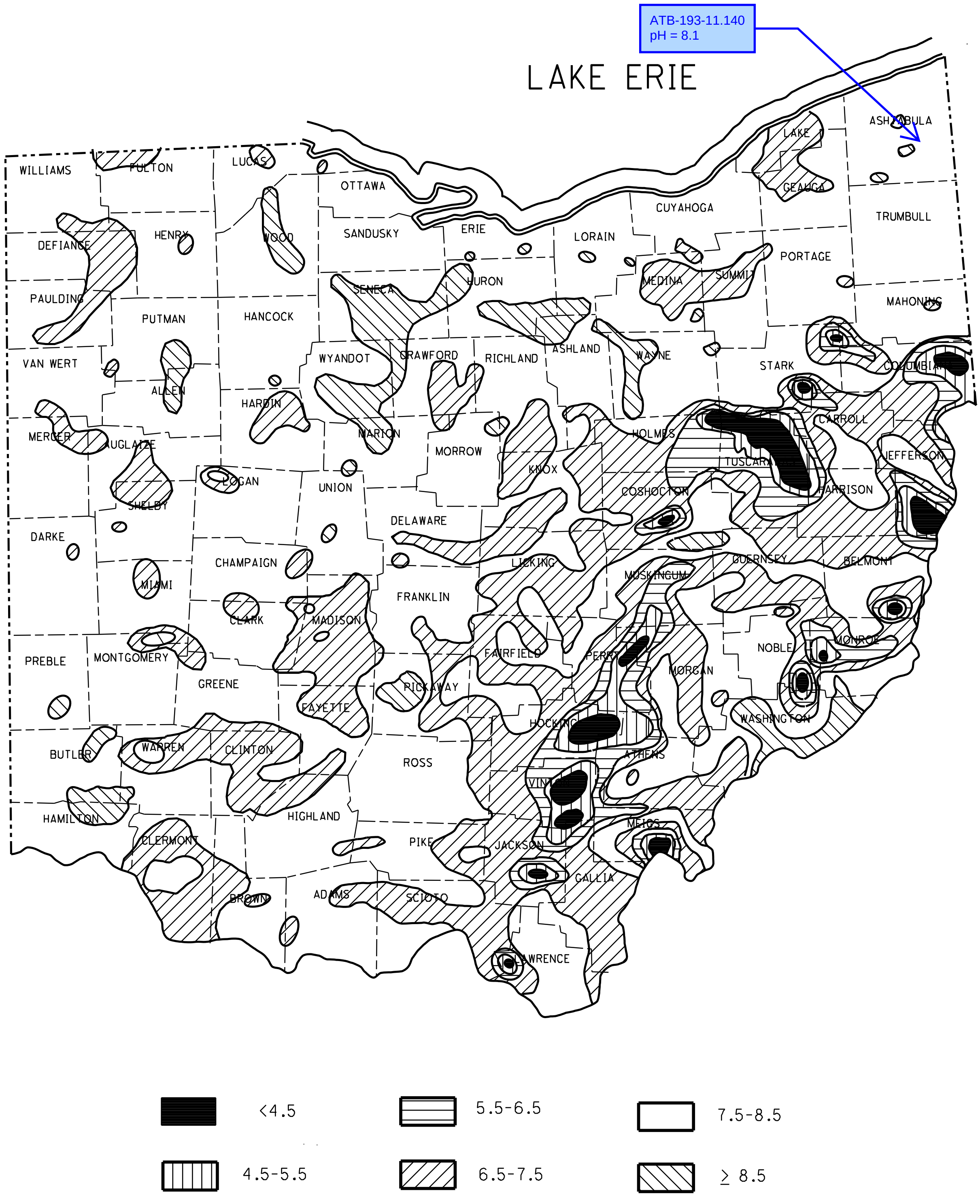


Cross-hatched	≤ 5.5
Grid	5.5-6.0
Vertical lines	6.0-6.5
Horizontal lines	6.5-7.0
Diagonal lines (/)	7.0-7.5
Blank	7.5-8.0
Diagonal lines (\)	≥ 8.0

WATER pH CONTOURS BASED ON pH VALUES OF INDIVIDUAL CULVERTS

1002-3

REFERENCE SECTION
1002.3.1



Form LD-33
Revised July 2022

Ohio Department of Transportation
County Engineer Approval Form

Date Submitted to District: ______________________

Date Submitted to County Engineer: ______________________

County - Route - Section: ______________________

PID: ______________________

Station	Size & Type	Culvert Invert Elevation		Ex. Channel Elevation		Skew
		Inlet	Outlet	Inlet	Outlet	

I have reviewed and hereby approve the drainage proposed for the highway designated hereon in accordance with the provisions of the Ohio Revised Code, Section 6131.631.

____
County

______________________ ______________________
County Engineer's Signature Date

Comments: ______________________

____

____

Form LD-35
Revised January 2015

PROJECT INFORMATION:

COUNTY	ROUTE	SECTION	PID
ATB	193	11.140	122339

PIPE POLICY:

The Pipe Policy of ODOT will be used for this project.

(Attach a copy of the written pipe policy or furnish a link to the policy. In lieu of a written policy, documentation of locally funded construction practices may be provided)

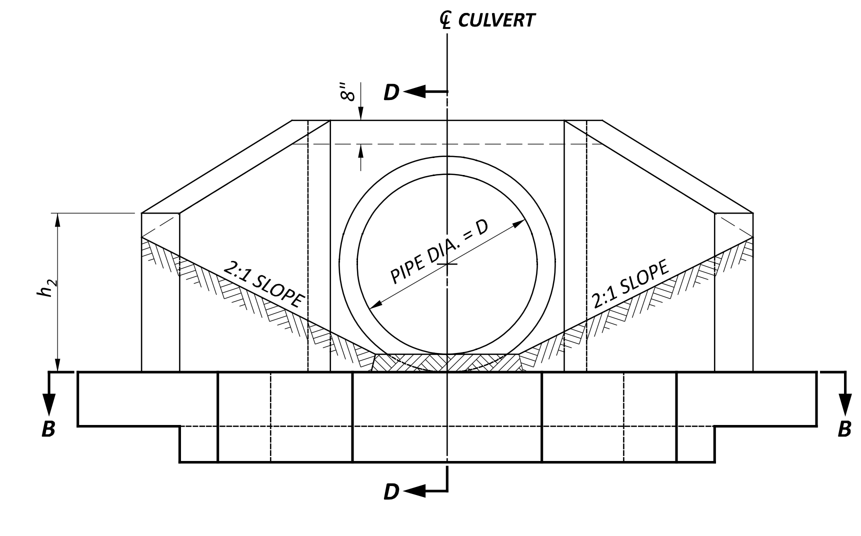
POST CONSTRUCTION BMP POLICY:

The Post Construction BMP Policy of ODOT will be used for this project.

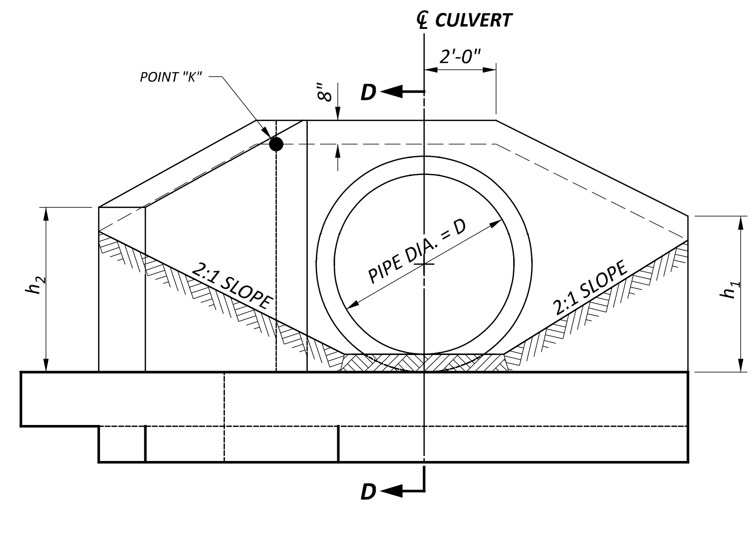
If a policy other than ODOT's is being used, the following BMP's are permitted:

DRAINAGE WATERSHED(S):

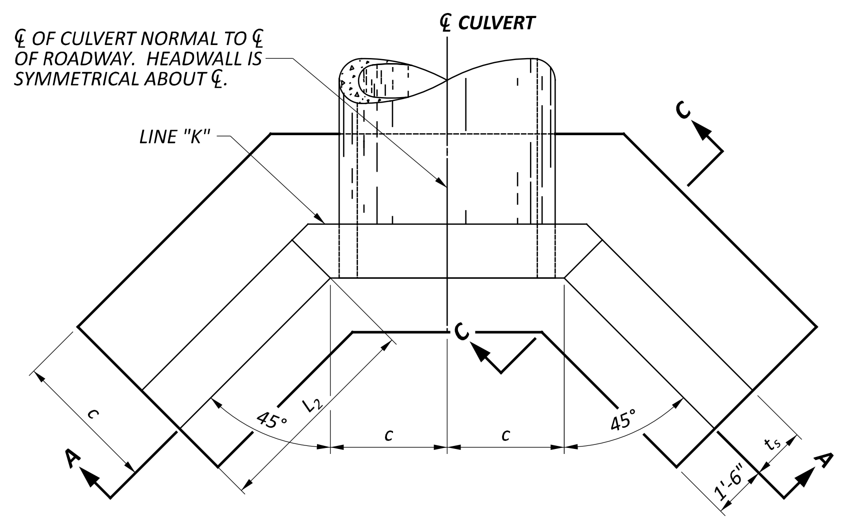
PROJECT SPECIFIC INFORMATION AFFECTING DRAINAGE:



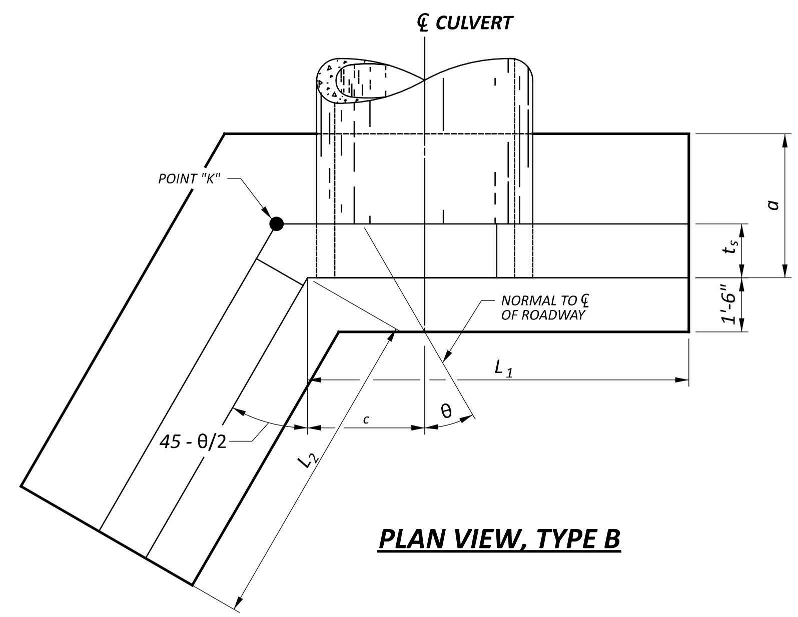
ELEVATION VIEW, TYPE A



ELEVATION VIEW, TYPE B



PLAN VIEW, TYPE A



PLAN VIEW, TYPE B

NOTES

APPLICATION: PROVIDE FULL HEIGHT HEADWALLS FOR SKEWED AND NON-SKEWED CULVERTS HAVING A DIAMETER OR RISE OF 42" TO 84" INCLUSIVE. USE TYPE "A" WHEN THE SKEW ANGLE (Θ) IS TEN DEGREES OR LESS AND TYPE "B" WHEN THE SKEW ANGLE IS OVER TEN DEGREES.

DESIGN DATA: THE FOLLOWING DESIGN DATA IS ASSUMED:

INTERNAL ANGLE OF FRICTION OF BACKFILL SOIL, ϕ_{bf} = 30°
TOTAL UNIT WEIGHT OF BACKFILL SOIL = 120 PCF
INTERNAL ANGLE OF FRICTION (DRAINED), FOUNDATION SOIL, ϕ_f = 28°
UNDRAINED SHEAR STRENGTH (COHESIVE), FOUNDATION SOIL, S_{uf} = 1500 PSF
UNIT WEIGHT OF CONCRETE = 150 PCF
SLOPE OF BACKFILL = 2:1

CONCRETE CLASS QC1 - COMPRESSIVE STRENGTH = 4000 PSI

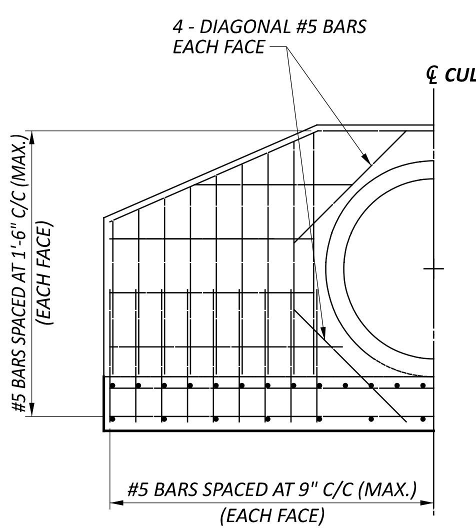
REINFORCING STEEL - ASTM A615, A616, OR A617 GRADE 60
MINIMUM YIELD STRENGTH 60,000 PSI
(ALL REINFORCING SHALL BE EPOXY COATED.)

BASED ON THE ASSUMED DESIGN DATA, THE HEADWALLS FOR THE STANDARD DESIGN ACHIEVE FACTORED BEARING RESISTANCES THAT ARE GREATER THAN THEIR RESPECTIVE FACTORED BEARING PRESSURES. IF A BACKFILL MATERIAL WITH A HIGHER INTERNAL ANGLE OF FRICTION OR A LIGHTER TOTAL UNIT WEIGHT IS USED; OR IF A FOUNDATION SOIL WITH A HIGHER DRAINED INTERNAL ANGLE OF FRICTION OR A HIGHER UNDRAINED SHEAR STRENGTH IS ENCOUNTERED; THEN THE STABILITY OF THE WALL IS SATISFACTORY.

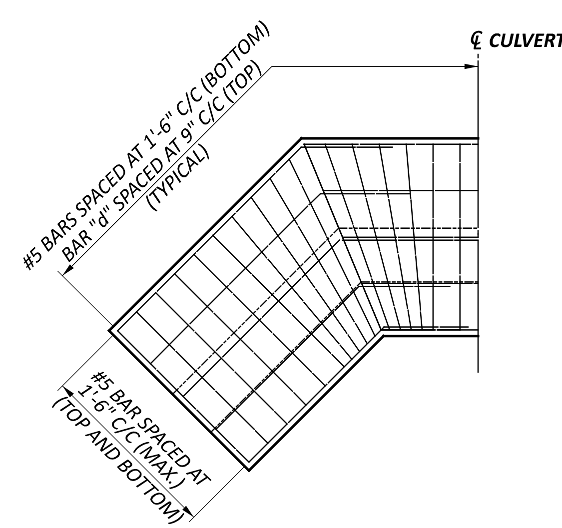
DETAILS AND QUANTITIES: ARE SHOWN FOR CIRCULAR SECTIONS ONLY. WHEN USED WITH REINFORCED ELLIPTICAL CONCRETE PIPE OR CORRUGATED METAL PIPE ARCHES, ADJUST DIMENSIONS AND QUANTITIES TO CONFORM TO THOSE LISTED FOR THE NEAREST SIZE CIRCULAR PIPE. APPLY THE DIMENSIONS ESTABLISHED BY VERTICAL DIAMETER TO SPAN. ROUND ALL CALCULATED DIMENSIONS ESTABLISHED BY HORIZONTAL DIAMETER TO THE NEAREST 1". CHAMFER ALL EXPOSED CORNERS ¾".

HEADWALL LOCATION: DETERMINE BY INTERSECTION OF THE EMBANKMENT SLOPE AT THE BACK OF THE HEADWALL AT POINT "K". PROVIDE 2:1 SLOPES ADJACENT TO THE HEADWALL.

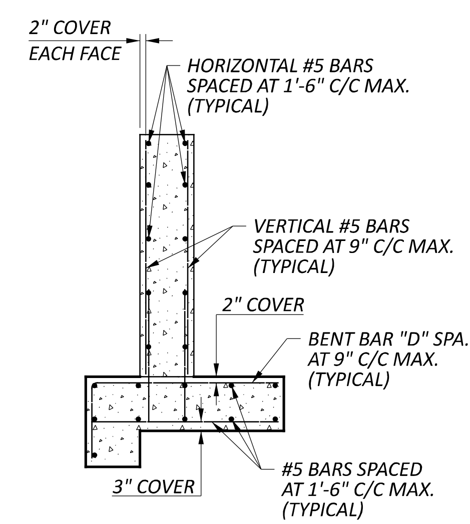
PAYMENT: ITEM 602 CONCRETE MASONRY INCLUDES REINFORCING.



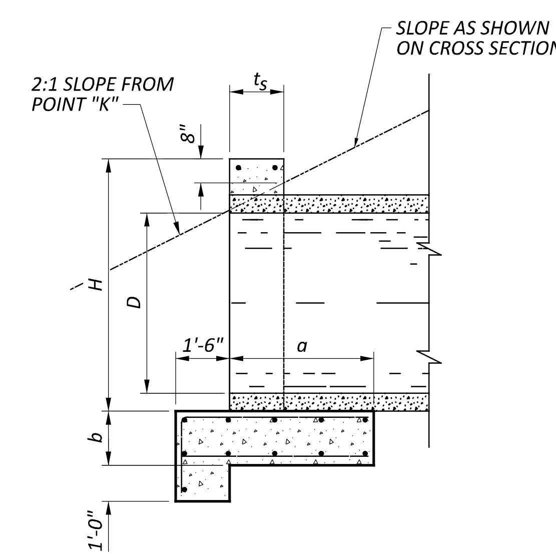
HALF SECTION A-A



HALF SECTION B-B



HALF SECTION C-C



HALF SECTION D-D

OFFICE OF STRUCTURAL ENGINEERING

REVISIONS
07-30-2007
07-20-2012
01-18-2013
09-22-2017
07-20-2018
07-19-2024

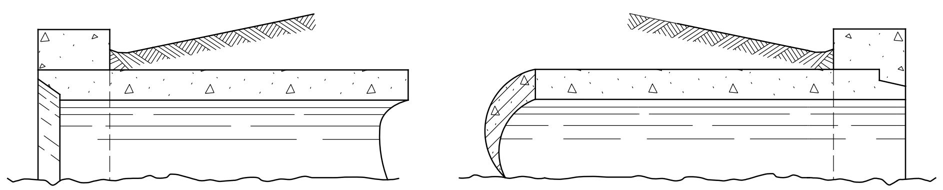
STATE OF OHIO OFFICE OF STRUCTURAL ENGINEERING ADMINISTRATOR
DATE: 07-20-2018

STANDARD BRIDGE DRAWING
FULL-HEIGHT HEADWALLS

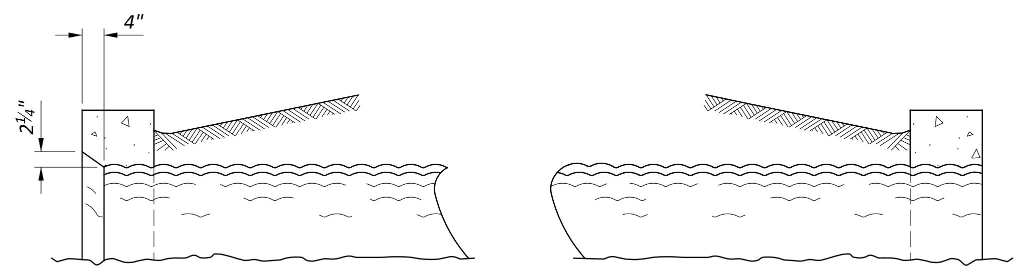
DESIGN AGENCY

SCD NUMBER
HW-1.1

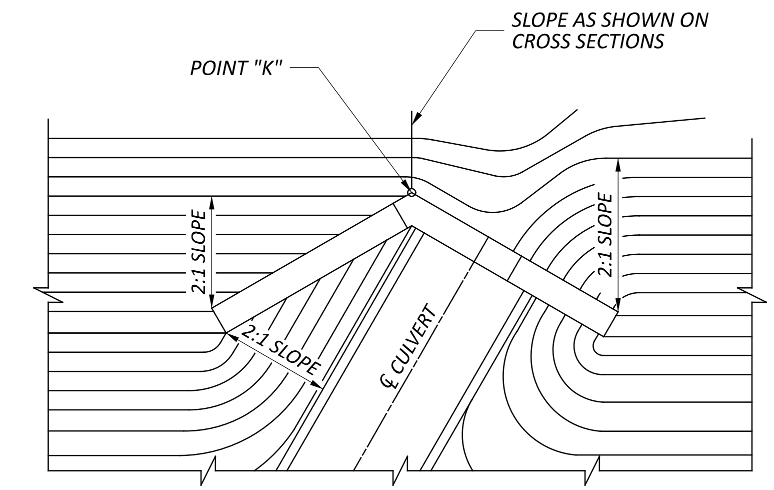
SHEET	TOTAL
1	2



RIGID PIPE
END TREATMENT OF HEADWALL



CORRUGATED PIPE
END TREATMENT OF HEADWALL



LOCATION AND GRADING PLAN FOR
SKEWED PIPE CULVERT -TYPE B

FULL-HEIGHT HEADWALLS (ENGLISH)

PIPE DIA. D	H	a	b	c	t_s	Bar# d	θ ≈ 0°					θ ≈ 15°							θ ≈ 30°							θ ≈ 45°							PIPE DIA. D
							L_2	h_2	CONC. CMP (cy)	CONC. RCP (cy)	STEEL (lbs.)	L_1	L_2	h_1	h_2	CONC. CMP (cy)	CONC. RCP (cy)	STEEL (lbs.)	L_1	L_2	h_1	h_2	Conc. CMP (cy)	Conc. RCP (cy)	STEEL (lbs.)	L_1	L_2	h_1	h_2	CONC. CMP (cy)	CONC. RCP (cy)	STEEL (lbs.)	
42"	5'-4"	3'-3"	1'-6"	2'-6"	1'-6"	#5	3'-7"	3'-6"	7.2	7.1	695	8'-9"	4'-6"	4'-1"	3'-7"	7.6	7.5	656	7'-10"	5'-9"	3'-7"	3'-8"	7.8	7.7	688	7'-10"	7'-9"	3'-7"	3'-8"	9.0	8.9	794	42"
48"	5'-10"	3'-6"	1'-6"	2'-9"	1'-6"	#5	4'-4"	3'-9"	8.8	8.6	861	10'-0"	5'-4"	4'-6"	3'-10"	9.3	9.1	806	8'-9"	6'-10"	3'-10"	3'-11"	9.4	9.2	833	8'-9"	9'-2"	3'-10"	4'-0"	10.9	10.8	970	48"
54"	6'-5"	3'-9"	1'-6"	3'-0"	1'-6"	#5	5'-2"	4'-2"	10.8	10.5	1,001	11'-4"	6'-3"	5'-0"	4'-2"	11.3	11.0	977	9'-8"	7'-11"	4'-2"	4'-3"	11.2	11.0	1,002	9'-8"	10'-7"	4'-2"	4'-4"	13.1	12.9	1,149	54"
60"	7'-0"	4'-0"	1'-6"	3'-3"	1'-6"	#5	5'-11"	4'-5"	12.7	12.4	1,151	12'-7"	7'-2"	5'-4"	4'-6"	13.4	13.1	1,127	10'-7"	9'-0"	4'-4"	4'-7"	13.2	12.9	1,124	10'-7"	12'-0"	4'-4"	4'-7"	15.4	15.1	1,306	60"
72"	8'-2"	4'-6"	1'-7"	3'-9"	1'-6"	#7	7'-5"	5'-0"	17.5	17.1	1,808	15'-1"	8'-11"	6'-2"	5'-1"	18.5	18.0	1,803	12'-5"	11'-2"	4'-10"	5'-2"	18.0	17.5	1,770	12'-5"	14'-10"	4'-10"	5'-3"	21.0	20.6	2,080	72"
84"	9'-4"	5'-0"	1'-10"	4'-3"	1'-6"	#8	9'-0"	5'-8"	24.6	24.0	2,608	17'-7"	10'-9"	7'-0"	5'-9"	25.7	25.1	2,563	14'-7"	13'-4"	5'-6"	5'-10"	25.1	24.5	2,559	14'-3"	17'-8"	5'-4"	5'-10"	28.9	28.3	2,943	84"

OFFICE OF STRUCTURAL ENGINEERING

REVISIONS
07-30-2007
07-20-2012
01-18-2013
09-22-2017
07-20-2018
07-19-2024

STATE OF OHIO OFFICE OF STRUCTURAL ENGINEERING ADMINISTRATOR

DATE: 07-20-2018

STANDARD BRIDGE DRAWING
FULL-HEIGHT HEADWALLS

DESIGN AGENCY

SCD NUMBER
HW-1.1

SHEET 2 TOTAL 2

HW-1.1

ATB-193-11.140
76"x48" 706.04 w/ 12 fps
14'LX12'Wx30"T Type B

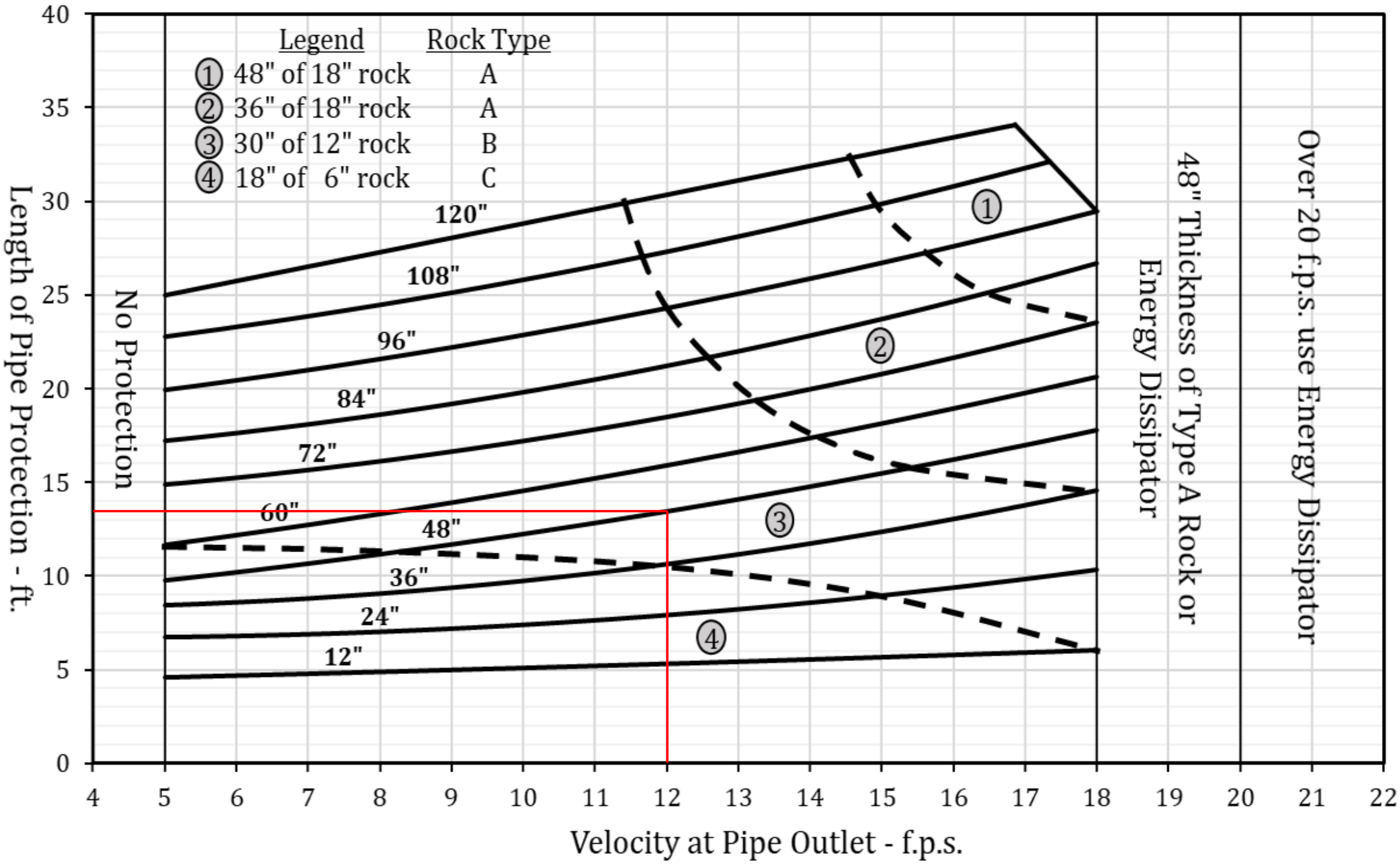
ROCK CHANNEL PROTECTION AT CULVERT AND STORM SEWER OUTLETS

1002-4

REFERENCE SECTION 1002.2.3

July 2021

Rock Channel Protection at Culvert and Storm Drain Outlets



ROCK CHANNEL PROTECTION AT CULVERT AND STORM SEWER OUTLETS	1002-4
	REFERENCE SECTION 1002.2.3

Notes:

Rock size (6", 12", 18") indicates the square opening on which 85% of the material by weight is retained.

Provide rock channel protection the width of the headwall with a minimum of 4'.

No rock channel protection is required where the natural stream bed will withstand the calculated velocity without erosion.

Equations for length of protection:

Rise	Length
120"	$L = 0.764996 * V + 21.17502$
108"	$L = 0.0203 * V^2 + 0.3004 * V + 20.765$
96"	$L = 0.0184 * V^2 + 0.3121 * V + 17.892$
84"	$L = 0.0261 * V^2 + 0.1234 * V + 15.970$
72"	$L = 0.0251 * V^2 + 0.0897 * V + 13.798$
60"	$L = 0.0139 * V^2 + 0.3683 * V + 9.4671$
48"	$L = 0.0151 * V^2 + 0.2661 * V + 8.0899$
36"	$L = 0.0262 * V^2 + 0.1341 * V + 8.4794$
24"	$L = 0.0182 * V^2 + 0.1404 * V + 6.983$
12"	$L = 0.0014 * V^2 + 0.0816 * V + 4.1255$

V=Velocity (f.p.s.)
L=Length of minimum Rock Channel Protection (ft.)