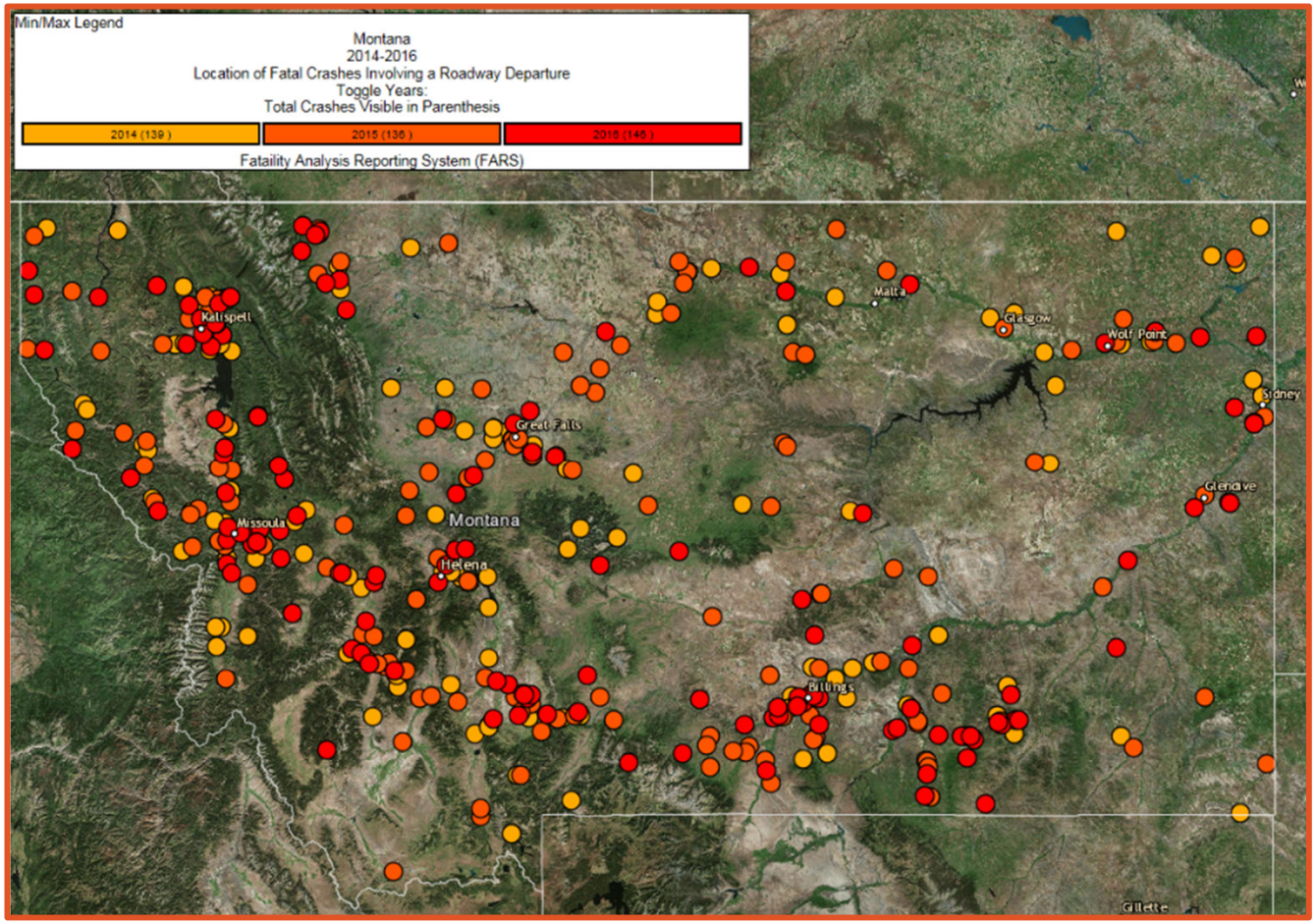
VISION ZERO
zero deaths • zero serious injuries
MONTANA DEPARTMENT OF TRANSPORTATION

MASH GUARDRAIL IMPLEMENTATION AND DESIGN



Chad Welborn, P.E.
MDT/MSU Design Engineer

MDT Preconstruction Conference
February 15, 2018



ROADWAY DEPARTURE CRASHES:

← fatal roadway departure crashes in the last three years (2014-2016)

20% of all crashes

67% of fatal crashes

Severe due to high speeds and rural conditions

1. Keep Vehicles on Roadway
2. Provide for Safe Recovery
3. Reduce Crash Severity



TRAINING OBJECTIVES

1. Describe MDT's MASH Implementation Plan
2. Recognize the changes to MDT's guardrail Detailed Drawings
3. Select and design roadside barriers using MASH devices
4. Incorporate MASH devices into the Road Plans

1 – MDT'S MASH IMPLEMENTATION PLAN

1.1 – Crash Testing (NCHRP 350 and MASH)

1.2 – AASHTO/FHWA Agreement and Implementation Schedule

1.3 – Applying the MDT Implementation Plan

NCHRP REPORTS

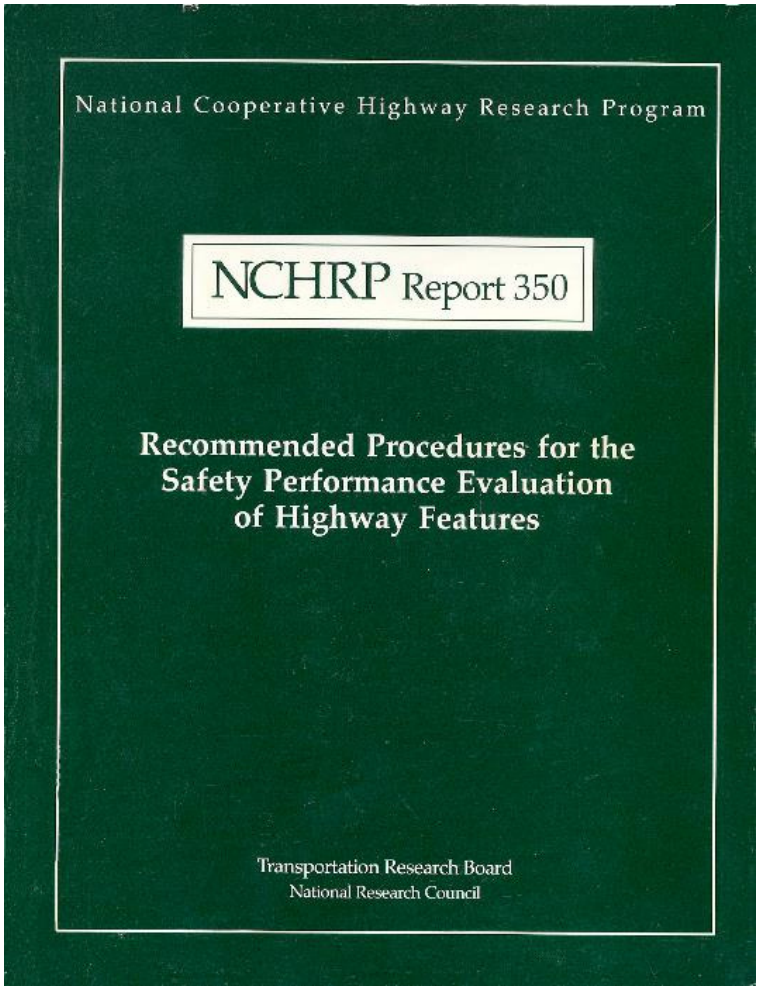
National Cooperative Highway Research Program

NCHRP Report 230 – 1980 to 1993

- 4500-pound passenger car

NCHRP Report 350 – 1993 to 2009

- ¾-ton pickup

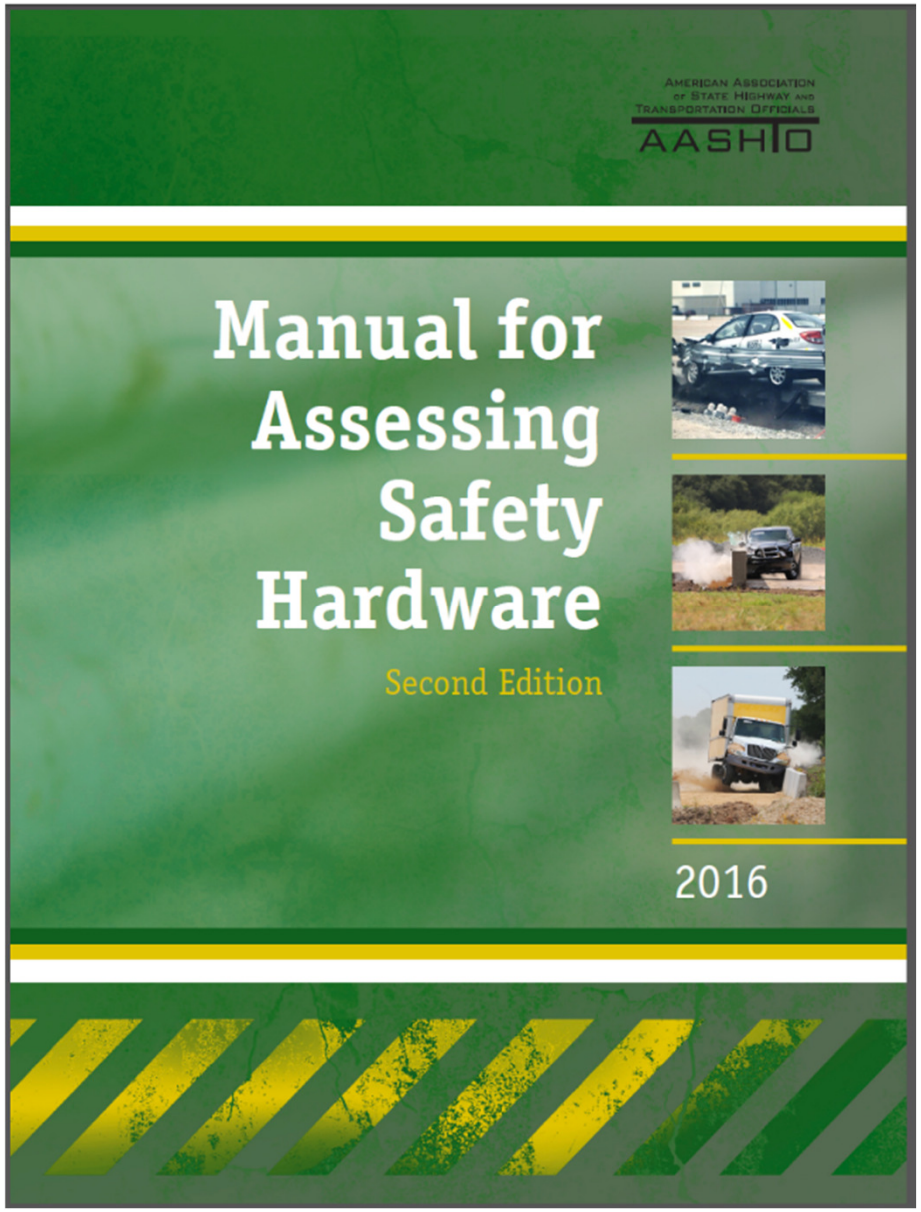


MASH

Manual for Assessing Safety Hardware

MASH – 2009 to Present

- Small Car and Pickup Mass Increased
- Impact Angles Increased



Test Parameter	NCHRP 350	MASH
Small car test vehicle	820 C vehicle (1,809 lbs.)	1100C Vehicle (2,420 lbs.)
Small car impact angle	20 degrees	25 degrees
Light truck test vehicle	2000P vehicle (4,409 lbs.)	2270P vehicle (5,000 lbs.)
Light truck impact angle	20 degrees	25 degrees
Intermediate test vehicle	None	1500A vehicle (3,300 lbs.)
TL-4 Truck Test	8000S vehicle (18,000 lbs.)	10000S vehicle (22,000 lbs.)





1.1 – CRASH TESTING (NCHRP 350 AND MASH)

MASH Test Level	Test Conditions			
1				
2				
3				
4				

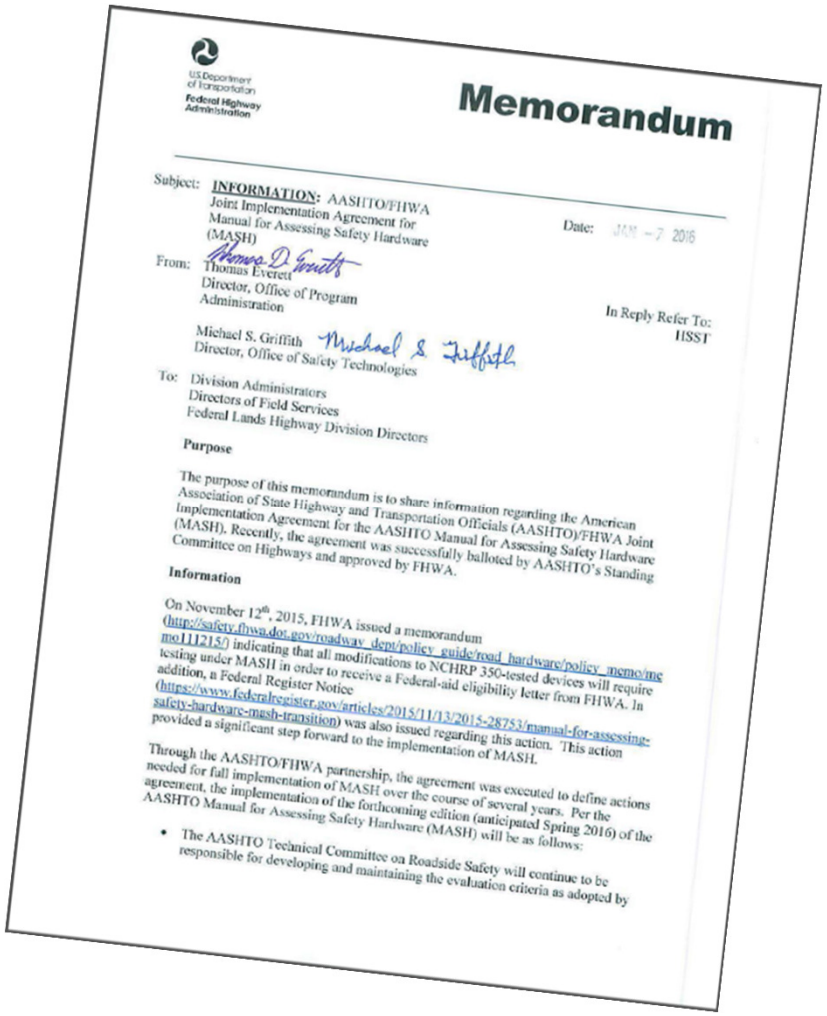
**From AASHTO MASH Table 1-1. Test Levels 5 and 6 also available for Tractor-Van Trailer and Tractor-Tank Trailer, respectively. Test conditions also include impact angle.*

MASH IMPLEMENTATION:

- MASH is an update to and supersedes NCHRP Report 350 for the purpose of evaluating new safety hardware products.

- Implementation agreement for MASH did not require a sunset date for NCHRP Report 350 hardware manufacturing or installation. Products such as the SKT and ET-Plus continue to be manufactured and installed today.

- AASHTO/FHWA Joint Implementation Agreement for the AASHTO Manual for Assessing Safety Hardware, approved December 21, 2015.



U.S. Department of Transportation
Federal Highway Administration

Memorandum

Subject: **INFORMATION:** AASHTO/FHWA Joint Implementation Agreement for Manual for Assessing Safety Hardware (MASH)

Date: JAN -7 2016

From: Thomas Everett
Director, Office of Program Administration

In Reply Refer To: HSST

Michael S. Griffith
Director, Office of Safety Technologies

To: Division Administrators
Directors of Field Services
Federal Lands Highway Division Directors

Purpose

The purpose of this memorandum is to share information regarding the American Association of State Highway and Transportation Officials (AASHTO)/FHWA Joint Implementation Agreement for the AASHTO Manual for Assessing Safety Hardware (MASH). Recently, the agreement was successfully balloted by AASHTO's Standing Committee on Highways and approved by FHWA.

Information

On November 12th, 2015, FHWA issued a memorandum (http://safety.fhwa.dot.gov/roadway_dept/policy_guide/road_hardware/policy_memo/memo111215/) indicating that all modifications to NCHRP 350-tested devices will require testing under MASH in order to receive a Federal-aid eligibility letter from FHWA. In addition, a Federal Register Notice (https://www.federalregister.gov/articles/2015/11/13/2015-28753/manual-for-assessing-safety-hardware-mash-transition) was also issued regarding this action. This action provided a significant step forward to the implementation of MASH.

Through the AASHTO/FHWA partnership, the agreement was executed to define actions needed for full implementation of MASH over the course of several years. Per the agreement, the implementation of the forthcoming edition (anticipated Spring 2016) of the AASHTO Manual for Assessing Safety Hardware (MASH) will be as follows:

- The AASHTO Technical Committee on Roadside Safety will continue to be responsible for developing and maintaining the evaluation criteria as adopted by

IMPLEMENTATION SCHEDULE:

Letting Date After:	MASH Hardware Required:	
December 31, 2017	W-Beam Barriers Cast-In-Place Concrete Barriers	
June 30, 2018 *(December 31, 2017 for MDT)*	W-Beam Terminals	
December 31, 2018	Cable Barriers, Terminals Crash Cushions	
December 31, 2019	Bridge Rails, Transitions Sign Supports All other barriers, terminals, breakaway hardware	

MDT POLICY:

POL 5.03.002 – ROADSIDE SAFETY HARDWARE UPGRADES (6/28/2017)

- Permanent new and full replacement hardware: meet 2016 MASH per compliance dates established
- Existing pre-NCHRP 350 hardware: remove and replace per the Guidelines for Nomination and Development of Pavement Projects



DESIGN MEMO

February 8, 2018: MASH Guardrail Implementation Guidance

- New Bid Items Overview
- Detailed Drawings Overview
- Design Guidance and Examples
- Policy Exceptions



OBJECTIVE SUMMARY

1

Describe MDT's MASH Implementation Plan

MASH replaced NCHRP 350 in 2009.

AASHTO/FHWA announced the implementation of MASH in late 2015.

MDT adopted a MASH transition policy in June 2017.

First deadline that will impact projects is December 31, 2017.

2 – DETAILED DRAWING CHANGES

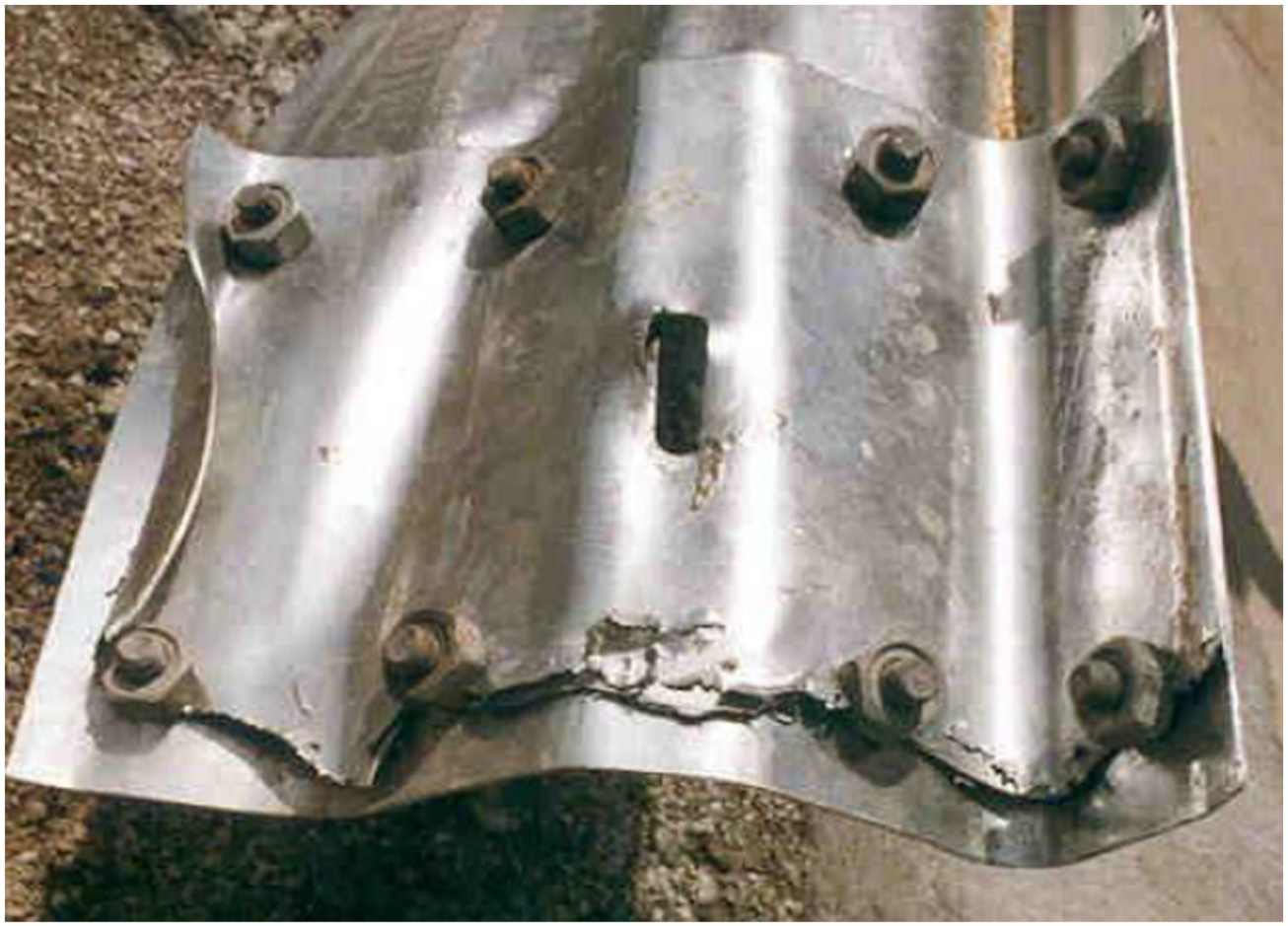
2.1 – MGS Metal Guardrail

2.2 – Terminal Sections

ISSUES WITH CURRENT W-BEAM:



ISSUES WITH CURRENT W-BEAM:



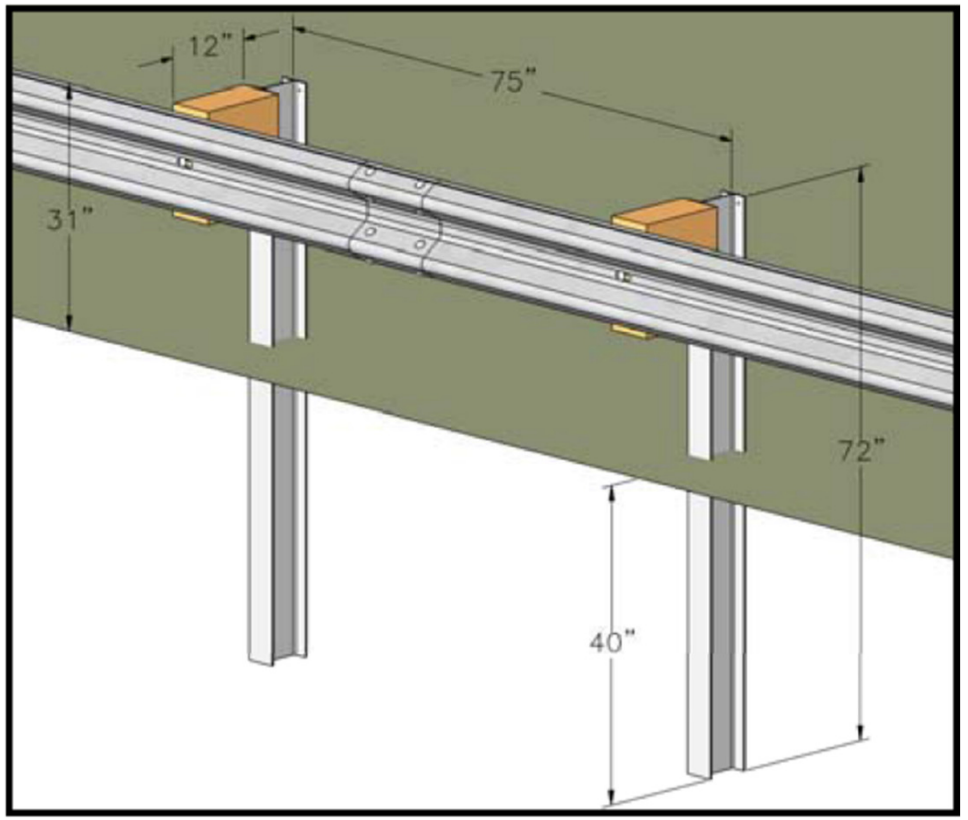
SOLUTION:

Midwest Guardrail System (MGS)

- Non-proprietary system developed by MwRSF (U of Nebraska) using the Midwest Pooled Fund Program.

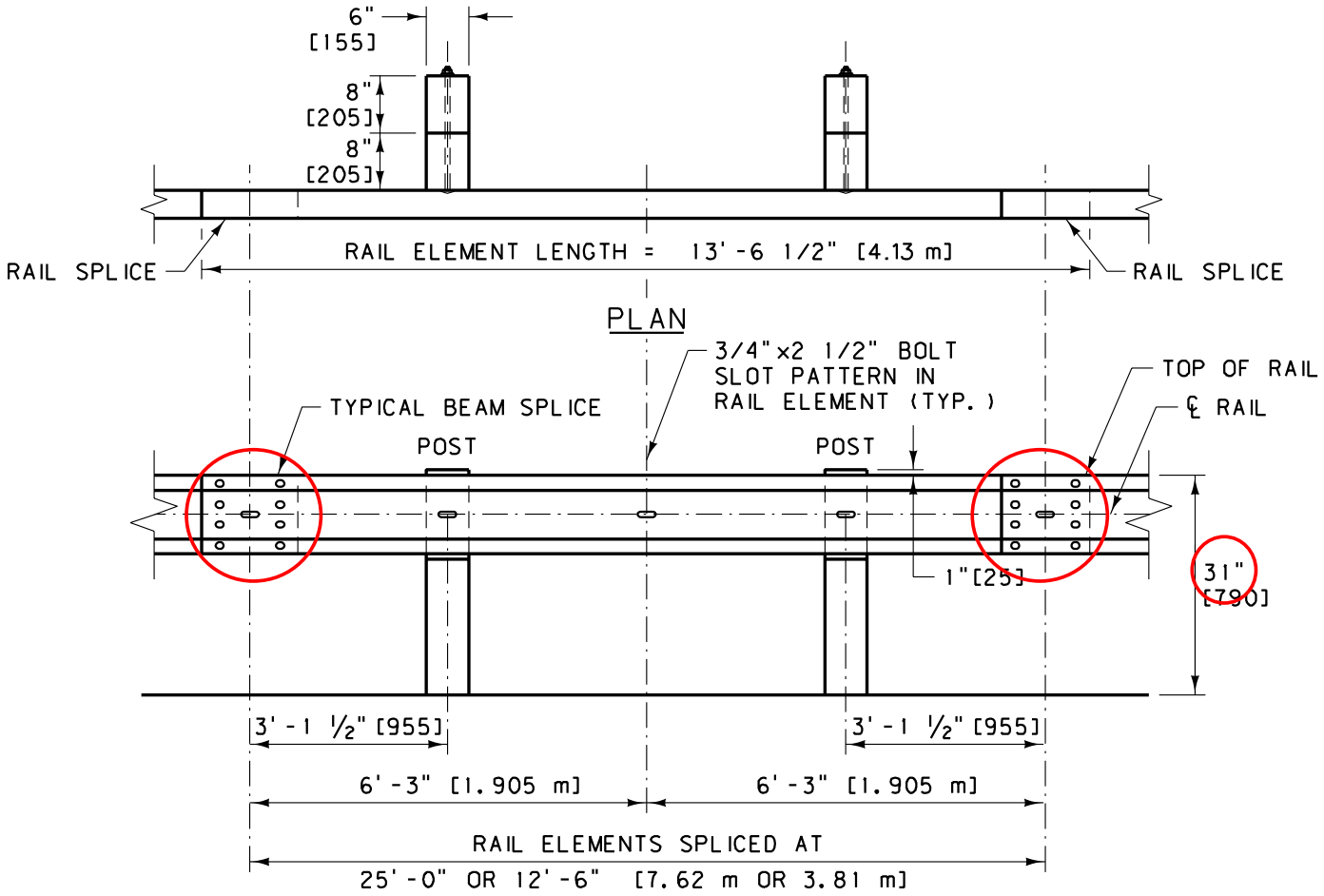
- 31” Top Rail Height
- Mid-Span Rail Splices
- 12” Blockouts (8” for MDT)

- No changes to: Rail, Posts, Post Spacing, Hardware



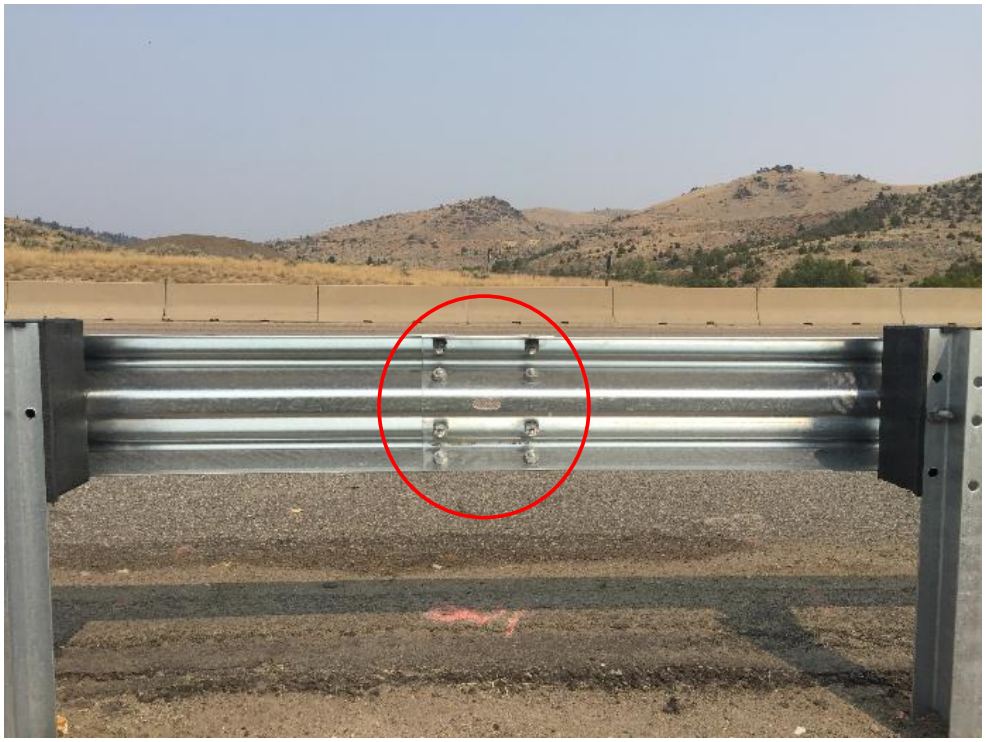
MDT DETAILED DRAWINGS:

- 606-05A: Metal Guardrail - Wood Posts (MGS)
- 606-05B: Metal Guardrail - Steel Posts (MGS)



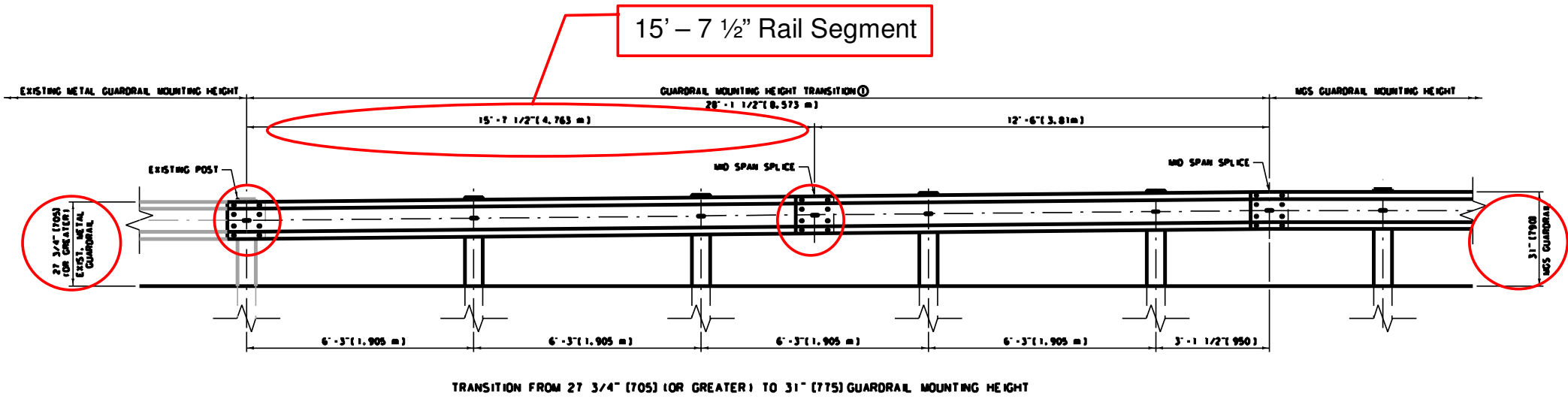
Midwest Guardrail System (MGS):





MDT DETAILED DRAWINGS:

606-20: MGS to Metal Guardrail Transition



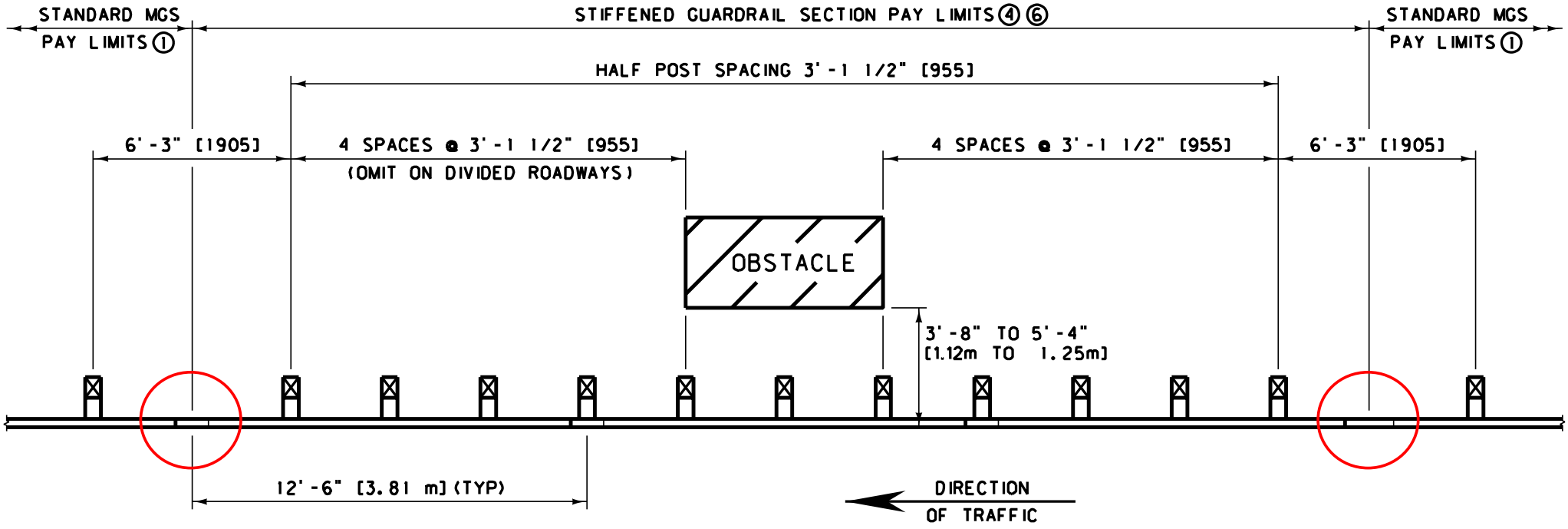
TRANSITION FROM 27 3/4" (705) (OR GREATER) TO 31" (775) GUARDRAIL MOUNTING HEIGHT

NOTES:

① THE MGS TO METAL GUARDRAIL TRANSITION IS PAID FOR AS LINEAR FEET OF MGS GUARDRAIL.

MDT DETAILED DRAWINGS:

606-07: Stiffened Guardrail Sections (MGS)

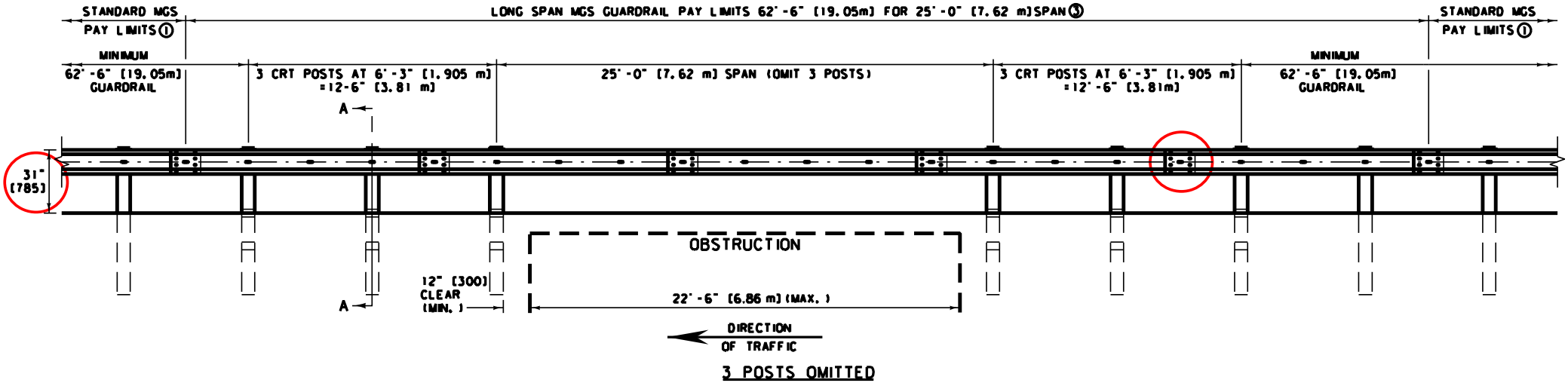


NOTES:

⑥ PAY LIMIT DEFINED BY RAILS CONTAINING A SECTION OF REDUCED POST SPACING. LIMITS SHOWN ARE FOR EXAMPLE ONLY, ACTUAL PAY LIMITS WILL DIFFER DEPENDING UPON SPLICE LOCATIONS.

MDT DETAILED DRAWINGS:

606-09: Long Span Guardrail (MGS) *(formerly nested guardrail)*



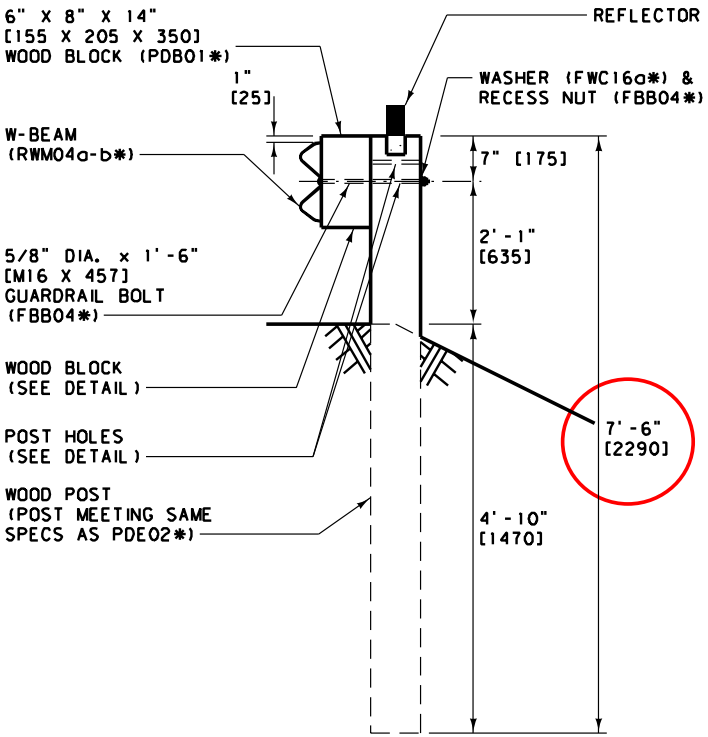
Nesting of rail elements no longer required.

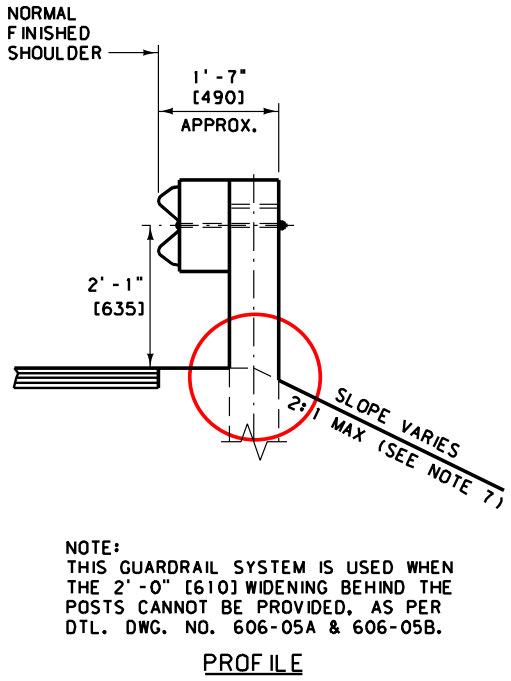
NOTES:

③ TYPICAL SPLICE LOCATIONS SHOWN, MAY VARY BASED ON ACTUAL RAIL SEGMENTS INSTALLED. PAY LIMITS NOT DEPENDENT ON SPLICE LOCATION.

MDT DETAILED DRAWINGS:

606-11A: Metal Guardrail - Long Posts - Wood (MGS)





NOTE:
THIS GUARDRAIL SYSTEM IS USED WHEN THE 2'-0" [610] WIDENING BEHIND THE POSTS CANNOT BE PROVIDED, AS PER DTL. DWG. NO. 606-05A & 606-05B.

PROFILE

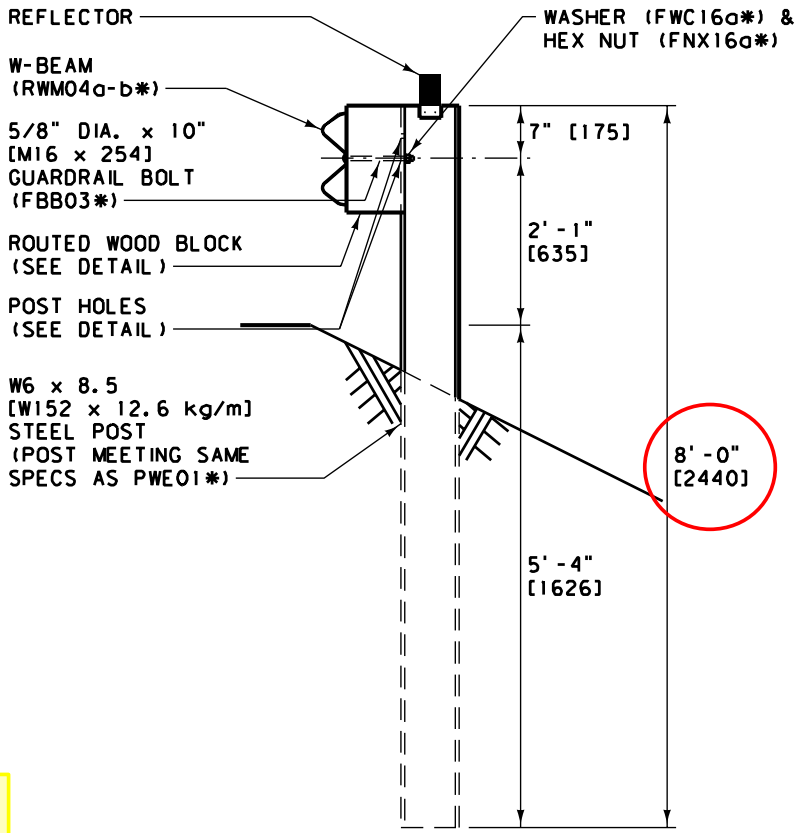
7' posts at half-spacing no longer an option.

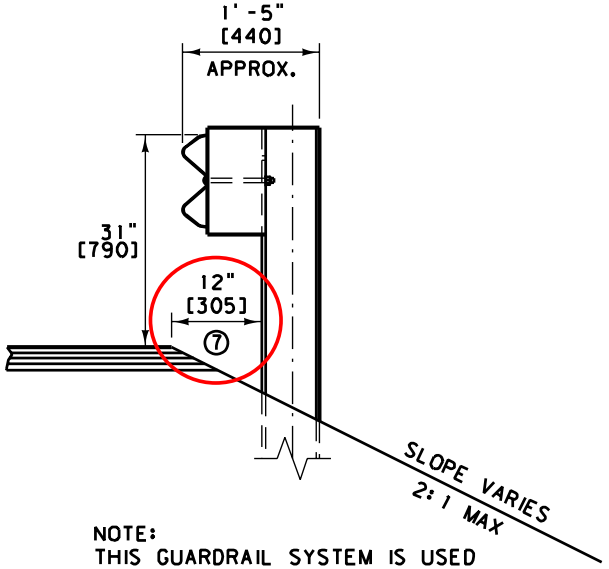
NOTES:

⑦ BEGIN INSLOPE BREAK AT CENTER OF POST.

MDT DETAILED DRAWINGS:

606-11B: Metal Guardrail - Long Posts - Steel (MGS)





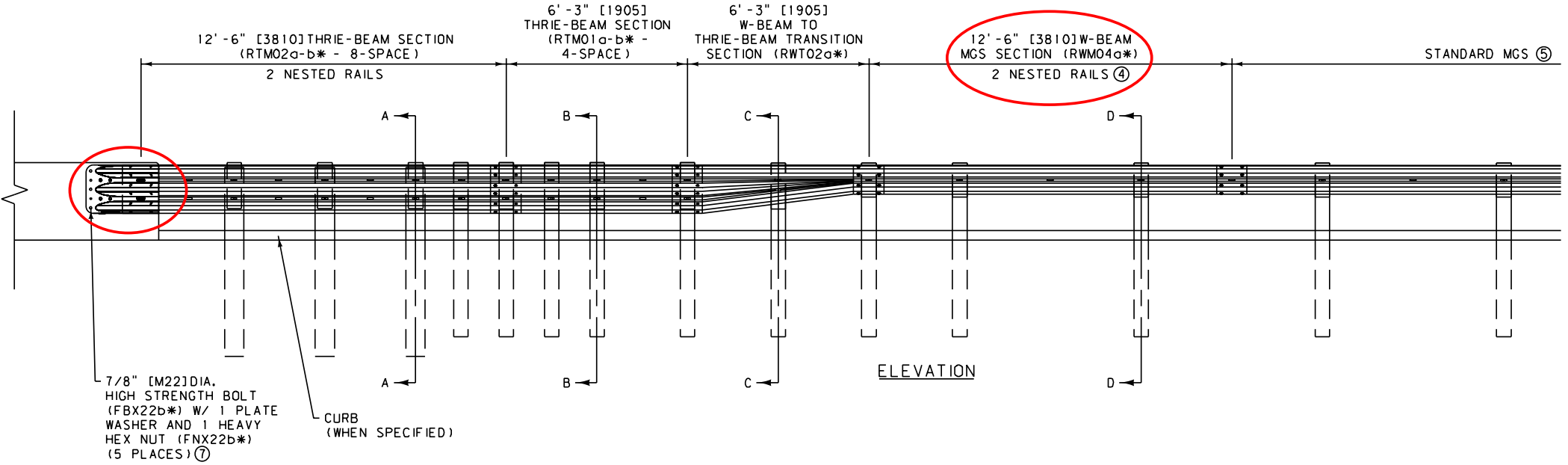
NOTES:

⑦ LOCATE POST 12" [305] (MAXIMUM) FROM INSLOPE BREAK.

7' posts at half-spacing no longer an option.

MDT DETAILED DRAWINGS:

- 606-23A: MGS Thrie Beam Bridge Approach Section - Wood Posts
- 606-23B: MGS Thrie Beam Bridge Approach Section - Steel Posts



NOTES:

④ WHERE CURB EXTENDS UPSTREAM OF POST NO. 5, FURNISH 2 NESTED 12-GAUGE W-BEAM RAILS FOR THIS 12'-6" [3810] SECTION. INCLUDE THIS ADDITIONAL RAIL IN THE COST OF THE BRIDGE APPROACH SECTION.

⑦ SEE BRIDGE PLANS FOR CONNECTION DETAILS AND BOLT LOCATIONS.

Standard w-beam bridge approach section details were not removed.

MGS/MASH TERMINAL SECTIONS

- MASH Optional Terminal Sections
  - MSKT (Road Systems, Inc.)
  - SoftStop® (Trinity Highway Products, LLC)
- MASH One-Way Departure Terminal Section
  - Non-Proprietary
- MGS Intersecting Roadway Terminal Section
  - Not tested to NCHRP 350 or MASH

MSKT TERMINAL SECTION:

(MASH Sequential Kinking Terminal)

Road Systems, Inc.

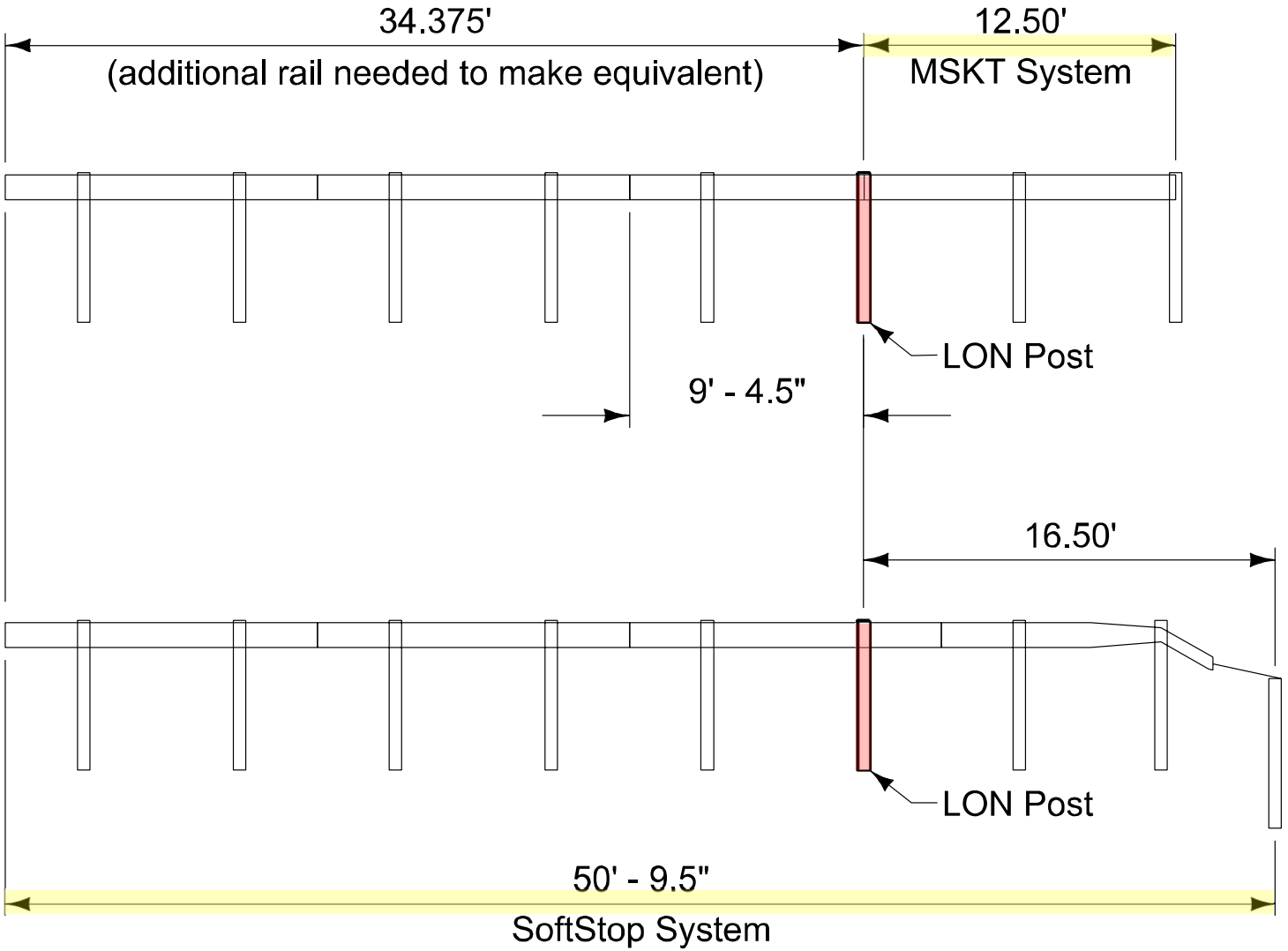


SoftStop® TERMINAL SECTION:

Trinity Highway Products, LLC



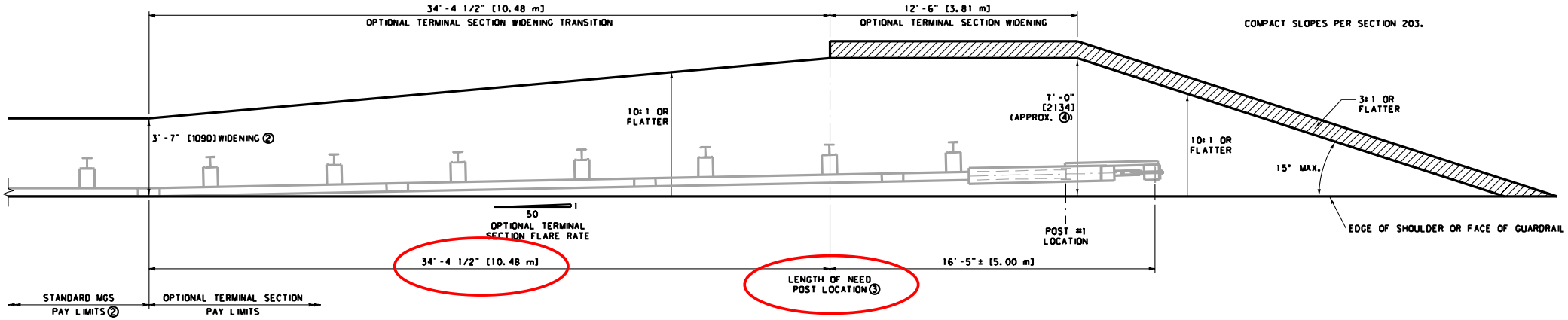
MSKT & SoftStop:



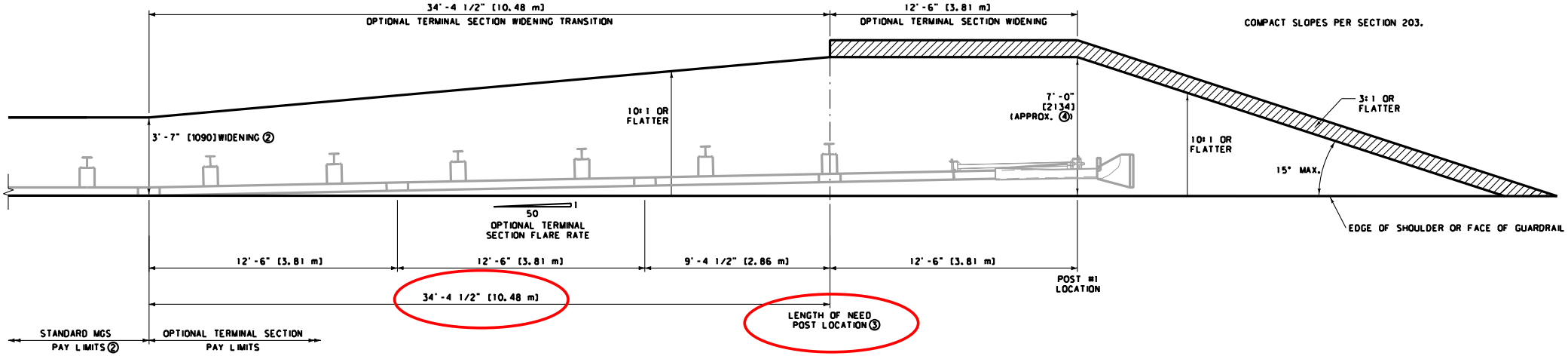
MDT DETAILED DRAWINGS:

606-13: MASH Optional Terminal Sections

Now Generic, OTS details not included.



TRINITY SOFTSTOP ①



MDT DETAILED DRAWINGS:

606-13: MASH Optional Terminal Sections

- Use for OTS Grading limits
- Use for OTS Pay Limits
- Use for Length of Need Post Location

(1) OPTIONAL TERMINAL SECTION SYSTEMS VARY, REFER TO MANUFACTURER'S DETAIL AND ASSEMBLY INSTRUCTIONS.

(3) LENGTH OF NEED POST LOCATION EQUALS STATION LIMITS INDICATED IN THE PLANS.

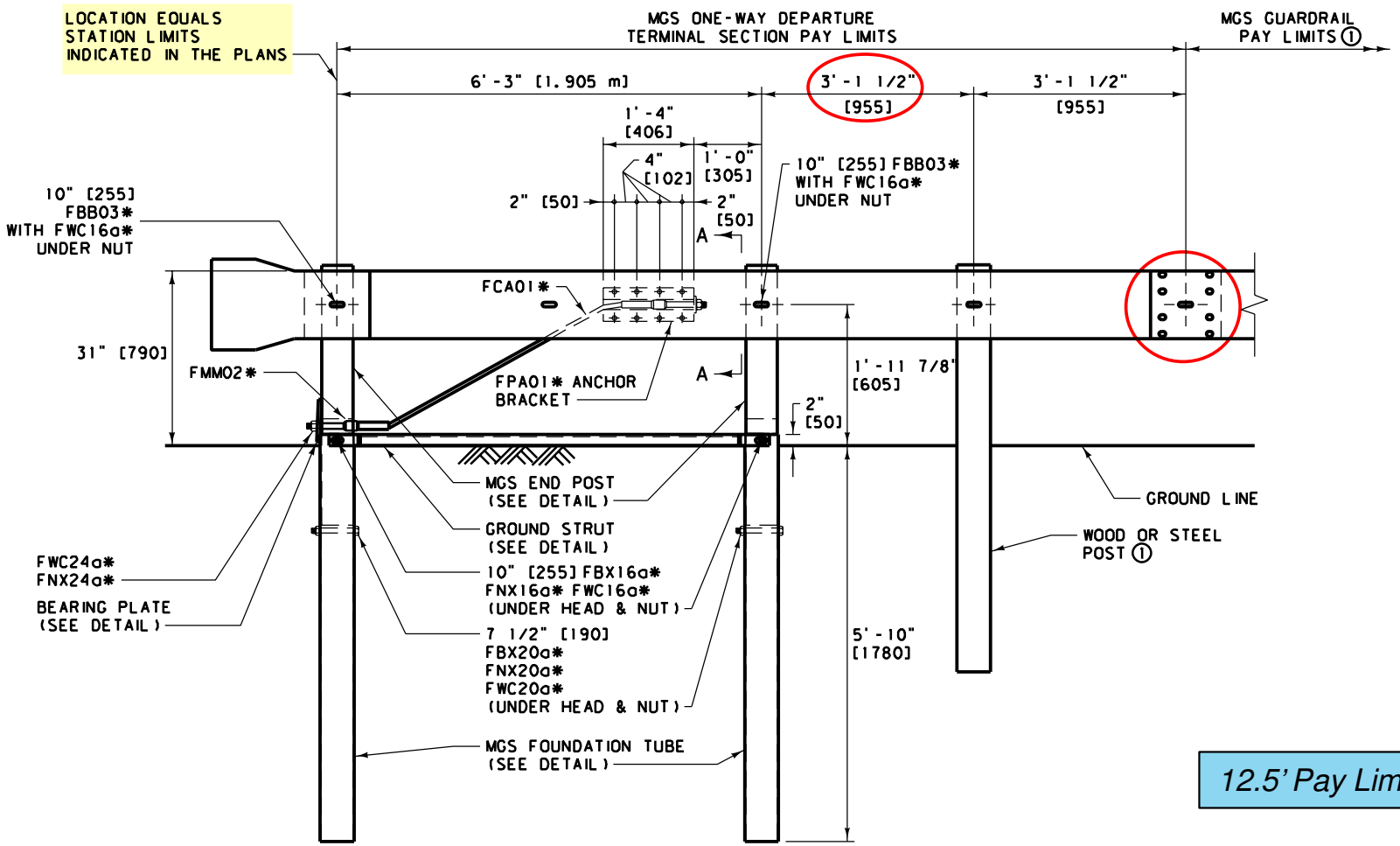
ONE-WAY DEPARTURE TERMINAL SECTION:

Non-Proprietary



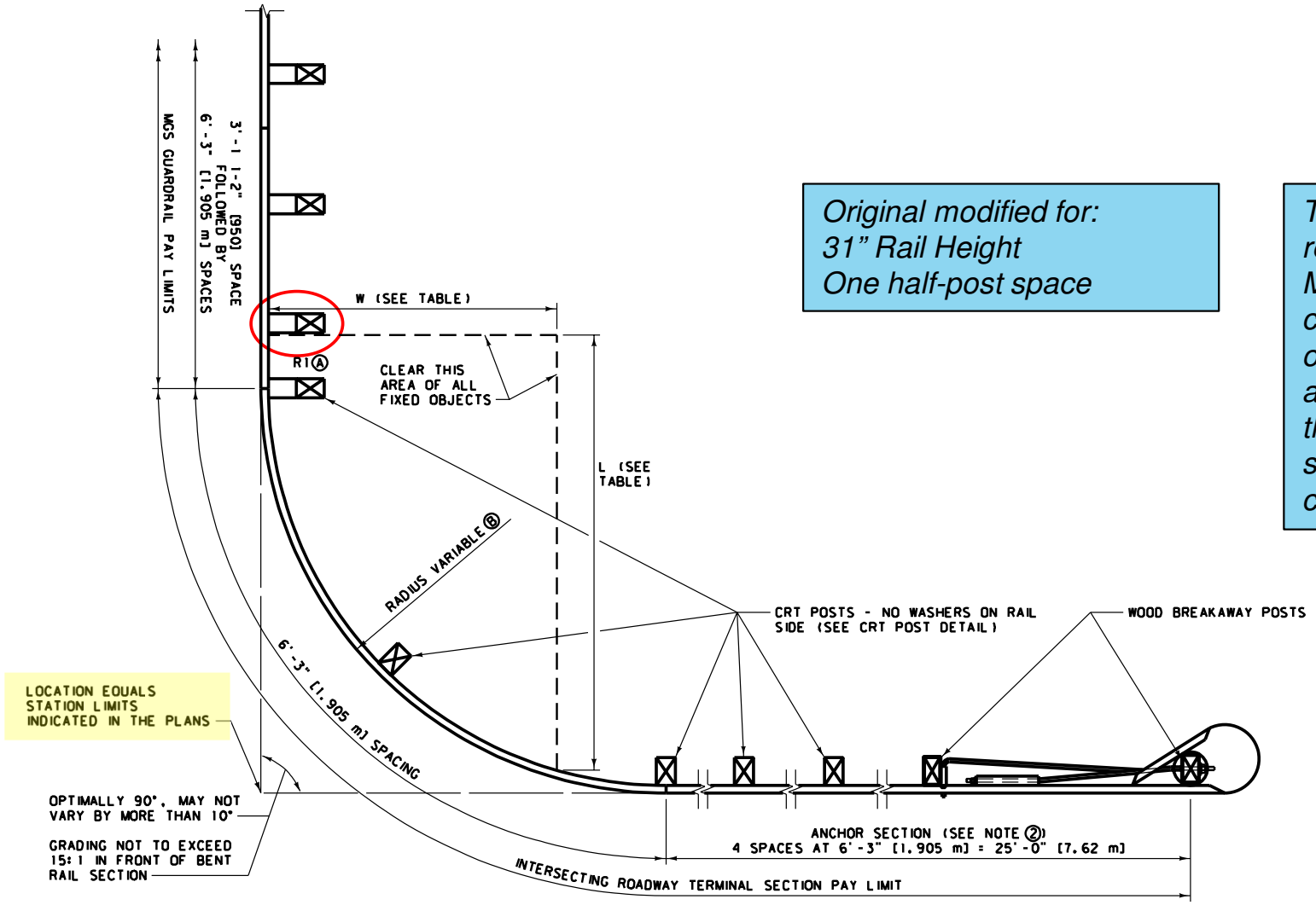
MDT DETAILED DRAWINGS:

606-18: One-Way Departure Terminal Section (MGS)



MDT DETAILED DRAWINGS:

606-46: Intersecting Roadway Terminal Section (MGS)



Original modified for:
31" Rail Height
One half-post space

This item does not meet the requirements of either MASH or NCHRP 350 criteria. Its continued use is only allowed when a MASH approved system providing the necessary hazard shielding will not fit the site conditions.

OBJECTIVE SUMMARY

2

Recognize the changes to MDT's guardrail Detailed Drawings

W-Beam Details revised to reflect Midwest Guardrail System (MGS).

Optional Terminal Sections now managed by the Qualified Products List.

The IRT is the only component not tested to MASH.

Supplemental Release is effective January 2018.

3 – GUARDRAIL DESIGN BASICS

3.1 – Roadside Design Principles

3.2 – Barrier Layout

3.3 – Retrofit Layout

ROADSIDE SAFETY DESIGN PROCESS

"Roadside safety is a design process involving the application of a clear zone and exercising good judgment in the evaluation of potential roadside safety treatments."

- MDT Road Design Manual, Ch. 9



ROADSIDE SAFETY DESIGN PROCESS

1. Determine clear zone

2. Identify obstacles within the clear zone

3. Determine roadside treatment for the obstacle:
   - Eliminating
   - Relocating
   - Making Breakaway
   - Shielding

4. Determine type and length of barrier



CLEAR ZONE APPLICATION

Design Clear Zone: A selected value used for design to provide recovery area for the majority* of errant drivers.

** about 80%*



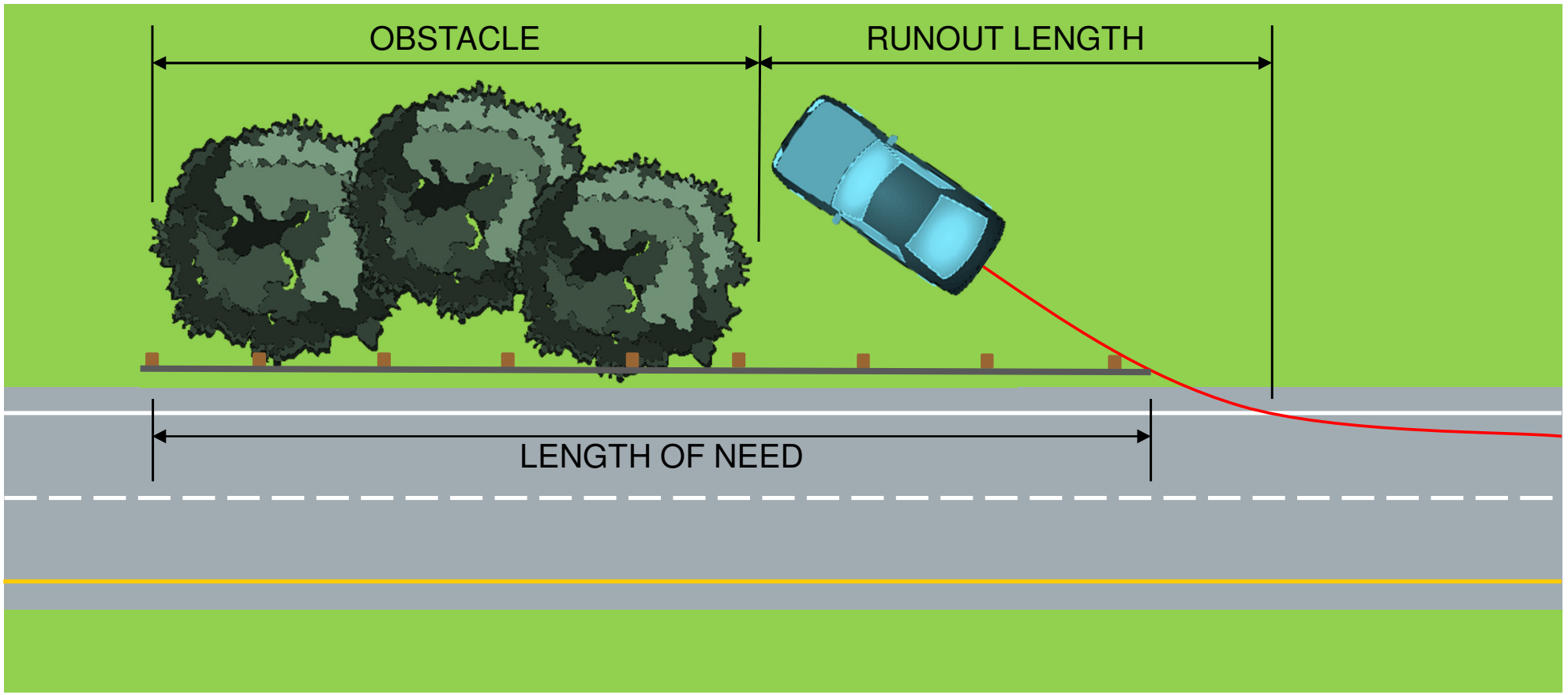
CLEAR ZONE APPLICATION

MDT Road Design Manual – Chapter 9 – Roadside Safety

Design Speed	Design AADT	Fill Slopes/Fore slopes		
		6:1 or Flatter	5:1	4:1
45 mph	< 750	10	12	14
	750-1499	14	16	18
	1500-6000	16	20	24
	> 6000	20	24	26
60 mph	< 750	16	20	24
	750-1499	20	26	32
	1500-6000	26	32	40
	> 6000	30	36	44
70 mph	< 750	20	22	26
	750-1499	24	30	36
	1500-6000	30	36	42
	> 6000	32	38	46

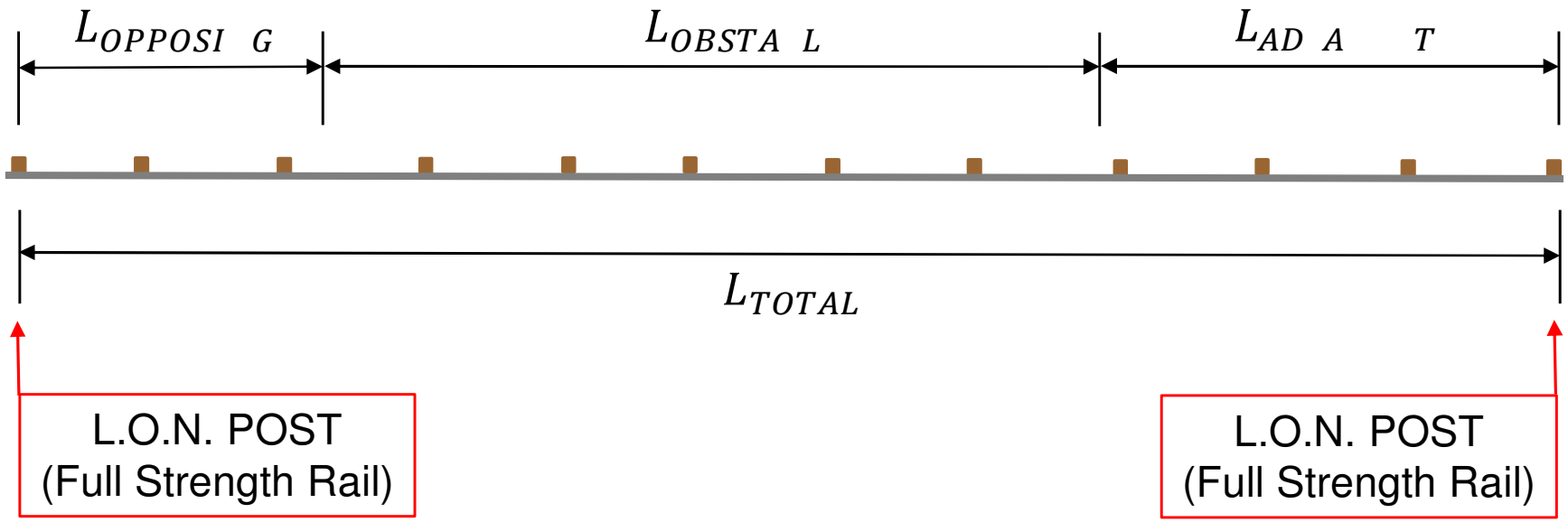
(Excerpt from Exhibit 9-1)

LENGTH OF NEED



LENGTH OF NEED

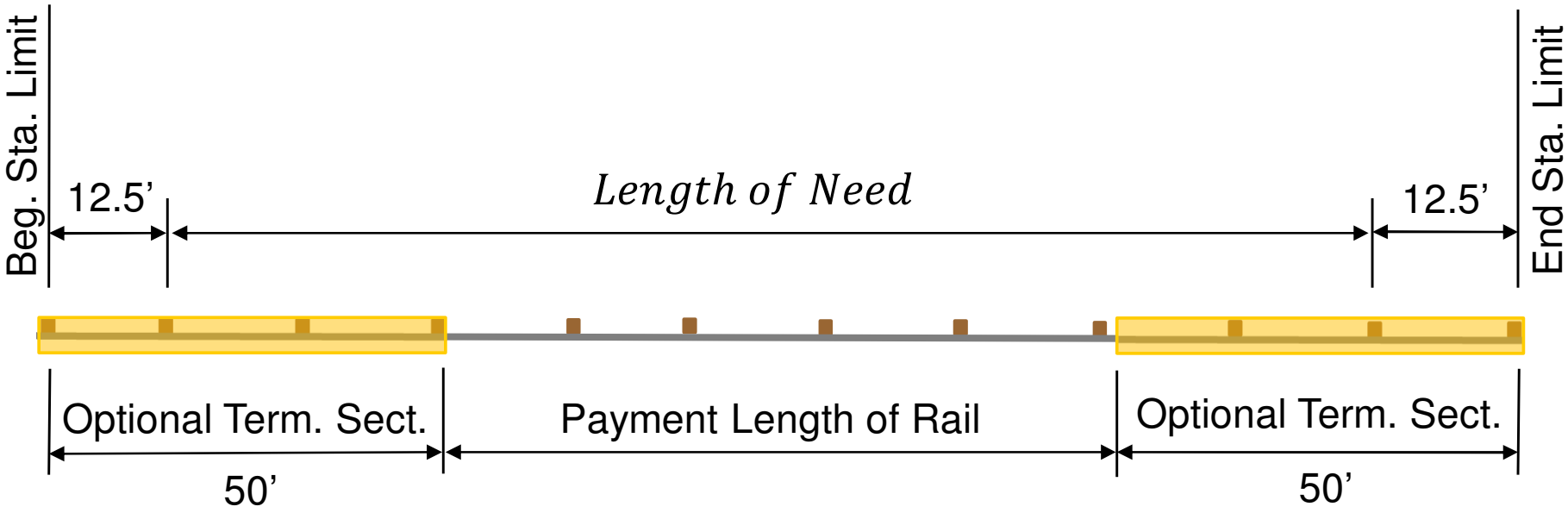
$$L_{TOTAL} = L_{AD\ A\quad T} + L_{OBSTA\ L} + L_{OPPOSI\ G}$$



STANDARD W-BEAM LAYOUT

Length of Need ≠ Payment Length

Length of Need ≠ Station Limits



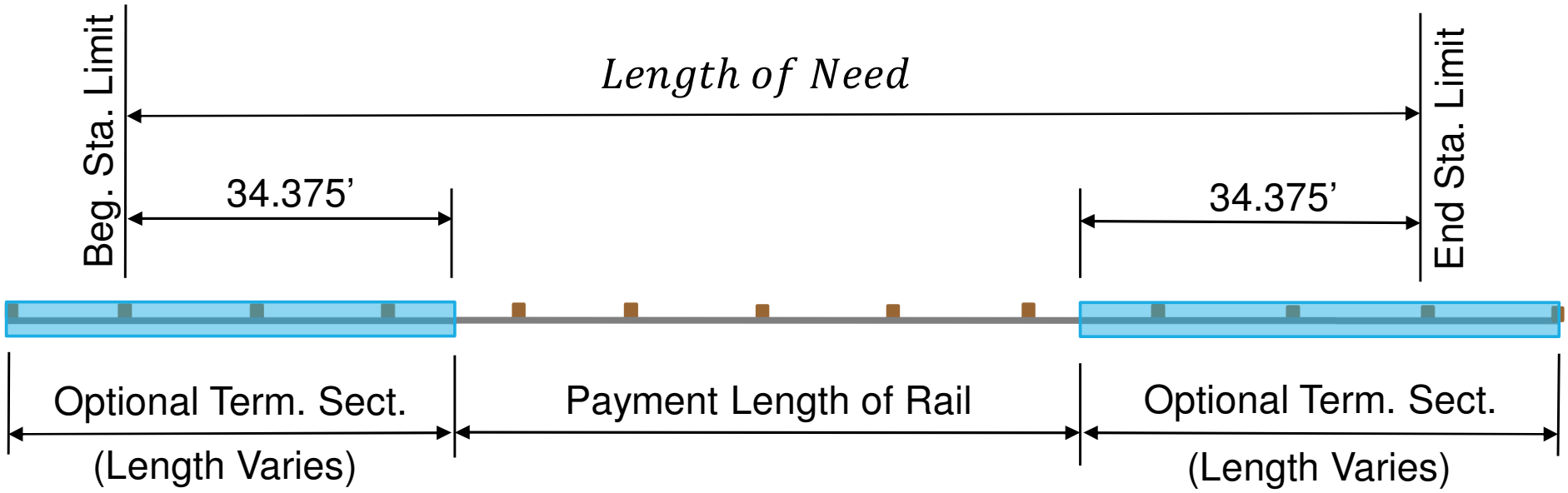
- MDT Road Design Manual, Exhibit 13-4

Layout Method for Standard W-Beam Rail

MGS LAYOUT

Length of Need ≠ Payment Length

Length of Need = Station Limits

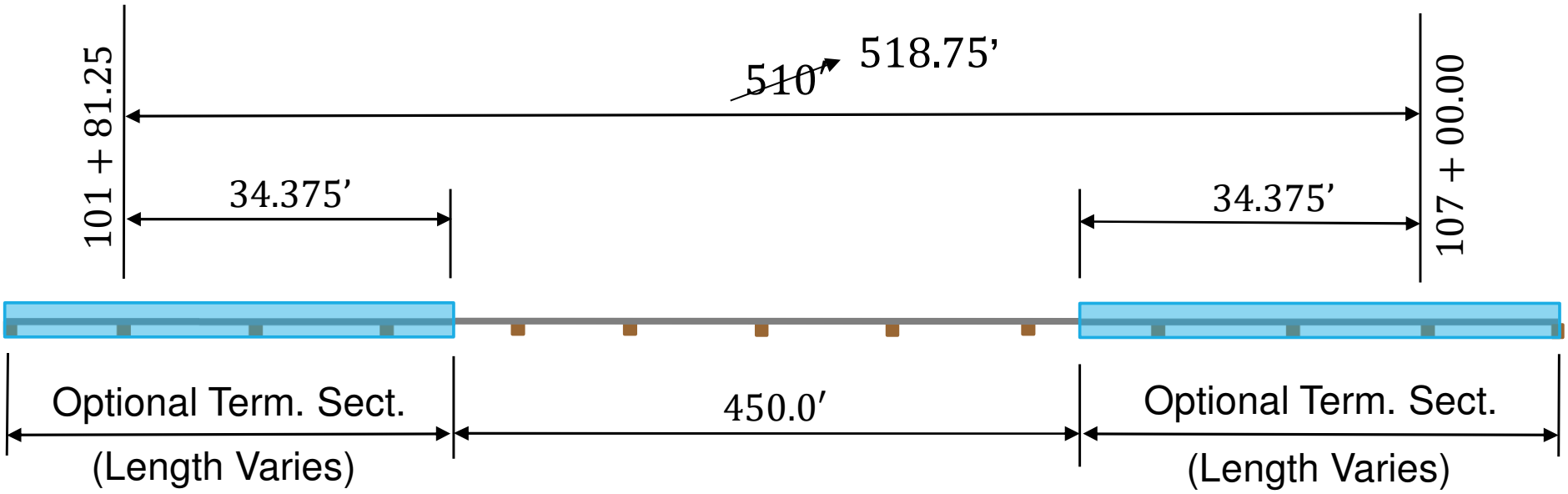


- MDT Road Design Manual, Exhibit 13-4 (Revised)

Layout Method for MGS Rail

MGS LAYOUT EXAMPLE

Guardrail Warrant: 101+90 to 107+00 (right of CL, two-way roadway)
[107+00] – [101+90] = 510’ Length of Need
(510’ – 2(34.375’)) ÷ 12.5’/section = 35.3… sections, Round ➔ 36 sections
36 × 12.5’ = 450.0’ Payment Length of Rail
Beg. Sta. = [107+00] – 450.0’ – 2(34.375’) = 101+81.25
End Sta. = L.O.N. Sta. = 107+00.00

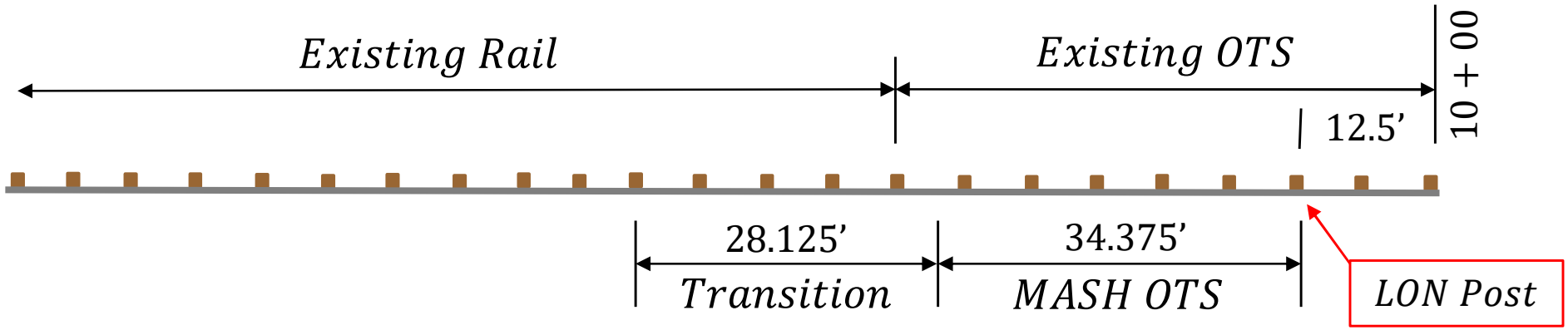


LAYOUT - CONNECTIONS TO EXISTING

Given: Existing NCHRP 350 OTS Post No. 1 Location = 10+00 RT.

L.O.N. Post Sta.: [10+00] + 12.5' = 10+12.5
Splice Sta.: [10+12.5] + 34.375' + 28.125' = 10+75.0

G.R. Removal Qty.: [10+75.0] – [10+00] = 75.0'
Beg. Sta. = L.O.N. Sta. = 10+12.5
End Sta. = Splice Sta. = 10+75.0
MGS Rail Qty. = Transition Length = 28.1'

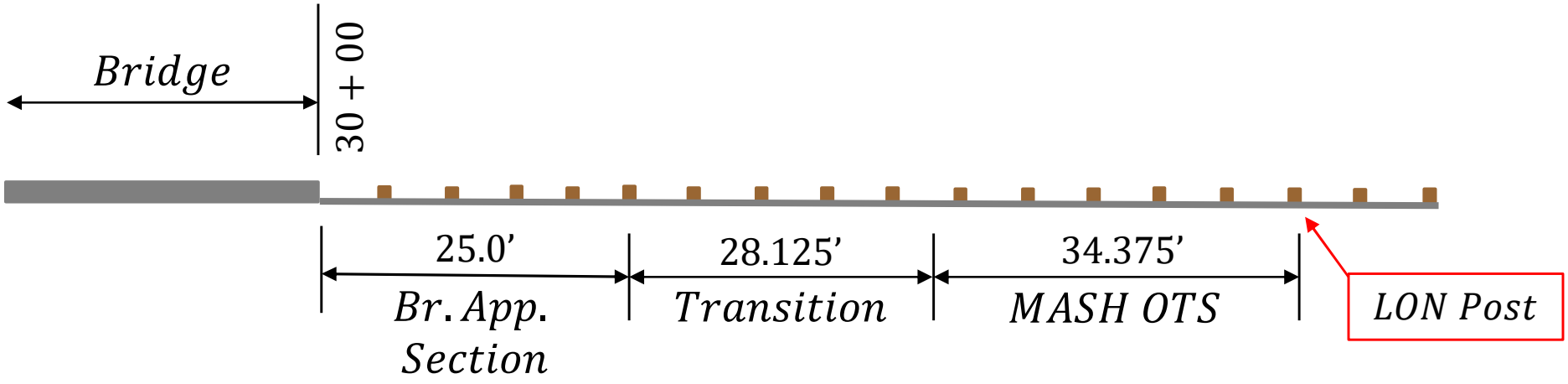


LAYOUT - CONNECTIONS TO BRIDGES

Given: Existing Bridge End Sta. = 30+00 RT.

Br. App. Section: [30+00] – 25.0’ = 29+75.0
Transition: [29+75.0] – 28.125’ = 29+46.9
MASH OTS: [29+46.9] – 34.375’ = 29+12.5

Beg. Sta. = L.O.N. Sta. = 29+12.5
End Sta. = Br. End Sta. = 30+00.0
MGS Rail Qty. = Transition Length = 28.1’



OBJECTIVE SUMMARY

3

Select and design roadside barriers using MASH devices

Roadside safety design process remains the same up to and including the Length of Need calculation.

Station Limits and Payment Length calculations have changed to correct for MGS dimensions.

Retrofits and connections to existing barrier requires additional consideration.

4 – ROAD PLANS

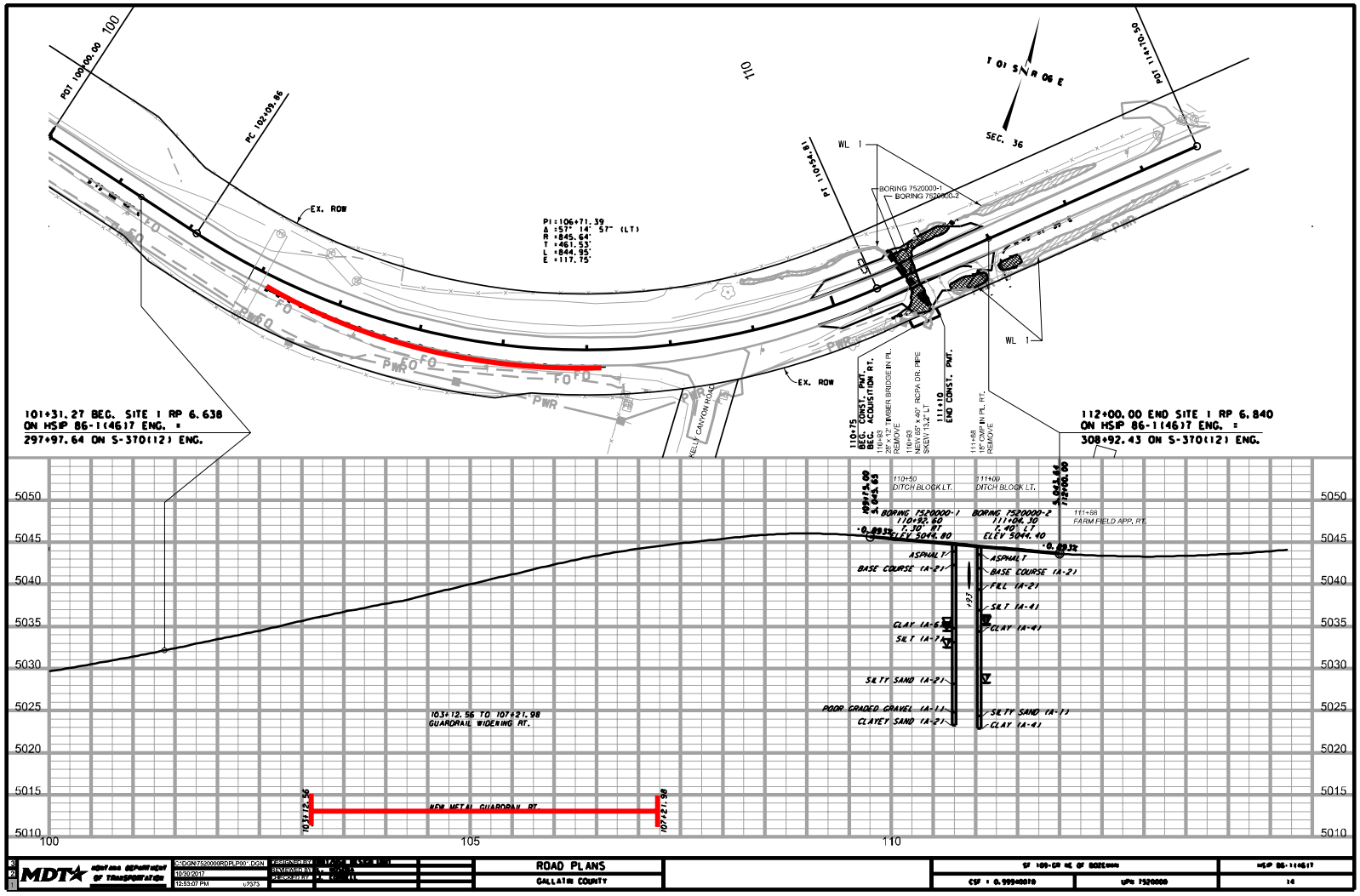
4.1 – Plan & Profile View

4.2 – Cross Sections

4.3 – Summary Frame

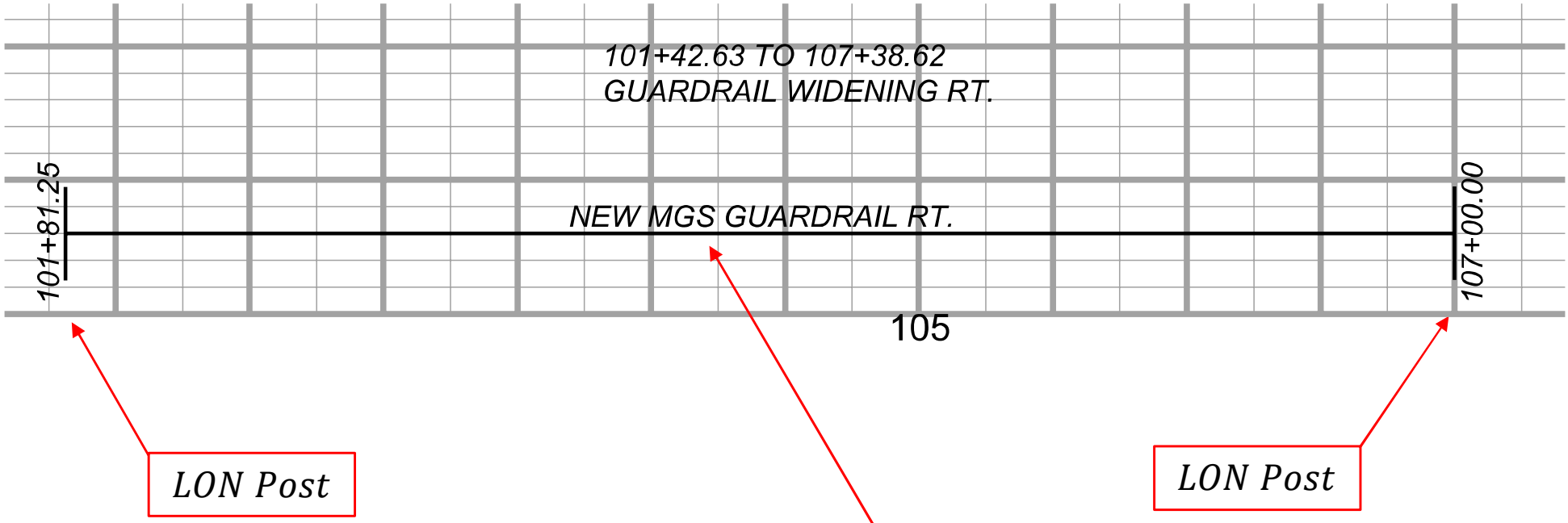
4.4 – Bid Items

MGS IN PLANS – PLAN & PROFILE



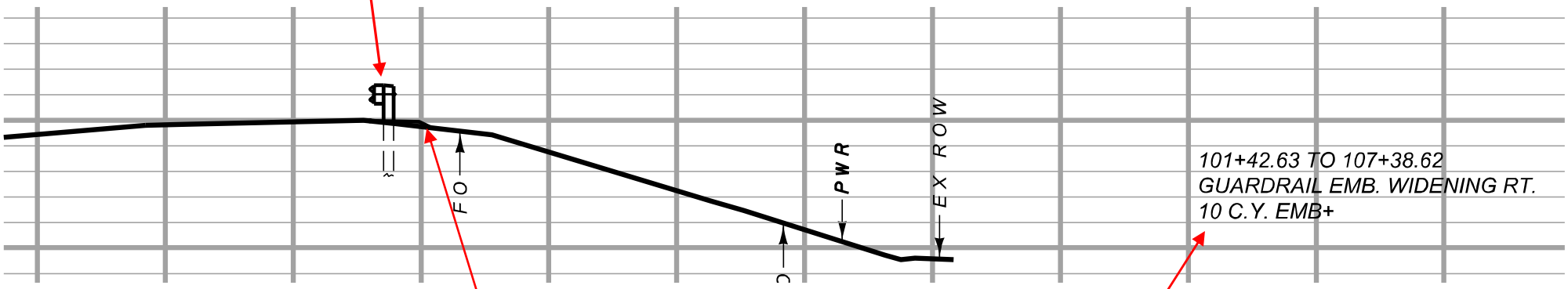
4.1 – PLAN & PROFILE VIEW

MGS IN PLANS – PLAN & PROFILE



(MDT RDM 12.3.10.3)

MGS IN PLANS – CROSS SECTIONS



G.R.Cell

Widening

Include note for widening limits only (do not call out guardrail limits)

MGS IN PLANS – SUMMARY FRAME

GUARDRAIL										
STATION		linear feet						each		
		MGS GUARDRAIL		MGS GUARDRAIL LONG POST		MGS INTERSECTING ROADWAY TERMINAL SECTION		MASH W-BEAM TERMINAL SECTION		
FROM	TO	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	LEFT	RIGHT	
NEW RAIL										
101+81.25	107+00.00		450.0						2	
REMOVE RAIL										
SUBTOTAL		~	450.0	~	~	~	~	~	2	
TOTAL		450.0		~		~		2		

LON Post Locations

Rounded to nearest 0.1′

NEW MGS/MASH BID ITEMS

Unique bid items assigned to accommodate transition.

MGS/MASH Barrier Item	NEW Bid Item No.	Detailed Drawing Reference
MGS GUARDRAIL	606 010 330	606-05A; 606-05B; 606-20
MGS GUARDRAIL/LONG POST	606 010 337	606-11A; 606-11B; 606-20
MGS LONG SPAN GUARDRAIL	606 010 338	606-09
MGS GUARDRAIL-STIFFENED	606 010 339	606-07
MGS ONE-WAY DEPARTURE TERMINAL SECTION	606 010 343	606-18
MASH W-BEAM TERMINAL SECTION	606 010 335	606-13
MGS INTERSECTING ROADWAY TERMINAL SECTION	606 010 346	606-46

OBJECTIVE SUMMARY

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Incorporate MASH devices into the Road Plans

Guardrail line work and station limits shown to the L.O.N. post for OTS applications.

Use consistent labels throughout that include “MGS” or “MASH” designators.

Use new bid items numbers for MGS/MASH barrier items in cost estimate.

MDT MASH RESOURCES

- MDT Detailed Drawings – January 2018 Release
  - http://www.mdt.mt.gov/business/contracting/detailed_drawings.shtml
- MDT/FHWA Joint Agreement (Pavement Preservation)
  - http://www.mdt.mt.gov/publications/docs/GUIDELINES-FOR-PAVEMENT-PROJECTS.PDF
- MDT MASH Policy
  - http://mdtinfo.mdt.mt.gov/other/webdata/internal/policies/docs/policies/POL-5-03-002.pdf
- MDT MASH Design Memo
  - http://www.mdt.mt.gov/other/webdata/external/cadd/design_memos/2018-02-08_MASH_wbeam_guidance.pdf

OTHER MASH RESOURCES

- AASHTO Manual for Assessing Safety Hardware
  - http://mdtinfo.mdt.mt.gov/mdt/library/journals.shtml
- AASHTO Roadside Design Guide
  - http://mdtinfo.mdt.mt.gov/mdt/library/journals.shtml
- FHWA Hardware Eligibility Letters
  - https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/listing.cfm?code=long
  - https://safety.fhwa.dot.gov/roadway_dept/countermeasures/reduce_crash_severity/listing.cfm?code=cushions
- Pooled Fund Research
  - www.roadsidepooledfund.org
  - https://mwrsf.unl.edu

Q & A

