Chapter 4

Roadside Design

Figures

Tables

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4 Roadside Design

4.1 A Introduction

This chapter presents guidelines and standards for roadside designs intended to reduce the likelihood and/or consequences of roadside crashes. Due to the variety of causative factors, the designer should review crash reports for vehicles leaving the traveled way at any location. On average, lane departure crashes in Florida represent approximately 1/3 of all crashes and almost 50% of all highway fatalities. Construction and maintenance of safe medians and roadsides are of vital importance in the development of safe streets and highways. More information on lane departure crashes in Florida can be found in the FDOT's ***Florida Strategic Highway Safety Plan***.

Many of the standards presented in **Chapter 3 – Geometric Design** are predicated to a large extent upon reducing the probability of vehicles leaving the proper travel path. The intent of this chapter is to reduce the consequences of crashes by vehicles leaving the roadway. The design of the roadside beyond the shoulder should be considered and conducted as an integral part of the total highway design.

The general objective of roadside design is to provide an environment that will reduce the likelihood and/or consequences of crashes by vehicles that have left the traveled way. The achievement of this general objective will be aided by the following:

- Roadside areas adequate to allow reasonable space and time for a driver to regain or retain control of the vehicle and stop or return to the traveled way safely.
- Shoulders, medians, and roadsides that may be traversed safely without vehicle vaulting or overturning.
- Location of roadside fixed objects and hazards as far from the travel lane as is economically feasible.
- Roadsides that accommodate necessary maintenance vehicles, emergency maneuvers and emergency parking.
- Providing adequate shielding of hazards where appropriate and compatible with vehicle speeds and other design variables.

Prior to any other consideration, the designer should, in order of preference, attempt to:

1. Eliminate the hazard
    a. Remove the hazard
    b. Redesign the hazard so it can be safely traversed
    c. Relocate the hazard outside the clear zone
2. Make the hazard crashworthy
3. Shield the hazard with a longitudinal barrier or crash cushion.
4. Delineate the hazard and leave the hazard unshielded. This treatment is taken only when the barrier or crash cushion is more hazardous than the hazard. See **Section 4.5.5** for information on making this determination.

This chapter contains standards and general guidelines for situations encountered in roadside design due to the variety and complexity of possible situations encountered. In addressing roadside hazards, the designer should utilize the following as basic guidelines to develop a safe roadside design.

4.2 ~~B~~ Roadside Topography

4.2.1 ~~B.1~~ Roadside Slopes, Clear Zone and Lateral Offset

Providing a sufficient amount of recoverable slope or clear zone adjacent to the roadway, free of obstacles and hazards provides an opportunity for an errant vehicle to safely recover. Minimum standards for roadside slopes, clear zone and lateral offsets to hazards are provided as follows.

4.2.1.1 ~~B.1.a~~ Roadside Slopes and Clear Zone

The slopes of all roadsides should be as flat as possible to allow for safe traversal by out of control vehicles. A slope of 1:4 or flatter should be used, desirably 1:6 or flatter. The transition between the shoulder and adjacent side slope should be rounded and free from discontinuities. A slope as steep as 1:3 may be used within the clear zone if the clear zone width is adjusted to provide a clear runout area as described below. If sufficient right of way exists, use flatter side slopes on the outside of horizontal curves.

Clear zone is the unobstructed, traversable area beyond the edge of the traveled way for the recovery of errant vehicles. The clear zone includes shoulders and bicycle lanes. The clear zone shall follow the requirements for clear zone and lateral offset shown in this manual. Clear zone width requirements are dependent on AADT, design speed, and roadside slope conditions. With regard to the ability of an errant vehicle to traverse a roadside slope, slopes are classified as follows:

- Recoverable Slope – Traversable Slope 1:4 or flatter. Motorists who encroach on recoverable foreslopes generally can stop their vehicles or slow them enough to return to the roadway safely.
- Non-Recoverable Slope – Traversable Slope steeper than 1:4 and flatter than 1:3. Non-recoverable foreslopes are traversable but most vehicles will not be able to stop or return to the roadway easily. Vehicles on such slopes typically can be expected to reach the bottom.
- Critical Slope – Non-Traversable Slope steeper than 1:3. A critical foreslope is one on which an errant vehicle has a higher propensity to overturn.

Clear zone widths for recoverable foreslopes 1V:4H and flatter are provided in **Table 4 – 1 Minimum Width of Clear Zone**. Clear zone is applied as shown in **Figures 4 – 1 Clear Zone Plan View** and **4 – 2 Basic Clear Zone Concept**. Clear zone is measured from the edge of the traveled way.

On non-recoverable slopes steeper than 1:4 and flatter than 1:3, a high percentage of encroaching vehicles will reach the toe of these slopes. Therefore, the clear zone distance cannot logically end at the toe of a non-recoverable slope. When such non-recoverable slopes are present within the clear zone width provided in **Table 4 – 1**, additional clear zone width is required. The minimum amount of additional width provided must equal the width of the non-recoverable slope with no less than 10 feet of recoverable slope provided at the toe of the non-recoverable slope. See **Figure 4 – 3 Adjusted Clear Zone Concept**.

When clear zone requirements cannot be met, see **Sections 4.3 ~~C~~, 4.4 ~~D~~ and 4.5 ~~E~~** for requirements for roadside barriers and other treatments for safe roadside design. In addition, the ***AASHTO Roadside Design Guide (2011)***, and ***AASHTO Guidelines for Geometric Design of Very Low Volume Local Roads (ADT ≤ 400) (2001)*** may be referenced for a more thorough discussion of roadside design.

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Table 4-1 Minimum Width of Clear Zone (feet)[1] (Curbed and Flush Shoulder Roadways)

Design Speed mph	AADT ≥ 1500			AADT < 1500		
	Travel Lanes & Multilane Ramps		Aux Lanes & Single Lane Ramps	Travel Lanes & Multilane Ramps		Aux Lanes & Single Lane Ramps
	1V:6H or flatter	1V:5H to 1V:4H	1V:4H or flatter	1V:6H or flatter	1V:5H to 1V:4H	1V:4H or flatter
≤ 40	14	16	10	10[2]	12[2]	10[2]
45 – 50	20	24	14	14	16	14
55	22	26	18	16	20	14
60	30	30[3]	24	20	26	18
65 – 70	30	30[3]	24	24	28	18

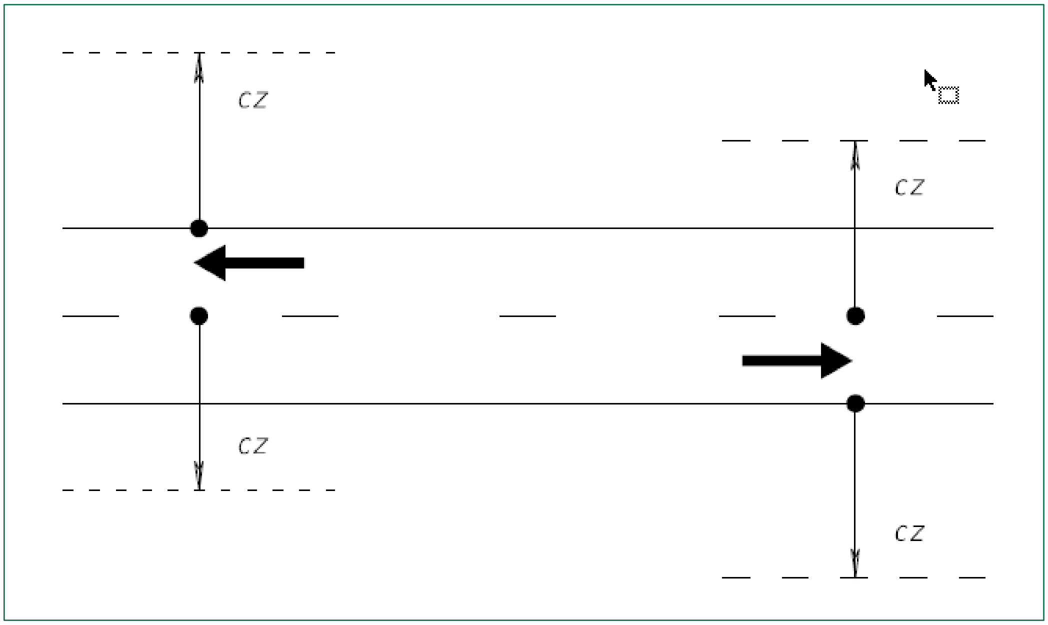
Notes:

1. Clear Zone for roads functionally classified as Local Roads with a design AADT ≤ 400 vehicles per day:
   a. A clear zone of 6 feet or more in width must be provided if it can be done so with minimum social/environmental impacts.
   b. Where constraints of cost, terrain, right of way, or potential social/environmental impacts make the provision of a 6 feet clear zone impractical, clear zones less than 6 feet in width may be used, including designs with 0 feet clear zone.
   c. In all cases, clear zone must be tailored to site-specific conditions, considering cost-effectiveness and safety tradeoffs. The use of adjustable clear zone widths, such as wider clear zone dimensions at sharp horizontal curves where there is a history of run-off-road crashes, or where there is evidence of vehicle encroachments such as scarring of trees or utility poles, may be appropriate. Lesser values of clear zone width may be appropriate on tangent sections of the same roadway.
   d. Other factors for consideration in analyzing the need for providing clear zones include the crash history, the expectation for future traffic volume growth on the facility, and the presence of vehicles wider than 8.5 feet and vehicles with wide loads, such as farm equipment.
2. May be reduced to 7 feet for a design AADT < 750 vehicles per day .
3. Greater clear zone widths provide additional safety for higher speed and volume roads. See Section 3.1 of the ***AASHTO Roadside Design Guide (2011)*** for further information.

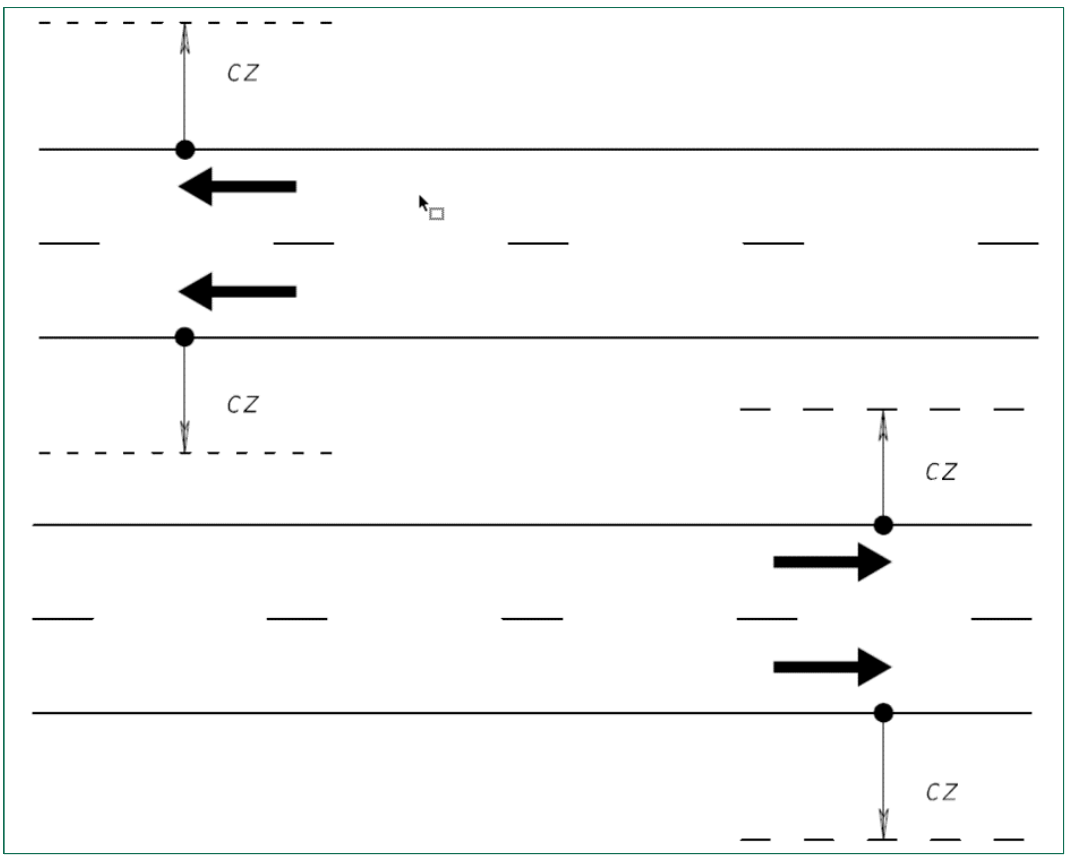
Source: Table 3 – 1, Suggested Clear Zone Distances in Feet from the Edge of the Travel Lane, 2011 AASHTO Roadside Design Guide.

Figure 4-1 Clear Zone Plan View

Two Lane, Two -Way Roadway



Multi-Lane Two-Way Roadway



Notes:

1. Lateral offset is measured out from the centerline of roadway and edge of traveled way or face of curb to a roadside object or feature.

Figure 4-2 Basic Clear Zone Concept

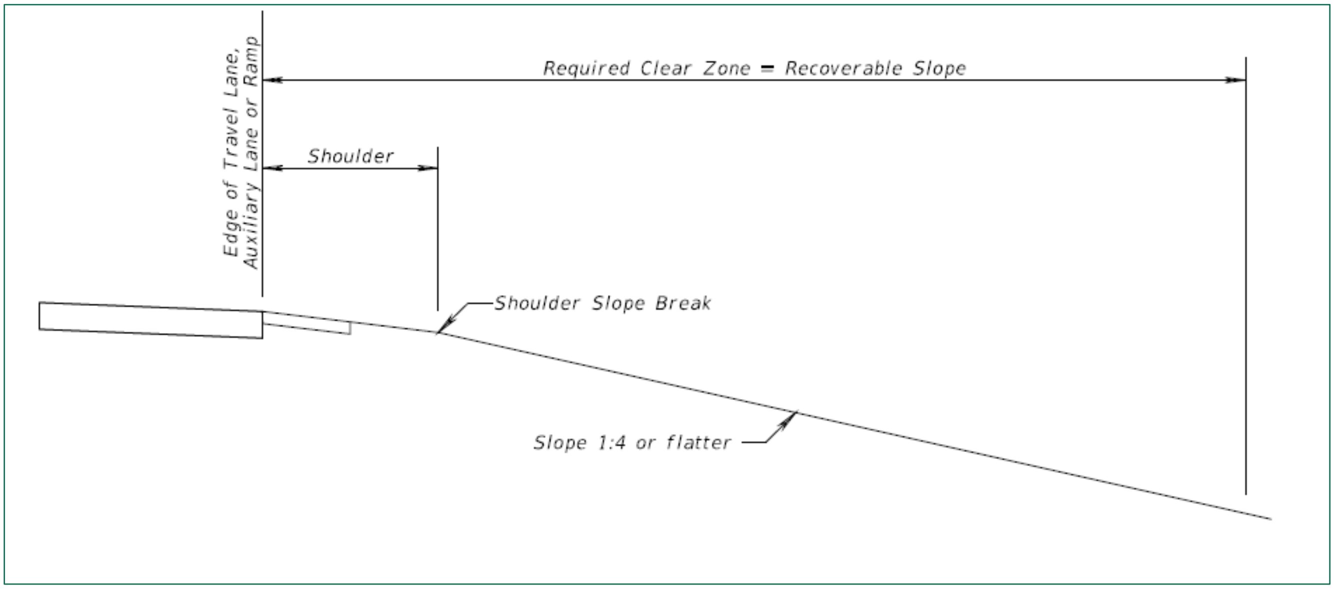
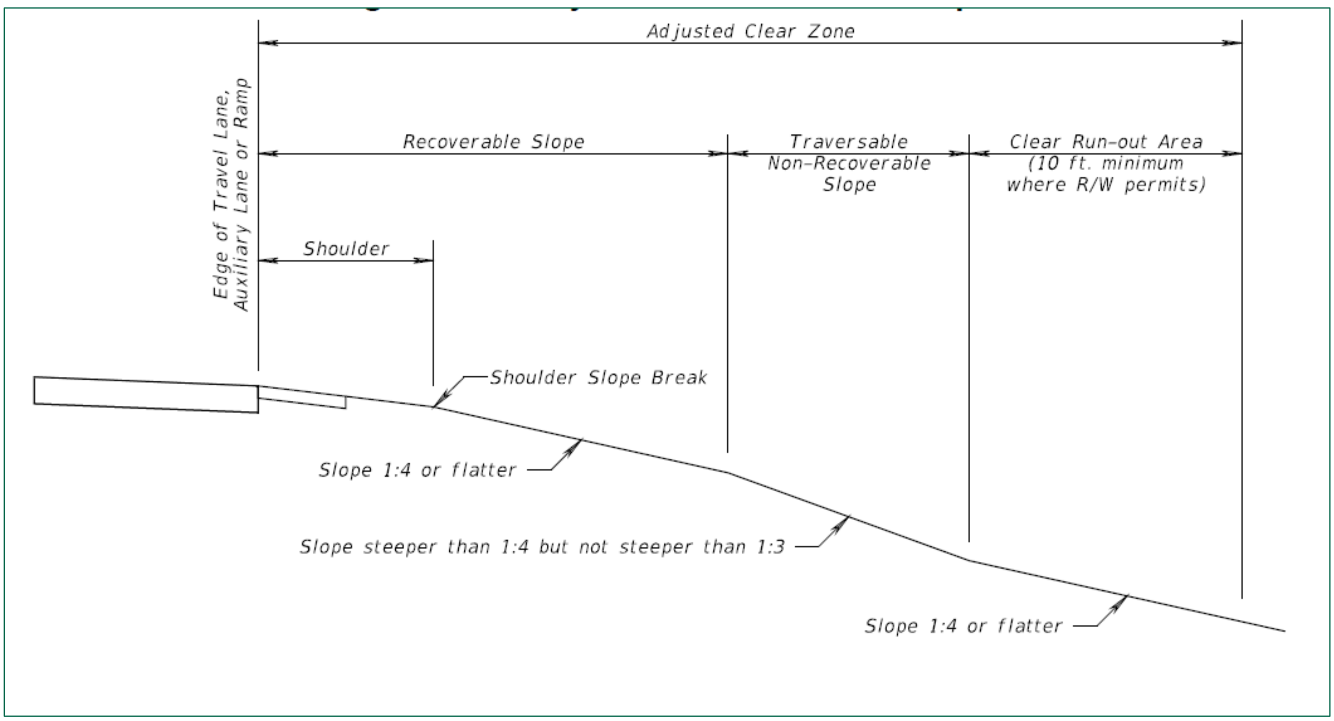


Figure 4-3 Adjusted Clear Zone Concept



Roadside ditches may be included within the clear zone if properly designed to be traversable. Acceptable cross section slope criteria for roadside ditches within the clear zone is provided in **Figure 4 – 4 Roadside Ditches – Bottom Width 0 to < 4 Feet** and **Figure 4 – 5 Roadside Ditches – Bottom Width ≥ 4 Feet**. These roadside ditch configurations are considered traversable.

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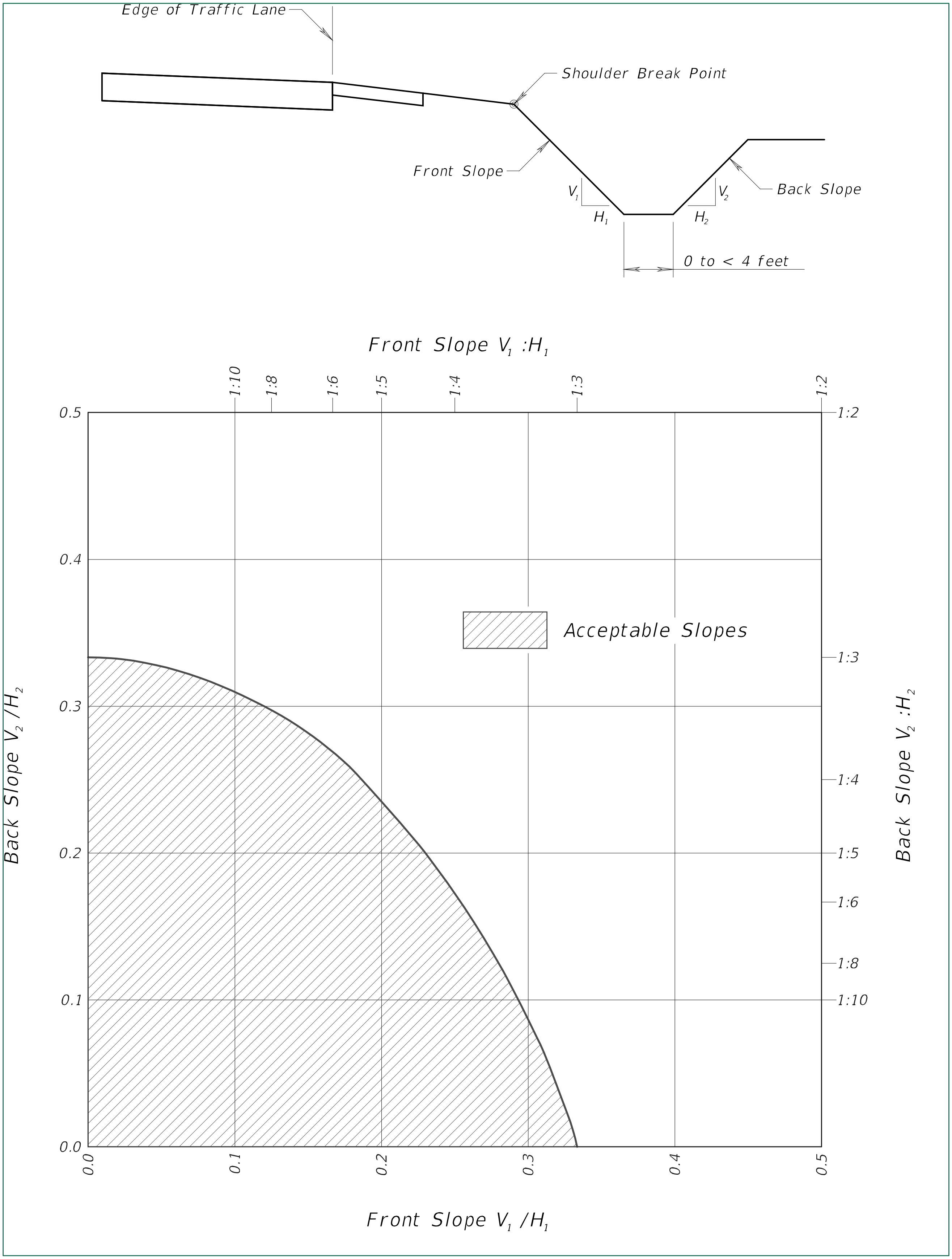
Figure 4-4 Roadside Ditches – Bottom Width 0 to < 4 Feet



Source: Figure 3 – 6, 2011 AASHTO Roadside Design Guide.

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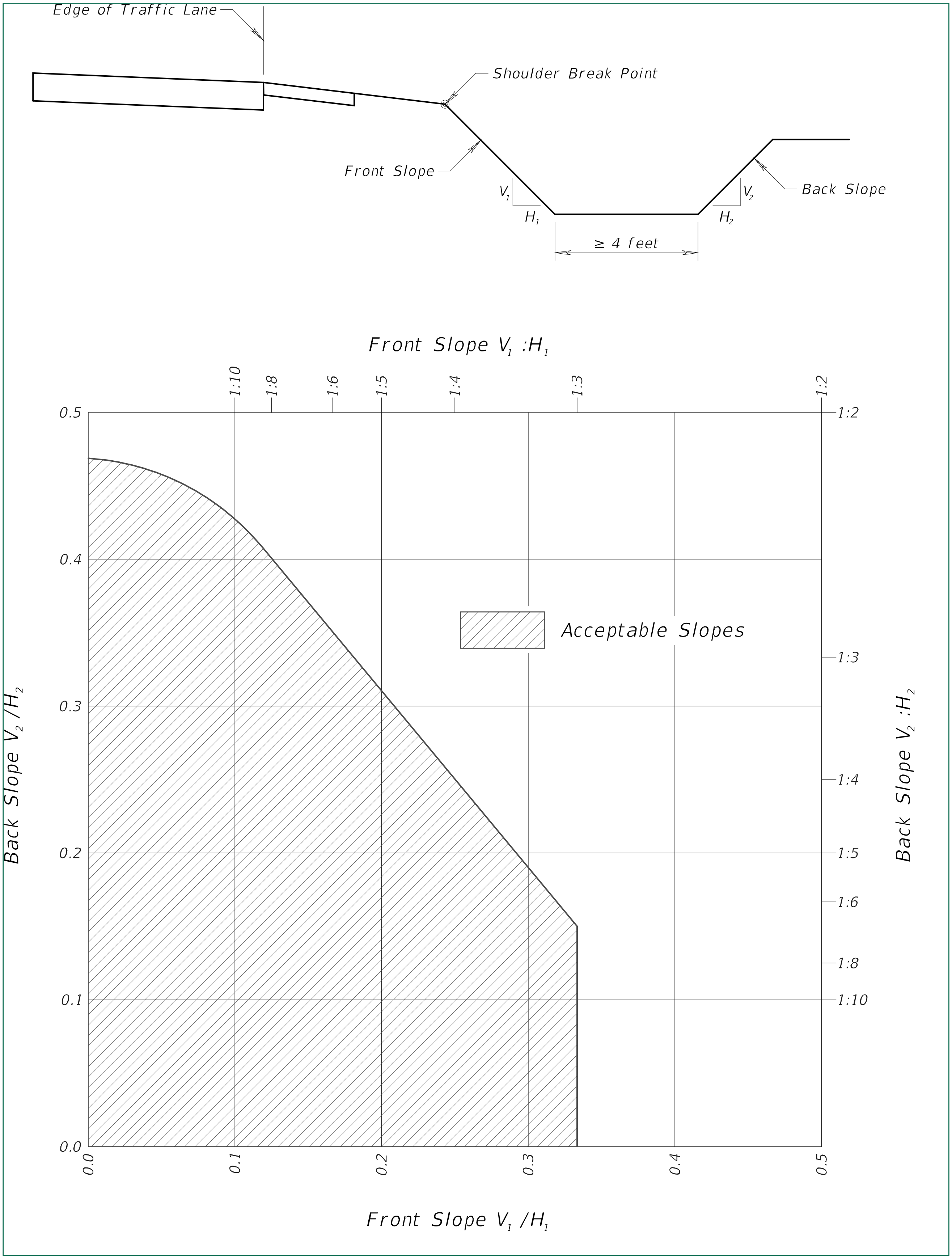
Figure 4-5 Roadside Ditches – Bottom Width ≥ 4 Feet



Source: Figure 3 – 6, 2011 AASHTO Roadside Design Guide.

4.2.1.2 ~~B.1.b~~ Lateral Offset

Table 4-2 Lateral Offset (feet)

Roadside Feature	Urban Curbed Roadways Design Speed ≤ 25 (mph)	Urban Curbed Roadways Design Speed ≤ 45 (mph)	All Other
Above Ground Objects[1]	1.5 ft. from Face of Curb[3,4]	4 ft. from Face of Curb[2,4]	Clear Zone Width
Drop Off Hazards5	Clear Zone Width	Clear Zone Width	Clear Zone Width
Water Bodies	Clear Zone Width	Clear Zone Width	Clear Zone Width
Canal Hazards	See Section 4.2.2.3 ~~Section B.2.c~~	See Section 4.2.2.3 ~~Section B.2.c~~	See Section 4.2.2.3 ~~Section B.2.c~~

Notes:

1. Above ground objects are anything greater than 4 inches in height and are firm and unyielding or 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.
2. May be reduced to 1.5 ft. from Face of Curb on roads functionally classified as Local Streets and, on all roads, where the 4 ft. minimum offset cannot be reasonably obtained and other alternatives are deemed impractical. For very low-volume roads, ≤ 400 vpd, a minimum of 1.5 feet of clearance is desirable but may be reduced to 6” from the face of curb where the corridor is constrained. ***AASHTO’s Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400), 2001*** provides additional information .
3. May only be used in areas where development patterns and land use would qualify as an Urban Center or Urban Core Context Classification.
    a. Urban Center - Mix of uses set within small blocks with a well-connected roadway network. Typically concentrated around a few blocks and identified as part of the community, town, or city of a civic or economic center.
    b. Urban Core - Areas with the highest densities and with building heights typically greater than four floors. Many are regional centers and destinations. Buildings have mixed uses, are built up to the roadway, and are within a well-connected transportation network.
4. 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.
5. Drop off hazards are:
    a. Any vertical faced structure with a drop off (e.g., retaining wall, wing-wall, etc.) located within the Clear Zone.
    b. Slopes steeper than 1:3 located within the Clear Zone.
    c. Drop-offs with significant crash history.

4.2.2 ~~B.2~~ Drainage Features

Drainage design is an important aspect of the long-term performance of a roadway, and to achieve an effective design, drainage features are necessary in close proximately to travel lanes. These features include ditches, curbs, and drainage structures (e.g., transverse/parallel pipes, culverts, endwalls, wingwalls, and inlets). The placement of these features is to be evaluated as part of roadside safety design. Refer to **Chapter 20 – Drainage** for information regarding proper hydraulic design.

When evaluating the design of roadside topography and drainage features, consider the future maintenance implications of the facility. Routine maintenance or repairs needed to ensure the continued function of the roadway slopes or drainage may lead to long-term expenses and activities, which disrupts traffic flow and exposes maintenance personnel to traffic conditions.

4.2.2.1 ~~B.2.a~~ Roadside Ditches

Minimum standards for side slopes and bottom widths of roadside ditches and channels within the clear zone are provided in **Section 4.2.1.1** ~~**Section B.1.a**~~.

4.2.2.2 ~~B.2.b~~ 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. The various drainage inlets and pipe end treatments needed for an efficient drainage design typically contain curb inlets, ditch bottom inlets, endwalls, wingwalls, headwalls, flared end sections and/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 Roadside Design Guide***.

Standard details for drainage structures and end treatments commonly used in Florida are provided the in the FDOT's ***Standards Plans***. Drainage features shown in the FDOT's ***Standards Plans*** have the potential for conflict with a motor vehicle or bicyclist either departing the roadway or within a commonly traversed section of a roadway. The FDOT's ***Drainage Manual*** identifies those standard drainage structures which are acceptable for use within the clear zone.

4.2.2.3 ~~B.2.c~~ Canals and Water Bodies

Roadside canals and other bodies of water close to the roadway should be eliminated wherever feasible. When not feasible, they should be located outside of the clear zone as shown in **Table 4 – 1 Minimum Width of Clear Zone**. If the body of water meets the definition of a canal hazard, additional lateral offset is required for arterial and collector roadways.

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 more than 3 feet for extended periods of time (24 hours or more). Other conditions shall be evaluated using clear zone conditions.

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 nearest the road. Minimum required lateral offset distances are as follows:

- Not less than 60 feet for flush shoulder and curbed roadways with design speeds of 50 mph or greater.
- Not less than 50 feet for flush shoulder roadways with design speeds of 45 mph or less.
- Not less than 40 feet for curbed roadways with design speeds of 45 mph or less.

See also **Figure 4 – 6 Minimum Offsets for Canal Hazards (Flush Shoulders) and Figure 4 – 7 Minimum Offsets for Canal Hazards (Curb and Curb and Gutter)**. On new alignments and/or 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 shall be shielded with a crashworthy roadside barrier. Barriers shall be located as far from the traveled way as practical. When shielding canal hazards the barrier shall be located outside the clear zone where possible. Guardrail shall be located no closer than 6 feet from the canal front slope and high tension cable barrier shall be no closer than 15 feet from the canal front slope.

Figure 4-6 Minimum Offsets for Canal Hazards (Flush Shoulders)

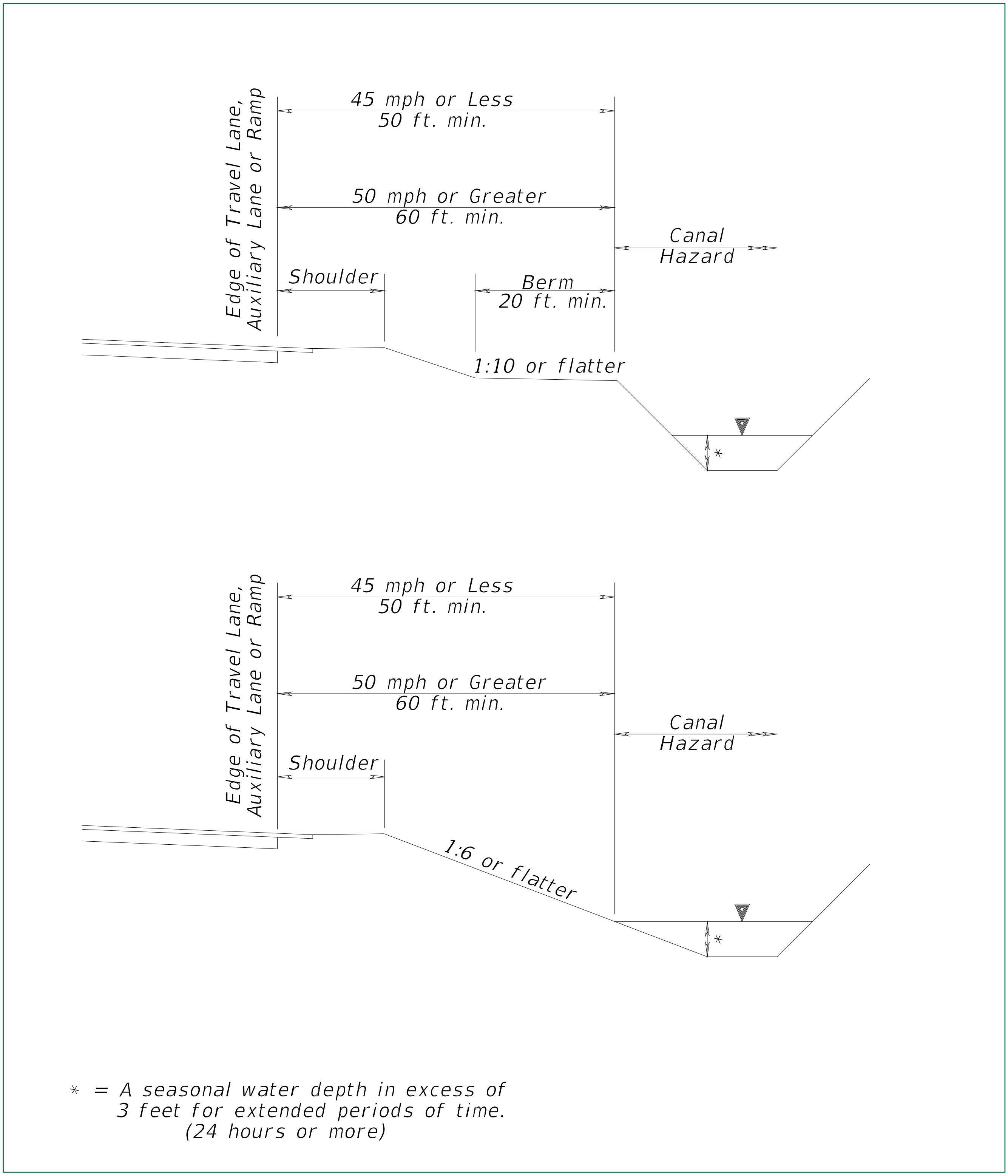
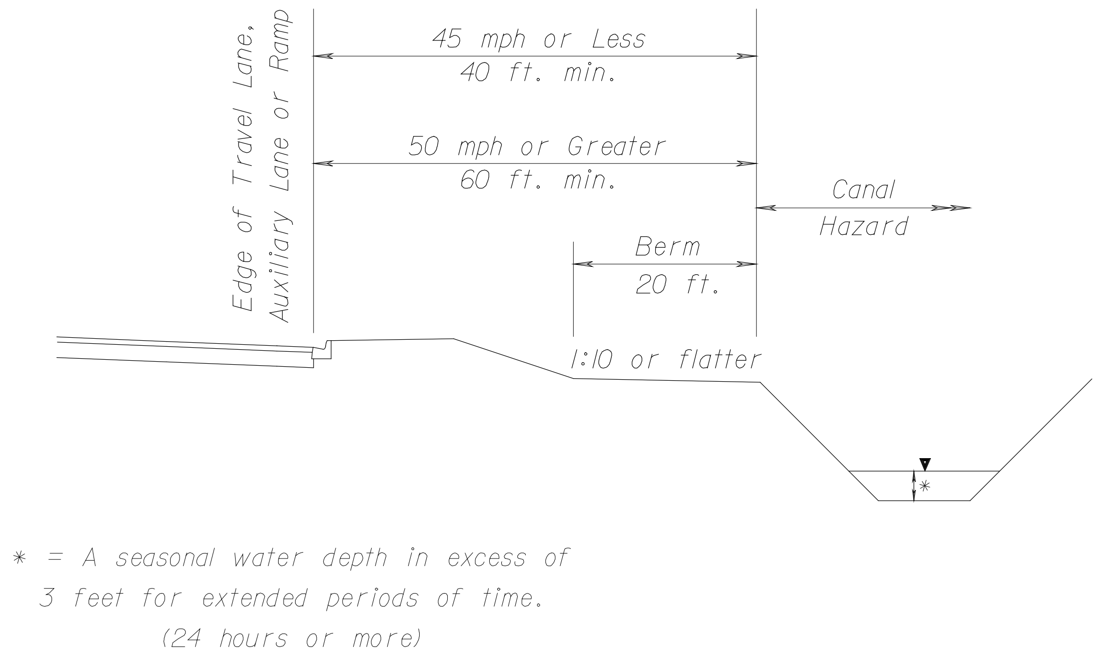


Figure 4-7 Minimum Offsets for Canal Hazards (Curbed)



4.2.2.4 ~~B.2.d~~ Curb

Curbs with closed drainage systems are typically used in urban areas to minimize the amount of right of way needed. Curbs also provide a tangible definition of the roadway limits and delineation of access points. These functions are important in urban areas because of the following typical characteristics:

- Low design speed (Design Speed ≤ 45 mph).
- Dense abutting development.
- Closely spaced intersections and accesses to property.
- Higher number of motorized vehicles, bicyclist, and pedestrian volumes.
- Restricted right of way.

Chapter 3 – Geometric Design provides criteria on the use of curbs. It should be noted that curbs have no redirectional capabilities except at very low speeds; less than the lowest design speeds typically used for urban streets. Therefore, curbs are not considered to be effective in shielding a hazard and are not to be used to reduce lateral offset requirements.

The FDOT's ***Standard Plans*** provide details for curb shapes commonly used in Florida. Typical applications for urban roadways include Type E and Type F curbs. Both curb types have a sloped face; however, the Type E has a flatter face to allow vehicles to traverse it more easily. Shoulder gutter is also frequently used along roadway fill sections and bridge approaches to prevent excessive runoff down embankment slopes. The FDOT's ***Drainage Manual*** may be referenced for direction on the use of shoulder gutter.

Curb types such as Type E (height 5" 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. The face of the curb shall be placed no closer to the edge of the traveled way than the required shoulder width.

- 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).

4.3 ~~C~~ Roadside Safety Features and Crash Test Criteria

While a traversable and unobstructed roadside is highly desirable from a safety standpoint, some appurtenances near the traveled way are necessary. Man-made fixed objects that frequently occupy road rights-of-way include traffic signs, traffic signals, roadway lighting, railroad warning devices, intelligent transportation systems (ITS), utility poles, and mailboxes. Other features include safety hardware such as barriers, end treatments and crash cushions which are often necessary to shield errant motorists from a variety of roadside hazards.

These features are in addition to trees and other vegetation often present, either naturally occurring or as part of landscaping. Applicable criteria for each of these features is presented in the following sections. Certain features are required to meet specific crash test criteria involving full scale crash testing.

4.3.1 ~~C.1~~ Crash Test Criteria

Crash test criteria for roadside safety features has been in existence since 1962. ***NCHRP Report 350, Recommended Procedures for the Safety Performance Evaluation of Highway Features***, published in 1993, has been the accepted criteria for safety hardware device testing for many years. Changes have occurred in vehicle design, hardware performance, and testing methodologies, which have led to improvements in crash barrier and roadside design.

More recently, the ***AASHTO Manual for Assessing Safety Hardware (MASH)*** was published and has superseded ***NCHRP Report 350*** as the most current criteria. To allow adequate time for the testing and development of features under MASH criteria, safety hardware installed on new and reconstruction projects shall meet ***NCHRP Report 350*** crash test criteria as a minimum. For projects on the National Highway System, a schedule has been established for implementing requirements for devices meeting MASH criteria. For more information see FHWA's web site for ***Roadway Departure Safety***. New and reconstruction projects not on the National Highway System are not required to conform to this implementation schedule, but should comply to the extent practical.

The FDOT maintains standard details, specifications, and approved products for all types of roadside devices commonly used in Florida that meet the required crash test criteria, and are acceptable for use on all public roadways. Non-proprietary, standardized devices are detailed in the FDOT's ***Standard Plans***. Proprietary products are included on the FDOT's ***Approved Product List (APL).*** These devices address the majority of roadside needs for all roads in Florida. The most current version of the ***Standard Plans*** and ***APL*** should be used as the FDOT maintains and updates these publications as necessary to comply with required implementation dates for changes in crash test criteria.

For cases where a device may be needed that is not covered by the FDOT's standards and approved products, the Federal Highway Administration (FHWA) maintains lists of eligible crashworthy devices, which can be found on their website for ***Roadway Departure Safety***. In addition, the AASHTO - Associated General Contractors of America (AGC) - American Road and Transportation Builders Association (ARTBA), ***Task Force 13 Guide to Standardized Roadside Safety Hardware*** provides engineering drawings for a multitude of barrier components and systems .

The criteria for crash testing specified in ***NCHRP Report 350*** and ***AASHTO MASH*** provides six Test Levels (TL-1 thru TL-6) for the evaluation of roadside hardware suitability. A test level is defined by impact speed and angle of approach, and the type of test vehicle. Test vehicles range in size from a small car to a loaded tractor trailer truck. Each Test Level provides an increasing level of service in ascending numerical order.

Tables 4 – 3 Test Levels for Barriers, Approach Terminals, Crash Cushions and **4 – 4 Test Levels for Breakaway Devices, Work Zone Traffic Control Devices** summarize the vehicle types, vehicle mass, test speeds and impact angles used in testing for each test level. **Tables 4 – 3** and **4 – 4** also show the differences in vehicle mass between MASH and ***NCHRP Report 350*** criteria for the small car, pickup, and single unit truck test vehicles.

In addition to differences in vehicle mass, MASH test criteria incorporated several other changes that differ from NCHRP Report 350. For additional information on crash test criteria, refer to the ***AASHTO MASH, NCHRP Report 350***, the ***AASHTO Roadside Design Guide***, and the FHWA web site for ***Roadway Departure Safety***.

Table 4-3 Test Levels for Barriers, Approach Terminals, Crash Cushions

Test Level	Test Vehicle Type	Vehicle Designation and Mass		Test Conditions MASH	
		NCHRP 350 (lbs.)	**MASH** (lbs.)	**Impact Speed** (mph)	**Impact Angle (for Barriers)** (degrees)
1	Passenger Car	820C 1800	1100C 2420	31	25
	Pickup Truck	2000P 4400	2270P 5000	31	25
2	Passenger Car	820C 1800	1100C 2420	44	25
	Pickup Truck	2000P 4400	2270P 5000	44	25
3	Passenger Car	820C 1800	1100C 2420	62	25
	Pickup Truck	2000P 4400	2270P 5000	62	25
4	Passenger Car	820C 1800	1100C 2420	62	25
	Pickup Truck	2000P 4400	2270P 5000	62	25
	Single-Unit Truck	8000S 17640	10000S 22000	56	15
5	Passenger Car	820C 1800	1100C 2420	62	25
	Pickup Truck	2000P 4400	2270P 5000	62	25
	Tractor-Van Trailer	36000V 79300	36000V 79300	50	15
6	Passenger Car	820C 1800	1100C 2420	62	25
	Pickup Truck	2000P 4400	2270P 5000	62	25
	Tractor-Tank Trailer	36000V 79300	36000V 79300	50	15

Notes:

1. Test Levels 1, 2, and 3 apply to end terminals and crash cushions, while all 6 Test Levels apply to barriers.

Table 4-4 Test Levels for Breakaway Devices, Work Zone Traffic Control Devices

Test Level	Feature	Test Vehicle Type	Vehicle Designation and Mass		Impact Speeds (mph)		Impact Angle (degrees)
			NCHRP 350 (lbs.)	MASH (lbs.)	Low Speed (mph)	High Speed (mph)	
2	Support Structures and Work Zone Traffic Control Devices	Passenger Car	820C 1800	1100C 2420	19	44	0 – 20
		Pickup Truck	Not Required	2270P 5000	19	44	0 – 20
	Breakaway Utility Poles	Passenger Car	820C 1800	1100C 2420	31	44	0 – 20
		Pickup Truck	Not Required	2270P 5000	31	44	0 – 20
3	Support Structures and Work Zone Traffic Control Devices	Passenger Car	820C 1800	1100C 2420	19	62	0 – 20
		Pickup Truck	Not Required	2270P 5000	19	62	0 – 20
	Breakaway Utility Poles	Passenger Car	820C 1800	1100C 2420	31	62	0 – 20
		Pickup Truck	Not Required	2270P 5000	31	62	0 – 20

Notes:

1. Criteria for Test Levels 2 and 3 are provided for support structures, work zone traffic control devices and breakaway utility poles. Test Level 3 is the basic test level used for most devices.

As noted in **Tables 4 – 3** and **4 – 4**, Test Levels 1 through 3 are limited to passenger vehicles while Test Levels 4 through 6 incorporate heavy trucks. The test speeds and impact angles used for testing represent approximately 92.5% of real word crashes. As implied by the information in **Tables 4 – 3** and **4 – 4:**

1. Test Level 1 devices should be used only on facilities with design speeds 30 mph and less.
2. Test Level 2 devices should be used only on facilities with design speeds 45 mph and less.
3. Test Level 3 through Test Level 6 devices are considered acceptable for all design speeds.
4. Test Level 3 devices are generally considered acceptable for facilities of all types and most roadside conditions.
5. Test Levels 4 through 6 should be considered on facilities with high volumes of heavy trucks and/or where penetration beyond the barrier would result in high risk to the public or surrounding facilities.

For additional information regarding appropriate application of Test Levels refer to the ***AASHTO Roadside Design Guide***.

4.3.2 ~~C.2~~ Safety Hardware Upgrades

On new construction and reconstruction projects existing obsolete safety hardware shall be upgraded or replaced with hardware meeting crash test criteria as described above.

For existing roadways, highway agencies should upgrade existing highway safety hardware to comply with current crash test criteria either when 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 Roadside Safety*** provides a list of considerations when investigating the need for upgrading barriers and other hardware. The FDOT's ***Standard Plans*** provide standard details for transitioning new barriers to existing barriers. The ***AASHTO Roadside Design Guide*** also provides guidelines for upgrading hardware.

4.4 ~~D~~ Signs, Signals, Lighting Supports, Utility Poles, Trees and Similar Roadside Features

4.4.1 ~~D.1~~ General

This section provides criteria for traffic sign supports, signal supports, lighting supports, utility poles, trees, and similar roadside features.

Generally, those roadside appurtenances and features that cannot be removed or located outside the clear zone must meet breakaway criteria to reduce impact severity. For those features located within the clear zone where it is not practical to meet breakaway criteria, shielding may be warranted and shall be considered.

4.4.2 ~~D.2~~ Performance Requirements for Breakaway Devices

The term breakaway support 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. Crash test criteria applicable to breakaway devices are presented in **Section 4.3** ~~**Section C**~~. Additional requirements for breakaway supports are provided in the ***AASHTO Standard Specifications for Structural Supports for Highway Signs, Luminaries, and Traffic Signals***. For a more detailed discussion on breakaway supports, refer to the ***AASHTO Roadside Design Guide***.

See **Section 4.3** ~~**Section C**~~ for references that provide additional information and details on crash tested breakaway supports.

4.4.3 ~~D.3~~ Sign Supports

Traffic signs and sign supports shall meet the requirements provided in the ***Manual on Uniform Traffic Control Devices (MUTCD)*** as stated in **Chapter 18 – Signing and Marking**. The **MUTCD** requires all sign supports within the clear zone to be crashworthy ~~shielded or breakaway~~. See **Section 4.2** ~~**Section B**~~ for clear zone requirements. Only when the use of breakaway supports is not practicable 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.

The FDOT's ***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*** details should be used as the FDOT maintains and updates these details as necessary to comply with required implementation dates for changes in crash test criteria.

Overhead signs and cantilever signs require relatively large size 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 (**Section 4.2** ~~**Section B**~~) or be shielded with a crashworthy barrier (**Section 4.5** ~~**Section E**~~). 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's ***Standard Plans*** provide details and instructions for the design of these systems.

4.4.4 ~~D.4~~ Traffic Signal Supports

Traffic signal supports commonly used in Florida are fixed base and shall meet the required lateral offset and clear zone criteria provided in **Section 4.2** ~~**Section B**~~. Traffic signal supports should not be located within medians. The FDOT's ***Standard Plans*** provide details and instructions for the design of traffic signal supports.

4.4.5 ~~D.5~~ Lighting Supports

Lateral offset criteria for lighting supports depend on whether the support is breakaway or fixed base as discussed below. See **Chapter 6 - Lighting** for additional design criteria for lighting.

4.4.5.1 ~~D.5.a~~ Conventional Lighting

Supports for conventional lighting (heights up to 60 feet) shall be breakaway which are typically frangible bases (cast aluminum transformer bases), slip bases, or frangible couplings (couplers). The FDOT's ***Standard Plans*** provide further information for breakaway lighting supports which are acceptable for use. 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 ***AASHTO Roadside Design Guide*** may be referenced for additional discussion on breakaway lighting supports.

On curbed roadways with design speeds 45 mph or less, breakaway lighting supports shall be located to meet lateral offset requirements provided in **Section 4.2** ~~**Section B**~~, **Table 4 – 2**.

On flush shoulder roadways, breakaway lighting supports shall be located a minimum of 20 feet from the nearest travel lane, 14 feet from the nearest auxiliary lane or outside the clear zone provided in **Section 4.2** ~~**Section B**~~, **Table 4 – 1**, whichever is less. The foreslope shall be 1:6 or flatter in cases where supports are located within the clear zone.

Lighting should not be located in medians, except in conjunction with barriers that are justified for other reasons.

4.4.5.2 ~~D.5.b~~ High Mast Lighting

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 shall be located outside the clear zone provided in **Section 4.2** ~~**Section B**~~, **Table 4 – 1**. High mast lighting shall not be located in medians except in conjunction with barriers that are justified for other reasons. The FDOT's ***Standard Plans*** provide additional information.

4.4.6 ~~D.6~~ Utility Poles

Utility poles shall be located to meet lateral offset and clear zone requirements provided in **Section 4.2** ~~**Section B**~~ and be located as close as practical to the right of way line. They should be installed per the permitting agency's requirements. The ***AASHTO Roadside Design Guide*** provides additional discussion and guidance on utility poles.

In accordance with **Section 337.403, F.S.**, 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 lateral offset requirements of **Table 4 – 2 Lateral Offset**. Utility poles that cannot be relocated and will remain within the clear zone, should be approved through the exception process prescribed in **Chapter 14 - Design Exceptions and Variations**.

4.4.7 ~~D.7~~ Trees

Trees with a diameter greater than 4 inches measured 6 inches above grade shall be located to meet lateral offset and clear zone requirements in **Section 4.2** ~~**Section B**~~, **Tables 4 – 1** and **4 – 2**. The ***AASHTO Roadside Design Guide*** provides additional discussion and guidance on trees.

4.2.8 ~~D.8~~ Miscellaneous

4.4.8.1 ~~D.8.a~~ Fire Hydrants

Most fire hydrants are made of cast iron and are expected to fracture upon impact, however, crash testing meeting current criteria has not been done to verify that designs meet breakaway criteria. For this reason, fire hydrants should be located as far from the traveled way as practical and preferably outside lateral offset/clear zone requirements in **Section 4.2** ~~**Section B**~~, yet 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.

4.4.8.2 ~~D.8.b~~ Railroad Crossing Warning Devices

See **Chapter 7 – Rail-Highway Crossings** for location requirements for railroad crossing warning devices.

4.4.8.3 ~~D.8.c~~ Mailbox Supports

Mailboxes and their location are subject to US 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 each highway agency adopt regulations for the design and placement of mail boxes within the right of way of public highways. The ***AASHTO Roadside Design Guide*** provides a model regulation that is compatible with US 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 shall be located as follows:

- On the right-hand side of the roadway in the carrier's direction of travel except on one-way streets, where they may be placed on the left-hand side.
- Where a mailbox is located at a driveway entrance, it shall 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 shall 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 shall 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 a distance no less than the greater of the following:

- 8 feet (where no paved shoulder exists and shoulder cross slope is 10 percent or flatter), or
- width of the shoulder present plus 6 to 8 inches, or
- 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 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 between 8 inches and 12 inches behind the edge of the pavement.

Design criteria for the mailbox support structure when located within the clear zone should consist of the following:

- Mailboxes shall be of light sheet metal or plastic construction conforming to the requirements of the U. S. Postal Service. Newspaper delivery boxes shall be of light metal or plastic construction of minimum dimensions 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, light-weight newspaper boxes may be mounted below the mailbox on the side of the mailbox support.
- A single 4 inch by 4 inch square or 4 inch diameter wooden post; or metal post, Schedule 40, 2 inch (normal size IPS (external diameter 2-3/8 inch) (wall thickness 0.154 inches) or smaller), embedded no more than 24 inches into the ground, shall be acceptable as a mailbox support. A metal post shall 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 structure or encasement 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 dimension 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.

The FDOT's ***Standard Plans*** and the ***AASHTO Roadside Design Guide*** provide details on hardware, supports and attachment details acceptable for mailboxes located within the clear zone which conform to the above requirements.

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*** web page.

4.4.8.4 ~~D.8.d~~ Bus Benches and Shelters

See **Chapter 3 – Geometric Design** for location criteria for bus benches and shelters. Additional criteria are provided in **Chapter 13 – Public Transit**.

4.5 ~~E~~ Barriers, Approach Treatments and Crash Cushions

4.5.1 ~~E.1~~ Roadside Barriers

Roadside barriers are used to shield motorists from roadside hazards and in some cases are used to protect bystanders, pedestrians, cyclists and/or workers from vehicular traffic. In still other cases, roadside barriers are used to protect bridge piers from vehicle impacts. Median barriers are similar to roadside barriers but are designed for vehicles striking either side and are primarily used to separate opposing traffic on a divided highway. Median barriers also may 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. Barriers are further classified as rigid, semi-rigid and flexible which are discussed in more detail below.

Barrier transition sections are used between adjoining barriers that have significantly different deflection characteristics. For example, a transition section is needed where a semi-rigid guardrail attaches to the approach end of a rigid concrete bridge rail, or when a barrier must be stiffened to shield fixed objects.

Requirements for bridge railings are provided in **Chapter 17 – Bridges and Other Structures**.

4.5.2 ~~E.2~~ End Treatments

End treatments include trailing anchorages, approach terminals, and crash cushions. Trailing anchorages are used to anchor a flexible or semi-rigid barrier to the ground to develop its tensile strength during an impact. Trailing anchorages are not designed to be crashworthy for head on impacts. They 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. Trailing anchorages are discussed in more detail below.

Approach terminals are basically crashworthy anchorages. 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. 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. Approach terminals are discussed in more detail below.

4.5.3 ~~E.3~~ Crash Cushions

Crash cushions, sometimes referred to as impact attenuators, are crashworthy end treatments typically attached at the approach end of median barriers, roadside barriers, bridge railings or other rigid fixed objects, such as bridge piers. Crash cushions may be used in a median, a ramp terminal gore, or other roadside application. Crash cushions are discussed in more detail below.

4.5.4 ~~E.4~~ Performance Requirements

Roadside barriers, transitions, approach terminals, and crash cushions must be crashworthy as determined by full scale crash testing in accordance with specific crash test criteria discussed in **Section 4.3** ~~Section C~~. Descriptions of commonly used devices in Florida are described below. **Section 4.3** ~~Section C~~ also provides references where more information can be found on crashworthy devices.

4.5.5 ~~E.5~~ Warrants

The determination as to when shielding is warranted for given hazardous roadside feature must be made on a case-by-case basis, and generally requires engineering judgment. It should be noted that the installation of roadside barriers presents a hazard in and of itself, and as such, the designer must analyze whether the installation of a barrier presents a greater risk than the feature it is intended to shield. The analysis should be completed using the ***Roadside Safety Analysis Program (RSAP)*** or in accordance with the ***AASHTO Highway Safety Manual (HSM)***.

Please see **Section 4.1** ~~Section A~~ for the considerations to be included when determining when to shield a roadside hazard.

The following hazards located within the clear zone are normally considered more hazardous than a roadside barrier:

4.5.5.1 ~~E.5.a~~ Above Ground Hazards

Above ground hazards are defined in **Section 4.2** ~~Section B~~, **Table 4 – 2 Lateral Offset**. They include but are not limited to:

1. Bridge piers, abutments, and railing ends
2. Parallel retaining walls with protrusions or other potential snagging features
3. Non-breakaway sign and lighting supports
4. Utility Poles

5. Trees greater than 4” in diameter measured 6” above ground.

4.5.5.2 ~~E.5.b~~ Drop-Off Hazards

Drop-off hazards are defined in Section 4.2 ~~Section B~~, **Table 4 –2 Lateral Offset**.

4.5.5.3 ~~E.5.c~~ Canals and Water Bodies

Criteria for addressing canal and water body hazards is provided in Section 4.2.2.3 ~~Section B.2.c~~.

4.5.6 ~~E.6~~ Warrants for Median Barriers

Median barriers shall 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 – 24 ~~Table 3 – 23~~ **Minimum Median Widths**. For locations where median widths are equal to or greater than the minimum, median barriers are not normally considered except in special circumstances, such as a location with 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 very difficult, if not impractical, 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 type facilities may be considered where median widths are less than minimum or where justified based on significant crossover crash history.

See Section 4.5 ~~Section E~~ for median barrier types and proper end treatment requirements. The AASHTO Roadside Design Guide and the ***FDOT Design Manual, Chapter 215 Roadside Safety*** and ***Standards Plans*** provide additional information and guidelines on the use of median barriers

4.4.7 ~~E.7~~ Temporary Barriers in Work Zones

See Section 4.7 ~~Section G~~ **- Roadside Design in Work Zones** for criteria on the use of temporary barriers in work zones.

4.5.8 ~~E.8~~ Barrier Types

Roadside barriers are classified as flexible, semi-rigid and rigid depending on their deflection characteristics when impacted. Flexible systems have the greatest deflection characteristics. Given much of the impact energy is dissipated by the deflection of the barrier and lower impact forces are imposed on the vehicle, flexible systems are generally more forgiving than rigid and semi-rigid systems. Rigid barriers, on the other hand, are assumed to exhibit no deflection under impact conditions so crash severity will likely be the highest of the three classifications.

In the following sections are basic descriptions of the barrier types commonly used in Florida for each these classifications. These commonly used barriers are those that are addressed in the FDOT's ***Standard Plans*** and ***FDOT Design Manual***. Those documents should be referenced for additional details and discussion on the proper use of these systems.

The basis for the FDOT 's systems and devices, as well as many other generic and proprietary guardrail systems meeting **NCHRP Report 350** and/or **MASH** criteria, can be found in the following documents:

- ***AASHTO Roadside Design Guide***
- ***Federal Highway Administration (FHWA) Countermeasures that Reduce Crash Severity***
- **AASHTO-Associated General Contractors of America (AGC}-American Road and Transportation Builders Association (ARTBA) Joint Committee Task Force 13** report, **A Guide to Standardized Highway Barrier Hardware available at: https://www.tf13.org/Guides/**

4.5.8.1 ~~E.8.a~~ Guardrail

The most commonly used barrier on new construction projects in Florida is the w-beam guardrail system detailed in the FDOT's ***Standard Plans*** referenced as "General TL-3 Guardrail". This w-beam guardrail system, sometimes referred to as a strong post guardrail system, is a semi-rigid system, uses posts at 6'-3" spacing, 8" offset blocks, and mid-span splices with a rail height of 2'-1" to center of the panel. This system was developed based on the 31" Midwest Guardrail System (MGS) and meets MASH Test Level 3 criteria. Compatible proprietary components may be referenced by the 31" height. This system can be used as a roadside barrier or in a double face configuration as a median barrier. Deflection space requirements for this system are provided in the ***FDOT Design Manual, Chapter 215 Roadside Safety***.

The current 31" height system replaces the 27" height system (1'-9" to center of panel) that had been used for many years and still present on roadways throughout Florida. **Section 4.3.3** ~~**Section C.3**~~ addresses requirements for upgrading existing 27" height systems.

The FDOT's ***Standard Plans*** also provide details for a similar w-beam guardrail system referenced as "Low Speed, TL-2 Guardrail", with posts at 12'- 6" spacing which meets MASH Test Level 2 criteria. While this TL 2 system may be used on low speed roadways 45 mph or less, it preferably should be used only on roadways with design speeds 35 mph and less to account for the potential for changes in posted speed limits and/or vehicles exceeding the design speed.

To achieve a minimum level of crash performance, guardrail installations shall have a minimum length of 75 feet with design speeds greater than 45 mph.

4.5.8.2 ~~E.8.b~~ Concrete Barrier

The most commonly used concrete barriers in Florida are detailed in the FDOT's ***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***.

The FDOT's 32" height F-Shape concrete barrier wall system that has been in use for many years meets ***NCHRP Report 350*** Test Level 4 criteria and MASH Test Level 3 criteria. The FDOT is replacing this 32" F-Shape system with a 38" height single slope concrete barrier system which meets MASH Test Level 4 criteria. In addition to improved crash test performance, the single slope face provides for simpler construction.

While shielding bridge piers to protect motorists from a hazard within the clear zone is often necessary, some bridge piers may need shielding for protection from damage due to 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's ***Standard Plans*** provides 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. As with median and shoulder concrete barrier walls, the FDOT is replacing the F-Shape pier protection barriers that have been in use for several years with single slope face systems.

4.5.8.3 ~~E.8.c~~ High Tension Cable Barrier

There are a variety of crash tested flexible barrier systems using w-beam and cable, but they historically have not been in common use in Florida. In recent years several proprietary high-tension cable barrier (HTCB) systems have been developed that meet ***NCHRP Report 350*** and MASH criteria. These systems are installed with a significantly greater tension in the cables than the generic low-tension systems that have been used in some states for many years. High tension cable barrier systems may be used for both median and roadside application. Deflection space requirements are dependent on the system, system length and post spacing, and are significantly greater than semi-rigid systems.

High tension cable barrier has shown to have several advantages over other types of flexible barrier systems. One advantage is they tend to result in less damage when impacted. Another is that certain systems have been tested for use on slopes as steep as 1:4. Still another advantage is that in many cases, the cables remain at the proper height after an impact that damages several posts. While no manufacturer claims their barrier remains functional in this condition, there is the potential that this offers a residual safety value under certain crash conditions. Posts are typically lightweight and can be installed in cast or driven sockets in the ground to facilitate removal and replacement. One disadvantage is that each vendor uses a different post design and cable arrangement, and therefore posts are not interchangeable between systems manufactured by different vendors.

The FDOT has used High Tension Cable Barrier (HTCB) in selected locations and continues to install these systems using the FDOT's ***Developmental Design Standards and Developmental Specifications (DDS)*** process. Detailed information on the usage requirements and design criteria of HTCB can be found on the FDOT's ***DDS*** website.

It includes the following:

- Developmental Standard Plans, Instructions D 540-001
- Developmental Standard Plans, Index D 540-001
- Developmental Specification, Dev540

4.5.8.4 ~~E.8.d~~ Temporary Barrier

As stated in **Section 4.5.5.5** ~~Section E.5.e~~, temporary barriers are used primarily in work zones for several purposes. The most used temporary barriers in Florida are those adopted for use by the FDOT. The FDOT's temporary barriers include:

- ***Low Profile Barrier – Standard Plans, Index 102-120*** (TL-2, NCHRP 350)
- ***Type K Barrier – Standard Plans, Index 102-110*** (TL-3, NCHRP 350)
- ***Proprietary Temporary Barrier –Standards Plans, Index 102-100*** and the ***Approved Products List (APL)*** (TL-2 & TL-3, NCHRP 350)

Additional information on the proper use of these barriers is provided in the ***FDOT Design Manual*** and the Vendor drawings on the FDOT's Approved Products List.

Additional information on temporary barrier systems meeting ***NCHRP Report 350*** and/or MASH criteria can be found in the ***Manual for Assessing Safety Hardware*** and the ***AASHTO Roadside Design Guide***.

4.5.8.5 ~~E.8.e~~ Selection Guidelines

The evaluation of numerous factors is required 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 4.5.6.6** ~~**Section E.6.f**~~)
- Traffic characteristics (e.g., vehicle types/percentages, volume, and growth)
- Site characteristics (e.g., terrain, alignment, geometry, access facility type, access locations, design speed, etc.)
- Expected frequency of impacts
- Initial and replacement/repair costs
- Ease of maintenance
- Exposure of workers when conducting repairs/maintenance
- Aesthetics

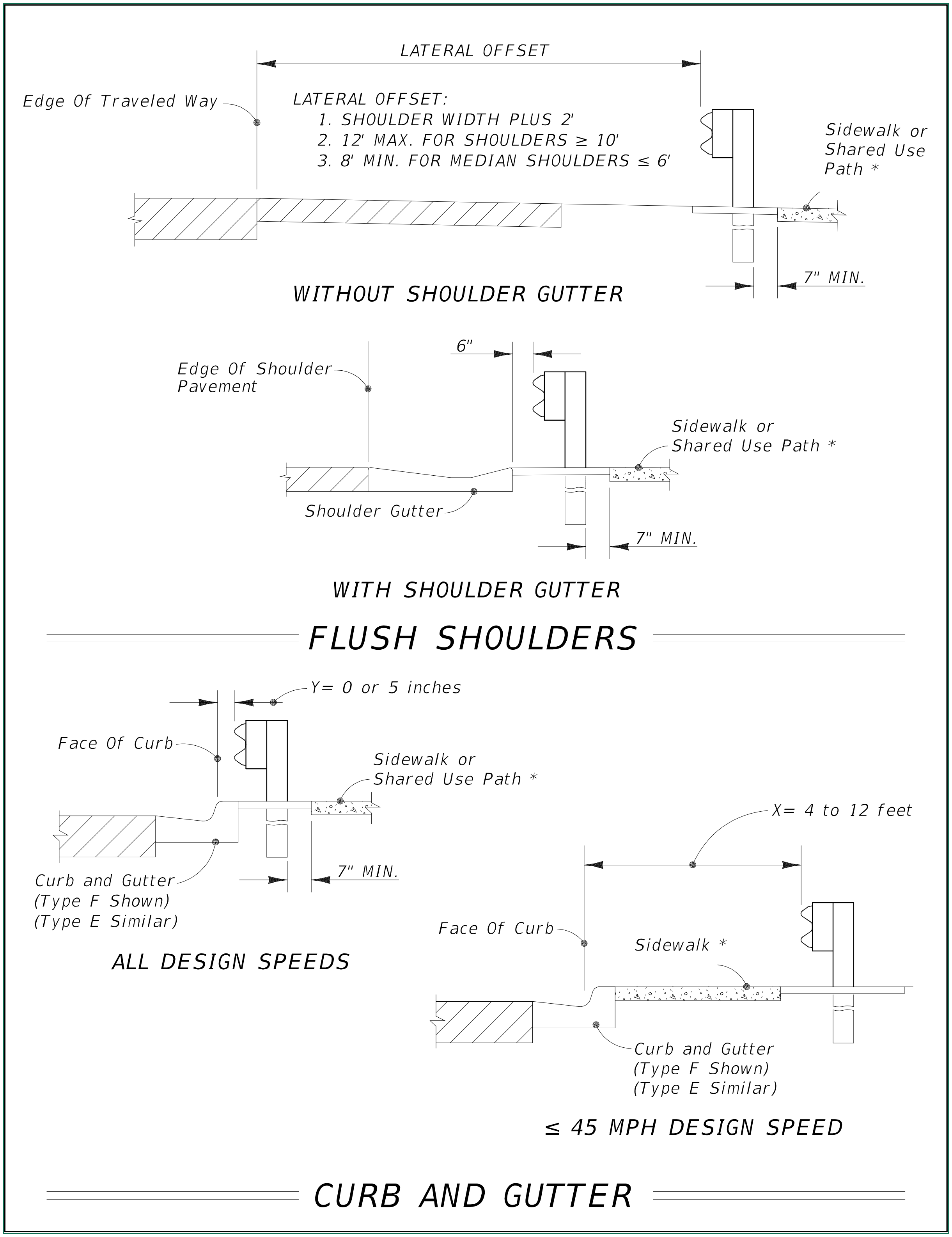
For additional information about considerations for barrier selections refer to the ***AASHTO Roadside Design Guide.*** Barrier type selection decisions and warrants should be documented.

4.5.8.6 ~~E.8.f~~ Placement

4.5.8.6.1 ~~E.8.f.1~~ Barrier Offsets

Roadside barriers should be offset as far from the travel lanes as practical with consideration for maintaining the proper performance of the barrier. For the barriers described above see the ***FDOT Design Manual, Chapter 215 Roadside Safety*** and ***Standard Plans*** for proper barrier placement. **Figure 4 – 8 Location of Guardrail** provides information on the offset of guardrail on curbed and flush shoulder roadways.

Figure 4-8 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).

4.8.8.6.2 ~~E.8.f.2~~ Deflection Space and Zone of Intrusion

In addition to travel lane lateral offset considerations, an adequate setback must be provided behind the barrier to ensure proper function. For flexible and semi-rigid barriers, the setback is based on deflection tolerances and is required to prevent the barrier from contacting aboveground 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. This requirement is based on the Zone of Intrusion (ZOI) concept as described in the ***AASHTO Roadside Design Guide***.

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

4.5.8.6.3 ~~E.8.f.3~~ Grading

The terrain effects between the traveled way and a barrier can have a significant impact on whether a barrier will perform as intended. Proper grading around a barrier will ensure that as a vehicle approaches a barrier its suspension is not dramatically affected, causing the vehicle to underride or override a barrier.

4.5.8.6.4 ~~E.8.f.4~~ Curbs

As with grading, the presence of curb in combination with barriers deserves special attention. A vehicle which traverses a curb prior to impact may override the barrier if it is partially airborne at the moment of impact. Conversely, the vehicle may "submarine" under the rail element of a guardrail system and snag on the support posts if it strikes the barrier too low.

4.5.8.6.5 ~~E.8.f.5~~ Flare Rate

A flared roadside barrier is when it is not parallel to the edge of the traveled way. A flared barrier may be necessary for several reasons:

- To locate the barrier terminal farther from the roadway
- To minimize a driver's reaction to an obstacle near the road by gradually introducing a parallel barrier installation
- To transition a roadside barrier to an obstacle nearer the roadway such as a bridge parapet or railing
- To reduce the total length barrier needed.

- To reduce the potential for barrier and terminal impacts and provide additional roadside space for an errant motorist to recover.

A concern with flaring a section of roadside barrier is that the greater the flare rate, the higher the angle at which the barrier can be hit. As the angle of impact increases, the crash severity increases, particularly for rigid and semi-rigid barrier systems. Another disadvantage to flaring a barrier installation is the increased likelihood that a vehicle will be redirected back into or across the roadway following an impact.

For the barriers described above, see the ***FDOT Design Manual, Chapter 215 Roadside Safety*** for acceptable flare rates. Additional information on flare rates are provided in the ***AASHTO Roadside Design Guide***.

4.5.8.6.6 ~~E.8.f.6~~ Length of Need

The length of need 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. Length of need must consider traffic from both directions.

A spreadsheet tool for calculating length of need is provided on the FDOT's ***Standard Plans*** web page, adjacent to ***Index 536-001*** in the Design Tools column. Additional information on length of need is provided in the ***AASHTO Roadside Design Guide***.

4.5.8.7 ~~E.8.g~~ Barrier Transitions

Guardrail transitions are necessary whenever standard W-Beam guardrail converges with rigid barriers. The purpose of the transition is to provide a gradual stiffening of the overall approach to a rigid barrier so that vehicular pocketing, snagging, or penetration is reduced or avoided at any position along the transition. Guardrail transitions must include sound structural connections, nested panels, and additional posts for increased stiffness. The FDOT's ***Standard Plans*** provide details for several transitions for both permanent and rigid barriers that meet MASH criteria. Additional information on transitions is provided in the ***FDOT Design Manual, Chapter 215 Roadside Safety*** and the ***AASHTO Roadside Design Guide***.

4.5.8.8 ~~E.8.h~~ Attachments to Barriers

Attachments to barriers such as signs, light poles, and other objects will affect crash performance and should be avoided where practical. Attachments not meeting the requirements discussed in **Section 4.5.6.6** ~~**Section E.6.f**~~ **- Placement**, should meet crash test criteria. See the ***FDOT Design Manual, Chapter 215 Roadside Safety*** for additional information on attachments to barriers.

4.5.9 ~~E.9~~ End Treatments and Crash Cushions

As previously discussed, end treatments include trailing anchorages, approach terminals, and crash cushions. Details for end treatments for each barrier type described above are detailed in the FDOT's ***Standard Plans*** and the ***Approved Products List (APL)***.

4.5.9.1 ~~E.9.a~~ End Treatments for Guardrail

End treatments for guardrail are categorized as follows:

1. Approach terminals – required for guardrail ends within the clear zone of approaching traffic. Guardrail approach end terminals are proprietary devices listed on the ***APL***. MASH compliant approach terminals are classified by Test Level (TL-2 for Design Speeds ≤ 45 mph or TL-3, which is acceptable for all Design Speeds) and as follows:
    a. Flared – preferred terminal for locations where sufficient space is available to offset barrier end from approaching traffic.
    b. Parallel – use only when sufficient space is not available for a flared terminal.
    c. Double Face – preferred end treatment for double faced guardrail installations.
2. Crash Cushions – See **Section 4.5.7.5** ~~Section E.7.e~~.
3. Trailing Anchorages (Type II) – required for anchoring of the trailing ends of guardrail. Trailing anchorages are non-crashworthy as an approach end treatment, and are not permitted as an approach end treatment, on the approach end within the Clear Zone, unless shielded by another run of barrier. The FDOT's Type II Trailing Anchorage, is detailed in the ***Standard Plans***.

Figures 4-9 and **4-10** below illustrate how to determine when an approach terminal, trailing anchorage or crash cushion should be selected when using guardrail to provide protection for a hazard.

Figure 4-9 End Treatment Usage When End of Guardrail is Within Clear Zone of Approaching Near Lane

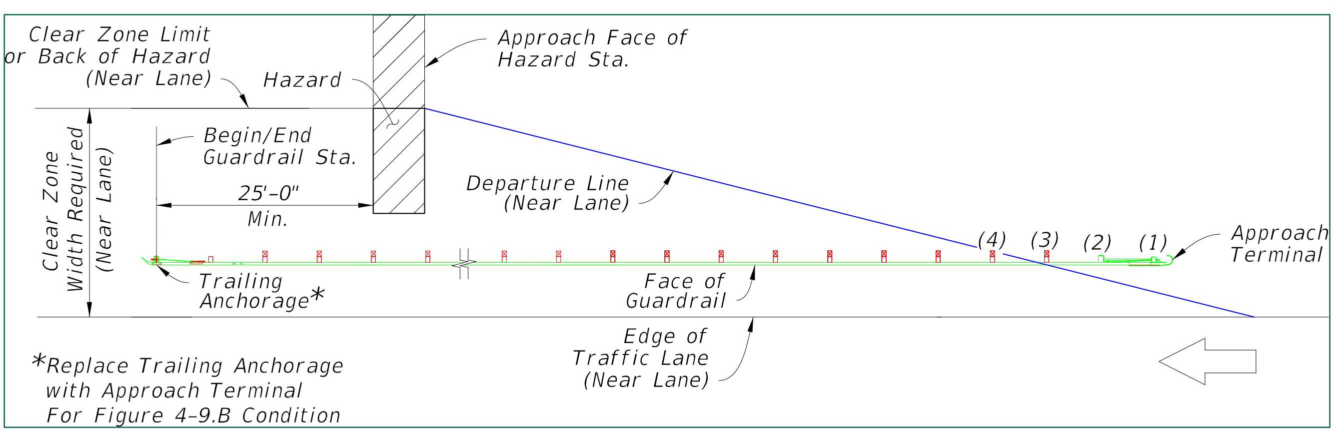
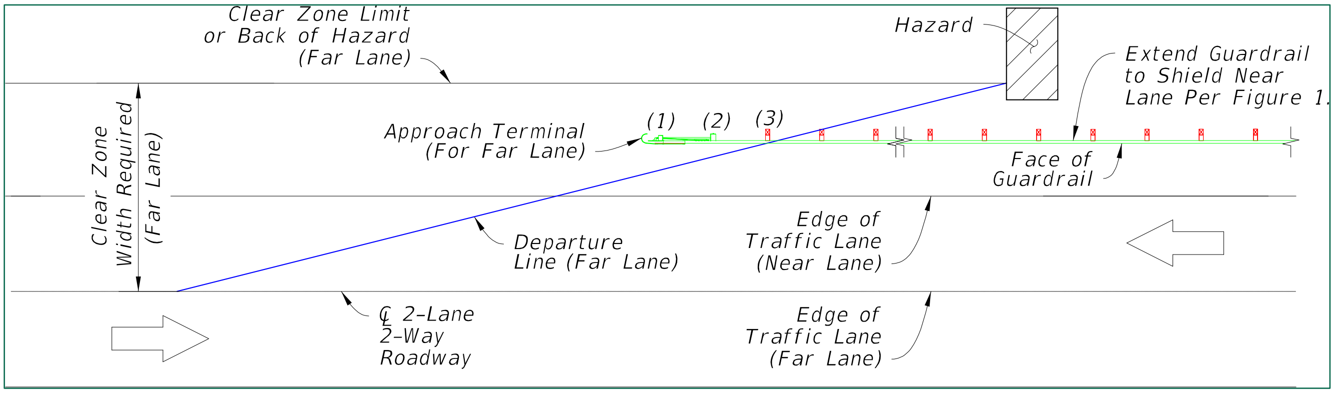


Figure 4-10 Approach Terminal Usage When End of Guardrail is Within Clear Zone of Approaching Far Lane (2-Lane, 2-Way Road Shown)



Additional information on guardrail end treatments is provided in the ***FDOT Design Manual, Chapter 215 Roadside Safety***.

4.5.9.2 ~~E.9.b~~ End Treatments for Rigid Barrier

Rigid Barrier ends must be terminated by either transitioning into another barrier system (e.g., guardrail), or by shielding with a Crash Cushion. Details are provided in the FDOT's ***Standard Plans***. 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.

4.5.9.3 ~~E.9.c~~ End Treatments for High Tension Cable Barrier (HTCB)

End treatments for high tension cable barrier are vendor specific. For additional information regarding the end treatment of HTCB, refer to the FDOT's developmental design standards discussed above.

4.5.9.4 ~~E.9.d~~ End Treatments for Temporary Barrier

Details for end treatments for the FDOT's Temporary Barrier are provided in the FDOT's ***Standard Plans*** and include:

1. Connecting to an existing barrier. Smooth, structural connections are required. Information on connections can be found in the FDOT's ***Standard Plans*** and ***APL***.
2. Shield end with a crash cushion as detailed in the FDOT's ***Standard Plans*** or ***APL*** for the specific type of Temporary Barrier (i.e., portable concrete barrier, steel, or water filled).
3. Attaching or Transitioning to a crashworthy end treatment as described above.
4. Flaring outside of the Work Zone Clear Zone.

4.5.9.5 ~~E.9.e~~ Crash Cushions

Crash cushions are classified based on Test Level and Design Speed which is shown for each system on each vendor's respective drawings posted on the FDOT's ***APL***.

The design of a crash cushion system must not create a hazard to opposing traffic. The ***APL*** drawings provide details for transitions for optional barrier types with and without bi-directional traffic.

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. Curbs should not be located within the approach area of a crash cushion.

The ***FDOT Design Manual, Chapter 215 Roadside Safety*** provides additional information on permanent and temporary crash cushions.

4.6 ~~F~~ Bridge Rails

See **Chapter 17 - Bridges and Other Structures** for requirements for bridge rails. The ***FDOT Design Manual, Chapter 215 Roadside Safety*** may be referenced for additional information and typical applications.

4.7 ~~G~~ Roadside Design in Work Zones

The roadside design concepts presented in the previous sections shall 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 clear zone and using traffic control devices and safety appurtenances that are crashworthy or properly shielded with crashworthy devices. However, because work zones are temporary and often involve restricted or limited space, modified criteria for clear zones, drop-off conditions and above ground hazards are provided as follows.

4.7.1 ~~G.1~~ Clear Zone Width in Work Zones

Clear zone is defined in **Section 4.2** ~~**Section B**~~ **Roadside Topography and Drainage Features**. Clear zone widths for work zones, as a minimum, shall be the lessor of clear zone requirements provided in **Table 4 – 1 Minimum Width of Clear Zone**, **Table 4 – 5 Clear Zone Width Requirements for Work Zones**, or existing clear zone width. Clear zone widths in work zones are measured from the edge of Traveled Way.

Table 4-5 Clear Zone Width Requirements for Work Zones

Work Zone Posted Speed (mph)	Travel Lanes & Multilane Ramps (feet)	Auxiliary Lanes & Single Lane Ramps (feet)
Curbed		
≤ 45 mph	4' Behind Face of Curb	4' Behind Face of Curb
> 45 mph	Same as Flush Shoulder	Same as Flush Shoulder
Flush Shoulder		
≤ 40	14	10
45 – 50	18	10
55	24	14
60 – 70	30	18

Notes:

1. The above clear zone widths apply to medians and roadside conditions other than for roadside canals. Where roadside canals are present, clear zone widths are to conform with the lateral offset distances to canals described in this Chapter.

The clear zone must be free of above ground fixed objects, water bodies and non-traversable edge drop-offs or critical slopes.

4.7.2 ~~G.2~~ Above ground Hazards in Work Zones

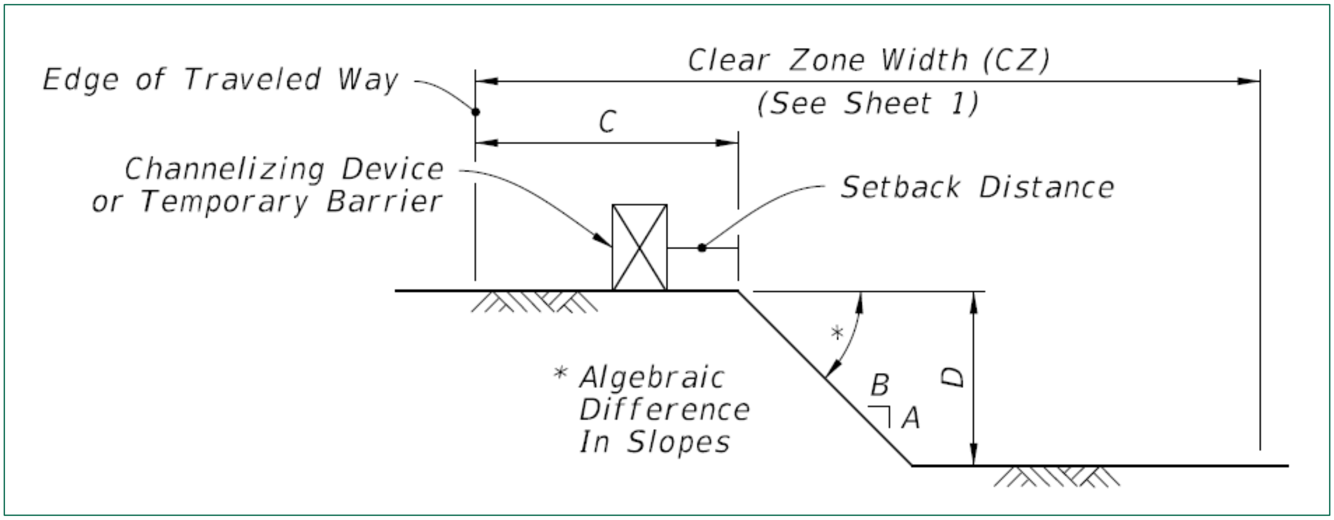
An above ground hazard in work zones is any object, material, or equipment other than temporary traffic control devices that is greater than 4 inches in height, firm and unyielding, and encroaches upon the clear zone. During working hours, above ground hazards in the work zone should be treated with 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.

4.7.3 ~~G.3~~ 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, greater than 3" with slope (A:B) steeper than 1:4. In superelevated sections, the algebraic difference in slopes should not exceed 0.25 (See **Figure 4 – 11 Drop-off Condition Detail)**.

Figure 4-11 Drop-Off Condition Detail



When an edge drop-off condition occurs within the clear zone, channelizing devices or temporary barriers shall be provided in accordance with **Table 4 – 6 Device Requirements for Edge Drop-Offs**.

Drop-offs may be mitigated by placing slopes of optional base material. See the FDOT's ***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.

Table 4-6 Device Requirements for Edge Drop-Offs

Condition	D (inches)	C (feet)	Device Required
1	>3	2 - 12	Temporary Barrier
2	>3 to ≤5	12 - CZ	Channelizing Device
3	>5	2 - 12	Temporary Barrier
4	Removal of Bridge or Retaining Wall Barrier		Temporary Barrier
5	Removal of portions of Bridge Deck		Temporary Barrier

Notes:

1. Do not allow any drop-off conditions greater than 3 inches within two feet of traveled way.
2. 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.
3. For Conditions 1 and 3 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.
4. When permanent curb heights are ≥ 6", no channelizing device will be required.

A setback distance appropriate for the type of barrier selected shall be provided. For further information on setback requirements for various types of barriers, see the FDOT's ***Standard Plans***.

Drop-offs adjacent to pedestrian facilities shall be provided with 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" 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".

4.7.4 ~~G.4~~ Temporary Barriers in Work Zones

When clear zone widths cannot be met, the use of temporary barriers shall be considered. Temporary barriers in work zones can serve several functions:

- Shield edge drop-offs and roadside excavations – see **Section 4.7.1** ~~**Section G.1**~~.
- Shield above ground hazards, including roadside structures, falsework for bridges, material storage sites and/or other exposed objects.
- Provide positive protection for workers.
- Separate two-way traffic.
- Separate pedestrians from vehicular traffic.

The decision to use temporary barriers for conditions not specifically addressed in **Section 4.7.1** ~~**Section G.1**~~ 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's ***Standard Plans***, the ***MUTCD*** and the ***AASHTO Roadside Design Guide*** provide additional information and guidance on the use of temporary barriers in work zones.

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4.8 ~~H~~ References for Informational Purposes

The following is a list of publications that may be referenced for further guidance:

- AASHTO Roadside Design Guide

  https://store.transportation.org/Item/CollectionDetail?ID=105

- Task Force 13 Guide to Standardized Roadside Safety Hardware

  http://www.tf13.org/Guides/

- FHWA Web Site

  http://safety.fhwa.dot.gov/roadway_dept/

- FDOT Design Manual

  http://www.fdot.gov/roadway/FDM/

- FDOT Standard Plans for Road and Bridge Construction (Standard Plans)

  http://www.fdot.gov/design/standardplans/

- FDOT Structures Design Guidelines

  http://www.fdot.gov/structures/StructuresManual/CurrentRelease/StructuresManual.shtm

- FDOT Drainage Manual,

  http://www.fdot.gov/roadway/Drainage/ManualsandHandbooks.shtm

- Florida Strategic Highway Safety Plan

  https://www.fdot.gov/safety/shsp/shsp.shtm