SECTION 3
GUIDE RAIL / MEDIAN BARRIER / ATTENUATOR DESIGN

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SECTION 3
GUIDE RAIL / MEDIAN BARRIER / ATTENUATOR DESIGN

3.1 INTRODUCTION

This Section is to provide guidance for permanent guide rail, median barriers and attenuators. Section 9 (Traffic Control During Construction) of this Manual addresses temporary barriers and attenuators.

Fixed objects within the clear distance should be removed, relocated or modified to be breakaway. When this is not practical, the obstruction should be shielded to prevent an impact of the obstruction by an errant vehicle.

3.2 GUIDE RAIL

It is the intention of the Authority to minimize the use of beam guide rail whenever feasible. Whereas guide rail is provided at obstructions or adjacent to high fills for safety reasons, elimination where possible of both the guide rail and potential hazard further reduces the chance of injury. Each guide rail installation should be evaluated in terms of economic (e.g. guide rail vs. flatter slope), safety, aesthetic and engineering considerations. The Engineer should be prepared to justify to the Authority's Engineering Department any use of guide rail or other attenuation device based on the above considerations.

3.2.1 Clear Zones

The clear zone for the New Jersey Turnpike roadway and ramps is a 30 feet minimum.

The clear zone for the Garden State Parkway roadway and ramps shall be determined as shown in Exhibit 3 - 1.

EXHIBIT 3 - 1
CLEAR ZONES FOR PARKWAY (FEET)

Design Speed	Design ADT	Foreslopes			Backslopes		
		1V:6H or flatter	1V:5H to 1V:4H	1V:3H	1V:3H	1V:5H to 1V:4H	1V:6H or flatter
40 mph or less	Under 750	7 – 10	7 – 10	**	7 – 10	7 – 10	7 – 10
	750 – 1500	10 - 12	12 - 14	**	10 - 12	10 - 12	10 - 12
	1500 – 6000	12 – 14	14 – 16	**	12 – 14	12 – 14	12 – 14
	over 6000	14 - 16	16 – 18	**	14 - 16	14 - 16	14 - 16
45 – 50 mph	Under 750	10 – 12	12 – 14	**	8 – 10	8 – 10	10 – 12
	750 – 1500	14 – 16	16 – 20	**	10 - 12	12 - 14	14 – 16
	1500 – 6000	16 – 18	20 – 26	**	12 – 14	14 – 16	16 – 18
	over 6000	20 - 22	24 – 28	**	14 - 16	18 - 20	20 - 22
55 mph	Under 750	12 – 14	14 – 18	**	8 – 10	10 – 12	10 – 12
	750 – 1500	16 – 18	20 – 24	**	10 – 12	14 – 16	16 – 18
	1500 – 6000	20 – 22	24 – 30	**	14 – 16	16 – 18	20 - 22
	over 6000	22 – 24	26 -32*	**	16 – 18	20 - 22	22 - 24
60 mph	Under 750	16 – 18	20 – 24	**	10 – 12	12 – 14	14 – 16
	750 – 1500	20 – 24	26 – 32*	**	12 – 14	16 – 18	20 - 22
	1500 – 6000	26 – 30	32 – 40*	**	14 – 18	20 – 22	24 – 26
	over 6000	30 – 32*	36 – 44*	**	20 - 22	22 – 24	26 – 28
65 – 70 mph	Under 750	18 – 20	20 – 26	**	10 – 12	14 – 16	14 – 16
	750 – 1500	24 – 26	28 – 36*	**	12 – 16	18 – 20	20 – 22
	1500 – 6000	28 – 32*	34 – 42*	**	16 – 20	22 – 24	26 – 28
	over 6000	30 – 34*	38 – 46*	**	22 - 24	26 - 30	28 - 30

* Where a site specific investigation indicates a high probability of continuing crashes, or such occurrences are indicated by crash history, the designer may provide clear-zone distances greater than the clear-zone shown in Exhibit 3 - 1. Clear zones may be limited to 30 feet for practicality and to provide a consistent roadway template if previous experience with similar projects or design indicates satisfactory performance.

** Since recovery is less likely on the unshielded, traversable 1V:3H slopes, fixed objects should not be present in the vicinity of the toe of these slopes. Recovery of high-speed vehicles that encroach beyond the edge of the shoulder may be expected to occur beyond the toe of slope. Determination of the width of the recovery areas at the toe of slope should take into consideration right of way availability, environmental concerns, economic factors, safety needs, and crash histories. Also, the distance between the edge of the through traveled lane and the beginning of the 1V:3H slope should influence the recovery area provided at the toe of slope. While the application may be limited to several factors, the foreslope parameters which may enter into determining a maximum desirable recovery area are illustrated in Exhibit 3 - 3.

Note 1: Clear zone is measured from edge of traveled way.

Note 2: The clear zone widths should be increased on the outside of curves. The amount of increase can be determined by Exhibit 3 - 2.

Note 3: See *Roadside Design Guide, AASHTO* for guide rail warranting obstructions.

EXHIBIT 3 - 2
HORIZONTAL CURVE ADJUSTMENTS

K_{cz} (Curve Correction Factor)							
Radius (ft)	Design Speed (mph)						
	40	45	50	55	60	65	70
2860	1.1	1.1	1.1	1.2	1.2	1.2	1.3
2290	1.1	1.1	1.2	1.2	1.2	1.3	1.3
1910	1.1	1.2	1.2	1.2	1.3	1.3	1.4
1640	1.1	1.2	1.2	1.3	1.3	1.4	1.5
1430	1.2	1.2	1.3	1.3	1.4	1.4	--
1270	1.2	1.2	1.3	1.3	1.4	1.5	--
1150	1.2	1.2	1.3	1.4	1.5	--	--
950	1.3	1.3	1.4	1.5	1.5	--	--
820	1.3	1.3	1.4	1.5	--	--	--
720	1.3	1.4	1.5	--	--	--	--
640	1.3	1.4	1.5	--	--	--	--
570	1.4	1.5	--	--	--	--	--
380	1.5	--	--	--	--	--	--

$CZ_c = (L_c)(K_{cz})$

Where:

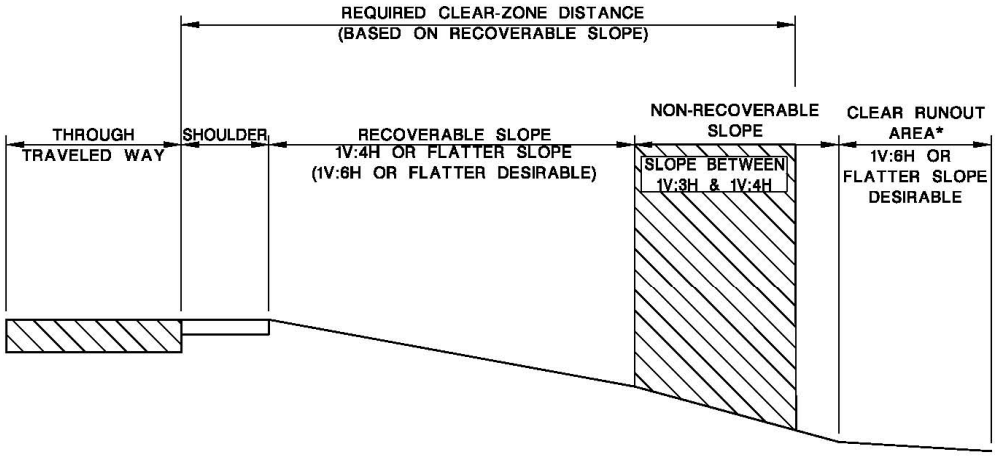
CZ_c = clear zone on outside of curvature, Feet

L_c = clear zone distance, feet (Exhibit 3 - 1)

K_{cz} = curve correction factor

Note:
The clear zone correction factor is applied to the outside of curves only. Curves flatter than 2,860 feet do not require an adjusted clear zone.

EXHIBIT 3 - 3
CLEAR ZONE EXAMPLE



* THE CLEAR RUNOUT AREA IS ADDITIONAL CLEAR-ZONE SPACE THAT IS NEEDED BECAUSE A PORTION OF THE REQUIRED CLEAR ZONE (SHADED AREA) FALLS ON A NON-RECOVERABLE SLOPE. THE WIDTH OF THE CLEAR RUNOUT AREA IS EQUAL TO THAT PORTION OF THE CLEAR ZONE DISTANCE THAT IS LOCATED ON THE NON-RECOVERABLE SLOPE.

3.2.2 Guide Rail Warrants

1. Embankment (Fill) Slopes
   A critical slope is one in which a vehicle is likely to overturn. Slopes steeper than 3H:1V fall into this category and ***may*** require guide rail. If a slope steeper than 3H:1V, ***that exceeds the maximum heights presented in Exhibit 3-4 and*** begins closer to the traveled way than the suggested clear zone distance, guide rail is warranted ***provided*** it is not practical to flatten the slope.

   A non-recoverable slope is defined as one that is traversable but the vehicle can be expected to travel to the bottom of the slope before steering recovery can be obtained. Embankments between 3H:1V and 4H:1V generally fall into this category. Fixed objects should not be constructed or located along such slopes that begin closer to the traveled way than the suggested clear zone distance. A clear runout area at the base of these slopes is desirable; see Exhibit 3 - 3 for an example. The designer should, therefore, evaluate each site before providing 3H:1V slopes without guide rail.

   When flattening existing slopes to remove guide rail, the proposed side slopes should be recoverable, that is, 4H:1V or flatter. Where embankment slopes are being constructed, the designer should investigate the feasibility of providing a recoverable slope instead of a critical slope with guide rail.

EXHIBIT 3 - 4
CRITICAL SLOPE WARRANTS

Critical Embankment (fill) Slopes	Maximum Height without Guide Rail
1 ½ H: 1V	3 ft.
2H: 1V	6 ft.
2 ½ H: 1V	9 ft.

2. Slopes in Cut Sections
   Slopes in cut sections should not ordinarily be shielded with guide rail. However, there may be obstructions on the slope that warrant shielding, such as bridge piers, retaining walls, drainage features, trees, rocks, etc. that may cause excessive vehicle snagging rather than permit relatively smooth redirection.

3.2.3 Dimensional Characteristics

1. Without Curb in Front of Guide Rail
   In general, the following offsets and slopes should be used:

   a. To the extent possible, guide rail should be located as far as possible away from the traveled way to provide a recovery area for errant

vehicles and to provide adequate sight distance along horizontal curves and at intersections.

b. The front face of the guide rail should desirably be 2 feet or more from the outside edge of shoulder along Turnpike mainline and ramps. Along Parkway mainline and ramps the desired offset shall be 4 feet or more from the outside edge of shoulder. Where these offsets are not possible, the guide rail should be installed flush with the gutter line.

c. Where guide rail is located at the top of an embankment slope, the posts should be a minimum of 2 feet from the PVI to the center of the post. When less than 2 feet is provided, the following post lengths, shown in Exhibit 3 - 5. below, should be used:

d. Guide rail shall be placed on slopes 10H:1V or flatter provided the rollover between the shoulder slope and the embankment slope is not greater than 10 percent.

e. See Exhibit 3 - 8 for the treatment of critical embankment slopes at approach guide rail end terminals.

EXHIBIT 3 - 5
ADDITIONAL POST LENGTH REQUIREMENTS

Where Distance From PVI to Center of Post is Less Than 2 Feet

Embankment Slopes	Additional Post Length
Flatter Than 6H:1V	No Change
6H:1V to 4H:1V	1 ft.
3H:1V to 2H:1V	2 ft.
Steeper Than 2H:1V	4 ft.

2. Curb or Raised Berm in Front of Guide Rail
Curb or a raised berm in front of guide rail should be avoided.

New installations of vertical curb shall not be constructed on the Parkway mainline but may be constructed on ramps.

On projects that involve upgrading existing roadways with curb in front of guide rail, removal of the curb should be the first consideration.

If curb is present and cannot be removed, the following apply:

a. Mainline:
Where sufficient roadside width is available, guide rail should be placed 7 feet or more behind the gutter line. Where this offset is not possible, guide rail should be installed flush with the gutter line.

Where providing an offset of 7 feet or more, the Engineer is advised that additional right of way or slope easements may be necessary to construct the flare offset and/or provide the 5 feet flat area (10H:1V minimum slope) adjacent to an approach end terminal as shown in

Exhibit 3 - 9. If the purchase of additional right of way is unfeasible, a tangent terminal should be provided at an offset of 7 feet, instead of a flared end terminal. If this is still unfeasible, then the guide rail should be installed flush with the gutter line to permit the construction of the flared end terminal with the required offset and flat area.

b. Rub Rail
When guide rail is constructed flush with the gutter line and the curb is 4 inches or greater in overall height, the mounting height is measured from the top of the curb and rub rail is required. Where guide rail is set flush to the gutter line and goes across short sections (i.e. less than 100 feet long at each location) of the curb, 4 inches or less in height, the mounting height may be measured from the gutter line, in which case, rub rail is not required.

On all projects involving new guide rail or the upgrading of existing guide rail, every effort should be given to the elimination or reduction in the use of rub rail.

Acceptable methods for reducing or eliminating the need for rub rail includes: providing sufficient offsets, providing designs without curb, and eliminating the existing curb where economically feasible.

3. At Fixed Objects
Where guide rail is used to shield an isolated obstruction, the guide rail should be located as far from the traveled way as possible to minimize the probability of impact. The distance from the back of the rail element to the face of obstruction should desirably be 4 feet or greater. If less than 4 feet must be used, the guide rail system must be modified with additional posts (see Standard Drawing GR-8).

4. On Bridges
When there is a difference in the offset to the approach guide rail and the offset to the bridge parapet, a transition flare of 15:1 should be used.

See Standard Drawings for the attachment of guide rail to bridges and structures.

3.2.4 End Treatments

The following provides general guidance for the use of end treatments. Refer to the current AASHTO Roadside Design Guide for approved end treatments.

1. Flared Guide Rail Terminals

a. Flared guide rail terminals shall be used on the approach ends of beam guide rail installations terminating within the clear zone, unless covered by conditions noted in 2 and 3 below.

A 37.5 foot flare shall be used with all flared guide rail terminal end treatments. This flare provides for an offset of 4 feet (see the Standard Drawings). A flared guide rail terminal shall be placed a minimum distance of 12.5 feet beyond the length of need.

b. A flared guide rail terminal shall not be installed behind a curb greater than 4 inches in height. Where there is an existing curb or proposed curb greater than 4 inches in height, 75 feet of the curb immediately in advance of and 50 feet beyond the front of a flared guide rail terminal shall be removed or replaced, if necessary, with 4-inch face concrete vertical curb.

c. A clear area shall be provided behind a flared guide rail terminal installation. The desired clear area is shown crosshatched on Exhibit 3 - 7. Slopes in front of guide rail and 5 feet behind the flared guide rail terminal shall be graded at 10H:1V or flatter, see Standard Drawing GR-6.

d. Rub rail, reduced post spacing, and double rail elements shall not be used within the 37.5-foot flare of a flared guide rail terminal.

e. Where guide rail is installed along a horizontal curve, the post offsets for the flare is measured from a line tangent to the horizontal curve.

2. Tangent Guide Rail Terminals

a. At locations where it is not possible to construct a flared guide rail terminal with 4 feet of flare offset, a tangent terminal should be used. The tangent terminal is 50 feet long and is erected parallel to the roadway without needing a flare to function properly. The tangent terminal shall be placed a minimum distance of 12.5 feet beyond the length of need.

b. Where the guide rail is installed flush with the gutter line, a tangent terminal shall be constructed with a 50:1 straight flare for its entire length so that the guide rail terminal does not protrude into the roadway.

c. Where a tangent terminal is installed along a horizontal curve, the terminal shall be constructed tangent to the curve (straight); therefore its offset from the roadway may have to be adjusted so it does not protrude into the roadway.

d. The curb requirements for a flared guide rail terminal in 1.b. above are applicable to a tangent terminal. Slopes in front of guide rail and 5 feet behind the tangent guide rail terminal shall be graded at 10H:1V or flatter, see Standard Drawing GR-6.

e. Rub rail, reduced post spacing, and double rail elements shall not be used within 50 feet from the end of a tangent terminal.

3. Beam Guide Rail Anchorage

a. On a one-way roadway or a divided roadway with a non-traversable median, trailing ends of guide rail installations should be anchored with a beam guide rail end anchorage, as shown in the Standard Drawing GR-4.

b. In special cases, where the approach end of a guide rail installation is located so that an end hit is unlikely, the end may be anchored with a Beam Guide Rail End Anchorage as shown in Standard Drawings.

4. Telescoping Guide Rail End Terminals

   a. Telescoping Guide Rail End Terminals shall be used when terminating dual face beam guide rail within a grass median, see Exhibit 3 - 10.

   b. Telescoping Guide Rail End Terminals shall be installed on relatively flat surfaces (8 percent or flatter). Use on raised islands or behind curbs is not recommended.

   c. All curbs, islands or elevated objects (delineators, signs, etc.) present at the telescoping guide rail end terminal site and over 2 inches high should be removed a minimum of 75 feet in front of the telescoping guide rail end terminal system and as far back as the rear of the system.

   d. If there is a cross slope of more than 8 percent at the telescoping guide rail end terminal location, a leveling pad must be used.

3.2.5 Approach Length of Need (L.O.N.)

The approach length of need is the minimum length of guide rail required in front of the warranting obstruction to shield it effectively.

1. On Embankment Slopes and Obstructions
   The approach L.O.N. at fixed objects should be determined in accordance with Exhibit 3 - 8.

   The approach L.O.N. and guide rail treatment for critical embankment slopes is shown in Exhibit 3 - 9.

   Exhibit 3 - 10 shall be used when determining the approach L.O.N. when terminating dual face beam guide rail within a grass median.

2. In a Cut Section
   See Exhibit 3 - 11 for an example of determining L.O.N. in a cut section. Also, see Exhibit 3 - 12 to determine the length required beyond the toe of the slope to bury the guide rail.

3. At Gore Areas
   It is desirable to provide a traversable and unobstructed gore area since the gore area may serve as a recovery area for errant vehicles. Urban areas, wetlands, parklands, etc. can put restrictions on this policy by placing warranting obstructions, such as critical embankment slopes, parapets or abutments close to gore areas. The closer the obstruction to the gore area, the closer the L.O.N. to the gore area, therefore the more limited the guide rail treatment becomes. Exhibit 3 - 13 and Exhibit 3 - 14 provide guide rail treatment examples for gore areas, starting from fewer restricted or open gore areas in Exhibit 3 - 13 to more restricted or limited gore areas in Exhibit 3 - 14.

   The preferred treatments for gore areas are no guide rail warrants at all.

3.2.6 General Comments

1. Guide rail should not restrict sight distance. Sight distances should be checked when guide rail is to be installed at intersections, ramp terminals, driveways, along sharply curving roadways, etc. If the sight distance is determined to be inadequate, the guide rail placement shall be adjusted.

2. Wherever part of an existing guide rail run is lengthened, reset or upgraded, then the entire run shall be upgraded to current standards including the bridge attachments. Also, always end a project outside the limits of a guide rail run.

3. Gaps of 200 feet or less between individual guide rail installations should be avoided where possible.

4. Guide rail should not be installed beyond the right of way unless easements or necessary right of way is acquired.

5. For the guide rail treatment at adjacent bridges, see the Standard Drawing GR-7. Guide rail between parapets is not required if there is a concrete connecting wall 3.5 feet high (minimum) between parapets.

6. Proposed guide rail set flush with the curb line along intersection radius returns should be checked with a truck turning template. Existing guide rail along radius returns that experience truck overhang or oversteering accidents shall either be reset farther from the curb line or redesign the radius returns for a larger design vehicle.

7. Thrie Beam
   With the exception of guide rail transitions at bridges, Thrie beam should not be substituted for W-beam with rub rail unless there are extenuating circumstances and then only with the approval from the Authority's Engineering Department.

8. All approach end treatments (flared guide rail terminals, tangent guide rail terminals, etc.) shall be located on the construction plans by station and offset. The applicable flare rate shall also be indicated.

   Grading work necessary for construction of the guide rail end treatments shall be shown on the construction plans. Grading shall conform to the Standard Drawings.

9. Conduits
   The plans shall indicate the location of existing conduits or shall include a notation where there is a possibility of conflict in driving the guide rail posts.

10. Berm Surfacing Under Guide Rail
    In order to reduce soil erosion and highway maintenance costs associated with spraying or trimming vegetation underneath guide rail, berm surfacing shall be applied underneath guide rail as follows:

Guide Rail Types	Conditions warranting use of berm surface
Existing Guide Rail	Where upgrading Where regrading berms Where resetting guide rail
New Guide Rail	All Cases

Berm surfacing shall be constructed as shown on Standard Drawing GR-9.

11. Asphalt lip curb shall be applied underneath guide rail to control stormwater runoff as needed, and be constructed as shown on Standard Drawing CU-2.

3.2.7 Warrants for Median Barriers

1. Turnpike mainline roadways
   a. Concrete median barrier curb is required for all standard center median locations as indicated in Section 1A of this manual.
   b. Dual or single face guide rail is required for all standard inner-outer medians as indicated in Section 1A of this manual.
   c. Non-standard center and inner-outer medians which are 50 feet or greater in width do not warrant median barrier protection, unless otherwise directed by the Authority. At such locations, the median should be evaluated to determine if any fixed object obstructions or critical slopes are present within the clear zone of either adjacent roadway that would warrant roadside (guide rail) protection.

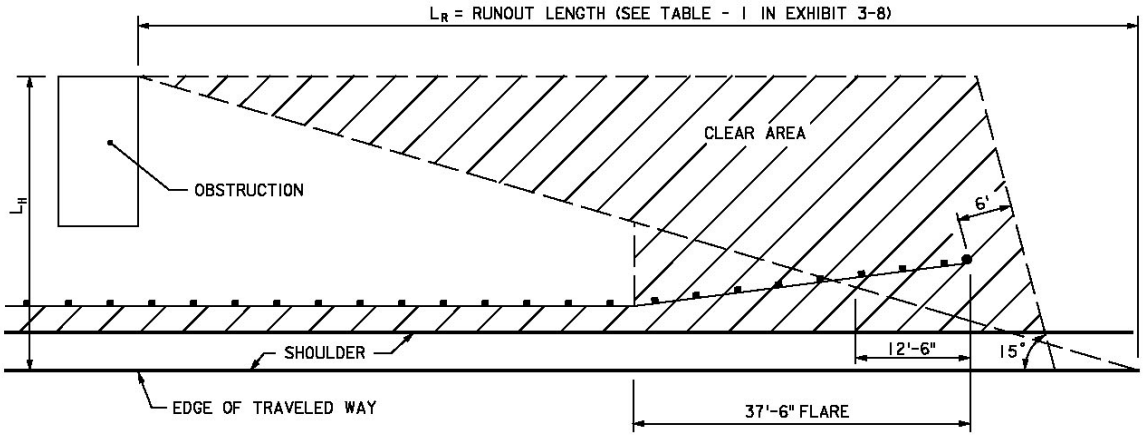
2. Parkway mainline roadways
   a. Median barrier is required for all medians less than 50 feet in width. Barrier type shall be as indicated in Exhibit 3-6.
   b. Medians which are 50 feet or greater in width do not warrant median barrier protection, unless otherwise directed by the Authority. At such locations, the median should be evaluated to determine if any fixed object obstructions or critical slopes are present within the clear zone of either adjacent roadway that would warrant roadside (guide rail) protection.

Concrete median barrier curb for both Turnpike and Parkway mainline roadways, when warranted, shall be as per Standard Drawing MB-1. Where barrier curb is used to shield an obstruction (bridge pier, abutment, sign bridge, etc.), a desirable offset of 4 feet or greater from the gutter line to the face of the obstruction shall be used. Where the desirable minimum offset is not feasible or practical, barrier curb should be placed directly in front of the obstruction face as shown on Standard Drawings GR-7 and MB-2.

EXHIBIT 3 - 6
MEDIAN WIDTH VS. MEDIAN BARRIER TYPE

Median Width	Median Barrier Type
Up to 12 ft.	Concrete Barrier Curb
13 ft. to 26 ft.	Concrete Barrier Curb (Preferred Treatment) or Dual Face Beam Guide Rail
Above 26 ft.	Dual Face Beam Guide Rail

EXHIBIT 3 - 7
CLEAR AREA AT FLARED APPROACH END TERMINAL



FLARED

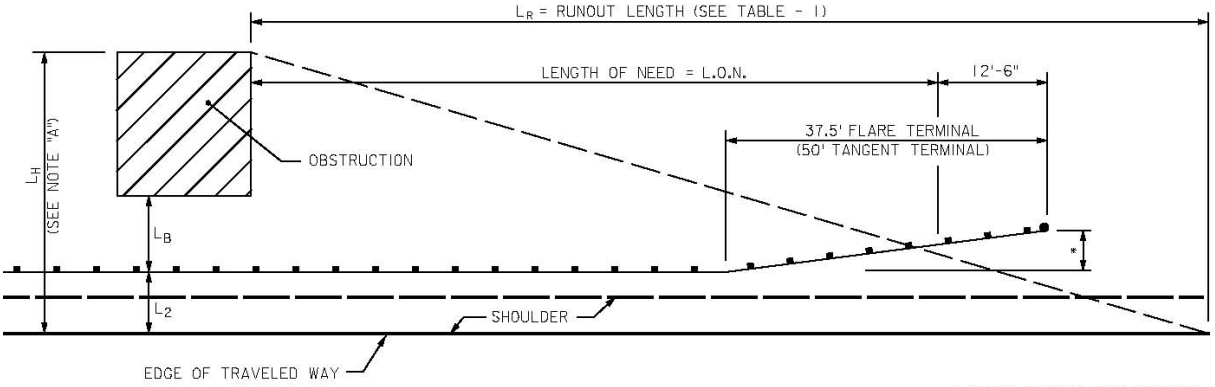
NOTES:

A. NO FIXED OBJECTS SHOULD BE WITHIN THE CROSS-HATCHED AREA.

B. IF L_H EXTENDS BEYOND R.O.W. LINE, THEN CLEAR AREA ONLY WITHIN R.O.W. LIMITS.

C. RUB RAIL, REDUCED POST SPACING, AND DOUBLE RAIL ELEMENTS SHALL NOT BE USED WITHIN THE FLARE.

EXHIBIT 3 - 8
APPROACH LENGTH AT OBSTRUCTION



* 4' FOR FLARED END TERMINAL
0' FOR TANGENT END TERMINAL

TABLE - 1

DESIGN SPEED (M.P.H.)	TRAFFIC VOLUME (A.D.T.) OVER 6,000 L_R	2,000-6,000 L_R	800-2,000 L_R	UNDER 800 L_R	SHY LINE OFFSET	STRAIGHT FLARE RATE
70	475	445	395	360	10.0	15:1
60	425	400	345	330	8.0	14:1
55	360	345	315	280	7.5	12:1
50	330	300	260	245	7.0	11:1
45	260	245	215	200	6.0	10:1
40	230	200	180	165	5.0	8:1
35	200	185	165	150	4.5	8:1
30	165	165	150	130	4.0	7:1
25	120	110	100	90	4.0	7:1

STEP 1. DETERMINE THE REQUIRED L.O.N.

FLARE TERMINAL

$$L.O.N. = \frac{L_R (L_H - L_2 - 2.7)}{L_H}$$

TANGENT TERMINAL

$$L.O.N. = \frac{L_H - L_2}{L_H / L_R}$$

NOTE A: IF OBSTRUCTION EXTENDS BEYOND CLEAR ZONE, MAKE L_H EQUAL TO CLEAR ZONE, EXCEPT IF OBSTRUCTION IS CRITICAL SLOPE, SEE EXHIBIT 3-9.

NOTE B: IF ROADWAY IS CURVED, DRAW LAYOUT TO SCALE AND OBTAIN L.O.N. DIRECTLY BY SCALING FROM DRAWING.

STEP 2. INCREASE L.O.N. TO NEAREST MULTIPLE OF 12'-6", WHICH IS THE LENGTH OF ONE RAIL ELEMENT.

STEP 3. ADD AN ADDITIONAL 12'-6" TO GET REQUIRED L.O.N. INCLUDING FLARE OR TANGENT TERMINAL.

STEP 4. COMPARE THE REQUIRED LENGTH IN STEP 3 TO THE MINIMUM FUNCTIONAL LENGTH SHOWN IN TABLE 2 AND USE THE GREATER OF THE TWO LENGTHS.

TABLE - 2

DISTANCE FROM BACK OF RAIL ELEMENT TO OBSTRUCTION (L_B)	MINIMUM FUNCTIONAL LENGTH: FLARE TERMINAL	TANGENT TERMINAL
$L_B \geq 4'$	37'-6"	50'-0"
$2' \leq L_B < 4'$	50'-0"	62'-6"
$L_B < 2'$	56'-3"	68'-9"
* GUIDE RAIL ATTACHMENT	56'-3"	68'-9"
* THRIE BEAM ATTACHMENT	56'-3"	68'-9"

* NOTE C: USE GUIDE RAIL ATTACHMENT FOR EXISTING GUIDE RAIL LOCATIONS ONLY. FOR NEW GUIDE RAIL LOCATIONS, USE THRIE BEAM ATTACHMENT.

NOTE D: THE TOTAL LENGTH OF A FREESTANDING GUIDE RAIL INSTALLATION INCLUDING APPROACH AND TRAILING END TREATMENTS SHOULD NOT BE LESS THAN 62'-6".

EXHIBIT 3 - 9
GUIDE RAIL TREATMENT FOR CRITICAL EMBANKMENT SLOPES

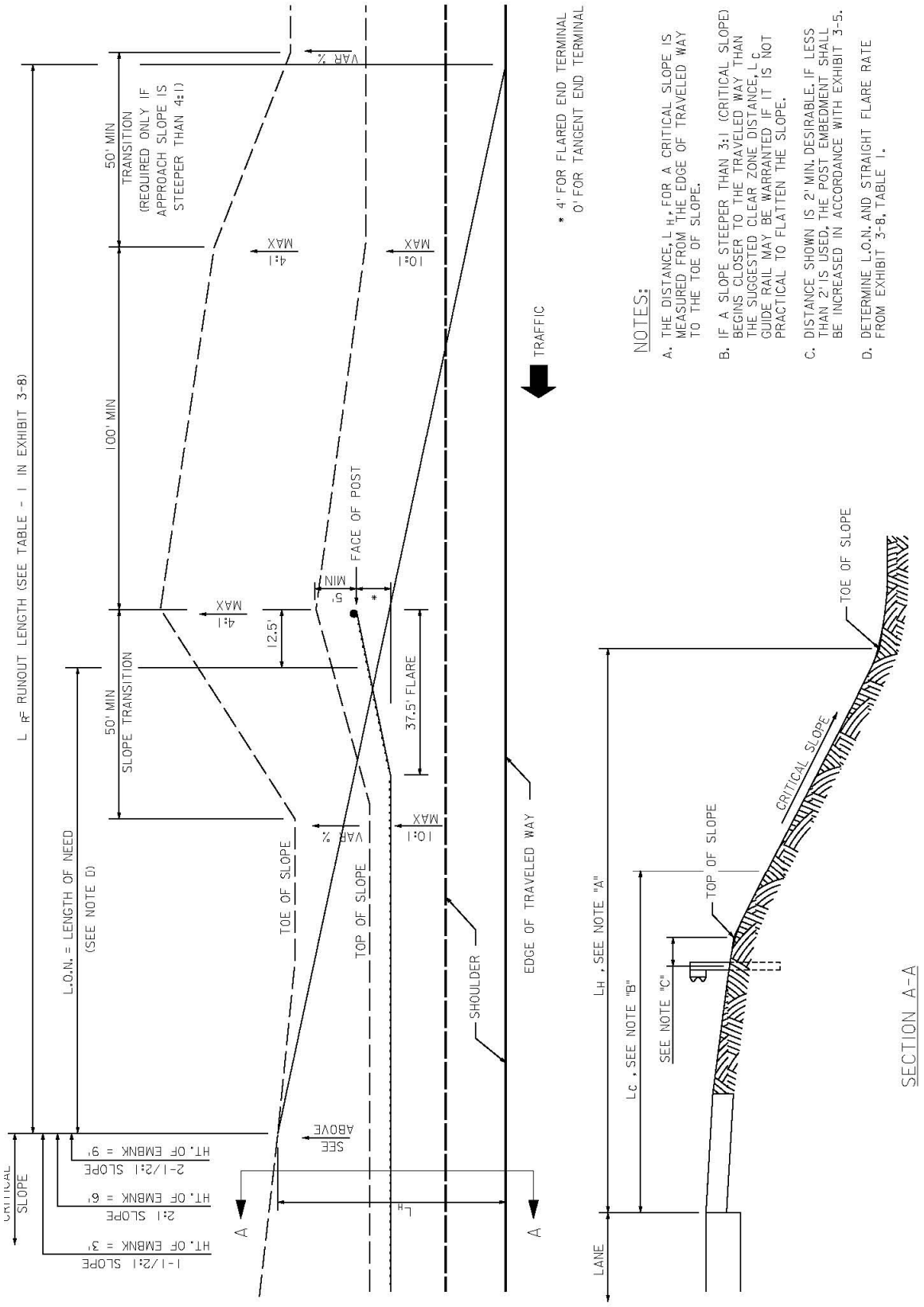
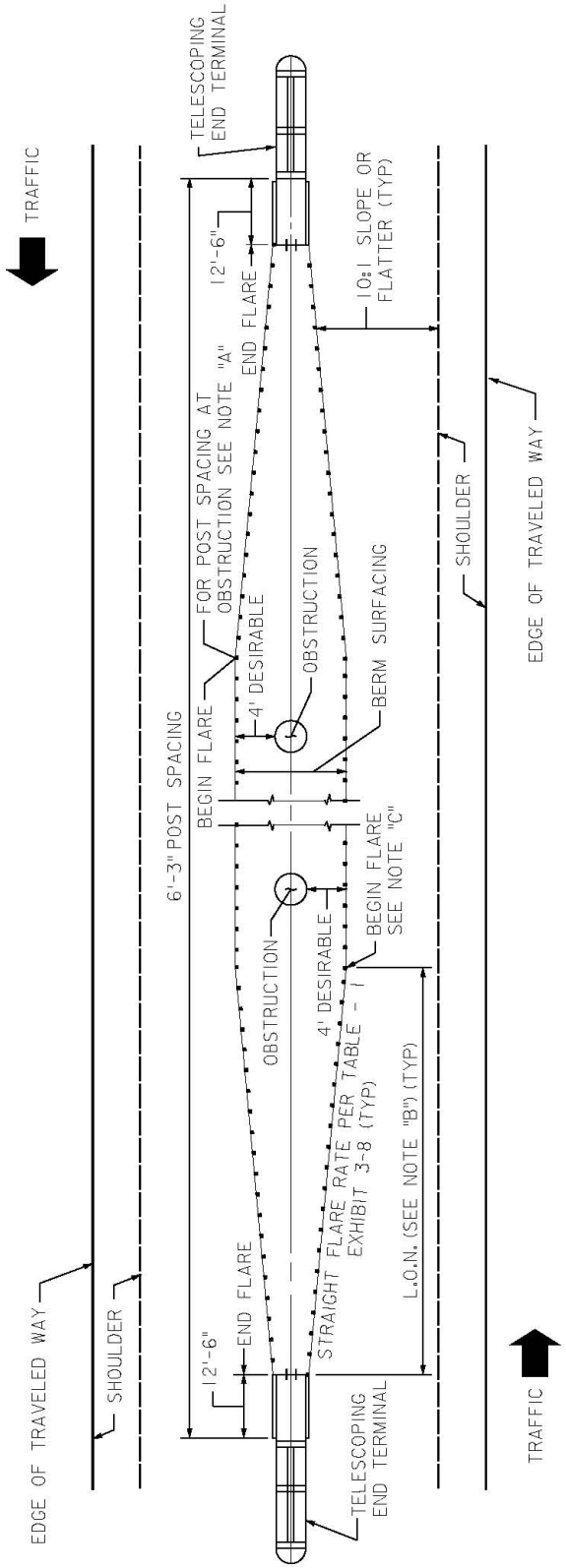


EXHIBIT 3 - 10
OBSTRUCTION IN MEDIAN APPROACH END TREATMENT



NOTE:

A. FOR POST SPACING AT OBSTRUCTION, SEE STANDARD DRAWINGS.

B. DETERMINE L.O.N. USING STRAIGHT FLARE RATE IN TABLE-1 OF EXHIBIT 3-8.

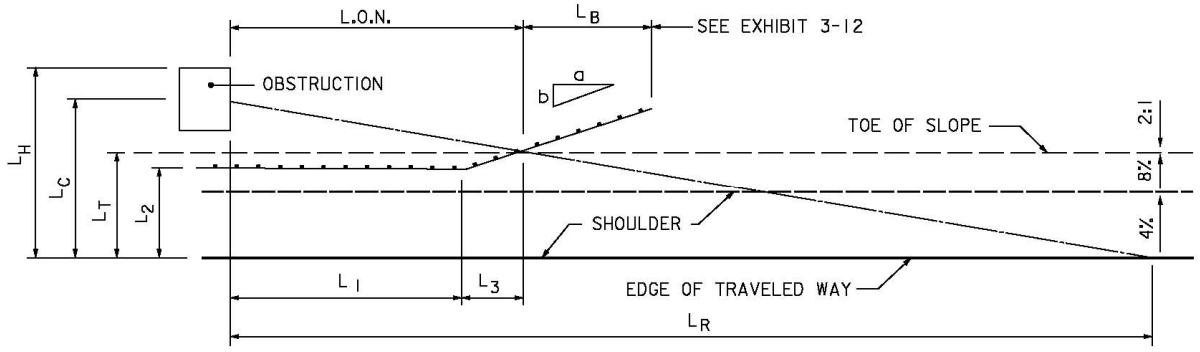
C. BEGIN FLARE AT FIRST POST THAT IS 6'-3" MINIMUM FROM OBSTRUCTION.

D. REFER TO STANDARD DRAWING GR-7 FOR ADDITIONAL DETAILS.

EXHIBIT 3 - 11
APPROACH LENGTH OF NEED IN CUT SECTIONS

WHERE AN OBSTRUCTION IS ENCOUNTERED IN A CUT SECTION AND IT IS TO BE SHIELDED WITH GUIDE RAIL, IT IS DESIRABLE THAT THE LENGTH OF NEED (L.O.N.) END AT THE TOE OF SLOPE, SEE EXHIBIT 3-12. IN ORDER TO ACCOMPLISH THIS, THE LENGTH OF GUIDE RAIL (L_1) PARALLEL TO THE TOE OF SLOPE MUST BE OBTAINED. THE FOLLOWING EXAMPLE SHOWS HOW THE L.O.N. IS COMPUTED:

EXAMPLE



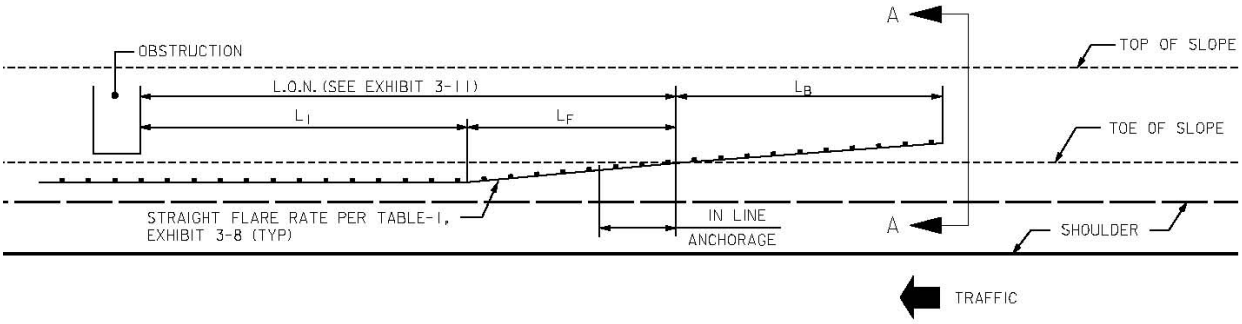
V = 60 M.P.H.
A.D.T. = 6,000
L_2 = 16 FEET
L_H = 32 FEET
L_R = 425 (FROM EXHIBIT 3-8, TABLE - 1)
L_T = 19 FEET
a/b = 14:1 STRAIGHT FLARE (FROM EXHIBIT 3-8, TABLE - 1)
L_C = 27 FEET (FROM EXHIBIT 3-1, L_C = 26' TO 30')
IF $L_H > L_C$ USE L_C
$L_1 = L_R - (L_T\ L_R\ / L_C) - a/b_T(L_T - L_2)$
$L_1 = 425 - (19 \times 425/27) - 14/1\ (19 - 16) = 83.9'$

83.9'/6.25' POST SPACING = 13.42 POSTS, THEREFORE, USE 14 POSTS AT 6.25' = 87.5 FT. = L_1
FLARE LENGTH $L_3 = (L_T - L_2)\ a/b = (19 - 16)\ 14/1 = 42$ FT.
42'/6.25' POST SPACING = 6.72 POSTS, THEREFORE, USE 7 POSTS AT 6.25' = 43.75 FT. = L_3
L.O.N. = 87.5 FEET + 43.75 FEET = 131.25 FEET

NOTES:

1. L_1 SHALL NOT BE LESS THAN 12'-6".
2. PARKWAY EXAMPLE SHOWN. FOR TURNPIKE ROADWAY, L_C = 30 FEET.

EXHIBIT 3 - 12
GUIDE RAIL TREATMENT FOR CUTS STRAIGHT FLARE



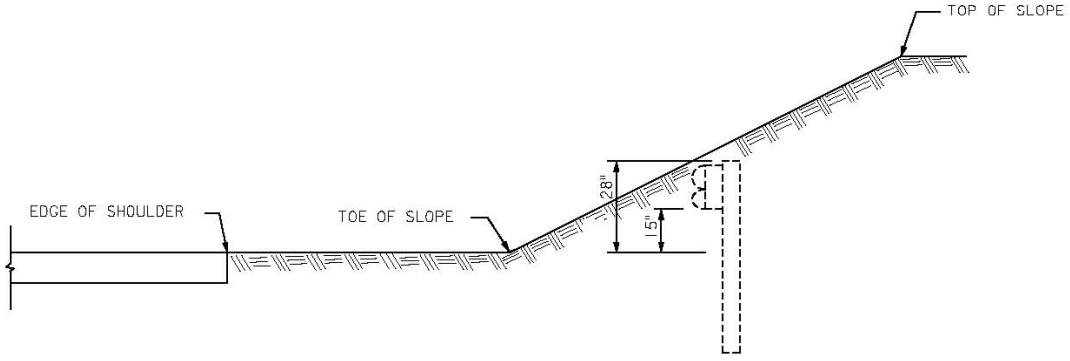
NOTES:

* L_B = LENGTH NEEDED BEYOND TOE OF SLOPE TO BURY GUIDE RAIL.

** IN-LINE ANCHORAGE MAY BE ELIMINATED BY CONSTRUCTING AT LEAST 7 POSTS AT 6'-3" SPACING BEYOND L.O.N.

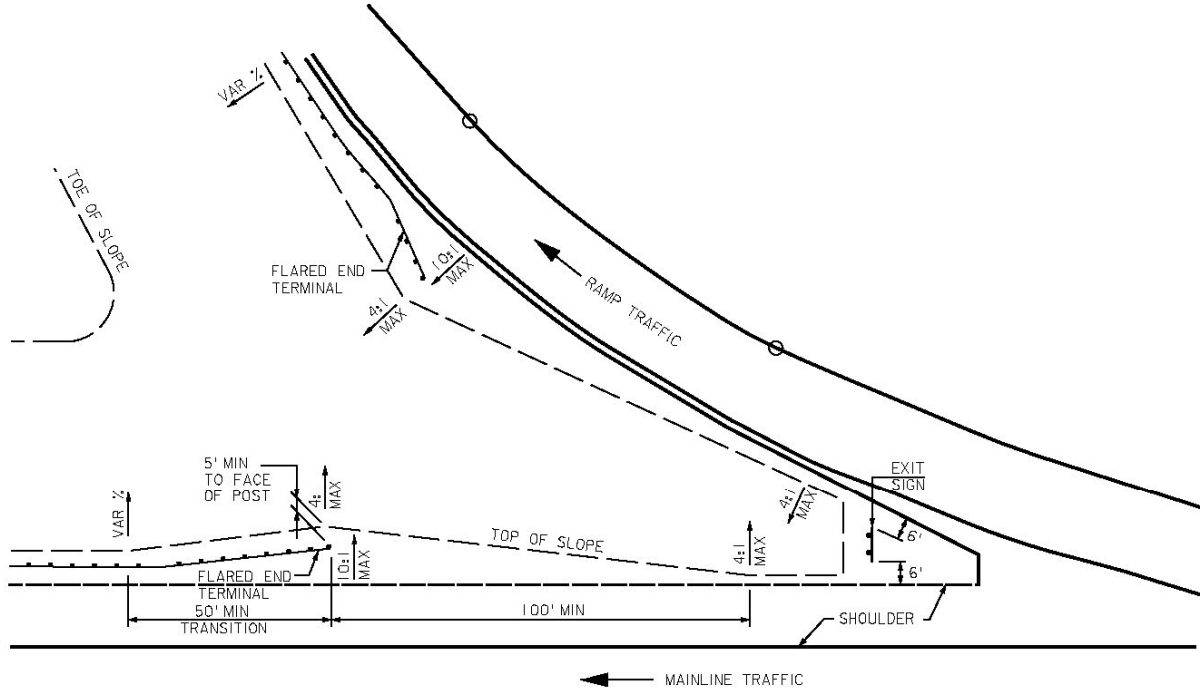
REFER TO STANDARD DRAWING GR-8 FOR ADDITIONAL DETAILS.

TABLE - 3			
SLOPE	FLARE	*L_B	IN-LINE ANCHORAGE REQUIRED
2:1	15:1	75.00	NO
	14:1	68.75	NO
	12:1	62.50	NO
	11:1	56.25	NO
	10:1	50.00	NO
	8:1	43.75	NO
	7:1	37.50	**YES



SECTION A-A

EXHIBIT 3 - 13
GUIDE RAIL TREATMENT EXAMPLES FOR OPEN GORE AREAS



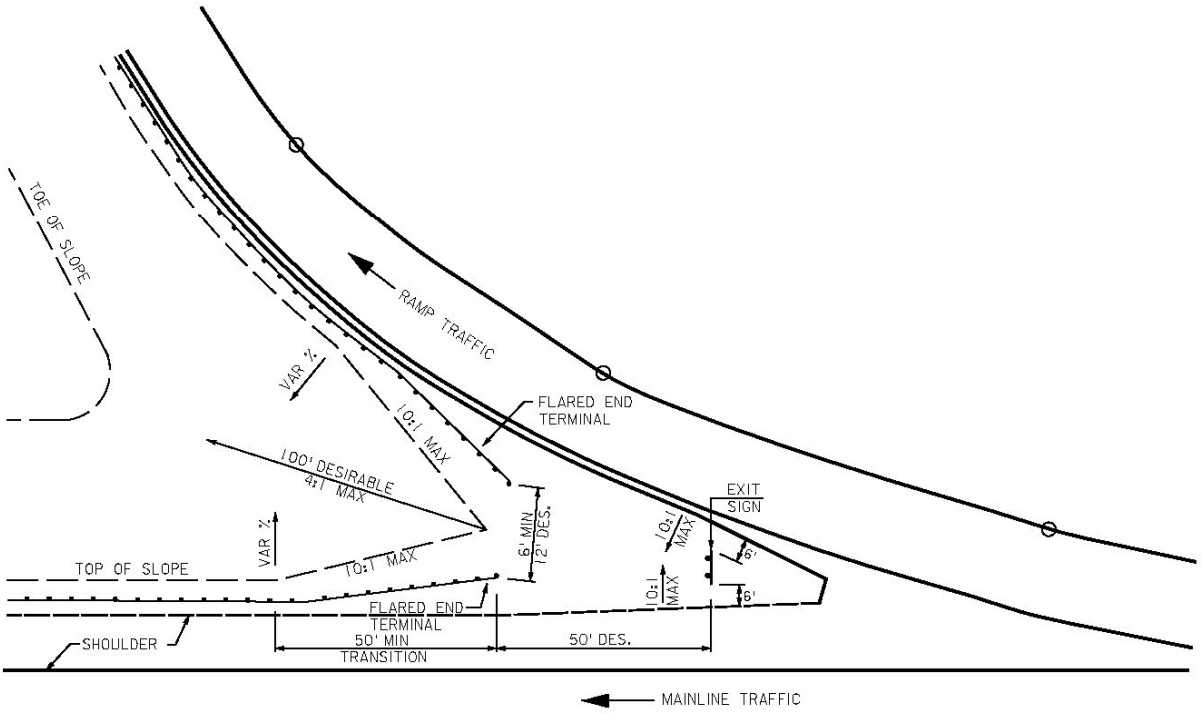
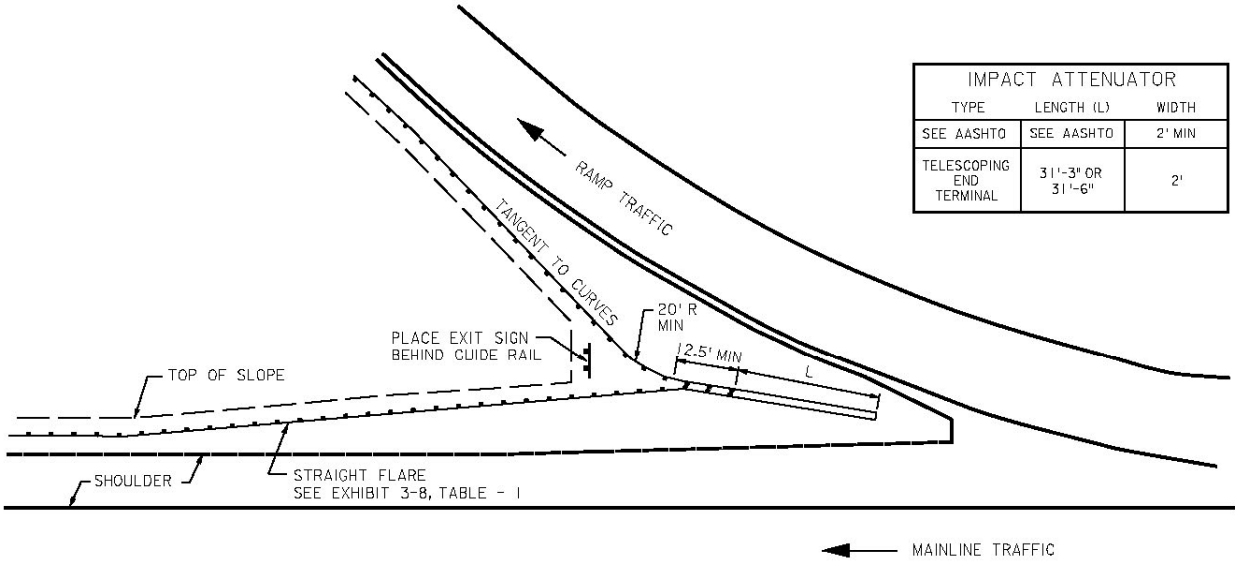


EXHIBIT 3 - 14
GUIDE RAIL TREATMENT EXAMPLES FOR LIMITED GORE AREAS



NOTES:

1. PROVIDING THE WIDEST IMPACT ATTENUATOR TO FIT THE SITE, FROM THE TABLE ABOVE, USUALLY PROVIDES THE GREATEST OFFSET FROM THE PHYSICAL NOSE.

3.2.8 Median Barrier End Terminals

When terminating the approach end of dual face guide rail beyond the clear zone, an end anchorage with end section (buffer) is required as shown in the Standard Drawings GR-2 and GR-4. The same shall be required for the trailing end of dual faced guide rail, regardless of clear zone.

Where a median barrier terminates within the clear zone area, a crashworthy end treatment shall be used. Acceptable methods of developing a crashworthy end treatment are to use an AASHTO-approved attenuator with concrete barrier curb; or a telescoping guide rail end terminal with dual face beam guide rail.

The introduction of new or existing median concrete barrier curb within the clear zone (other than at intersections) shall be protected with an attenuator regardless of the posted speed.

3.3 ATTENUATORS

3.3.1 General

The following provides general guidance for the use of attenuators. Refer to the current AASHTO Roadside Design Guide for approved attenuators. The designer shall always consider site-specific conditions and consult with the Authority-for their preferred devices when selecting attenuators.

An attenuator is a type of traffic barrier that can be used to shield warranting obstructions such as overhead sign supports, bridge piers, bridge abutments, ends of retaining walls, bridge parapets, bridge railings, longitudinal barriers, etc. Due to the maintenance needs of attenuators, the Engineer shall, attempt to place obstructions beyond the clear zone when practical, or provide designs that will avoid the need to require shielding by attenuator.

The most common use of an attenuator is to prevent errant vehicles from impacting a warranting obstruction in a gore. However, an attenuator can also be used to prevent errant vehicles from impacting warranting obstructions in the median and along the roadside (see Exhibit 3 - 15).

Existing attenuators shall be evaluated to determine whether repairs or replacements are necessary.

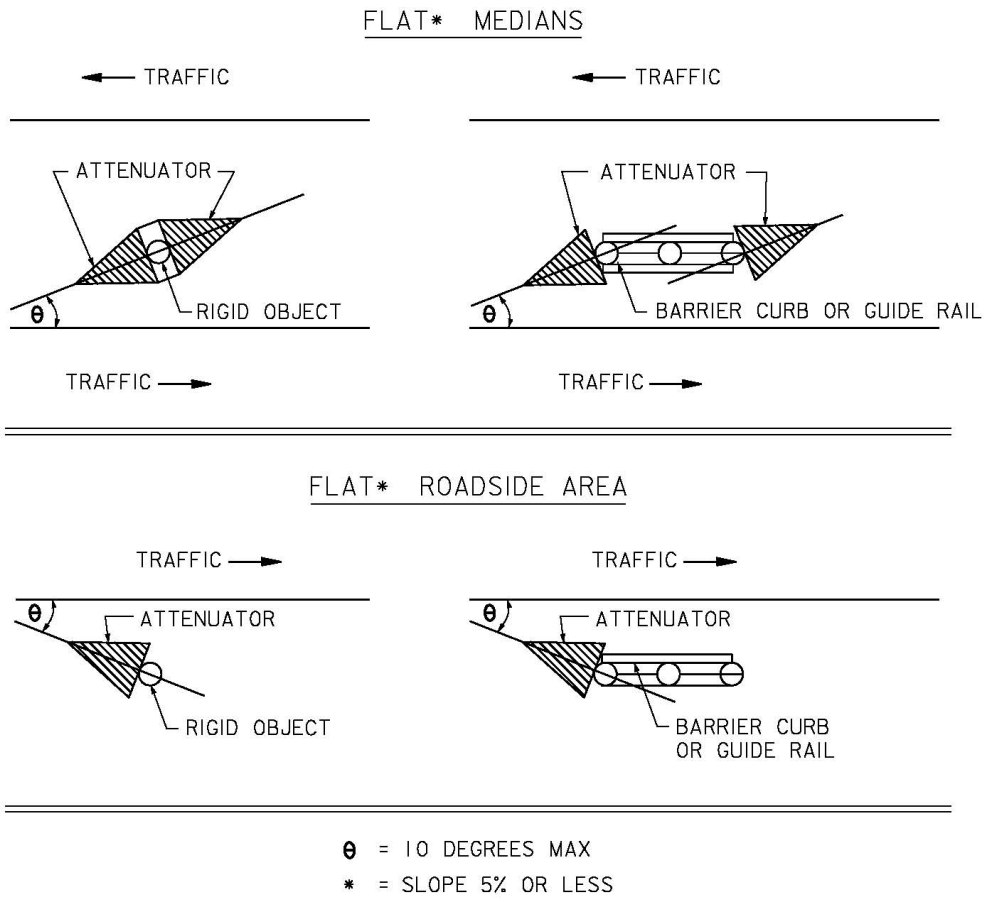
Several factors must be evaluated when selecting and placing an attenuator. The factors which normally should be considered are briefly discussed below. Use the manufacturer's design manual when designing an attenuator.

3.3.2 Dimensions of the Obstruction

The attenuator shall be the necessary width to shield the obstruction.

Attenuators are not ordinarily used along the length of an obstruction. Usually guide rail or barrier curb is used. Exhibit 3 - 15 shows typical installations where an attenuator is used in conjunction with a barrier curb or guide rail.

EXHIBIT 3 - 15
ATTENUATORS IN MEDIAN AND ROADSIDE



θ = 10 DEGREES MAX
* = SLOPE 5% OR LESS

3.3.3 Space Requirement

1. Reserve area for attenuator:

   Exhibit 3 - 16 shows dimensions to be used in determining if adequate space is available for the installation of an attenuator. Although it depicts a gore location, the same recommendations will apply to other types of obstructions that require shielding by an attenuator. Also, Exhibit 3 - 16 shows a range of dimensions, the significance of which is as follows:

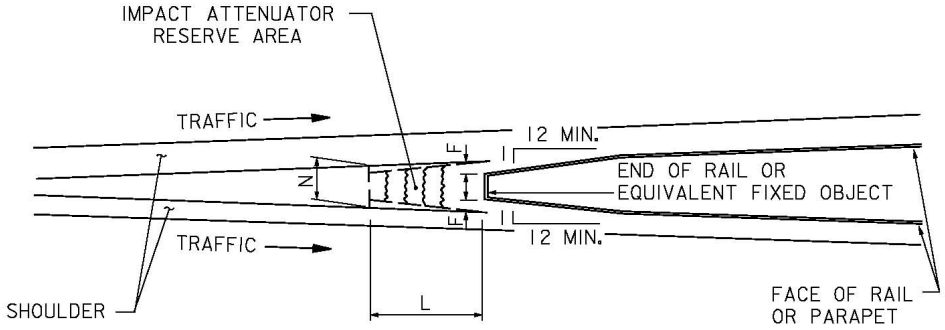
   a. Minimum:
   Restricted Conditions - These dimensions approximately describe the space required for installation of the current systems without encroachment on shoulders and the nose of the device offset slightly back of the parapet or shoulder line.

   Unrestricted Conditions - These dimensions should be considered as the minimum for all projects where plan development is not far advanced except for those sites where it can be shown that the increased cost for accommodating these dimensions, as opposed to those for Restricted Conditions, will be unreasonable. For example, if the use of the greater dimensions would require a considerable

increase in construction or property acquisition costs, then the lesser dimensions might be considered.

b. Preferred:
These dimensions, which are considerably greater than required for the present generation of attenuators, should also be considered optimum. There is no intention to imply that if a space is provided in accordance with these dimensions that the space will be fully occupied by an attenuator. The reason for proposing these dimensions is so that, if experience shows that attenuators should be designed for greater ranges of vehicle weights and/or for lower deceleration forces, there will be space available for installation of such attenuators in the future. In the meantime, the unoccupied reserved attenuator space will provide valuable additional recovery area.

EXHIBIT 3 - 16
ATTENUATOR RESERVE AREA



DESIGN SPEED ON MAINLINE (M.P.H.)	DIMENSIONS FOR ATTENUATOR RESERVE AREA ON NEW CONSTRUCTION (FEET)								
	MINIMUM						PREFERRED		
	RESTRICTED CONDITIONS			UNRESTRICTED CONDITIONS					
	N	L	F	N	L	F	N	L	F
30	6	8	2	8	11	3	12	17	4
50	6	17	2	8	25	3	12	33	4
70	6	28	2	8	45	3	12	55	4

NOTE:
FOR INTERMEDIATE DESIGN SPEEDS, USE VALUES FOR THE HIGHER DESIGN SPEED (I.E. FOR DESIGN SPEED OF 40 M.P.H. USE VALUES FOR 50 M.P.H. DESIGN SPEED).

3.3.4 Geometrics of the Site

The vertical and horizontal alignments, especially curvature of the road and sight distance, are important factors to be considered. Adverse geometrics could contribute to a higher than normal frequency of impacts.

3.3.5 Physical Conditions of the Site

The presence of a curb can seriously reduce the effectiveness of an attenuator. It is recommended that all curbs and islands be removed approximately 50 feet in front of an attenuator and as far back as the unit's backup. New curbs should not be built where attenuators are to be installed. It is not essential to remove existing curbs less than 4 inches in height, but it is recommended. Curbs from 4 inches to 6 inches in height should be removed unless consideration of the curb shape, site geometry, impending overlays that would reduce the curb height, and cost of removal indicates the appropriateness of allowing the curb to remain. Curbs over 6 inches high should be removed before installing an attenuator. When a curb is terminated behind an attenuator, the curb should be gently flared and/or ramped. Flares of 15:1 and ramps of 20:1 are recommended.

All attenuators should be placed on a concrete or asphalt surface as required by the manufacturer.

It is recommended that attenuators be placed on a relatively flat surface. Longitudinal and transverse slopes in excess of 5 percent could adversely affect the performance of an attenuator and should be avoided. If the cross slope varies more than 2 percent over the length of the unit, compensating alterations may have to be made at the site.

Joints, especially expansion joints, in the attenuator area may require special design accommodations for those attenuators that require anchorage.

3.3.6 Redirection Characteristics

Consider the redirection capabilities of each type of attenuator.

3.3.7 Maximum Impact Speed

Consider whether each type of attenuator can be designed for any reasonable speed.

3.3.8 Allowable Deceleration Force

Where practical, attenuators should be designed for a deceleration force of 6G's. Where space is limited, an attenuator may be designed for a maximum of 8G's.

3.3.9 Backup Structure Requirements

Consider whether each type of attenuator requires a backup structure that is capable of withstanding the forces of an impact.

3.3.10 Anchorage Requirements

Consider whether each type of attenuator requires an anchorage, which is capable of restraining the attenuator during an impact.

3.3.11 Maintenance

Consider which parts of each attenuator are typically reusable and which parts are not after a collision.

REFERENCE

Roadside Design Guide, AASHTO