Session 3: Guardrail Design and Site-specific Installation Considerations

Course Topics

- Session 2 – Testing Requirements and Performance Characteristics of Common Barrier Systems, Terminals and Crash Cushions
- Session 3 – Guardrail Design and Site-specific Installation Considerations

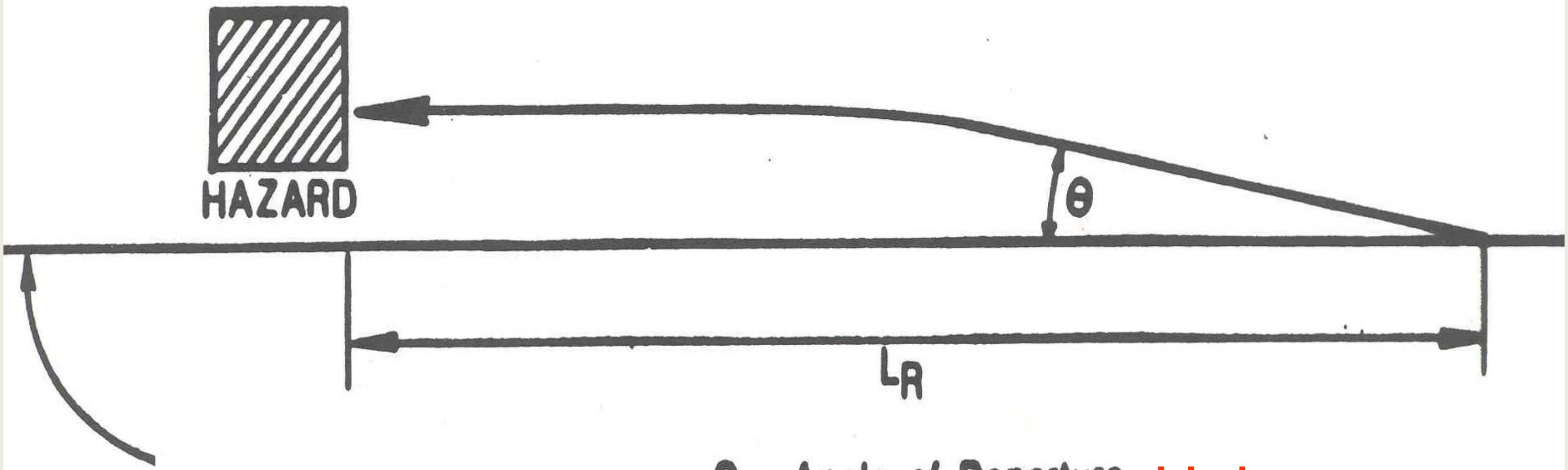
Session 3 Objectives

- Define Barrier Length of Need (LON) and Explain its Basis
- Evaluate Examples of Field Installations
- Apply a Field Procedure to Check LON Adequacy
- Describe the Basic Principles of an Optimal Barrier Installation

Session 3 Outline

- Length of Need (LON)
- Guardrail Placement
- Special Situations
  - Guardrail over Low Fill Culvert
  - Guardrail Posts in Rock/Mowing Strips
  - Guardrail at Turnout
  - Weathering Steel Guardrail
  - Steel-backed Timber Rail
  - Transitions to Bridge Railings/Parapets

Length of Need (LON) Theory



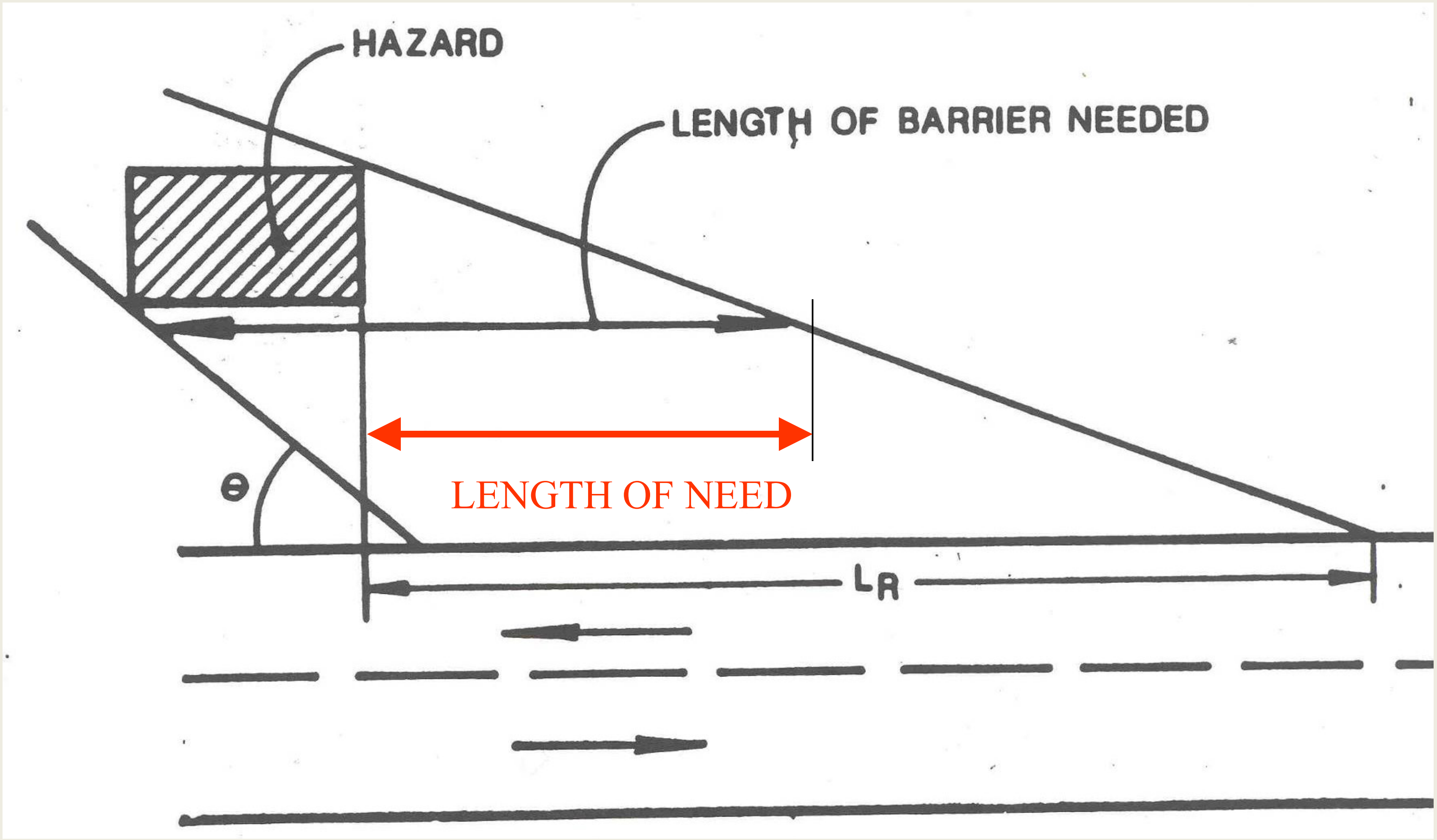
θ = Angle of Departure: Unknown

LR = Runout Length

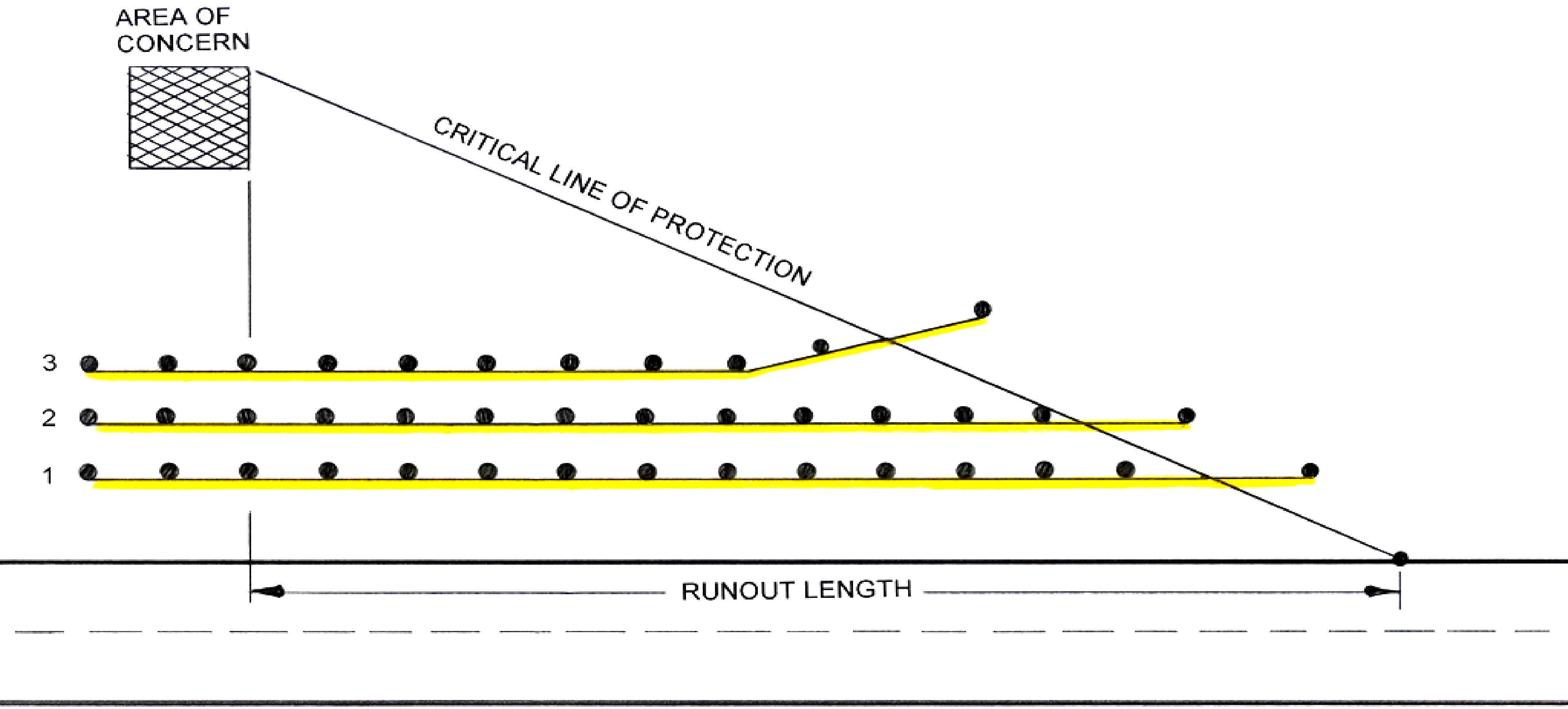
Length of Need (LON) Definition

The length of barrier needed in advance of the primary hazard to intercept and redirect the path of an encroaching vehicle.

Graphical Depiction of LON



Proper Length of Need



1 MINIMUM OFFSET / LONGER BARRIER LENGTH

2 FARTHER OFFSET / SHORTER BARRIER RUN NEEDED

3 WHEN SOME OR ALL OF BARRIER IS FLARED / EVEN LESS BARRIER NEEDED

Length of Need

- Calculating the length of need (X)

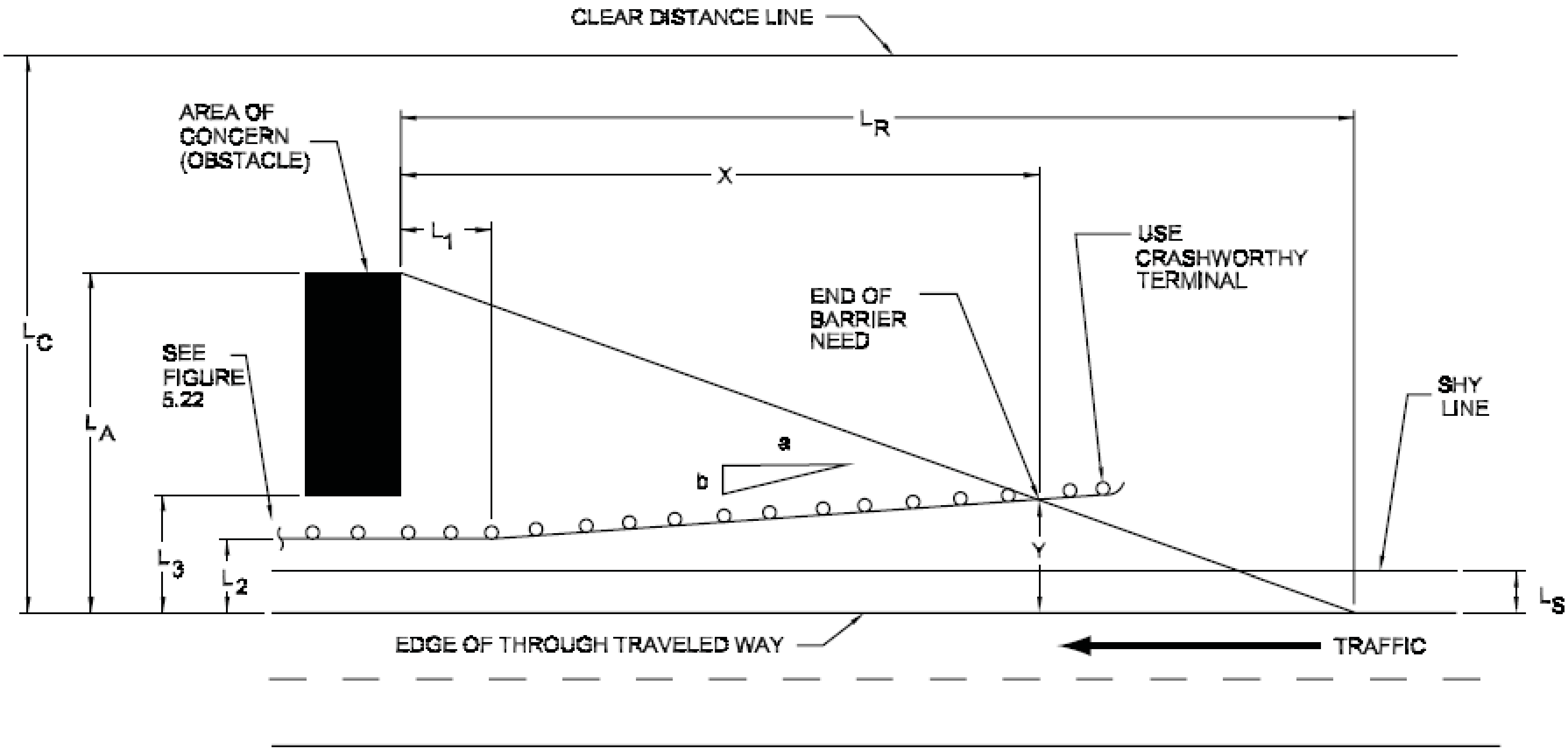
  - For <u>straight or nearly straight</u> sections of roadway:

$$X = \frac{L_A + (b/a)(L_1) - L_2}{(b/a) + (L_A/L_R)}$$

  - For <u>parallel</u> installations (no flare):

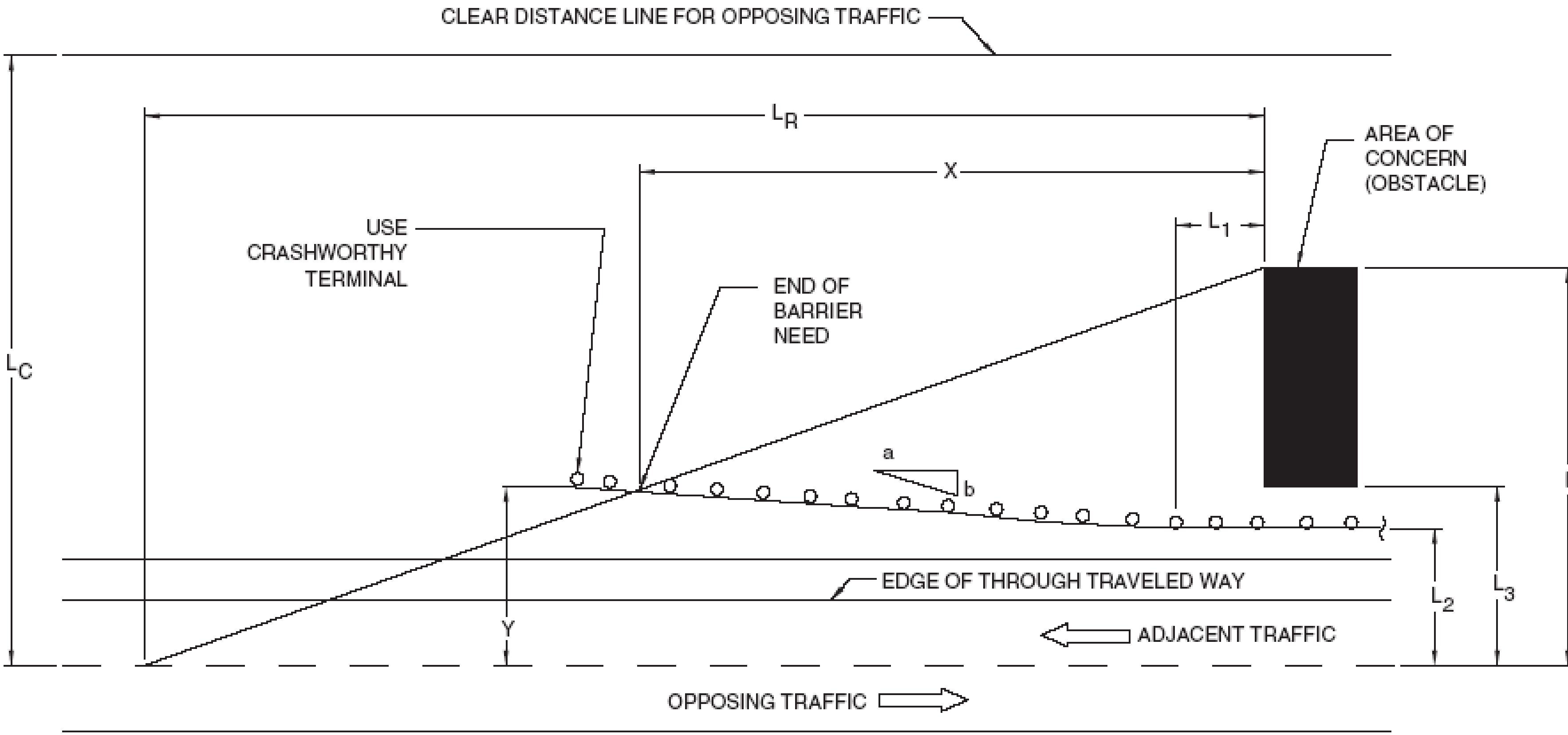
$$X = \frac{L_A - L_2}{L_A/L_R}$$

LON Design for Approach Barrier Layout



Ref: AASHTO Roadside Design Guide, 4th Edition, Figure 5.39, Pg. 5-49

LON Design for Opposing Traffic



Ref: AASHTO Roadside Design Guide, 4th Edition, Figure 5.42, Pg. 5-54

Suggested Runout Lengths

Design Speed (mph)	Runout Length (L_R) Given Traffic Volume (ADT) (ft)			
	Over 10,000 veh/day	5,000 to 10,000 veh/day	1,000 to 5,000 veh/day	Under 1,000 veh/day
80	470	430	380	330
70	360	330	290	250
60	300	250	210	200
50	230	190	160	150
40	160	130	110	100
30	110	90	80	70

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – TABLE 5.10, Pg. 5-50


6 2:11PM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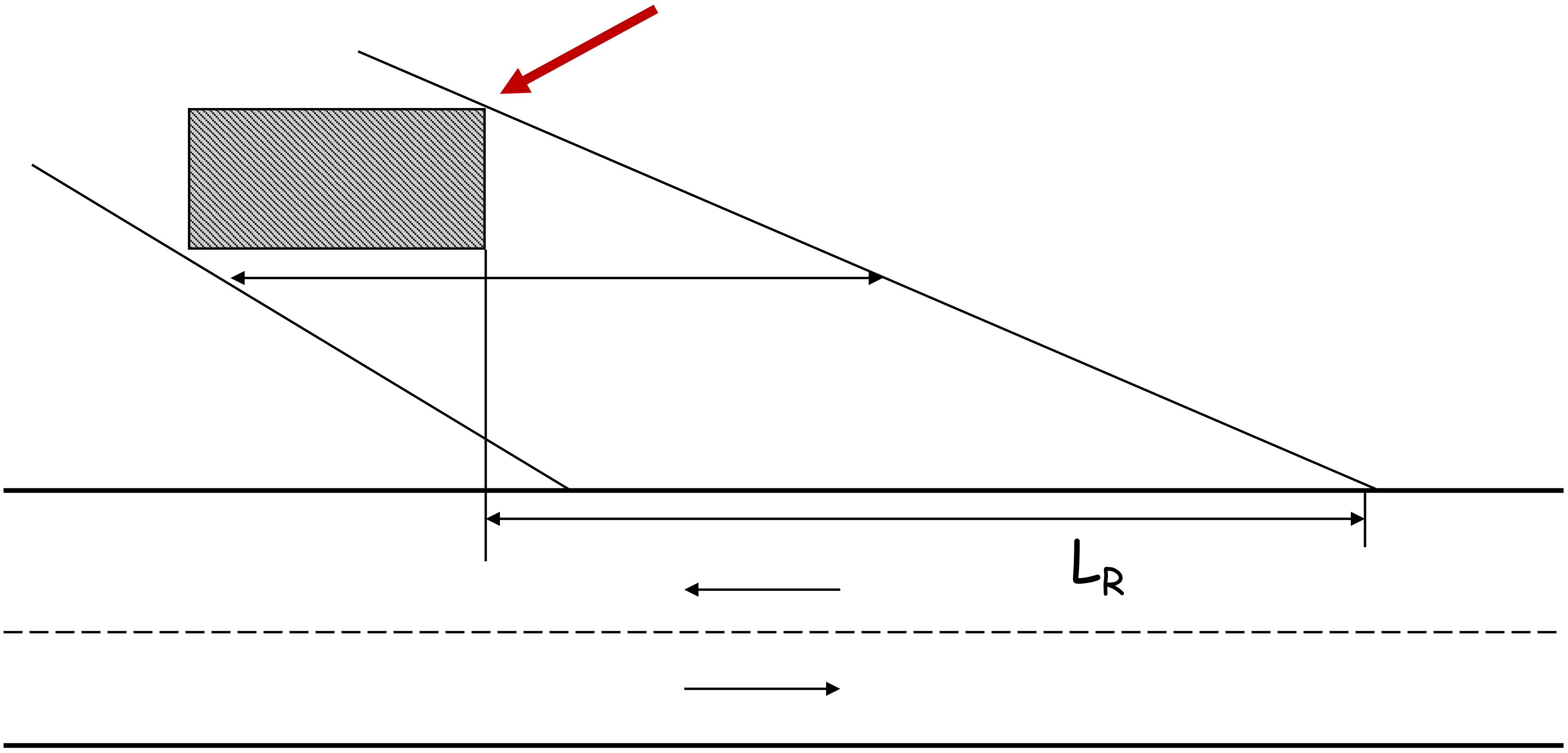
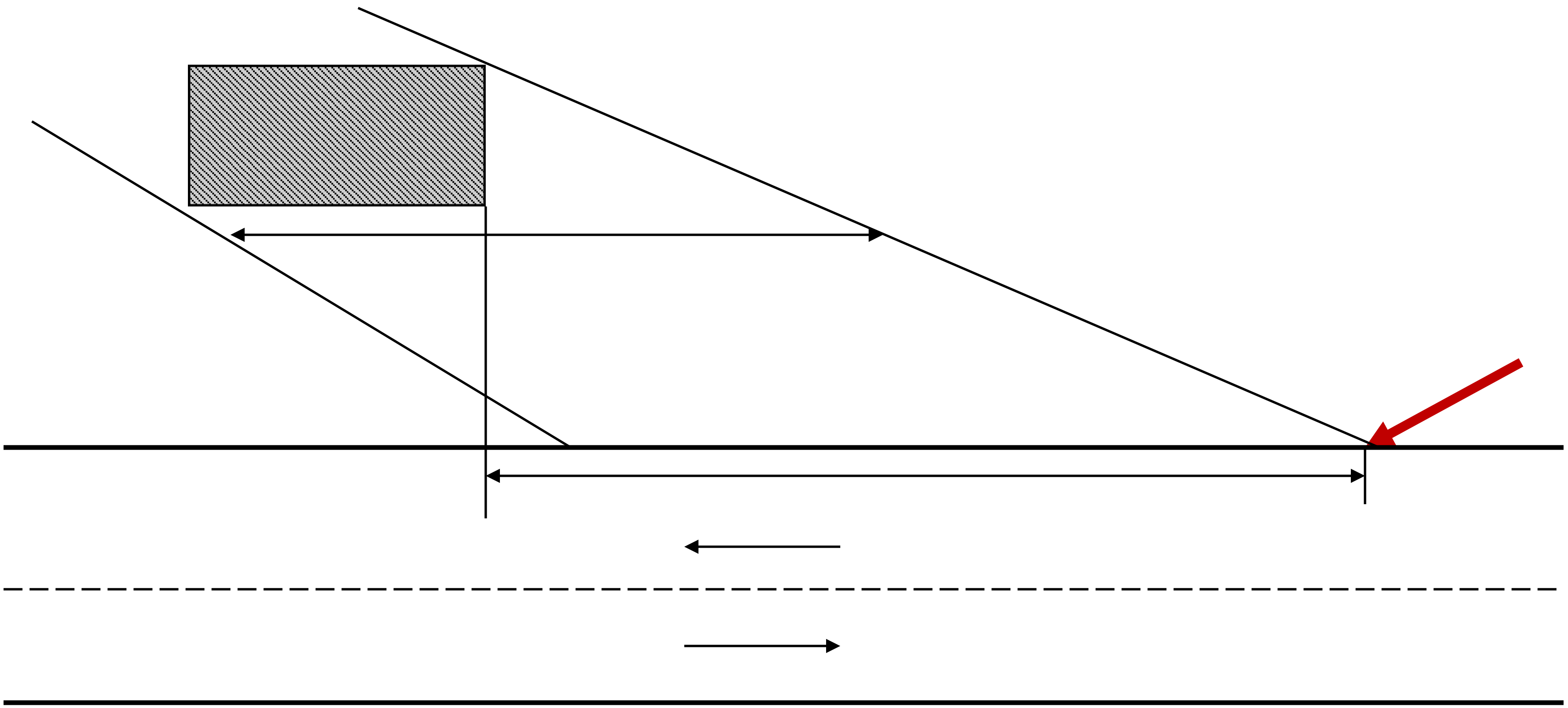
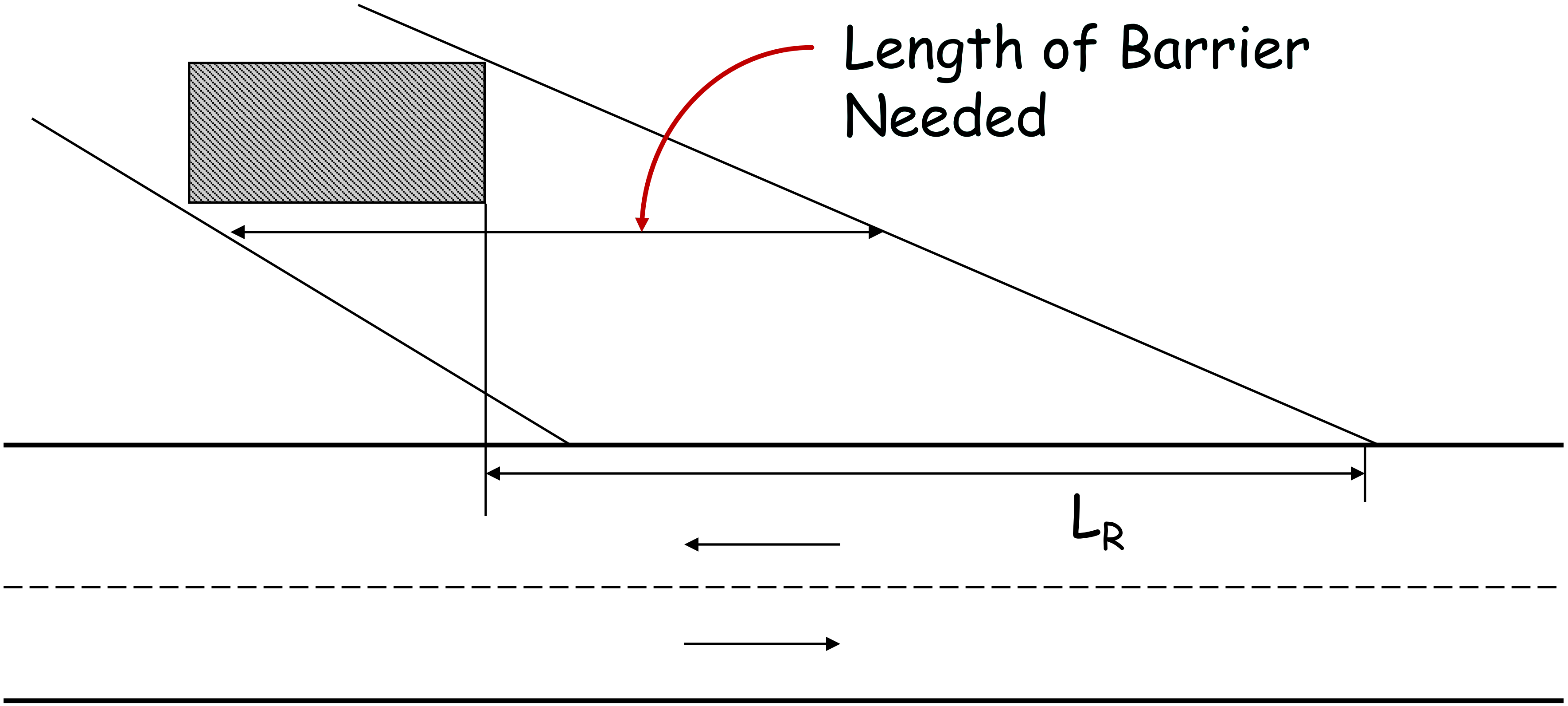
Step 1: Identify the Hazard



Step 2: Define the Point of Departure



Step 3: Intersect the Hypotenuse



Quick Field Check of LON

1. Stand on roadway edgeline opposite the upstream edge of the hazard.
2. Pace upstream along edgeline appropriate runout length (based on speed of roadway and traffic volume).
3. Turn and look at far lateral edge of hazard.
4. If planned (or existing) guardrail run intercepts this line of sight, it satisfies basic design length of need.
5. Check for “secondary” hazards that could be economically shielded by extending barrier.
6. Check for better terminal location by extending barrier a short distance.

DelDOT Guidelines for Dual Bridges

The need for guardrail at a bridge approach is based on the clear zone requirements for fixed hazards. For twin bridges, the length of approach rail on the median side of each bridge should be long enough to prevent an errant vehicle from impacting the bridge rail end of the other bridge. If it is within, or close to, the design clear zone, the guardrail should be long enough to protect the area between bridges at the edge of the clear zone. Consideration should be given to including a transverse berm between the endwalls of the two bridges.

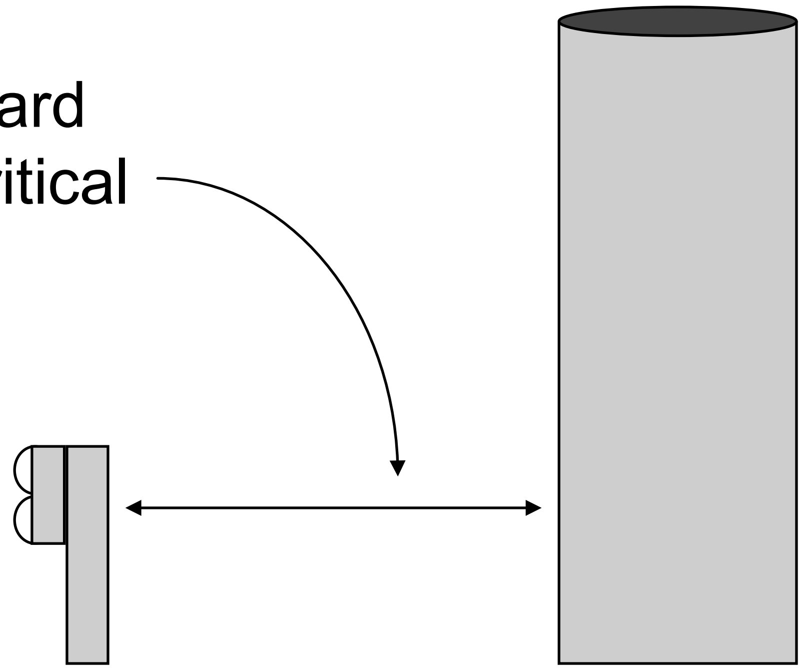
Ref: DelDOT Roadside Design Manual, Chp.10

Guardrail Placement

Place as far from outside edge of traffic lane as practical

Principle 1: Deflection Distance

Barrier to Hazard
Distance Is Critical
Element



Deflection Distance

Results of Inadequate Transition Design

Reducing Strong Post W-beam deflection

- Reduce post spacing to 3’-1½”
- Reduce post spacing again to 1’-6¾”
- Nest rail element

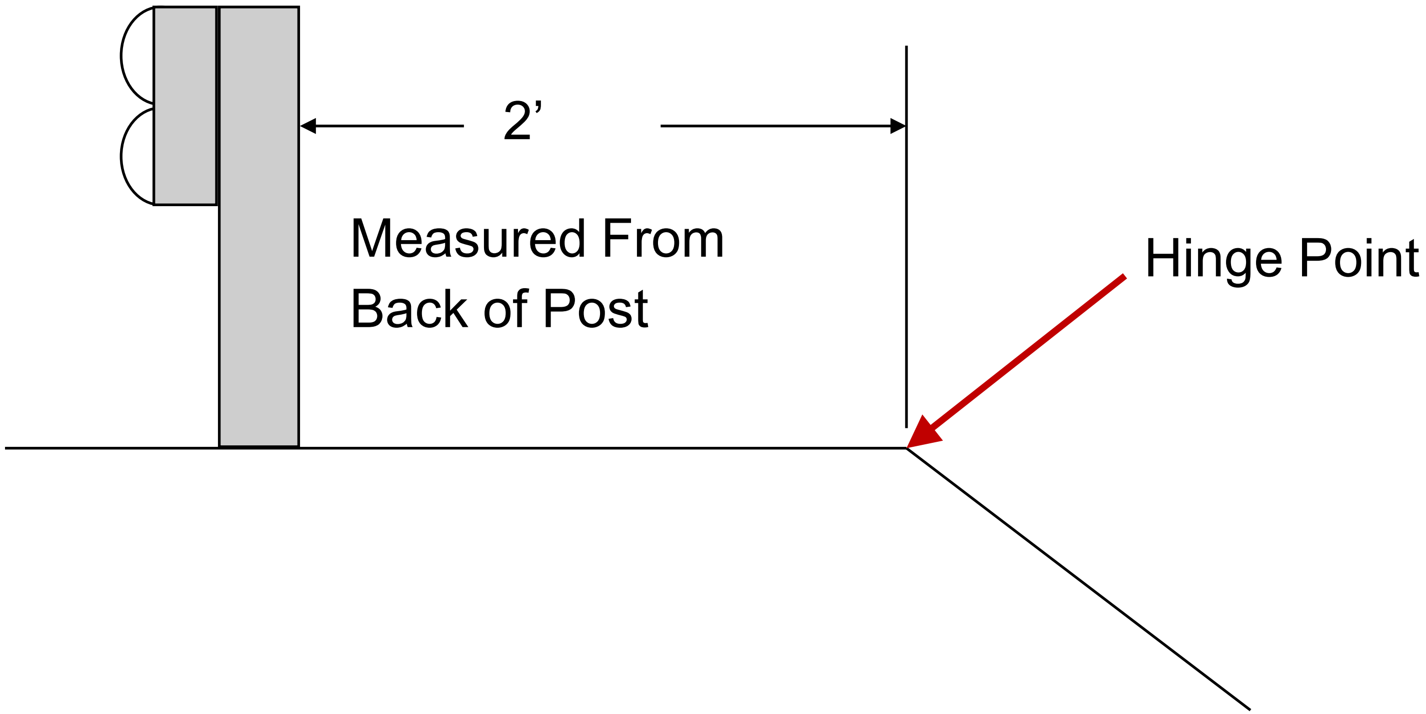
Application of Stiffening Method

Rule of thumb:

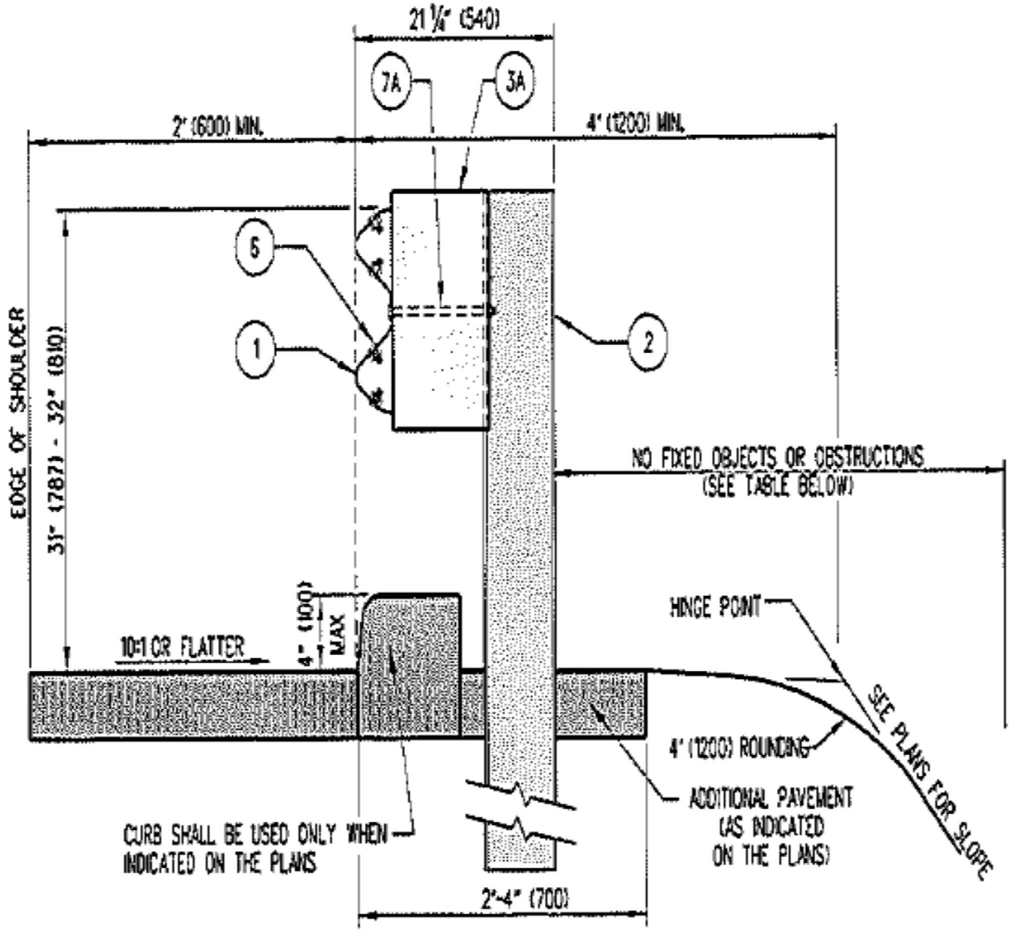
Each stiffening method reduces deflection by approximately one half

Stiffened Guardrail – Is it Necessary?

Principle 2: Soil Backing For Fill Locations



Guidelines for Guardrail on Fills

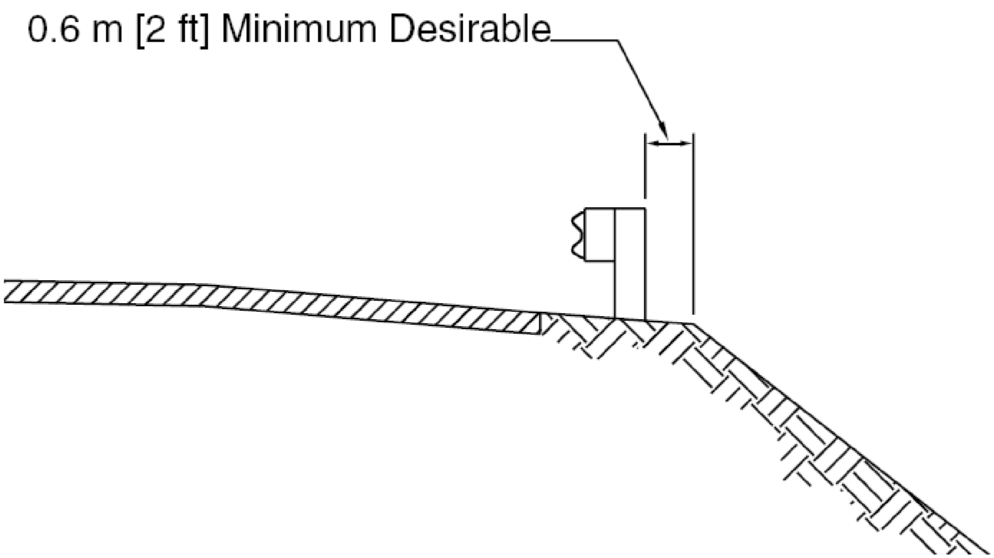


TYPE	POST SPACING	CLEAR AREA BEHIND POST
1	6'-3" (1905)	3'-0" (900) MIN
2	3'-1 ½" (952.5)	2'-0" (200) MIN

Ref: DelDOT Standard Construction Details, B-1 (2010)

Adequate Soil Backing?

Soil Backing Recommendation



1. Slope can be as steep as 2H:1V with 2-ft. backing in strong soil with 6 ft. posts.

2. Backing can be less than 2 ft. with 2H:1V slope in strong soil with 7 ft. posts.

Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – FIGURE 5.33, Pg. 5-41

Recent Test Results

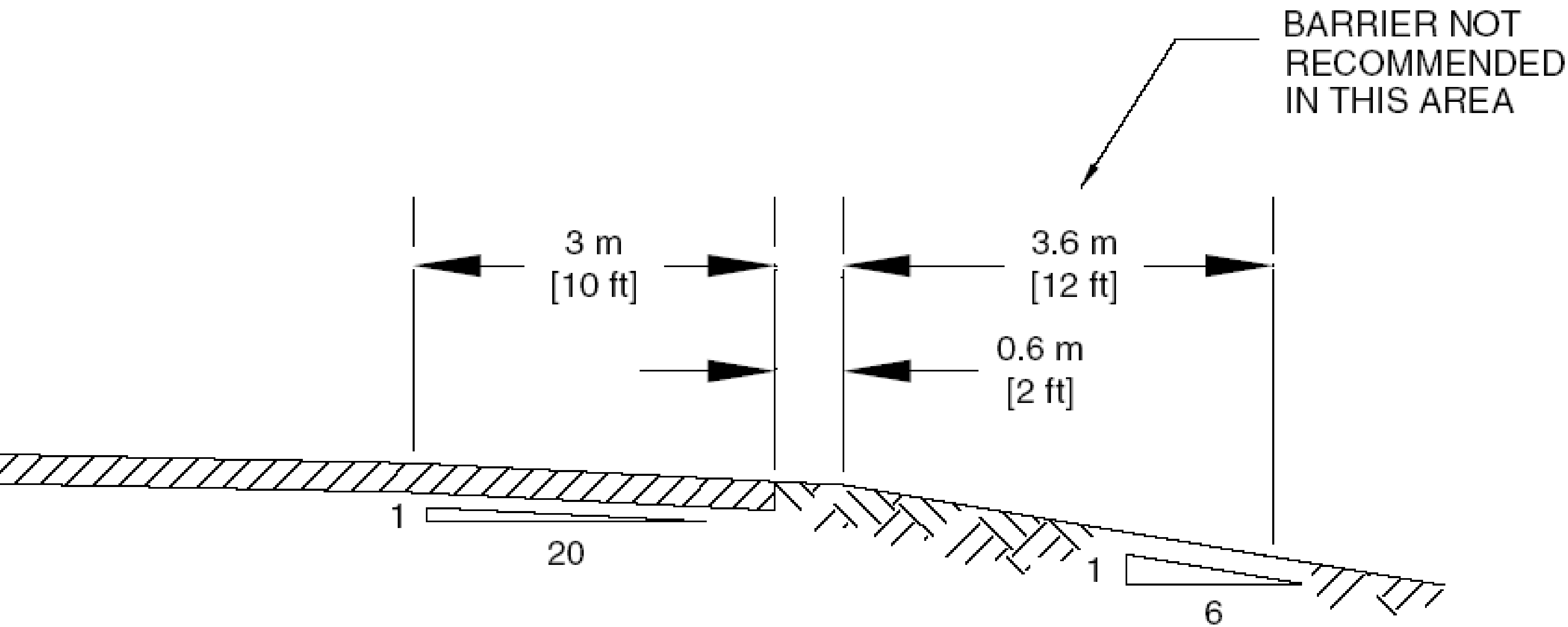
Midwest Roadside Safety Facility has tested the MGS System installed at the breakpoint of a 2H:1V slope using both 9 ft. steel posts and 7.5 ft. wood posts. Both designs used a standard 6’-3” post spacing.

Principle 3: Slope in Front of Guardrail

Guardrail on Slopes

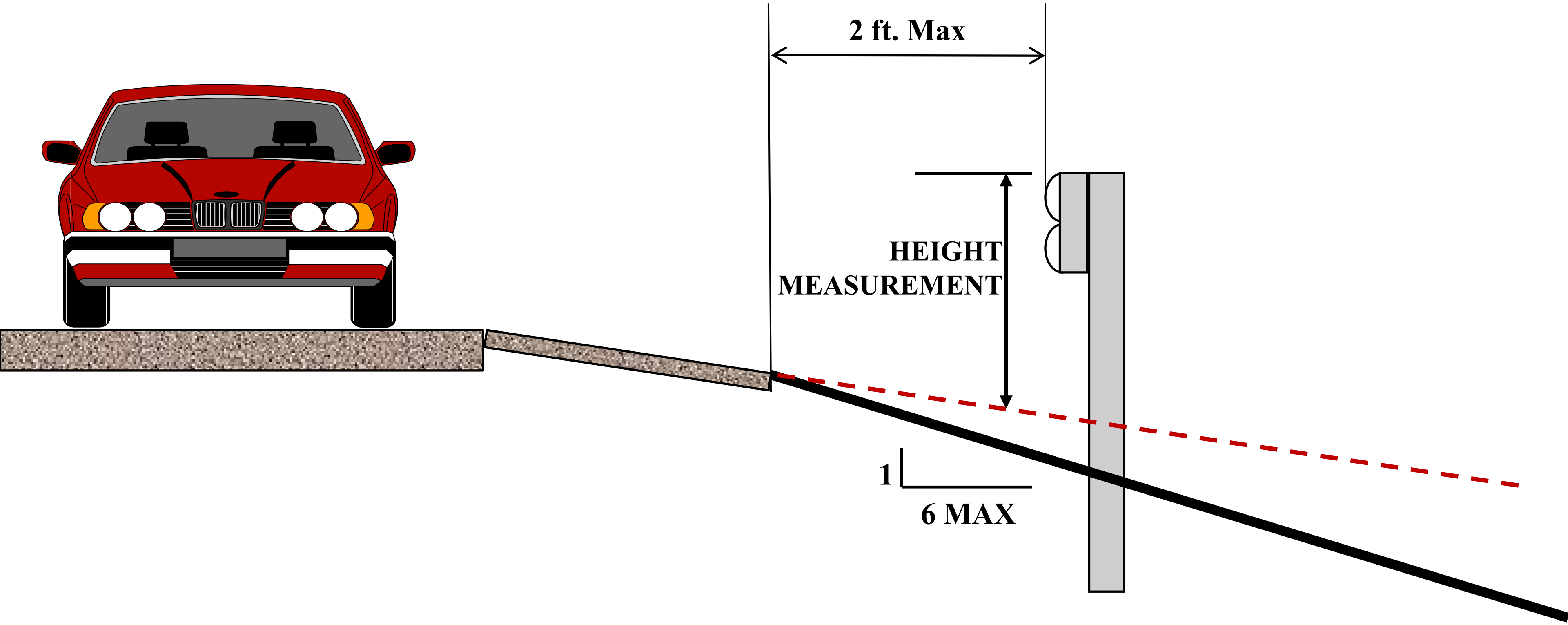
10H:1V or Flatter in Front of Barriers

Recommended beam Guardrail placement on slopes



Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – FIGURE 5.38, Pg. 5-47

Guardrail Height Measurement



Guardrail on Slopes

Guardrail on Slopes

- Any barrier may be placed anywhere on a 10H:1V or flatter slope.
- No barrier should be placed on a slope steeper than 6H:1V (exception for some high tension cable).
- Cable Guardrail may be placed on slopes of 6H:1V or steeper, but its location on these slopes is critical for minimizing penetrations.
- On slopes steeper than 10H:1V but no steeper than 6H:1V, metal beam guardrail should be placed in compliance with Figure 5-38 (AASHTO RDG).

Location of Cable in Swales

CABLE SHOULD NOT BE PLACED BETWEEN 1' AND 8' BEYOND THE BOTTOM OF A DITCH

Principle 4: Flare Rate

Flared barriers are those that are not parallel to the edge of the traveled way. They are used to:

- Locate terminals farther from the roadway.
- Lessen driver reaction to a roadside obstacle.
- Transition from barrier to an obstacle nearer the roadway (bridge parapet or railing).
- Reduce total length of rail needed.
- Reduce nuisance hits.

Flare Rate

Disadvantages of flared barriers:

- Flare *increases the maximum angle* at which the barrier can be hit.
- Flare *increases the probability* that a vehicle will be redirected into or across the roadway after an impact.
- Flared barriers may *require more grading* to provide a flat area between the traveled way and the barrier.

Flared W-Beam Guardrail Example

Flare Rate Table

Design Speed (mph)	Flare Rate for Barrier Inside Shy Line	Fare Rate for Barrier at or Beyond Shy Line	
		A	B
70	30:1	20:1	15:1
60	26:1	18:1	14:1
55	24:1	16:1	12:1
50	21:1	14:1	11:1
45	18:1	12:1	10:1
40	16:1	10:1	8:1
30	13:1	8:1	7:1

A – Suggested maximum flare rate for rigid barrier system.
B – Suggested maximum flare rate for semi-rigid barrier system

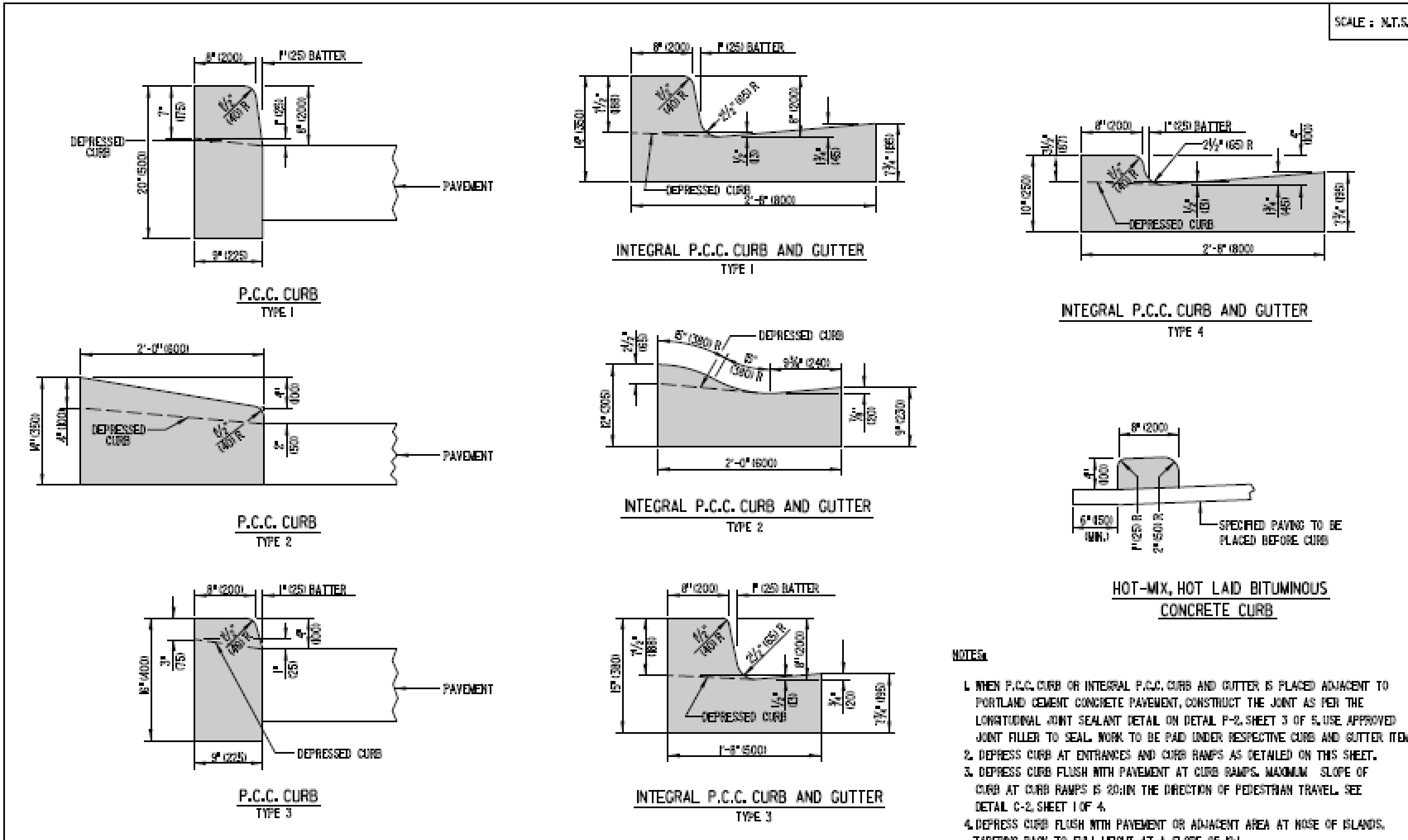
Ref: AASHTO ROADSIDE DESIGN GUIDE, 4th EDITION – TABLE 5.9, Pg. 5-48

Principle 5: Guardrail and Curbs

- Curbs – may function to channelize traffic, to control drainage, improve delineation, control access, and reduce erosion.
- Curbs are not adequate to prevent a vehicle from leaving the roadway; they are not a barrier.
- Use of any guardrail/curb combination where high-speed, high-angle impacts are likely should be discouraged.

Curbs

- Vertical – Intended to discourage vehicles from leaving the roadway and range from 6 to 8 inches high. Should not be used on high-speed facilities.
- Sloping – Designed so vehicles can cross them (mountable) readily when the need arises.
  - Steeper than 1H:1V are limited to 4 in.
  - Face slope between 1H:1V & 2H:1V, the height should be limited to 6 in.



Ref: DelDOT Standard Construction Details, C-1 (2010)

Guardrail and Curbs

Curbs should not be used along High-Speed Roadways

Effects of Terrain

- Curbs
  - Curbs and guardrails should not be used in combination where high-speed, high-angle impacts are likely.
  - If no other alternative is feasible, the effects can be reduced by stiffening the guardrail or using curbs of 4 in. or less in height.

Barrier behind 4” AC Curb

Guardrail/Curb Recommendations

Best: Remove curb

May also: Limit curb height to 4” or

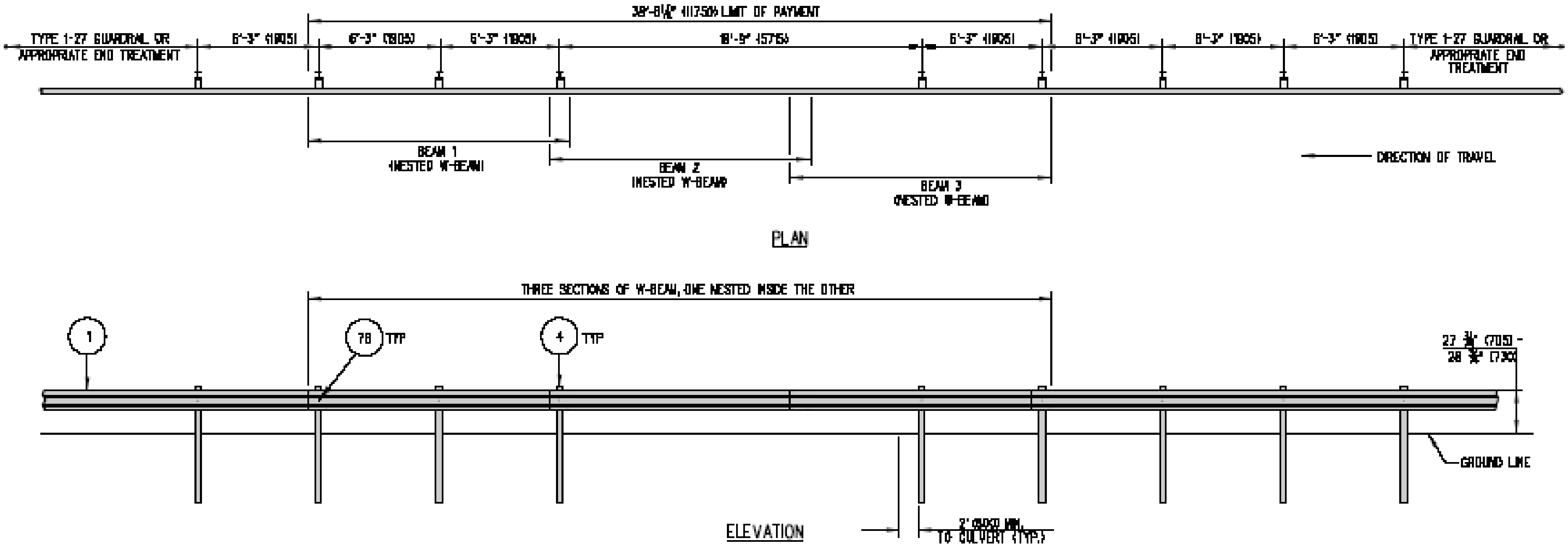
Stiffen guardrail by:

- Adding rail to back of post
- Adding a rubrail
- Reducing the post spacing
- Nesting rail elements

Special Situations

- Guardrail over Low Fill Culverts
- Guardrail Posts in Rock
- Guardrail at Intersections/Turnouts
- Weathering Steel Guardrail
- Steel-backed Timber Rail
- Transitions to Bridge Railings/Parapets

Guardrail over Low Fill Culverts



Ref: DELDOT STANDARD CONSTRUCTION DETAILS, B-16

Example of Guardrail over Culvert

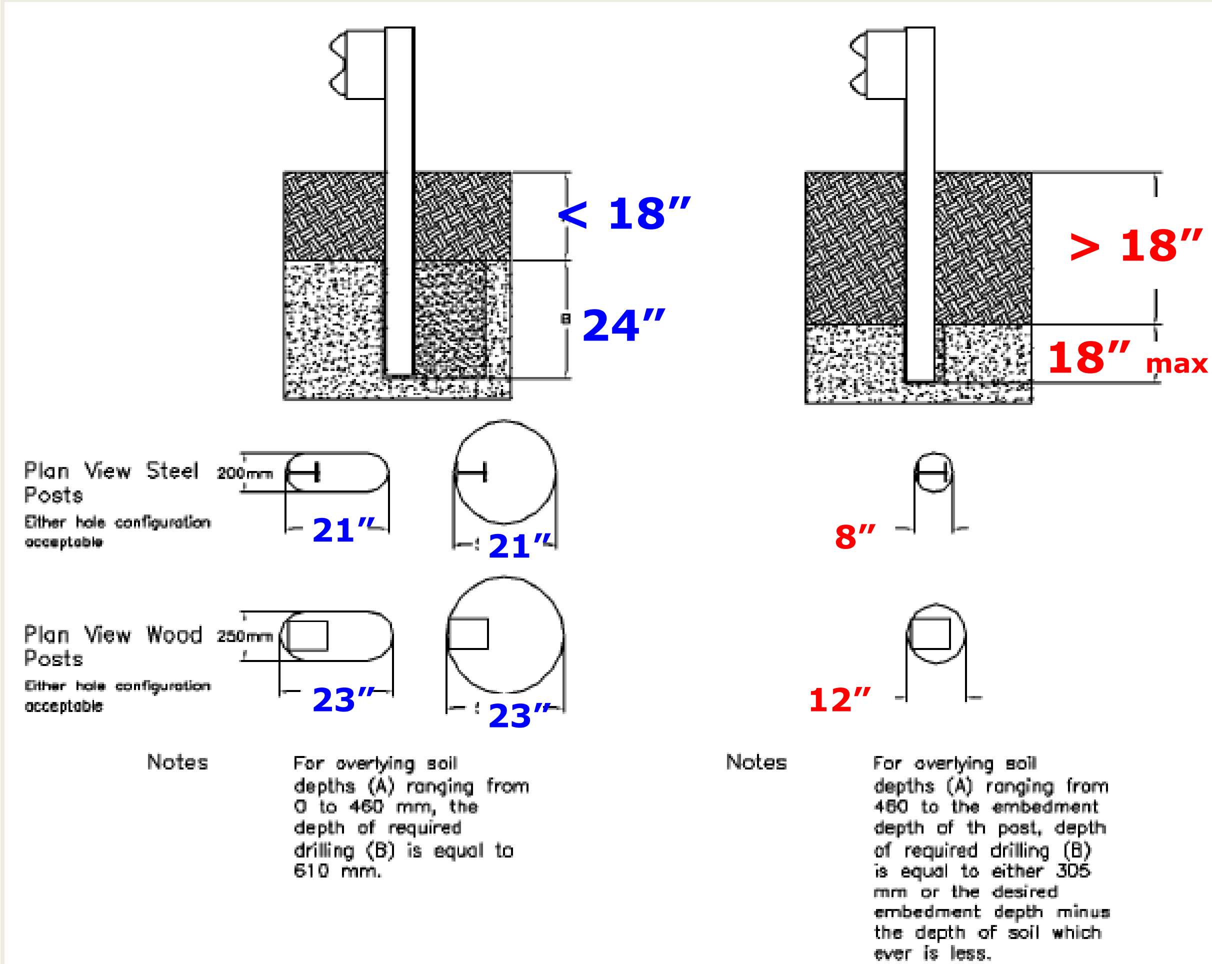
Guardrail Posts in Rock

Drill a 12”-16” diameter hole so that the Guardrail post is a minimum of 20” into the rock (extra length may be cut off/galvanize end) or its full length.

Concrete cannot be used as backfill.

Ref: DelDOT Specifications 720566

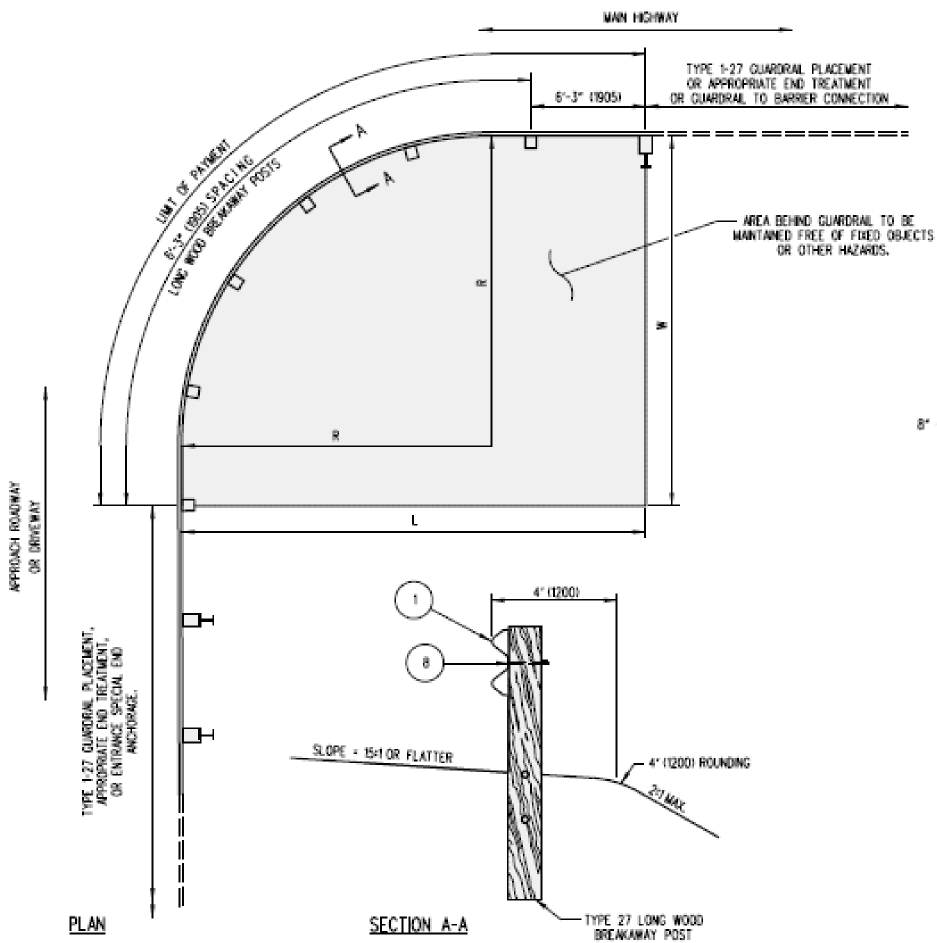
Guardrail Posts in Rock



Guardrail at Intersections

Short Radius at Intersecting roadways

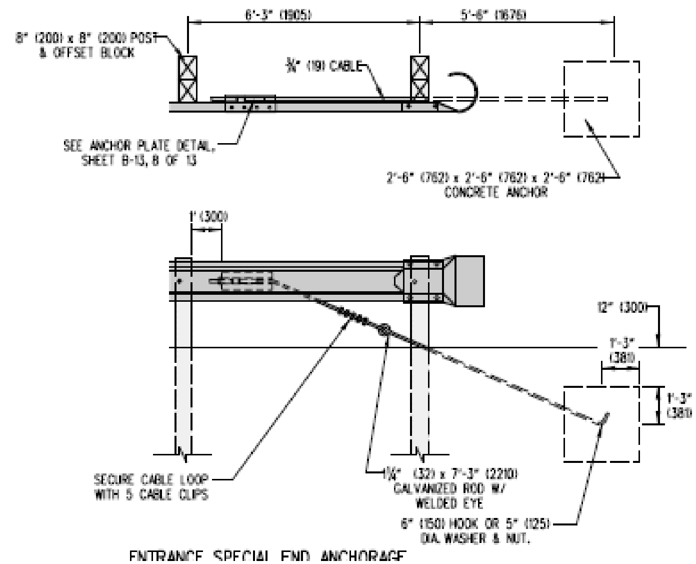
Guardrail Placement at Intersections



SCALE : N.T.S.

RADIUS	MIN. REQUIRED AREA FREE OF FIXED OBJECTS L x W
8'-6" (2600)	25' x 15' (7600 x 4500)
17'-0" (5200)	30' x 15' (9144 x 4500)
25'-6" (7800)	40' x 20' (1200 x 6000)
35'-0" (10700)	50' x 20' (15200 x 6000)

NOTES:
1). NO WASHERS ARE USED ON THE RAIL SIDE OF THE LONG WOOD BREAKAWAY POSTS.
2). THE CURVED GUARDRAIL SECTION SHALL BE SHOP BENT.
3). PLACE GUARDRAIL DELINEATORS AT THE INTERVALS SPECIFIED IN THE DELAWARE MANUAL ON UNIFORM TRAFFIC CONTROL DEVICES.
4). IF CURB IS USED IN CONJUNCTION WITH CURVED GUARDRAIL SECTION, THE CURB CANNOT BE HIGHER THAN 2" (50).
5). ON THE 8'6' (2600) RADIUS SYSTEM ONLY, THE RAIL IS NOT TO BE BOLTED TO THE CENTER POST.



Ref: DELDOT STANDARD CONSTRUCTION DETAILS, B-18

Guardrail Placement at Intersections

- Curved Radius Treatment
  - Treatment for driveways, turnouts, or side roads along what would otherwise be a continuous run of barrier.
  - Common treatment uses shop-bent W-beam panels around the intersection radius, using either standard post spacing or halving the post spacing to create additional stiffness.
  - NCHRP 230 design used weakened wood posts around the radius and removed the bolt from the rail-to-post connection at the center post; acted like a bullnose.
  - Need sufficient unobstructed area behind the radius to allow for the large deflection of the system (should be specified on the detail).


SPEED LIMIT
40


28 SOUTH
Dulles Airport
Centreville
EXIT 1/2 MILE
SPEED LIMIT 50
SPEED LIMIT 50


Creek

Weathering Steel Guardrail

- Cor-Ten Steel (A-588)
- Powder-coated Steel

Use of Weathering Steel Guardrail (Cor-Ten or A-588)

Q. Is it OK to use Weathering Steel (sometimes called Cor-Ten, A-588, or Rusting Steel) in longitudinal barriers?

A. … the use of weathering steel Guardrail is not recommended.... However, where aesthetic concerns are **primary,** weathering steel Guardrail may be used **if the owner agency adopts a frequent periodic inspection and replacement schedule….**

When exposed to salt spray or de-icing chemicals, weathering steel may not develop the 'patina' that slows corrosion. Eventually, significant section loss can result. ..

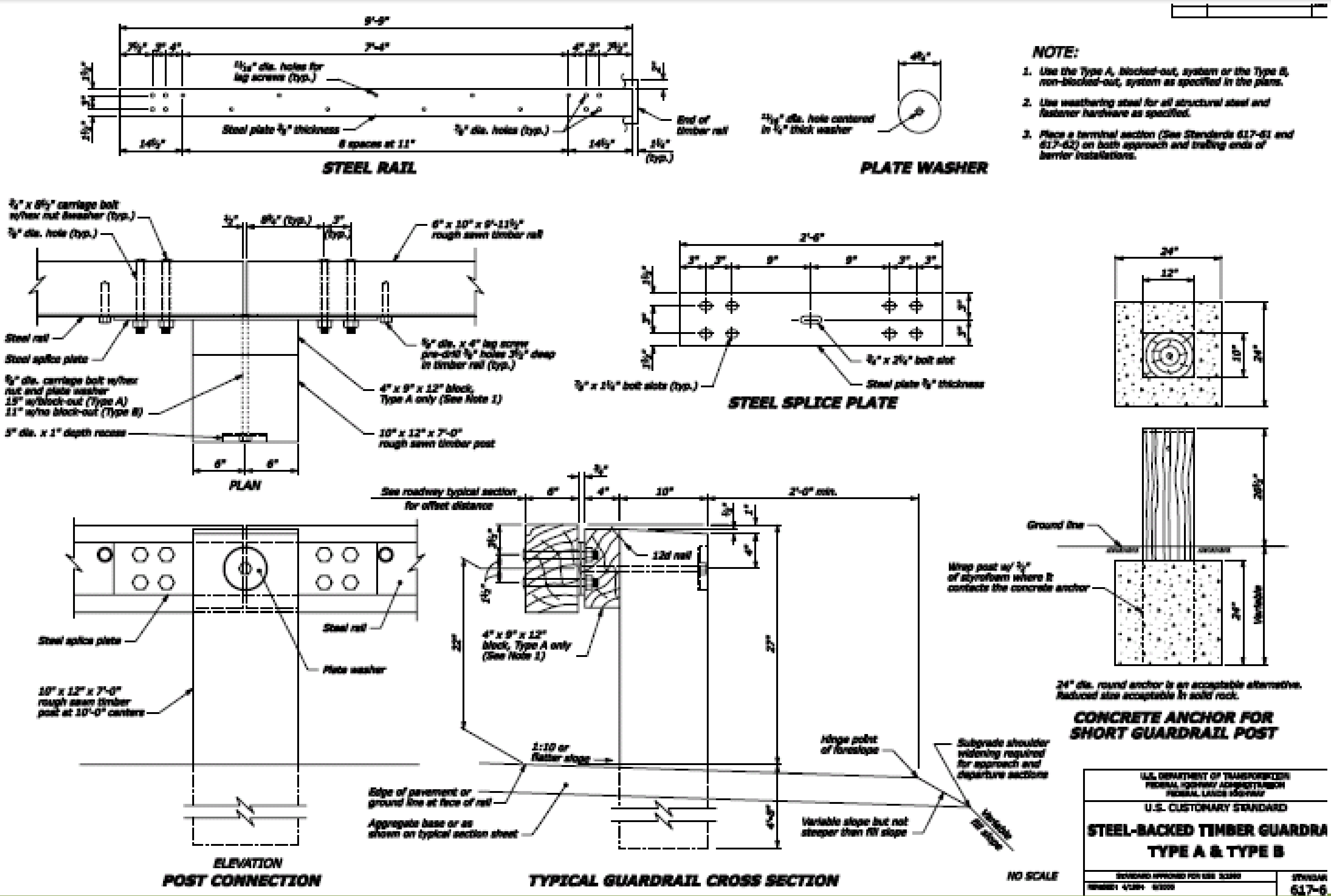
The lapped splices in w-beams panels can corrode rapidly to the point where the barrier becomes ineffective…

http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/qa_bttabr.cfm#brrs1


Commuter
Information
800-745-RIDE

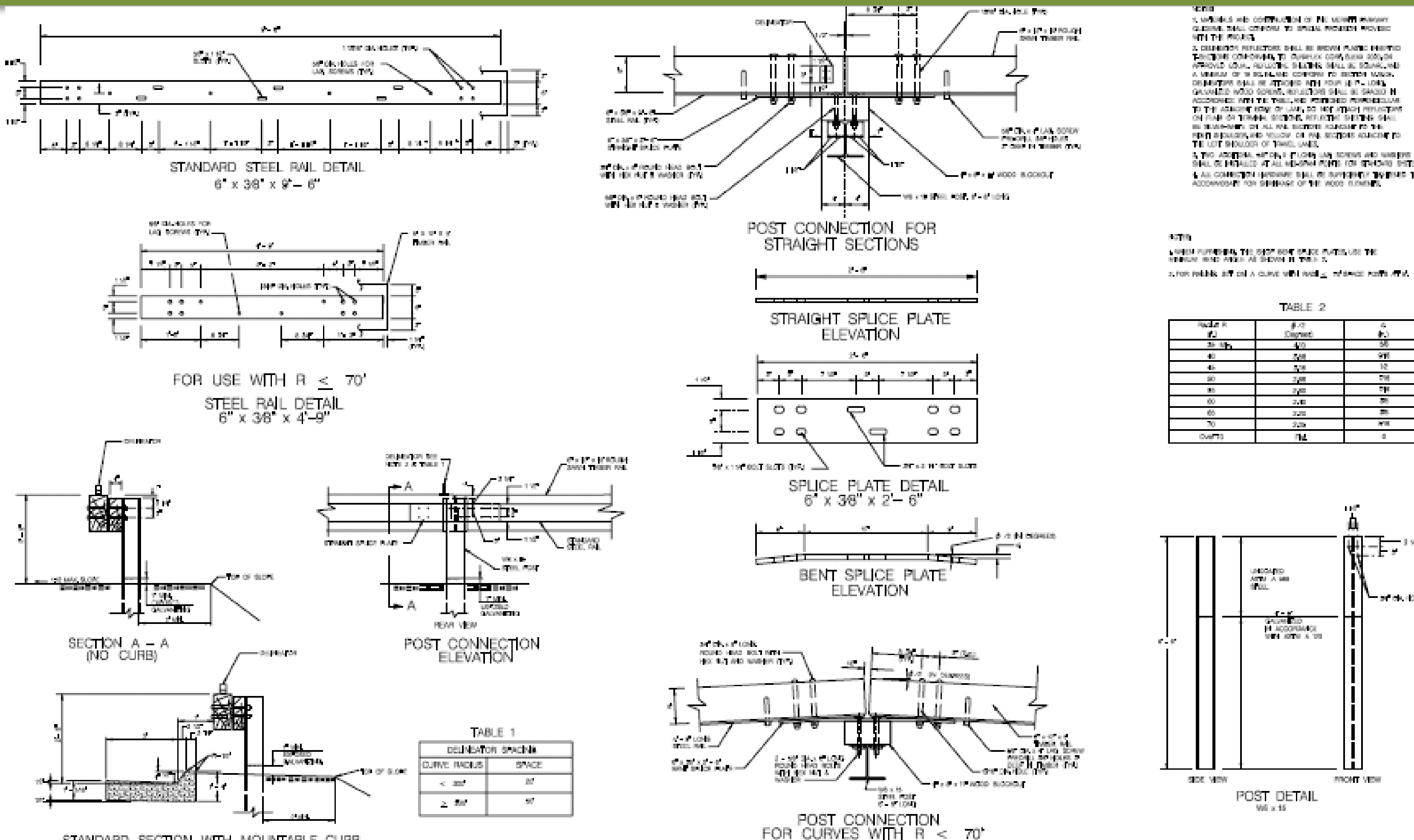

Steel-Backed Timber Rail

Steel-Backed Timber Guardrail



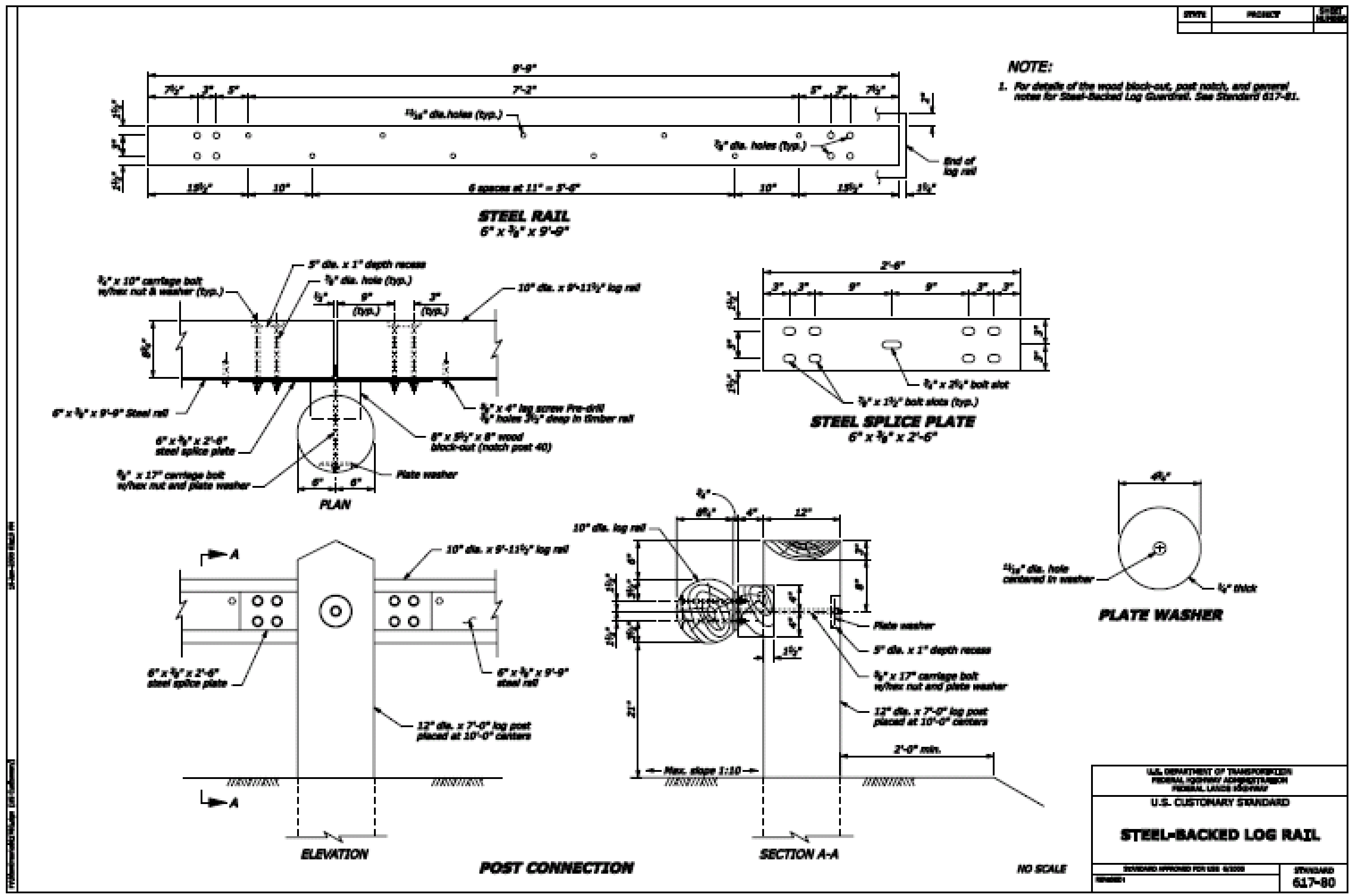
Ref: Eastern Federal Lands

Merritt Parkway Guardrail



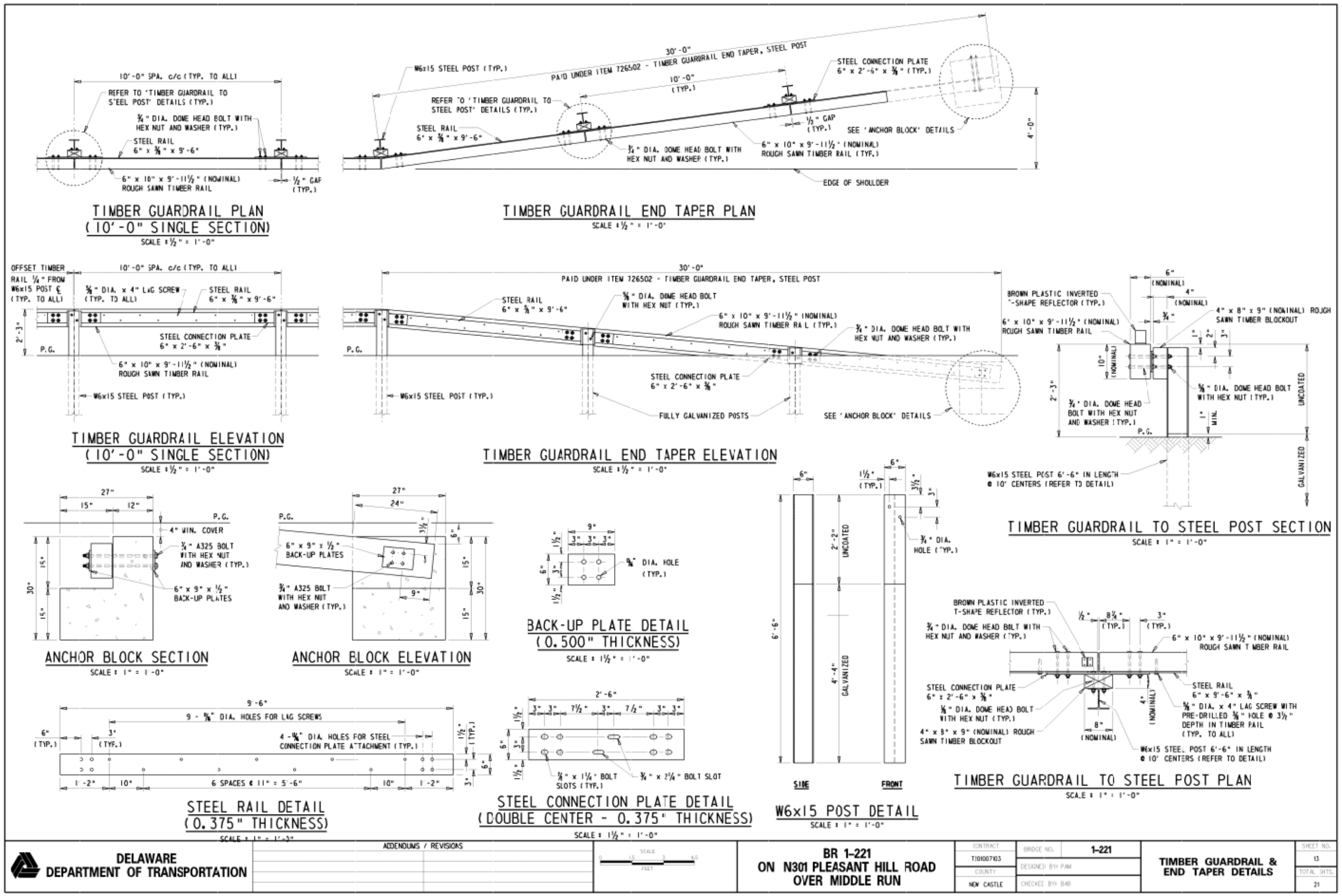
Ref: Connecticut DOT

Steel-Backed Log Guardrail



Ref: Eastern Federal Lands

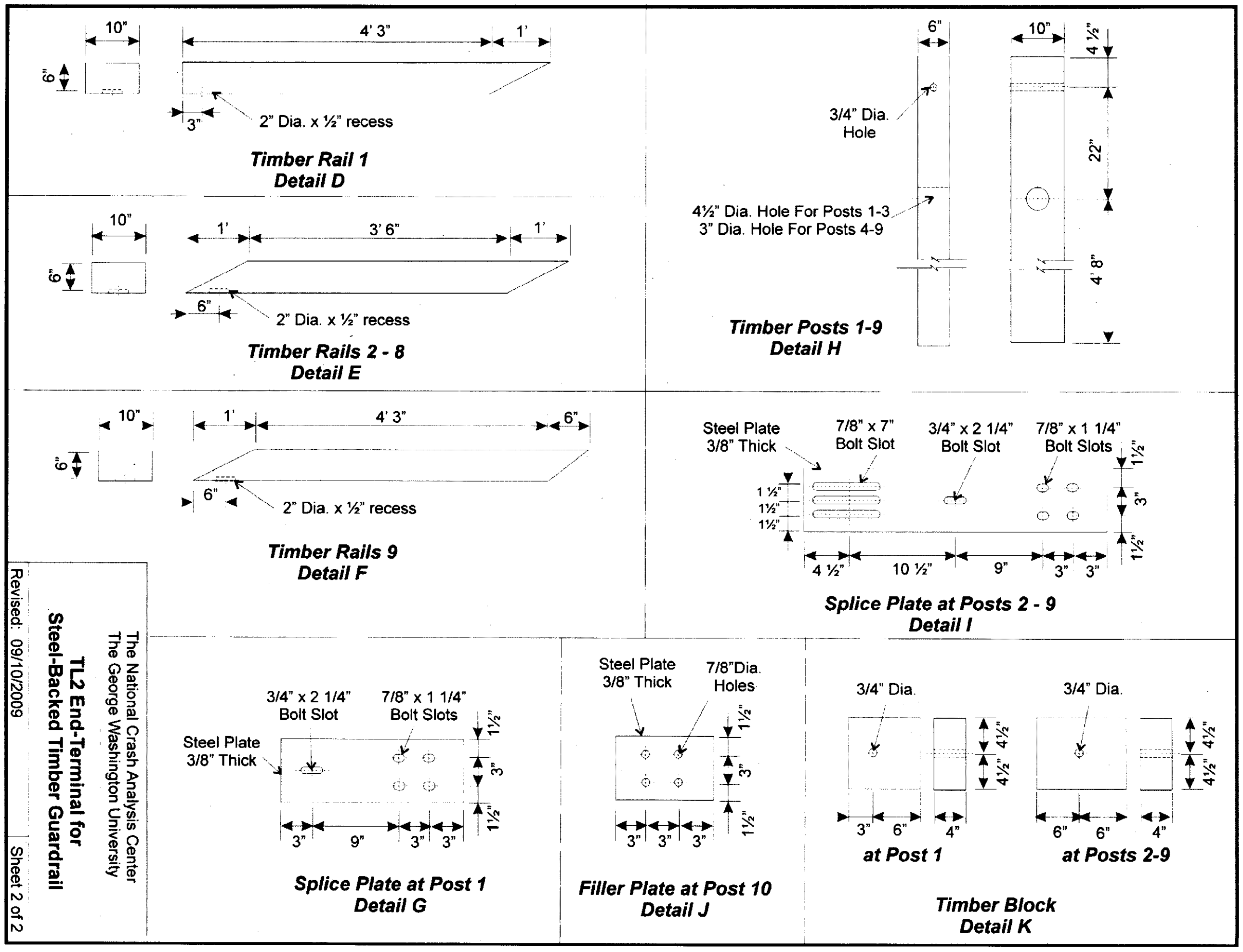
Timber Guardrail and End Treatment Details



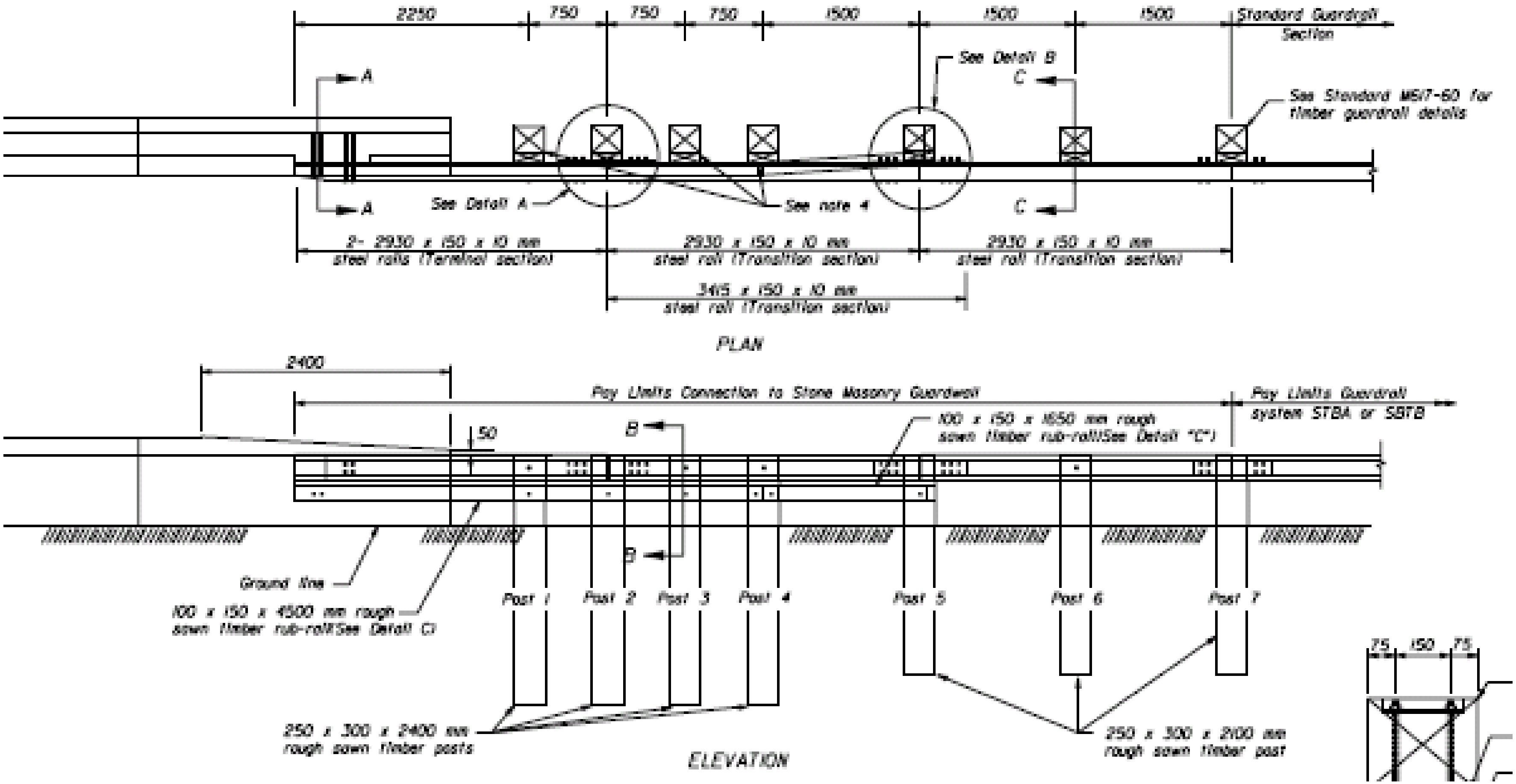
Ref: DelDOT Timber Guardrail & End Taper Details, BR 1-221

TL-2 Timber Guardrail Terminal

TL-2 Terminal Details

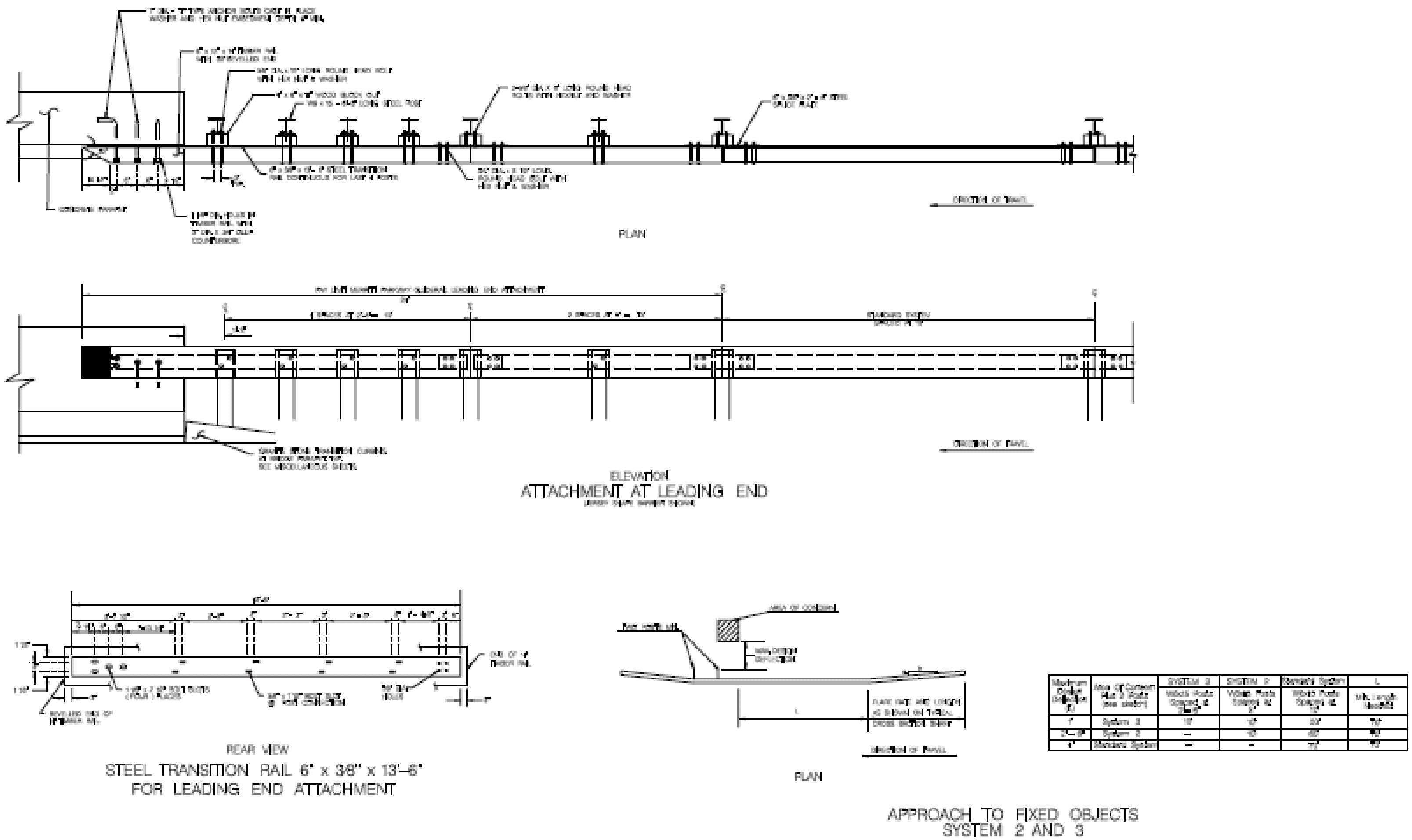


Steel-Backed Timber Guardrail Transition to Masonry Wall



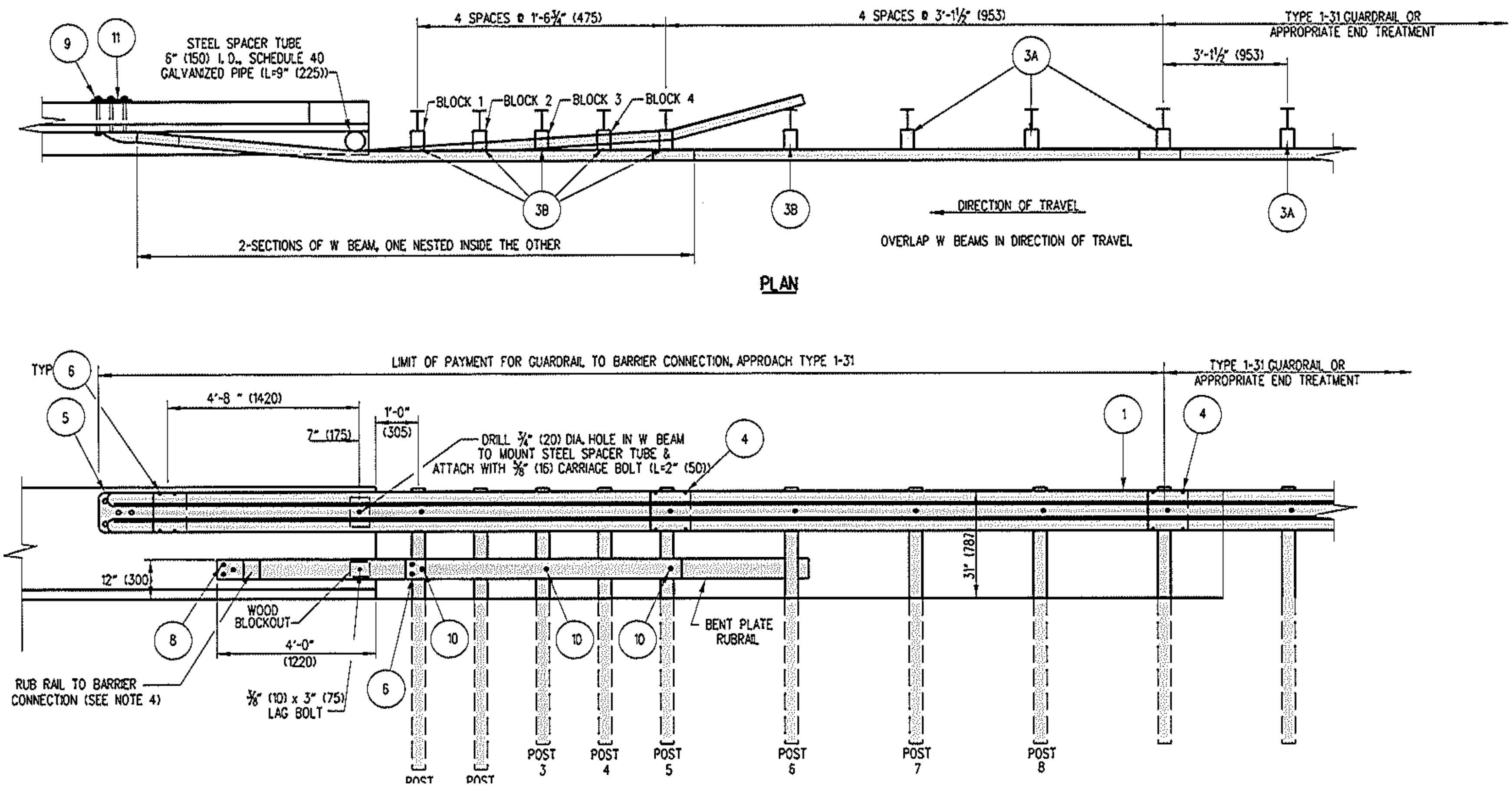
Ref: Eastern Federal Lands

Steel-Backed Timber Guardrail Transition



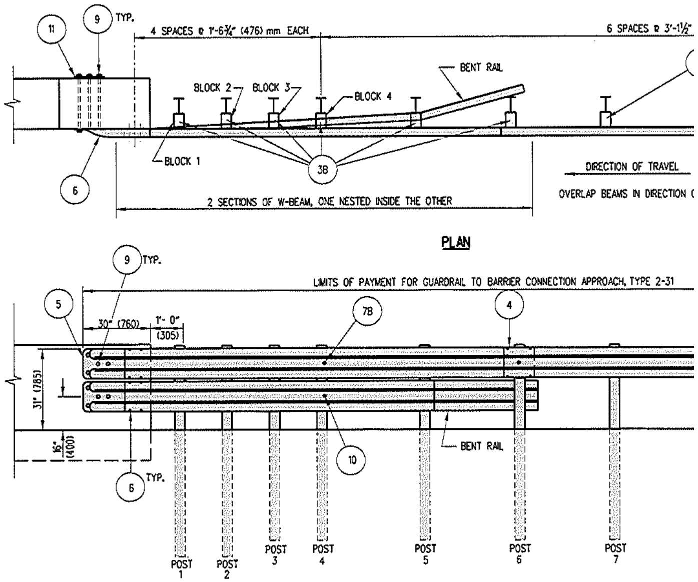
Ref: Connecticut DOT

Transitions to Bridge Railings

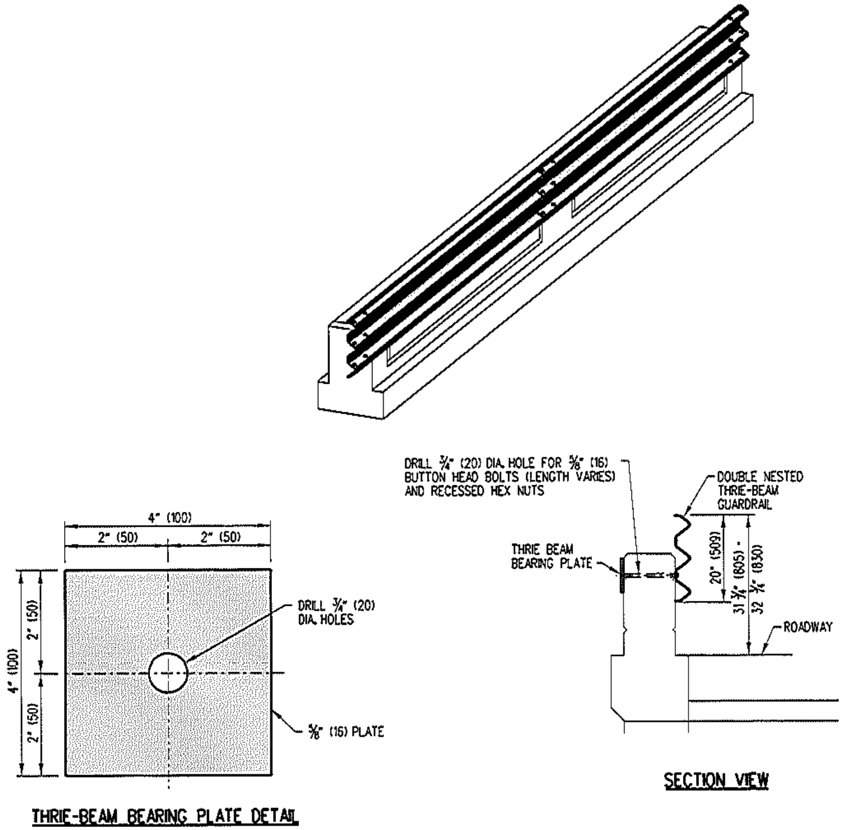


Ref: DelDOT Standard Construction Details, B-5

Bridge Transition and Retrofit Design



Type 2-31 Transition



Type 4 Retrofit

Ref: DelDOT Standard Construction Details

Session 3 Outcomes

- Define LON and Evaluate Examples of Field Installations.
- Apply a Field Procedure to Check LON adequacy.
- Understand site characteristics impacting barrier layout and crash performance.