Florida Greenbook

Manual of Uniform Minimum Standards for Design, Construction and Maintenance for Streets and Highways

Sub-committee Meeting

Chapter 4 – Roadside Design

Agenda

October 30, 2025 1:00 PM – 2:00 PM	**Virtual on Microsoft Teams** ***MS Teams Link***

1:00 PM	Welcome and Introductions	Derwood Sheppard
1:10 PM	Chapter 4 Review (17th Edition)	Jacqui Morris, Kittelson Staff
1:30 PM	Sub-Committee Discussion	Chapter 4 Sub-Committee
1:40 PM	Action Items and Next Steps	Jacqui Morris, Kittelson Staff
1:50 PM	Closing remarks • Public Comment	Jacqui Morris

Manual of Uniform Minimum Standards for Design, Construction and Maintenance for Streets and Highways

Commonly known as the

Florida Greenbook

Subcommittee Meeting
Chapter 4 – Roadside Design

October 30, 2025

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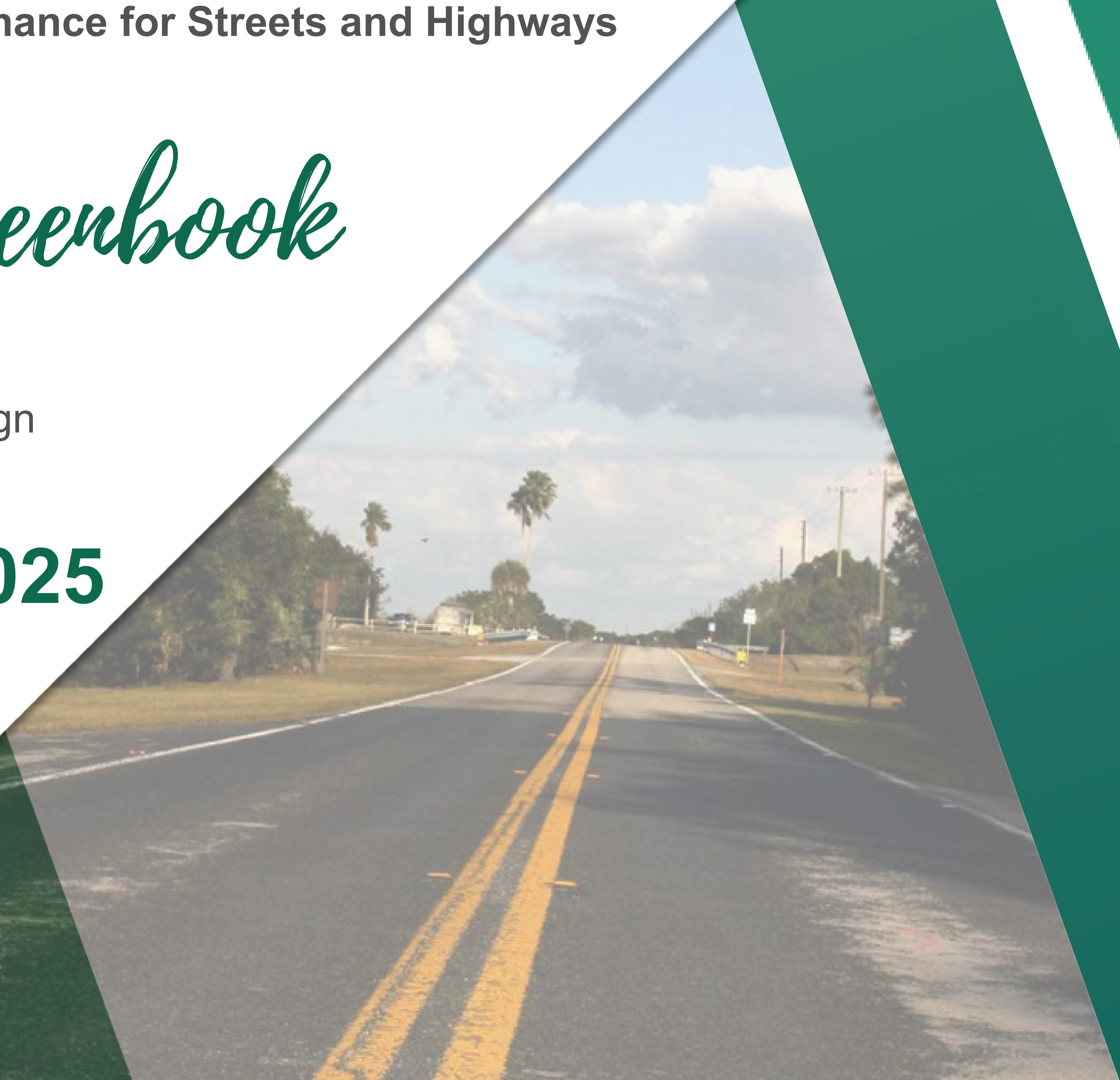
Public Meeting



FDOT

Welcome & Introductions

Derwood C. Sheppard, Jr., M.Eng., P.E.
Florida Greenbook Chair

Florida Department of Transportation -
State Roadway Design Engineer

Agenda

October 30, 2025

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1:50 PM	Closing remarks • Public Comment	Jacqui Morris

Online Attendees

Meeting Logistics

The chat feature can be used to ask questions to the presenters or share resources.

Be sure to mute your microphone unless you are asking a question.

You may turn on or off your video camera accordingly.

Raise your virtual hand to ask a live question.

Chapter 4 - Review

Table 1. Chapter 4 Roadside Design Organization

Chapter Title	Chapter Description and Key Guidance
Section 4.1: Introduction	Introduces roadway departure crashes, FHWA's approach to roadway departure safety, the USDOT Safe System Approach, FDOT Target Zero, and FDOT's approach to context-based design.
Section 4.2: Keeping Vehicles on the Roadway	Provides guidance on in-vehicle and roadway-based countermeasures that can be used to prevent road departure events and crashes.
Section 4.3: Provide for a Safe Recovery	Provides guidance on designing a roadside that is recoverable (i.e., vehicles are able to return to the roadway after encroaching on the roadside). Covers topics like clear zone and minimum lateral offset.
Section 4.4: Design Requirements for Functional Roadside Infrastructure	Provides specific design guidance for various roadside features (e.g., signal supports, trees, etc.) that are located within the clear zone.
Section 4.5: Longitudinal Barrier Evaluation, Selection, and Design	Provides information on design and implementation elements that apply across different types of longitudinal barriers (e.g., barrier assessment methods, placement consideration, length of need, etc.).
Section 4.6: Semi-Rigid (Metal Guardrail) Barriers	Describes the types of metal guardrails, the considerations for implementation (e.g., site conditions, cost, etc.), and their use cases and compares them to other roadside barrier types.
Section 4.7: Rigid (Concrete) Barriers	Describes the types of concrete barriers, the considerations for implementation (e.g., site conditions, cost, etc.), and their use cases and compares them to other roadside barrier types.
Section 4.8: Flexible (High-Tension Cable) Barriers	Describes the types of cable barriers, the considerations for implementation (e.g., site conditions, cost, etc.), and their use cases and compares them to other roadside barrier types.
Section 4.9: Treating Barrier ends	Describes the importance and types of barrier end shielding and compatible barrier and end shielding types.
Section 4.10: Bridge Traffic Railings	Redirects Greenbook users to Chapter 17 of the Greenbook and FDOT Design Manual Chapter 215.
Section 4.11: Roadside Safety in Work Zones (Temporary Barriers)	Includes guidance for temporary roadside designs and temporary barriers for work zones.
Section 4.12: References for Informational Purposes	Contains a list of supplementary references for those wanting to learn more about roadside design and safety.

Chapter 4

Roadside Safety Design

17th Edition

Subcommittee Discussion

FDOT

Open for public comment

Online Attendees

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Raise your virtual hand to ask a live question.

Thank you for attending!

Contact

If you have any questions, comments or suggestions regarding the ***Florida Greenbook***, please contact:

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FDOT

Florida Greenbook

Manual of Uniform Minimum Standards for Design, Construction and Maintenance for Streets and Highways

Sub-Committee Meeting – Chapter 4 Roadside Design

Agenda

October 30, 2025 1:00 PM – 2:00 PM	**Virtual on Microsoft Teams**

Attendees	Robert Behar Karen Byram Allie Caldwell Joey DeFrancisco Daniel Eichler Amanda Exposito-Ferree James Frimmel Andres (Andy) Garganta Tim Holley Melissa Hollis Chad Johnson Keith Krieger Laura Hardwicke Robert Hatton Mark Musselman	Ricardo Navarro Steven Nolan John Olson Terra Parish Richard Stepp Clint Caps Kathy Thomas Allan Urbonas Jacqueline (Jacqui) Morris Derwood Sheppard Morgan Dean Jennifer Musselman DeWayne Carver

Topic		
1	Welcome and Introduction [Slide #1 – 3]	Derwood Sheppard
	Jaqui Morris introduced herself and welcomed everyone. Jacqui invited committee members and FDOT technical staff to introduce themselves.	
2	Chapter 4 Outline Review (17th Edition) [Slide #4]	Jacqui Morris, Kittelson Staff

Jacqui introduced the materials shared with the committee including a supplement document providing an overview of the chapter sections and an annotated outline for Chapter 4.

Morgan Dean facilitated the chapter review. She started with an overview of the supplemental document and each of the key topics.

Morgan then started working through the draft chapter and the following points of discussion for the committee:

- Inclusion of more education statements within the Greenbook
    - Allan Urbonas noted that he appreciates the educational aspects but believes it is counter to the purpose of the Greenbook.
    - Derwood Sheppard added a preference to avoid including things that may become dated.
    - Richard Stepp agreed with removing exact statistics
- Overview of context classification
    - Allan noted that barrier shielding may not be practical in urban areas
    - Morgan noted that the team will check to make sure the language and guidance regarding urban environments in this paragraph is consistent with the later section on barriers in low-speed environments.
    - Robert Hatton suggested using terminology other than “consider” to provide more clarity
    - Derwood clarified that Chapter 4 won’t have as much context criteria, and this section is meant to provide an overview.
- Types of strategies to keep vehicles on the roadway
- Current practice related to clear zone including shoulders and bicycle lanes

- Clear zone distances following FHWA's 2005 Barrier Guide for Low Volume and Low Speed Roads
- Inclusion of AASHTO Roadside Design Guide (RDG) edition
- Distinction between lateral offset, clear zone, and border width concepts with a figure
    - Bob Behar mentioned that border width was included in Chapter 3 which is a good place for it with a reference in Chapter 4
- Policies related to tree safety and removal and inclusion of more national research references
    - Derwood shared there is not a policy within FDOT.
    - Derwood also shared there is not consistent best practice among states. Every designer needs to take into consideration project conditions.
    - Jacqui mentioned the option to have a resource portal separate from the chapter to keep the chapter from becoming outdated.
    - Morgan added that the portal could provide resource summaries and additional guidance on how to use the resources.
    - Andy asked if this would apply to other chapters as well. Derwood replied affirmatively.
- Effect of lateral offset criteria on ADA pedestrian button placement and which standard plans should be referenced
- Utility criteria
    - Derwood shared the committee has typically wanted to include more utility criteria but there may be challenges including additional criteria
    - Derwood recommends keeping the reference to the UAM
- Mailbox criteria that should remain and what could be pared down
    - Bob shared that it continues to be an issue and the criteria should remain
    - Richard noted it would be good to know where this information comes from and if any of the information is related more to placement for the mail carriers as opposed to placement for roadside safety.
- Approved Products List

	○ It was stated that many of the local agencies use the DOT APL even though they are not bound to it; there are instances where local agencies may do something different. ○ It was noted that it may be good to include that projects funded by federal funds and projects joint with FDOT have to conform to the Build America, Buy America Act.	
4	Sub-Committee Discussion [Slide #5]	Chapter 3 Sub-Committee
	No additional discussion was had. See the above section for discussion that occurred throughout the Chapter 4 Outline Overview.	
5	Action Items and Next Steps [Slide #5]	Jacqui Morris, Kittelson Staff
	Jacqui requested that the committee members individually review the annotated outline / draft chapter and provide their comments before the end of November.	
6	Closing Remarks Public Comment [Slide #6-7]	Jacqui Morris
	Jacqui provided a reminder that this is a public meeting and provided an opportunity for public comment. No comments were made. Jacqui thanked everyone for their time and participation.	

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Chapter 4

Roadside Safety Design

4 Roadside Safety Design

Committee – Let us know if there are details not currently included in this chapter that you would like to see included.

4.1 Introduction

4.1.1 Overview of Roadside Safety Design

Roadside safety is vital to the goal of reducing fatalities and serious injuries on our roadway facilities. In fact, it's been shown that, historically, about 50% of all U.S. roadway fatalities were the result of roadway departure crashes. Accordingly, the prevention or mitigation of roadway departure crashes is the main focus of this chapter. Roadway departure crashes are the result of errant vehicles exiting the intended traveled way before ultimately colliding with another vehicle, rolling over, or encountering hazards such as fixed objects or drop-offs.

Committee – What are your thoughts on including the educational statement in the previous paragraph (regarding the 50% of all U.S. roadway fatalities)?

FHWA acknowledges the need to address roadway departure safety and identifies three types of countermeasures that can be implemented to address roadway departure crashes: (1) keep vehicles on the roadway, (2) provide for safe recovery, and (3) reduce crash severity. These concepts generally form the basis for roadside safety design.

Further, roadside safety supports the USDOT Safe System Approach and FDOT Target Zero initiatives, which both have the goal of eliminating fatal and serious injuries on Florida's roadways.

4.1.2 Context-Based Design

Committee – Does this capture context-based design without introducing too many concepts / jargons that have not yet been discussed?

Considering context classification generally means thinking about the way the roadway types, roadside areas, design speeds, and facility users might influence design decisions. For example, locations with high truck traffic and limited space may benefit from "rigid" concrete barriers, while locations with large and clear medians may benefit from a "flexible" cable barrier system. Alternatively, a "semi-rigid" guardrail system may offer the best solution for balancing the needs of cost and deflection space available. Next, some rural or natural locations may offer roadside conditions with clear and level terrain, so clear zone needs can be met with no barrier shielding needed. By contrast, more urbanized locations tend to have more roadside objects and hazardous features, so barrier shielding is more likely required to improve safety. The goal of this chapter is to provide roadway designers with the information needed to address a wide variety of contexts and conditions for roadside safety.

4.1.3 How to Use This Chapter

FDOT roadside safety and design criteria are provided in the following documents:

- This Florida Greenbook provides minimum requirements for or roadways governed by local agencies, including cities and counties, that are not on state or national highway systems (i.e., off-system roadways).
- The FDOT Design Manual (FDM) provides design requirements for roadway facilities on Florida's state or national highway systems (i.e., on-system roadways).
  - The FDM is supplemented by additional publications, including the FDOT Standard Plans, Standard Plans Instructions (SPIs), and Standard Specifications for Road and Bridge Construction. These documents may be used for additional information at the discretion of local agencies.

In addition, national roadside safety and design guidance is provided in the following:

- The AASHTO Roadside Design Guide (RDG) 4^{th} Edition (2011) provides guidance on roadside design, including information on different barrier types, tradeoffs, and use cases.
- The AASHTO Manual for Assessing Safety Hardware provides guidance on assessing and evaluating the performance of roadside safety hardware.
- Several additional resources are made available through FHWA's Roadway Departure Safety webpage.
- The FHWA Manual on Uniform Traffic Control Devices (MUTCD) specifies standards for traffic control devices, including traffic signs, signals, and surface markings, among others.

4.2 Keeping Vehicles on the Roadway

The first consideration for roadside safety design is the prevention of roadway departures before they occur. Described below are some of the design features that can be used to reduce the likelihood of vehicles departing the roadway:

Committee – Please review the design features below that have been selected for summarization. Are there any key ones missing?

- **Rumble strips:** Raised and ground-in rumble strips provide auditory and haptic warnings to drivers who have encroached on the lane boundary. Rumble strips can be used on their own or in conjunction with striping.
  - Standard Plans, Index 546-001: Raised Rumble Strips
  - Standard Plans, Index 546-010: Ground-In Rumble Strips—Limited Access
  - Standard Plans, Index 546-020: Ground-In Rumble Strips—Arterials and Collectors
    - This option is designed with a “sinusoidal” wave pattern to reduce noise outside the vehicle while still being felt and heard inside the vehicle. This helps reduce disturbances to nearby homes and businesses.
- **Wider edge lines:** Edge lines are used to identify the boundaries of travel lanes. Increasing the width of edge lines from 4 to 6 inches has been shown to reduce road departure crashes.
  - Standard Plans, Index 711-001: Pavement Markings
  - FHWA Proven Safety Countermeasure: Wider Edge Lines (FHWA-SA-21-055)
- **Pavement friction:** Pavement friction treatments are used to enhance friction and skid resistance and can be particularly helpful where vehicles are frequently turning, slowing, and stopping.
  - FDOT High Friction Surface Treatment Guidelines
  - AASHTO Guide for Pavement Friction (2022)
  - FHWA Proven Safety Countermeasure: Pavement Friction Management (FHWA-SA-21-052)
  - FHWA High Friction Surface Treatment Site Selection and Installation Guide (FHWA-SA-21-093)
- **Horizontal curve safety:** Horizontal curve safety countermeasures help drivers identify the location and nature of horizontal curves so they can safely adjust their speed and direction to successfully negotiate the curve. Examples of horizontal curve safety countermeasures

include reflective pavement markers, chevron signs, speed advisory signs and pavement markings, and speed feedback signs. For a more comprehensive list, see the resources below.

- FHWA Horizontal Curve Safety
- FHWA Proven Safety Countermeasure: Roadside Design Improvement at Curves (FHWA-SA-21-029)

- **Nighttime visibility:** Nighttime visibility countermeasures help improve visibility of and for all road users. This includes visibility of other road users as well as roadway characteristics and facilities.
  - Standard Plans, Index 706-001: Typical Placement of Raised Pavement Markers
  - FHWA Proven Safety Countermeasure: Lighting (FHWA-SA-21-050)

In addition to road-based countermeasures, there are also in-vehicle systems that aim to reduce and eliminate road departure events. For example, some newer vehicles offer lane departure warning (LDW) and lane keep assist (LKA) systems provide a combination of haptic, auditory, and visual warnings to alert drivers when they are encroaching on the lane boundary. In addition to warning cues, LKA systems will provide minor steering assistance to redirect the vehicle to stay in the appropriate travel lane. Maintaining MUTCD-compliant lane and edge lines help these systems to perform as intended.

4.3 Provide for a Safe Recovery

Should an errant vehicle depart the roadway, the ideal scenario would result in the driver returning the vehicle safely to the roadway without rolling over or colliding with any roadside hazards. This section provides information on roadside features and clear areas required to help errant vehicles safely recover from roadway departures.

4.3.1 The Clear Zone and Roadside Hazards

The "Clear Zone" is the portion of the roadside that must be kept clear of hazards (see the definition for "hazard" in the following paragraph) to help avoid roadway departure crashes. The clear zone includes shoulders and bicycle lanes. Refer to the following tables, figures, and chapter sections for additional guidance related to the clear zone and roadside hazards:

Committee – Is the statement regarding the clear zone including shoulders and bicycle lanes consistent with current practice?

- See Table 4-1 and Table 4-2 for minimum clear zone width requirements. Clear zone width requirements are dependent on annual average daily traffic (AADT), design speed, and roadside slope conditions.
- See Figure 4-1 and Figure 4-2 for additional clear zone location information.
- See Section 4.3.2: Design Option Hierarchy for Treating Roadside Hazards in the Clear Zone.
- See Section 4.3.3: Slopes in the Clear Zone.
- See Section 4.4: Design Requirements for Functional Roadside Infrastructure for clear zone guidance for specific types of hazards.

A roadside "hazard" is a feature on the roadside that could pose harm to the occupant(s) of an errant vehicle departing the roadway. Such hazardous features include:

1. **Aboveground fixed objects** taller than 4 inches that are firm and unyielding
2. **Steep cross slopes** not meeting the requirements of Section 4.3.4: Minimum Lateral Offset
3. **Roadside ditches** not meeting the requirements of Section 4.3.4: Minimum Lateral Offset
4. **Drop-off hazards** per Table 4-3
5. **Water bodies and canal hazards** per Section 4.4.14: Canals and Water Bodies

Table 4-1. Minimum Clear Zone Distance (ft) (40–70 mph)

Design Speed (mph)	AADT ≥ 1500: Travel Lanes & Multilane Ramps: 1V:6H or Flatter	AADT ≥ 1500: Travel Lanes & Multilane Ramps: 1V:5H to 1V:4H	AADT ≥ 1500: Aux Lanes & Single Lane Ramps: 1V:4H or Flatter	AADT < 1500: Travel Lanes & Multilane Ramps: 1V:6H or Flatter	AADT < 1500: Travel Lanes & Multilane Ramps: 1V:5H to 1V:4H	AADT < 1500: Aux Lanes & Single Lane Ramps: 1V:4H or Flatter	AADT ≤ 400
≤ 35	See Table 4-2: Minimum Clear Zone Distance (ft) (20–35 mph)						
40	14	16	10	10 7 if AADT < 750 vehicles/day	12	10	**Preferred:** 6 **Exception:** Less than 6 where constraints of cost, terrain, right of way, or potential social/environmental impacts make the provision of a 6 feet clear zone impractical.
45–50	20	24	14	14	16	14	
55	22	26	18	16	20	14	
60	30	30[1]	24	20	26	18	
65–70	30	30[1]	24	24	28	18	

1. Greater clear zone widths provide additional safety for higher-speed and -volume roads. See Section 3.1 of the **AASHTO Roadside Design Guide 4th Edition (2011)** for further information.

Table 4-2. Minimum Clear Zone Distance (ft) (20–35 mph)

Design Speed (mph)	Design ADT	Front Slopes: 1V:6H or Flatter	Front Slopes: 1V:5H to 1V:4H	Front Slopes: 1V:3H	Back Slopes: 1V:3H	Back Slopes: 1V:5H to 1V:4H	Back Slopes: 1V:6H or Flatter
20	Under 750	2–6	3–7	See "note" below	2–6		3–7
	750 –1,500	3–7	5–8		2–6		3–7
	1,500–6,000	5–8	6–10		3–7		5–8
	Over 6,000	7–10	7–10		5–8		7–10
25–30	Under 750	3–7	5–8		2–6		3–7
	750–1,500	5–8	6–10		3–7		5–8
	1,500–6,000	7–10	7–10		5–8		7–10
	Over 6,000	7–10	10–12		7–10		7–10
35	Under 750	5–8	6–10		3–7		5–8
	750 –1,500	7–10	7–12		5–8		7–10
	1,500–6,000	10–12	12–14		7–10		10–12
	Over 6,000	12–14	14–16		10–12		12–14

Note: Front slopes between 1V:4H and 1V:3H are traversable but non-recoverable. Since vehicles will not reduce speed or change direction on these slopes, the needed clear zone is determined by the slopes above and below the non-recoverable slope and extended by the width of the non-recoverable slope. See the AASHTO RDG 4th Edition (2011) for more information on this procedure. Front slopes steeper than 1V:3H are considered hazards.

Committee – The values in Table 4-2 are from FHWA's 2005 Barrier Guide for Low Volume and Low Speed Roads: https://highways.dot.gov/sites/fhwa.dot.gov/files/docs/federallands/resources/highway-safety/12791/flh-barrier-guide.pdf Are you comfortable providing this guidance?

Figure 4-1. Clear Zone Plan View (Two-Lane, Two-Way Roadway)

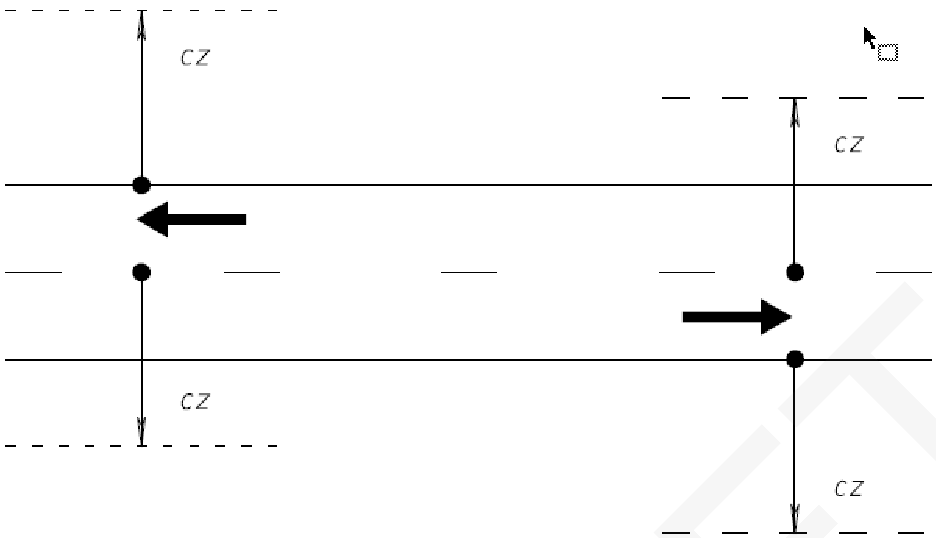
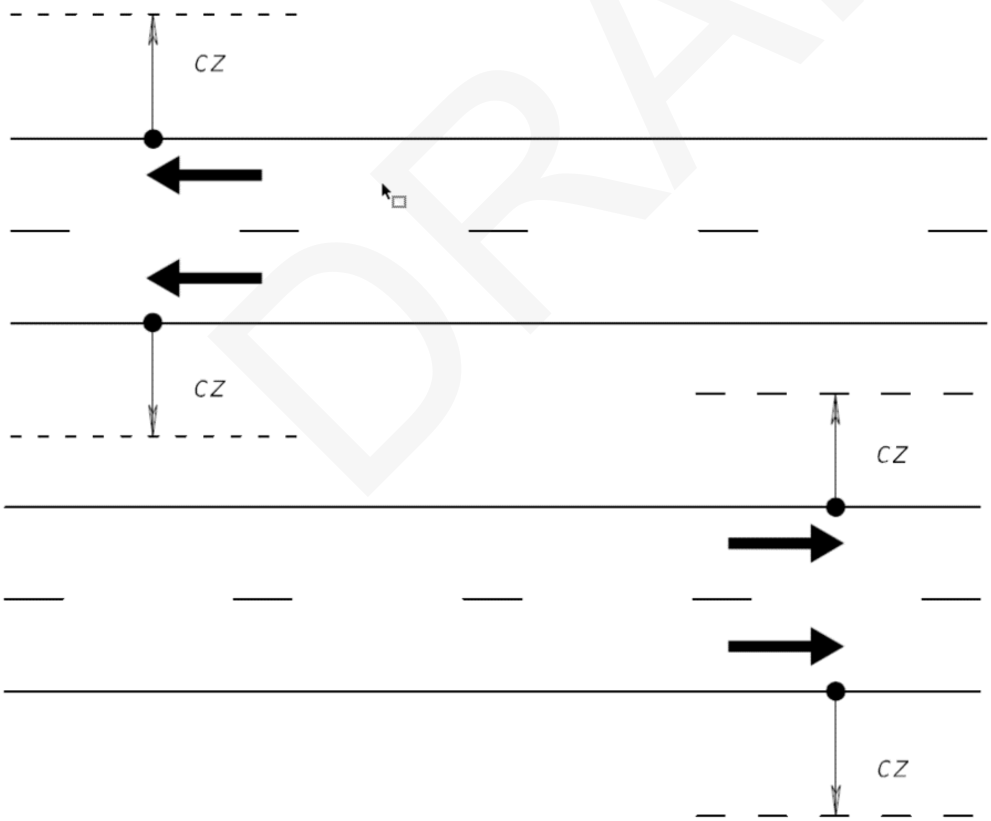


Figure 4-2. Clear Zone Plan View (Multilane, Two-Way Roadway)



4.3.2 Design Option Hierarchy for Treating Roadside Hazards in the Clear Zone

There are several design options that can be used to address hazards within the clear zone. The following design options are adapted from the AASHTO RDG 4th Edition (2011). This hierarchy should be used to determine the appropriate course of action to protect vehicle occupants from roadside hazards:

1. **Remove** the roadside feature.
2. **Redesign** the feature so it can be traversed safely (including steep slopes, ditches, and drop-offs).
3. **Relocate** the feature to a point where it is less likely to be encountered.
4. **Reduce** impact severity by using an appropriate breakaway device or crash cushion.
5. **Shield** the feature with a longitudinal traffic barrier if it cannot be eliminated, relocated, or redesigned.
6. **Delineate** the feature if the above alternatives are not practical or cost effective.

In addition to the design option hierarchy, the AASHTO Roadside Design Guide 4th Edition (2011) provides guidance on the preferred treatments for different types of hazards. Consult the most recent edition of the AASHTO RDG 4th Edition (2011) for this information.

Committee – The Greenbook is required to be very specific in its references. References to documents, such as the RDG will always include the specific year/edition. FDM references will include the specific section.

Last, it's important to note that not all fixed objects are considered hazards, and not all fixed objects require treatment if within the clear zone. For more information on these special considerations, see Section 4.3.4: Minimum Lateral Offset and Section 4.4: Design Requirements for Functional Roadside Infrastructure.

4.3.3 Slopes in the Clear Zone

In addition to being free from roadside hazards per Section 4.3.1: The Clear Zone and Roadside Hazards and Section 4.3.2: Design Option Hierarchy for Treating Roadside Hazards in the Clear Zone, clear zones must also include considerations for roadside slopes.

4.3.3.1 Types of Slopes

Roadside slopes are described in three ways:

1. **Front Slope (i.e., Foreslope)**: A cross slope measured in the direction perpendicular to the roadway, resulting in a decreasing finished grade elevation with increasing distance from the roadway. This is often the slope that is closest to the roadway, and the bottom of this slope is generally referred to as the toe.
2. **Back Slope:** A cross slope measured in the direction perpendicular to the roadway, resulting in an increasing finished grade elevation with increasing distance from the roadway. This slope is generally farther from the roadway than the front slope, but not always.
3. **Transverse Slope**: A slope that is measured in the direction parallel to the roadway. This is often created by a side street or driveway.

For additional information and visuals regarding roadside slope terminology, see Figure 4-5 and Figure 4-6 along with the AASHTO RDG 4th Edition (2011).

4.3.3.2 Slope Grade Categories

Slopes may be traversable (recoverable or non-recoverable) or non-traversable. The following summarizes these categories of slope grading:

1. **Traversable Slope** – Smooth terrain, unobstructed by fixed objects:
    a. **Traversable, Recoverable**, 1:4 or flatter
    b. **Traversable, Non-Recoverable**, 1:3 or flatter and steeper than 1:4
2. **Non-Traversable Slope** – Rough terrain, obstructed, or slopes steeper than 1:3

Roadside front slopes must generally be considered “Traversable, Recoverable” for the entire clear zone width per Figure 4-3. Where a steeper slope is needed within the clear zone, “Traversable, Non-Recoverable” slope may be used, but the overall clear zone width must then be extended by the width of this steeper slope per Figure 4-4. Additionally, the outermost 10 feet of this adjusted clear zone should be “Traversable, Recoverable” slope where practical, as shown in Figure 4-4. These roadside slope classifications are provided as follows:

For curbed roadways with restricted right of way area, front slopes of 1:2 or flatter may be used only as necessary to meet the finished grade elevation at the right of way line. Where possible, use flatter slopes and place steeper slopes as far from the roadway as practical.

Back slopes of 1:3 or flatter may be located within the clear zone width. However, when the combination of front slope and back slope creates a roadside ditch condition per Figure 4-5 and Figure 4-6, all the requirements in the provided chart must be met.

Last, provide transverse slopes of 1:10 or flatter for freeways and interstates. For all other roadways, 1:4 or flatter may be used.

For drop-off hazard slope condition definitions, see Table 4-3.

Figure 4-3. Basic Clear Zone Concept

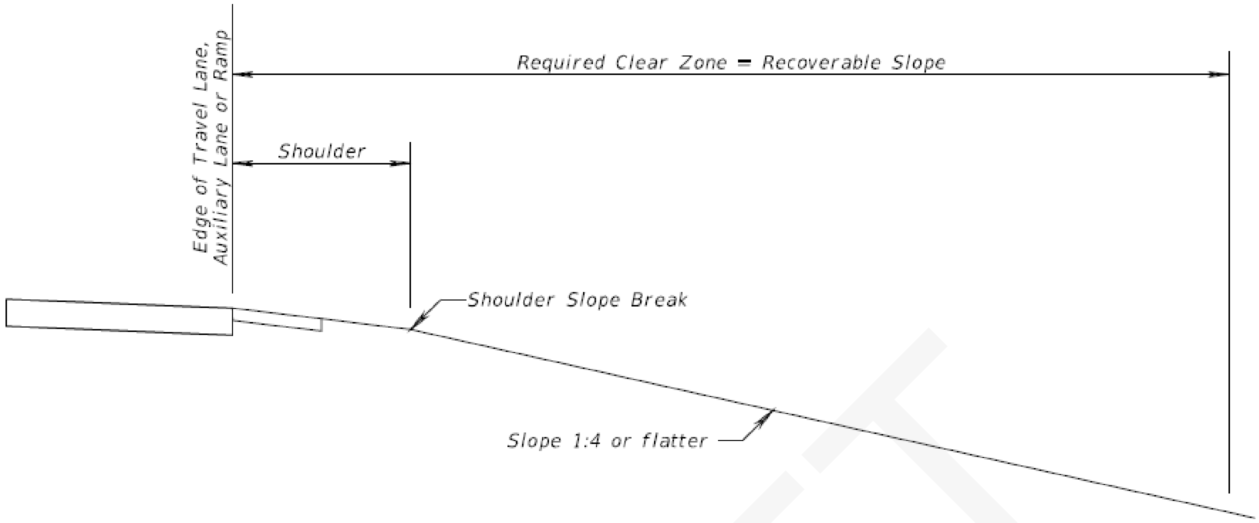


Figure 4-4. Adjusted Clear Zone Concept

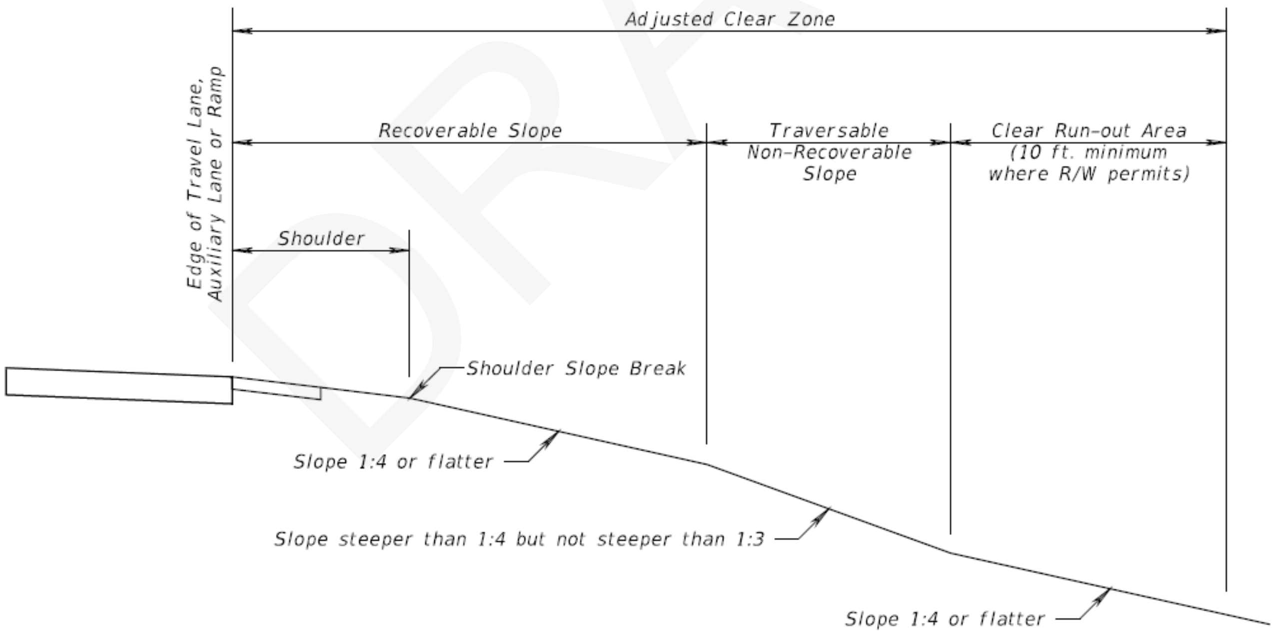


Figure 4-5. Roadside Ditches—Bottom Width 0 to < 4 ft (Source: Figure 3-6, AASHTO Roadside Design Guide 4th Edition [2011])

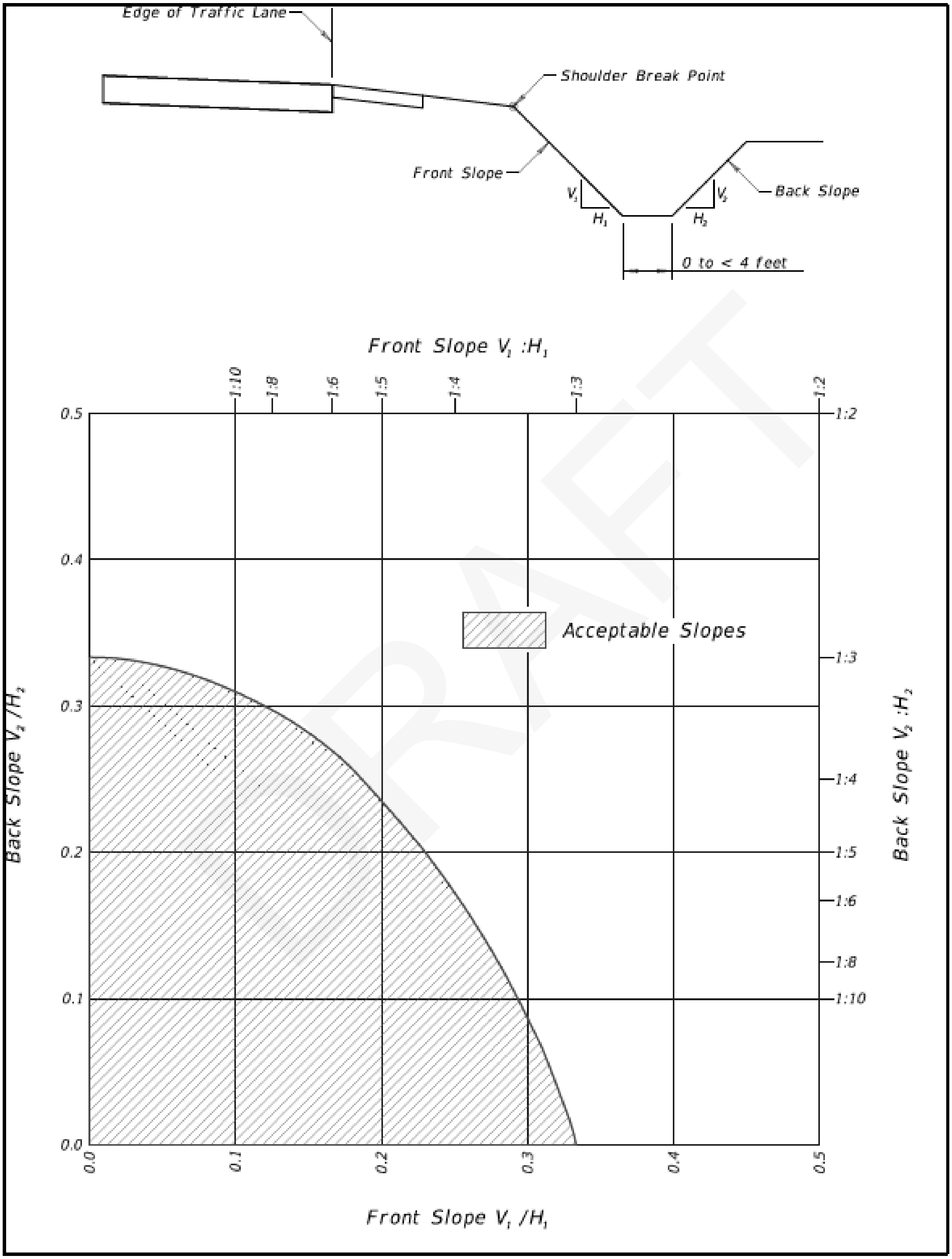
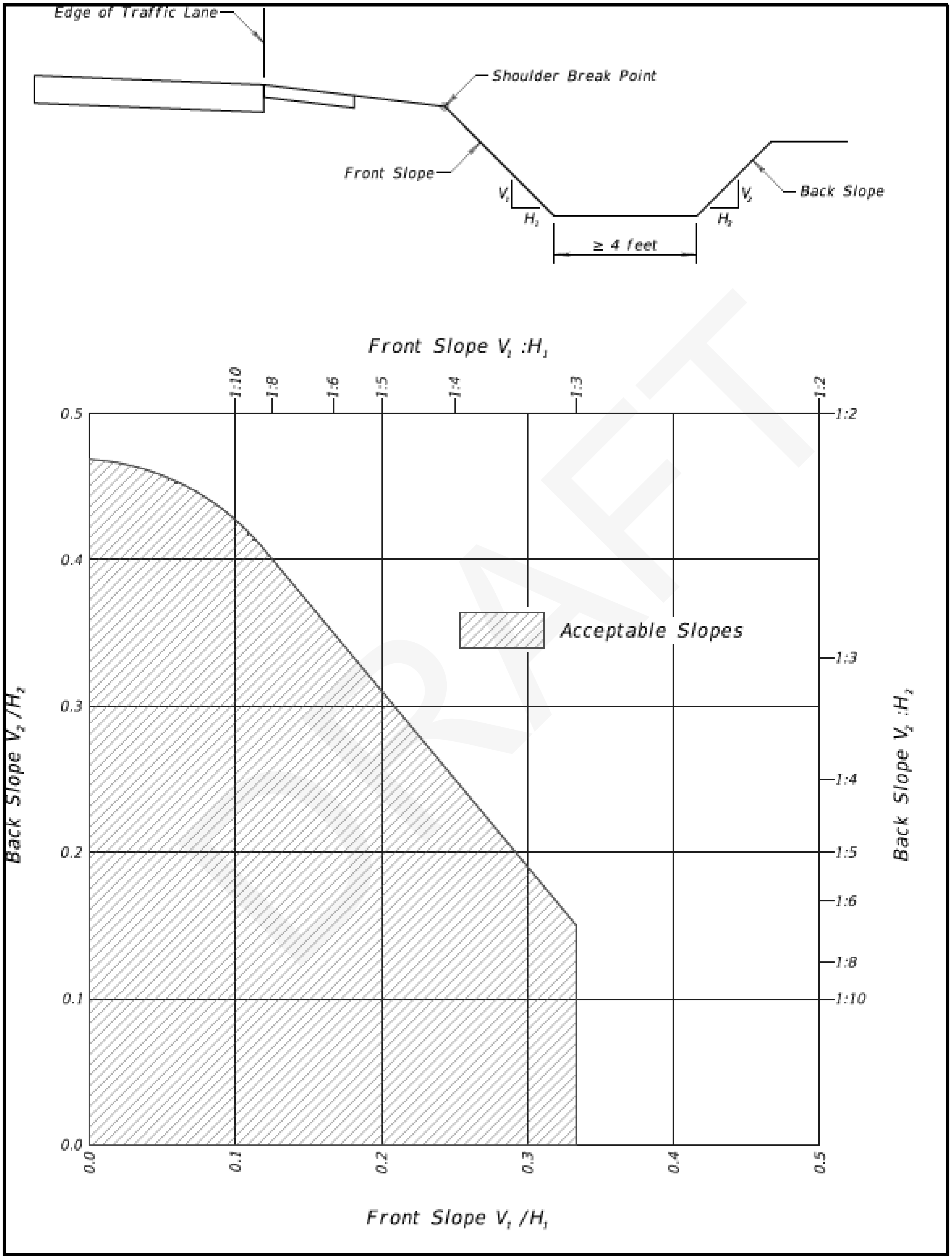


Figure 4-6. Roadside Ditches—Bottom Width ≥ 4 ft (Source: Figure 3-6, AASHTO Roadside Design Guide 4th Edition [2011])



4.3.2.1 Safety Edge Considerations

When drivers mistakenly depart the roadway, small vertical drop-offs at the edge of pavement may prevent them from easily returning to the roadway. This issue is typically caused by soil erosion at the edge of pavement. To overcome such drop-offs, errant drivers may increase their steering and acceleration inputs. This can result in a loss of control, vehicle rollover, or steering overcorrection that may lead to a collision. To help reduce such vertical drops and vehicle instability, Safety Edge technology can be applied during the paving process to shape the pavement edge to 30-degree slopes. This treatment can also improve pavement durability by reducing edge raveling. More information can be seen in the following sources.

- FHWA Proven Safety Countermeasure: Safety Edge (FHWA-SA-21-038)
- Safety Evaluation of the Safety Edge Treatment, Summary Report (FHWA-HRT-11-025)

4.3.4 Minimum Lateral Offset

Due to right-of-way limitations, it is often necessary to place functional roadside components within the clear zone. Such roadside components include fixed objects that are integral to the safe and efficient operation of roadway operations, including but not limited to, light poles, signal supports, and bridge piers.

These components are subject to the minimal lateral offset requirements per Table 4-3. The minimum lateral offset is the minimum distance that a hazardous feature must be placed from the roadway. Minimum lateral offset requirements offer additional requirements and considerations which may supersede the clear zone concept. Like the clear zone, lateral offset is measured from the roadway’s edge of traveled way or the face of curb, if present.

It’s important to consider that these values are considered a “minimum” requirement, so an effort should be made to place hazards farther than the minimum lateral offset wherever practical.

Additionally, some roadside features, such as canal hazards, receive even more specialized consideration than traditional hazards within the clear zone. As a result, canal hazards may require shielding if present outside of the clear zone, so minimum lateral offsets may exceed the clear zone width. For more information on defining canal hazards, see Section 4.4.14: Canals and Water Bodies.

For more information on the lateral offset requirements for individual roadside features, see Section 4.4: Design Requirements for Functional Roadside Infrastructure.

Table 4-3. Minimum Lateral Offset Distances (ft)

<table>
<tr><th rowspan="3">Roadside Feature</th><th colspan="4">Minimum Lateral Offset

(Distance from Face of Curb or Edge of Traveled Way, ft)</th></tr>
<tr><th rowspan="2">Urban Curbed Roadways Design Speed ≤ 25 (mph) Context Classification: Urban Center (C5) or Urban Core (C6)</th><th colspan="2">Urban Curbed Roadways Design Speed ≤ 45 (mph)</th><th rowspan="2">All Other</th></tr>
<tr><th>Low-Volume Roads (≤ 400 vpd)</th><th>All Roads</th></tr>
<tr><td>Above-Ground Objects
Objects that are > 4” in height, firm/unyielding, and do not meet crashworthy or breakaway criteria.
For urban curbed areas ≤ 45 mph, this also includes crashworthy or breakaway objects except those necessary for the safe operation of the roadway.
Includes bridge piers, abutments, and other above-ground structures meeting the above criteria.
Note: A design variation for failure to meet clear zone criteria is not required for existing, low-speed, curbed roadways if the requirements for the placement of above-ground fixed objects are met.</td><td>1.5</td><td>Preferred: 1.5

Exception: 6” where corridor is constrained

See: AASHTO’s Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400)</td><td>Preferred: 4

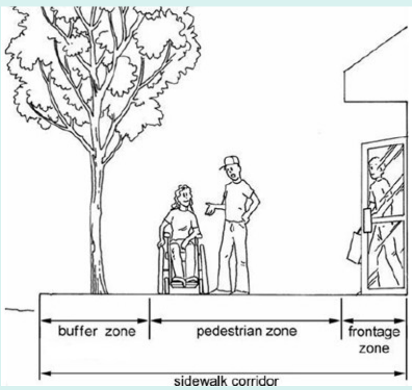
Exception: 1.5 where 4 cannot be reasonably obtained and other alternatives are impractical</td><td>Clear zone width</td></tr>
<tr><td>Drop-Off Hazards
Any vertical-faced structure with a drop-off (e.g., retaining wall, wing wall, etc.) that is located within the clear zone.
Slopes that are steeper than 1:3 and higher than 6 feet that are located within the clear zone.
Slopes steeper than 1:2.
Any drop-off with a significant crash history.</td><td colspan="4">Clear zone width</td></tr>
<tr><td>Water Bodies</td><td colspan="4">Clear zone width</td></tr>
<tr><td rowspan="3">Canal Hazards
Canal hazard lateral offset is the distance from the edge of travel lane, auxiliary lane, or ramp to the top of the canal side slope</td><td colspan="2">Design Speed ≤ 45 (mph)</td><td colspan="2" rowspan="2">Design Speed 50+ (mph) All Roadways</td></tr>
<tr><td>Curbed Roadways</td><td>Flush Shoulder Roadways</td></tr>
<tr><td>40’</td><td>50’</td><td colspan="2">60’</td></tr>
</table>

nearest the road. Section XX provides drawings for minimum offsets.	

4.3.5 Border Width (Area)

Border width, also known as border area, “provides space for roadside design components (e.g., signing, drainage features, sidewalks, and traffic control devices), a buffer between vehicles and pedestrians, and permitted public utilities. It also provides space for construction and maintenance of the facility.” For more details on border area, see Chapter 3: Geometric Design.

Committee – We will create or adapt a figure that differentiates clear zone, lateral offset, and border width/area. Something like this –



4.4 Design Requirements for Functional Roadside Infrastructure

In addition to the clear zone and minimum lateral offset requirements, roadside components and features often have unique considerations based on differing roadway contexts and historical best practices. This section provides this additional information for specific items.

4.4.1 Performance Requirements for Breakaway Devices

Except for some specific items permitted to follow minimum lateral offsets, roadside objects located within the clear zone must meet breakaway criteria to reduce impact severity. If objects in the clear zone cannot meet breakaway criteria, then shielding with barriers may be warranted and must be considered per Section 4.5: Longitudinal Barrier Evaluation, Selection, and Design.

The term “breakaway” generally refers to traffic sign, highway lighting, and other supports that are designed to yield, fracture, or separate when impacted by a vehicle. The release mechanism may be a slip plane, plastic hinge, fracture element, or combination thereof.

Typically, the term "breakaway" inherently refers to *crashworthy* breakaway devices. This means that the device performs in such a way that it is compliant with the breakaway device performance requirements set forth in NCHRP Report 350 (NCHRP 350) or the AASHTO Manual for Assessing Safety Hardware (MASH) (2016) (see 4.5.2: Section Crash Test Criteria and Evaluation Criteria).

Devices that break away upon impact but that do not conform to the AASHTO MASH 2nd Edition (2016) guidelines should be treated as non-breakaway devices. For the most up-to-date guidance on breakaway device performance guidelines, see the AASHTO MASH 2nd Edition (2016) and the AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals.

4.4.2 Trees

Trees with an expected diameter of greater than 4 inches (when measured 6 inches above grade) must be located to meet clear zone requirements in Table 4-1 and Table 4-2. Trees with multiple trunks or groups of small trees may be considered as one single tree with their combined cross-sectional area. Typically, large trees should be removed from within the clear zone for new construction and reconstruction.

Committee – The RDG recommends states develop "policies that focus solely on the safety aspects of trees and promote tree removal over other measures may not be acceptable to all involved parties." Does FDOT have anything like this?

A note on context: Trees are often integrated into the roadside environment along lower speed or multimodal roadways. Trees may be used to achieve speed management in these contexts and in areas transitioning from rural to suburban or from suburban to rural contexts (gateway). However, features that are desirable in gateways, such as raised flowerbeds, trees, large signs, and walls, could be considered potentially hazardous roadside features. When making design decisions for these contexts, consider the mature size of trees and shrubs, and specifically how they will affect safety, visibility, and maintenance cost. Additionally, consider that trees should be combined with other gateway and traffic-calming features to achieve the desired effect, rather than posing an additional hazard.

The most recent version of the AASHTO RDG 4th Edition (2011) should be considered for additional discussion and guidance on trees. This includes reviewing the treatment and barrier guidelines for trees as well as any other sections that discuss trees as they relate to roadside safety and road departure crashes. Other resources that address collisions with trees include Volumes 3, 6, and 8 of NCHRP Report 500.

Committee – The RDG recommends states develop “policies that focus solely on the safety aspects of trees and promote tree removal over other measures may not be acceptable to all involved parties.” Does FDOT have anything like this?

Would it be helpful to add a section to the end of the document that highlights ongoing / recent research documents that can be referenced for additional context/guidance on various topics?

4.4.3 Sign Supports

4.4.3.1 Traffic Signs and Sign Supports

Traffic signs and sign supports must meet the requirements provided in the MUTCD as stated in Chapter XX: Signing and Marking. The MUTCD requires all sign supports within the clear zone (see Table 4-1 and Table 4-2) to be shielded or breakaway (see Section 4.4.1: Performance Requirements for Breakaway Devices). Only when the use of breakaway supports is not practical should a traffic barrier or crash cushion be used exclusively to shield sign supports. In addition, sign supports should be located where they are least likely to be hit. Where possible, signs should be placed behind existing roadside barriers beyond the design deflection distance or on existing structures.

FDOT Standard Plans provide details for breakaway supports for single- and multi-post ground-mounted signs that are acceptable for use within the clear zone. The most current version of these Standard Plans should be used as FDOT maintains and updates these details as necessary to comply with required implementation dates for changes in crash test criteria.

4.4.3.2 Overhead Signs and Cantilever Signs

Overhead signs and cantilever signs require relatively large sign support systems. The potential safety consequences of these systems falling necessitate a fixed-base design that cannot be made breakaway. Overhead sign and cantilever sign supports therefore are required to be located outside the clear zone (Table 4-1 and Table 4-2) or to be shielded with a crashworthy barrier (Section 4.5: Longitudinal Barrier Evaluation, Selection, and Design). Where possible, these supports should be located behind traffic barriers shielding nearby overpasses or other existing structures, or the signs should be mounted on the nearby structure. The FDOT Standard Plans provide details and instructions for the design of these systems.

4.4.4 Traffic Signal Supports

The traffic signal supports commonly used in Florida:

- are fixed base;
- must meet the minimum lateral offset criteria provided in Table 4-3; and

- should not be located within medians.

Committee – How does bullet #2 affect placing the poles in such a way that pushbutton locations are ADA compliant? Should we comment on this?

See FDOT Standard Plans listed below for details and instructions for the design of traffic signal supports:

Committee – Which Standard Plans should be referenced here?

4.4.5 Lighting Supports

Lateral offset criteria for lighting supports depend on whether the support is breakaway or fixed base, as discussed below. See Chapter XX: Lighting for additional design criteria for lighting.

4.4.5.1 Conventional Lighting (Breakaway Supports)

Supports for conventional lighting (heights up to 60 feet) must be breakaway, which are typically frangible bases (cast aluminum transformer bases), slip bases, or frangible couplings (couplers). See FDOT Standard Plans Index 715-002 and 715-003 for examples of such breakaway poles.

Generally, a breakaway lighting support will fall near the line of the path of an impacting vehicle. The mast arm usually rotates and points away from the roadway when resting on the ground. For poles located on the outside of the roadway (not in medians), this action generally results in the pole not falling into other traffic lanes. However, the designer should remain aware that these falling poles may endanger other motorists or bystanders such as pedestrians and bicyclists.

The following guidance applies to light structures with conventional breakaway supports:

- On curbed roadways with design speeds of 45 mph or less, breakaway lighting supports must be located to meet the minimum lateral offset requirements provided in Table 4-3.
- On flush shoulder roadways, breakaway lighting supports must be located according to the smallest value of the following:
  - a minimum of 20 feet from the nearest travel lane or multi-lane ramp;
  - 14 feet from the nearest auxiliary lane or single-lane ramp; or
  - outside the clear zone provided in Table 4-1 and Table 4-2.
- Where supports are located within the clear zone, the front slope must be 1:6 or flatter.

- Lighting should not be located in medians, except in conjunction with barriers that are justified for other reasons.
- The AASHTO RDG 4th Edition (2011) may be referenced for additional discussion on breakaway lighting supports.

4.4.5.2 High-Mast Lighting (Fixed-Base Supports)

High-mast or high-level lighting supports are fixed-base support systems that do not yield or break away on impact. High-mast lighting supports:

- must be located outside the clear zone provided in Table 4-1 and Table 4-2; and
- must not be located in medians except in conjunction with barriers that are justified for other reasons.

See the FDOT Standard Plans Index 715-010 for additional information.

4.4.6 Utility Poles

Utility poles:

- must be located to meet minimum lateral offset requirements provided in Table 4-3;
- should be located as close as practical to the right-of-way line; and
- should be installed per the permitting agency's requirements.

In accordance with Florida Statute Section 337.403, existing utility poles must be relocated when unreasonably interfering with the "convenient, safe, or continuous use, or the maintenance, improvement, extension, or expansion" of public roads.

Utility poles adjacent to road improvement projects, but not directly interfering with construction, should be considered for relocation (to the extent they can be relocated) to achieve the minimum lateral offset requirements in Table 4-3.

Utility poles that cannot be relocated and will remain within the minimum lateral offset should be approved through the exception process prescribed in Chapter XX: Design Exceptions and Variations.

The AASHTO RDG 4th Edition (2011) and FDOT Utility Accommodation Manual provide additional discussion and guidance on utility poles.

4.4.7 Midblock Crossing Infrastructure

Overhead structural supports serving midblock crosswalks (e.g., signals or pedestrian hybrid beacons) may be placed in medians if project constraints prevent placement elsewhere. Place the supports near the center of the median to the greatest extent practical while also meeting the minimum lateral offsets in Table 4-3. Also see the FDM Section 215.2.9.

Committee – FSM Section 215.2.9 will be released Nov 1 (noted by Richard).

4.4.8 Fire Hydrants

Most fire hydrants are made of cast iron and are expected to fracture upon impact; however, crash testing has not been done to verify that designs meet current breakaway criteria. For this reason, fire hydrants should be located:

- as far from the traveled way as practical;
- preferably outside the minimum lateral offset requirements listed in Table 4-3; and
- where they are still readily accessible to and usable by emergency personnel.

Any portion of the hydrant not designed to break away should be within 4 inches of the ground.

4.4.9 Railroad Crossing Warning Devices

See Chapter XX: Rail-Highway Crossings for location requirements for railroad crossing warning devices.

4.4.10 Mailbox Supports

Committee – Is all this information being used? If not, what can be removed?

Mailboxes and their locations are subject to U.S. Postal Service requirements. They are often located within the clear zone and pose a potential hazard. However, with proper design and placement, the severity of impacts with mailboxes can be reduced. To achieve consistency, it is recommended that each highway agency adopt regulations for the design and placement of mailboxes within the right-of-way of public highways. The AASHTO RDG 4th Edition (2011) provides a model regulation that is compatible with U.S. Postal Service requirements. The following requirements apply to mailbox installations on public roadways:

- No mailbox will be permitted where access is obtained from a freeway or where access is otherwise prohibited by law or regulation.
- Mailboxes must be located on the righthand side of the roadway in the carrier's direction of travel except on one-way streets, where they may be placed on the lefthand side.
- Where a mailbox is located at a driveway entrance, it must be placed on the far side of the driveway in the carrier's direction of travel.

- Where a mailbox is located at an intersecting road, it must be located a minimum of 200 feet beyond the center of the intersecting road in the carrier's direction of travel. This distance may be decreased to 100 feet on very low-volume roads.
- When a mailbox is installed in the vicinity of an existing guardrail, it should, when practical, be placed behind the guardrail.
- The bottom of the box must be set at a height established by the U. S. Postal Service, usually from 41 to 45 inches above the roadway surface.
- On flush shoulder roadways, the roadside face of the box should be offset from the edge of the traveled way at a distance no less than the greater of the following:
    - eight feet (where no paved shoulder exists and the shoulder cross slope is 10% or flatter), or
    - the width of the shoulder present plus 6 to 8 inches, or
    - the width of a turnout specified by the jurisdiction plus 6 to 8 inches.
- On very low-volume flush shoulder roads with low operating speeds, the offset may be reduced to 6 feet from the traveled way.
- On curbed streets, the roadside face of the mailbox should be set back from the face of the curb by 6 to 8 inches.
- On residential streets without curbs or all-weather shoulders that carry low traffic volumes operating at low speeds, the roadside face of the mailbox should be offset behind the edge of the pavement by between 8 and 12 inches.
- Design criteria for the mailbox support structure when located within the clear zone should consist of the following:
    - Mailboxes must be of light sheet metal or plastic construction conforming to the requirements of the U. S. Postal Service. Newspaper delivery boxes must be of light metal or plastic construction of dimensions minimally suitable for holding a newspaper.
    - No more than two mailboxes may be mounted on a support structure unless crash tests have shown the support structure and mailbox arrangement to be safe. However, lightweight newspaper boxes may be mounted below the mailbox on the side of the mailbox support.
    - A single wooden post (4-inch-by-4-inch square or 4-inch-diameter); or metal post (Schedule 40, 2-inch, nominal Iron Pipe Size [external diameter 2-3/8 inch] [wall thickness 0.154 inches]; or smaller), embedded no more than 24 inches into the ground, must be acceptable as a mailbox support. A metal post must not be fitted with an anchor

plate, but it may have an anti-twist device that extends no more than 10 inches below the ground surface.

- Unyielding supports, such as heavy metal pipes, concrete posts, brick, stone or other rigid foundation structures or encasements, should be avoided.
- 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 exact support hardware dimensions and design may vary, such as having a two-piece platform bracket or alternative slot-and-hole locations. The product must result in a satisfactory attachment of the mailbox to the post, and all components must fit together properly.
- The minimum spacing between the centers of support posts should be the height of the posts above the ground line. Mailbox support designs not described in this regulation are acceptable if approved by the jurisdiction.

FDOT Standard Plans and the AASHTO Roadside Design Guidance provide details on the hardware, supports, and attachment details that are acceptable for compliant mailboxes located within the clear zone.

Additional information on the design and construction of residential and commercial mailboxes, including outdoor cluster boxes, can be found on the United States Postal Service's Delivery Growth Management webpage.

4.4.11 Bus Benches and Shelters

See Chapter XX: Geometric Design for location criteria for bus benches and shelters. Additional criteria are provided in Chapter XX: Public Transit.

4.4.12 Curbs

Curbs have no redirectional capabilities except at very low speeds—less than the lowest design speeds typically used for urban streets. Therefore, do not use curbs to mitigate clear zone violations. The addition of curb for the sole purpose of achieving lateral offset criteria is prohibited.

Curbs with closed drainage systems provide a tangible definition of the roadway limits and delineation of access points. This makes curbs useful in urban areas due to the following typical urban areas characteristics:

- Low design speed (≤ 45 mph)
- Dense abutting development

- Closely spaced intersections and accesses to property
- Higher number of motorized vehicle, bicyclist, and pedestrian volumes
- Restricted right-of-way

FDOT Standard Plans, Index 520-001 provides details for curb shapes commonly used in Florida. Typical applications for urban roadways include Type E and Type F curbs. Note that these raised curb designs are not considered aboveground hazards due to their smooth edges and continuous design. Both curb types have a sloped face; however, the Type E has a flatter face to allow vehicles to traverse it more easily.

Some raised curb types, such as Type E (height 5 inches or less with a sloping face equal to or flatter than the Type F), may be used in the following cases on high-speed roadways. In these cases, the face of the curb must be placed no closer to the edge of the traveled way than the required shoulder width. The cases include:

- High-speed multilane divided highways with design speeds of 55 mph and less; for examples, see the FDOT Design Manual, Chapter 210 Arterials and Collectors
- Directional median openings; for examples, see the FDOT Design Manual, Chapter 212 Intersections
- Transit stops (harmonize with flush shoulder accessible transit stops)

As an alternative to raised curb, shoulder gutter is also frequently used along roadway fill sections and bridge approaches to prevent excessive runoff down embankment slopes. This relatively flat feature is not speed restricted. Shoulder gutter does not have a raised face like Type E or Type F, so its usage would not be considered a “curbed” roadway condition. The FDOT Drainage Manual may be referenced for direction on the use of shoulder gutter.

See Chapter XX: Geometric Design for additional criteria on the use of curbs and shoulder gutter.

4.4.13 Drainage Structures

Drainage structures and their associated end treatments located along the roadside should be implemented using either a traversable design or located outside the required clear zone. An efficient drainage design typically contains curb inlets, ditch bottom inlets, endwalls, wingwalls, headwalls, and flared end sections or mitered end sections. If not adequately designed or properly located, these features can create hazardous conditions (e.g., abrupt deceleration or rollovers) for vehicles.

For detailed background information concerning traversable designs, refer to the AASHTO RDG 4th Edition (2011). Standard details for drainage structures and end treatments commonly used in Florida are provided in the FDOT Standard Plans. Drainage features shown in FDOT Standard Plans have the potential to conflict with a motor vehicle or bicyclist either departing the roadway or within a commonly traversed section of a roadway. The FDOT Drainage Manual identifies those standard drainage structures which are acceptable for use within the clear zone

4.4.14 Canals and Water Bodies

Wherever practical, avoid the placement of water bodies near roadways. If such placement is unavoidable, locate water bodies outside of the clear zone per Table 4-1 and Table 4-2.

Additionally, if the water body meets the following definition of a canal hazard, minimum lateral offsets must be followed per Table 4-3, and these required offsets will generally exceed clear zone width requirements.

A canal hazard is defined as an open ditch parallel to the roadway for a minimum distance of 1,000 feet and with seasonal water depth of more than 3 feet for extended periods of time (24 hours or more). See Figure 4-7 and Figure 4-8 and apply the following guidance:

- On new alignments and for new canals, greater distances should be provided to accommodate future widening of the roadway.
- On fill sections, a flat berm (maximum 1:10 slope) no less than 20 feet in width between the toe of the roadway front slope and the top of the canal side slope nearest the roadway should be provided.
- When the slope between the roadway and the "extended period of time" water surface is 1:6 or flatter, the minimum distance can be measured from the edge of the travel lane, auxiliary lane, or ramp to the "extended period of time" water surface. A berm is not required.
- On sections with ditch cuts, a minimum of 20 feet between the toe of the front slope and the top of the canal side slope nearest the roadway should be provided.
- When the required minimum lateral offset cannot be met, the canal hazard must be shielded with a crashworthy roadside barrier. Barriers must be located as far from the traveled way as practical. When shielding canal hazards, the barrier must be located outside the clear zone where possible. Guardrail must be located no closer than 6 feet from the canal front slope, and high-tension cable barrier must be no closer than 15 feet from the canal front slope.
- If the above offset criteria would locate the barrier within the clear zone, instead follow the barrier offset requirements of Section 4.5.5: Barrier Placement.

Figure 4-7. Minimum Offsets for Canal Hazards (Flush Shoulders)

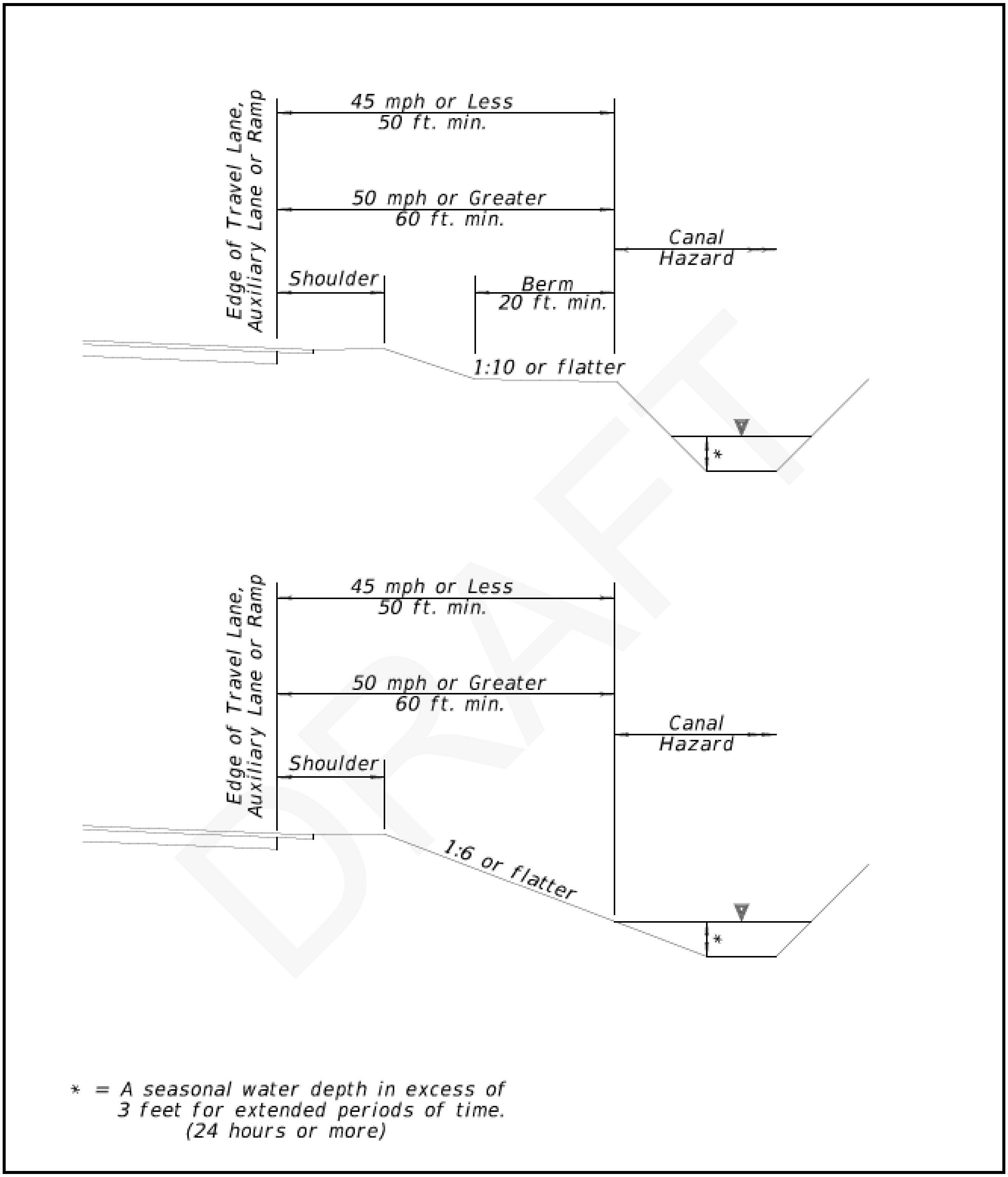
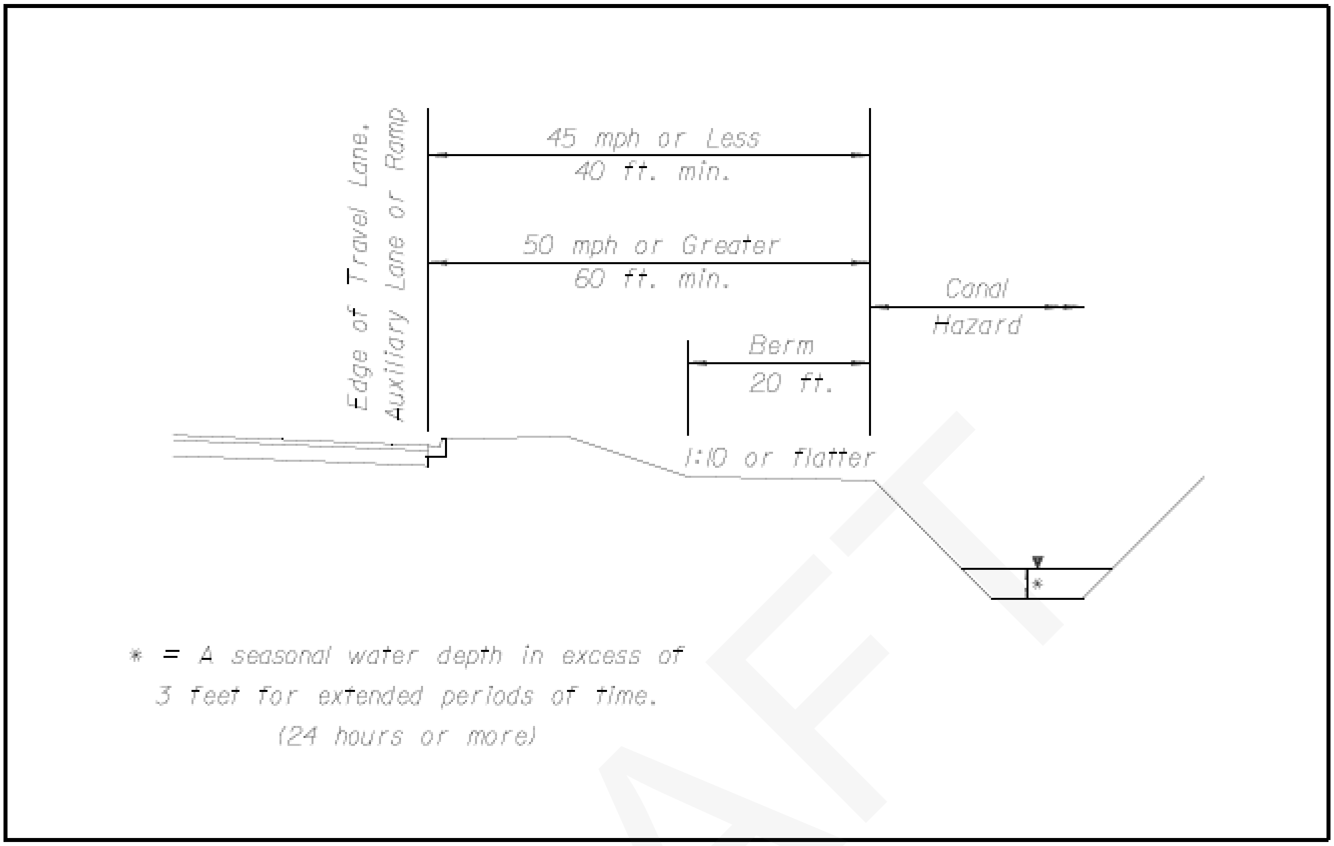


Figure 4-8. Minimum Offsets for Canal Hazards (Curbed)



4.4.15 Retaining Walls and Noise Walls

The design of conventional, anchored, mechanically stabilized, and prefabricated modular retaining wall structures must meet the requirements of the latest version of the AASHTO Load and Resistance Factor Design (LRFD). Local agencies should consider using only wall types approved by FDOT. These are described in Section 3.12 of the FDOT Structures Design Guidelines (SDG). Local agencies should also follow the design criteria for retaining walls found in SDG Section 3.13. Additionally, the design of noise walls should meet the requirements of the SDG, Section 3.16. For noise walls within the clear zone, their design should comply with the following:

- For noise walls attached to the top of traffic railings, use only crash tested systems consistent with the design speed of the facility. FDOT has standards for TL-4 systems that meet the requirements of NCHRP 350 or the AASHTO MASH 2nd Edition (2016).
- Non-crash tested noise walls may be attached to structures if located behind an approved traffic railing and mounted at least 5 feet from the face of the traffic railing at deck level.

Potential existing offsite stormwater that inflows through the proposed wall location should be verified in the field and considered in the wall design. For railings on top of walls, see Chapter 17 Section C.3.c. Railings.

4.4.16 Poles for Intelligent Transportation Systems (ITS)

"Intelligent transportation systems" (ITS) refers to technology used to enhance roadway safety and operations. One example of this type of technology is dynamic message signs (DMS), which use electronic signs to project real-time traffic alerts to drivers. See FDM Section 233 for general usage and placement information. ITS infrastructure should meet minimum lateral offset requirements per Table 4-3.

Refer to FDM Section 215 for information regarding proposed attachments to bridge traffic railings, concrete median barrier walls, concrete shoulder barrier walls, or regarding the evaluation of existing attachments.

4.5 Longitudinal Barrier Evaluation, Selection, and Design

4.5.1 Overview of Roadside Barriers

Roadside barriers are used to shield motorists from roadside hazards and, in some cases, are used to protect bystanders, pedestrians, cyclists, and workers from vehicular traffic. In other cases, roadside barriers are used to prevent median crossover crashes or to shield bridge piers from vehicle impacts. When selecting the appropriate type of barrier, several factors must be considered, including but not limited to, vehicle design speeds, roadway context, and terrain features. When a barrier type is selected, there are several additional considerations related to system design and placement, including but not limited to, the length of the system, lateral offset of the system, and system taper rate (i.e., flare rate).

This chapter discusses various factors that should be considered when selected and installing a longitudinal barrier system.

4.5.1.1 Barrier System Types and Components

The main types of longitudinal roadside barriers are metal guardrail (semi-rigid), concrete barrier (rigid), high-tension cable barrier (flexible), and portable/temporary barrier for work zone environments. See Section 4.6: Semi-Rigid (Metal Guardrail) Barriers, Section 4.7: Rigid (Concrete) Barriers, Section 4.8: Flexible (High-Tension Cable) Barriers, Section 4.11: Roadside Safety in Work Zones (Temporary Barriers), and the FDOT Standard Plans for more detailed information on each barrier type.

Specific types of longitudinal barriers may be best suited to median placement. For example, median barriers (i.e., double-faced barriers) are designed for vehicles to strike either side and are primarily used to separate opposing traffic on a divided highway. In limited cases, median barriers may also be used on heavily traveled roadways to separate through traffic from local traffic or to separate high-occupancy vehicle (HOV) and managed lanes from general purpose lanes.

Additionally, most barrier ends require a special end treatment device. Primarily, untreated approach ends of barrier systems may pose a hazard. To increase crashworthiness, these upstream barrier ends must be treated with either an approach terminal, crash cushion, or transition connection to a different barrier. Barrier transition connection segments are used to join different barrier types in order to mitigate their different deflection characteristics (see Section 4.9.6: Barrier Transition Connections (from semi-rigid to rigid barriers)). For example, a transition segment is needed where a semi-rigid guardrail attaches to the approach end of a rigid concrete bridge rail.

Last, trailing ends of semi-rigid or flexible barrier generally require an anchorage for effectively developing system strength and redirective capability. See Section 4.9: Treating Barrier Ends for more detailed information on these methods for treating barrier ends.

Work zones, due to being temporary designs, often require the use of temporary (portable) devices. For more information related to temporary (portable) devices for roadside safety and design in work zones, see Section 4.11: Roadside Safety in Work Zones (Temporary Barriers).

The FDOT Approved Products List provides a comprehensive list of products that are approved for use on FDOT roadways. Note that local designs are not required to follow the APL.

Committee – Can you confirm this statement regarding local designs and the APL is true?

4.5.2 Crash Test Criteria and Evaluation Criteria

New roadside barriers, transitions, approach terminals, and crash cushions should be crashworthy as determined by full-scale crash testing in accordance with specific crash-test guidance provided in the AASHTO MASH 2nd Edition (2016). Existing system do not need to be MASH-compliant.

Before the AASHTO MASH 2nd Edition (2016), NCHRP Report 230 and then NCHRP 350 were the first documents to provide guidance on roadside hardware crash testing. Most recently, the AASHTO MASH 2nd Edition (2016) is the document that prescribes the modern process to 1) perform crash tests to assess roadside hardware performance and 2) evaluate roadside hardware performance.

The longitudinal barrier crash test matrix divides crash tests into six test levels (TL). TL-1 through TL-3 use two sizes of passenger vehicles, while TL-4 through TL-6 use heavy, commercial-grade vehicles. As the crash TL increases, so does the impact severity, which describes the magnitude of loading on the barrier. As a result, the TL of the barrier indicates what roadway speeds it is appropriate to install the barrier on.

Consult the AASHTO MASH 2nd Edition (2016) for the complete longitudinal barrier crash test matrix and additional details on crash testing and evaluation methods and criteria.

4.5.3 Safety Hardware Upgrades

The industry requires permanent installation of new barriers and full replacements on the National Highway System to meet the AASHTO MASH 2nd Edition (2016) criteria. This means that for new construction and reconstruction projects, NCHRP 350 hardware must be upgraded or replaced with MASH-approved hardware. Otherwise, an NCHRP 350-approved system may remain on existing roadways until it becomes damaged beyond repair, or when an individual agency's maintenance policies require an upgrade to the safety hardware.

The FDOT Design Manual Chapter 215 provides a list of considerations when investigating the need for upgrading barriers and other hardware. The FDOT's Standard Plans provide details for transitioning new barriers to existing barriers. The AASHTO RDG 4th Edition (2011) also provides guidelines for upgrading hardware.

4.5.4 Barrier Selection Guidelines

Numerous factors may be considered to ensure that the appropriate barrier type is selected for a given application. Consideration should be given to the following factors when evaluating each site:

- Barrier placement requirements (see Section 4.5.5: Barrier Placement)
- Traffic characteristics (e.g., common vehicle sizes, volume, and growth)
- Site characteristics (e.g., terrain, geometry, facility type, design speed, etc.)
- Expected frequency of roadway departures
- Installation and replacement/repair costs
- Ease of maintenance
- Aesthetics

For additional information about considerations for barrier selection, refer to the AASHTO RDG 4th Edition (2011). Document all barrier type selection decisions and warrants.

4.5.5 Barrier Placement

This section contains additional requirements for barrier placement.

4.5.5.1 Length of Need (LON)

Barrier LON is the length of barrier needed in advance of a roadside hazard or a non-traversable terrain feature to prevent a vehicle that has left the roadway from striking the hazard or feature.

The LON for a particular barrier type is calculated based on several factors, including the length of the hazard, the lateral area of concern, run-out length, and other factors. LON must consider traffic and clear zones for both directions of traffic where applicable. LON is calculated using the guidance provided in AASHTO RDG 4th Edition (2011), equation 5-3.

To assist with calculating LON, a spreadsheet is provided on FDOT's Standard Plans webpage, adjacent to Index 536-001, in the Design Tools column.

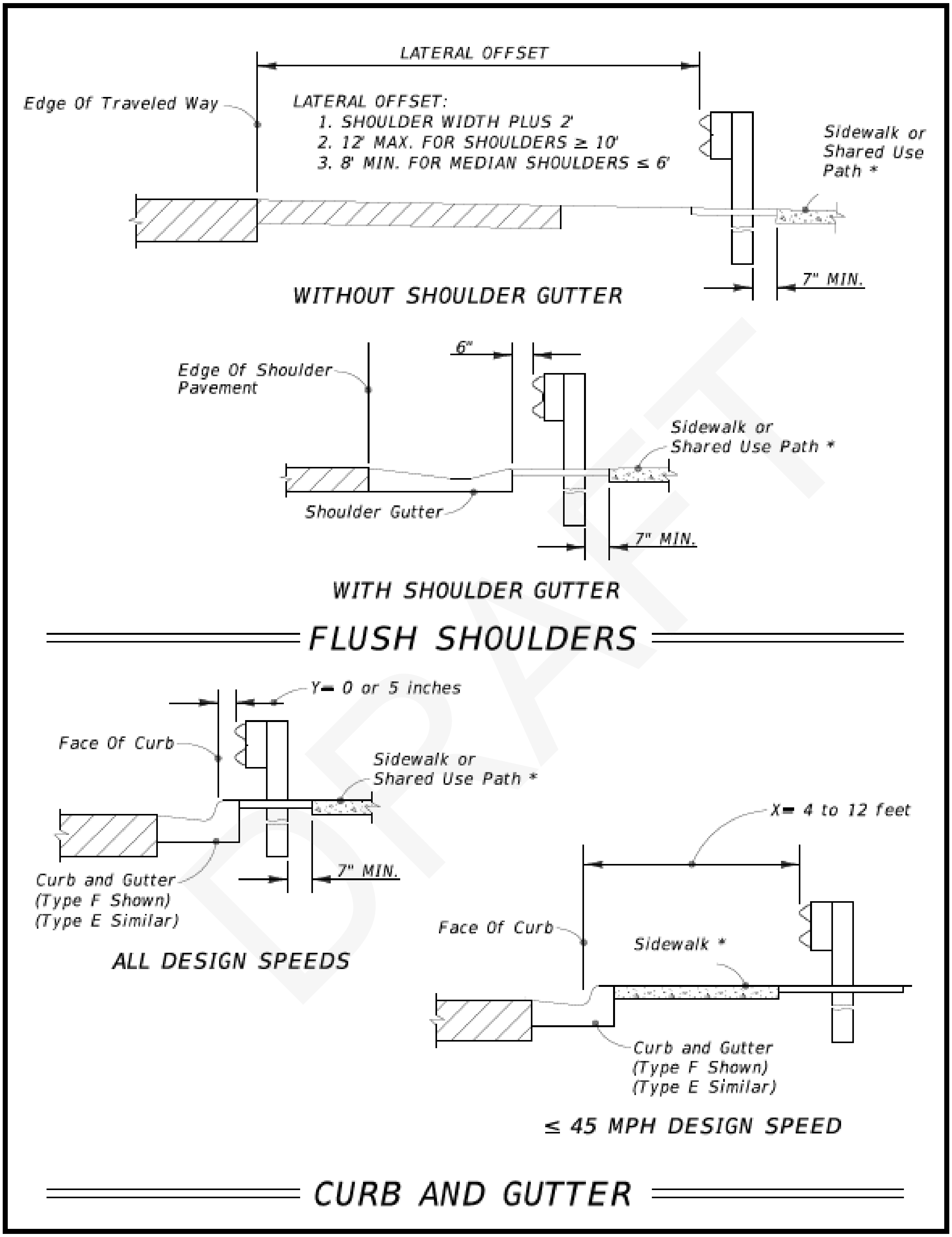
4.5.5.2 Barrier Offsets

See the FDOT Design Manual, Chapter 215 Roadside Safety and Standard Plans for proper barrier placement. Figure 4-9 provides information on the offset of guardrail on curbed and flush shoulder roadways.

Committee – Note for the following figures (and other figures in this chapter): we will work with Daniel Eichler to ensure all the drawings are from the pending 2026 FDM and have any modifications necessary to be applicable to the Greenbook.

This is a working document
that has not been adopted.

Figure 4-9. Location of Guardrail



*When a sidewalk is present or planned, see Chapter 8: Pedestrian Facilities and Chapter 9: Bicycle Facilities for criteria for sidewalks and shared use paths (e.g., width of facility plus clear, graded areas adjacent to the path or sidewalk).

4.5.5.3 Taper Rate

In general, longitudinal barriers must remain parallel to the roadway for crashworthiness regarding crash test assumptions for impact angle. That said, gradual tapers are permitted to meet roadway needs as described below. A tapered barrier is defined as being not parallel to the edge of the traveled way. “Taper rate” (or “flare rate”) describes the rate at which the barrier deviates from parallel. A tapered barrier may be necessary for several reasons:

- To locate the barrier terminal farther from the roadway
- To transition a roadside barrier to an obstacle nearer the roadway such as a bridge parapet or railing
- To reduce the total length of barrier needed, assuming “flared” approach terminals are available to meet the needed test criteria (See Section 4.5.5.1: Length of Need)
- To reduce the potential for barrier and terminal impacts and provide additional roadside space for an errant motorist to recover

Disadvantages associated with flaring a barrier installation are the following:

- As the taper rate increases, so does the angle at which the barrier can be hit, which in turn increases crash severity. This is especially the case for rigid and semi-rigid barrier systems.
- Tapering a barrier installation may increase the likelihood that a vehicle will be redirected back into or across the roadway following an impact.

See the FDOT Design Manual, Chapter 215 Roadside Safety for acceptable taper rates. Additional information on flare rates is provided in the AASHTO RDG 4th Edition (2011).

4.5.5.4 Setback and Zone of Intrusion

In addition to travel lane lateral offset considerations, an adequate setback must be provided behind the barrier to ensure proper barrier function. This setback is based on the zone of intrusion (ZOI) concept as described in the AASHTO RDG 4th Edition (2011). ZOI describes the region above and behind the face of the barrier where an impacting vehicle may extend during an impact and is influenced by several factors, including barrier height, barrier profile, and vehicle size, speed, and impact angle.

- For flexible and semi-rigid barriers, the setback is based on deflection tolerances and is required to prevent the barrier from contacting above-ground objects.
- For rigid barriers, the setback is required to keep the area above and behind the barrier face free of obstructions that could penetrate or damage the vehicle compartment.

These requirements do not apply to objects located within the setback distances detailed in the FDOT's Standard Plans (e.g., pedestrian/bicycle railing, fencing, noise walls, etc.).

See the FDOT Design Manual, Chapter 215 (Roadside Safety) for acceptable barrier setback distances for objects behind the barrier face. Additional information on setback distances is provided in the AASHTO RDG 4th Edition (2011).

Committee - Should this section provide any additional guidance on accommodating the ZOI? For another agency, we included something like this in their guidance:

"For TL-4 and higher, and where practical, it is recommended the designer try to accommodate for the ZOI. Some specific measurements exist for ZOI for barrier systems of different TLs. Handbook users should consult NCHRP Report 1018: Zone of Intrusion Envelopes Under MASH Impact Conditions for Rigid Barrier Attachments and the most recent version of the AASHTO RDG for more detailed guidance and ZOI measurements."

4.5.5.5 Barriers on Slopes

While barriers may be used to shield roadside slopes, the slope between the traveled way and a barrier can have a significant effect on the barrier performance. When barriers are placed on slopes that exceed the maximum allowable slope, it increases the likelihood that the vehicle will interact with the barrier in a way that's not intended (e.g., underride or override the barrier). For FDOT's standardized rigid and semi-rigid barriers, the general permitted approach slope is 1:10 or flatter. Additional information on allowable slopes for Guardrail and High Tension Cable Barrier may be found in the FDOT Stand Plans Instructions (SPIs) for Index 563-001 and D540-001, respectively. See Section 4.3.3: Slopes for guidance on when barriers should be used to shield hazardous slope conditions.

4.5.5.6 Barriers Near and on Curbs

Committee – What are the appropriate Standard Plans to list in this section?

As with grading, the presence of curb in combination with barriers deserves special attention. A vehicle that traverses a curb prior to impact may override the barrier if it is partially airborne upon impact. Conversely, the vehicle may underride the rail element of a guardrail system and snag on the support posts if it strikes the barrier too low. In general, guardrail is the barrier most commonly used adjacent to curb. See Figure 4-9 for guardrail placement requirements with respect to the face of curb.

Committee – Would it be helpful to add a section to the end of the document that highlights ongoing / recent research documents that can be referenced for additional context/guidance on various topics?

We could include NCHRP Research Report 1089: Development of Installation Guidelines for Midwest Guardrail System in Combination with Roadside Curbs for MASH TL-3 Applications.

This report, published in 2024, provides guidance for lateral offset of the 31” tall Midwest Guardrail System (MGS) behind curbs. This guidance is ≤ 0.5 feet when the MGS installation height is 31” tall relative to the roadway surface and 1 to 6 feet when the MGS installation height is 31” tall relative to the top of curb/soil backfill.

4.5.6 Median Barrier Warrants

In addition to the shielding of hazards, median barriers may also be used for the prevention of cross-median crashes into oncoming vehicles. As such, median barriers must be used on high-speed, limited-access facilities where the median width is less than the minimum values given in Chapter 3, Geometric Design, Table 3 – 23 Minimum Median Widths. For locations where median widths are equal to or greater than the minimum requirement, median barriers are not normally used except in special circumstances, such as a location with a significant history of cross-median crashes. Any determination to use a median barrier on limited-access facilities must consider the need for barrier openings for median crossovers that are appropriately spaced to avoid excessive travel distances by emergency vehicles, law enforcement vehicles, and maintenance vehicles. The FDOT Design Manual may be referenced for additional criteria and guidelines for locating and designing median crossovers on limited-access facilities.

On high-speed divided arterials and collectors, median barriers are not normally used due to several factors that are challenging to address. Such factors include right-of-way constraints, property access needs, presence of at-grade intersections and driveways, adjacent commercial development, intersection sight distance, and barrier end termination. However, provided these factors can be properly addressed, median barriers for these facilities may be considered where median widths are less than the requirement or where barriers are otherwise justified due to a significant crossover crash history.

4.5.7 Attachments to Barriers

Attachments to barriers such as signs, light poles, and other objects will affect the crash performance of the barrier and should be avoided where practical. When they are used, attachments should meet the AASHTO MASH 2nd Edition (2016) crash test criteria. See the

FDOT Design Manual, Chapter 215 Roadside Safety for additional information on attachments to barriers.

4.6 Semi-Rigid (Metal Guardrail) Barriers

Metal Guardrail Summary:

Metal guardrails use a combination of bending and tension to absorb impact energy. The systems are comprised of metal **rail** mounted to wood or metal **posts** with wood or composite **blockouts** and an **end treatment**.

Metal rail may be a w-beam rail (two-wave design; the most common design) or a thrie-beam rail (three-wave design). Thrie-beam rails provide some additional strength to the system, and are generally used for approach transition connections to rigid barrier (see Section 4.9.6: Barrier Transition Connections (from semi-rigid to rigid barriers)).

Offset blocks are mounted between the rail and the posts, providing an offset between these two components.

End treatments for metal guardrails include approach terminals, trailing anchorages, and crash cushions. See Section 4.9: Treating Barrier Ends for details on end treatments.

Posts may be wooden or steel per Standard Plans, Index 536-001.

4.6.1 FDOT Guardrail Systems

The most commonly used barrier on new construction projects in Florida is the TL-3 w-beam guardrail system, shown in FDOT Standard Plans Index 536.001. This semi-rigid, w-beam, strong post guardrail system was developed based on the 31-inch Midwest Guardrail System (MGS) and exhibits the following characteristics:

- 6-foot-3-inch post spacing
- 8-inch (nominal) offset blocks
- Mid-span splices with a rail height of 2-feet-1-inch to center of the panel
- Can be used as a roadside barrier or in a double face configuration as a median barrier

This current 31-inch height system replaces the 27-inch height system (1-foot-9-inches to center of panel) that had been used for many years and is still present on roadways throughout Florida. See Section 4.5.3: Safety Hardware Upgrades for requirements for upgrading existing 27-inch height systems.

4.6.2 Installation Guidance and Considerations

Adhering to the following guidance and considerations will help determine whether a metal guardrail is the appropriate system to improve system performance:

- To achieve a minimum level of crash performance, guardrail installations must have a minimum length of 75 feet with design speeds greater than 45 mph.
- Refer to deflection space requirements for this system in the FDOT Design Manual, Chapter 215 Roadside Safety.
- See FDOT Standard Specifications for Road and Bridge Construction, Section 536 and 967 for general installation and material needs.
- See FDOT Standard Plans, Index 536 for construction details and options.

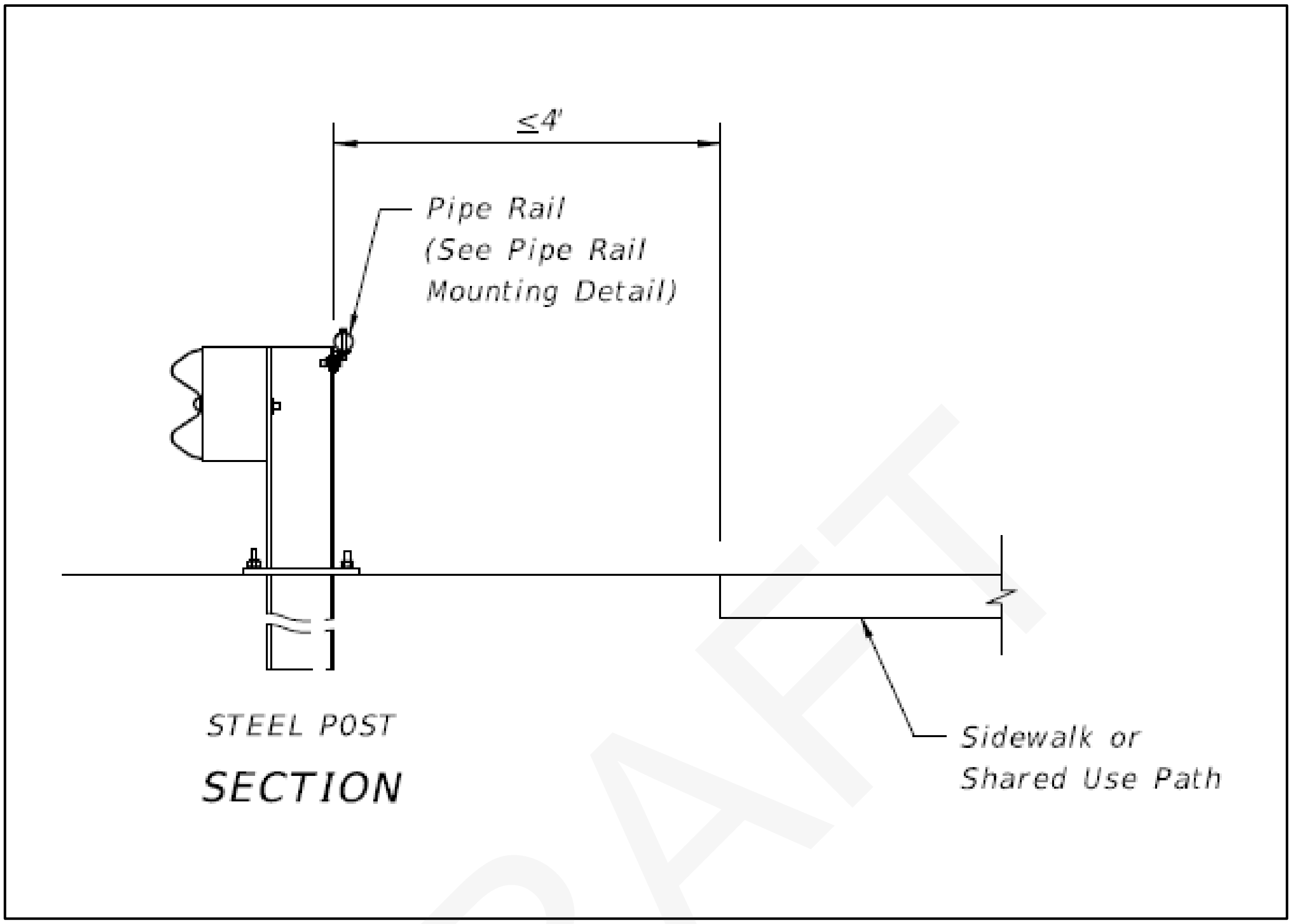
4.6.3 Roadside Safety Hardware in Low-Speed Environments

In lower-speed environments, it may be appropriate and cost-effective to use end treatments that are approved for lower-speed test levels (i.e., TL-2 systems).

The FDOT's Standard Plans also provide details for TL-2 end treatments. While TL-2 systems may be used on low-speed roadways (45 mph or less), they preferably should only be used on roadways with design speeds of 35 mph and less to account for the potential for changes in posted speed limits.

When a new sidewalk or shared use path is within 4 feet of the back of a guardrail with steel posts, a pipe rail must be installed on the back of the post. For a guardrail with timber posts, the bolt ends must be trimmed flush with the post or recessed. See Figure 4-10 for an illustration of when a pipe rail is needed. Additional information on the design of guardrails adjacent to a sidewalk or shared use path can be found in the FDOT Standard Plans.

Figure 4-10. Guardrail with Pipe Rail Detail



4.7 Rigid (Concrete) Barriers

Concrete Barrier Summary:

Concrete barriers maintain their shape and redirect impacting vehicles. They come in various shapes, including **single-slope**, **Jersey shape**, and **F-shape**. The ends of concrete barriers should be shielded either by a crash cushion or a transition to another barrier.

Single-slope barriers have a uniform slope that redirects vehicles impacting at shallow angles but can cause instability in vehicles impacting at higher speeds or higher angles.

Jersey shape barriers have a profile comprised of two slopes of differing angles.

F-shape barriers improve upon the Jersey barrier design to reduce vehicle climb in higher-severity impacts. This improves post-crash vehicle trajectories and reduces the likelihood that small cars will roll over due to the impact.

Crash cushions and **barrier transitions** are covered in Section 4.9: Treating Barrier Ends.

4.7.1 FDOT Concrete Systems

Committee – Which standard plans should be included here?

The most commonly used concrete barriers in Florida are detailed in the FDOT Standard Plans. Details are provided for median application, shoulder application, and pier protection. Additional information on these barriers is provided in the FDOT Design Manual, Chapter 215 Roadside Safety.

FDOT's 32-inch-height F-Shape concrete barrier system has been installed in prior years and meets NCHRP 350 TL-4 criteria and the AASHTO MASH 2nd Edition (2016) TL-3 criteria. More recently, FDOT has replaced this 32-inch F-Shape system with a 38-inch-height, single-slope concrete barrier system that meets the AASHTO MASH 2nd Edition (2016) TL-4 criteria. In addition to improved crash test performance, the single-slope face provides for simpler construction connections.

Committee – What is the protocol for replacing existing 32" F-shape systems with 38" single slope systems? Would it be helpful to include this information?

While the shielding of bridge piers to protect motorists is often necessary, some bridge piers also need shielding for "pier protection" from impact damage due to their own design limitations (i.e., piers not designed for vehicular collision forces). Coordination with the Structural Engineer of Record is required to determine if pier protection is warranted. The FDOT Standard Plans provide details for crashworthy pier protection barriers, and the FDOT Design Manual, Chapter 215 (Roadside Safety) provides a process for determining the appropriate level of pier protection.

4.7.2 Installation Guidance and Considerations

Adhering to the following guidance and considerations will help determine whether a concrete barrier is the appropriate system to improve system performance:

- Concrete barriers should not be installed on slopes.
- While concrete barriers are more expensive to install, their rigidity allows them to maintain their shape upon impact, resulting in lower maintenance demands.
- Concrete barriers require less setback distance to an object behind the barrier due to their rigidity.
- Concrete barriers generally have more severe impacts than other barrier types due to their rigidity, but they offer a reduced likelihood of vehicle penetration through the barrier.
- See FDOT Standard Specifications for Road and Bridge Construction, Section 521 for general installation and material needs.
- See FDOT Standard Plans, Index 521-002 & 521-002 for construction details and options.

4.8 Flexible (High-Tension Cable) Barriers

High-Tension Cable Barrier (HTCB) Summary:

HTCBs help to reduce injury potential by absorbing a vehicle's energy and redirecting the vehicle along the length of the barrier. A HTCB system is comprised of **cables**, **steel posts**, and **anchors**, and are generally proprietary systems. **Anchors** are covered in Section 4.9: Treating Barrier Ends.

4.8.1 FDOT Systems

Committee – Which standard plans should be included here?

FDOT has used HTCBs in select locations and continues to install these systems using the Developmental Standard Plans and Developmental Specifications process. Detailed information on the usage requirements and design criteria of HTCB can be found in FDOT Standard Plans Index D540-001 and Developmental Standard Plans Index D540-001.

Committee – Would it be helpful to add a section to the end of the document that highlights ongoing / recent research documents that can be referenced for additional context/guidance on various topics?

We could include NCHRP Report 711: Guidance for the Selection, Use, and Maintenance of Cable Barrier Systems (2012)

4.8.2 Installation Guidance and Considerations

Adhering to the following guidance and considerations will help determine whether an HTCB is the appropriate system to improve system performance:

- HTCB systems may be used for both median and outside shoulder applications, provided large areas are available behind the barrier for deflection upon impact. Deflection space requirements are dependent on the system, system length, and post spacing. Place HTCBs such that there is 10 feet of space behind the barrier to accommodate larger deflection magnitudes. **Committee** – Is this consistent with current practice?
- HTCB systems generally have the least severe impacts as compared to other barrier types, but they require large clear areas for deflection space (generally more ideal for wide medians).

- HTCBs are designed to be impacted without causing permanent damage to the barrier, so this may result in cost savings (repair needs avoided).
- HTCB generally needs a maintenance operation to "reset" significant lengths of barrier after an impact. Because HTCB is generally not effective for these affected lengths after impact, maintenance plans should be in place to reset these systems relatively quickly after impact.
- On slopes steeper than 1V:10H, semi-rigid and flexible systems may be preferred over rigid barriers. Some systems have been tested for use on slopes as steep as 1V:4H.
- Because cable tension must continue over the entire length of the barrier system, manufacturers generally place limitations on the length of continuous barriers. Limitations of horizontal and vertical curvature are also commonly placed to ensure posts are not dislodged from the cable tension.
- Cable barrier systems tend to be proprietary, so their components are not usually interchangeable between different makes and models.

4.9 Treating Barrier Ends

4.9.1 Overview and Types of Barrier Ends

Barrier ends may pose a hazard to motorists if not treated or shielded properly. This section discusses the treatment methods commonly used in Florida. Table 4-4 summarizes which treatment and shielding methods apply to the different barrier types.

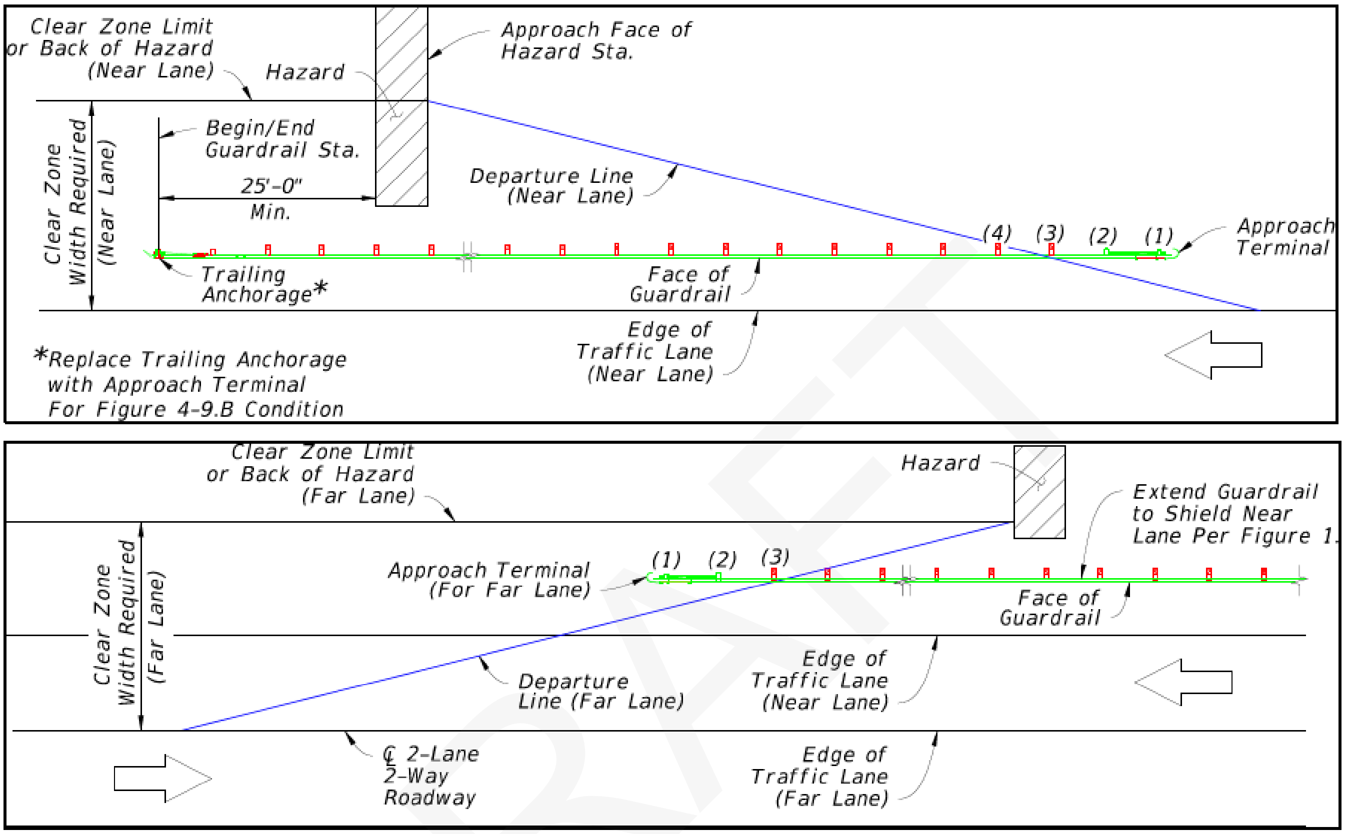
Figure 4-10 illustrates how to determine placement of approach terminals and trailing anchorages for guardrail based on direction of travel for adjacent travel lanes within the clear zone.

Table 4-4. End Treatment Methods for Each Barrier Type

End Treatment	Barrier Type
Approach Terminals and Trailing Anchorages	Metal Guardrail
End Terminals	High-tension Cable Barrier **Committee** – Should metal guardrail be added here as well?
Crash Cushions	Guardrail and Concrete Barrier
Barrier Transition Connections	Metal Guardrail to Concrete Barrier
Note: For more information and options, see FDOT Design Manual 215 and the Standard Plans Instructions for the corresponding barrier types.	

Committee – Figure 4-11 currently refers to Figure 4-9 B and will be corrected when we begin updating all the figures.

Figure 4-11. Approach Terminal Usage When End of Guardrail Is Within Clear Zone of Approaching Near (Top) and Far (Bottom) Lane (Two-Lane, Two-Way Road Shown)



4.9.2 Crash Test Criteria

Like longitudinal barriers, approach terminals, crash cushions, and transitions must be crashworthy as determined by full-scale crash testing. The most recent version of the AASHTO MASH 2nd Edition (2016) provides the recommended test matrix for approach terminals and crash cushions. The test levels associated with FDOT end treatments are TL-2 and TL-3.

4.9.3 Approach Terminals (for Flexible and Semi-Rigid Barriers)

Purpose: Approach terminals are used to anchor a flexible or semi-rigid barrier to the ground at the end of a barrier that is within the minimum clear zone and exposed to approaching traffic.

Use Cases: Approach terminals are required for guardrail ends within the clear zone of approaching traffic. Most approach terminals are designed for vehicular impacts from only one side of the barrier; however, some are designed for median applications where there is potential for impact from either side (i.e., “double-faced” approach terminal).

Crashworthiness and Design: MASH-compliant approach terminals are classified by TL; TL-2 is intended for design speeds ≤ 45 mph, while TL-3 is intended for all design speeds.

FDOT Systems: See the APL for a list of FDOT-approved proprietary end terminals. For more information for Guardrail, see Standard Plans Index 536-001 (with SPI). Approach terminals for guardrail are classified by the following three types:

- **Flared terminals** are preferred for locations where sufficient space is available to offset the barrier end from approaching traffic.
- **Parallel terminals** should be used only when sufficient space is not available for a flared terminal.
- **Double-faced terminals** are the preferred end treatment for double-faced guardrail installations.

For more information on HTCB, see Developmental Standard Plans D550-804 (with SPI).

4.9.4 Trailing Anchorages (for Flexible and Semi-Rigid Barriers)

Purpose: Trailing anchorages are used to anchor a flexible or semi-rigid barrier to the ground to develop its tensile strength during an impact.

Use Cases: Trailing anchorages are typically used on the trailing end of a roadside barrier on one-way roadways, or on the approach or trailing end of a flexible or semi-rigid barrier that is located outside the clear zone or that is shielded by another barrier system. They are required for anchoring the trailing ends of guardrail.

Crashworthiness and Design: As a result of their use cases, these anchorages are not crashworthy for approach ends and they are not permitted for use as an approach end treatment within the clear zone unless shielded by another run of barrier.

FDOT Systems: FDOT’s Trailing Anchorage for guardrail is detailed in its Standard Plans Index 536-001. For more information on HTCB, see Developmental Standard Plans D550-804 (with SPI).

4.9.5 Crash Cushions (for Rigid Barriers, Semi-Rigid Barriers, and Miscellaneous Hazards)

Purpose: Crash cushions, sometimes referred to as "impact attenuators," are crashworthy end treatments typically attached at the approach end of guardrail, concrete barriers, bridge traffic railings, or other rigid fixed objects, such as bridge piers.

Use Cases: Crash cushions may be used in a median, a ramp terminal gore area, or other roadside applications to shield barrier ends. Alternatively, a rigid barrier end may be shielded by transitioning into another barrier system (e.g., guardrail). Treatment of the trailing end of rigid barriers is not required unless additional hazards exist beyond the rigid barrier or the barrier is within the clear zone of opposing traffic.

Placement Considerations: An impacting vehicle should strike the systems at normal height, with the vehicle's suspension system neither collapsed nor extended. Therefore, the terrain surrounding crash cushions must be relatively flat (i.e., 1:10 or flatter) in advance of and along the entire design length of the system. Wherever practical, curbs should not be located within the approach area of a crash cushion.

Crashworthiness and Design: Crash cushions are classified based on TL and design speed. Each vendor's respective system drawings are posted on FDOT's APL. The design of a crash cushion system must not create a hazard to opposing traffic.

FDOT Systems: Details are provided in FDOT's Standard Plans, Index 544-001 (with SPI). The FDOT Design Manual, Chapter 215 Roadside Safety provides additional information on permanent and temporary crash cushions.

4.9.6 Barrier Transition Connections (from semi-rigid to rigid barriers)

Purpose: The purpose of the guardrail transition is to provide a gradual stiffening of the approach to the concrete rigid barrier connection so that an impacting vehicle will not get snagged by guardrail pocketing or otherwise penetrate the guardrail. In addition to providing stiffer guardrail near the concrete connection point, guardrail transition systems also generally include a curb underneath the guardrail to help prevent vehicle wheels from snagging on the approach face of the concrete barrier.

Use Cases: Guardrail transitions are necessary whenever guardrail connects with the upstream, approach end of rigid barriers (including roadside concrete barrier or bridge traffic railings).

Crashworthiness and Design: See the FDOT Standard Plans for design requirements.

FDOT Systems: FDOT Standard Plans, Index 536-001 and 536-002 provides details for several transitions for both permanent and rigid barriers that meet the AASHTO MASH 2nd Edition (2016) criteria. Further information on transitions is provided in the FDOT Design Manual, Chapter 215 Roadside Safety and the AASHTO RDG 4th Edition (2011).

4.10 Bridge Traffic Railings

Concrete bridge traffic railings are generally designed for AASHTO MASH 2nd Edition (2016) TL-3 or TL-4. See the Standard Plans Index 521 series for more information. For very low-volume roads with a design speed less than or equal to 45 mph, TL-2 designs may be considered. For additional requirements for bridge rails, see Chapter 17: Bridges and Other Structures. The FDOT Design Manual, Chapter 215 Roadside Safety may be referenced for additional information and typical applications.

Committee - Do you prefer to keep this Bridge Traffic Railings as its own section?

4.11 Roadside Safety in Work Zones (Temporary Barriers)

4.11.1 Overview of Work Zone Roadside Safety

The roadside design concepts presented in the previous sections must be applied to work zones as appropriate for the type of work being done and to the extent existing roadside conditions allow. This includes providing appropriate clear zone and using traffic control infrastructure that is crashworthy or properly shielded with crashworthy barriers. However, because work zones are temporary and often involve restricted or limited space, there are modified criteria for clear zones, drop-off conditions, and above-ground hazards. Additionally, alternative barrier types may be used in work zone settings to channelize vehicles and protect construction workers. Special considerations and requirements for these temporary conditions are provided below.

4.11.2 Clear Zone Width in Work Zones

Work zone clear zones must be free of above-ground hazards, water bodies, non-traversable edge drop-offs, or critical slopes. Otherwise, shielding of hazards is required using permanent or temporary barriers as described below. Clear zone widths in work zones are measured from the edge of the traveled way or face of curb and, as a minimum, must be the lesser of the following:

- Clear zone requirements in Table 4-1 and Table 4-2
- Clear zone requirements in Table 4-5
- Existing clear zone width

Table 4-5. Clear Zone Width Requirements for Work Zones (Feet)

Work Zone Posted Speed (mph)	Travel Lanes & Multilane Ramps	Auxiliary Lanes & Single-Lane Ramps
Curbed (measured from face of curb)		
≤ 45 mph	4	4
> 45 mph	Same as flush shoulder **Committee** – Is this measurement still taken behind face of curb?	Same as flush shoulder
Flush Shoulder (measured from edge of traveled way)		
≤ 40 mph	14	10
45–50 mph	18	10
55	24	14
60–70 mph	30	18
Note: The above clear zone widths do not apply for roadside canals. Where roadside canals are present, clear zone widths must conform with the lateral offset distances for canals as described in this chapter.		

4.11.3 Above-Ground Hazards in Work Zones

Above-ground hazards in work zones include any objects or equipment, other than temporary traffic control devices, that are greater than 4 inches in height and considered firm and unyielding. During working hours, above-ground hazards in the work zone should be treated with appropriate precautions.

During nonworking hours, all objects, materials, and equipment that constitute an above-ground hazard must be stored/placed outside of the clear zone or be shielded by a barrier or crash cushion.

4.11.4 Non-Traversable Edge Drop-Offs, Critical Slopes, and Roadside Excavations

Non-traversable edge drop-offs, critical slopes, and roadside excavations located within the clear zone are to be addressed as follows:

- A drop-off is defined as a drop in elevation, parallel to the adjacent travel lanes, that is greater than 3 inches with a slope (A:B) that is steeper than 1:4 (see Figure 4-12). In superelevated sections, the algebraic difference in slopes should not exceed 0.25.

- When an edge drop-off condition occurs within the clear zone, channelizing devices or temporary barriers must be provided in accordance with Table 4-6.
- Drop-offs may be mitigated by placing slopes of optional base material. See FDOT Standard Specifications, Section 285 for further information. Slopes shallower than 1:4 may be required to avoid an algebraic difference in slopes greater than 0.25.
- A setback distance appropriate for the type of barrier selected must be provided. For further information on setback requirements for various types of barriers, see FDOT Standard Plans, Index 102-100 and 102-110.
- Drop-offs adjacent to pedestrian facilities must be accompanied by pedestrian longitudinal channelizing devices, temporary barrier wall, or approved handrail. Adjacent to pedestrian facilities, a drop-off is defined as:
    - a drop in elevation greater than 10 inches that is closer than 2 feet from the edge of the sidewalk or shared use path; or
    - a slope steeper than 1:2 that begins closer than 2 feet from the edge of the sidewalk or shared use path when the total drop-off is greater than 60 inches.

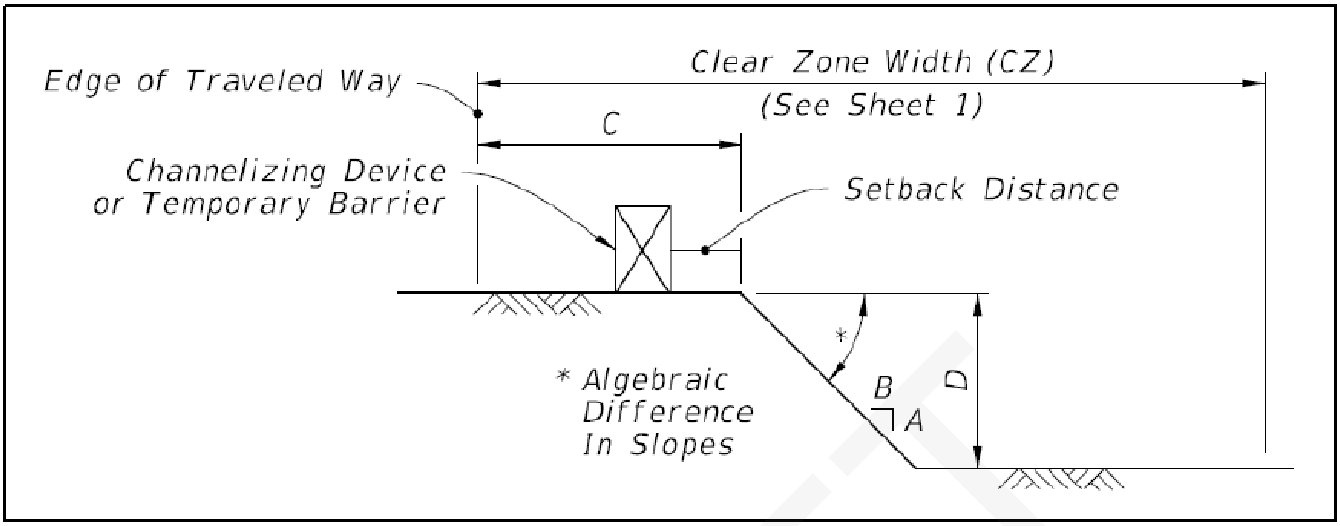
Table 4-6. Device Requirements for Edge Drop-Offs (Use with Figure 4-12)

Condition	D (in)	C (ft)	Device Required
1*	> 3	0 – 12	Temporary barrier
2	> 3 to ≤ 5	12 – Clear Zone	Channelizing Device
3*	> 5	0 – Clear Zone	Temporary barrier
4	Removal of bridge or retaining wall barrier		Temporary barrier
5	Removal of portions of bridge deck		Temporary barrier
Permanent curb heights ≥ 6 inches			No channelizing devices required
All	Do not allow any drop-off conditions > 3 inches within 2 feet of the traveled way.		

*For conditions 1 and 3:

- Channelizing devices and placement of slopes 1:4 or flatter constructed of base material per the FDOT Specifications Section 285 may be used in lieu of temporary barriers. Slopes shallower than 1:4 may be required to avoid algebraic difference in slopes greater than 0.25.
- Any drop-off condition that is created and restored within the same work period will not be subject to the use of temporary barriers. However, channelizing devices will be required.

Figure 4-12. Drop-Off Condition Detail (Use with Table 4-6)



4.11.5 Temporary Barrier Usage in Work Zones

Where the clear zone requirements are not met as described above, temporary barriers must be used to shield features as described in FDOT Standard Plans Index 102-100 series and 102-600 series (with SPIs). Note that permanent barriers that are installed for use after construction may also be substituted for temporary barriers to provide shielding during construction. In summary, temporary barriers in work zones can serve several functions, including:

- Shield edge drop-offs and roadside excavations (see Section 4.11.2: Clear Zone Width in Work Zones)
- Shield above ground hazards, including roadside structures, falsework for bridges, material storage sites, and other exposed objects
- Separate two-way traffic
- Separate pedestrians from vehicular traffic
- Provide positive protection for workers per below.

Positive protection describes using devices for containing or redirecting errant vehicles in order to prevent any intrusion into work areas, thereby improving worker safety. The most common form of positive protection is the use of temporary barriers to shield work areas from vehicles following LON concepts and layouts in the Standard Plans 102-100 series (with SPI).

As work zones and work zone devices are generally temporary, barriers for work zones are also designed to be temporary and portable. Work zone barriers may be concrete safety-shape barriers, portable steel barriers, or plastic water-filled barriers. The most used temporary barriers in Florida are the following:

Committee - Can you confirm whether this list is the most up to date?

Are there any other considerations you'd like to see discussed here? Cost, durability, maintenance?

Does FDOT have guidance on when to select which type of barrier (based on site conditions, etc.) to promote effective performance?

- Low-Profile Barrier—Standard Plans, Index 102-120 (TL-2, NCHRP 350)
  - Applicable for work zone speeds of 45 mph or less.
- Type K Barrier—Standard Plans, Index 102-110 (TL-3, NCHRP 350)
- Proprietary Temporary Barrier Standard Plans, Index 102-100 and the APL (TL-2 & TL-3, NCHRP 350)
  - May be concrete (freestanding or anchored), steel (anchored), or water-filled (freestanding).

The decision to use temporary barriers for conditions not specifically addressed in Section 4.11.2 should be based on engineering judgement and analysis. There are many factors, including traffic volume, traffic operating speed, offset, and duration, that affect barrier needs within work zones. The FDOT Standard Plans, the FHWA MUTCD, and the AASHTO RDG 4th Edition (2011) provide additional information and guidance on the use of temporary barriers in work zones.

Additional information on the proper use of these barriers is provided in the FDOT Design Manual and in the manufacturer's drawings on the FDOT APL. Additional information on temporary barrier systems meeting NCHRP 350 or the AASHTO MASH 2nd Edition (2016) criteria can be found in the AASHTO MASH 2nd Edition (2016) and the AASHTO RDG 4th Edition (2011).

4.11.6 End Treatments for Temporary Barriers

Like permanent longitudinal barrier installations, the upstream approach end of a temporary barrier must also be treated with one of the following:

- Shield the end with a connected crash cushion.
- Shield the end behind another longitudinal barrier, meeting LON requirements of this chapter.

- Terminate the end outside of clear zone, which may include flaring the barrier with allowable taper rates.
- Connect the end to another barrier per FDOT requirements, creating a smooth and continuous impact surface over the connection.

For additional information on the above options, see FDOT Standard Plans, Index 102-100 series (with SPI).

4.12 References for Informational Purposes

- Reference to roadside safety related organizations, programs, and research (e.g., AASHTO, FHWA, Task Force 13, NCHRP, etc.).