
Appendix L
Peak Period Shoulder Lane Memorandum



COLORADO
Department of
Transportation

**I-25 PEL: CO Springs Denver South
Connection**

Peak Period Shoulder Lane – Part-time Shoulder Use Best Practices and Future Considerations

I-25 PEL: Colorado Springs Denver South Connection

August 2019

Prepared For:
Colorado Department of Transportation

CDOT Project No.
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CDOT Project Code
21102

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Foreword

The February 2016 Federal Highway Administration (FHWA) *Use of Freeway Shoulders for Travel – Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy* was used as guidance to synthesize information and best practices for part-time shoulder use evaluations for the Interstate 25 (I-25) South Planning and Environmental Linkages (PEL) Study.

Purpose and Background

The purpose of this technical memorandum is to explore, at a high level, the opportunities to implement part-time shoulder use as a phased implementation strategy on I-25 in the PEL Study Area. Part-time shoulder use is a Transportation System Management and Operation (TSM&O) strategy for addressing congestion and reliability issues within the transportation system. There are many forms of part-time shoulder use or shoulder running options; however, they all involve use of the left or right shoulders of an existing roadway for temporary travel during certain hours of the day. For this PEL Study, it is anticipated that the inside shoulders would be the most effective for potential part-time shoulder use to easily connect with Express Lanes (ELs) being implemented in the corridor between the Town of Monument and the City of Castle Rock. It is also anticipated that the use of outside shoulders is unlikely primarily because of vehicle weaving conflicts that would occur at closely spaced interchanges.

Implementation

Implementation of part-time shoulder use typically occurs within the existing paved roadway area and primarily has the potential to impact resources related to traffic volume and speed such as air quality, greenhouse gas emissions, and noise. However, some part-time shoulder use projects involve widening the shoulder, which creates the potential for impacts to resources that may be adjacent to the road (e.g., water resources, wildlife habitat, and private property). Unless the project is controversial or involves an unusual degree of impacts, part-time shoulder use projects can often be approved with a Categorical Exclusion.

Although part-time shoulder use can be a very cost-effective solution, it may not be an appropriate strategy where minimum geometric clearances, visibility, and pavement requirements cannot be met or may have an adverse impact on safety.

The decision to pursue the option of a part-time shoulder use should be made as part of a formal and comprehensive Performance-Based Practical Design assessment of design and operations. A variety of stakeholders including planning, environmental, maintenance, operations, design, and emergency responders be involved in future decisions to ensure a successful outcome.

Preliminary engineering activities should inventory the physical roadway conditions and consider the following:

- Is shoulder width adequate or can it be widened?
- Are vertical clearances adequate?

- Is the shoulder pavement structural capacity adequate in terms of drainage, depth and rideability?
- Is it feasible to provide supplemental emergency pull-off or refuge areas beyond the shoulder at reasonable intervals?
- Is a sufficiently long segment available or is an acute bottleneck being relieved?

If the answers to these questions determine part-time shoulder use is feasible, a specific operating scheme can be selected.

Existing Conditions

For this PEL Study, the approximate widths of existing inside and outside shoulders along the I-25 corridor were evaluated, including improvements currently underway for the I-25 South Gap Project that is part of the No Action Alternative. Results from this evaluation provide a better understanding of whether sufficiently long segments are available to implement a Peak Period Shoulder Lane (PPSL) or if acute bottlenecks exist that necessitate widening the interstate.

Table 1, Existing Shoulders Evaluation for Conversion to PPSL, is a straight-line diagram illustrating the existing lane configurations, inside and outside shoulder conditions, and possible opportunities for inside shoulders to be converted to a PPSL. Evaluation of shoulder widths revealed that the following is true, in general:

- The segment of I-25 from State Highway (SH) 105 at Mile Post (MP) 160.8 to MP 162.5 has an inside shoulder width ranging from 8 to 11 feet and could accommodate a PPSL with moderate widening.
- Shoulder widths reduce to 4 feet at locations where Toll Points and Enforcement Zones exist between County Line Road (MP 163.5) and Sky View Lane (MP 173.75). Widening would be necessary in these locations to implement a PPSL.
- Shoulder widths reduce to 2 feet at the existing UPRR bridge structure (MP 172.25), which is not being widened as part of the I-25 South Gap Project and would need to be widened to accommodate a PPSL.
- The bridge overpass structures at County Line Road (MP 163.5) and Sky View Lane (MP 173.75) are not being improved as part of the I-25 South Gap Project and as a result would require widening or replacement to accommodate a PPSL.

Table 1. I-25 South PEL (Level 4 Evaluation) Existing Shoulders Evaluation for Conversion to PPSL

GEOMETRICS		SH 105																County Line Rd.									
		Weigh Station																									
		161	161.3	162	161.8	162	162.3	162.5	162.8	163	163.3	163.5	163.75	164	164.3	165	164.8	165	165.3	166	165.8	166	166.3	167	166.8	167	167.3
Median Safety Feature		Concrete Guardrail Type 9												Concrete Guardrail Type 9													
Primary Surface Type		Asphalt												Asphalt													
Left	Inside Shoulder Width	12	8	10	11	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Outside Shoulder Width	6	8	13	12	10	12	8	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	8
	General Purpose Lane Quantity	3												3				2									
	Tolled Express Lane w/4-ft Buffer	0												0				1									
	Additional Lane Type	Accel	None			Decel	None			Accel	None			Decel Ramp	None			Truck Climbing Lane			None	Accel					
Right	Inside Shoulder Width	11	8	10	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12	12
	Outside Shoulder Width	6	7	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	8
	General Purpose Lane Quantity	3												3				2									
	Tolled Express Lane w/4-ft Buffer	0												0				1									
	Additional Lane Type	Aux	Truck Climbing Lane			Decel	None			Accel	None			None			None			None	Decel						
Opportunities for PPSL - Existing Shoulder Assumptions:																											
≥ 12 ft	Adequate space is available for PPSL. 12-foot-wide existing shoulders typically do not require a design exception.																										
ft to 8	Moderate widening anticipated. Investigate PBPD and design exceptions.																										
< 8 ft	More significant widening anticipated. May as well build with no design exception if possible.																										
The following items are not accounted for in this assessment:																											
1)	This assessment does not account for drainage inlet conflicts.																										
2)	This assessment does not account for dynamic ITS requirements.																										
3)	This assessment does not account for bridge crossing conflicts.																										

Table 1. I-25 South PEL (Level 4 Evaluation) E

GEOMETRICS		Greenland Rd.										Northbound Rest Area		Southbound Rest Area		Upper Lake Gulch Rd.		UPRR Crossing		Spruce Mountain Rd.										
		168	167.8	168	168.3	169	168.8	169	169.3	170	169.8	170	170.3	171	170.8	171	171.3	172	171.8	172	172.3	173	172.8	173	173.3	174				
Median Safety Feature		Concrete Guardrail Type 9												Concrete Guardrail Type 9																
Primary Surface Type		Asphalt												Asphalt																
Left	Inside Shoulder Width	15												15												4	12	15	15	10
	Outside Shoulder Width	12	8	12								12	8	12	8	12	8	12	18	15	8	8								
	General Purpose Lane Quantity	2												2																
	Tolled Express Lane w/4-ft Buffer	1												1																
	Additional Lane Type	None	Decel	None								None	Accel	None	Decel	None	Accel	None	Decel	None	Aux	Aux								
Right	Inside Shoulder Width	15												15												4	12	15	15	10
	Outside Shoulder Width	12	8	12								12	8	12				15	9	12	12									
	General Purpose Lane Quantity	2												2																
	Tolled Express Lane w/4-ft Buffer	1												1																
	Additional Lane Type	None	Accel	None								None	Decel	None	Accel	None	Decel	None	Accel	None	None	Decel								
Opportunities for PPSL - Existing Shoulder Assu																														
≥ 12 ft	Adequate space is available for PPSL. 12-foot-wide existing shoulders typically do not require a design exception.																													
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Table 1. I-25 South PEL (Level 4 Evaluation) E

GEOMETRICS		Sky View Ln.															Crystal Valley												
		173.8	174	174.3	175	174.8	175	175.3	176	175.8	176	176.3	177	176.8	177	177.3	178	177.8	178	178.3	179	178.8	179	179.3	180	179.8	180	180.3	181
Median Safety Feature		Concrete Guardrail Type 9															Concrete Guardrail Type 9												
Primary Surface Type		Asphalt															Asphalt												
Left	Inside Shoulder Width	5	7	10	11					11					11	10	15	12	11										
	Outside Shoulder Width	12	6	12	12	11		12	15	14	12	13		12		12		15											
	General Purpose Lane Quantity	2			2					3			3																
	Tolled Express Lane w/4-ft Buffer	1			1					1			1																
	Additional Lane Type	None	Decel	None					None					None			Accel												
Right	Inside Shoulder Width	5	7	11		10	11		11					11	10														
	Outside Shoulder Width	6		12	13	12	11	12	11	12			12	12															
	General Purpose Lane Quantity	2			2					2		3																	
	Tolled Express Lane w/4-ft Buffer	1			1					1		0																	
	Additional Lane Type	None	Accel	None					None					None			Decel												
Opportunities for PPSL - Existing Shoulder Assu																													
≥ 12 ft	Adequate space is available for PPSL. 12-foot-wide existing shoulders typically do not require a design exception.																												
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Table 1. I-25 South PEL (Level 4 Evaluation) E

GEOMETRICS		Plum Creek Pkwy.	5th St.	Wolfensberger Rd.	UPRR Crossing	Liggett Rd.	Black Feather Trail	Meadows Pkwy./Founders Pkwy.	Castle Rock Pkwy.	Happy Canyon Rd.																						
		180.8	181	181.3	182	181.8	182	182.3	183	182.8	183	183.3	184	183.8	184	184.25	185	184.8	185	185.3	186	185.8	186	186.3	187	186.8	187	187.25	188	187.8	188	188.3
Median Safety Feature	Type 9	Concrete Guardrail Type 9										Concrete Guardrail Type 9																				
Primary Surface Type	Concrete	Concrete										Concrete																				
Left	Inside Shoulder Width	10	11	10	10	9	7	7	11	12	11																					
	Outside Shoulder Width	12	8	12	8	12	10	10	10	6																						
	General Purpose Lane Quantity						3	4	4																							
	Tolled Express Lane w/4-ft Buffer	0						0																								
	Additional Lane Type	None	Aux	None	Decel	None	Accel	None	Decel	None	None	Decel	None	None	Decel	None	Accel	None	Decel	Ramp	None	Accel										
Right	Inside Shoulder Width	9	10	9	10	11	12	13	12	10	9																					
	Outside Shoulder Width	6	12	6	12	11	10	9	9	9	9																					
	General Purpose Lane Quantity						3	4	4																							
	Tolled Express Lane w/4-ft Buffer						0																									
	Additional Lane Type	None	Aux	None	Accel	None	Decel	None	Accel	None	Decel	None	Accel	None	Decel	None	Decel	None	Accel	None	Decel	None										
Opportunities for PPSL - Existing Shoulder Assu																																
≥ 12 ft	Adequate space is available for PPSL. 12-foot-wide existing shoulders typically do not require a design exception.																															
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Table 1. I-25 South PEL (Level 4 Evaluation) E

GEOMETRICS		Castle Pines Pkwy.		Oak Hill Ln.				Surrey Dr.		RidgeGate Pkwy.		LRT & Sky Ridge Ave.		Lincoln Ave.		LRT Pedestrian Bridge		C/E-470																											
		189	188.8	189	189.3	190	189.8	190	190.3	191	190.8	191	191.3	192	191.8	192	192.3	193	192.8	193	193.3	194	193.8	194	194.3																				
Median Safety Feature		Concrete Guardrail Type 9											Concrete Guardrail Type 9																																
Primary Surface Type		Concrete											Concrete																																
Left	Inside Shoulder Width	11											11											10																					
	Outside Shoulder Width	10											10											7 8 10 6 12 0 12																					
	General Purpose Lane Quantity	4											4											4																					
	Tolled Express Lane w/4-ft Buffer	0											0											0																					
	Additional Lane Type	None	Decel	None				None		Accel	None		Aux		None	Aux		None		Aux		None		None																					
Right	Inside Shoulder Width	9											9											10											7										
	Outside Shoulder Width	5	8	9				12		9	9		6	15	5	17	9		5		5		5																						
	General Purpose Lane Quantity	4											4											4											3										
	Tolled Express Lane w/4-ft Buffer	0											0											0											0										
	Additional Lane Type	Accel		None				None		Decel	None		Aux		Aux		None		Aux		None		None		None																				
Opportunities for PPSL - Existing Shoulder Assu																																													
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- The segment of I-25 just south of the Sky View Lane interchange (MP 172.25 to MP 173.5) has an inside shoulder width ranging from 10 to 15 feet and could accommodate a PPSL with moderate or no widening.
- The shoulder width along I-25 from MP 173.5 to MP 174.0 is limited by the Sky View Lane bridge structure. The inside shoulder width between the abutments ranges from 5 to 7 feet and there is no additional space for widening. The existing structure would need to be widened or replaced through this segment to accommodate a PPSL.
- The following MP locations have shoulder rotation limits that were added to the I-25 South Gap Project to induce shoulder drainage through flat, longitudinal sections of the interstate. These locations of variable sloped shoulders are not conducive for high-speed vehicle travel and suggest a full reconstruction of pavement in these sections:
 - MP 174.5 to MP 174.63
 - MP 176.18 to MP 176.9
 - MP 177.1 to MP 177.25
 - MP 178.25 to MP 178.7
- The segment from MP 174.0 just north of Sky View Lane to MP 194.0 at C/E-470 has an inside shoulder width ranging from 8 to 11 feet and could accommodate a PPSL with moderate widening. It is also noted that this stretch of interstate is concrete pavement and will present challenges dealing with longitudinal concrete joints not lining up with PPSL pavement markings.
- Three MP locations along the ELs within the I-25 South Gap Project have inside shoulders reducing to a width of 4 feet to accommodate Toll Point and Enforcement Zones. As a result, these locations would require widening to accommodate a PPSL. Plan layouts for the following three MP locations are attached to this technical memorandum for further details (Figure 2):
 - MP 177.75
 - MP 166.90
 - MP 173.35

Future Design Considerations

Beginning and End Segments

Logical termini consistent with National Environmental Policy Act (NEPA) guidance should be established during project scoping and preliminary engineering.

Peak period shoulder use may begin and end along certain segments of the corridor; however, these segments of a static or dynamic shoulder use would desirably be located where it is highly visible and easily comprehended to approaching drivers. Horizontal curves, crest vertical curves, and overpasses may limit a driver's visibility of a downstream roadway. Dropping any type of lane, including a shoulder open to part-time travel, within or immediately beyond these features should be avoided if possible. Likewise, dropping any type of lane in or immediately beyond an area with extensive, complex signing or other features contributing to high driver workload should be avoided if possible. The desirable locations for lane drops are also desirable locations to begin shoulder use.

PPSL Width

For shoulders designated for part-time travel, a width of 12 or more feet is generally preferred. Shoulders less than 12 feet wide will typically require a design exception if they are designated for part-time shoulder use. If an entire roadway is repurposed and general purpose lanes are reduced to less than 12 feet wide to accommodate part-time shoulder use (for any shoulder width), a design exception is also required.

Shoulders less than 10 feet wide are not recommended for part-time shoulder use. However, shoulders narrower than 12 feet may be adequate depending upon the type of vehicles using the part-time shoulder lane, the available lateral offset to obstruction beyond the pavement edge, and speed restrictions being used when the shoulder is open. The following considerations are relevant:

- If trucks and large side charter buses are prohibited from using the shoulder, then widths as narrow as 10 feet may be adequate.
- A 10-foot shoulder may be inadequate for part-time shoulder use if the lateral offset to obstruction is less than 1.5 feet or a high volume of larger vehicles such as buses is anticipated.
- Opening the shoulder only when congestion is present and reducing the speed limit when the shoulder is open will likely improve the safety of a narrow shoulder designated for part-time use.

For the purpose of this PPSL evaluation, no buffer widths were considered to separate the PPSL from general purpose lanes. This is to explore opportunities to minimize impacts and distinguish this PPSL concept as an interim improvement before implementing a full, standard EL configuration.

Because there is a median barrier on I-25 the entire length of the Study Area, a 1.5-foot lateral offset from this obstruction will be needed. Lateral offset to obstruction is the distance from the edge of the traveled way to the nearest physical obstruction such as a median barrier, guard rail, bridge support, or bridge rail. The lateral offset between the edge of a lane designated for part-time shoulder use and an obstruction should be at least 1.5 feet. This will effectively make the PPSL lane a minimum of 11.5 feet wide.

In practice, states have relocated guardrails and other obstructions (sign and lighting structures) and obtained design exceptions for segments adjacent to bridge rails/barriers, abutments, or other concrete barriers where lateral offset to obstruction is less than 1.5 feet.

Shoulder Width

It is desirable to leave several feet of pavement beyond the portion of the shoulder designated for part-time shoulder use to decrease the likelihood of vehicles departing the roadway and decrease pavement maintenance needs. Part-time shoulder use will require a design exception, since the remaining paved shoulder (beyond the portion of the shoulder designated for part-time shoulder use) will not meet the minimum width requirements.

Bridge Width

Many bridges have narrower shoulders than the approach roadways. The minimum width of a bridge shoulder that could be designated for part-time shoulder use is 11.5 feet. This dimension

provides 10 feet of the shoulder as an effective part-time lane and 1.5 feet of the shoulder as an effective lateral offset to obstruction. It is not necessary for a shoulder designated for part-time use on a bridge to be the same width as a shoulder designated for part-time use on the approaching roadway; however, it does need to be at least 11.5 feet wide. In these circumstances, design exceptions may be needed for shoulder widths less than 12 feet wide and/or if the lateral offset to obstruction dimension is not met.

Stopping Sight Distance

On the inside of horizontal curves, a shoulder designated for part-time use will be closer to guardrails or median barriers if they are present. This may reduce sight distance, potentially below American Association of State Highway and Transportation Officials (AASHTO) minimum design values. If this occurs, it may be appropriate to relocate the barrier causing the sight-distance obstruction, impose speed restrictions, or obtain a design exception.

Vertical Clearance

Before implementing part-time shoulder use, agencies typically field-measure the height of bridges along a route and any substandard vertical clearances dictate vehicle restrictions.

Requests for Experiment

Most part-time shoulder use projects have not required experimental traffic control devices. However, some complex part-time shoulder use projects, such as those with other Active Traffic Management elements or extensive use of dynamic lane control signs, may require a request for experimentation.

Preliminary Engineering

Preliminary engineering activities typically occur concurrently with NEPA and inform the NEPA decision-making process. Once planning activities determine part-time shoulder use is a desired mobility improvement for a given facility, a quick checklist review can be conducted to see if any design and operation concepts are feasible. The following criteria are assessed (Figure 1):

- Does the paved shoulder width meet agency minimum widths for carrying traffic?
 - Would a lower speed limit or prohibiting trucks solve the problem?
- Do bridges over the shoulder meet agency minimum clearance height requirements?
 - Is a special height restriction on shoulder lane users acceptable?
- Does the shoulder pavement cross section meet agency minimum depths for carrying traffic?
 - Is prohibiting heavy vehicles from using the part-time shoulder use an option?
 - Can the equivalent annual axle load be limited (e.g., allowing only relatively infrequent heavy vehicle use of the shoulder, such as scheduled local buses)?

- Is the drainage compatible with driving on the shoulder?
 - Are additional inlets or other drainage modifications needed to manage hydraulic spread and remove standing water from the shoulder?
 - Does the current drainage use a superelevation rate on the shoulder that will not support vehicle travel?
- Is the segment long enough?
 - Is there a long enough segment to provide meaningful congestion relief?
 - If short, is the segment addressing an acute bottleneck?
- Can safety concerns be resolved?
 - Can ramp merge visibility and merging distance issues be resolved?
 - Can substandard geometry be mitigated through lower speeds, vehicle restrictions, or Active Traffic Management?
 - Can the concerns of emergency responders and maintenance personnel be resolved?

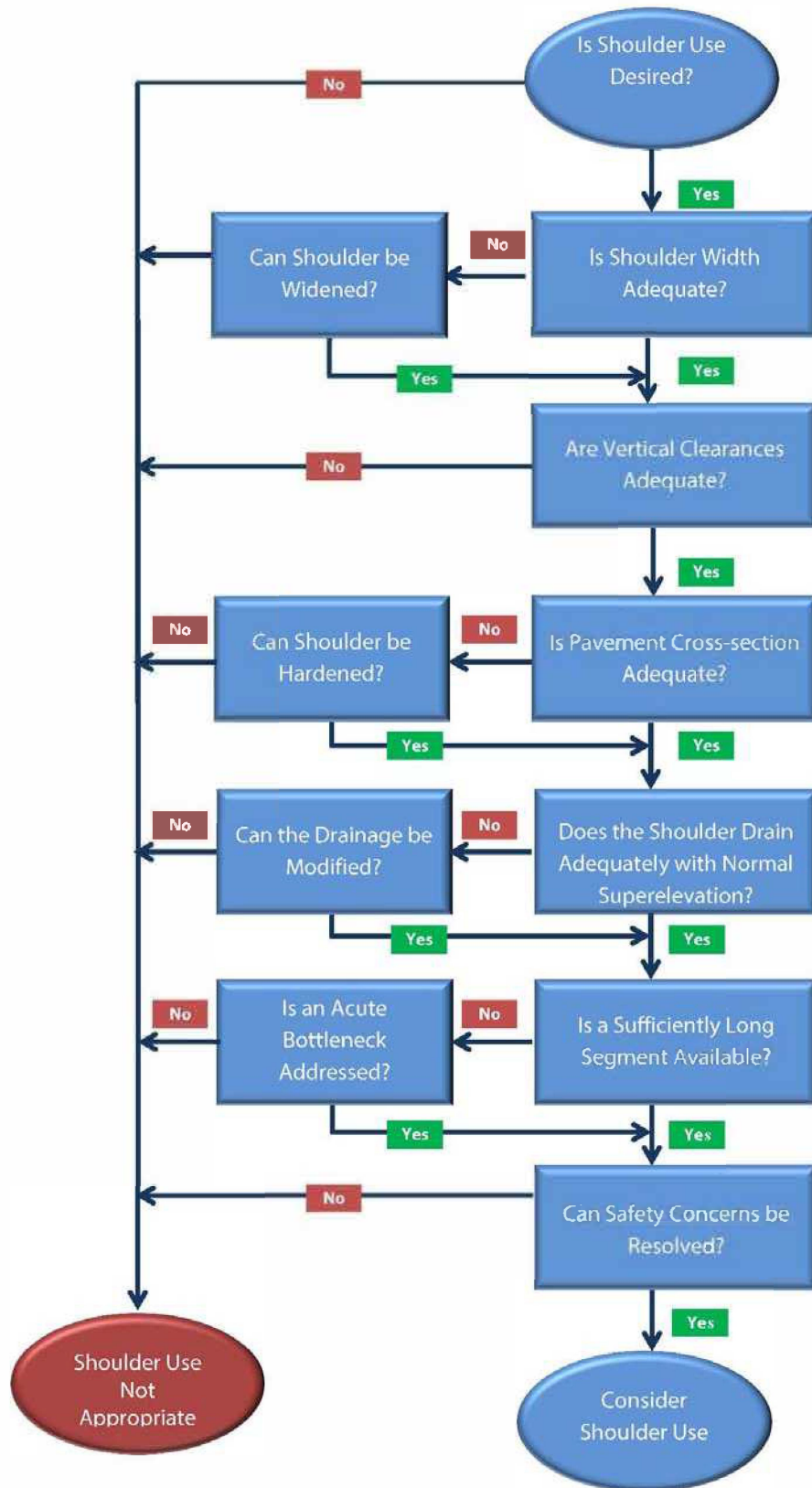
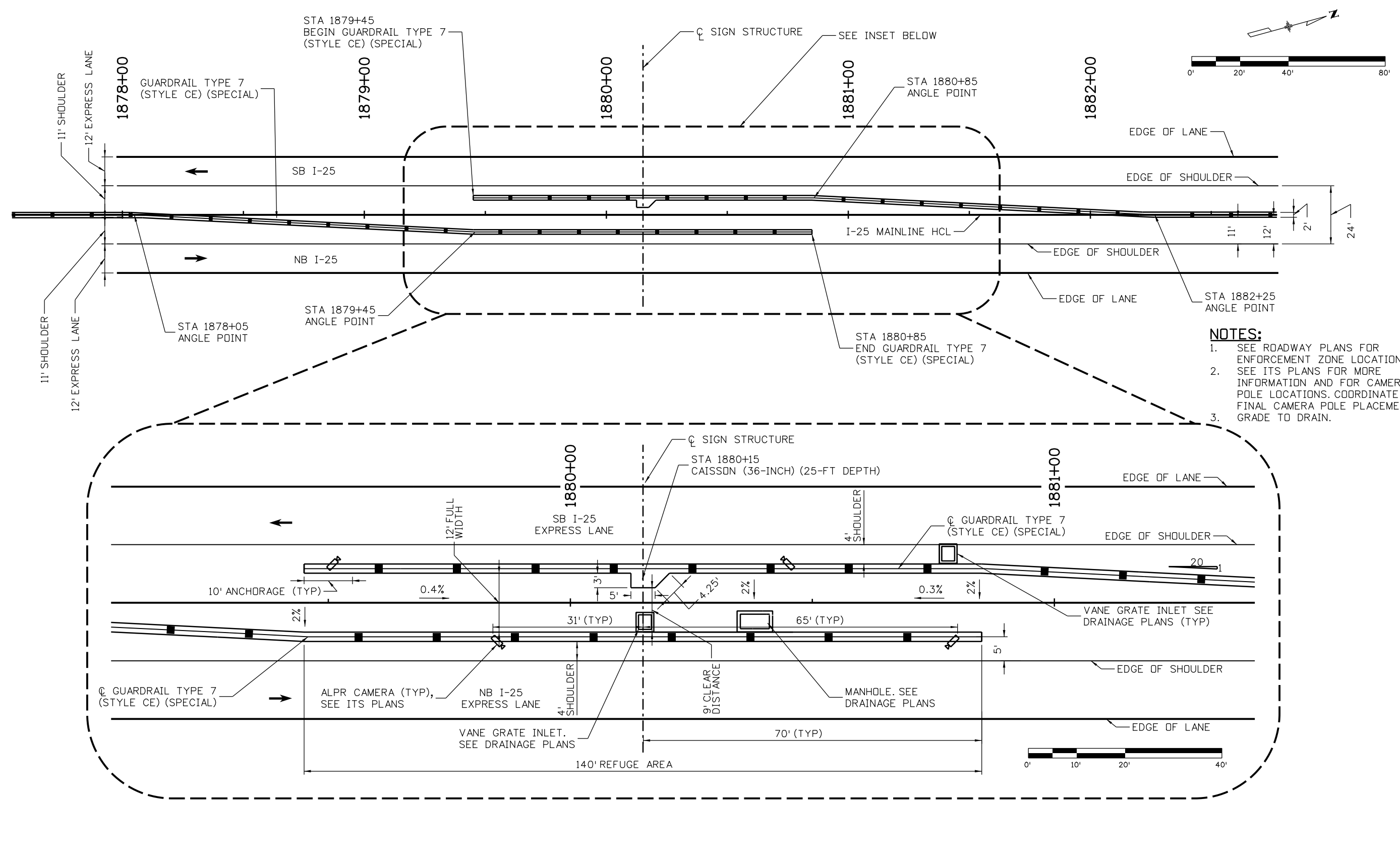


Figure 1. Illustration. Part-time shoulder use screening decision tree.

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- NOTES:**
- SEE ROADWAY PLANS FOR ENFORCEMENT ZONE LOCATION.
 - SEE ITS PLANS FOR MORE INFORMATION AND FOR CAMERA POLE LOCATIONS. COORDINATE FINAL CAMERA POLE PLACEMENT. GRADE TO DRAIN.
 -

Print Date: 7/31/2018
File Name: RD01-22589-RDDT_01-PKG1_CH2.dgn
Horiz. Scale: 1:40.0001 Vert. Scale: As Noted
Unit Information Unit Leader Initials
ch2m

Sheet Revisions		
Date:	Comments	Init.

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 Suite 204A
 Centennial, CO 80112
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Region 1 **JSH**

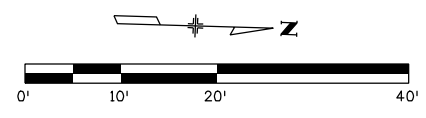
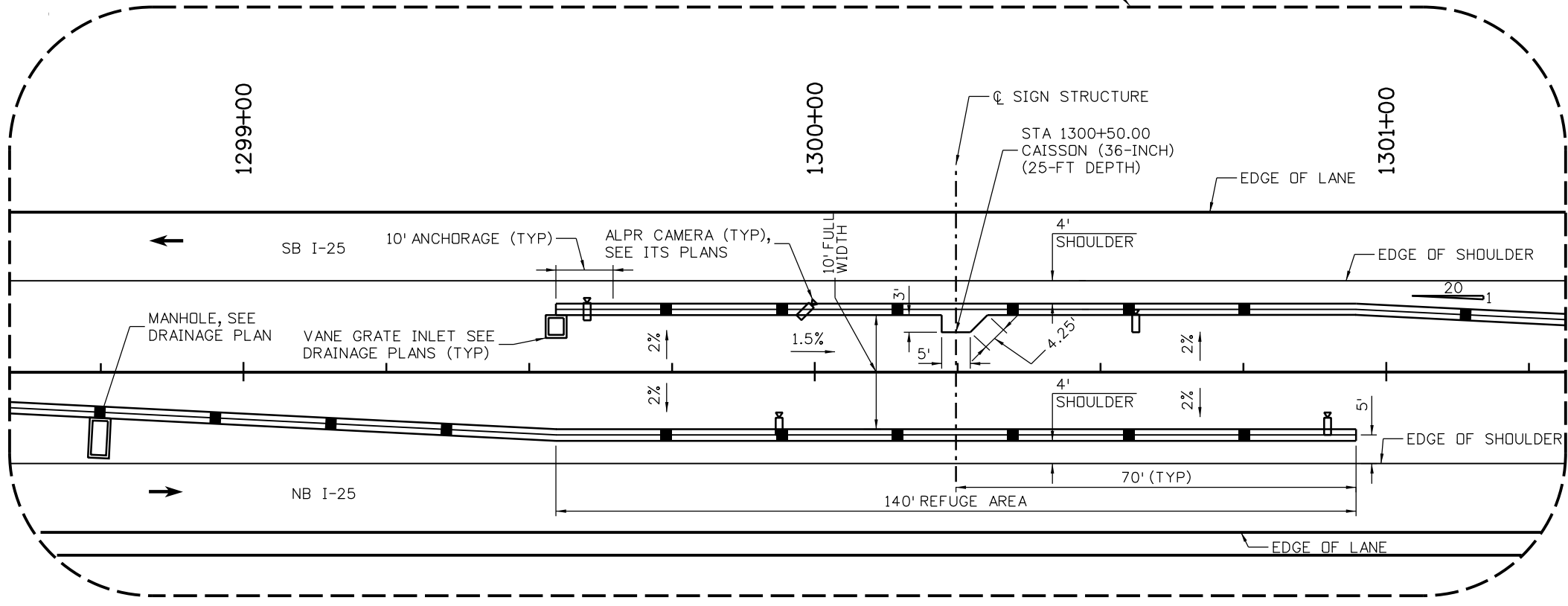
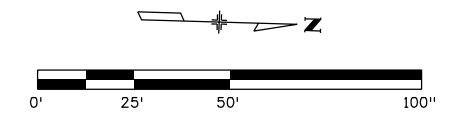
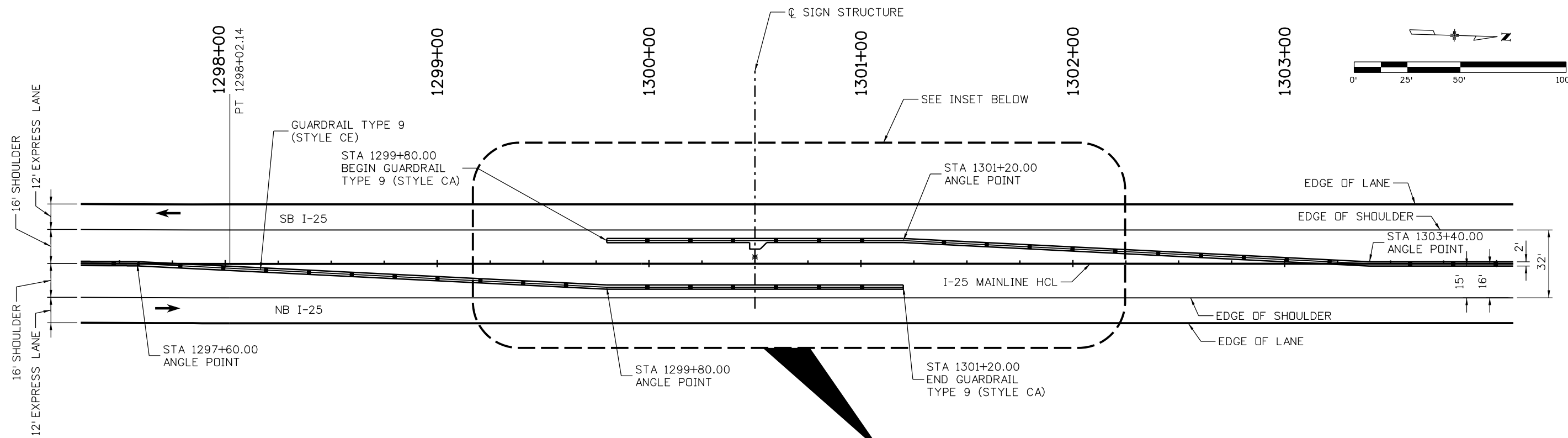
As Constructed
No Revisions:
Revised:
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PACKAGE 1: I-25 SOUTH GAP	
TOLL POINT AND ENFORCEMENT ZONE LAYOUT (STATION 1880+15)	
Designer: M. STRAND	Structure Numbers
Detailer: D. BERNARD	
Sheet Subset: RD DETAIL	Subset Sheets: RD01 of 7

Project No./Code
C 0252-475
22589
Sheet Number 157

FINAL PLANS - FOR CONSTRUCTION

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- NOTES:**
- SEE ROADWAY PLANS FOR ENFORCEMENT ZONE LOCATION.
 - SEE ITS PLANS FOR MORE INFORMATION AND FOR CAMERA POLE LOCATIONS. COORDINATE FINAL CAMERA POLE PLACEMENT.
 - GRADE TO DRAIN.

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 Unit Information Unit Leader Initials

Sheet Revisions		
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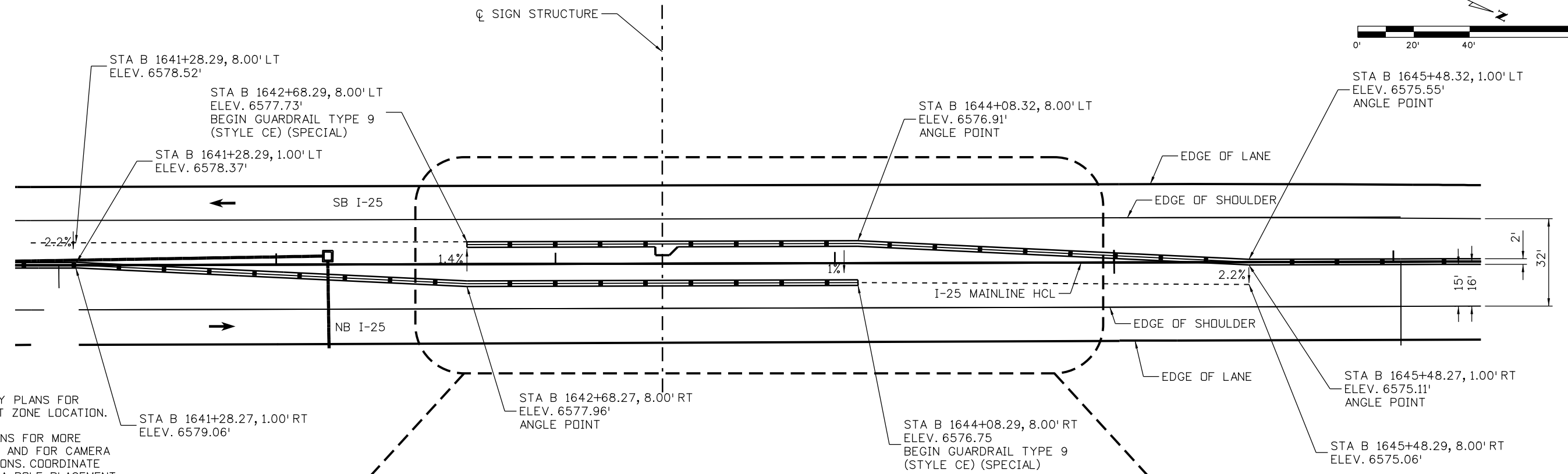
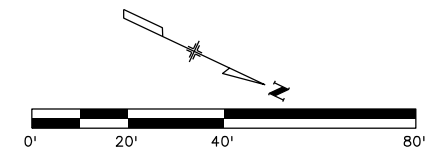
 7328 S. Revere Parkway
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Region 1 **JSH**

As Constructed
 No Revisions:
 Revised:
 Void:

PACKAGE 2: I-25 SOUTH GAP
TOLL POINT & ENFORCEMENT ZONE LAYOUT (STA 1300+50)
 Designer: W. VOSS Structure Numbers
 Detailer: M. ALKHAYRI
 Sheet Subset: RD DETAIL Subset Sheets: RD13 of 13

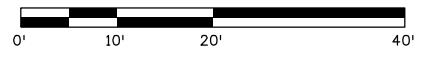
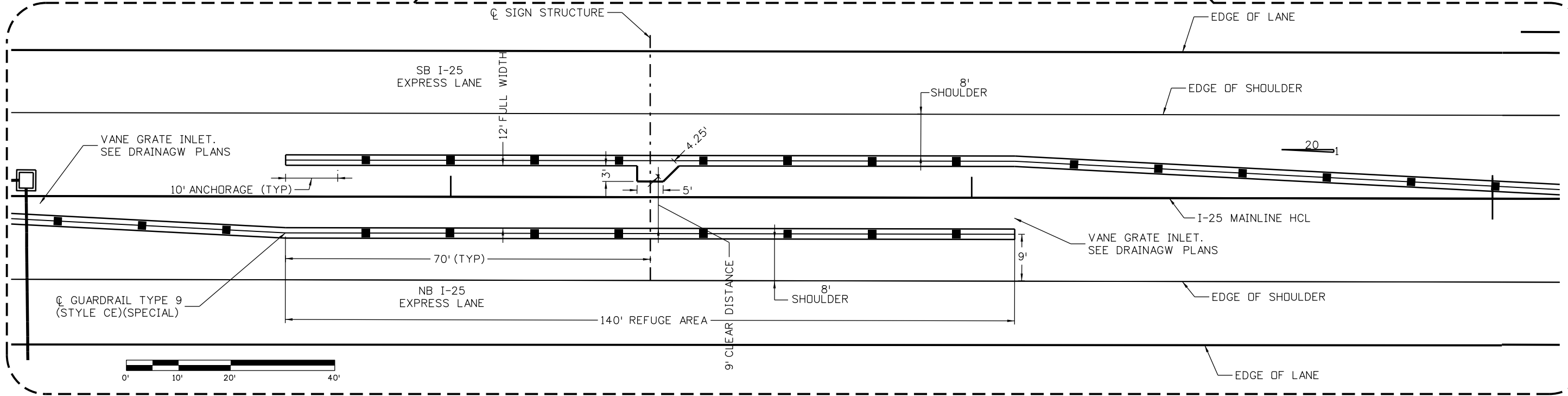
Project No./Code
 NHPP 0252-476
 22590
Sheet Number 470

FINAL DESIGN - FOR CONSTRUCTION



NOTES:

1. SEE ROADWAY PLANS FOR ENFORCEMENT ZONE LOCATION.
2. SEE ITS PLANS FOR MORE INFORMATION AND FOR CAMERA POLE LOCATIONS. COORDINATE FINAL CAMERA POLE PLACEMENT.
3. GRADE TO DRAIN.



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Print Date: 2/26/2019	
File Name: RD15-22591-RDDT_015-PKG3_CH2.dgn	
Horiz. Scale: 1:40	Vert. Scale: As Noted
Unit Information	Unit Leader Initials
ch2m	

Sheet Revisions		
Date:	Comments	Init.

Colorado Department of Transportation

7328 S. Revere Parkway
Suite 204A
Centennial, CO 80112
Phone: 303-365-7234 FAX: 303-790-1037

Region 1 **JSH**

As Constructed
No Revisions:
Revised:
Void:

PACKAGE 3: I-25 SOUTH GAP	
TOLL POINT AND ENFORCEMENT ZONE LAYOUT (STA B 1643+66.44)	
Designer: E. TYSON	Structure Numbers
Detailer: M. ALKHAYRI	
Sheet Subset: RD DETAIL	Subset Sheets: RD15 of 19

Project No./Code
NHPP 0252-477
22591
Sheet Number 418

90% DESIGN SUBMITTAL - NOT FOR CONSTRUCTION

References

Federal Highway Administration. 2016. *Use of Freeway Shoulders for Travel – Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy*. February. <https://ops.fhwa.dot.gov/publications/fhwahop15023/fhwahop15023.pdf>.