SECTION PAGE

SECTION 8

GUIDELINES FOR GUIDE RAIL DESIGN AND MEDIAN BARRIERS

8-01 INTRODUCTION

These guidelines are based on the *Roadside Design Guide, AASHTO, 1996.*

The information in this section is intended to serve as guidelines that will assist the designer in determining conditions that warrant the installation of guide rail and the dimensional characteristics of the installations. Also, this section contains information to serve as guidelines to assist the designer in determining conditions that warrant the installation of a median barrier.

It is important that application of these guidelines be made in conjunction with engineering judgment and thorough evaluation of site conditions to arrive at a proper solution.

It should be emphasized that guide rail should not be installed indiscriminately. Every effort should be made to eliminate the obstruction for which the guide rail is being considered.

In some cases, another type of traffic barrier may be more effective than guide rail. For example, obstructions in gores can often be more effectively shielded with a crash cushion. The designer should consider such alternatives and choose the most suitable solution based on safety requirements, economic limitations, maintenance, and aesthetic considerations.

8-02 GUIDE RAIL WARRANTS

8-02.1 General

Guide rail is considered a longitudinal barrier whose primary functions are to prevent penetration and to safely redirect an errant vehicle away from a roadside or median obstruction.

8-02.2 How Warrants are Determined

An obstruction's physical characteristics and its location within the clear zone are the basic factors to be considered in determining if guide rail is warranted.

Although some wide ranges of roadside conditions are covered below, special cases will arise for which there is no clear choice about whether or not guide rail is warranted. Such cases must be evaluated on an individual basis, and, in the final analysis must usually be solved by engineering judgment. In the absence of

pertinent criteria, a cost-effective analysis could be used to evaluate guide rail needs.

8-02.3 Clear Zone

Clear zone is defined as the area, starting at the edge of the traveled way, that is available for safe use by errant vehicles.

The width of the clear zone (L_c) varies with the speed, roadside slope and horizontal roadway alignment. The design speed should be used when determining the clear zone. Use "Table 2-1 Design Speed vs. Posted Speed" to determine the design speed.

Figure 8-A contains the suggested range of clear zone distances on tangent sections of roadway based on selected traffic volumes, speed and roadside slopes. Clear zones may be limited to 9 m for practicality and to provide a consistent roadway section if previous experience with similar projects or designs indicates satisfactory performance. According to the *Roadside Design Guide, AASHTO, 1996*, the designer may provide clear zone distances greater than 9 m as indicated in Figure 8-A, where such occurrences are indicated by accident history.

Figure 8-B contains examples of determining clear zone distances. More examples and further explanation are contained in the *Roadside Design Guide, AASHTO, 1996.*

Horizontal alignment does affect the clear zone width. Therefore, clear zone widths on the outside of horizontal curves should be adjusted as shown in Figure 8-C.

8-02.4 Warrants

A warranting obstruction is defined as a non-traversable roadside or a fixed object located within the clear zone and whose physical characteristics are such that injuries resulting from an impact with the obstruction would probably be more severe than injuries resulting from an impact with guide rail.

1. Non-traversable Roadside

   Examples of a non-traversable roadside that may warrant guide rail are: rough rock cuts, large boulders, streams or permanent bodies of water more than 600 mm in depth, roadside channels with slopes steeper than 1:1 and depths greater than 600 mm, embankment slopes and slopes in cut sections as described in the following.

a. Embankment (Fill) Slopes

A critical slope is one in which a vehicle is likely to overturn. Slopes steeper than 1:3 generally fall into this category. If a slope steeper than 1:3 begins closer to the traveled way than the suggested clear zone distance, guide rail might be warranted if it is not practical to flatten the slope. Guide rail warrants for critical slopes are shown in Table 8-1.

Table 8-1
Critical Slope Warrants

Critical Embankment (fill) Slopes	Maximum Height Without Guide Rail
1:1½	1.0 m
1:2	1.8 m
1:2½	2.7 m

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 1:3 and 1:4 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 Figure 8-B for an example. The designer should, therefore, evaluate each site before providing 1:3 slopes without guide rail.

When flattening existing slopes to remove guide rail, the proposed side slopes should be recoverable, that is, 1:4 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. Rounding should be provided at slope breaks; see Figures 5-C, 5-H and 5-I.

b. 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, trees, rocks, etc. that may cause excessive vehicle snagging rather than permit relatively smooth redirection.

Slopes in cut section of 1:2 or flatter may be considered traversable; and, as the cut slope steepens, the chance of rollover increases. Where feasible, slopes steeper than 1:2 should be flattened. If there is a warranting obstruction on the cut slope, the following apply:

(1) Guide rail should be installed if the warranting obstruction is on a slope flatter than 1:0.7 and is within the clear zone width specified in Section 8-02.3

(2) Guide rail should be installed if the warranting obstruction is on a slope of 1:0.7 or steeper and is less than 1.8 m (measured along the slope) from the toe of the slope and is within the clear zone width specified in Section 8-02.3.

(3) Guide rail is not required if the warranting obstruction is on a slope of 1:0.7 or steeper and is 1.8 m or more (measured along the slope) from the toe of the slope.

c. Drainage Features

Channels should be designed to be traversable. Where feasible, existing channels should be reconstructed to be traversable.

Figures 8-R and 8-S show criteria for preferred cross sections for channels. According to the *Roadside Design Guide, AASHTO, 1996*:

> ". . .Cross sections which fall in the shaded region of each of the figures are considered to have traversable cross sections. Channel sections which fall outside the shaded region are considered less desirable and their use should be limited where high-angle encroachments can be expected, such as the outside of relatively sharp curves. Channel sections outside the shaded region may be acceptable for projects having one or more of the following characteristics: restrictive right-of-way; rugged terrain; resurfacing, restoration, or rehabilitation (RRR) construction projects; or on low-volume or low-speed roads and streets, particularly if the channel bottom and backslopes are free of any fixed objects.
>
> If practical, roadside channels with cross sections outside the shaded regions and located in vulnerable areas may be reshaped and converted to a closed system (culvert or pipe), or in some cases, shielded by a traffic barrier. . ."

2. Fixed Objects

Examples of fixed objects that may warrant guide rail are: overhead sign supports, traffic signals and luminaires supports of non-breakaway design, concrete pedestals extending more than 100 mm above the ground, bridge piers, abutments and ends of parapets and railings, wood poles or posts with a cross sectional area greater than 0.032 m^2 and drainage structures.

In no case shall breakaway, bendaway or non-breakaway design supports, highway lighting, trees, utility poles, fire hydrants, mailboxes and signs on new or upgraded guide rail installations remain in front of guide rail.

Overhead sign supports should be located as close to right-of-way line as practical. Guide rail protection for all overhead sign supports should be provided regardless of location beyond the clear zone. This will limit severe implications resulting from impacts to the sign support.

a. Trees

Trees, 150 mm in diameter, are considered fixed objects. However, trees are not considered a warranting obstruction for guide rail since guide rail is not installed solely for shielding trees. The following guidance is provided for the treatment of trees within the clear zone:

(1) On freeways and interstate routes, trees shall not be located within the clear zone.

(2) Although it is desirable to provide a clear zone free of trees on land service roads, it is likely that situations will be encountered where removal of trees within the clear zone cannot be accomplished. For instance, the aesthetic appeal of the trees may cause local opposition to their removal, the trees may not be within the right-of-way, or removal of the trees may not be environmentally acceptable.

In some cases it may be appropriate to plant replacement trees outside the clear zone so that the removal of trees in close proximity to the roadway may be accomplished without severe public criticism.

Factors such as accident experience, traffic volume, speed, clearance from the traveled way and roadway geometry should be evaluated when determining whether it is appropriate to leave trees within the clear zone.

Sick and diseased trees that are beyond reasonable repair, along with dead trees, trees that cause sight distance problems

and trees with a significant accident history shall be removed regardless of public criticism. Also, trees that will be harmed beyond reasonable repair due to construction shall be removed (i.e. new curb that destroys the main root system). The Bureau of Landscape and Urban Design should be consulted for the tree's physical assessment.

Trees that have grown behind guide rail, which is less than 1.2 m from the back of the rail element, shall be removed regardless of size. Trees, shrubs and overhanging branches shall be removed where they block or obscure horizontal sight distance whether they are behind guide rail or not. As a minimum, branches overhanging the roadway shall be removed up to a height of 5 m. The following areas should be checked for sight distance problems:

(1) Along the inside of horizontal curves (mainline, ramps and jughandles)

(2) Ramp and jughandle entrances and exits.

(3) Within the sight triangle at intersections.

(4) Sign obstructions.

If clearing work is necessary within existing utility lines, the designer should request the utility company to perform regular trimming maintenance (at their cost) in the locations during the utility notification process. However, if clearing work is necessary where poles are to be relocated, then the utility company or the contractor shall be compensated for this work.

b. Utility Poles

Although utility poles have a cross-sectional area greater than 0.032 m^2 (200 mm diameter.), they should not be handled the same as other warranting obstructions. It is questionable whether a safer roadside would result from installing guide rail for the sole purpose of shielding utility poles within the clear zone. Utility poles shall be located as close to the right-of-way line as practical. For the offset to the utility pole from the traveled way, the designer should refer to the current *Utility Accommodation Regulation (NJAC 16:25)*. For a quick and easy reference refer to the *NJDOT Design Criteria for Above Ground Utilities* dated January 26, 1995.

Desirably on projects where new right-of-way is to be purchased, sufficient right-of-way should be acquired to permit the placement of the poles beyond the clear zone.

On existing highways, where the utility pole offset does not meet the Department standards (*Utility Accommodation Regulation (NJAC 16:25)*), the designer should prepare an accident analysis of existing pole locations to determine if the relocation of the utility poles further from the edge of a through lane is warranted. Any utility pole that has been struck three times or more within three years, will require corrective action. Also, neighboring poles that have been struck a total of three or more times within three years will require corrective action. If corrective action is necessary, safety measures such as utility pole relocation and/or the improvement of the contributing roadway feature should be considered instead of guide rail.

Utility poles should not be placed in vulnerable locations, such as in gore areas, small islands or on the outside of sharp horizontal curves. For the purpose of these guidelines, a sharp horizontal curve is considered as any horizontal curve with a safe speed less than the posted speed.

In no case, shall utility poles on new or upgraded guide rail installations remain in front of the guide rail. The guide rail offset has preference to existing utility pole offsets where there is sufficient right-of-way. Therefore, where practical, do not place the guide rail closer to the road, instead, relocate the pole behind the guide rail. Guide rail is an obstruction in itself and should be placed as far from the traveled way as possible.

Where utility poles are placed behind guide rail, desirably the face of the pole should be 1.2 m or greater from the back of the rail. Where the offset is less than 1.2 m, provide reduced post spacing and double rail element as per the *Standard Roadway Construction Details.* However as a minimum, the face of the pole shall be no closer than 300 mm from the back of the rail.

It should be noted that spacing of guide rail posts at long runs of guide rail or at bridge installations may conflict with the spacing of the utility poles. In this case when a pole will be located directly behind a post, the minimum pole offset should be no closer than 450 mm from the back of the rail, which equals 150 mm from the back of the post.

Utility poles should not be located within the 11.43 m parabolic flare of a slotted guide rail terminal and within the 15.24 m length of an extruder terminal, see Figure 8-D. Also, utility poles should be at least 7.5 m or greater in advance of a slotted guide rail terminal or an extruder terminal.

c. Fire Hydrants

Since fire hydrants do not meet the current AASHTO definition for breakaway design, they fall into the category of fixed objects that may warrant guide rail. The same reasoning applies here as was applicable to utility poles.

The acceptable solution is to locate the hydrants as far from the traveled way as possible. In no case shall fire hydrants be located in front of the guide rail. However, the hydrants must be located to be readily accessible at all times.

Where guide rail is required for some other reason and will be in front of a hydrant, the preferred treatment is to raise the hydrant to permit connection to be made over the guide rail. Usually, the connection may be a maximum of 900 mm above grade. It is the responsibility of the designer to confirm with the local Fire Department that such a treatment is acceptable. A less desirable treatment is to provide a short opening in the guide rail at the hydrant. Where an opening is provided, slotted guide rail terminals or an anchorage must be provided in accordance with Section 8-03.2. The guide rail must be modified as per Section 8-03.1.3 when the offset to the hydrant face from the back of a rail element is less than 1.22 m.

d. Mailbox Supports

Limited accident data has shown that mailbox supports can contribute to the severity of an accident. The following guidelines should be followed on new construction, reconstruction and projects that involve resurfacing:

No more than two mailboxes may be mounted on a single support structure unless the support structure and mailbox arrangement have been shown to be safe by crash testing. Lightweight newspaper boxes may be mounted below the mailbox on the side of the mailbox support.

Mailbox supports shall not be set in concrete unless the support design has been shown to be safe by crash tests when so installed, see cantilever mailbox design in the *Standard Roadway Construction Details.*

A single 100 by 100 mm wooden post or a 100 mm diameter wooden post or a metal post with a strength no greater than a 50 mm diameter, standard strength, steel pipe and embedded no more than 600 mm into the ground will be acceptable as a mailbox support, see the *Standard Roadway Construction Details*. A metal post shall not

be fitted with an anchor plate, but it may have an anti-twist device that extends no more than 250 mm below the ground surface.

In areas where snow removal is a problem or the mailbox is placed behind guide rail, a cantilever mailbox-type support as shown in the *Standard Roadway Construction Details* may be permitted to allow snow plows to sweep under or near mailboxes without damage to their supports.

The post-to-box attachment details should be of sufficient strength to prevent the box from separating from the post top if the installation is struck by a vehicle. The *Standard Roadway Construction Details* show acceptable attachment details.

The minimum spacing between the centers of support posts shall be 75 percent of the height of the posts above the ground line.

For more information on mail stop design and mailbox location, see *A Guide for Erecting Mailboxes on Highways, AASHTO, May 24, 1984.*

3. Pedestrians

Guide rail may be used where there is a reasonable possibility of an errant vehicle encroaching into an unprotected area used by pedestrians. Some examples are where a playground, school yard, or a public beach is adjacent to the right-of-way line. The basis for assessing the needs should be the accident experience of the immediate area and the specifics for the cause(s) of the accidents. There may be times when no causative factor can be isolated, and sound engineering judgment must be applied.

This policy is not intended to indiscriminately permit the installation of guide rail at every location where a request for guide rail has been received, but to offer some flexibility to the designer when unique circumstances occur.

There are locations where existing guide rail and the PVI (top of the slope) of a steep slope are both located directly behind a pedestrian sidewalk area. If new guide rail is installed in front of the sidewalk area, the existing guide rail should either be left in place or the existing guide rail should be removed and a fence installed in its place. When guide rail is placed between the roadway and the sidewalk, a rail element may be attached to the back of the guide rail post so that pedestrians are shielded from the exposed back of post. The rail element, if added, shall not be located within the 11.43 m parabolic flare of a slotted guide rail terminal or within the 15.24 m of an extruder terminal.

8-03 DIMENSIONAL CHARACTERISTICS

8-03.1 Clearance From the Traveled Way

1. Without Curb or Raised Berm in Front of Guide Rail

A highly desirable characteristic of any roadway is a uniform clearance from the traveled way to the guide rail. It is desirable to place the guide rail at a distance beyond which it will not be perceived as a threat by the driver, see Figure 8-E, Table-1: Shy Line Offset. 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. On interstate highways and freeways, the front face of the guide rail should desirably be 1.2 m or more from the outside edge of shoulder. Where this offset is not possible, the guide rail should be installed flush with the gutter line.

c. On land service highways where there is a sidewalk or a sidewalk area used by pedestrians, the front face of the guide rail should desirably be 2.1 m or more from the outside edge of shoulder. Where this offset is not possible, the guide rail should be installed flush with the gutter line.

On land service highways where there is no sidewalk and the border area is not used by pedestrians, the front face of the guide rail may be placed any distance from the gutter line; however, an offset of 1.2 m or more is preferred.

Where providing an offset of 2.1 m or more, the designer is advised that additional right-of-way or slope easements may be necessary to construct the parabolic flare offset and/or provide the 1.8 m flat area (1:10 minimum slope) adjacent to a slotted guide rail terminal as shown in Figure 8-D. If the purchase of additional right-of-way is infeasible, an extruder terminal should be provided at an offset of 2.1 m or more, instead of a slotted guide rail terminal. If this is still infeasible, then the guide rail should be installed flush with the gutter line to permit the construction of a slotted guided rail terminal with the parabolic flare offset and flat area.

d. Where guide rail is located at the top of an embankment slope, the posts should be a minimum of 600 mm from the PVI to the center of the post.

When less than 600 mm is provided, the following post lengths, shown in Table 8-2 below, should be used:

Table 8-2
Additional Post Length Requirements Where
Distance From PVI to Center of Post is Less Than 600 mm

Embankment Slopes	Additional Post Length
Flatter Than 1:6	No Change
1:6 to 1:4	0.3 m
1:3 to 1:2	0.7 m
Steeper Than 1:2	1.3 m

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

f. Figure 8-D illustrates the slope treatment for embankment slopes at a slotted guide rail terminal.

2. Curb or Raised Berm in Front of Guide Rail

Curb or a raised berm in front of guide rail should be avoided, see Section 5-06, "Curbs", for the type and location of curb.

On freeways and Interstate highways, new installations of vertical curb shall not be constructed. However, sloping curb may be constructed on urban freeways and urban Interstate highways but the overall curb height shall not exceed 100 mm. On land service highways, a design without curb or raised berm in front of guide rail should be provided where possible.

On projects that involve upgrading existing roadways, where there is a curb or a raised berm in front of guide rail, removal or modification of the curb or raised berm should be the first consideration. If a raised berm in front of the guide rail cannot be removed, it shall be regraded at 1:10. Where curb in front of guide rail cannot be removed, 23 m of curb in advance of and 15.24 m beyond the front of a slotted guide rail terminal or an extruder terminal shall be no greater than 100 mm.

If curb (vertical and/or sloping curb) is present and cannot be removed, the following apply (along with Section 8-03.1: 1d, e and f):

a. Highways With a Posted Speed of More than 40 MPH:

On freeways and interstate highways where sufficient roadside width is available, guide rail should be placed 3 m or more behind the gutter line. On land service roadways where there is a sidewalk or sidewalk area used by pedestrians, guide rail should be placed at 2.1 m or more behind the gutter line. Where the above offsets are not possible, the guide rail should be installed flush with the gutter line and rub rail installed in accordance with Section 8-03.1: 2c, "Rub Rail".

Where providing an offset of 2.1 m or more, the designer is advised that additional right-of-way or slope easements may be necessary to construct the parabolic flare offset and/or provide the 1.8 m flat area (1:10 minimum slope) adjacent to a slotted guide rail terminal as shown in Figure 8-D. If the purchase of additional right-of-way is infeasible, an extruder terminal should be provided at an offset of 2.1 m or more, instead of a slotted guide rail terminal. If this is still infeasible, then the guide rail should be installed flush with the gutter line to permit the construction of the slotted guide rail terminal with the parabolic flare offset and flat area.

b. On Roadways With a Posted Speed of 40 MPH or Less:

Guide rail may be placed any distance behind the gutter line. Usually an offset of 1.2 m or more (freeway or Interstate ramps), or 2.1 m or more (land service roadways) should be used.

Where the 1.2 m or more and 2.1 m or more offsets are not possible, the guide rail should be installed in accordance with the previous discussion on parabolic flare offset and flat area (use 1.2 m or more instead of 2.1 m or more when addressing freeway or interstate ramps).

c. Rub Rail

When guide rail is constructed less than 900 mm from a curb (vertical and/or sloping curb) or raised berm that is 100 mm or greater in overall height, the mounting height is measured from the top of the curb or raised berm and rub rail is required. Where guide rail is set flush to the gutter line and goes across short sections (i.e. less than 30 m long at each location) of the curb, 100 mm 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, removing or revising earth berms, 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 it is more important that the guide rail 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 1.2 m or greater, see *Standard Roadway Construction Details* CD-612-8.3. If less than 1.2 m must be used, the guide rail system must be modified (See CD-612-8.1, 8.2 and 8.6).

4. On Bridges

a. Safetywalks range in width from 460 mm to less than 1.2 m. On existing freeway and interstate structures with safetywalks where it is not feasible to remove and provide a concrete, barrier-shaped parapet, the guide rail shall be carried across the structure along the gutter line. However, on existing freeway and Interstate ramps where the posted speed or advisory speed is 40 mph or less and the safetywalk are 760 mm or less in width, it is not necessary to carry guide rail across the structure since vaulting is not likely to occur. In this case, guide rail should only be provided across the structure if the parapet is not crashworthy.

b. When the roadway approaching a structure has curbs or berms, the guide rail mounting height on the structure should be measured from the top of curb and rub rail is required. However, on long structures the guide rail mounting height may be measured from the gutter line provided the face of guide rail is flush with the curb face. In this case rub rail will not be required.

The guide rail mounting height should be measured from the gutter line on those structures where the approach roadway is an umbrella section and the face of guide rail is set flush with the curb face on the structure.

Where guide rail is set flush with the curb face and the mounting height is measured from the gutter line, rub rail is not required.

c. 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.

d. Attachment of guide rail to bridges and structures shall be in accordance with the Department's *Standard Roadway Construction Details*, revised or modified Standard Details or Special Details.

e. Where there is considerable pedestrian traffic, the guide rail may be set flush to the curb face to physically separate pedestrians from vehicular traffic if feasible (see Section 8-02.4.3).

8-03.2 End Treatments

1. Slotted Guide Rail Terminals (SRT)

a. Slotted 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 Section 8-03.2.2, 8-03.2.3, 8-03.2.4 or 8-03.2.5. Also, if the approach end of guide rail for opposing traffic is within the clear zone, a slotted guide rail terminal shall be used (see Figure 8-H).

An 11.43 m parabolic flare shall be used with all slotted guide rail terminal end treatments. This parabolic flare provides for a flare offset of 1.22 m, see *Standard Roadway Construction Details*. A slotted guide rail terminal shall be placed a minimum distance of 3.81 m beyond the length of need.

b. A slotted guide rail terminal shall not be installed behind a curb greater than 100 mm in height. Where there is an existing curb or proposed curb greater than 100 mm in height, 23 m of the curb immediately in advance of and 15.2 m beyond the front of a slotted guide rail terminal shall be removed and replaced with 225 by 400 mm (100 mm face) white concrete vertical curb.

c. A clear area shall be provided behind a slotted guide rail terminal installation. The desired clear area is shown crosshatched on Figure 8-D. Slopes in front of guide rail and 1.8 m behind the slotted guide rail terminal shall be graded at 1:10 or flatter, see Figure 8-D.

d. Rub rail, reduced post spacing, and double rail elements shall not be used within the 11.43 m parabolic flare of a slotted guide rail terminal.

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

2. Extruder Terminals

   a. At locations where it is not possible to construct a slotted guide rail terminal with 1.22 m of parabolic flare offset, an extruder terminal should be used. The extruder terminal is 15.24 m long and is erected parallel to the roadway without needing a parabolic flare to function properly. The extruder terminal shall be placed a minimum distance of 3.81 m beyond the length of need.

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

   c. Where an extruder terminal is installed along a horizontal curve, the extruder 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 slotted guide rail terminal in 1.b. above are applicable to an extruder terminal. An extruder terminal shall have a clear area 1.8 m behind an extruder terminal for its entire length of 15.24 m.

   e. Rub rail, reduced post spacing, and double rail elements shall not be used within 15.24 m from the end of an extruder terminal.

3. Beam Guide Rail Anchorages

   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 *Standard Roadway Construction Details* CD-612-4.2.

   b. In cut sections, the approach ends of guide rail installations should be anchored with a beam guide rail in-line anchorage and buried in the slope as shown in Figure 8-K and in the *Standard Roadway Construction Details* CD-612-4.1 and CD-612-8.4. A straight flare should be used where the guide rail is buried in a cut slope. Table-1 of Figure 8-E shows the straight flare rate allowable for various speeds.

   c. 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 Roadway Construction Details* CD-612-4.2. One example would be where the approach end of a guide rail installation for opposing traffic is outside the clear zone, see Figure 8-H, Step 1.

4. Telescoping Guide Rail End Terminals

   a. A telescoping guide rail end terminal shall be used when terminating dual face beam guide rail within a grass median, see Figure 8-I.

   b. A telescoping guide rail end terminal shall be installed on relatively flat surfaces (8 percent or flatter slope). Use on raised islands or behind curbs is not recommended.

      All curbs, islands, or elevated objects (delineators, signs) present at the telescoping guide rail end terminal site and over 50 mm high should be removed. Curbs greater than 50 mm high should be removed a minimum of 23 m in front of the telescoping guide rail end terminal system and as far back as the rear of the system, and replaced with 50 mm high curb.

      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.

   c. The telescoping guide rail end terminals are 9.525 m long (measured from the centerline of first post to the centerline of sixth post) or 9.601 m long (measured from the centerline of anchor assembly to the centerline of sixth post). A tail end attachment to dual face beam guide rail is also required which is an additional 3.81 m.

   d. There are two end terminals permitted for use as a telescoping guide rail end terminal. Both the Crash Cushion Attenuating Terminal (C.A.T.) and Brakemaster are permitted when this item is required.

5. Controlled Release Terminals (CRT)

   a. If a raised berm in front of a CRT cannot be removed, it shall be regraded at 1:10. Where curb in front of the CRT cannot be removed, curb shall be no greater than 50 mm.

   b. A clear area free of any obstructions and graded to 1:10 or flatter shall be provided behind the CRT. See Figure 8-M for the required clear area dimensions.

6. Existing Breakaway Cable Terminals (BCT) and Eccentric Loader Terminals (ELT)

   An existing BCT or ELT shall be replaced with the end treatments discussed in Section 8-03.2 at the following locations:

   a. A BCT or an ELT that must be replaced due to accident damage shall be upgraded with an end treatment other than a BCT or an ELT.

b. Any BCT or ELT installed within the clear zone without an 11.43 m parabolic flare (1.22 m offset) shall be replaced in conjunction with regularly scheduled roadway work in the same area.

Where a BCT or an ELT require replacement in 'a.' and 'b.' above, upgrade the entire run of guide rail that the BCT or ELT is attached.

8-03.3 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

   The approach L.O.N. on the embankment (fill) slopes should be determined in accordance with Figures 8-E and 8-F. On a two-way, undivided highway or on a divided highway with a narrow traversable median, an "approach end" treatment may be required for both directions of traffic; see Figure 8-H to determine the approach L.O.N. for opposing traffic on the embankment (fill) slopes.

   The guide rail treatment for critical embankment slopes is shown in Figure 8-G.

   Figure 8-I 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 Figure 8-J for an example of determining L.O.N. in a cut section. Also, see Figure 8-K to determine the length required beyond the toe of the slope to bury the guide rail.

3. At Driveways

   If the existing driveway falls outside the L.O.N., design guide rail as shown in Figure 8-E.

   Where existing driveways are located within the L.O.N., the designer's first consideration should be to relocate the driveway as far away from the warranting obstruction as the property line allows. If the relocated driveway falls outside the L.O.N., design guide rail as shown in Figure 8-E.

   If a driveway cannot be relocated beyond the L.O.N., use treatments shown in Figures 8-L or 8-M. The CRT shown in Figure 8-M is the preferred design. Where the minimum functional length of a slotted guide rail terminal in Figure 8-L is longer than the space available from the obstruction to the driveway or the right-of-way purchase is impractical for the CRT in Figure 8-M, consideration should be given to using a QuadGuard system.

Driveway openings sometimes fall within a continuous guide rail run. An example of a guide rail treatment at this location is shown in Figure 8-N.

4. 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. Figures 8-O and 8-P provide guide rail treatment examples for gore areas, starting from fewer restricted or open gore areas in Figure 8-O to more restricted or limited gore areas in Figure 8-P.

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

8-03.4 Guide Rail Details

The dimensions and other characteristics of beam guide rail posts, rail elements, fasteners, etc. are shown in the *Standard Roadway Construction Details*.

8-03.5 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 60 m 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 *Standard Roadway Construction Details* CD-612-7.4. Guide rail between parapets is not required if there is a concrete connecting wall 685 mm 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 of the Bureau of Quality Management Services.

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

The grading work necessary for the construction of the guide rail end treatments shall be shown on the construction plans. The grading shall conform to the *Standard Roadway Construction Details*.

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. Nonvegetative Surface Under Guide Rail

In order to reduce soil erosion and highway maintenance costs associated with spraying or trimming vegetation underneath guide rail, nonvegetative surfaces shall be applied underneath guide rail as follows:

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

The nonvegetative surface shall be constructed as shown in *Standard Roadway Construction Details* CD-814-1.

8-04 MEDIAN BARRIER

A median barrier is a longitudinal system used to prevent an errant vehicle from crossing that portion of a divided highway separating traveled ways for traffic in opposite directions.

8-04.1 Warrants for Median Barriers

1. Interstate and Freeways

Figure 8-Q presents the warrants for median barriers on high speed, access-controlled highways with traversable slopes 1:10 or flatter.

At low ADT's, the probability of a vehicle crossing the median is relatively small. Thus, for ADT's less than 20,000 and median widths within the optional areas of Figure 8-Q, a median barrier is warranted only if there has been a history of cross-median accidents. Likewise, for relatively wide medians the probability of a vehicle crossing the median is also low. Thus, for median widths greater than 10 m and within the optional area of the figure, a median barrier may or may not be warranted, again depending on the cross-median accident history. Flat medians that are wider than 15 m do not warrant a barrier unless there is a significant history of across-the-median accidents.

2. Land Service Highways

Careful consideration should be given to the installation of median barriers on land service highways or other highways with partial control of access. Problems are created at each intersection or median crossover because the median barrier must be terminated at these points.

An evaluation of the number of crossovers, accident history, alignment, sight distance, design speed, traffic volume and median width should be made before installation of median barriers on land service highways. Each location should be looked at on a case-by-case basis with the prevailing reason for its installation being the number of crossover accidents.

3. Median Barrier Type

Median barrier type, when warranted, is related to median width as shown in Table 8-3.

Table 8-3
Median Width vs. Median Barrier Type

Median Width	Median Barrier Type
Up to 3.6 m:	Concrete Barrier Curb
3.6 to 8 m:	Concrete Barrier Curb (Preferred Treatment) or Dual Face Beam Guide Rail
Above 8 m:	Dual Face Beam Guide Rail

Where barrier curb is used to shield an obstruction (bridge piers, abutments, sign bridges, etc.), a minimum offset of 990 mm from the gutter line to the face of the obstruction shall be used, since high profile vehicles have a tendency to lean when impacting barrier curb at a high speed (60 mph or greater) and angle (25 degrees) and may strike the obstruction behind it, see Figure 5-K.

4. End Treatments

When terminating the approach end of dual face, beam guide rail beyond the clear zone, an end anchorage with end section (buffer) is required as shown in the *Standard Roadway Construction Details* CD-612-2. When terminating the approach end of a concrete barrier curb beyond the clear zone, a tapered concrete terminal section is required as shown in the *Standard Roadway Construction Details* CD-605-3.5.

Where a median barrier terminates within the clear zone area on freeways and Interstate highways, a crashworthy end treatment shall be used. Acceptable methods of developing a crashworthy end treatment would be to use a crash cushion such as a QuadGuard system with concrete barrier curb; or use a telescoping guide rail end terminal with dual face beam guide rail.

In the past, on land service highways, tapered concrete terminal sections have been provided where the concrete barrier curb terminated at an intersection. Since pavement edge markings are not generally provided through intersections, there is no visual reference for the guidance of the driver through the intersection during adverse weather and visibility conditions. Therefore, at existing concrete barrier curb locations, a crashworthy end treatment may be appropriate on the concrete barrier curb end located on the outside of a horizontal curve with a radius of approximately 305 m or less. A dotted line may be used to extend markings as necessary through the intersection to guide vehicles making left-turn moves from the cross street or to guide vehicles in the high speed through lanes.

On land service highways where the posted speed exceeds 40 mph, all concrete barrier curb that terminates within the clear zone on any roadway segment shall have the exposed concrete barrier curb end protected by a crash cushion at:

a. New locations of the concrete barrier curb.

b. New locations of the concrete barrier curb that are being installed to replace substandard height barrier curb.

c. Existing locations of the concrete barrier curb on a reconstruction project.

d. A new, relocated or widened opening in existing barrier curb for emergency "U" turns, pedestrian crossings, jughandles or intersections.

The introduction of new or existing median concrete barrier curb within the clear zone other than at intersections shall be protected with a crash cushion regardless of the posted speed.

See Figure 6-P for treatment of the concrete barrier curb at median openings.

On December 22, 1993, the Federal Highway Administration has taken the position that any project that includes existing or proposed tapered concrete terminal section within the clear zone, on any roadway segment where the posted speed exceeds 40 mph, for the locations previously discussed, without providing the protection of a crash cushion, will make the entire project ineligible for Federal-Aid highway funds, except if proper documentation is provided in the Scope Summary. This documentation should be performed for all projects, regardless of funding.

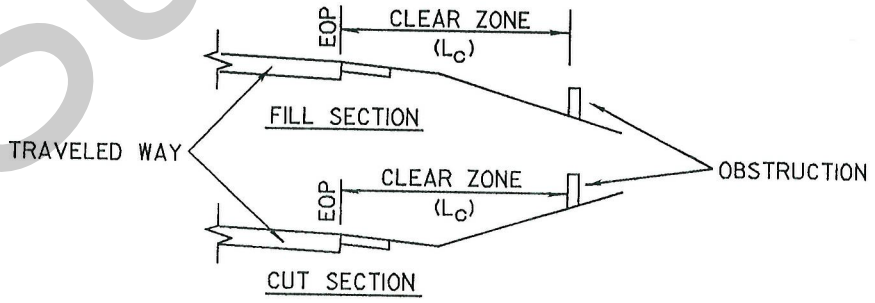
CLEAR ZONE (L_C)

FIGURE: 8-A

DATE: 05/15/98

THE FOLLOWING TABLE CONTAINS THE SUGGESTED RANGE OF CLEAR ZONE DISTANCES ON TANGENT SECTIONS OF ROADWAY BASED ON SELECTED TRAFFIC VOLUMES, SPEED AND ROADSIDE SLOPES:

DESIGN SPEED	DESIGN ADT	CLEAR ZONE DISTANCES (IN METERS FROM EDGE OF THROUGH LANE)				
		FILL SLOPES		CUT SLOPES		
		1:6 OR FLATTER	1:5 TO 1:4	1:3 OR STEEPER	1:4 TO 1:5	1:6 OR FLATTER
60 km/h OR LESS	UNDER 750	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0	2.0-3.0
	750-1500	3.0-3.5	3.5-4.5	3.0-3.5	3.0-3.5	3.0-3.5
	1500-6000	3.5-4.5	4.5-5.0	3.5-4.5	3.5-4.5	3.5-4.5
	OVER 6000	4.5-5.0	5.0-5.5	4.5-5.0	4.5-5.0	4.5-5.0
70 - 80 km/h	UNDER 750	3.0-3.5	3.5-4.5	2.5-3.0	2.5-3.0	3.0-3.5
	750-1500	4.5-5.0	5.0-6.0	3.0-3.5	3.5-4.5	4.5-5.0
	1500-6000	5.0-5.5	6.0-8.0	3.5-4.5	4.5-5.0	5.0-5.5
	OVER 6000	6.0-6.5	7.5-8.5	4.5-5.0	5.5-6.0	6.0-6.5
90 km/h	UNDER 750	3.5-4.5	4.5-5.5	2.5-3.0	3.0-3.5	3.0-3.5
	750-1500	5.0-5.5	6.0-7.5	3.0-3.5	4.5-5.0	5.0-5.5
	1500-6000	6.0-6.5	7.5-9.0	4.5-5.0	5.0-5.5	6.0-6.5
	OVER 6000	6.5-7.5	8.0-10.0	5.0-5.5	6.0-6.5	6.5-7.5
100 km/h	UNDER 750	5.0-5.5	6.0-7.5	3.0-3.5	3.5-4.5	4.5-5.0
	750-1500	6.0-7.5	8.0-10.0	3.5-4.5	5.0-5.5	6.0-6.5
	1500-6000	8.0-9.0	10.0-12.0	4.5-5.5	5.5-6.5	7.5-8.0
	OVER 6000	9.0-10.0	11.0-13.5	6.0-6.5	7.5-8.0	8.0-8.5
110 km/h	UNDER 750	5.5-6.0	6.0-8.0	3.0-3.5	4.5-5.0	4.5-4.9
	750-1500	7.5-8.0	8.5-11.0	3.5-5.0	5.5-6.0	6.0-6.5
	1500-6000	8.5-10.0	10.5-13.0	5.0-6.0	6.5-7.5	8.0-8.5
	OVER 6000	9.0-10.5	11.5-14.0	6.5-7.5	8.0-9.0	8.5-9.0



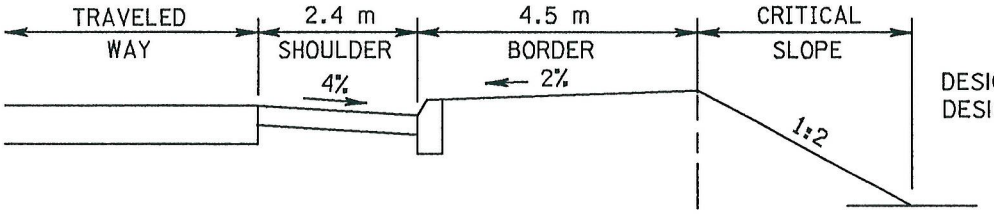
SOURCE: 'CHAPTER 3: ROADSIDE TOPOGRAPHY AND DRAINAGE FEATURES.' ROADSIDE DESIGN GUIDE. AASHTO, WASHINGTON D.C., JANUARY 1996.

i:\dotstds\rdwydesmanual\met-ic\chapter8\approved\m8a.dgn
08-MAY-1998 10:53

CLEAR ZONE EXAMPLES

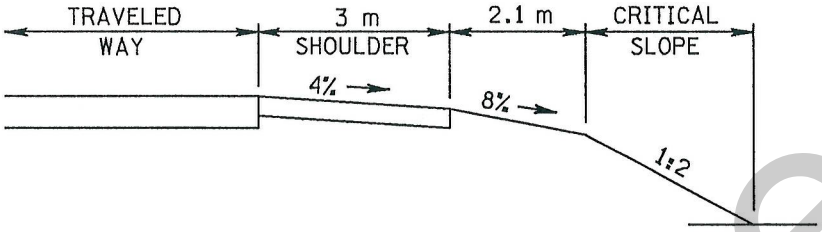
FIGURE: 8-B

DATE: 05/15/98



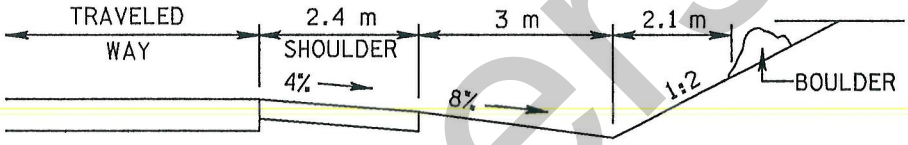
DESIGN SPEED = 80 km/h
DESIGN A.D.T. = OVER 6000

THE SUGGESTED CLEAR ZONE DISTANCE FOR THE 2% SLOPE (SEE FIGURE 8-A, CUT SLOPE, 1:6 OR FLATTER) = 6 - 6.5 m.
THE AVAILABLE 6.9 m IS 0.4 TO 0.9 m GREATER THAN THE SUGGESTED RECOVERY AREA, THEREFORE, THE CRITICAL SLOPE (1:2) IS OUTSIDE THE CLEAR ZONE.



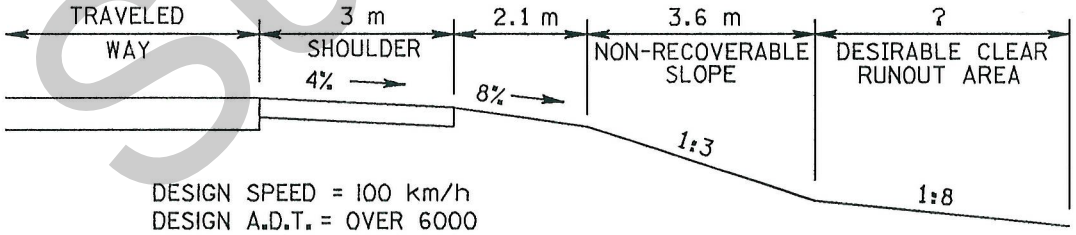
DESIGN SPEED = 100 km/h
DESIGN A.D.T. = OVER 6000

THE SUGGESTED CLEAR ZONE DISTANCE FOR THE 8% SLOPE (SEE FIGURE 8-A, FILL SLOPE, 1:6 OR FLATTER) = 9 - 10 m. THE AVAILABLE 5.1 m IS 3.9 TO 4.9 m LESS THAN THE SUGGESTED RECOVERY AREA, THEREFORE, THE CRITICAL SLOPE (1:2) IS INSIDE THE CLEAR ZONE.



DESIGN SPEED = 90 km/h
DESIGN A.D.T. = OVER 6000

THE SUGGESTED CLEAR ZONE DISTANCE FOR THE 8% SLOPE (SEE FIGURE 8-A, FILL SLOPE, 1:6 OR FLATTER) = 6.5 - 7.5 m. THE AVAILABLE 5.4 m TO THE CHANNEL IS 1.1 TO 2.1 m LESS THAN THE SUGGESTED RECOVERY AREA FOR THE FILL SLOPE. THE CHANNEL IS NOT WITHIN THE PREFERRED CROSS SECTION AREA OF FIGURE 8-R. BUT THE BOULDER HAS 7.5 M AVAILABLE WHICH IS 0 TO 1 m OUTSIDE THE CLEAR ZONE FOR THE FILL SLOPE. SINCE THE CHANNEL BOTTOM AND BACKSLOPE ARE FREE OF OBSTRUCTIONS WITHIN THE CLEAR ZONE, GUIDE RAIL IS NOT REQUIRED.



DESIGN SPEED = 100 km/h
DESIGN A.D.T. = OVER 6000

THE SUGGESTED CLEAR ZONE DISTANCE FOR THE 1:8 SLOPE IN THE CLEAR RUNOUT AREA (SEE FIGURE 8-A, FILL SLOPE 1:6 OR FLATTER) = 9 - 10 m. THE RECOVERY DISTANCE BEFORE BREAKPOINT OF NON-RECOVERABLE SLOPE = 5.1 m. THEREFORE THE DESIRABLE CLEAR RUNOUT AREA IS:

9 - 10 m MINUS 5.1 m = 3.9 TO 4.9 m.

11\dotstds\rdwydesmanual\metric\chapter8\approved\m8b.dgn
08-MAY-1998 10:53

HORIZONTAL CURVE ADJUSTMENTS FOR CLEAR ZONE

FIGURE: 8-C

DATE: 05/15/98

THE CLEAR ZONE WIDTHS OBTAINED FROM FIGURE 8-A SHOULD BE INCREASED ON THE OUTSIDE OF CURVES. THE AMOUNT OF INCREASE CAN BE DETERMINED BY THE FOLLOWING TABLE:

RADIUS (m)	Kcz (CURVE CORRECTION FACTOR) DESIGN SPEED, km/h					
	60	70	80	90	100	110
900	1.1	1.1	1.1	1.2	1.2	1.2
700	1.1	1.1	1.2	1.2	1.2	1.3
600	1.1	1.2	1.2	1.2	1.3	1.4
500	1.1	1.2	1.2	1.3	1.3	1.4
450	1.2	1.2	1.3	1.3	1.4	1.5
400	1.2	1.2	1.3	1.3	1.4	
350	1.2	1.2	1.3	1.4	1.5	
300	1.2	1.3	1.4	1.5	1.5	
250	1.3	1.3	1.4	1.5		
200	1.3	1.4	1.5			
150	1.4	1.5				
100	1.5					

$$CZc = (Lc)(Kcz)$$

CZc = CLEAR ZONE ON OUTSIDE OF HORIZONTAL CURVE, METER.
Lc = CLEAR ZONE DISTANCE FROM FIGURE 8-A, METER.
Kcz = CURVE CORRECTION FACTOR.

NOTE: CLEAR ZONE CORRECTION FACTOR IS APPLIED TO OUTSIDE OF HORIZONTAL CURVES ONLY. CURVES FLATTER THAN 900 m DO NOT REQUIRE AN ADJUSTED CLEAR ZONE. ALSO, ADJUSTMENTS ARE NOT NECESSARY FOR DESIGN SPEEDS LESS THAN 60 km/h.

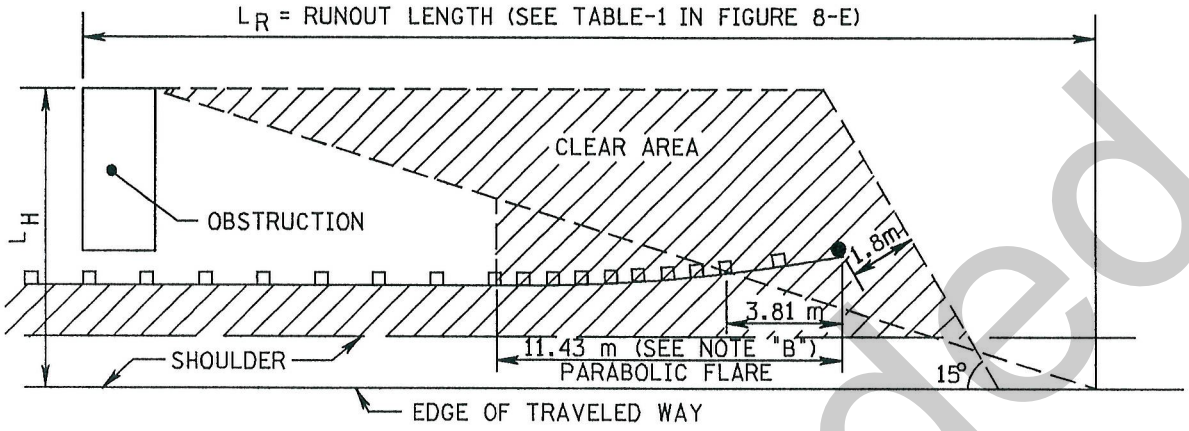
SOURCE: 'CHAPTER 3: ROADSIDE TOPOGRAPHY AND DRAINAGE FEATURES.' ROADSIDE DESIGN GUIDE. AASHTO, WASHINGTON D.C., JANUARY 1996.

u:\dotstds\rdwydesmanual\metric\chapter8\approved\m8c.dgn
08-MAY-1998 10:54

CLEAR AREA AT S.R.T. AND SLOPE TREATMENT AT S.R.T.

FIGURE: 8-D

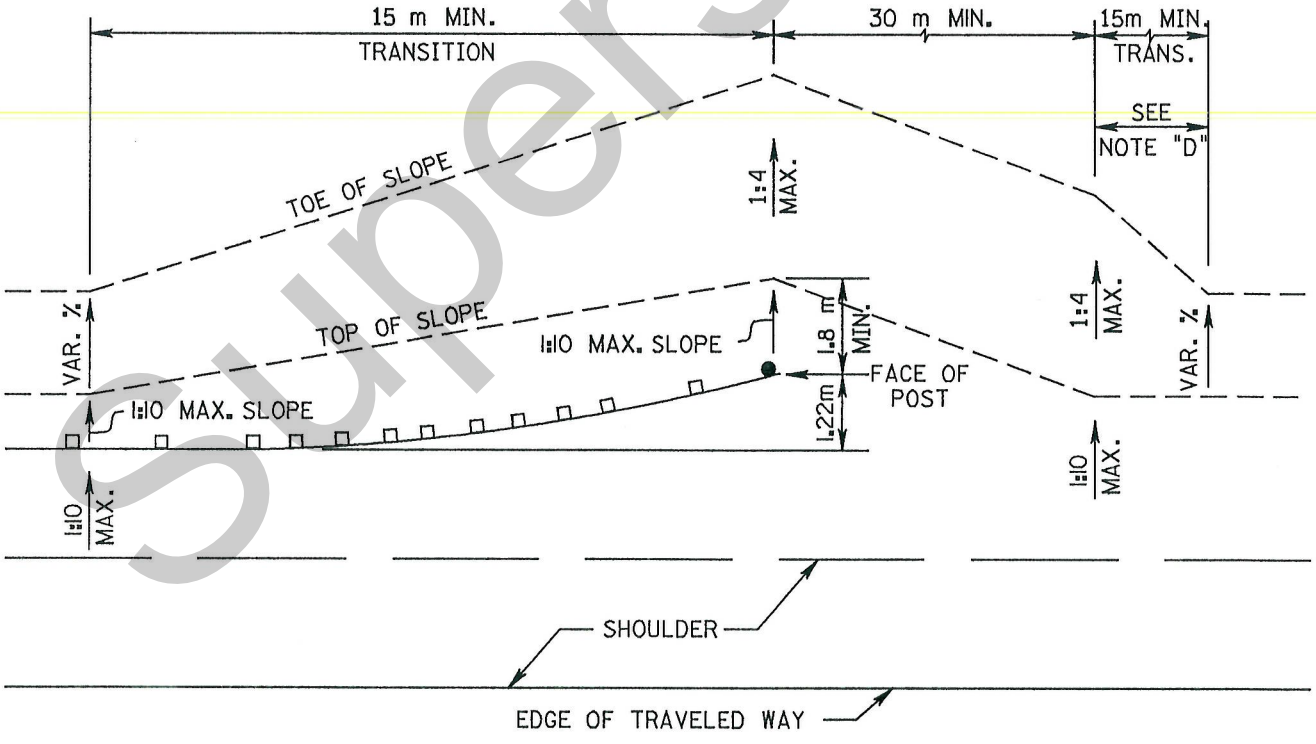
DATE: 05/15/98



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

NOTE "B": RUB RAIL, REDUCED POST SPACING, AND DOUBLE RAIL ELEMENTS SHOULD NOT BE USED WITHIN THE 11.43 m PARABOLIC FLARE.

NOTE "C": IF L_H EXTENDS BEYOND R.O.W. LINE, THEN CLEAR AREA ONLY WITHIN R.O.W. LIMITS.



NOTE "D": THIS TRANSITION IS ONLY NEEDED IF THE APPROACHING SLOPE IS STEEPER THAN 1:4.

i:\dotstds\rdwydesmanual\met-ic\chapter8\approved\m8d.dgn
08-MAY-1998 10:54

APPROACH LENGTH OF NEED ON EMBANKMENT (FILL) SLOPES

FIGURE: 8-E

DATE: 05/15/98

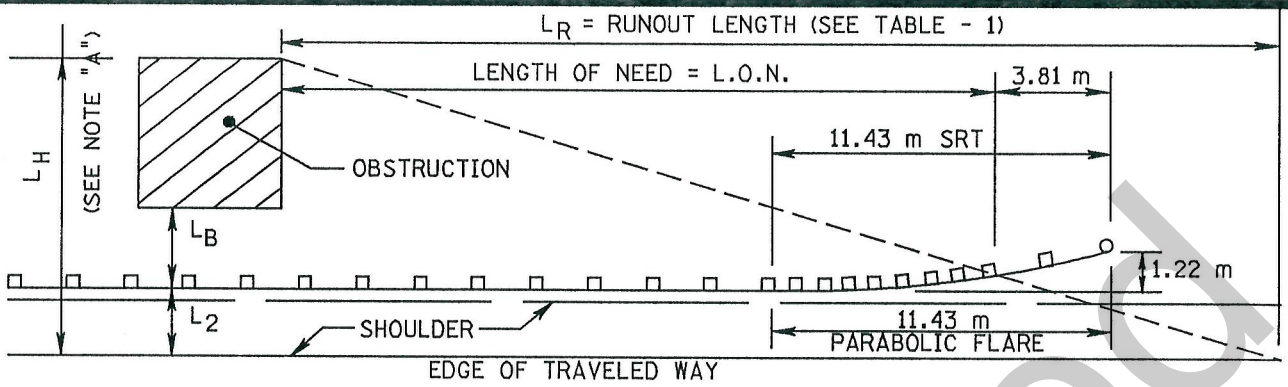


TABLE - 1

DESIGN SPEED (km/h)	TRAFFIC VOLUME (A.D.T.) OVER 6000 RUNOUT LENGTH L_R (m)	2000-6000 RUNOUT LENGTH L_R (m)	800-2000 RUNOUT LENGTH L_R (m)	UNDER 800 RUNOUT LENGTH L_R (m)	SHY LINE OFFSET (m)
110	145	135	120	110	2.8
100	130	120	105	100	2.4
90	110	105	95	85	2.2
80	100	90	80	75	2.0
70	80	75	65	60	1.7
60	70	60	55	50	1.4
50	50	50	45	40	1.1

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

PARABOLIC FLARE (SRT)

$$L.O.N. = \frac{L_R(L_H - L_2 - 0.47\ m)}{L_H}$$

NO FLARE (EXTRUDER 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 A CRITICAL SLOPE, SEE FIGURE 8-G.

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 3.81 m, WHICH IS THE LENGTH OF ONE RAIL ELEMENT.

STEP 3. ADD AN ADDITIONAL 3.81 m TO GET REQUIRED L.O.N. INCLUDING S.R.T. OR EXTRUDER 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 SRT	EXTRUDER TERMINAL
$L_B \geq 1.2$ m	11.43 m	15.24 m
$0.6\ m \leq L_B < 1.2$ m	15.24 m	19.05 m
$L_B < 0.6$ m	17.145 m	20.955 m
* GUIDE RAIL ATTACHMENT	17.145 m	20.955 m
* THRIE BEAM ATTACHMENT	17.145 m	20.955 m

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

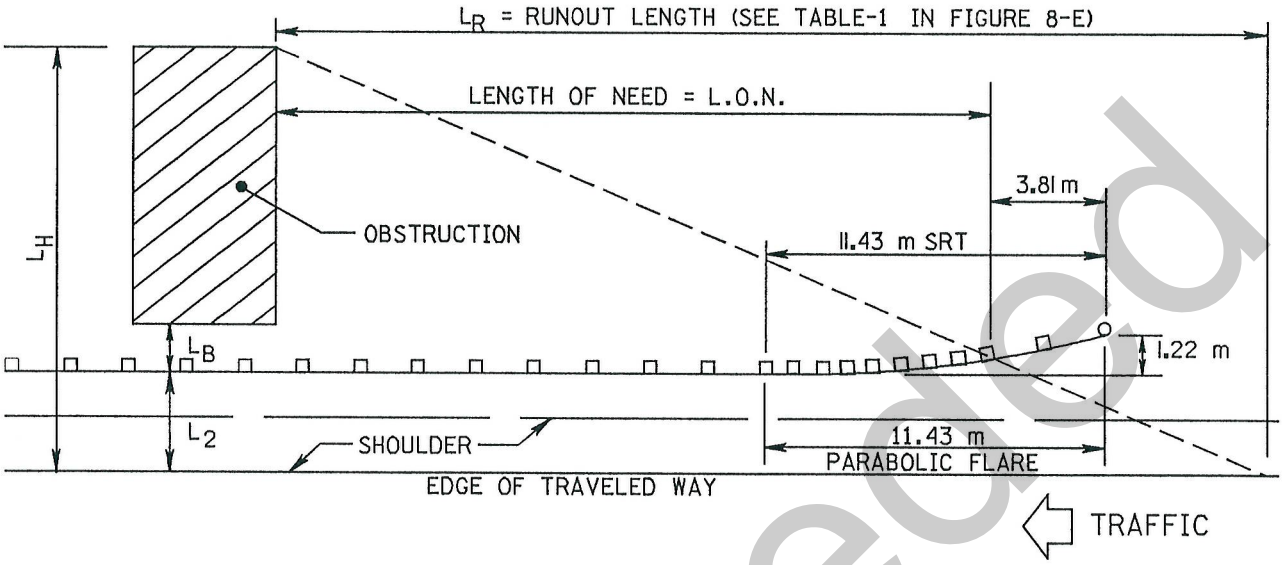
NOTE D: THE TOTAL LENGTH OF A FREE-STANDING GUIDE RAIL INSTALLATION INCLUDING APPROACH AND TRAILING END TREATMENTS SHOULD NOT BE LESS THAN 19.05 m.

u:\dotstds\rdwydesmanual\metric\chapter8\approved\m8e.dgn
08-MAY-1998 11:03

EXAMPLE OF APPROACH LENGTH OF NEED ON EMBANKMENT (FILL) SLOPES

FIGURE: 8-F

DATE: 05/15/98



EXAMPLE

DESIGN SPEED = 110 km/h
TANGENT ROADWAY
A.D.T. = 7000

L_B = 1.2 m

L_H = 6.6 m

L_R = 145 m

L_2 = 4.8 m

STEP 1. $L.O.N. = \dfrac{L_R (L_H - L_2 - 0.47\ m)}{L_H}$

$L.O.N. = \dfrac{145\ m\ (6.6\ m - 4.8\ m - 0.470\ m)}{6.6\ m}$

L.O.N. = 29.22 m

STEP 2. INCREASE 29.22 m TO NEAREST MULTIPLE OF 3.81 m, L.O.N. = 30.48 m.

STEP 3. ADD AN ADDITIONAL 3.81 m TO GET REQUIRED L.O.N. INCLUDING S.R.T., USE L.O.N.-PLUS-S.R.T. = 34.29 m.

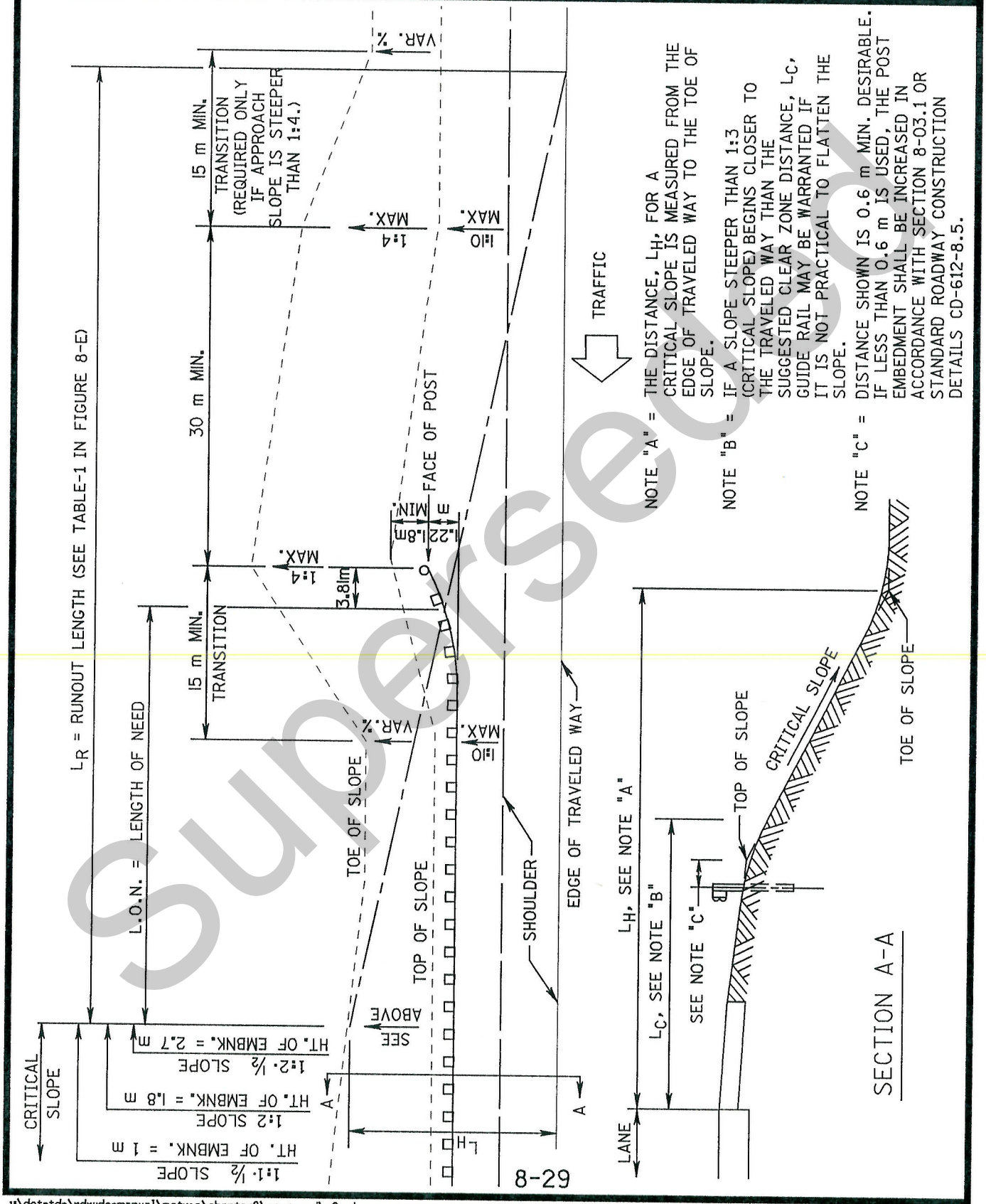
STEP 4. FROM TABLE 2 IN FIGURE 8-E, THE MINIMUM FUNCTIONAL LENGTH = 11.43 m. SINCE L.O.N.-PLUS-S.R.T. IS GREATER THAN 11.43 m, USE 34.29 m.

u:\dotstds\rdwydesmanual\metr-10\chapter8\approved\m8f.dgn
08-MAY-1998 10:55

GUIDE RAIL TREATMENT FOR CRITICAL EMBANKMENT SLOPES

FIGURE: 8-G

DATE: 05/15/98



I:\dotstds\rdwydesmanual\metric\chapter8\approved\m8g.dgn
08-MAY-1998 11:10

APPROACH LENGTH OF NEED FOR OPPOSING TRAFFIC ON EMBANKMENT (FILL) SLOPES

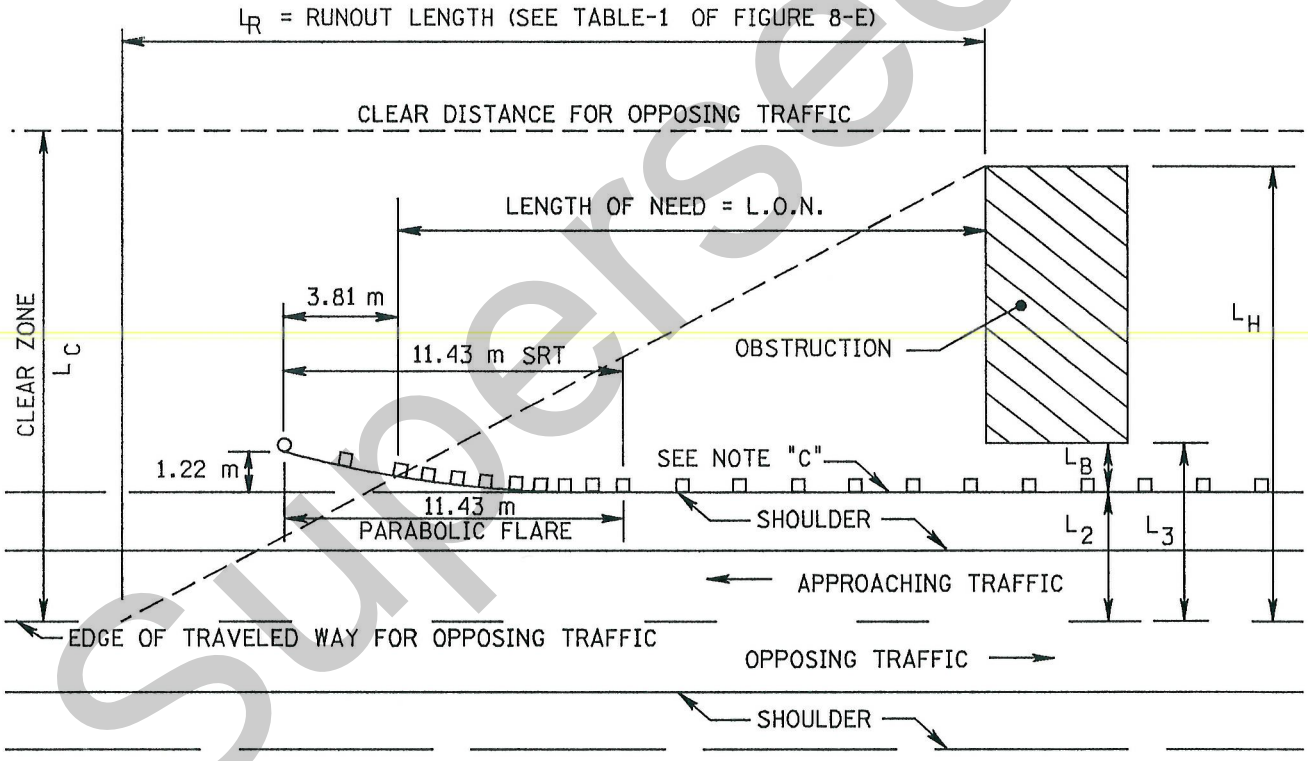
FIGURE: 8-H

DATE: 05/15/98

STEP 1. $L_2 > L_C$:
IF GUIDE RAIL IS OUTSIDE THE CLEAR ZONE (L_C), NO ADDITIONAL GUIDE RAIL AND NO CRASHWORTHY END TREATMENT IS REQUIRED; THEREFORE, USE BEAM GUIDE RAIL END ANCHORAGE AS SHOWN IN THE STANDARD ROADWAY CONSTRUCTION DETAILS CD-612-4 AND CD-612-8.

STEP 2. $L_2 < L_C$ AND $L_3 > L_C$:
IF GUIDE RAIL IS WITHIN THE CLEAR ZONE, BUT THE OBSTRUCTION IS BEYOND IT, USE AN S.R.T. AND THE PARABOLIC FLARE WITH THE MINIMUM FUNCTIONAL LENGTHS SHOWN IN TABLE 2 IN FIGURE 8-E.

STEP 3. $L_3 < L_C$:
IF THE OBSTRUCTION IS WITHIN THE CLEAR ZONE (L_C), SEE BELOW. USE VARIABLES AS SHOWN BELOW AND STEPS 1 THROUGH 4 AS SHOWN IN FIGURE 8-E TO DETERMINE THE REQUIRED L.O.N.-PLUS-S.R.T.

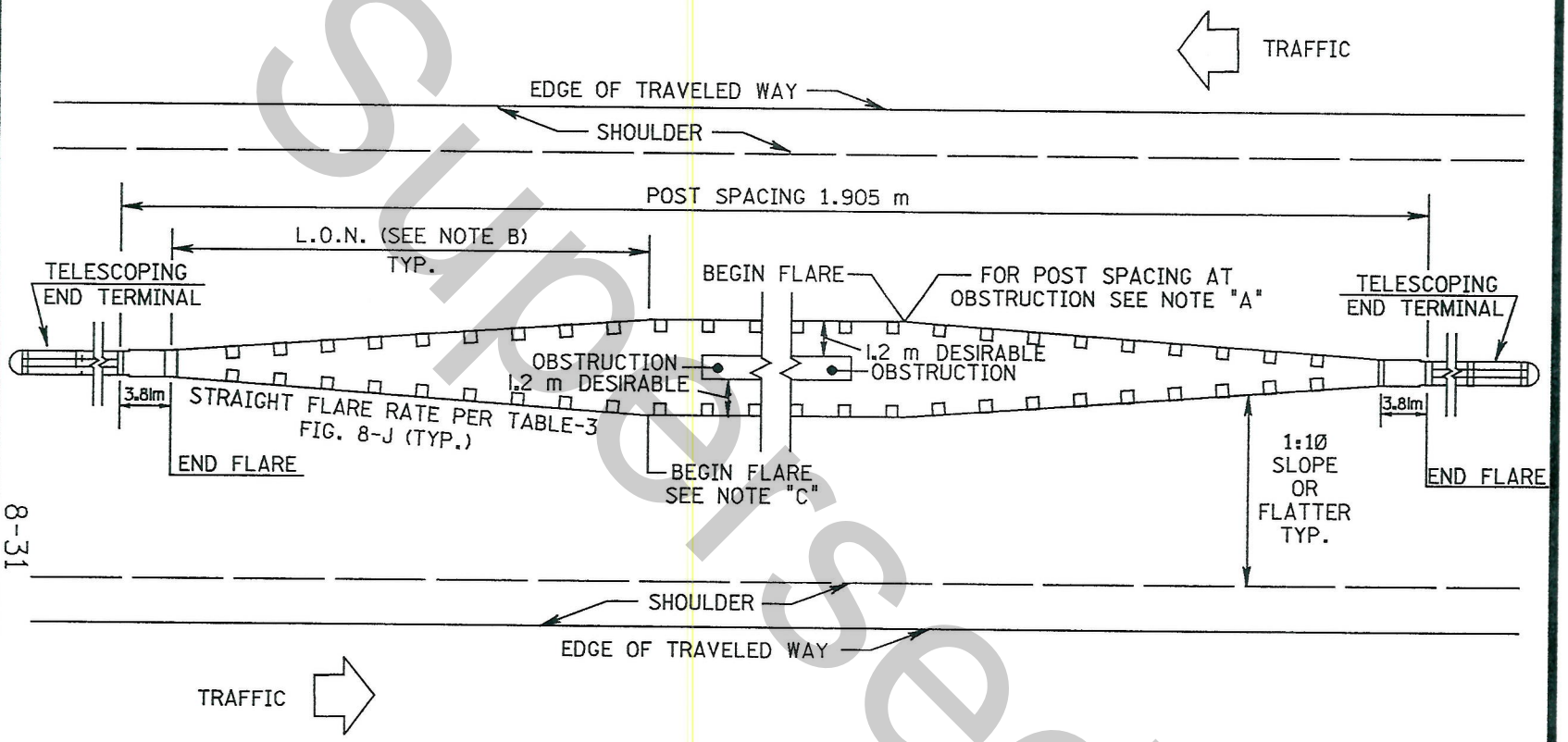


NOTE A: IF THERE IS A TRAVERSABLE MEDIAN SEPARATING TRAFFIC, THE MEDIAN WIDTH SHOULD BE INCLUDED WHEN DETERMINING L_2, L_3, AND L_H FOR OPPOSING TRAFFIC.

NOTE B: FOR A DIVIDED HIGHWAY WITH A NONTRAVERSABLE MEDIAN, USE BEAM GUIDE RAIL END ANCHORAGE, AS SHOWN IN THE STANDARD ROADWAY CONSTRUCTION DETAILS CD-612-8.1, 8.2, 8.3 & 8.7.

NOTE C: SEE STANDARD ROADWAY CONSTRUCTION DETAILS CD-612-7 AND CD-612-8 FOR REQUIRED POST SPACING AND DOUBLE RAIL ELEMENT REQUIREMENTS.

i:\dotstds\rdkydesmanual\metric\chapter8\approved\m8h.dgn
08-MAY-1998 10:57



NOTE "A" : FOR POST SPACING AT OBSTRUCTION SEE STANDARD ROADWAY CONSTRUCTION DETAILS.

NOTE "B" : DETERMINE L.O.N. USING STRAIGHT FLARE RATE IN TABLE 3 OF FIGURE 8-J.

NOTE "C" : BEGIN FLARE AT FIRST POST THAT IS 1.905 m MINIMUM FROM OBSTRUCTION.

OBSTRUCTION IN MEDIAN APPROACH END TREATMENT

DATE: 05/15/98

FIGURE: 8-1

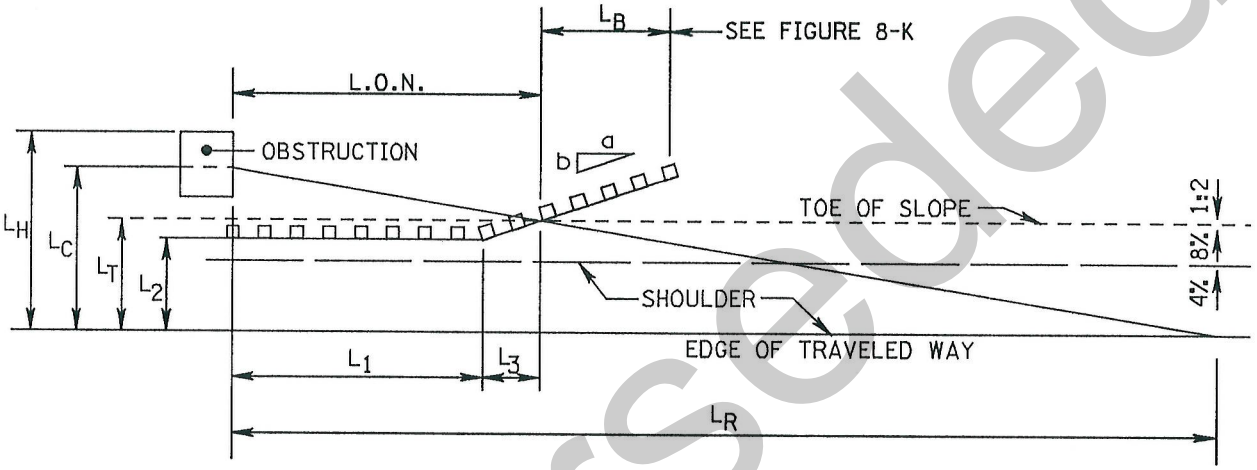
APPROACH LENGTH OF NEED IN CUT SECTIONS

FIGURE: 8-J

DATE: 05/15/98

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 FIGURE 8-K. 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 = 100 km/h

A.D.T. = 6000

L_2 = 4.8 m

L_H = 9.6 m

L_R = 120 m (FROM FIGURE 8-E, TABLE-1)

L_T = 5.8 m

a/b = 14:1 STRAIGHT FLARE (FROM TABLE -3)

L_C = 9m (FROM FIGURE 8-A, L_C = 8m TO 9m)

IF $L_H > L_C$ USE L_C

$L_1 = L_R - (L_T L_R / L_H) - a/b\ (L_T - L_2)$

$L_1 = 120 - (5.8 \times 120/9) - 14/1\ (5.8 - 4.8) = 28.67$ m

TABLE-3	
DESIGN SPEED (km/h)	STRAIGHT FLARE RATE (a/b)
110	15:1
100	14:1
90	12:1
80	11:1
70	10:1
60	8:1
50	7:1

28.67 m/1.905 m POST SPACING = 15.05 POSTS, THEREFORE, USE 15 POSTS AT 1.905 m = 28.575 m = L_1

FLARE LENGTH $L_3 = (L_T - L_2)\ a/b = (5.8 - 4.8)\ 14/1 = 14$ m

14 m/1.905 m POST SPACING = 7.35 POSTS, THEREFORE, USE 8 POSTS AT 1.905 m = 15.24 m = L_3

L.O.N. = 28.575 m + 15.24 m = 43.815 m

NOTE: L_1 SHALL NOT BE LESS THAN 3.81 m

z:\dotstds\rdwydesmanual\metric\chapter8\approved\m8j.dgn
08-MAY-1998 10:58

GUIDE RAIL TREATMENT FOR CUTS
STRAIGHT FLARE
(APPROACH END BURIED IN SLOPE)

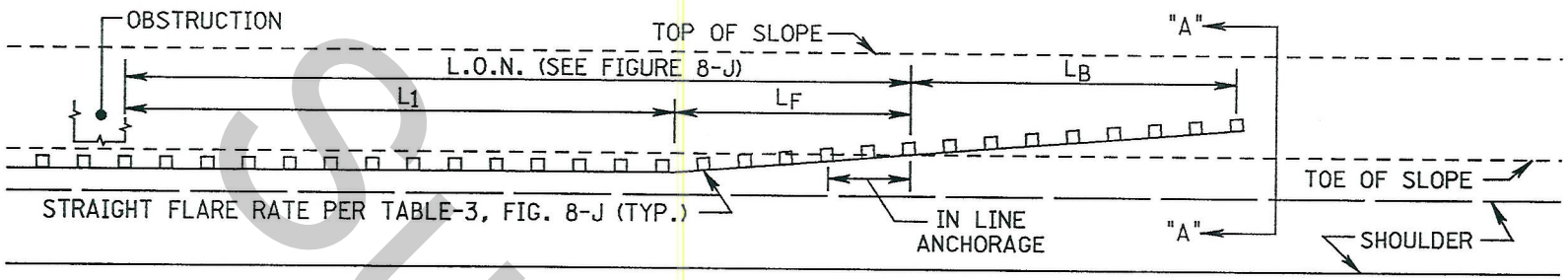
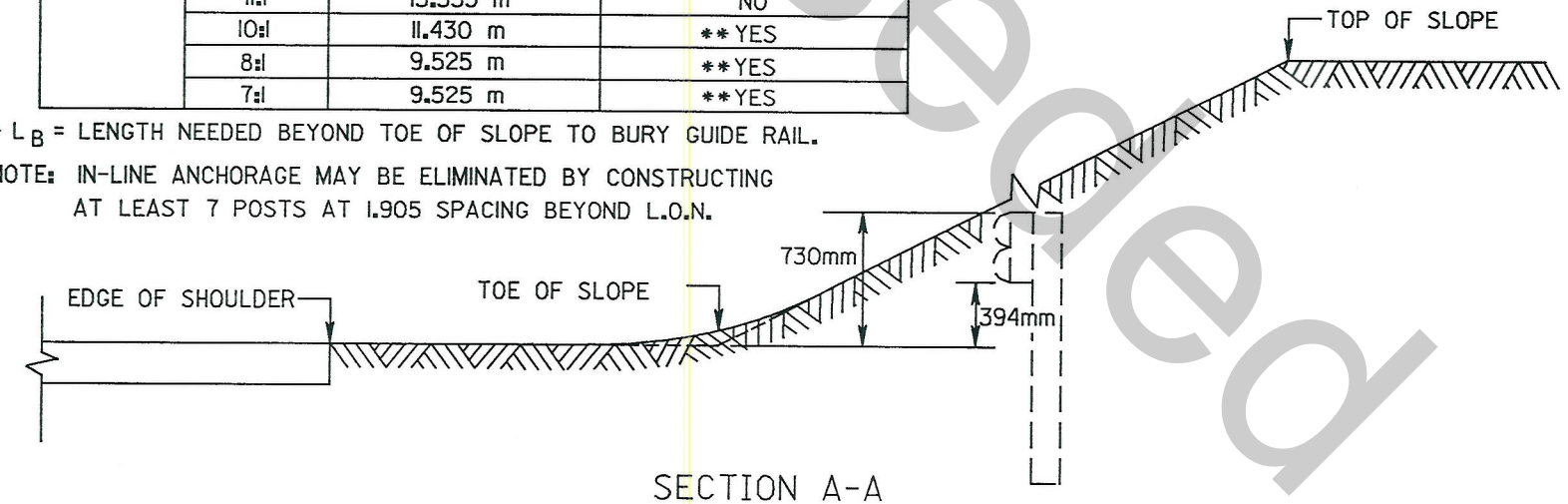


TABLE-4

SLOPE	FLARE	* L_B	IN-LINE ANCHORAGE REQUIRED
1:2	15:1	22.860 m	NO
	14:1	20.955 m	NO
	12:1	19.050 m	NO
	11:1	17.145 m	NO
	10:1	15.240 m	NO
	8:1	13.335 m	NO
	7:1	11.430 m	** YES
1:1½	15:1	17.145 m	NO
	14:1	17.145 m	NO
	12:1	13.335 m	NO
	11:1	13.335 m	NO
	10:1	11.430 m	** YES
	8:1	9.525 m	** YES
	7:1	9.525 m	** YES

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

** NOTE: IN-LINE ANCHORAGE MAY BE ELIMINATED BY CONSTRUCTING AT LEAST 7 POSTS AT 1.905 SPACING BEYOND L.O.N.



SECTION A-A

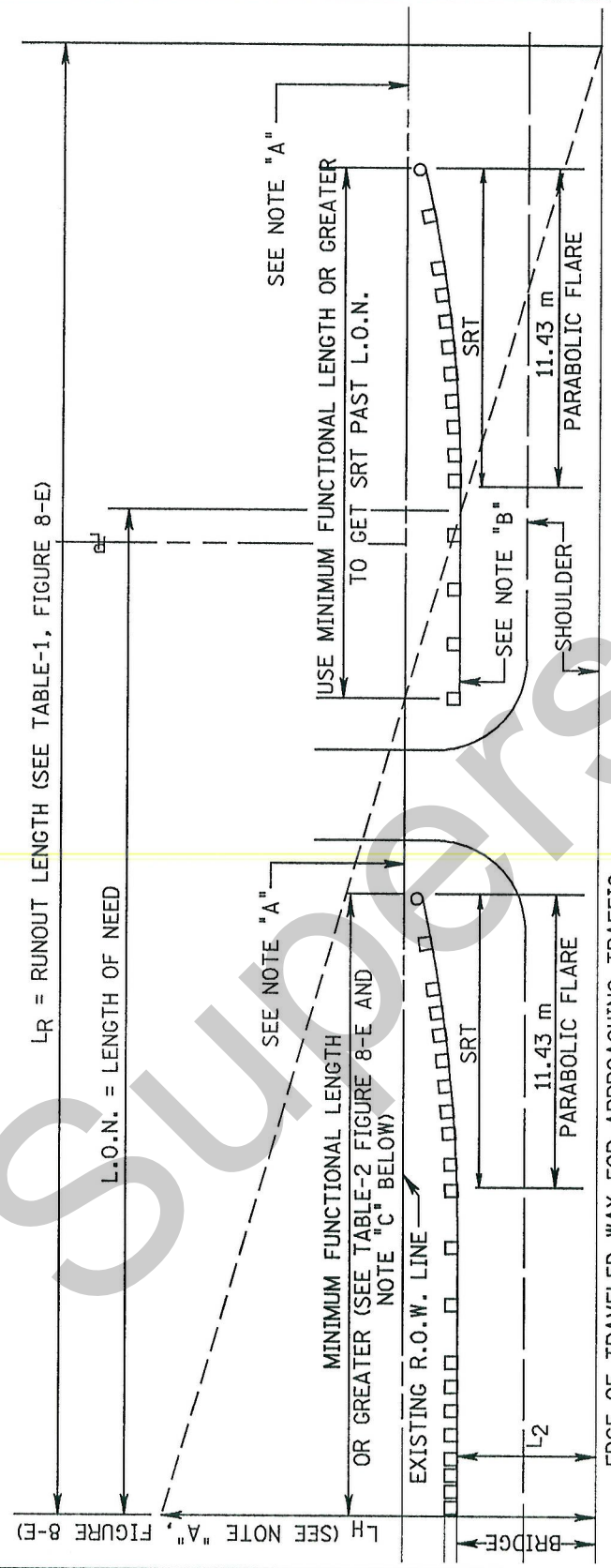
FIGURE: 8-K

DATE: 05/15/98

EXAMPLE OF GUIDE RAIL TREATMENT AT DRIVEWAY LOCATED WITHIN LENGTH OF NEED

FIGURE: 8-L

DATE: 05/15/98



STEP 1. DETERMINE L.O.N., SEE FIGURE 8-E.

STEP 2. IF DRIVEWAY FALLS WITHIN L.O.N., RELOCATE DRIVEWAY AS FAR AWAY FROM OBSTRUCTION AS THE PROPERTY LINE ALLOWS. SEE THE NEW JERSEY HIGHWAY ACCESS MANAGEMENT CODE FOR THE MINIMUM DRIVEWAY OFFSET TO PROPERTY LINE (LOT LINE).

STEP 3. IF DRIVEWAY STILL FALLS WITHIN L.O.N., USE TREATMENTS SHOWN IN FIGURES 8-L OR 8-M. IF DRIVEWAY FALLS OUTSIDE L.O.N., DESIGN GUIDE RAIL AS SHOWN IN FIGURE 8-E.

STEP 4. CHECK SIGHT DISTANCE AT DRIVEWAY, SEE FIGURE 6-B. DRAW THE LINE OF SIGHT FOR VEHICLE EXITING DRIVEWAY. POSITION GUIDE RAIL AT DRIVEWAY SO IT DOES NOT INTERFERE WITH LINE OF SIGHT.

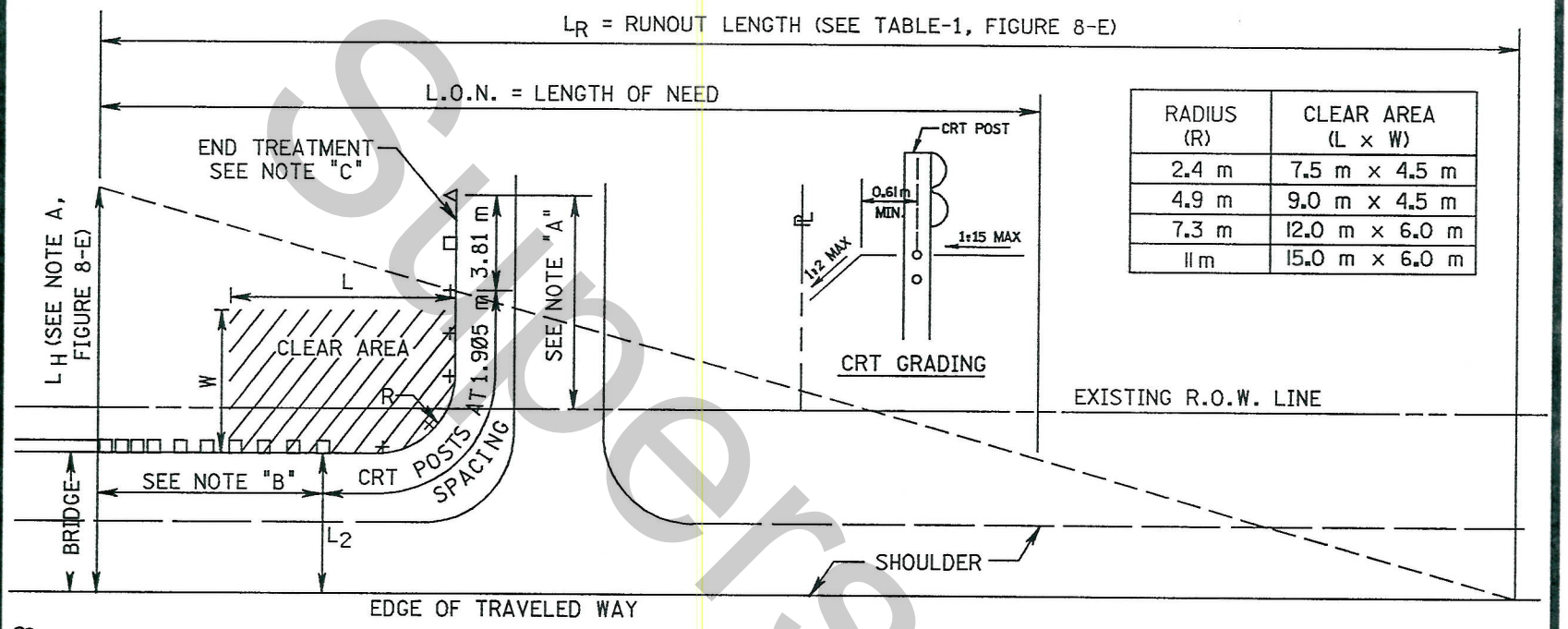
NOTE "A": THE SLOPE TREATMENT AT AN SRT MAY REQUIRE SLOPE EASEMENT PARCELS. SEE FIGURE 8-D FOR SLOPE TREATMENT.

NOTE "B": FOR THE END TREATMENT, SEE FIGURE 8-H. A PARABOLIC FLARE WITH AN SRT MAY BE REQUIRED TO OBTAIN PROPER SIGHT DISTANCE OF VEHICLE IN DRIVEWAY.

NOTE "C": IF YOU CANNOT FIT THE MINIMUM FUNCTIONAL LENGTH OF AN SRT BETWEEN THE OBSTRUCTION (BRIDGE) AND DRIVEWAY, TRY USING FIGURE 8-M OR A QUADGUARD SYSTEM.

u:\dotstds\rdwydesmanual\metric\chapter8\approved\m8l.dgn
08-MAY-1998 10:58

EXAMPLE OF GUIDE RAIL TREATMENT AT DRIVEWAY LOCATED WITHIN LENGTH OF NEED



RADIUS (R)	CLEAR AREA (L x W)
2.4 m	7.5 m x 4.5 m
4.9 m	9.0 m x 4.5 m
7.3 m	12.0 m x 6.0 m
ll m	15.0 m x 6.0 m

STEP 1. SEE STEPS 1 TO 4 IN FIGURE 8-L.

NOTE 'A': A RIGHT-OF-WAY FEE PARCEL IS REQUIRED FOR THE GUIDE RAIL SYSTEM AND GRADING OUTSIDE THE R.O.W. LINE. A CONSTRUCTION AND MAINTENANCE EASEMENT PARCEL IS REQUIRED FOR THE CLEAR AREA OUTSIDE THE R.O.W. LINE. IF THE GUIDE RAIL SYSTEM TIES INTO EXISTING GUIDE RAIL OUTSIDE THE R.O.W. LINE, THEN A C. AND M. EASEMENT PARCEL IS REQUIRED FOR THE GUIDE RAIL SYSTEM, GRADING AND CLEAR AREA.

NOTE 'B': ALLOW AT LEAST 5.715 m FOR A GUIDE RAIL BRIDGE ATTACHMENT OR FOR A THRIE BEAM BRIDGE ATTACHMENT.

NOTE 'C': WHERE THE DRIVEWAY IS 'IN ONLY', USE THE SPECIAL ANCHORAGE. WHERE THE EXIT DRIVEWAY SPEED IS 25 M.P.H. OR LESS, USE THE SPECIAL ANCHORAGE. WHERE THE EXIT DRIVEWAY SPEED IS GREATER THAN 25 M.P.H., USE THE SRT.

NOTE 'D': THIS GUIDE RAIL TREATMENT IS NOT APPLICABLE WHERE SIDEWALK IS LOCATED BEHIND GUIDE RAIL.

NOTE 'E': FOR THE VARIOUS CRT RADIUS DESIGNS & HARDWARE, SEE N.J.D.O.T. STANDARD ROADWAY CONSTRUCTION DETAILS CD-612-6. THESE DESIGNS ARE BASED ON AN INTERSECTION ANGLE OF 90 DEGREES. IF FIELD CONDITIONS VARY EXCESSIVELY FROM 90 DEGREES, A SPECIAL DETAIL SHALL BE MADE OF THE CURVED GUIDE RAIL SECTION SO THAT THE CURVED RAILS WILL FIT THE DRIVEWAY OR INTERSECTION GEOMETRY AND THAT ONLY FULL SECTIONS OF RAIL ELEMENT WILL BE SHOP BENT FOR INSTALLATION.

NOTE 'F': IF CURB IS PRESENT AND CANNOT BE REMOVED, SEE SECTION 8-03.1.2.

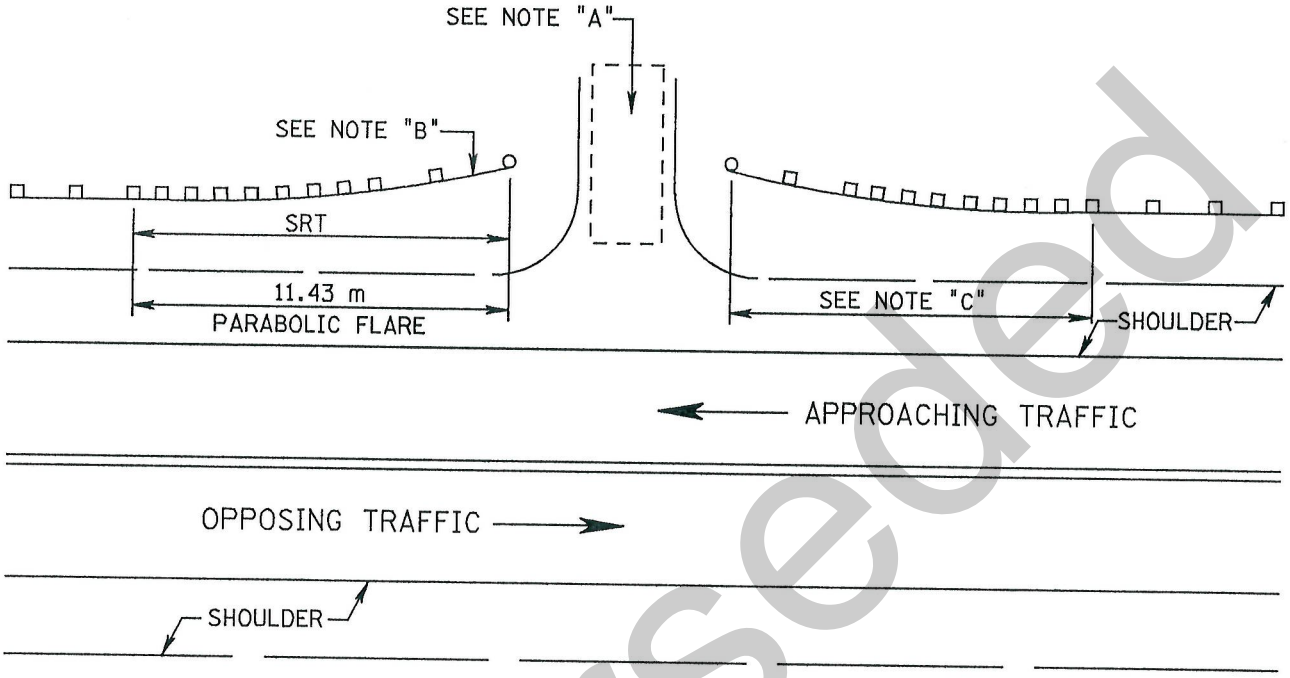
FIGURE: 8-M

DATE: 05/15/98

EXAMPLE OF A TREATMENT AT DRIVEWAY OPENING LOCATED WITHIN A CONTINOUS GUIDE RAIL RUN

FIGURE: 8-N

DATE: 05/15/98



NOTE "A": CHECK SIGHT DISTANCE AT DRIVEWAY, SEE FIGURE 6-B. DRAW THE LINE OF SIGHT FOR VEHICLE EXITING DRIVEWAY. POSITION GUIDE RAIL AT DRIVEWAY SO IT DOES NOT INTERFERE WITH LINE OF SIGHT.

NOTE "B": THE SLOPE TREATMENT AT AN SRT MAY REQUIRE SLOPE EASEMENT PARCELS. SEE FIGURE 8-D FOR SLOPE TREATMENT.

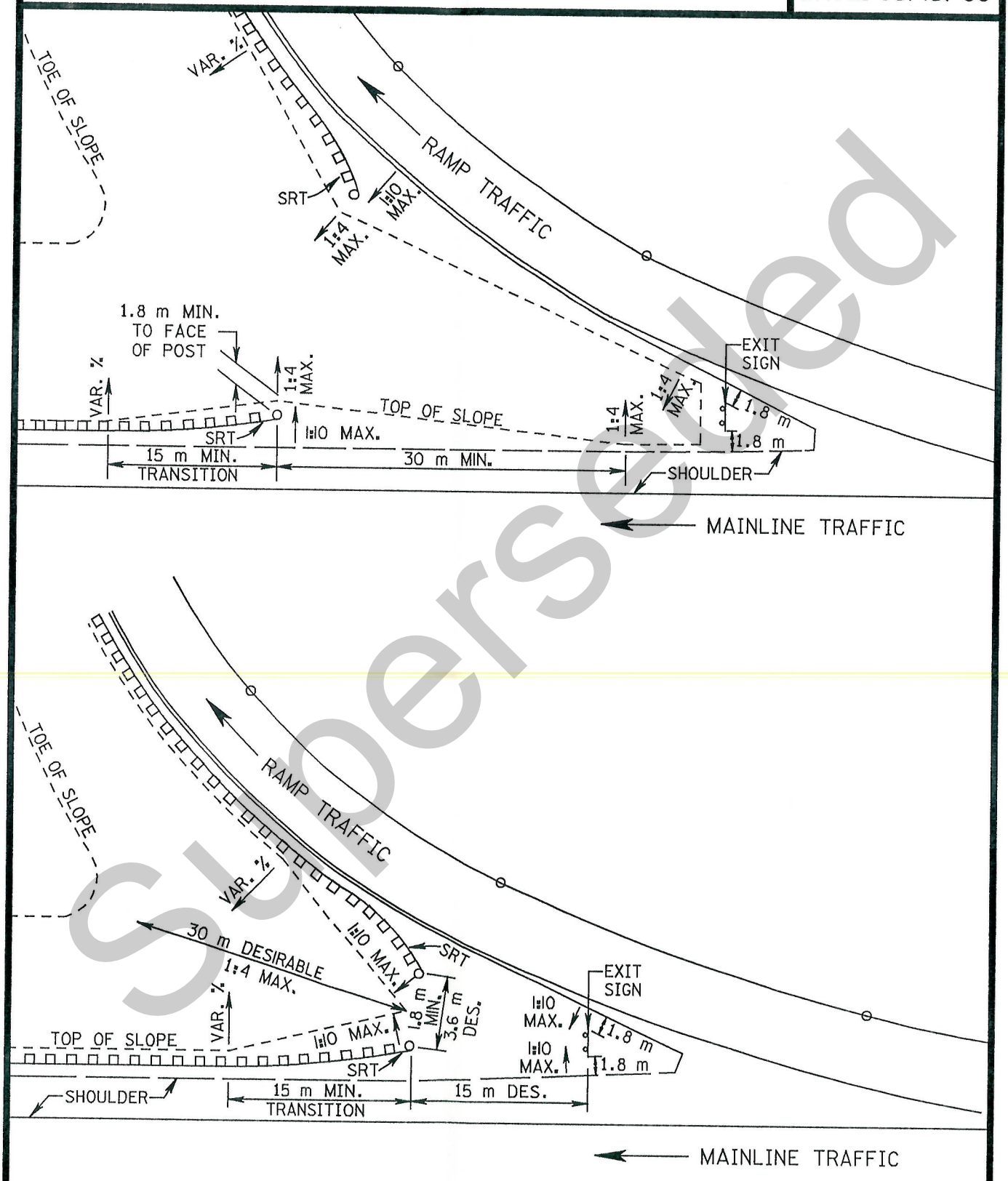
NOTE "C": FOR THE END TREATMENT, SEE FIGURE 8-H. A PARABOLIC FLARE WITH AN SRT MAY BE REQUIRED TO OBTAIN PROPER SIGHT DISTANCE OF VEHICLE IN DRIVEWAY.

u:\dotatds\rdwydesmanual\metric\chapter8\approved\m8n.dgn
08-MAY-1998 10:59

GUIDE RAIL TREATMENT EXAMPLES FOR OPEN GORE AREAS

FIGURE: 8-0

DATE: 05/15/98

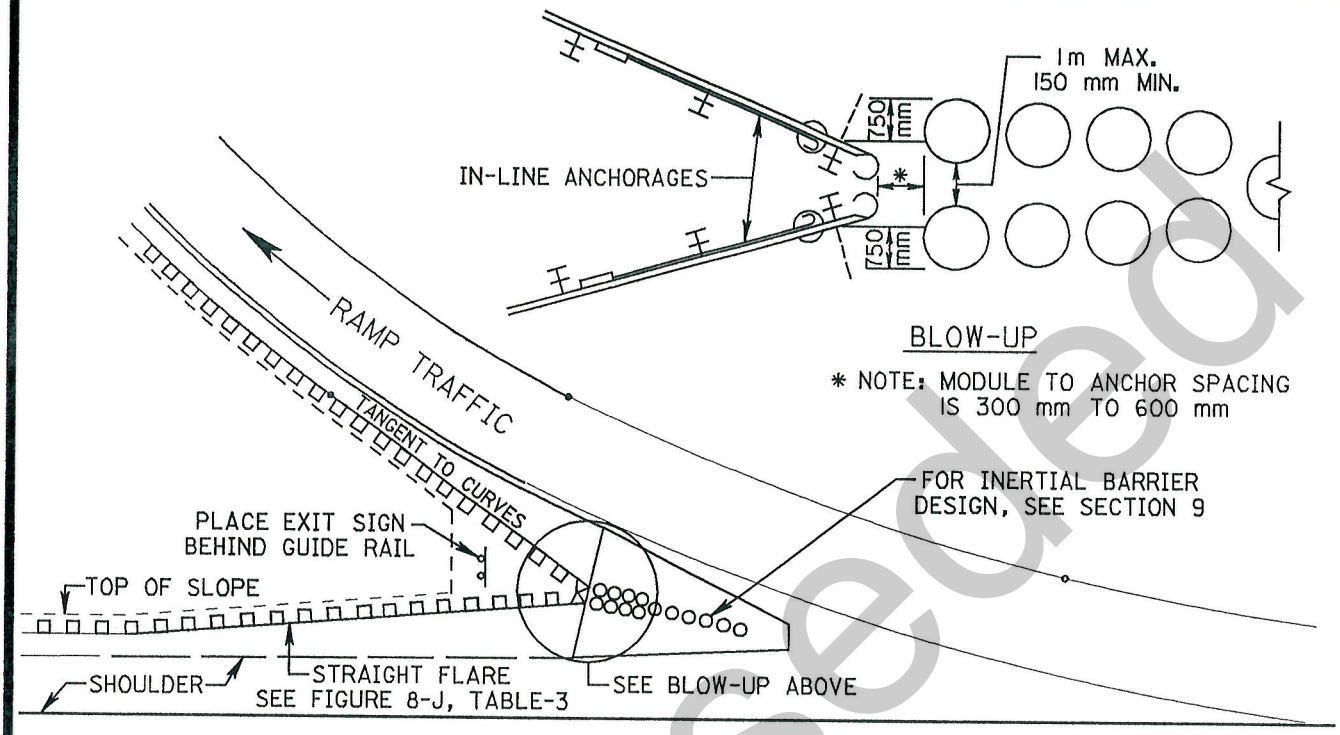


z:\dotstds\rdmydesmanual\metro\chapter8\approved\m80.dgn
08-MAY-1998 11:00

GUIDE RAIL TREATMENT EXAMPLES FOR LIMITED GORE AREAS

FIGURE: 8-P

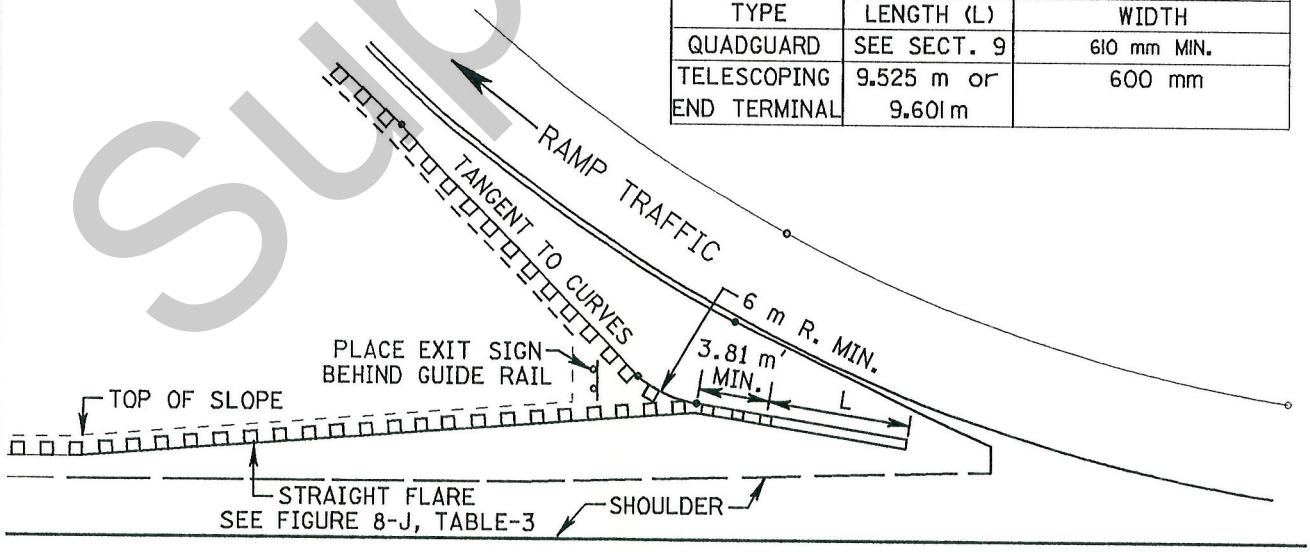
DATE: 05/15/98



NOTE 'A': THE IMPACT ATTENUATORS SHOWN BELOW ARE PREFERRED OVER THE INERTIAL BARRIER SYSTEM AT LOCATIONS WHERE NUISANCE HITS MAY BE COMMON OR WHERE THERE IS A HIGH PROBABILITY OF ACCIDENTS.

NOTE 'B': PROVIDING THE WIDEST IMPACT ATTENUATOR TO FIT THE SITE, FROM THE TABLE BELOW, USUALLY PROVIDES THE GREATEST OFFSET FROM THE PHYSICAL NOSE.

IMPACT ATTENUATOR		
TYPE	LENGTH (L)	WIDTH
QUADGUARD	SEE SECT. 9	610 mm MIN.
TELESCOPING END TERMINAL	9.525 m or 9.601 m	600 mm

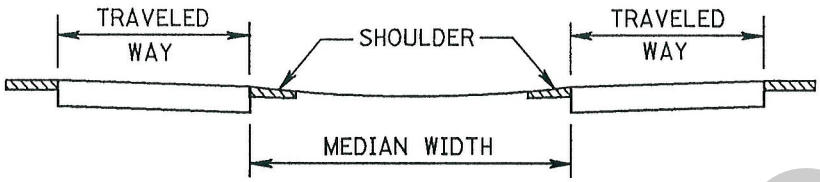


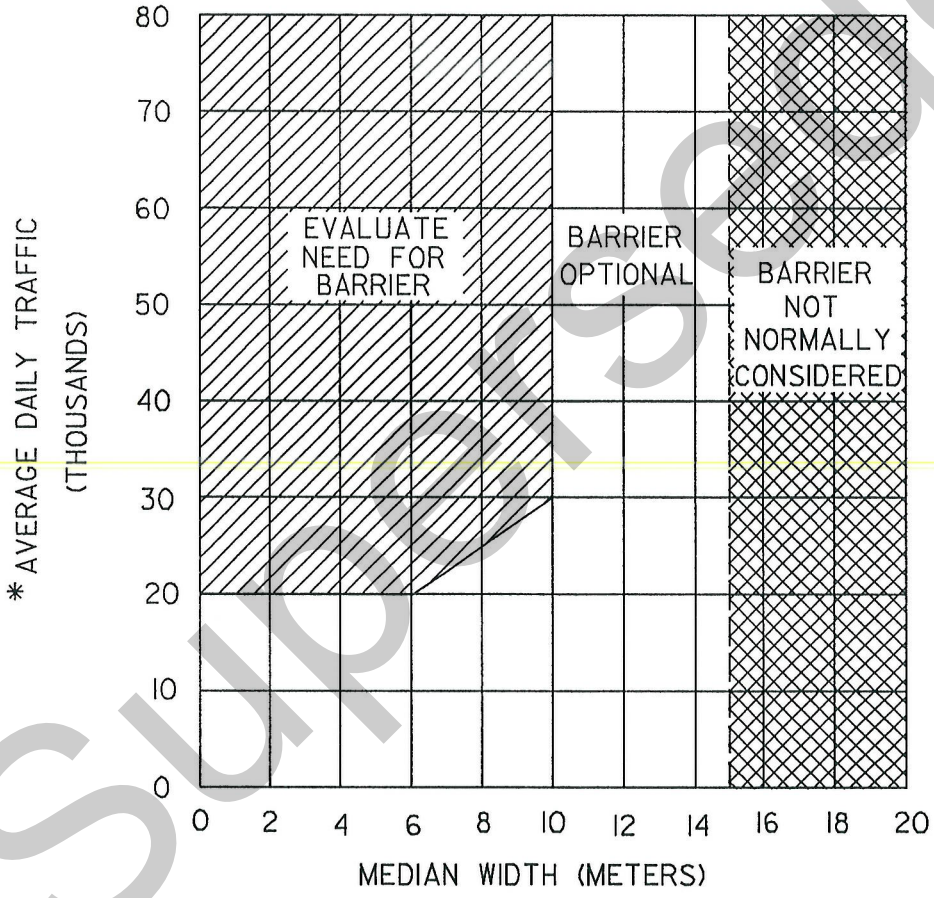
u:\dotstds\rdkydesmanual\metric\chapter8\approved\m8p.dgn
08-MAY-1998 11:00

WARRANTS FOR MEDIAN BARRIER FOR FREEWAYS AND EXPRESSWAYS

FIGURE: 8-Q

DATE: 05/15/98





* BASED ON A 5-YEAR PROJECTION, TWO-WAY

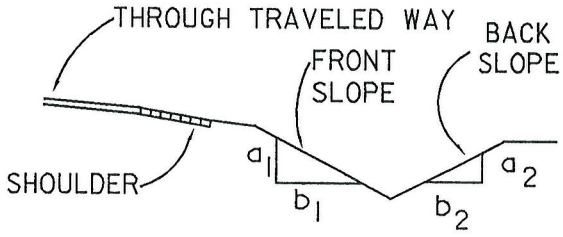
SOURCE: ROADSIDE DESIGN GUIDE, AASHTO, JANUARY 1996.

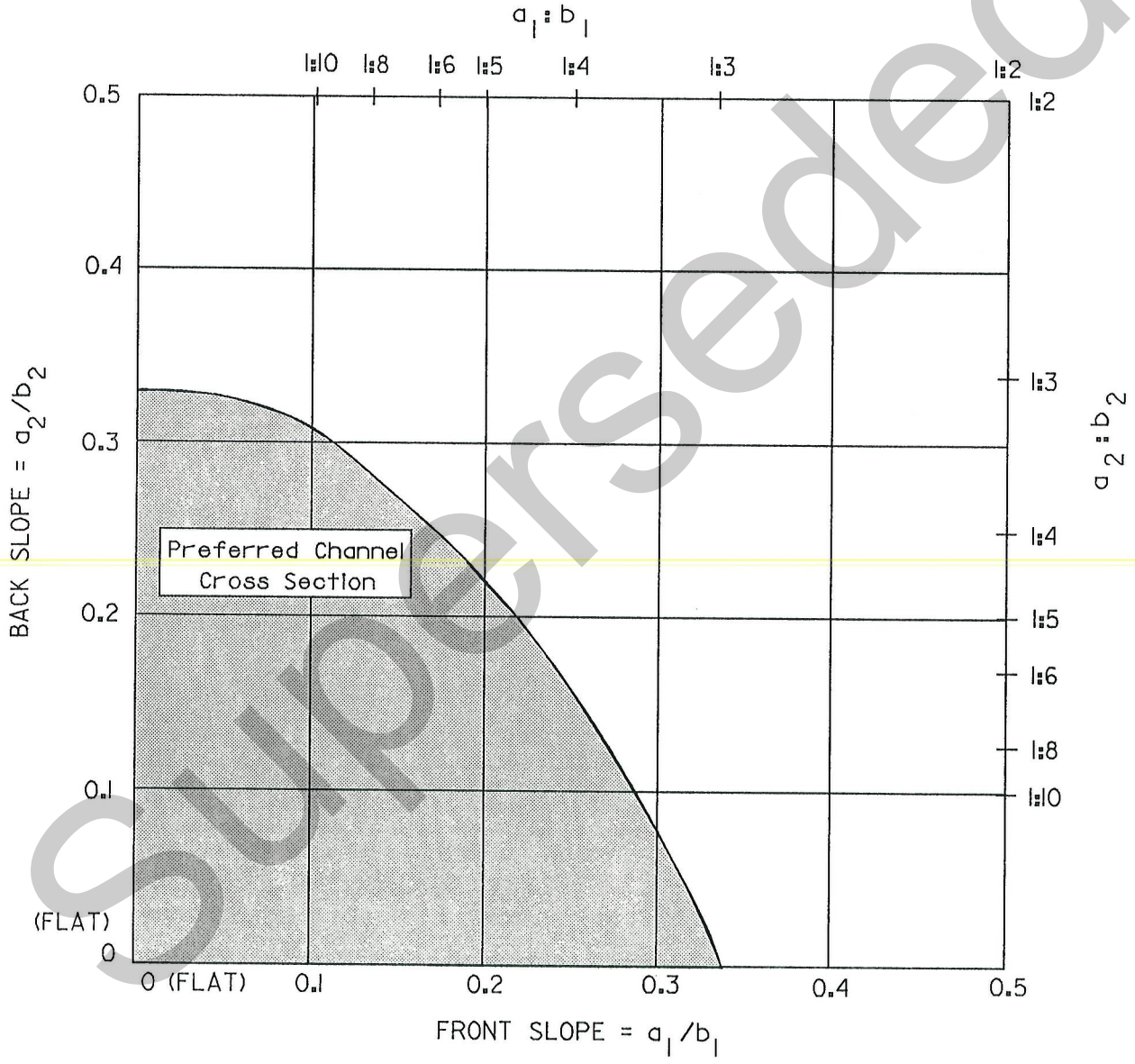
u:\dotstds\rdwydesmanual\metric\chapter8\approved\m8q.dgn
08-MAY-1998 11:00

PREFERRED CROSS SECTIONS FOR CHANNELS WITH ABRUPT SLOPE CHANGES

FIGURE: 8-R

DATE: 05/15/98





NOTE: THIS CHART IS APPLICABLE TO ALL VEE DITCHES, ROUNDED CHANNELS WITH A BOTTOM WIDTH LESS THAN 2.4 m, AND TRAPEZOIDAL CHANNELS WITH BOTTOM WIDTHS LESS THAN 1.2 m.

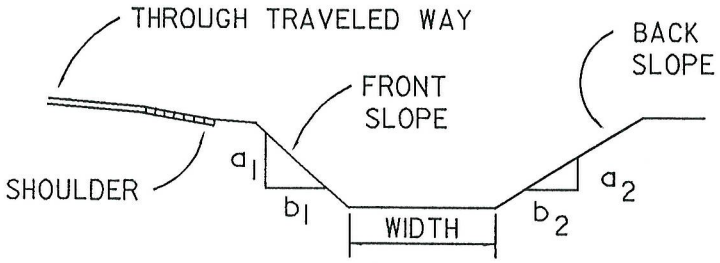
SOURCE: ROADSIDE DESIGN GUIDE, AASHTO, JANUARY 1996.

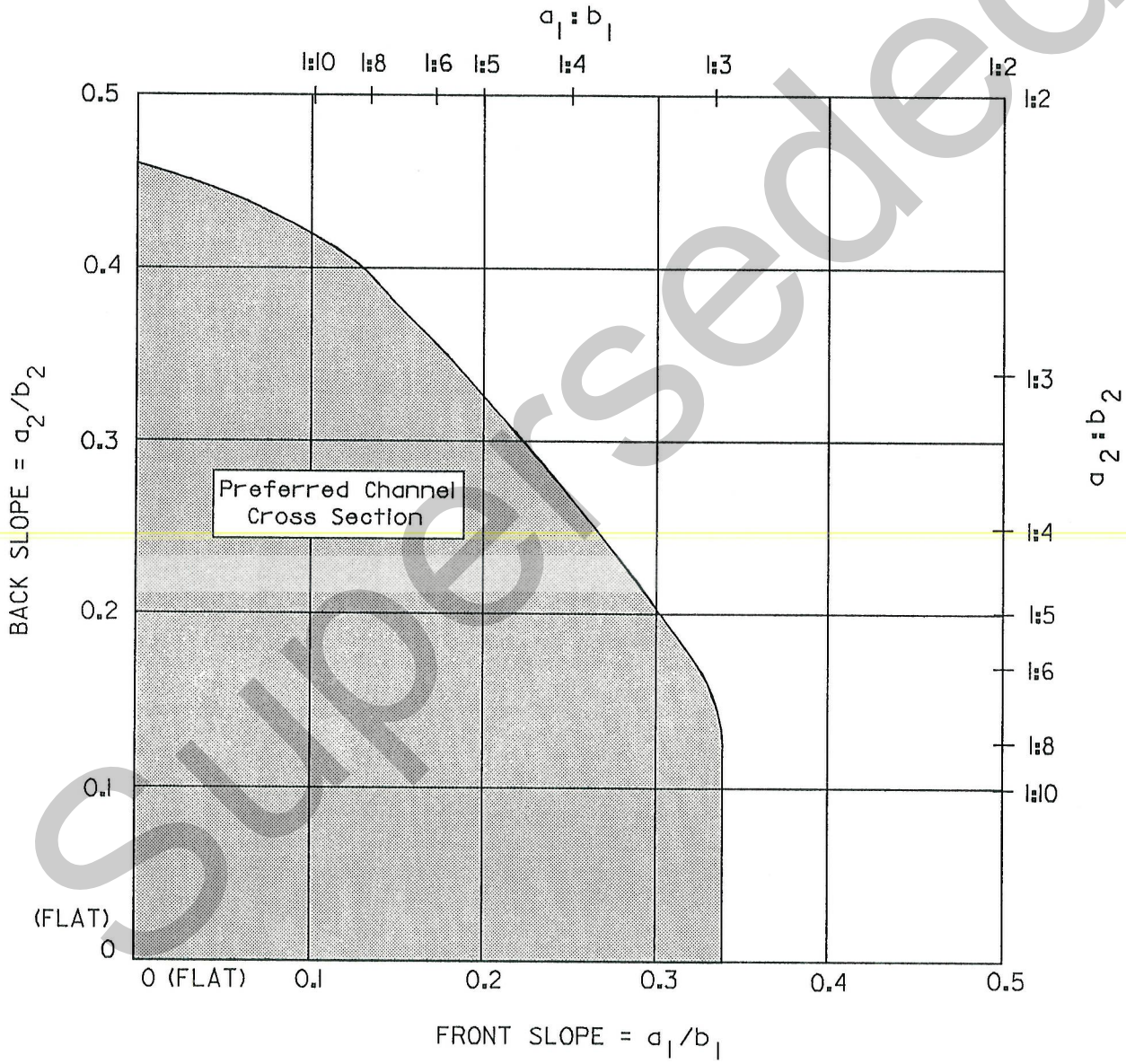
n:\dotstds\rdwydesmanual\met-10\chapter8\approved\m8r.dgn
08-MAY-1998 11:15

PREFERRED CROSS SECTIONS FOR CHANNELS WITH GRADUAL SLOPE CHANGES

FIGURE: 8-S

DATE: 05/15/98





NOTE: THIS CHART IS APPLICABLE TO ROUNDED CHANNELS WITH BOTTOM WIDTHS OF 2.4 m OR MORE, AND TO TRAPEZOIDAL CHANNELS WITH BOTTOM WIDTHS EQUAL TO OR GREATER THAN 1.2 m.

SOURCE: ROADSIDE DESIGN GUIDE, AASHTO, JANUARY 1996.

u:\dotstds\rdwydesmanual\metric\chapter8\approved\m8s.dgn
08-MAY-1998 11:14