Table 6 – 2 Illuminance and Luminance Design Values

Roadway and Walkway Classification	Off-Roadway Light Sources	Illuminance Method					Luminance Method			Additional Values (both Methods)
		Average Maintained Illuminance (Horizontal)				Illuminance Uniformity Ratio	Average Maintained Luminance			Veiling Luminance Ratio
		R1	R2	R3	R4		Lavg	Uniformity		
	General Land Use	(foot -candles) (min)	(foot-candles) (min)	(foot-candles) (min)	(foot-candles) (min)	avg/min (max) (6)	cd/m2 (min)	Lavg/Lmin (max)	Lmax/Lmin (max)	Lv(max)/Lavg (max)[3]
Principal Arterials (partial or no control of access)	Commercial	1.1	1.6	1.6	1.4	3:1	1.2	3:1	5:1	0.3:1
	Intermediate	0.8	1.2	1.2	1.0	3:1	0.9	3:1	5:1	0.3:1
	Residential	0.6	0.8	0.8	0.8	3:1	0.6	3.5:1	6:1	0.3:1
Minor Arterials	Commercial	0.9	1.4	1.4	1.0	4:1	1.2	3:1	5:1	0.3:1
	Intermediate	0.8	1.0	1.0	0.9	4:1	0.9	3:1	5:1	0.3:1
	Residential	0.5	0.7	0.7	0.7	4:1	0.6	3.5:1	6:1	0.3:1
Collectors	Commercial	0.8	1.1	1.1	0.9	4:1	0.8	3:1	5:1	0.4:1
	Intermediate	0.6	0.8	0.8	0.8	4:1	0.6	3.5:1	6:1	0.4:1
	Residential	0.4	0.6	0.6	0.5	4:1	0.4	4:1	8:1	0.4:1
Local	Commercial	0.6	0.8	0.8	0.8	6:1	0.6	6:1	10:1	0.4:1
	Intermediate	0.5	0.7	0.7	0.6	6:1	0.5	6:1	10:1	0.4:1
	Residential	0.3	0.4	0.4	0.4	6;1	0.3	6:1	10:1	0.4:1
Alleys	Commercial	0.4	0.6	0.6	0.5	6:1	0.4	6:1	10:1	0.4:1
	Intermediate	0.3	0.4	0.4	0.4	6:1	0.3	6:1	10:1	0.4:1
	Residential	0.2	0.3	0.3	0.3	6:1	0.2	6:1	10:1	0.4:1

Continued next page

Table 6 – 2
Illuminance and Luminance Design Values
(Continued)

Sidewalks	Commercial	0.9	1.3	1.3	1.2	3:1	Use illuminance requirements
	Intermediate	0.6	0.8	0.8	0.8	4:1	
	Residential	0.3	0.4	0.4	0.4	6:1	
Pedestrian Ways and Bicycle Ways[(2)]	All	1.4	2.0	2.0	1.8	3.1	

Notes

1. Meet either the Illuminance design method requirements or the Luminance design method requirements and meet veiling luminance requirements for both illuminance and Luminance design methods.
2. Assumes a separate facility. For Pedestrian Ways and Bicycle Ways adjacent to roadway, use roadway design values. Use R3 requirements for walkway/bikeway surface materials other than the pavement types shown.
3. Lv (max) refers to the maximum point along the pavement, not the maximum in lamp life. The Maintenance factor applies to both the Lv term and the Lavg term.
4. There may be situations when a higher level of illuminance is justified. The higher values for freeways may be justified when deemed advantageous by the agency to mitigate off-roadway sources.
5. Physical roadway conditions may require adjustment of spacing determined from the base levels of illuminance indicated above.
6. Higher uniformity ratios are acceptable for elevated ramps near high-mast poles.
7. See AASHTO publication entitled, "A Policy on Geometric Design of Highways and Streets" for roadway and walkway classifications.
8. R1, R2, R3 and R4 are Road Surface Classifications, defined in the AASHTO Roadway Lighting Design Guide and further described in Table 6.2.

F UNIFORMITY OF ILLUMINATION

To avoid vision problems due to varying illumination, it is important to maintain illumination uniformity over the roadway. It is recommended the ratio of the average to the minimum initial illumination on the roadway be between 3:1 to 4:1.

A maximum to minimum uniformity ratio of 10:1 should not be exceeded. It is important to allow time for the driver's eye to adjust to lower light levels. The first light poles should be located on the side of the incoming traffic approaching the illuminated area. The eye can adjust to increased or increasing light level more quickly. In transition from a lighted to an unlighted portion of the highways, the level should be gradually reduced from the level maintained on the lighted section. This may be accomplished by having the last light pole occur on the opposite roadway. The roadway section following lighting termination should be free of hazards or decision points. Lighting should not be terminated before changes in background lighting or roadway geometry, or at the location of traffic control devices.

It is also important to ensure color consistency when lighting a highway/pedestrian corridor. Mixing of different types of lighting may reduce the lighting uniformity. As we transition to LED, it is acceptable to have mixed lighting segments along the same corridor.

The use of spot lighting at unlit intersections with a history of nighttime crashes is an option.

Close coordination between the Engineer of Record and the responsible local governmental agency is essential.

G UNDERPASSES AND OVERPASSES

One of the criteria to be followed to determine requirements for underpass lighting is the relative level between illumination on the roadway inside and outside of the underpass. The height, width, and length of the underpass determines the amount of light penetration from the exterior.

The need for lighting of independent sidewalks or shared use paths should be evaluated on a project specific basis. Considerations include the likelihood of night time use, the role of the facility in the community's bicycle and pedestrian network, and whether alternatives are available for night time travel.

When lighting an underpass, use a wall-mounted luminaire that is attached to a pier, pier cap, or the wall copings underneath the bridge.

G.1 Daytime Lighting

A gradual decrease in the illumination level from day time level on the roadway, sidewalk or path to the underpass should be provided. Consider daytime lighting for vehicles in underpasses greater than 80 feet in length.

Supplemental lighting of sidewalks or shared use paths in roadway underpasses less than 80 feet in length should be considered. Sidewalks and shared use paths on independent alignments with little natural light should be illuminated, especially if the exit is not visible upon entry.

G.2 Night Lighting

The night time illumination level in the underpass of the roadway should be maintained near the night time level of the approach roadway. Lighting of sidewalks or shared use paths adjacent to roadways in underpasses should be considered. Sidewalks and shared use paths on independent alignments open to travel during darkness should be illuminated. Due to relatively low luminaire mounting heights in underpasses, care should be exercised to avoid glare.

H DECORATIVE ROADWAY LIGHTING

Decorative or architectural roadway lighting is acceptable provided it meets the minimum design criteria and the objectives contained in this Manual. Examples include architectural lighting posts, cross arms, wall brackets, bollards, and light fixtures.

I ADAPTIVE LIGHTING

Some locations such as coastal roadways where sea turtles may be affected, may require lower lighting levels and different colors than what might normally be provided. FHWA's publication ***The Guidelines for the Implementation of Reduced Lighting on Roadways*** describes a process by which an agency or a lighting designer can select the required lighting level for a road or street and implement adaptive lighting for a lighting installation or lighting retrofit. This document supplements existing lighting guidelines.

J OVERHEAD SIGN LIGHTING

If the visibility of the sign due to roadway geometry or retro reflectivity of the sign sheeting is inadequate, overhead sign lighting should be provided. It is recommended that the level of illumination for overhead signs not be less than guidelines found in Table 6 – 3 Illuminance and Luminance Levels for Sign Lighting. See ***Chapter 18 – Signing and Marking*** for signage retroreflectivity requirements.

Table 6 – 3 Illuminance and Luminance Levels for Sign Lighting

Ambient Luminance	**Sign Illuminance**		**Sign Luminance***	
	Footcandles	**Lux**	**Candelas per Square Meter**	**Candelas per Square Foot**
Low	10 - 20	100 - 200	22 - 44	2.2 – 4.4
Medium	20 - 40	200 - 400	44 - 89	4.4 – 8.9
High	40 - 80	400 - 800	89 - 78	89 – 178

Source: AASHTO Roadway Lighting Design Guide (October, 2005), Table 10 – 1 Illuminance and Luminance Levels for Sign Lighting.

*Based upon a maintained reflectance of 70 percent for white sign letters.

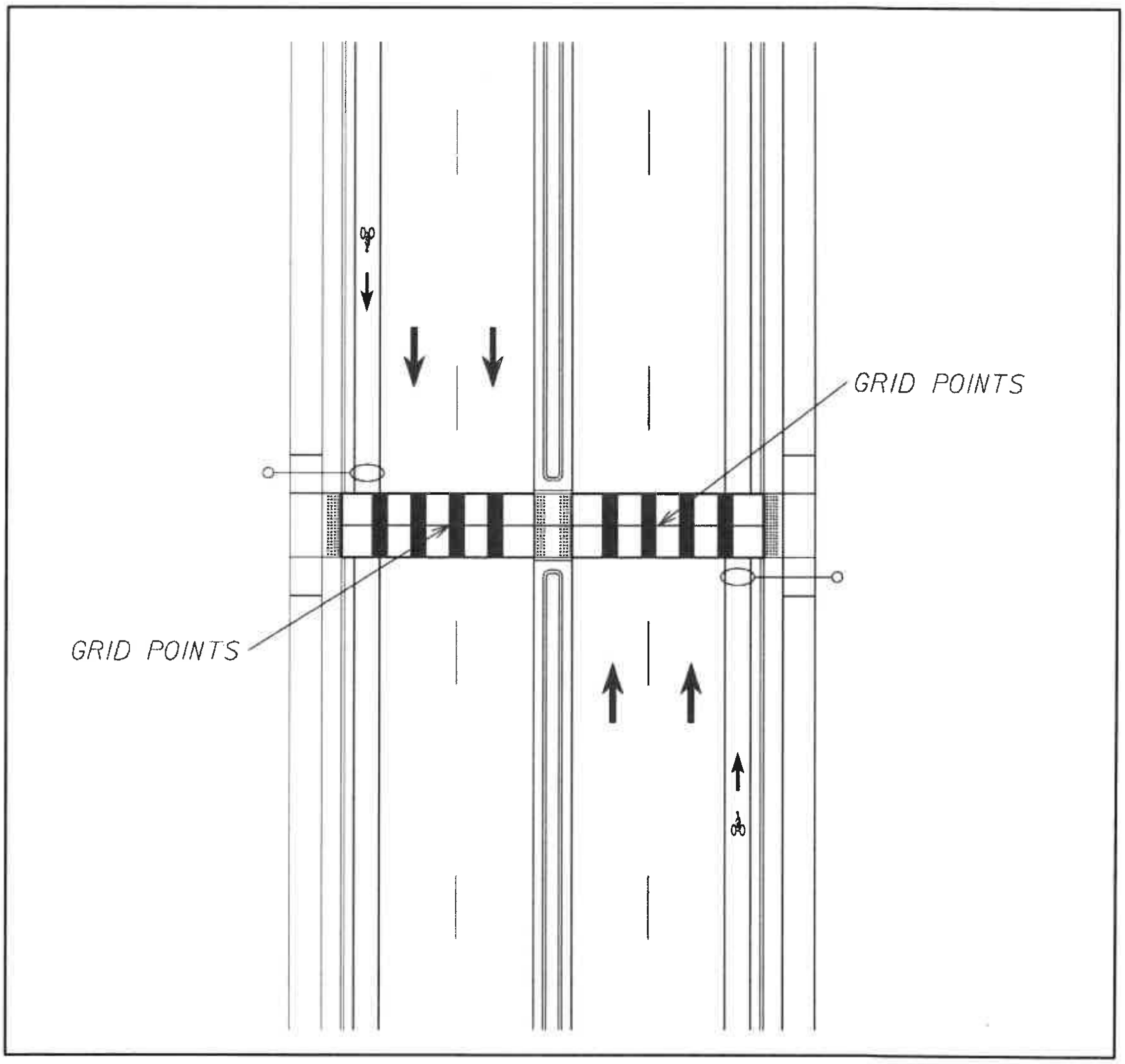
K ROUNDABOUTS

Roundabouts should be supplemented with roadway lighting. Where pedestrians are expected, provide additional lighting of 2.0-foot candles of maintained vertical illumination, measured at 5 feet from the road surface. Calculate the vertical illuminance for the crosswalk on each near side approach entering and exiting the roundabout.

L MIDBLOCK CROSSWALKS

At midblock pedestrian crossings, provide 2.0-foot candles of maintained vertical illumination, measured at 5 feet from the road surface. Calculate the vertical illuminance for the crosswalk on each near side approach.

Figure 6 – 2 Horizontal and Vertical Illuminance for Mid-Block Crosswalk



M MAINTENANCE

A program of regular preventive maintenance should be established to ensure levels of illumination do not go below required values. The program should be coordinated with lighting design to determine the maintenance period. Factors for consideration include a decrease in lamp output, luminaire components becoming dirty, and the physical deterioration of the reflector or refractor. The maintenance of roadway lighting should be incorporated in the overall maintenance program specified in ***Chapter 10 – Maintenance and Resurfacing***.

N LIGHT POLES

Light poles should not be placed in the sidewalk when adequate right of way is available beyond the sidewalk. Placement of lighting structures and achieved illumination may be limited by existing conditions such as driveways, overhead and underground utilities, drainage structures, and availability of right of way.

Light poles should not be placed so as to provide a hazard to errant vehicles. Non-frangible light poles should be placed outside of the clear zone. They should be as far removed from the travel lane as possible or behind adequate guardrail or other barriers. Light poles should be placed on the inside of the curves when feasible. Foundations or light poles and rigid auxiliary lighting components that are not behind suitable barriers should be constructed flush with or below the ground level.

The use of high mast lighting should be considered, particularly for lighting interchanges and other large plaza areas. This use tends to produce a more uniform illumination level, reduces glare, and allows placement of the light poles farther from the roadway. Additional emphasis lighting should be considered to illuminate specific and desired pedestrian crossings.

The placement of light poles should not interfere with the driver's sight distance or visibility of signs, signals, or other traffic control devices. In addition, the ***National Electrical Code (NEC)*** requires a working area for safety purposes around the poles. Further criteria regarding the placement of roadside structures, including light poles, is specified in ***Chapter 4 – Roadside Design***.

O REFERENCES FOR INFORMATIONAL PURPOSES

The publications referenced in this chapter can be obtained at the following web sites.

- Roadway Lighting, ANSI/RP-8-14
  http://www.ies.org/store/product/roadway-lighting-ansiies-rp814-1350.cfm

- Design Guide for Residential Street Lighting (2015), Illuminating Engineering Society
  https://www.ies.org/store/design-guides/design-guide-for-residential-street-lighting/

- AASHTO - Roadway Lighting Design Guide (October 2005)
  https://bookstore.transportation.org

- Guidelines for the Implementation of Reduced Lighting on Roadways PUBLICATION NO. FHWA-HRT-14-050 JUNE 2014
  http://www.fhwa.dot.gov/publications/research/safety/14050/14050.pdf

- The Lighting Handbook, 10th Edition, Illuminating Engineering Society (IESA)
  https://www.ies.org/store/lighting-handbooks/lighting-handbook-10th-edition/

- National Electric Code
  https://www.nfpa.org/NEC/About-the-NEC/Free-online-access-to-the-NEC-and-other-electrical-standards

CHAPTER 7

RAIL-HIGHWAY CROSSINGS

TABLES

FIGURES

CHAPTER 7

RAIL-HIGHWAY CROSSINGS

A INTRODUCTION

The basic design for grade crossings should be similar to that given for highway intersections in ***Chapter 3 – Geometric Design***. Rail-highway grade crossings should be limited in number and should, where feasible, be accomplished by grade separations. Where at-grade crossings are necessary, adequate traffic control devices and proper crossing design are required to limit the probability of crashes.

B OBJECTIVE AND PRIORITIES

The primary objective in the design, construction, maintenance, and reconstruction of rail-highway crossings is to provide safety for both rail and roadway vehicles in a feasible and efficient manner. The achievement of this objective may be realized by utilizing the following techniques in the listed sequence of priority.

B.1 Conflict Elimination

The elimination of at grade rail-highway conflicts is the most desirable procedure for promoting safe and efficient traffic operations. This may be accomplished by the closing of a crossing or by utilizing a grade separation structure.

B.2 Hazard Reduction

The design of new at-grade crossings should consider the objective of hazard reduction. In addition, an effective program of reconstruction should be directed towards reducing crash potential at existing crossings.

The regulation of intersections between railroads and all public streets and highways in Florida is vested in the ***Florida Administrative Code, (Rule Chapter 14-57: Railroad Safety and Clearance Standards, and Public Railroad-Highway Grade Crossings***. This rule contains minimum requirements for all new grade crossings.

The Department's rail office has other documents available that contain additional guidance for the design, reconstruction, and upgrading of existing rail-highway grade crossings, and may be contacted for further information.

C RAIL-HIGHWAY GRADE CROSSING NEAR OR WITHIN PROJECT LIMITS

Federal-aid projects must be reviewed to determine if a rail-highway grade crossing is within the limits of or near the terminus of the project. If such rail-highway grade crossing exists, the project must be upgraded to meet the requirements of the ***Manual on Uniform Traffic Control Devices (2009 Edition with Revision Numbers 1 and 2, May 2012) (MUTCD)*** in accordance with ***Title 23, United States Code (U.S.C.), Chapter 1, Section 109(e)*** *and* ***23 C.F.R. 646.214(b).***

These requirements are located in ***Chapter 8*** of the ***MUTCD***. "Near the terminus" is defined as being either of the following:

- If the project begins or ends between the crossing and the MUTCD-mandated advanced placement distance for the advanced (railroad) warning sign. See ***MUTCD, Table 2C-4 (Condition B, Column "0" mph)*** for this distance.
- An intersection traffic signal within the project is linked to the crossing's flashing light signal and gate.

D DESIGN OF RAIL-HIGHWAY CROSSINGS

The primary requirement for the geometric design of a grade crossing is that it provides adequate sight distance for the motorist to make an appropriate decision as to stop or proceed at the crossing.

D.1 Sight Distance

The minimum sight distance requirements for streets and highways at rail-highway grade crossings are similar to those required for highway intersections (***Chapter 3 – Geometric Design***).

D.1.a Stopping Sight Distance

The approach roadways at all rail-highway grade crossings should consider stopping sight distance no less than the values given in ***Chapter 3,*** Table 3 – 3 Minimum Stopping Sight Distances for the approach to stop signs. This distance shall be measured to a stopping point prior to gates or stop bars at the crossing, but not less than 15 feet from the nearest track. All traffic control devices shall be visible from the driver eye height of 3.50 feet.

D.1.b Sight Triangle

At grade crossings without train activated signal devices, a sight triangle should be provided.

The provision of the capability for defensive driving is an important aspect of the design of rail-highway grade crossings. An early view of an approaching train is necessary to allow the driver time to decide to stop or to proceed through the crossing.

The size of this sight triangle, which is shown in Figure 7 – 1 Visibility Triangle at Rail-Highway Grade Crossings, is dependent upon the train speed limit, the highway design speed, and the highway approach grade. The minimum distance along the highway (d_H), includes the requirements for stopping sight distance, the offset distance (D) from the edge of track to the stopped position (15 feet), and the eye offset (d_e) from the front of vehicles (8 feet); (Figure 7 – 1, Case A). The required distance (d_T) along the track, given in Table 7 – 1 Sight Distance at Rail-Highway Grade Crossings, is necessary to allow a vehicle to stop or proceed across the track safely. Where the roadway is on a grade, the lateral sight distance (d_T) along the track should be increased as noted (Table 7 – 1). This lateral sight distance is desirable at all crossings. In other than flat terrain it may be necessary to rely on speed control signs and devices and to predicate sight distance on a reduced speed of operation. This reduced speed should never be less than 15 mph and preferably 20 mph.

D.1.c Crossing Maneuvers

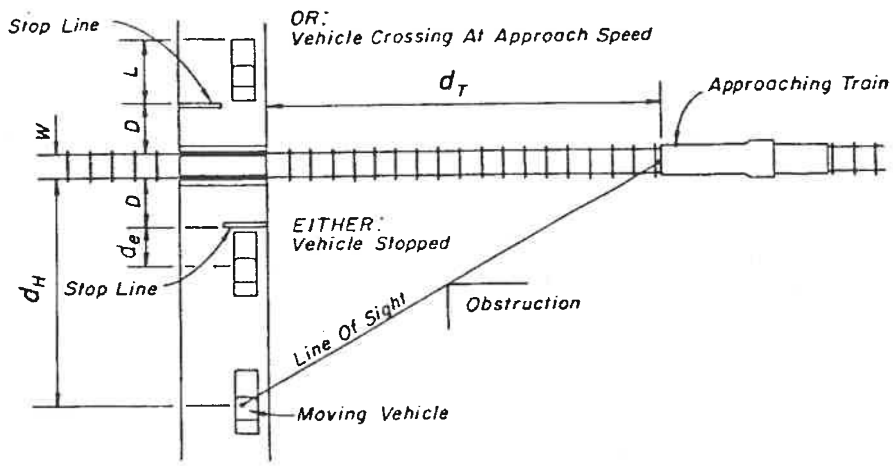
The sight distance required for a vehicle to cross a railroad from a stop is essentially the same as that required to cross a highway intersection as given in ***Chapter 3 – Geometric Design***.

An adequate clear distance along the track in both directions should be provided at all crossings. This distance, when used, shall be no less than the values obtained from Figure 7 – 1 Visibility Triangle at Rail-Highway Grade Crossings and Table 7 – 1 (Case B), Sight Distance at Rail-Highway Grade Crossings. Due to the greater stopping distance required for trains, this distance should be increased wherever possible.

The crossing distance to be used shall include the total width of the tracks, the length of the vehicle, and an initial vehicle offset. This offset shall be at least 10 feet back from any gates or flashing lights, but not less than 15 feet from the nearest track. The train speed used shall be equal to or greater than the established train speed limit.

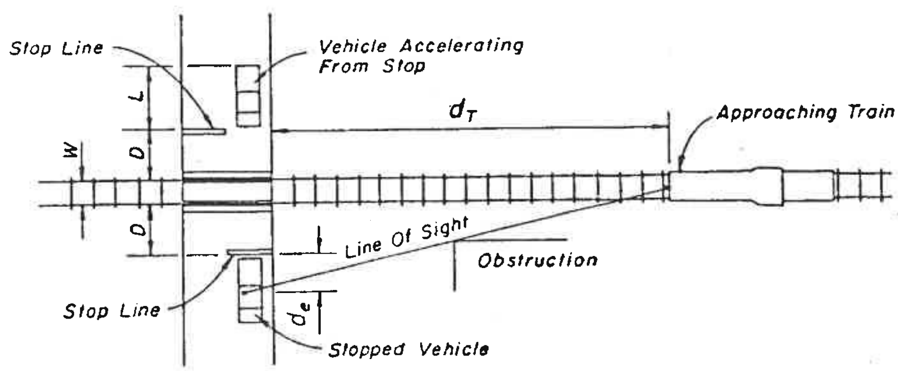
The setback for determining the required clear area for sight distance should be at least 10 feet more than the vehicle offset. Care should be exercised to ensure signal supports and other structures at the crossing do not block the view of drivers preparing to cross the tracks.

Figure 7 – 1 Visibility Triangle at Rail-Highway Grade Crossings



CASE A

APPROACHING VEHICLE TO SAFELY CROSS OR STOP AT RAILROAD CROSSING



CASE B

VEHICLE DEPARTING FROM STOPPED POSITION TO SAFELY CROSS RAILROAD TRACK

For d_H and d_T values and crossing conditions see Table 7-1.

Table 7 – 1 Sight Distance at Rail-Highway Grade Crossings

Design Sight Distances for Combinations of Train and Highway Vehicle Speeds Conditions:								
Single Track 90° Crossing Design Vehicle WB-62FL and WB-67 (L=73.5' d_e=8') Flat Highway Grades				Track Width (W) = 5' Vehicle Stop Position (D) = 15' No Train Activated Warning Devices				
Train Speed (mph)	Case B Vehicle Departure From Stop	Case A Moving Vehicle						
	Vehicle Speed (mph)							
	0	10	20	30	40	50	60	70
	d_t (feet) Sight Distance Along Railroad Track							
10	255	155	110	102	102	106	112	119
20	509	310	220	203	205	213	225	239
30	764	465	331	305	307	319	337	358
40	1019	619	441	407	409	426	450	478
50	1274	774	551	509	511	532	562	597
60	1528	929	661	610	614	639	675	717
70	1783	1084	771	712	716	745	787	836
80	2038	1239	882	814	818	852	899	956
90	2292	1394	992	915	920	958	1012	1075
100	2547	1548	1102	1017	1023	1064	1124	1194
110	2802	1703	1212	1119	1125	1171	1237	1314
120	3057	1858	1322	1221	1227	1277	1349	1433
130	3311	2013	1433	1322	1329	1384	1461	1553
(Continued on Next Page)								

Table 7 – 1
Sight Distance at Rail-Highway Grade Crossings
(continued)

d_H (feet) Sight Distance Along Highway							
	69	135	220	324	447	589	751

Notes: 1. Sight distances are required in all quadrants of the crossing.

2. Corrections must be made for conditions other than shown in the table, such as, multiple rails, skewed angle crossings, ascending and descending grades, and curvature of highways and rails. For condition adjustments and additional information refer to Railroad-Highway Grade Crossings under ***Chapter 9*** of "***A Policy on Geometric Design of Highways and Streets", AASHTO (2011)***. Additional information is available on FHWA's website for *Highway-Rail Grade Crossing Surfaces* and ***NCHRP Synthesis 250 Highway – Rail Grade Crossing Surfaces, TRB, (1998).***"

Source: Developed from ***Table 9 – 32, A Policy on Geometric Design of Highway and Streets, AASHTO (2011).***

D.2 Approach Alignment

The alignment of the approach roadways is a critical factor in developing a safe grade crossing. The horizontal and vertical alignment, and particularly any combination thereof, should be as gentle as possible.

D.2.a Horizontal Alignment

The intersection of a highway and railroad should be made as near to the right angle (90 degrees) as possible. Intersection angles less than 70 degrees should be avoided. The highway approach should, if feasible, be on a tangent, because the use of a horizontal curve tends to distract the driver from a careful observation of the crossing. The use of superelevation at a crossing is normally not possible, since this would prevent the proper grade intersection with the railroad.

D.2.b Vertical Alignment

The vertical alignment of the roadway on a crossing is an important factor in safe vehicle operation. The intersection of the tracks and the roadway should constitute an even plane. All tracks should, preferably, be at the same elevation, thus allowing a smooth roadway through the crossing. Where the railroad is on a curve with superelevation, the vertical alignment of the roadway shall coincide with the grade established by the tracks.

Vertical curvature on the crossing should be avoided. This is necessary to limit vertical motion of the vehicle.

The vertical alignment of the approach roadway should be adjusted when rail elevations are raised to prevent abrupt changes in grade and entrapment of low clearance vehicles

The roadway approach to crossing should also coincide with the grade established by the tracks. This profile grade, preferably zero, should be extended a reasonable distance (at least two times the design speed in feet) on each side of the crossing. Where vertical curves are required to approach this section, they should be as gentle as possible. The length of these vertical curves shall be of sufficient length to provide the required sight distance.

D.3 Highway Cross Section

Preserving the continuity of the highway cross section through a grade crossing is important to prevent distractions and to avoid hazards at an already dangerous location.

D.3.a Pavement

The full width of all travel lanes shall be continued through grade crossings. The crown of the pavement shall be transitioned gradually to meet the cross sectional grade of the tracks. This pavement cross slope transition shall be in conformance with the requirements for superelevation runoff. The lateral and longitudinal pavement slopes should be designed to direct drainage away from the tracks.

D.3.b Shoulders

All shoulders shall be carried through rail-highway grade crossings without interruption.

The use of full-width paved shoulders is required at all new crossings to maintain a stable surface for emergency maneuvers. The shoulders should be paved a minimum distance of 50 feet on each side of the crossing, measured from the outside rail. It is desirable to pave 100 feet on either side to permit bicycles to exit the travel lane, slow for their crossing, and then make an adequate search before selecting a gap for a return to the travel lane. See ***Chapter 3, Table 3 – 11 Shoulder Widths for Rural Highways*** for further information on shoulder width.

D.3.c Medians

It is recommended that the full median width on divided highways should be continued through the crossing. The median should be contoured to provide a smooth transition on the tracks.

A raised median is the ideal deterrent to discourage motorists from driving around the gates to cross the tracks or making a U-turn prior to the tracks. Flush medians should have channelization devices as a deterrent. Railroad signals and gate assemblies should be installed in the median only when gate arms of 36 feet will not adequately span the approach roadway.

Figure 7 – 2 Flush Median Channelization Devices

Alexander Street, SR 39A, Plant City, FL 1

D.3.d Sidewalks and Shared Use Paths

To provide an accessible route for pedestrians at grade rail-highway crossings, new or existing sidewalks and shared use paths shall be continued across the rail crossing. The surface of the crossing shall be:

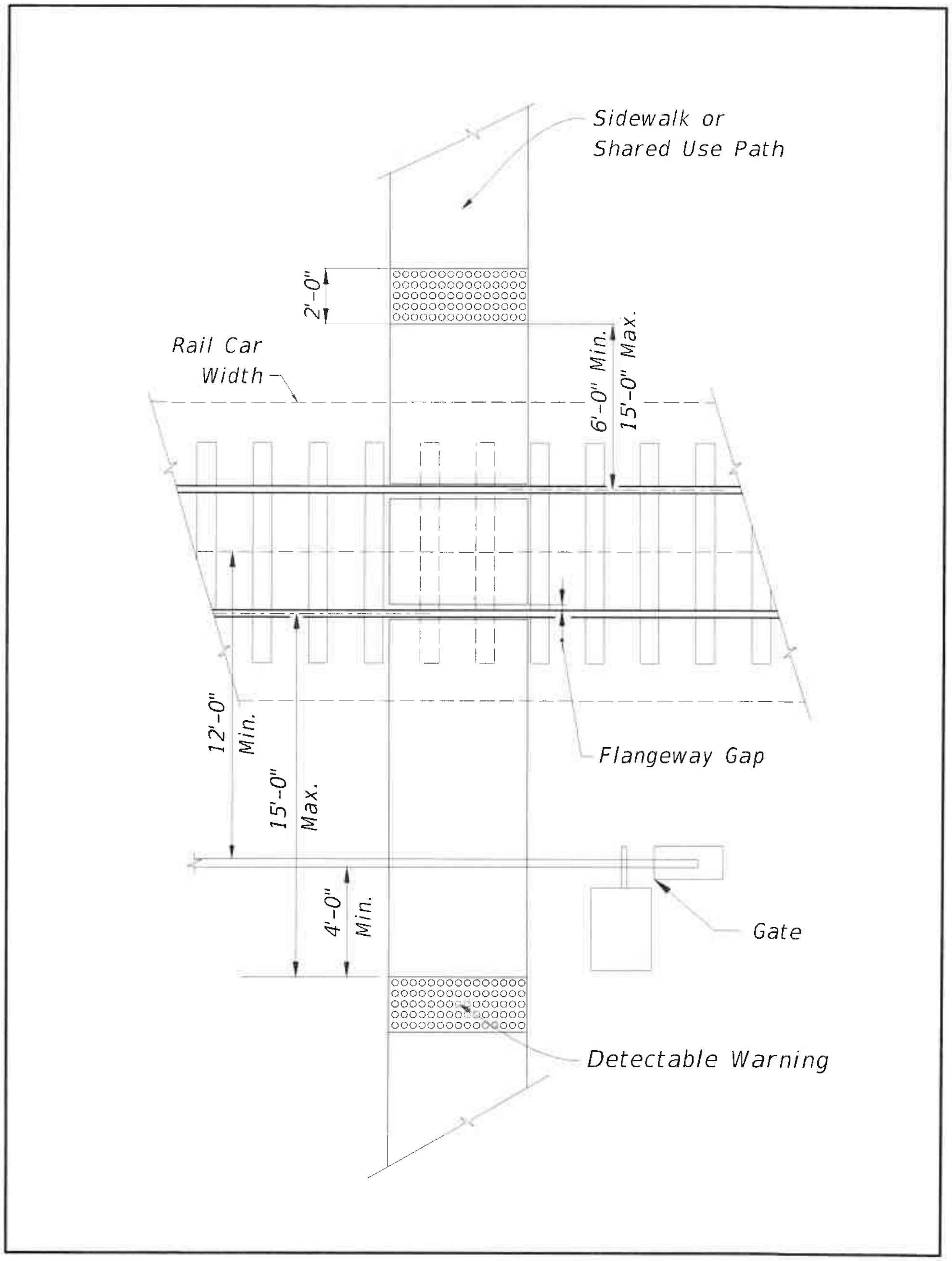
- firm, stable and slip resistant,
- level and flush with the top of rail at the outer edges of the rails, and
- area between the rails align with the top of rail.

Detectable warnings shall be placed on each side of the rail-highway crossing, extend 2.0 feet in the direction of pedestrian travel and the full width across the sidewalk or shared use path, as shown in Figure 7 – 3 Pedestrian Crossings.

The edge of the detectable warning nearest the rail crossing shall be 6.0 to 15.0 feet from the centerline of the nearest rail. Where pedestrian gates are provided, detectable warnings shall be placed a minimum of 4.0 feet from the side of the gates opposite the rail, and within 15.0 feet of the centerline of the nearest rail.

If traffic control signals are in operation at a crossing that is used by pedestrians or bicyclists, an audible device such as a bell shall also be provided and operated in conjunction with the traffic control signals. See ***MUTCD, Chapters 8B and 8C*** for further information and to determine if additional signals, signs, or pedestrian gates should be included. See ***MUTCD, Chapter 8D*** for additional information on designing crossings for shared use paths.

Figure 7 – 3 Pedestrian Crossings

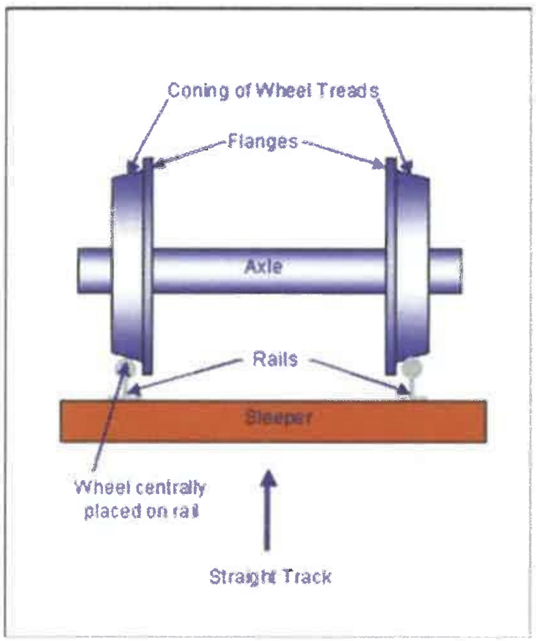


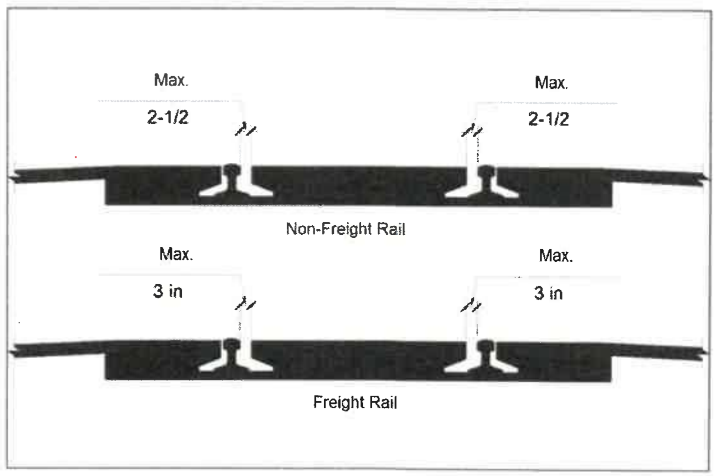
Note: Pedestrian gates may be installed on the outside of the sidewalk/shared use path or in the utility strip.

Flangeway gaps are necessary to allow the passage of train wheel flanges; however, they pose a potential hazard to pedestrians who use wheelchairs because the gaps can entrap the wheelchair casters. Flangeway gaps at pedestrian at-grade rail crossings shall be 2 ½" maximum on non-freight rail track and 3" maximum on freight rail track.

Figure 7 – 4 Flangeways and Flangeway Gaps illustrates where the flanges are located on the wheel, how they interact with the rails, and the maximum gap allowed.

Figure 7 – 4 Flangeways and Flangeway Gaps





See ***Chapter 8 – Pedestrian Facilities*** and ***Chapter 9 – Bicycle Facilities*** for further information on designing sidewalks and shared use paths. The *2006 Americans with Disabilities Act – Standards for Transportation Facilities* and the *2017 Florida Accessibility Code* impose additional requirements for the design and construction of pedestrian facilities.

D.3.e Roadside Clear Zone

Although it is often not practical to maintain the full width of the roadside clear zone, the maximum clear area feasible should be provided. This clear zone shall conform to the requirements for slope and change in grade for roadside clear zones.

D.3.f Auxiliary Lanes

Auxiliary lanes are permitted but not encouraged at signalized rail-highway grade crossings that have a large volume of bus or truck traffic required to stop at all times. These additional lanes should be restricted for the use of these stopping vehicles. The approaches to these auxiliary lanes shall be designed as storage for deceleration lanes. The exits shall be designed as acceleration lanes.

D.4 Roadside Design

The general requirements for roadside design given in ***Chapter 3 – Geometric Design*** and ***Chapter 4 – Roadside Design***, should be followed at rail-highway grade crossings. Supports for traffic control devices may be required within the roadside recovery area. Due to the structural requirements and the necessity for continuous operation, the use of a breakaway design is not recommended. The use of a guardrail or other longitudinal barrier is also not recommended, because an out of control vehicle would tend to be directed into the crossing.

In order to reduce the hazard to errant vehicles, all support structures should be placed as far from the traveled way as practicable.

D.5 Vertical Clearance

Minimum vertical clearances for grade separated rail-highway crossings are shown in Table 7 – 2 Minimum Vertical Clearances for New Bridges. Minimum vertical clearance is the least distance between the bottom of the superstructure and the top of the highest rail utilized anywhere within the horizontal clearance zone.

Table 7 – 2 Minimum Vertical Clearances for New Bridges

Facility Type	Clearance
Railroad over Roadway	16'-6"
Roadway over Railroad[1]	23'-6"
Pedestrian over Railroad[1]	23'-6"

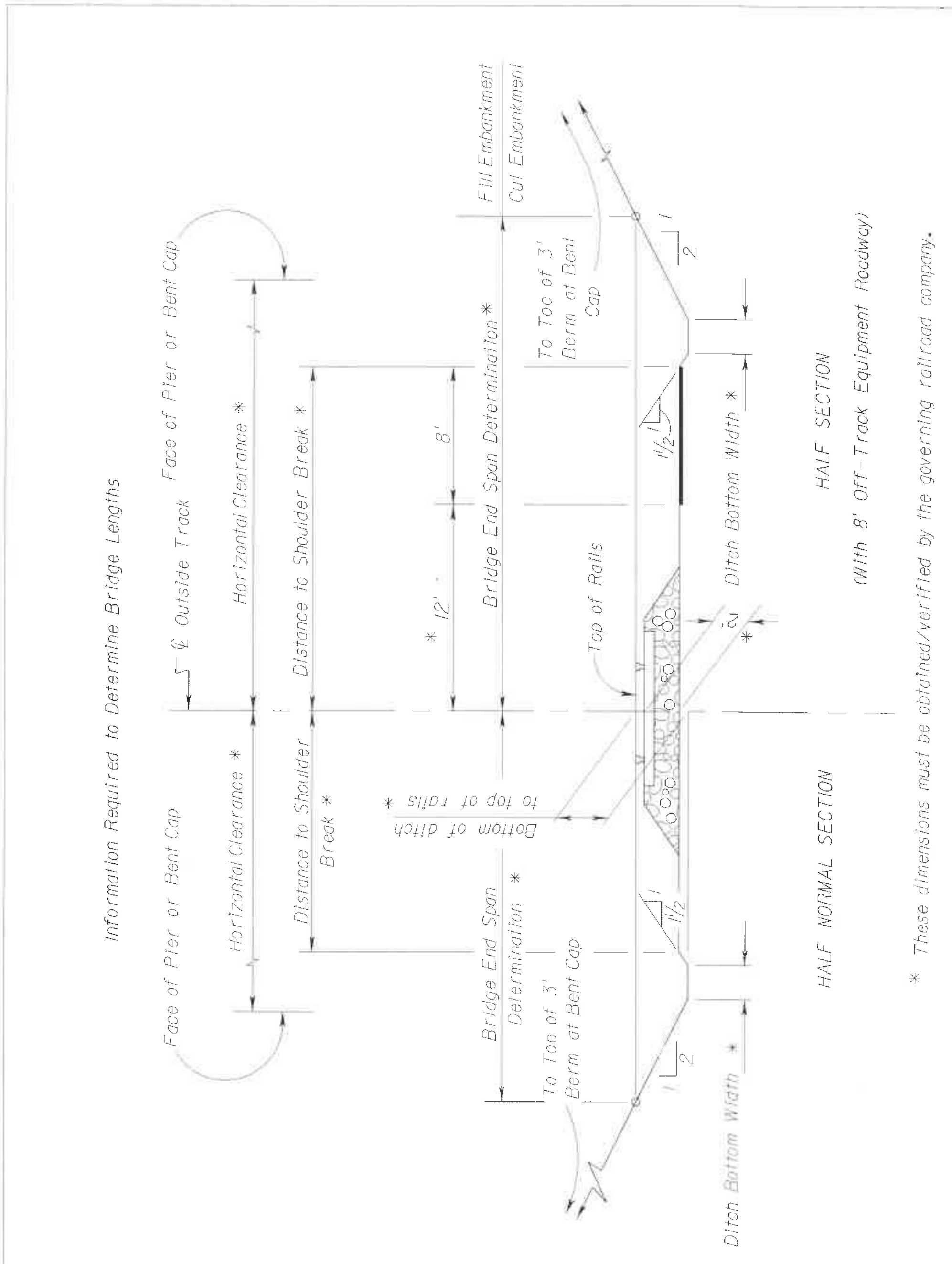
1. Over High Speed Rail Systems, see the latest version of ***American Railway Engineering and Maintenance-of-Way Association (AREMA)*** guidelines, or the design office of the high-speed rail line of interest for specific guidelines and specifications. Over Electrified Railroad, the minimum vertical clearance shall be 24 feet 3 inches. (See ***Department Topic No. 000-725-003: South Florida Rail Corridor Clearance***.)

For any construction affecting existing bridge clearances (e.g., bridge widenings or resurfacing) vertical clearances less than 16' - 0" shall be maintained or increased. If reducing the design vertical bridge clearance to a value between 16' - 0" and 16' - 2", the design vertical clearance dimension in the plans shall be stated as a minimum.

D.6 Horizontal Clearance

Horizontal clearances shall be measured in accordance with Figure 7 – 5 Track Section. The governing railroad company occasionally may accept a waiver from normal clearance requirements if justified; i.e., for designs involving widening or replacement of existing overpasses. The Department's District Rail Coordinator should be consulted if such action is being considered for FDOT owned rail corridors. For other rail crossings, coordinate with the owner of the rail corridor.

Figure 7 – 5 Track Section



The minimum horizontal clearances measured from the centerline of outermost existing or proposed tracks to the face of pier cap, bent cap, or any other adjacent structure are shown in Table 7 – 3 Horizontal Clearances for Railroads but must be adjusted for certain physical features and obstructions such as track geometry and physical obstructions.

Table 7 – 3 Horizontal Clearances for Railroads

Minimum Clearance Requirements	Normal Section[1]	With 8' Required Clearance for Off-Track[2]	Temporary Falsework Opening
With Crash Walls	18 ft.	22 ft.	10 ft.
Without Crash Walls	25 ft.	25 ft.	N/A

[1] Any proposed structure over the South Florida Rail Corridor shall be designed and constructed to provide a horizontal clear span of a minimum of 100 feet but not less than 25 feet from the center line of the outermost existing or proposed tracks. (See ***Department Topic No. 000-725-003-j: South Florida Rail Corridor Clearance.***)

[2] The additional 8 ft. horizontal clearance for off-track equipment shall be provided only when specifically requested in writing by the railroad.

D.6.a Adjustments for Track Geometry

When the track is on a curve, the minimum horizontal clearance shall be increased at a rate of 1.5 inches for each degree of curvature. When the track is superelevated, clearances on the inside of the curve will be increased by 3.5 inches horizontally per inch of superelevation. For extremely short radius curves, the AREMA requirements shall be consulted to assure proper clearance.

D.6.b Adjustments for Physical Obstructions

Columns or piles should be kept out of the ditch to prevent obstruction of drainage. Horizontal clearance should be provided to avoid the need for crash walls unless extenuating circumstances dictate otherwise.

Figure 7 – 5 Track Sections shows horizontal dimensions from the centerline of track to the points of intersection of a horizontal plane at the rail elevation with the embankment slope. These criteria may be used to establish the preliminary bridge length, which normally is also the length of bridge eligible for FHWA participation; however, surrounding topography, hydraulic conditions, and economic or structural considerations may warrant a decrease or an increase of these dimensions. These dimensions must be coordinated with the governing railroad company.

The ***Department's Structures Design Guidelines, Section 2.6.7*** provide additional information on the design of structures over or adjacent to railroad and light rail tracks.

D.7 Access Control

The general criteria for access control in ***Chapter 3 – Geometric Design*** for streets and highways should be maintained in the vicinity of rail-highway grade crossings. Private driveways should not be permitted within 150 feet, nor intersections within 300 feet, of any grade crossing.

D.8 Parking

No parking shall be permitted within the required clear area for the sight distance visibility triangle.

D.9 Traffic Control Devices

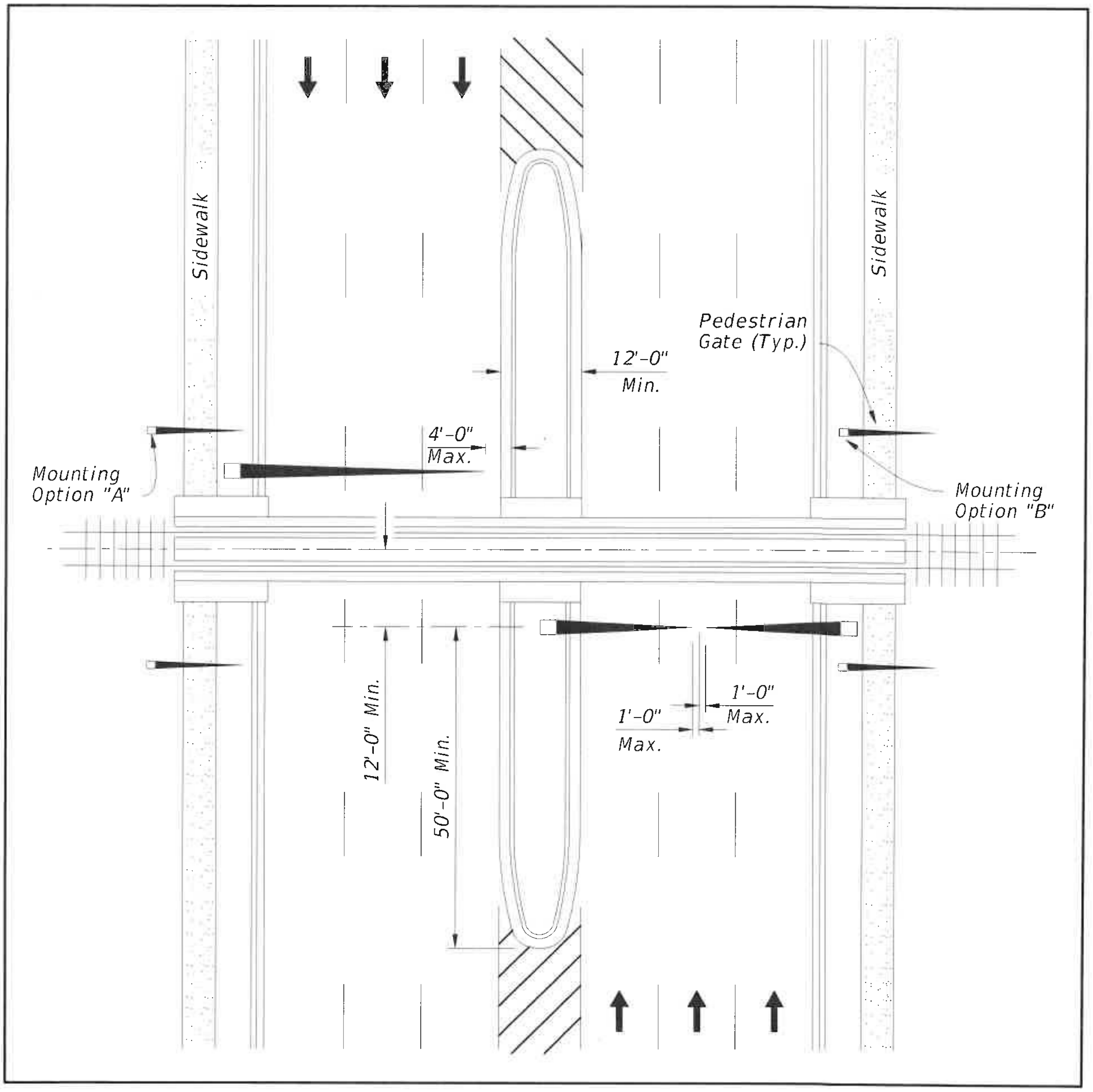
The proper use of adequate advance warning and traffic control devices is essential for all grade crossings. Advance warning should include pavement markings and two or more signs on each approach. Each new crossing should be equipped with train-activated flashing signals.

Automatic gates, when used, should ideally extend across all lanes, but shall at least block one-half of the inside travel lane. It is desirable to include crossing arms across sidewalks and shared use paths.

Traffic control devices shall meet the requirements of the ***MUTCD***. See Section E of this chapter for additional requirements for traffic control devices in Quiet Zones.

Figure 7 – 6 Median Signal Gates for Multilane Curbed Sections provides an example of gate installation when a median is present.

Figure 7 – 6 Median Signal Gates for Multilane Curbed Sections



D.10 Rail-Highway Grade Crossing Surface

Each crossing surface should be compatible with highway user requirements and railroad operations at the site. When installing a new rail-highway crossing or reworking an existing at-grade crossing, welded rail should be placed the entire width from shoulder point to shoulder point. Surfaces should be selected to be as maintenance free as possible.

D.11 Roadway Lighting

The use of roadway lighting at grade crossings should be considered to provide additional awareness to the driver. Illumination of the tracks can also be a beneficial safety aid.

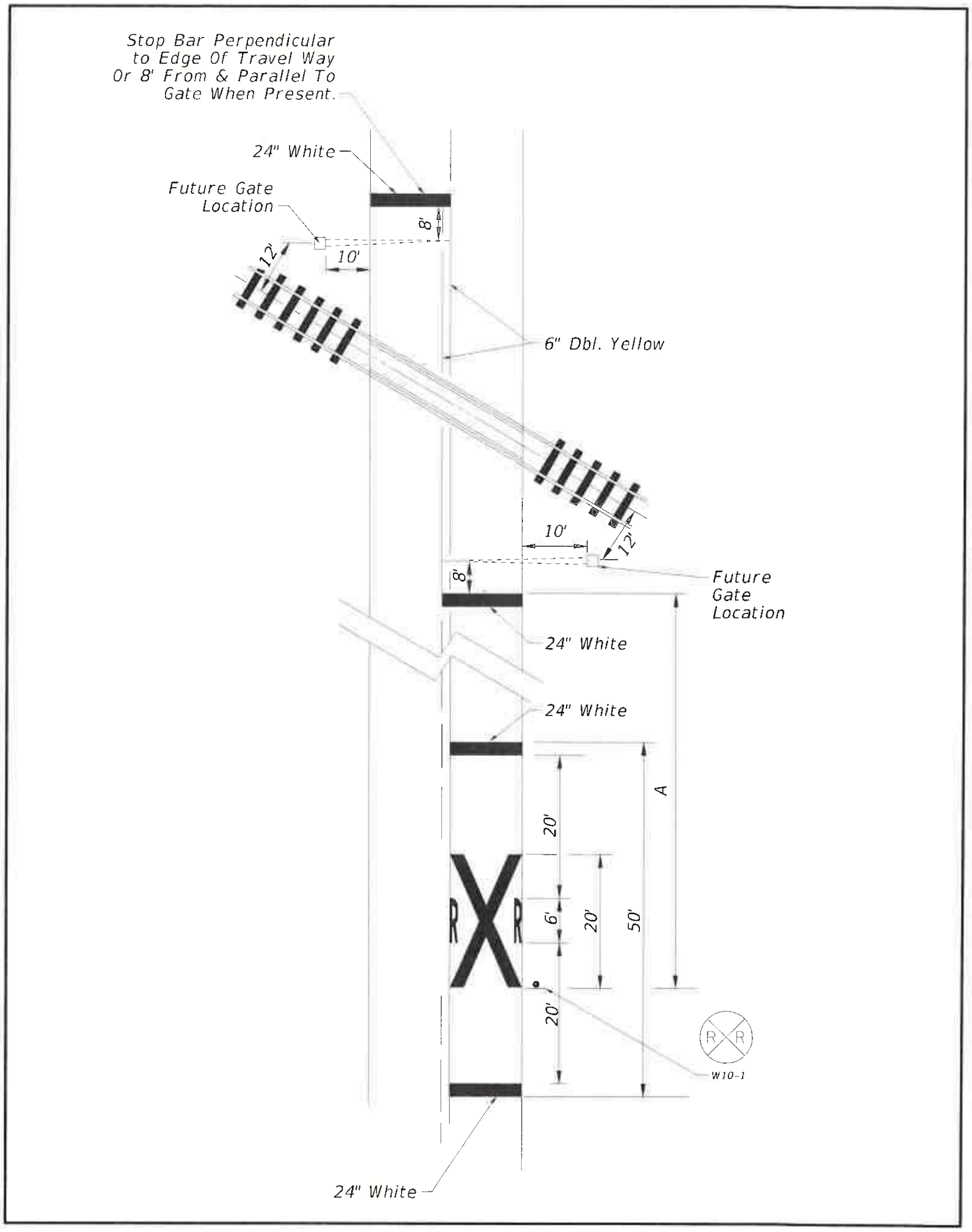
D.12 Crossing Configuration

Recommended layouts for grade crossings are shown in Figures 7 – 7 Passive Rail-Highway Grade Crossing Configuration and 7 – 8 Active Rail-Highway Grade Crossing Configuration. The distance "A" in the Figures is determined by speed and shown in the ***MUTCD, Table 2C – 4. Guidelines for the Advance Placement of Warning Signs***. Although the design of each grade crossing must be "tailored" to fit the existing situation, the principles given in this section should be followed in the design of all crossings. Additional information on the design of rail-highway crossings can be found in the Department's ***Design Standards, Index 17881 and 17882***.

Passive rail-highway grade crossings include traffic control devices that provide static messages of warning, guidance, and, in some instances, mandatory action for the driver. *(Source: **FHWA Railroad-Highway Grade Crossing Handbook**)*

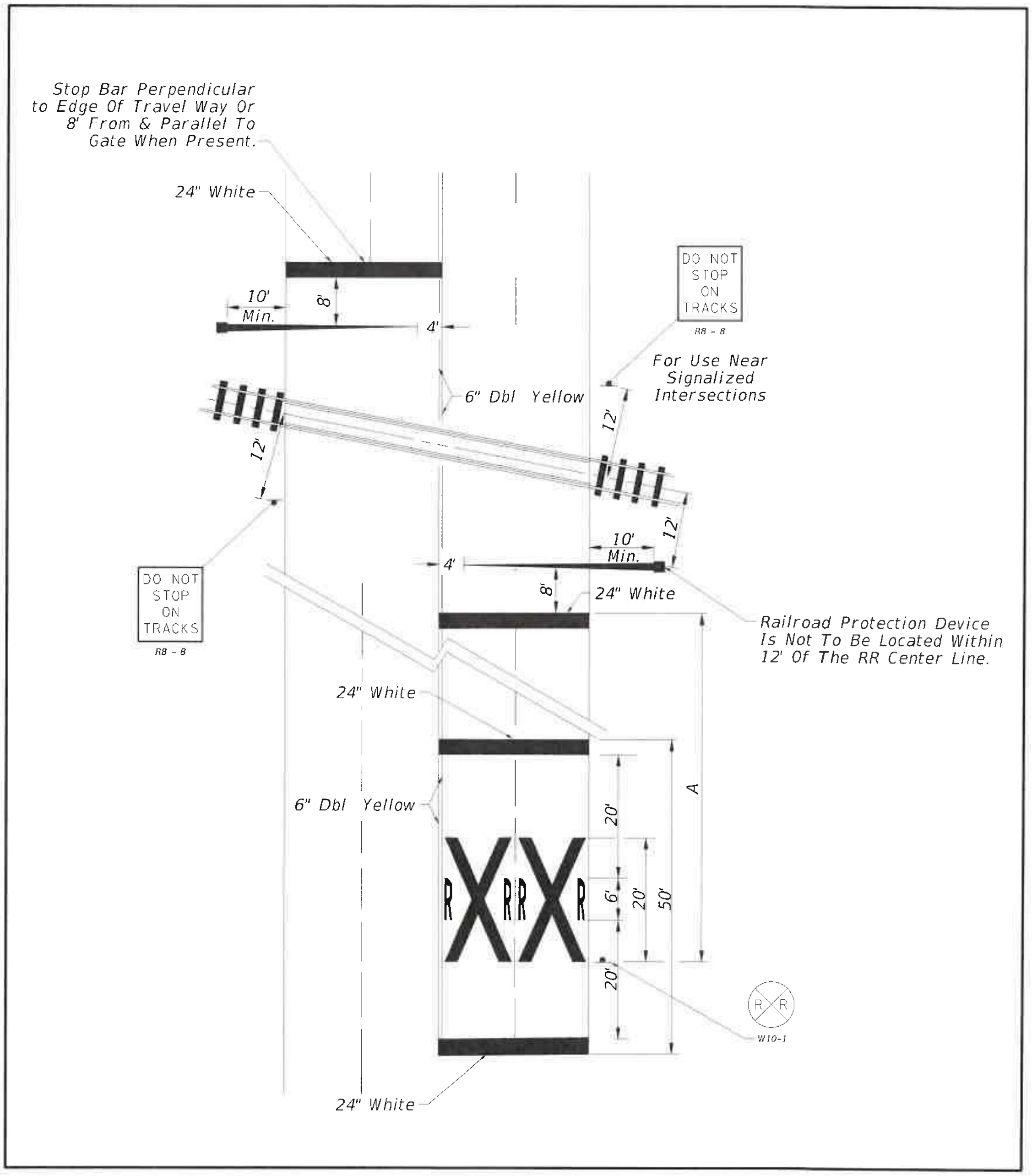
Active rail-highway grade crossings include traffic control devices that give advance notice of the approach of a train. *(Source: **FHWA Railroad-Highway Grade Crossing Handbook**)*.

Figure 7 – 7 Passive Rail-Highway Grade Crossing Configuration



Note: The distance "A" is determined by speed and shown in the MUTCD, Table 2C – 4. Guidelines for the Advance Placement of Warning Signs.

Figure 7 – 8 Active Rail-Highway Grade Crossing Configuration



Note: The distance "A" is determined by speed and shown in the MUTCD, Table 2C – 4. Guidelines for the Advance Placement of Warning Signs.

E QUIET ZONES

Quiet Zone means a segment of a rail line that includes public rail-highway crossings at which locomotive horns are not routinely sounded. The Federal Railroad Administration (FRA) has established guidelines the applying jurisdiction must follow for approval of quiet zones. Applying entities can go to the FRA's website and the ***Code of Federal Regulations (CFR), Title 49, Subtitle B, Chapter II, Part 222*** for further information on the process for approval of Quiet Zones.

Coordinate with the Department's District Rail Coordinator to determine if crossings are located within designated Quiet Zones for State owned rail corridors or crossings of state highways. State owned rail corridors include the ***Central Florida Rail Corridor*** and ***South Florida Rail Corridor***. For other rail crossings, coordinate with the local government who maintains the crossing roadway, sidewalk or shared use path to determine if the location has been approved by the FRA for a Quiet Zone.

For a crossing within a Quiet Zone that requires supplemental safety measures, approved supplemental safety measures include:

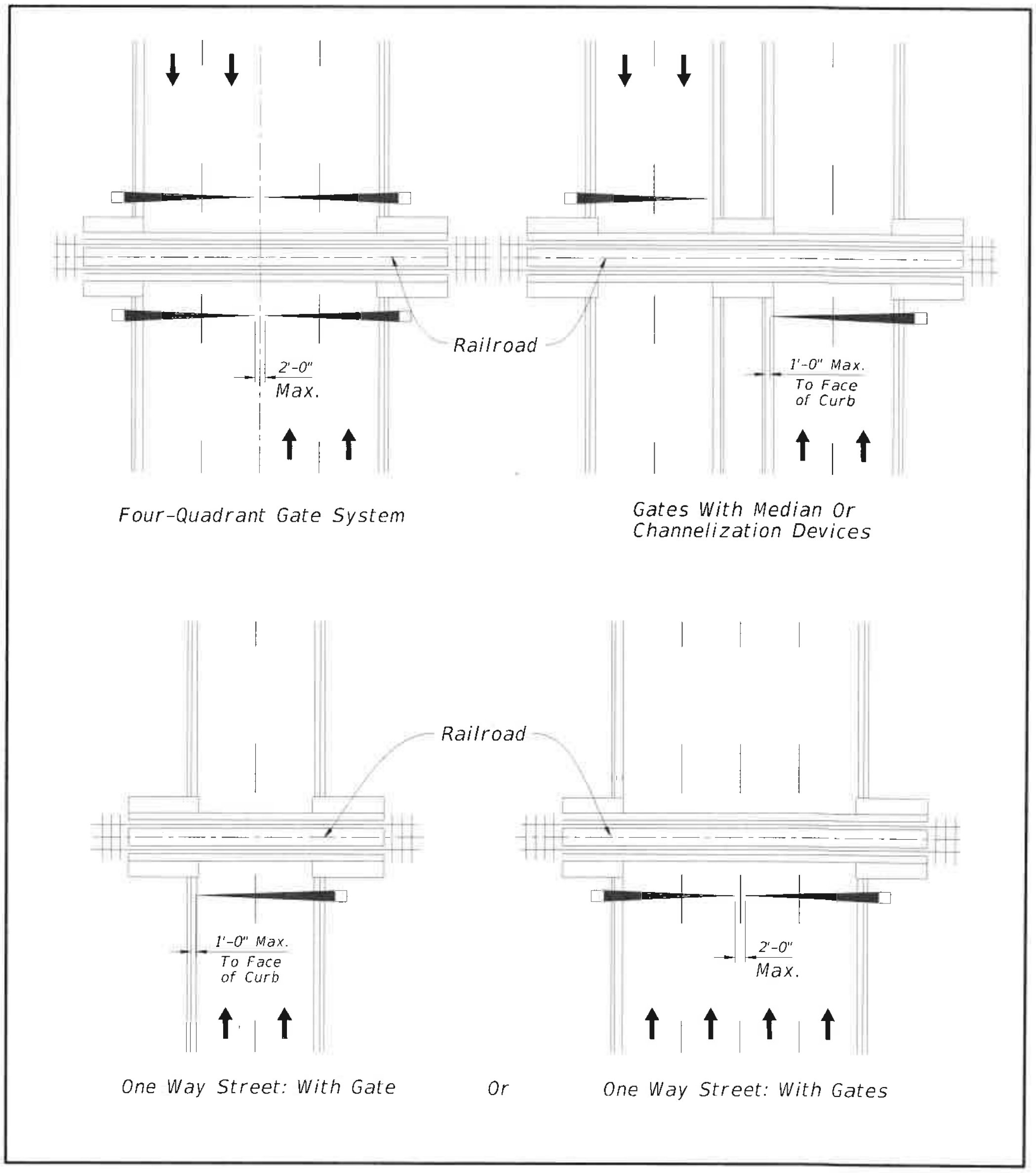
- Temporary closure of a public railroad-highway-rail grade crossing;
- Four-quadrant gate systems;
- Gates with medians or channelization devices;
- One way street with gate(s); and
- Permanent closure of a public highway-rail grade crossing.

The ***CFR, Title 49, Chapter II, Part 222, Appendix A, Approved Supplemental Safety Measures*** provides additional information on the design of Quiet Zones to meet federal approval. The ***CFR*** also requires that any traffic control device and its application where used as part of a Quiet Zone shall comply with all applicable provisions of the ***MUTCD.*** See ***MUTCD, Part 8, Traffic Control for Railroad and Light Rail Transit Grade Crossings*** for further information. Pedestrian gates, audible device, and detectable warnings are required when a sidewalk or shared use path is present or proposed.

For Quiet Zones that cross state owned rail corridors, the Department's ***Design Manual, Chapter 220 Railroads*** provides additional information.

Figure 7 – 9 Gate Configurations for Quiet Zones illustrates the maximum gap allowed for gates at rail-highway crossings within Quiet Zones, based upon ***CFR, Title 49, Chapter II, Part 222.***

Figure 7 – 9 Gate Configuration for Quiet Zones



F HIGH SPEED RAIL

The establishment of high-speed rail service is governed by ***49 U.S. Code 26106 – High-Speed Rail Corridor Development***.

The ***High-Speed Rail (HSR) Strategic Plan*** divides potential operations into four categories or generic descriptions:

- HSR – Express. Frequent express service between major population centers 200 - 600 miles apart, with few intermediate stops. Top speeds of at least 150 mph on completely grade-separated, dedicated rights-of-way (with the possible exception of some shared track in terminal areas). Intended to relieve air and highway capacity constraints.

- HSR – Regional. Relatively frequent service between major and moderate population centers 100 - 500 miles apart, with some intermediate stops. Top speeds of 110 - 150 mph, grade-separated, with some dedicated and some shared track (using positive train control (PTC) technology). Intended to relieve highway and, to some extent, air capacity constraints.

- Emerging HSR. Developing corridors of 100 - 500 miles, with strong potential for future HSR Regional and/or Express service. Top speeds of up to 80 - 110 mph on primarily shared track (eventually using PTC technology), with advanced grade crossing protection or separation. Intended to develop the passenger rail market and provide some relief to other modes.

- Conventional Rail. Traditional intercity passenger rail services of more than 100 miles with as little as 1 to as many as 7 - 12 daily frequencies; may or may not have strong potential for future high-speed rail service. Top speeds of up to 79 mph generally on shared track. Intended to provide travel options and to develop the passenger rail market for further development in the future.

Further information on the implementation of high-speed rail service can be found on the Federal Railroad Administration's website ***High Speed Rail Overview***.

G MAINTENANCE AND RECONSTRUCTION

The inspection and maintenance of all features of rail-highway grade crossings shall be an integral part of each highway agency's and railroad company's regular maintenance program (***Chapter 10 – Maintenance And Resurfacing***). Items that should be given a high priority in this program include: pavement stability and skid resistance, clear sight distance, and all traffic control and protective devices.

The improvement of all substandard or hazardous conditions at existing grade crossings is extremely important and should be incorporated into the regular highway reconstruction program. The objective of this reconstruction program should be to upgrade each crossing to meet these standards. The priorities for reconstruction should be based upon the guidelines set forth by the Department.

H REFERENCES FOR INFORMATIONAL PURPOSES

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

- Federal Highway Administration Railroad-Highway Grade Crossing Handbook, Revised Second Edition, August 2007
  http://safety.fhwa.dot.gov/xings/com_roaduser/07010/

- Code of Federal Regulations (CFR), Title 49 Transportation, Part 222, Use of Locomotive Horns at Public Highway-Rail Grade Crossings
  http://www.ecfr.gov/cgi-bin/text-idx?tpl=/ecfrbrowse/Title49/49cfr222_main_02.tpl

- The Train Horn Rule and Quiet Zones
  https://www.fra.dot.gov/Page/P0104

- MUTCD, Part 8, Traffic Control for Railroad and Light Rail Transit Grade Crossings
  http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/part8.pdf

- The American Railway Engineering and Maintenance-of-Way Association (AREMA)
  https://www.arema.org/

- Florida Administrative Code, (Rule 14-57: Railroad Safety and Clearance Standards, and Public Railroad-Highway Grade Crossings
  https://www.flrules.org/gateway/RuleNo.asp?title=Railroad Safety And Clearance Standards, And Public Railroad-Highway Grade Crossings&Id=14-57.011

- Florida Department of Transportation Rail Contacts
  http://www.dot.state.fl.us/rail/contacts.shtm

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 8

PEDESTRIAN FACILITIES

FIGURES

CHAPTER 8

PEDESTRIAN FACILITIES

A INTRODUCTION

Pedestrian facilities shall be given full consideration in the planning and development of transportation facilities, including the incorporation of such facilities into state, regional, and local transportation plans and programs under the assumption that transportation facilities will be used by pedestrians. Pedestrian facilities should be considered in conjunction with the construction, reconstruction, or other significant improvement of any transportation facility. Special emphasis should be given to projects in or within 1 mile of an urban area.

In addition to the design criteria provided in this chapter, the ***2006 Americans with Disabilities Act Standards for Transportation Facilities*** as required by ***49 C.F.R 37.41 or 37.43*** and the ***2017 Florida Accessibility Code for Building Construction*** as required by ***61G20-4.002*** impose additional requirements for the design and construction of pedestrian facilities. Examples of pedestrian facilities include sidewalks, shared use paths, over and under passes, curb ramps, median refuges, and crosswalks.

Each highway agency responsible for a system of streets and highways should establish and maintain a program for implementing pedestrian facilities, and for maintaining existing pedestrian facilities.

B TYPES OF PEDESTRIAN FACILITIES

There are several ways in which pedestrians can be accommodated in the public right of way

B.1 Sidewalks

Sidewalks are walkways parallel to the roadway and designed for use by pedestrians. Sidewalks should be provided along both sides of roadways that are in or within one mile of an urban area. If sidewalks are constructed on the approaches to bridges, they should be continued across the structure. If continuous sidewalks are constructed on only one side of the street, pedestrians should be provided access to facilities and services located on the opposite side of the street. Newly constructed, reconstructed, or altered sidewalks shall be accessible to and usable by persons with disabilities.

The minimum width of a sidewalk shall be 5 feet on both curb and gutter and flush shoulder roadways. The minimum separation for a 5-foot sidewalk from the back of curb is 2 feet. If the sidewalk is located adjacent to the curb, the minimum width of sidewalk is 6 feet. For sidewalks, not adjacent to the curb, at least a 1-foot wide graded area should be provided on both sides, flush with the sidewalk and having a maximum 1:6 slope. Wider sidewalks should be considered in Central Business Districts and in areas where heavy two-way pedestrian traffic is expected.

A 5-foot wide (minimum) sidewalk that connects a transit stop or facility with an existing sidewalk or shared use path shall be included to comply with ADA accessibility standards. ***Chapter 13 – Transit*** provides illustrations of the connection between the sidewalk and transit facility.

Particular attention shall be given to pedestrian accommodations at the termini of each project. If full accommodations cannot be provided due to the limited scope or phasing of a roadway project or an existing sidewalk is not present at the termini, an extension of the sidewalk to the next appropriate pedestrian crossing or access point should be considered. If pedestrian facilities are provided, they shall be connected with facilities (e.g. sidewalks, shared use path, and crosswalks on the adjoining projects.

For new construction and reconstructed roadways, grades on sidewalks or shared use paths shall not exceed 5%, unless accessible ramps and landings are provided. However, in a roadway right of way, the grade of sidewalks or shared use paths is permitted to equal the general grade established for the adjacent street or highway. There should be enough sidewalk or path cross slope to allow for adequate drainage, however the maximum shall be no more than 2% to comply with ADA requirements.

Where existing physical constraints make it impracticable for altered elements, spaces, or facilities to fully comply with the requirements for new construction, compliance is required to the extent practicable within the scope of the project. Existing physical constraints include, but are not limited to, underlying terrain, right-of-way availability, underground structures, adjacent developed facilities, drainage, or the presence of a notable natural or historic feature. The location of new poles or relocated poles shall provide at least 48" minimum unobstructed sidewalk width.

Evaluate existing driveways and turnouts for compliance to ADA requirements. Nonconforming driveways are not required to be upgraded if it is not feasible within the scope of the project.

Additional information on designing accessible pedestrian facilities is provided by the United States Access Board at the following web site:

Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way

Edge drop-offs should be avoided. When drop-offs cannot be avoided, they should be shielded as discussed in Section F, Drop-Off Hazards for Pedestrians.

For additional information concerning the design of sidewalks, refer to ***Section C.7.d*** of ***Chapter 3 – Geometric Design***.

B.2 Shared Use Paths

Paths are usually set back from the roadway and separated by a green area, ditch, swales or trees. Shared use paths are intended for the use by both pedestrians and bicyclists and shall be accessible. For additional information concerning the design of shared-use paths, refer to ***Chapter 9 – Bicycle Facilities***.

B.3 Shared Streets

Shared uses of a street for people walking, bicycling and driving are referred to as shared streets. These are usually specially designed spaces such as pedestrian streets which are local urban streets with extremely low vehicle speed.

B.4 Shoulders

Highway shoulders are not intended for frequent use by pedestrians, but do accommodate occasional pedestrian traffic. Highway shoulders often have cross slopes which exceed 2%; consequently they are not considered or expected to fully meet ADA criteria.

C MINIMIZING CONFLICTS

The planning and design of new streets and highways shall include provisions that support pedestrian travel and minimize vehicle-pedestrian conflicts. These may include:

- Sidewalks and/or shared use paths parallel to the roadway
- Marked pedestrian crossings
- Raised median or refuge islands
- Pedestrian signal features such as pedestrian signal heads and detectors
- Transit stops and shelters

In some situations it may be possible to eliminate a vehicle-pedestrian conflict through close coordination with the planning of pedestrian facilities and activity outside of the highway right of way. Care should be exercised to ensure the elimination of a given conflict point does not transfer the problem to a different location. Any effort to minimize or eliminate conflict points must consider the mobility needs of the pedestrian. The desired travel path should not be severed and the number of required crossing points and/or walking distances should not be significantly increased. Some crossings should be redesigned rather than eliminated or relocated.

C.1 General Needs

Minimizing vehicle-pedestrian conflicts can be accomplished by providing adequate horizontal, physical, or vertical (primarily for crossings) separation between the roadway and the pedestrian facility.

C.2 Horizontal Separation

The development of independent systems for pedestrian and motor vehicular traffic is the preferred method for providing adequate horizontal separation.

C.2.a General Criteria

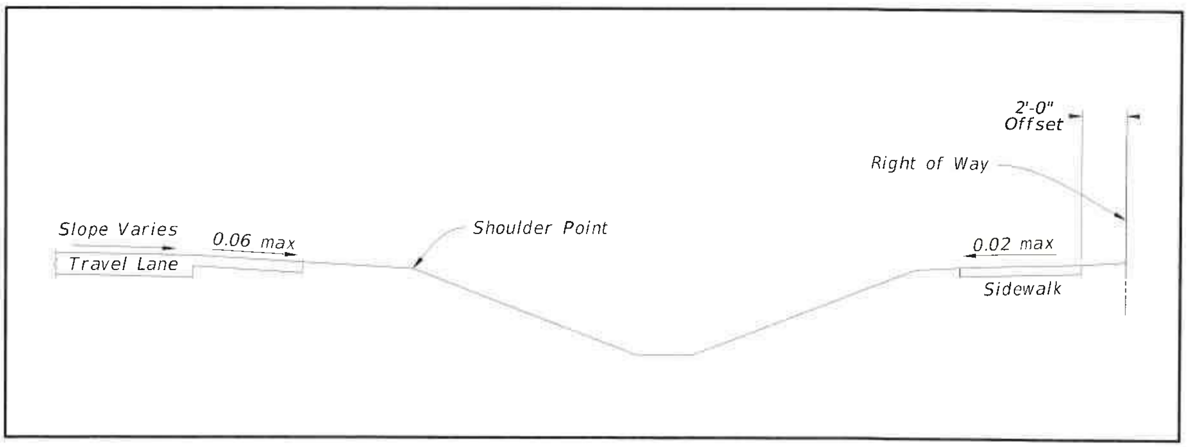
New sidewalks should be placed as far from the roadway as practical in the following sequence of desirability:

1. As near the right of way line as possible. (ideally, 3 feet of width should be provided behind the sidewalk for above ground utilities)
2. Outside of the clear zone.
3. Sufficiently off-set from the curb to allow for the placement of street trees, signs, utilities, parking meters, benches or other street furniture outside of the sidewalk in urban locations (e.g. town center, business or entertainment district).
4. Five feet from the shoulder point on flush shoulder roadways.
5. At the grass shoulder point of flush shoulder roadways.

Figure 8 – 1 Shoulder Point with Sidewalk provides an illustration of the location of the shoulder point.

On arterial or collector roadways, sidewalks shall not be constructed contiguous to the roadway pavement, unless a curb or other barrier is provided. Nearing intersections, the sidewalk should be transitioned as necessary to provide a more functional crossing location that also meets driver expectation. Further guidance on the placement of stop or yield lines and crosswalks is provided in the ***MUTCD, Part 3***.

Figure 8 – 1 Shoulder Point with Sidewalk



C.2.b Buffer Widths

Providing a buffer can improve pedestrian safety and enhance the overall walking experience. Buffer width is defined as the space between the sidewalk and the edge of traveled way. On-street parking or bike lanes can also act as an additional buffer. The planting strip or buffer strip should be 6 feet where practical to eliminate the need to narrow or reroute sidewalks around driveways. With this wider buffer strip, the sidewalk is placed far enough back so that the driveway slope does not have to encroach into the sidewalk.

C.3 Other Considerations

When designing urban highways, the following measures may be considered to help increase the safe and efficient operation of the highway for pedestrians:

- Use narrower lanes and introduce raised medians to provide pedestrian refuge areas
- Provide pedestrian signal features and detectors
- Prohibit right turn on red
- Control, reduce, or eliminate left and/or right turns
- Prohibit free flow right turn movements
- Reduce the number of lanes

D BARRIER SEPARATION

Barriers may be used to assist in the separation of motor vehicular and pedestrian traffic.

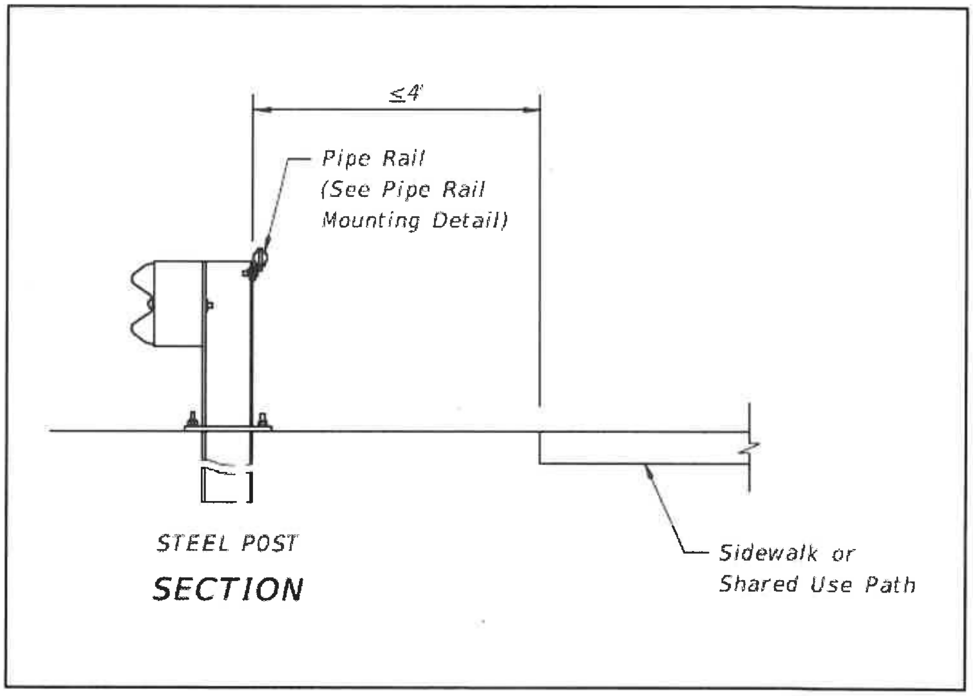
D.1 Longitudinal Barriers

Longitudinal barriers such as guardrails, rigid barriers, and bridge railings are designed primarily to redirect errant vehicles away from roadside hazards. These barriers can also be used to provide valuable protection of pedestrian facilities from out of control vehicles.

Where adequate horizontal separation is not feasible, or where there is a significant hazard from out of control vehicles, longitudinal barriers may be utilized. If electing to use barriers, special consideration should be made to ensure proper sight distance near driveways and intersections is maintained. See Chapter 4, Figure 4 – 8 Location of Guardrail for information on the correct placement of a sidewalk in conjunction with a guardrail.

When a sidewalk or shared use path is within 4 feet of the back of a guardrail with steel posts, a pipe rail should be installed on the back of the post. For a guardrail with timber posts, the bolt ends should be trimmed flush with the post or recessed. See Figure 8 – 2 Guardrail with Pipe Rail Detail 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 Department's ***Standard Plans, Index 536-001*** .

Figure 8 – 2 Guardrail with Pipe Rail Detail



D.2 Fencing, Pedestrian Channelization Devices or Landscaping

Fencing, pedestrian channelization devices or landscaping may be used to discourage pedestrian access to the roadway and aid in channeling pedestrian traffic to the proper crossing points. These should not be considered a substitute for longitudinal barriers, but may be used in conjunction with redirection devices.

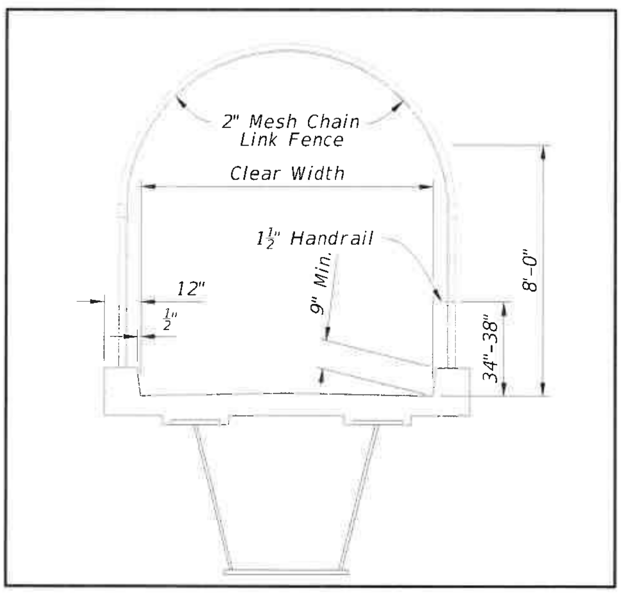
E GRADE SEPARATION

Grade separation may be selectively utilized to support the crossing of large pedestrian volumes across highways where the traffic volume on the roadway is at or near capacity or where speeds are high. Overpasses or underpasses may be justified at major pedestrian generators such as schools, shopping centers, sports and amusement facilities, transit centers, commercial buildings, parks and playgrounds, hospitals, and parking facilities.

The minimum clear width of any stand-alone pedestrian overpass or underpass on a pedestrian accessible route is 8 feet. However, if the contiguous sidewalk or path is greater than 8 feet wide, the clear width of the overpass or underpass should match that width. The minimum clear height of a pedestrian overpass or underpass is 8 feet. See Figure 8 – 3 Pedestrian Bridge Typical Section for an example of a pedestrian bridge typical section.

The ***FDOT Structures Manual - Volume 1 - Structures Design Guidelines (SDG), Section 10*** provide additional guidance on engineered steel and concrete pedestrian bridges.

Figure 8 – 3 Pedestrian Bridge Typical Section



Notes: 1. Pedestrian handrails may be required. See the ***2006 Americans with Disabilities Act Standards for Transportation Facilities***.

2. Other superstructure configurations may be used provided an 8 ft. minimum headroom is maintained.

E.1 Overpasses

Pedestrian overpasses are typically bridge structures over major roadways or railroads. Overpasses should provide elevator access if they are not designed to provide accessible ramps with compliant slopes, level landings, and handrails on both sides. Bridges over roadways should be covered or screened to reduce the likelihood of objects being dropped or thrown below. The area adjacent to overpasses may be fenced to prevent unsafe crossings and to channel pedestrians to the overpass structure.

E.2 Underpasses

Pedestrian underpasses or tunnels perform the same function as overpasses. Their use is convenient when the roadway is elevated above the surrounding terrain.

Underpasses should be adequately maintained to reduce potential problems in lighting, cleaning, policing, and flooding and to maximize safety. The area adjacent to underpasses may be fenced to prevent unsafe crossings and to channel pedestrians to the underpass structure.

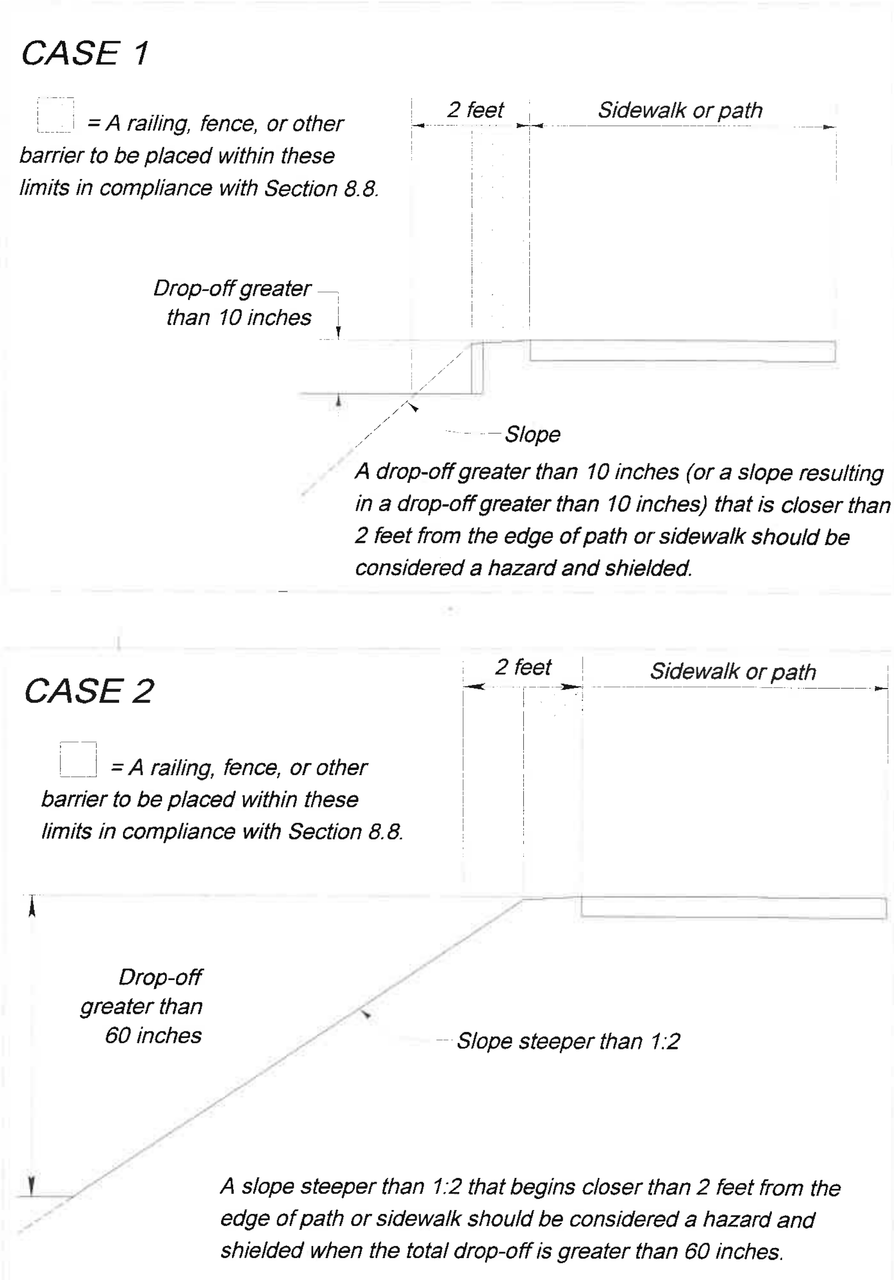
F DROP-OFF HAZARDS FOR PEDESTRIANS

Drop-off hazards are defined as steep or abrupt downward slopes that can be perilous to pedestrians and bicyclists. Consider shielding any drop-off determined to be a hazard. Care should be taken when using Pedestrian/Bicycle Railings or fencing near intersections or driveways as they could obstruct the driver's line of sight. To reduce the need for railings as a sidewalk or shared use path approaches an intersection, consider extending cross drains and side drains to minimize drop-offs.

There are two cases that require shielding as shown in Figure 8 – 4 Drop-Off Hazards for Pedestrians and Bicyclists. Depending on the depth of the drop-off and severity of the conditions below, shielding may be necessary for cases other than described above.

Railings or fences should be provided for vertical drop-off hazards or where shielding is required. The standard height for a pedestrian/bicycle railing is 42 inches. A 48 inch tall pedestrian/bicycle railing should be used when sidewalk grades are steeper than 5% and bicycle travel is expected. A standard railing is generally intended for urbanized areas, locations attaching to bridge rail or along concrete walkways. Fencing is generally intended for use in rural areas along paths and trails.

Figure 8 – 4 Drop-Off Hazards for Pedestrians and Bicyclists



G PEDESTRIAN CROSSINGS

The design of pedestrian crossings and parallel pathways within the right of way shall be considered an integral part of the overall design of a street or highway.

The development of protection at any remaining crossings or conflict points must be adequate to achieve a total pedestrian transportation mode that is reasonably safe.

G.1 Crosswalks

The design of pedestrian crosswalks should be based on the following requirements:

- Crosswalks should be placed at locations with sufficient sight distances
- At crossings, the roadway should be free from changes in alignment or cross section
- The entire length of crosswalk shall be visible to drivers at a sufficient distance to allow a stopping maneuver
- Stop bars or yield markings, in conjunction with the appropriate signing, shall be provided at all marked crosswalks
- Crosswalks shall be easily identified and clearly delineated, in accordance with the ***Manual on Uniform Traffic Control Devices (MUTCD) and Rule 14-15.010, F. A. C.***

G.1.a Marked Crosswalks

Marked crosswalks are one tool to allow pedestrians to cross the roadway safely. They are often used in combination with other treatments (signs, flashing beacons, curb extensions, pedestrian signals, raised median or refuge islands, and enhanced overhead lighting). Marked crosswalks serve two purposes: 1) to inform motorists of the location of a pedestrian crossing so that they have time to lawfully yield to or stop for a crossing pedestrian; and 2) to assure the pedestrian that a legal crosswalk exists at a particular location. See Figure 8 – 5 Pedestrian Median Refuge with Curb Extensions for an example of a pedestrian median refuge with a curb extension.

Figure 8 – 5 Pedestrian Median Refuge with Curb Extension

Urban Street Design Guide, National Association of City Transportation Officials (NACTO)

Marked crosswalks on an uncontrolled leg of an intersection or a mid-block location shall be supplemented with other treatments (such as signing, beacons, curb extensions, raised medians, raised traffic islands, or enhanced overhead lighting) when any of the following conditions exist:

1. Where posted speeds are greater than 40 mph.
2. On a roadway with 4 or more lanes without a raised median or raised traffic island that has an ADT of 12,000 or greater.
3. On a roadway with 4 or more lanes with a raised median or raised traffic island that has or is projected to have (within 5 years) an ADT of 15,000 or greater.

See ***Chapter 6 – Lighting*** for information on illuminating crosswalks and pedestrian facilities.

Additional guidance on marked crosswalks can be found in the ***AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities*** and ***FHWA's Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines*.**

Marked crosswalks can also be used to create midblock crossings.

G.1.b Midblock Crosswalks

Midblock crosswalks facilitate crossings to places that people want to go but that are not well served by the existing sidewalk or path network. These pedestrian crossings commonly occur at schools, parks, museums, waterfronts, and other destinations. Designers should study both existing and projected pedestrian volumes in assessing warrants for midblock crossings to account for latent demand.

Midblock crossings are located according to a number of factors including pedestrian volume, traffic volume, roadway width, traffic speed and type, desired paths for pedestrians, land use, and to accommodate transit connectivity. Midblock crossings should not be installed where sight distance or sight lines are limited for either the motorist or pedestrian.

Midblock crossings should be marked and signed in accordance with the ***MUTCD***. See Figure 8 – 6 Raised Midblock Crosswalks for an example of a midblock crosswalk.

Figure 8 – 6 Raised Midblock Crosswalk

Suwannee Street, Tallahassee, Florida

Crosswalks may be supplemented with Pedestrian Hybrid Beacons (PHB) or Rectangular Rapid Flashing Beacons (RRFBs). Illumination should be evaluated if night-time pedestrian activity is expected. See ***Chapter 6 – Lighting*** for further information.

A PHB is a special type of beacon used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk. ***Chapter 4F. Pedestrian Hybrid Beacons, MUTCD*** provides additional information regarding their installation. See Figure 8 – 7 Pedestrian Hybrid Beacon for an example of a pedestrian hybrid beacon.

Figure 8 – 7 Pedestrian Hybrid Beacon (PHB)

16th Street South, St. Petersburg, Florida

The RRFB uses rectangular-shaped high-intensity LED-based indications, flashes rapidly in a wig-wag "flickering" flash pattern, and is mounted immediately between the crossing sign and the sign's supplemental arrow plaque. Use of PHBs should be limited to locations with the most critical safety concerns, such as pedestrian and school crosswalks across uncontrolled approaches.

The use of RRFBs require interim approval from FHWA. The MUTCD provides further information on obtaining *interim approval* for the use of RRFBs. See Figure 8 – 8 Pedestrian Median Refuge with Rectangular Rapid Flashing Beacon for an example of a Rectangular Rapid Flashing Beacon (RRFB).

Figure 8 – 8 Pedestrian Median Refuge with Rectangular Rapid Flashing Beacons (RRFB)

4th Street North, St. Petersburg, Florida

G.2 Curb Ramps and Blended Transitions

A continuous accessible pedestrian route, including curb ramps and blended transitions is needed along pedestrian networks. Blended transitions are raised pedestrian street crossings, depressed corners or similar connections between pedestrian access routes at the level of the sidewalk or shared use path and level of the pedestrian street crossing that have a grade of 5% or less. Blended transitions can be used when geometrics and allocated space doesn't allow for separated curb ramps.

Include sidewalk curb ramps at the following locations:

- At curbed returns for intersections and turnouts. Include a landing at the top of each ramp.
- On curbed roadways between intersections where a crosswalk has been established, such as midblock crossings and side streets.

Relocate or adjust pull boxes, manholes and other types of existing surface features to meet the ADA requirements for nonslip top surfaces, ¼ inch height protrusion, and slopes flush with the surrounding surface.

Curb ramps should be in line with the crossing. At intersections where more than one road is crossed, provide curb ramps at both ends of each crossing. Crossings are required to meet the same grade and cross slope requirements as sidewalks. Where criteria for maximum cross slope of the crossing cannot be met, provide the minimum attainable cross slope. When following the profile grade of the roadway, curb ramp slopes should not exceed 15 feet in length.

Provide transition slopes (flared sides) where a pedestrian circulation path crosses the curb ramp. The maximum slope of transition slopes is 1:10, measured parallel with and adjacent to the curb line.

When altering an existing pedestrian facility and conditions preclude the accommodation of a curb ramp slope of 1:12, provide a slope from 1:12 to 1:10 with a maximum rise of 6 inches.

Further information on curb ramps, landings and blended transitions is provided in the Department's ***Standard Plans, Index 522-002***

G.3 Detectable Warnings

Install detectable warnings to cover the full width of the walking surface and 2 feet in length. They are required on sidewalks and shared use paths at the following locations:

- Curb ramps and blended transitions at street crossings
- Cut-through pedestrian refuge islands or medians six feet wide or greater
- Pedestrian at-grade rail crossings

- Commercial driveways with a stop sign, yield sign or traffic signal
- Boarding and alighting areas adjacent to the roadway at bus stops where there is an at-grade connection to the roadway
- Edges of rail boarding platforms not protected by screens or guards

Detectable warnings are not required where sidewalk intersects urban flared turnouts or sidewalks that run continuously through driveways. Do not place detectable warnings on transition slopes or over grade breaks.

The detectable warning systems on the Department's ***Approved Product List (APL)*** are designed to work with concrete surfaces. In areas where the pedestrian facility has an asphalt surface, such as a shared use path, specify an appropriate detectable warning system. In these cases, consider including a short section of concrete that will accommodate any system.

Further information on detectable warnings are provided in the Department's ***Standard Plans, Index 522-002***.

G.4 Controls

Signs, signals, and markings should be utilized to provide the necessary information and direction for pedestrians. All directions and regulations should be clear, consistent and logical, and should, at a minimum, conform to the requirements given in the ***MUTCD***. The use of accessible pedestrian signals that include audible and/or vibro-tactile, and visual signals should be considered for pedestrian traffic control and regulation.

G.5 Sight Distance

The general requirements for sight distances for the driver are given in ***Chapter 3 - Geometric Design***.

Stopping sight distances greater than the minimum should be provided at all pedestrian crossings. These sight distances should include a clear view of the pedestrian approach pathway. Where parallel pedestrian pathways are within the roadside recovery area, or where casual pedestrian crossings are likely, the normal required stopping sight distance should also include a clear view of the entire roadside recovery area.

Sight distances shall be based upon a driver's eye and object height as discussed in ***Chapter 3 – Geometric Design***. Due to the small size of some pedestrians (particularly children), they are generally easy to confuse with other background objects.

Parking shall be prohibited where it would interfere with the required sight distance. Particular care should be exercised to ensure ample mutual sight distances are provided at all intersections and driveways.

G.6 Rail Crossings

Roadways, sidewalks and shared use paths at grade may cross light rail, street car rail, passenger rail, and freight railroads. Special design considerations are needed for these pedestrian intersections so that pedestrians are warned of the crossing and potential presence of a train. In addition, these crossings have specific accessibility requirements relating to surface continuity which must be met. See ***Chapter 7 – Rail-Highway Crossings*** for further information. The ***Federal Railroad Administration*** may impose additional requirements for the design and construction of rail crossings.

H LIGHTING

Lighting of the roadway itself is not only important for the safety of vehicular traffic, but also valuable for the protection of pedestrians. Vehicle headlamps often do not provide sufficient lighting to achieve the required stopping sight distance. Since this requirement is of vital importance at any potential pedestrian crossing point, lighting of the crossing should be considered. Lighting a street or highway is also valuable in improving the pedestrian's view of oncoming vehicles. At intersections or other locations with vehicle turning maneuvers, vehicle headlights may not be readily visible to the pedestrian.

Lighting shall be provided in pedestrian underpasses and should be considered on pedestrian overpasses. All pedestrian lighting shall be vandal resistant. The installation of daytime lighting is warranted when underpass user visibility requirements are not met with sunlight. Pedestrian underpass and overpass lighting should conform to the general lighting requirements given in the American Association of State Highway and Transportation Officials (AASHTO) Roadway Lighting Design Guide.

The general requirements for lighting on streets and highways are given in ***Chapter 6 – Lighting***. Pathways adjacent to a street or highway should not be illuminated to a level more than twice that of the roadway itself.

In general, lighting should be considered as warranted when it is necessary, at night, to provide the mutual sight distance capabilities described in the preceding ***Chapter 3 – Geometric Design***. Locations with significant night time pedestrian traffic that should be considered for lighting of the roadway and adjacent pedestrian facilities include the following:

- Any street or highway that meets the warranting criteria given in ***Chapter 6 – Lighting***
- Streets and highways with speed limits in excess of 40 mph that do not have adequate pedestrian conflict elimination
- Sections of highway with minimal separation of parallel pedestrian pathways
- Intersections, access and decision points, and areas adjacent to changes in alignment or cross sections
- Areas adjacent to pedestrian generators
- Transit stops and other mass transit transfer locations
- Parking facilities

- Entertainment districts, sports/recreation complexes, schools, and other activity centers generating night travel
- Pedestrian crossings
- Any location where improvement of night time sight distance will reduce the hazard of vehicle-pedestrian conflicts

See ***Chapter 6 – Lighting*** for further information on lighting of pedestrian facilities and shared use paths.

I REFERENCES FOR INFORMATIONAL PURPOSES

- Florida Department of Transportation Transit Facility Design
  http://www.dot.state.fl.us/transit/Pages/NewTransitFacilitiesDesign.shtm
- USDOT/FHWA ADA Standards for Accessible Design (ADAAG)
  http://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/ada-standards
- 2006 Americans with Disabilities Act Standards for Transportation Facilities
  https://www.access-board.gov/guidelines-and-standards/transportation/facilities/ada-standards-for-transportation-facilities
- 2012 Florida Accessibility Code for Building Construction
  https://www.flrules.org/gateway/ruleno.asp?id=61G20-4.002
- AASHTO – Guide for the Planning, Design, and Operation of Pedestrian Facilities
  https://bookstore.transportation.org/
- AASHTO – Roadway Lighting Design Guide
  https://bookstore.transportation.org/
- NACTO Urban Streets Design Guide
  http://nacto.org/usdg
- Designing Walkable Urban Thoroughfares (CNU and ITE)
  http://www.cnu.org/streets
- Project Management Handbook (CSS)
  http://www.dot.state.fl.us/projectmanagementoffice/Publications/default.shtm
- FHWA Policy Memo for Flexibility in Pedestrian and Bicycle Facility Design
  http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/design_flexibility.cfm
- AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, 6h Edition, (2012) with 2013 Interim Revisions
  https://bookstore.transportation.org/Home.aspx
- Federal Railroad Administration General Manual - Policies, Procedures, and General Technical Bulletins (July 2014)
  http://www.fra.dot.gov/Elib/Details/L16208

CHAPTER 9

BICYCLE FACILITIES

TABLES

FIGURES

CHAPTER 9

BICYCLE FACILITIES

A INTRODUCTION

Bicycle facilities should be given full consideration in the planning and development of transportation facilities, including the incorporation of such facilities into state, regional, and local transportation plans and programs under the assumption that transportation facilities will be used by cyclists. Bicycle facilities should be established in conjunction with the construction, reconstruction, or other change of any transportation facility and special emphasis should be given to projects in or within 1 mile of an urban area. The provision for bicycle facilities is also desirable for resurfacing, restoration & rehabilitation (RRR) projects.

Bicycle and pedestrian facilities are not required to be established:

1. Where their establishment would be contrary to public safety;
2. When the cost would be excessively disproportionate to the need or probable use; or
3. Where other available means or factors indicate an absence of need.

Appropriately designed and located bicycle facilities play an important role in supporting bicycle travel. Bicyclists should be considered in all phases of transportation planning, design, construction and maintenance activities. Particular emphasis should be given to new construction, reconstruction, intersection improvement, and transit projects. Bicycle facilities can include bicycle lanes, paved shoulders, wide curb lanes, shared lanes, shared use paths, and bicycle parking facilities.

In addition to the design criteria provided in this chapter, the ***2006 Americans with Disabilities Act Standards for Transportation Facilities*** as required by ***49 C.F.R 37.41*** or ***37.43*** and the ***2017 Florida Accessibility Code for Building Construction*** as required by ***61G20-4.002*** impose additional requirements for the design and construction of facilities such as shared use paths and structures that include provisions for pedestrians.

B ON-STREET FACILITIES

Provisions for bicycle traffic should be incorporated in the original roadway design. All roadways, except where bicycle use is prohibited by law, should be designed, constructed and maintained under the assumption they will be used by bicyclists. Roadway conditions should be favorable for bicycling, with smooth pavement and limited changes in elevation along edge lines. Drainage inlets and utility covers that cannot be moved out of the travel way should be designed flush with grade, well seated, and make use of bicycle-compatible grates and covers.

Railroad grade crossings on a diagonal can cause steering difficulties for bicyclists. Crossings for bicycle facilities should be perpendicular to the rail. This can be accomplished with a widened shoulder or bicycle lane, or separate path. Consideration should be given to improving the smoothness of the crossing and reducing the width and depth of the flangeway opening. Flangeway fillers can be used on heavy rail lines to minimize the size of the opening adjacent to the rail.

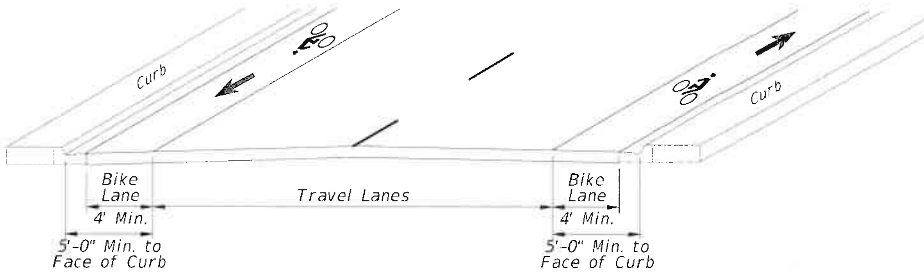
Bicycle lanes, paved shoulders, wide curb lanes, or shared lanes should be included to the fullest extent feasible. The appropriate selection of a bicycle facility depends on many factors, including motor vehicle and bicycle traffic characteristics, adjacent land use and expected growth patterns. All new or reconstructed arterial and collector roadways, in and within one mile of an urban area, should include bicycle lanes.

Rumble strips used in a traffic lane to alert operators to conditions ahead (e.g. stop signs, traffic signals or curves) should provide clear space (free of rumble strips) for bicyclists. This clear space may be a paved shoulder or if no paved shoulder is present, a minimum of 1.5 feet of clear space at the outermost portion of the lane.

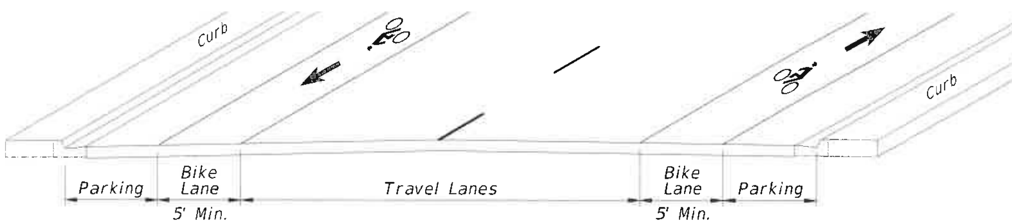
B.1 Bicycle Lanes

Bicycle lanes delineate available roadway space for preferential use by bicyclists; providing more predictable movements by motorists and bicyclists. Bicycle lanes also help increase the total capacity of highways carrying mixed bicycle and motor vehicle traffic. Bicycle lanes shall have a minimum functional width of 4 feet. At least 1 foot additional width is needed when the bicycle lane is adjacent to a curb or other barrier, on-street parking is present, there is substantial truck traffic (>10%), or posted speeds exceed 50 mph. Minimum bicycle lane widths are illustrated in Figure 9 – 1 Minimum Widths for Bicycle Lanes. The 4-foot bicycle lane shown in the flush shoulder typical section assumes the grass portion of the shoulder provides emergency maneuvering room.

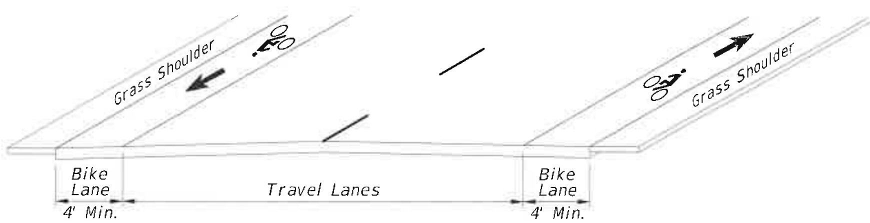
Figure 9 – 1 Minimum Widths for Bicycle Lanes



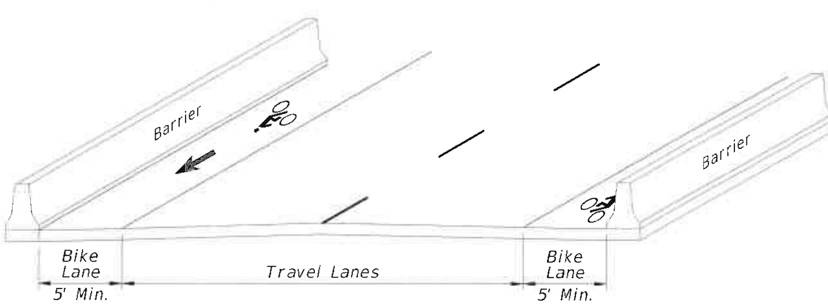
a) Curbed Street Without Parking



b) Curbed Street With Parking



c) Roadway Without Curb and Gutter



d) Roadway With Flush Shoulder and Barrier

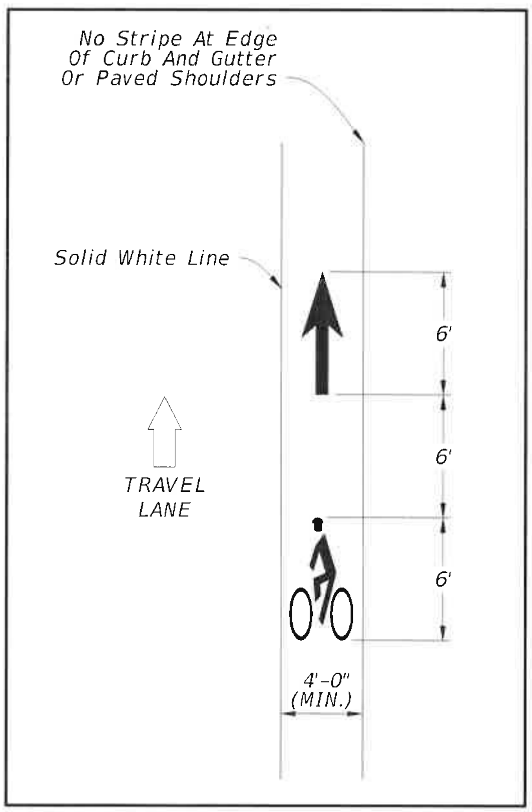
Bicycle lanes are one-way facilities and carry bicycle traffic in the same direction as the adjacent motor vehicle traffic. A bicycle lane should be delineated from the travel lanes with a solid white line and be marked with the bicycle symbol and arrow as shown in Figure 9 – 2 Detail of Bicycle Lane Markings. The dimensions for each pavement marking is 72" long, separated by 72".

The recommended placement of bicycle lane markings is:

a) At the beginning of a bicycle lane, on the far side of major intersections, and prior to and within the bicycle lane between a through lane and turn lane.

b) Along the roadway as needed to provide a maximum spacing of 1,320 for posted speeds less than or equal to 45 mph, 2,640 feet for a posted speed of 50 mph or greater.

Figure 9 – 2 Detail of Bicycle Lane Markings



If used, bike lane signs and plaques should be placed in advance of the upstream end of the bicycle lane, at the downstream end of the bicycle lane, and at periodic intervals based upon prevailing speed of bicycle and other traffic, block length, and distances from adjacent intersections, and other considerations. They should only be used in conjunction with marked bicycle lanes. Bike lane signs are not required.

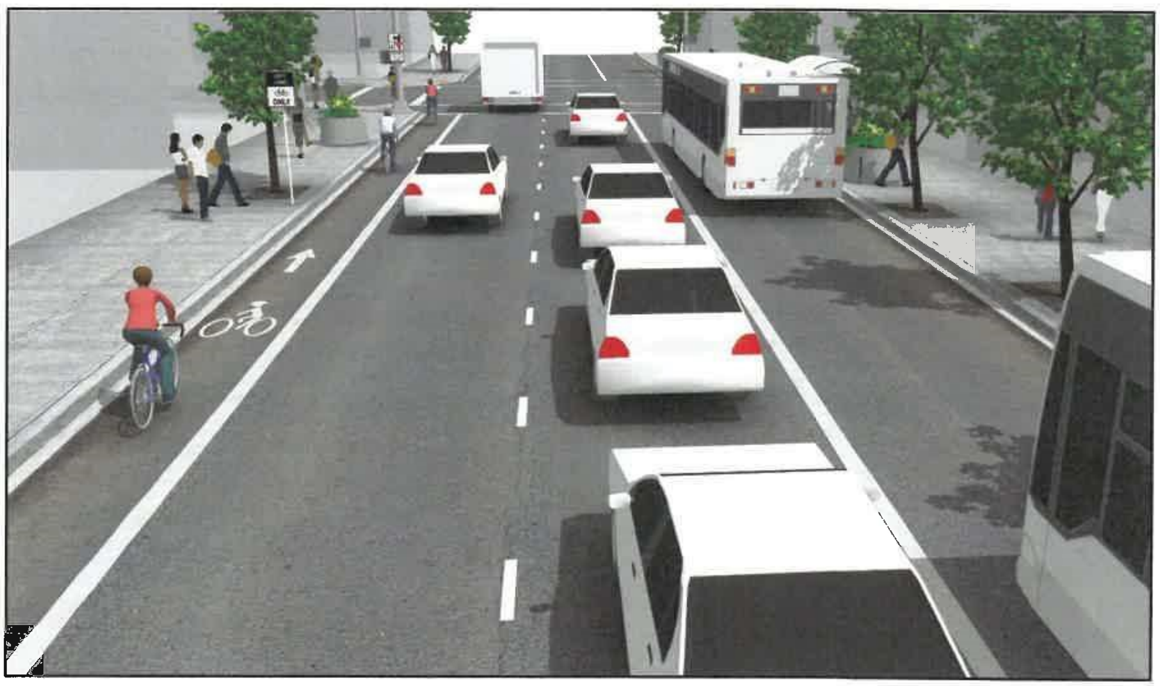
Figure 9 – 3 Bicycle Lanes

NACTO Urban Bikeway Design Guide, National Association of City Transportation Officials

A through bicycle lane shall not be positioned to the right of a right turn only lane or to the left of a left turn only lane. For new construction, reconstruction, and traffic operations projects, where bicycle lanes are provided between the through lane and right turn lane, bus bay or parking lane they shall be a minimum of 5 feet wide. For bicycle lanes adjacent to parking lanes, if the parking volume is substantial or the turnover is high a width of 6-7 feet is desirable to avoid opening vehicle doors.

On one-way streets, bicycle lanes should generally be placed on the right side of the street. A bicycle lane on the left side of the street can be considered when a bicycle lane on the left will substantially decrease the number of conflicts, such as those caused by frequent bus traffic, heavy right turning movements, high-turnover parking lanes, or if there are a significant number of left turning bicyclists. See Figure 9 – 4 Left Side Bicycle Lanes for an illustration.

Figure 9 – 4 Left Side Bicycle Lanes



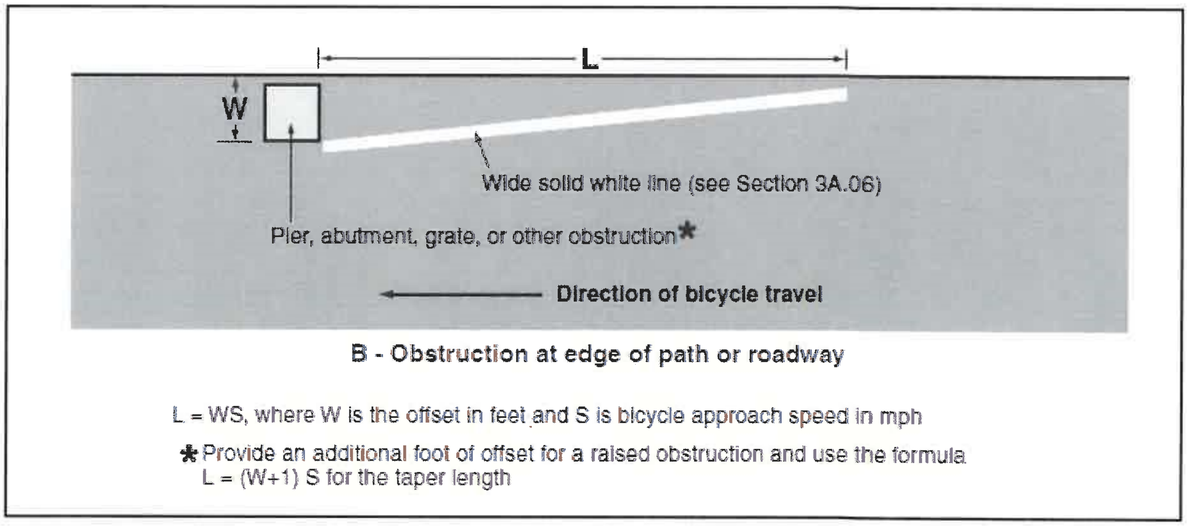
NACTO Urban Bikeway Design Guide, National Association of City Transportation Officials

Bicycle lanes shall not be provided on the circular roadway of a roundabout, and shall be transitioned prior to the roundabout in accordance with the MUTCD.

Existing drainage inlets, grates and utility covers shall be evaluated as to whether they present an obstruction to bicyclists, and should be relocated out of the cyclist's path of travel. Drainage inlets, grates and utility covers to remain should be adjusted to be flush with the adjacent pavement surface, utilize a grate recommended for bicycle travel, and may be marked as an obstruction.

Advance warning of an inlet or other obstruction may be provided as shown in the *MUTCD, Part 9*. Additional information on appropriate drainage inlets in or near pedestrian and bicycle facilities can be found in the Department's *Drainage Manual, Section 3.7.4 Inlet Placement, January 2018 Edition.*

Figure 9 – 5 Example of Obstruction Pavement Markings



Traffic signals should be responsive to bicyclists. Regular maintenance of bicycle lanes should be a priority, since bicyclists are unable to use a lane with potholes, debris or broken glass.

In conjunction with resurfacing projects, the roadway width shall be redistributed when practical to provide for bicycle facilities. The types of bicycle facilities considered for implementation include buffered bicycle lanes, bicycle lanes, wide outside lanes, and shared lanes. Lane widths on urban multilane roadways and two-lane curb and gutter roadways may be reduced as shown in Table 9 – 1 Lane Widths to provide for bicycle facilities.

Table 9 – 1 Lane Widths
Urban Multilane or Two-Lane with Curb and Gutter

Design Year AADT	Design Speed (mph)	Minimum Thru Lane (ft.)	Minimum Turn Lane (ft.)	Minimum Parking Lane (ft.)
ALL	ALL	10 [1]	9 [2]	7 [3]

1. 11 ft. where either of the following conditions exist:
   a) Trucks are >10% of Design Year Traffic.
   b) Design Speed is 40 mph or greater.
2. 10 ft. for 2 Way Left Turn Lanes.
3. A minimum width of 7 ft. measured from face of curb may be left in place. Otherwise provide 8 ft. minimum, measured from face of curb.

Various configurations of bicycle lanes on curb and gutter and flush shoulder typical sections are illustrated in Figures 9 – 6 to 9 – 23.

Figure 9 – 6 Bicycle Lane Markings

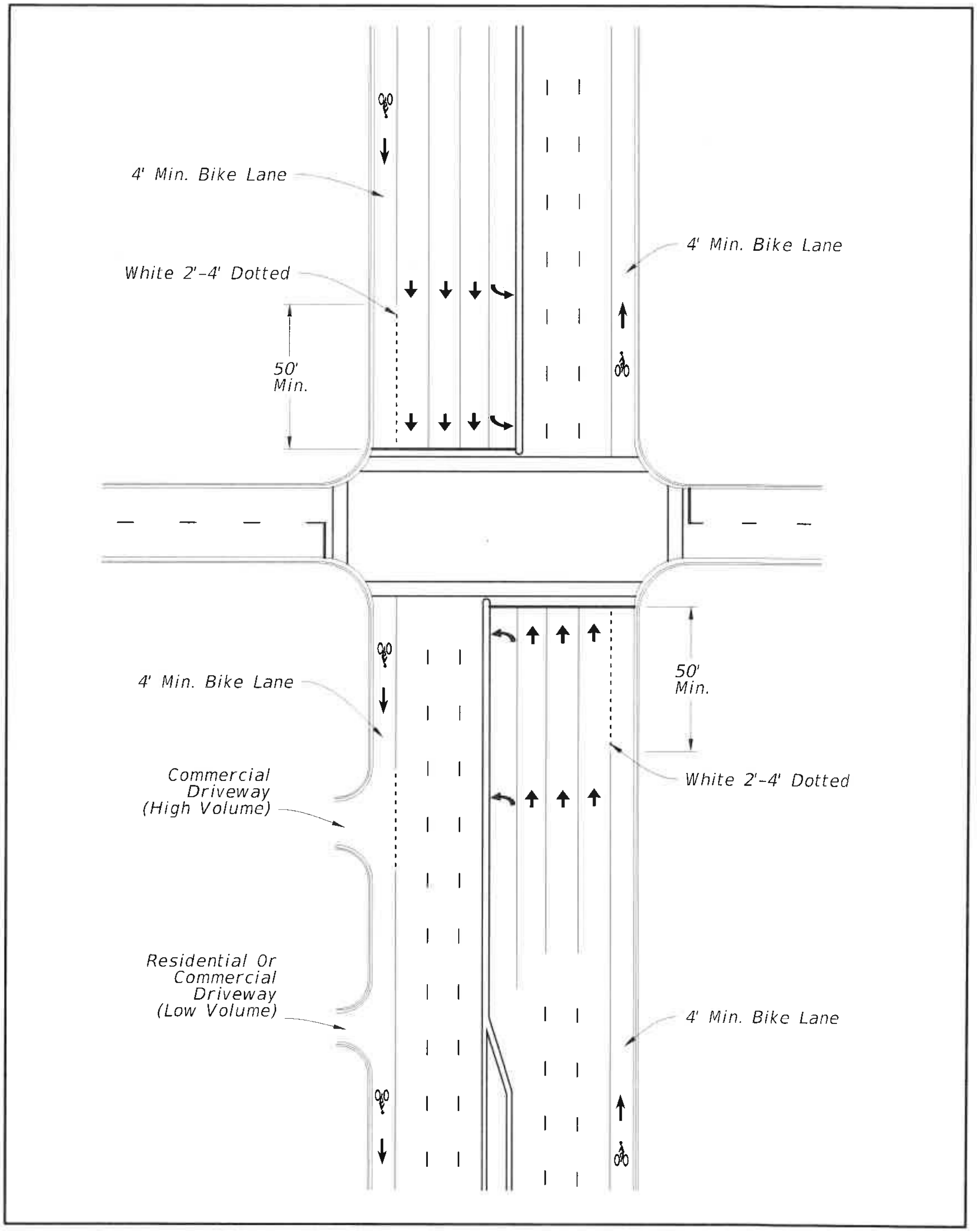


Figure 9 – 7 Bicycle Lanes with Separate Right Turn Lane (Curb and Gutter)

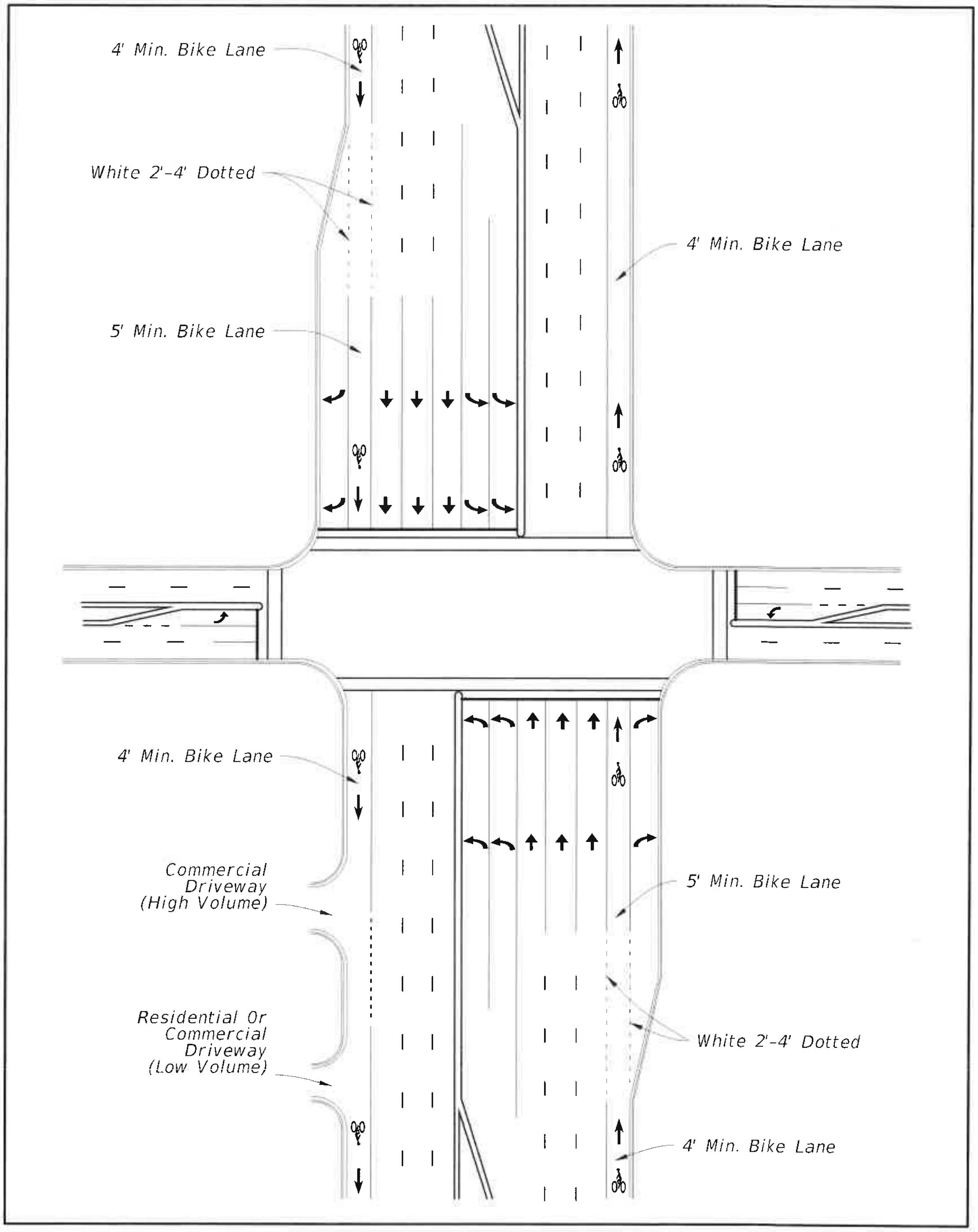


Figure 9 – 8 Bicycle Lanes with On Street Parking, No Right Turn Lane (Curb and Gutter)

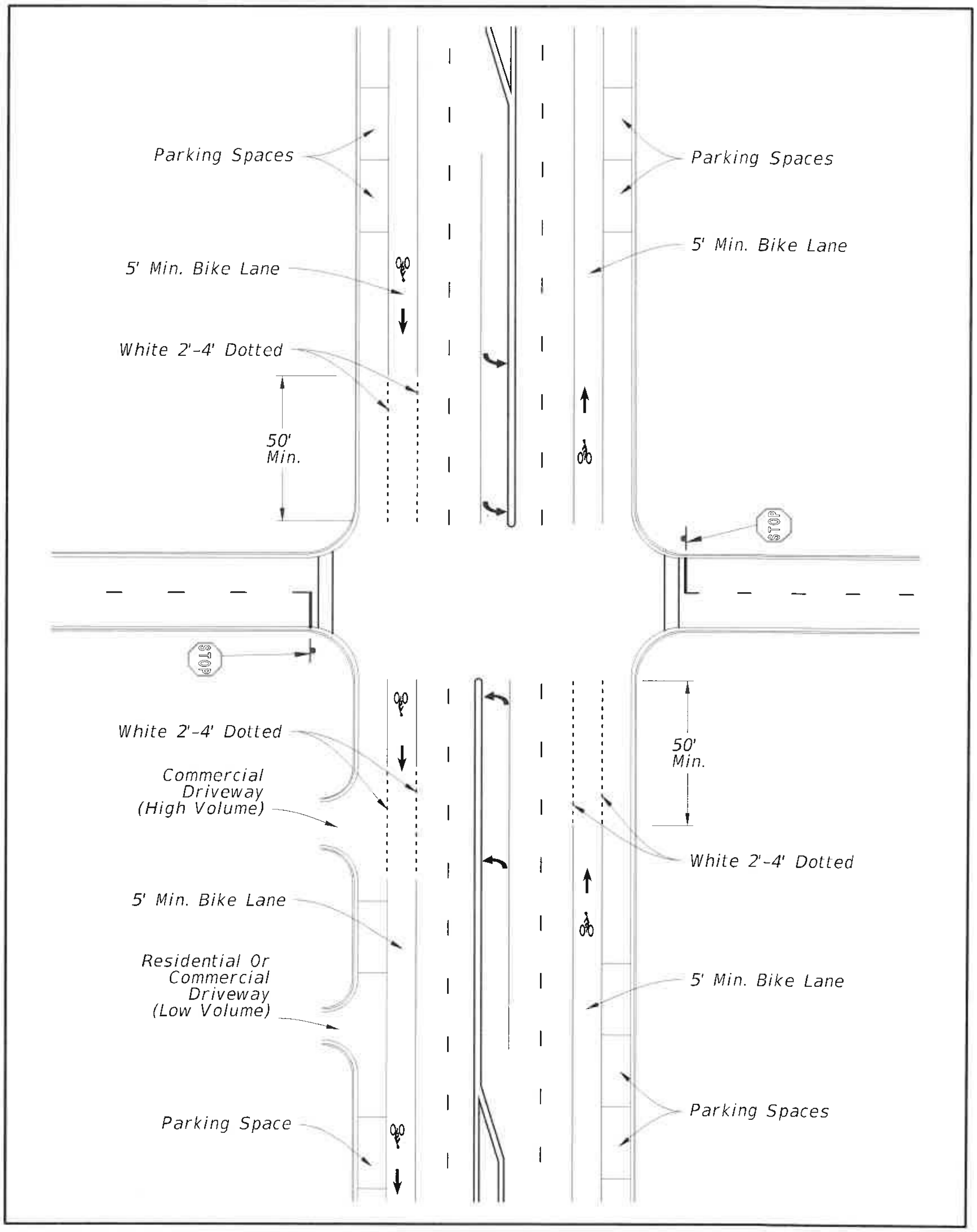


Figure 9 – 9 Bicycle Lane with Right Turn Drop Lane (Curb and Gutter)

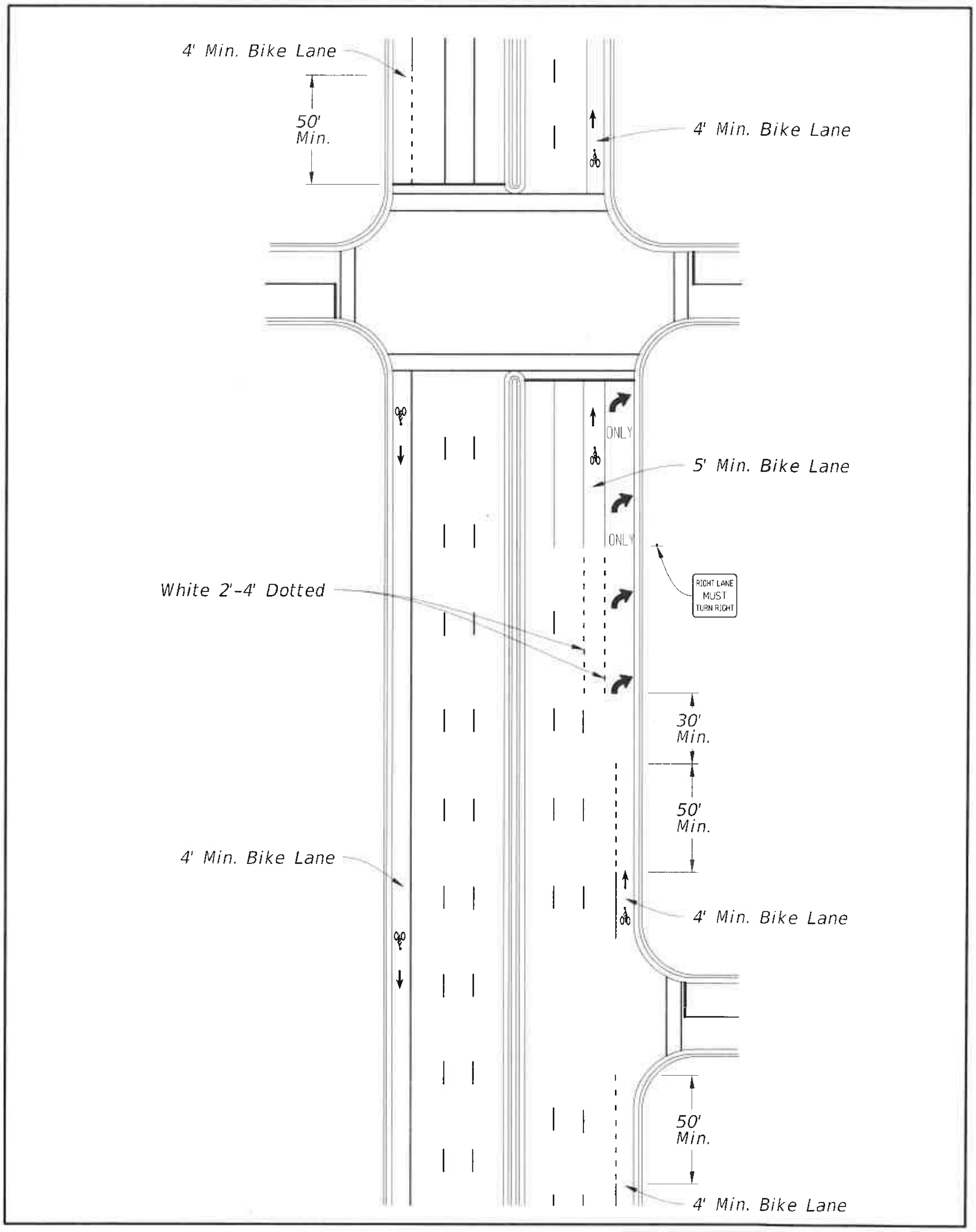


Figure 9 – 10 "Tee" Intersection with Bicycle Lane, Separate Right and Left Turn Lanes (Curb and Gutter)

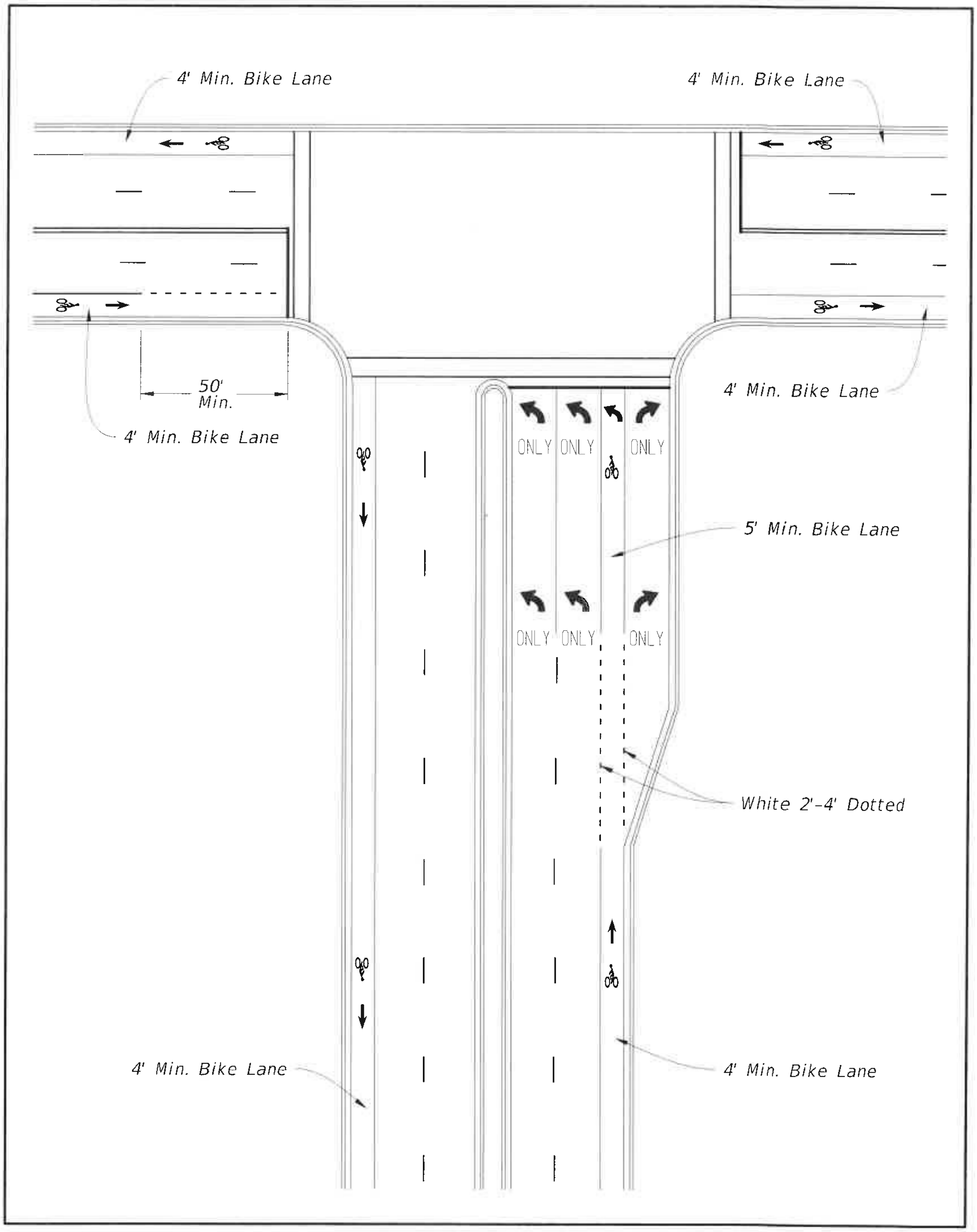


Figure 9 – 11 "Tee" Intersection with Bicycle Lanes, Left Turn Lane and Right Turn Drop Lane (Curb and Gutter)

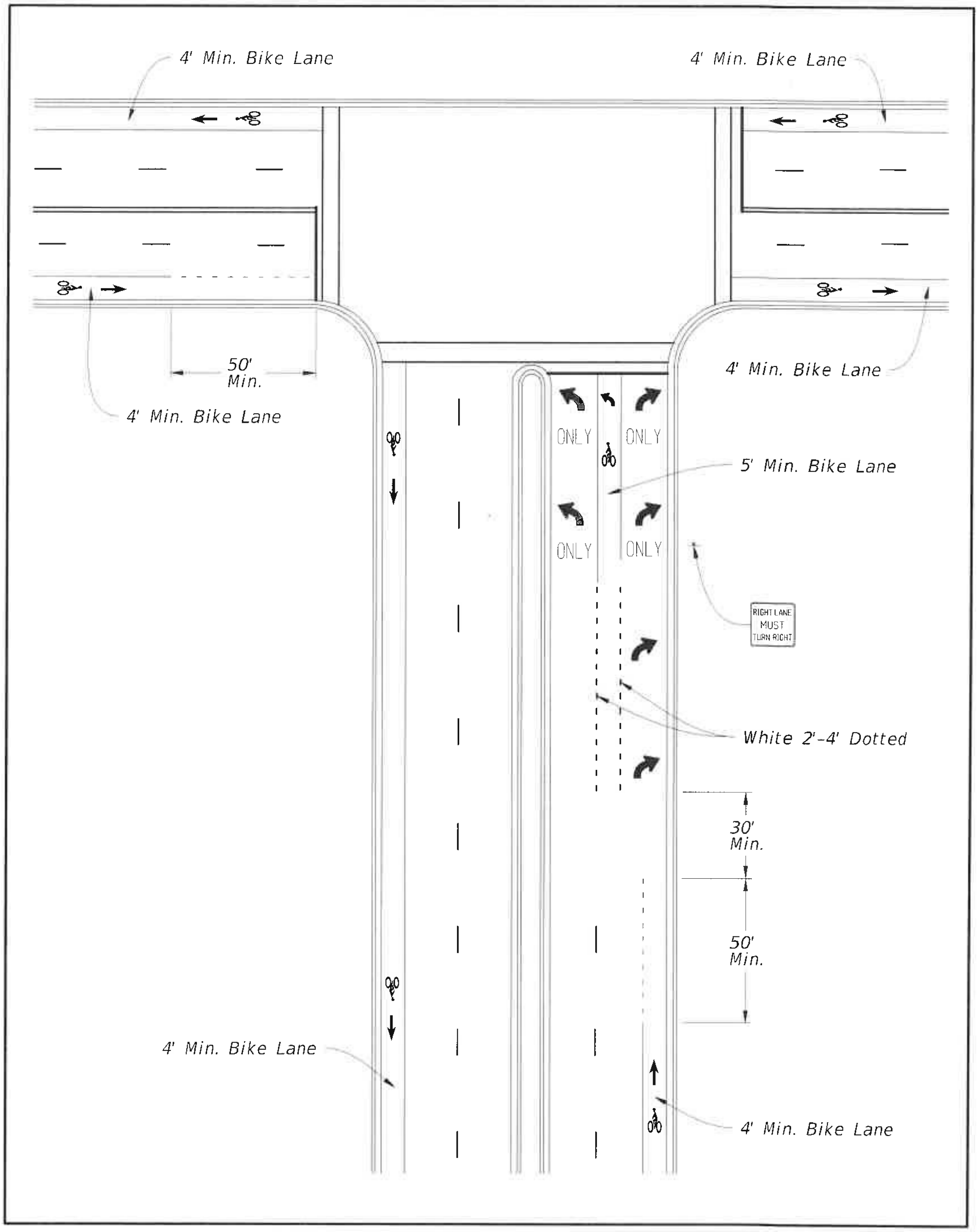


Figure 9 – 12 Bicycle Lanes with No Right Turn Lane (Flush Shoulder)

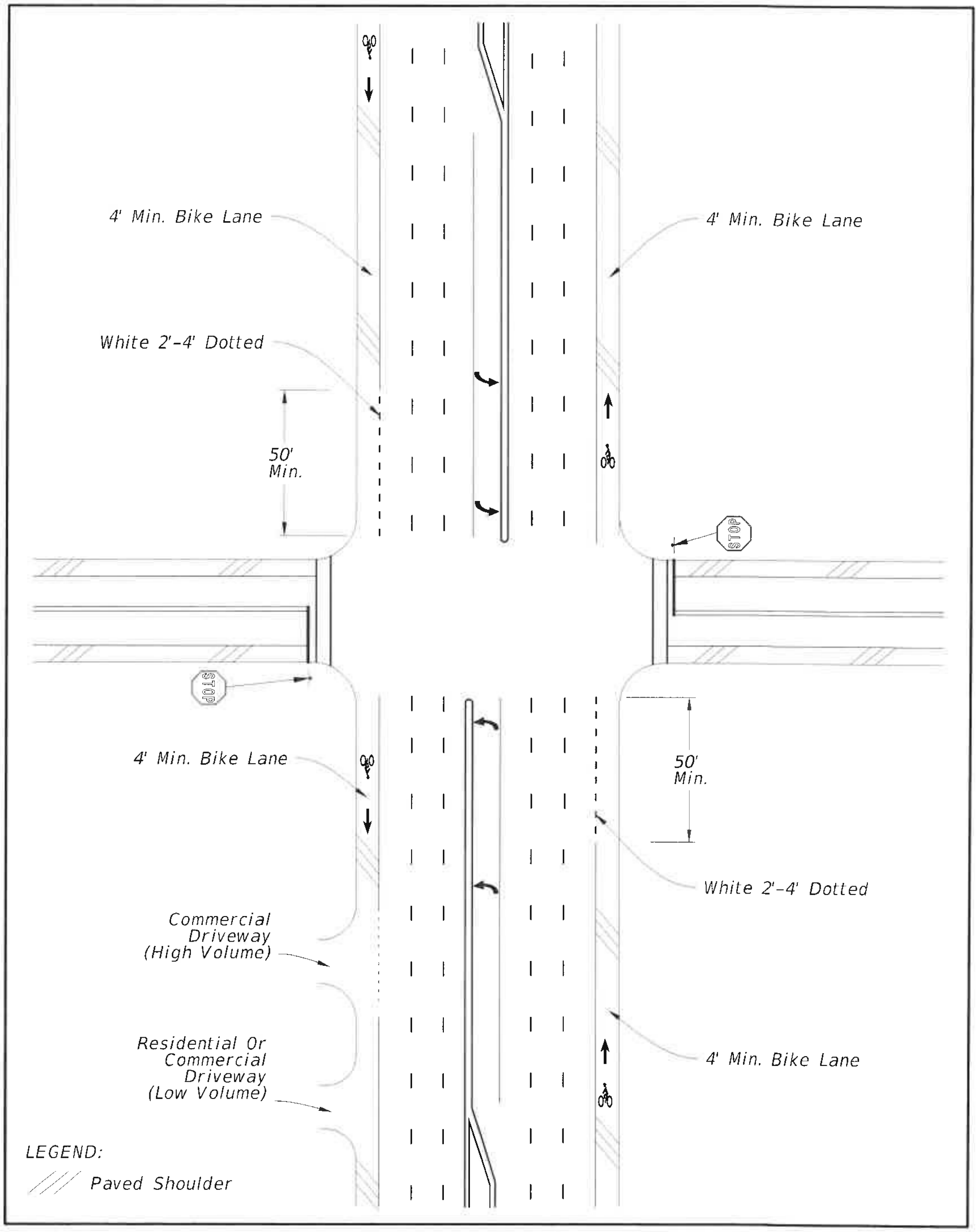


Figure 9 – 13 Bicycle Lane with Separate Right Turn Lane (Flush Shoulder)

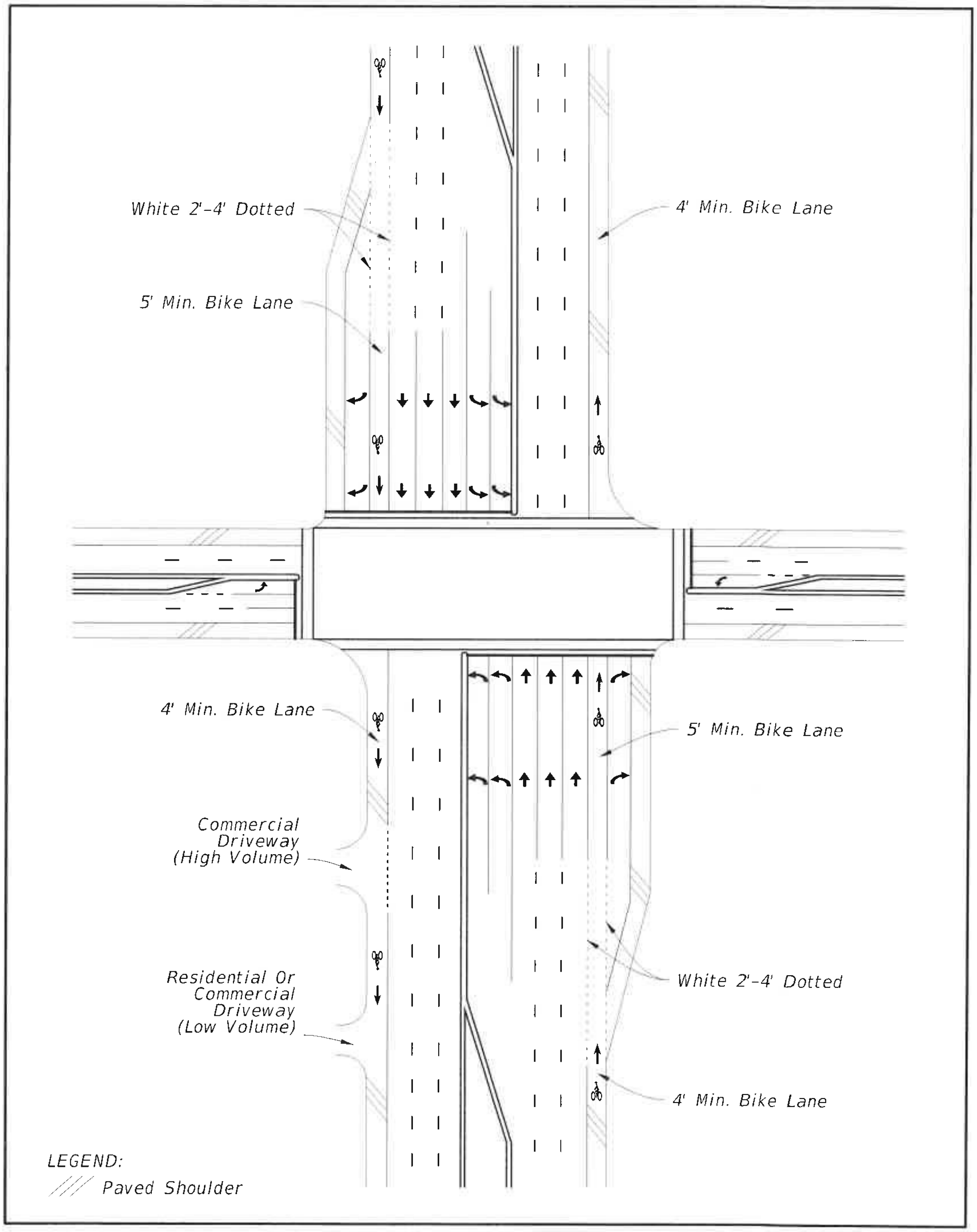


Figure 9 – 14 Bicycle Lanes with Bus Bay, No Right Turn Lane (Curb and Gutter)

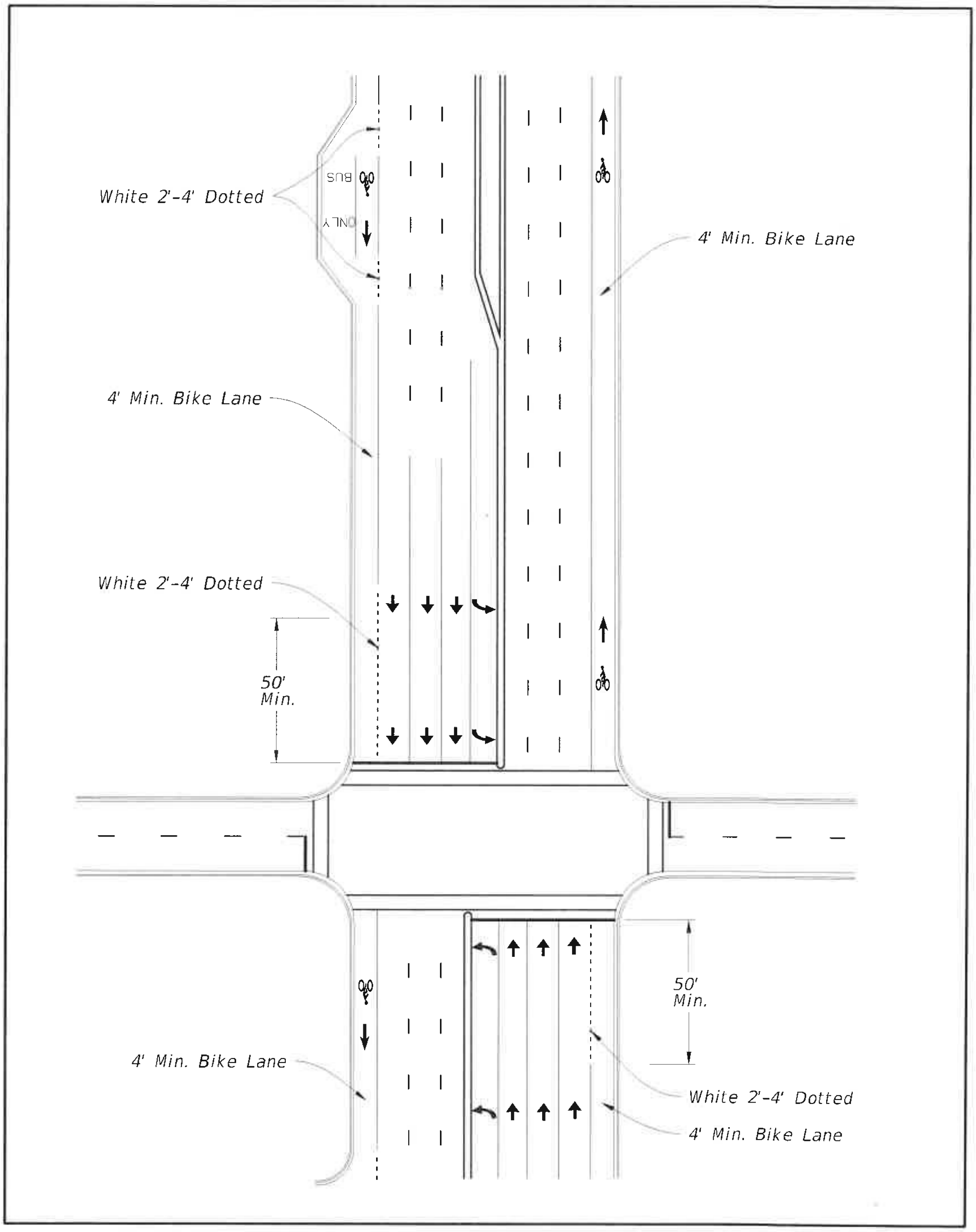
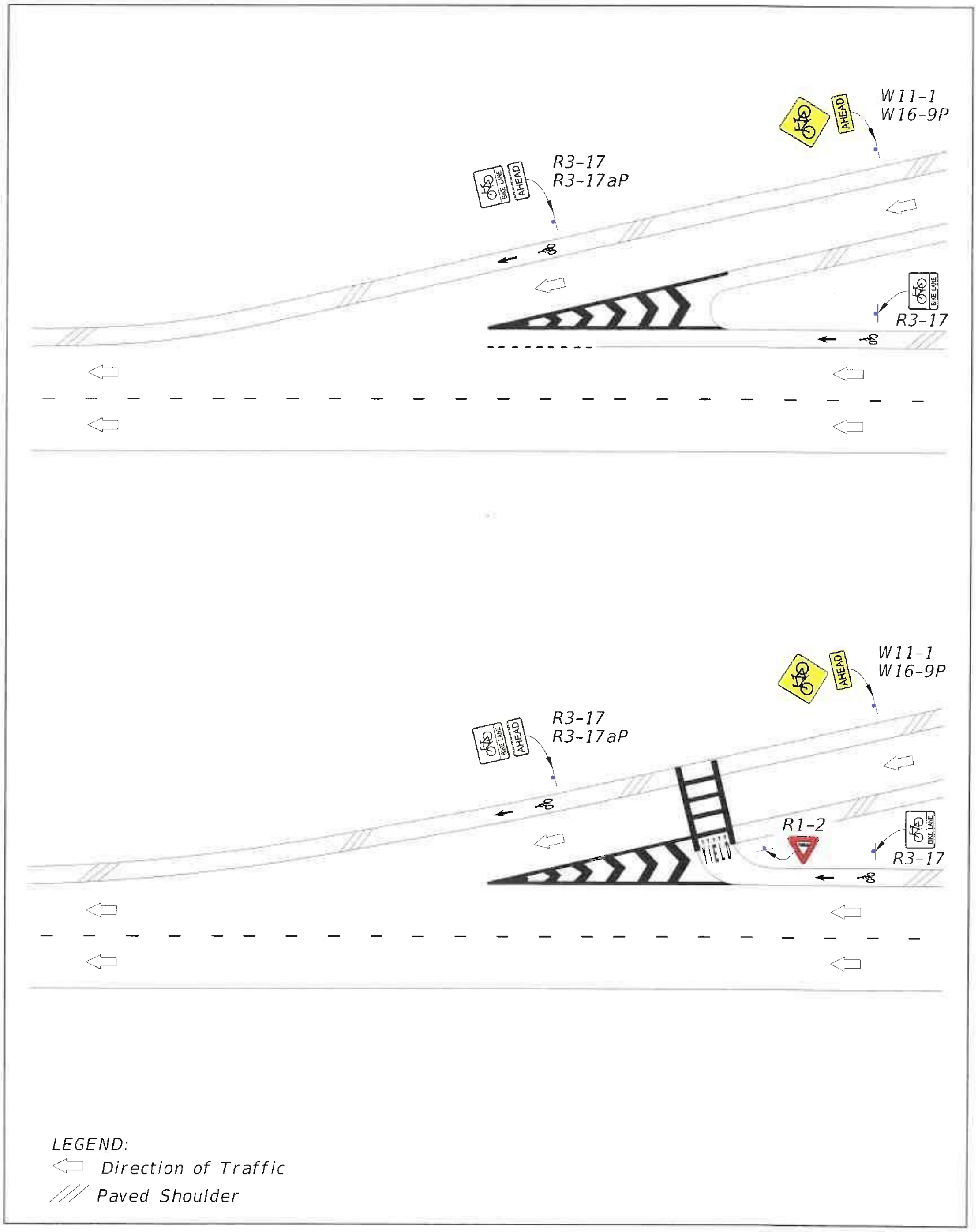


Figure 9 – 15 Bicycle Lanes on Interchange Ramps (Flush Shoulder)



B.2 Buffered Bicycle Lanes

Buffered bicycle lanes are bicycle lanes separated from either the adjacent travel lane or parking lane with a marked buffer area. They provide greater shy distance between motor vehicles and bicyclists and encourage bicyclists to ride outside of the "door zone" of parked cars. Typical applications include streets with high travel speeds, high traffic volumes, high amounts of truck or transit traffic, or where there are underutilized travel lanes or extra pavement width.

The bicycle lane symbol and arrow markings shall be used, along with longitudinal lines to create the buffer. There are several options for marking the buffer area, including a wide solid double line (crossing prohibited), wide solid single line (crossing discouraged) or wide dotted single line (crossing permitted to make right hand turn). Where the buffer space is wider than 4 feet and crossing the buffer is prohibited, chevron markings should be placed in the buffer area.

At an intersection approach, the buffer striping should transition to a wide dotted stripe using a 2/4 skip pattern. The transition should begin 150 feet in advance of an intersection to provide sufficient distance for an automobile or truck to merge into the bicycle lane before turning right. Figures 9 – 16, 17 and 18 provide examples of buffered bicycle lanes. ***Chapter 3D. Markings for Preferential Lanes*** of the ***MUTCD*** provides additional information on the striping of buffered bicycle lanes.

Figure 9 – 16 Buffered Bicycle Lane Adjacent to On-Street Parking

NACTO Urban Bikeway Design Guide, National Association of City Transportation Officials

Figure 9 – 17 Buffered Bicycle Lane Markings

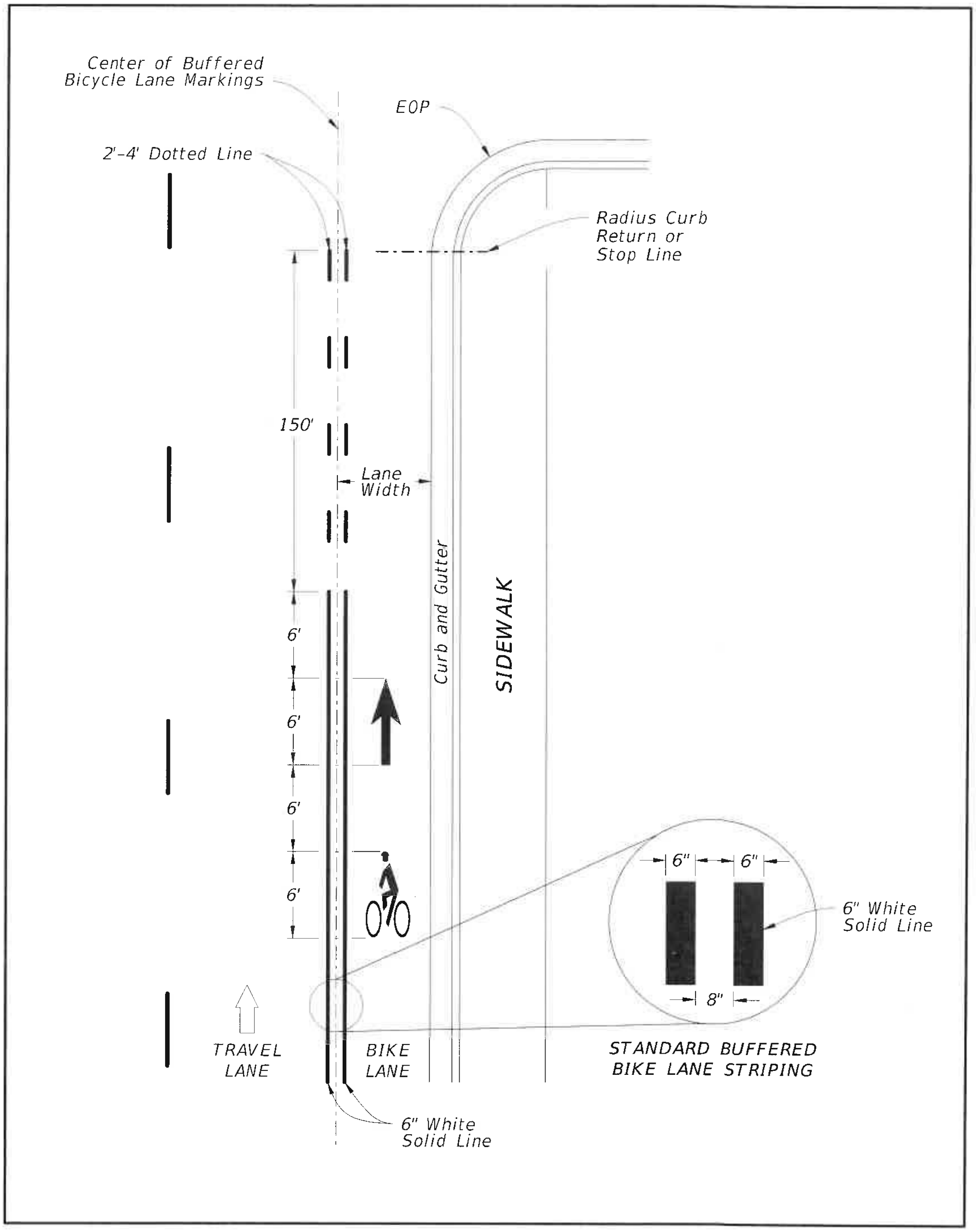
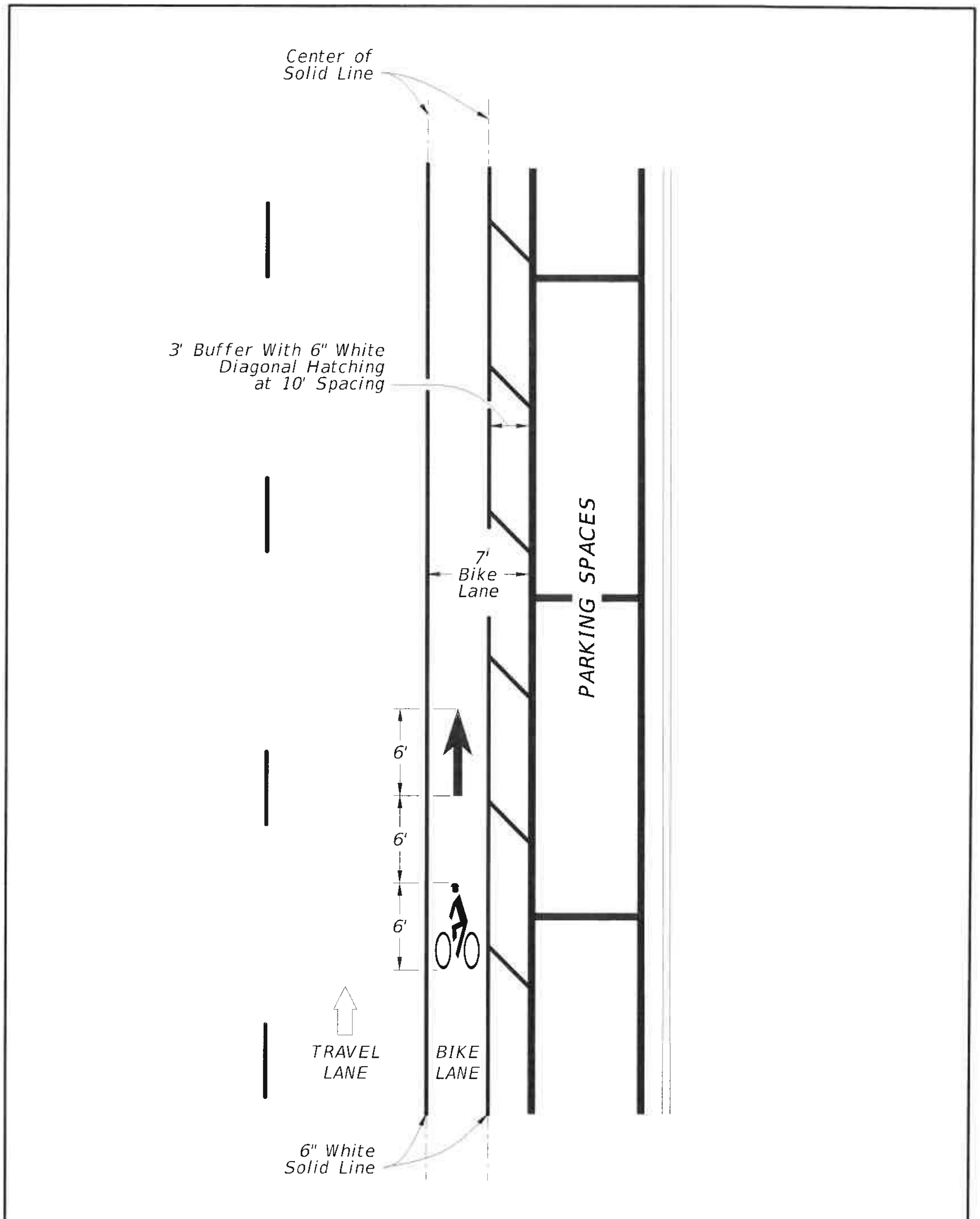


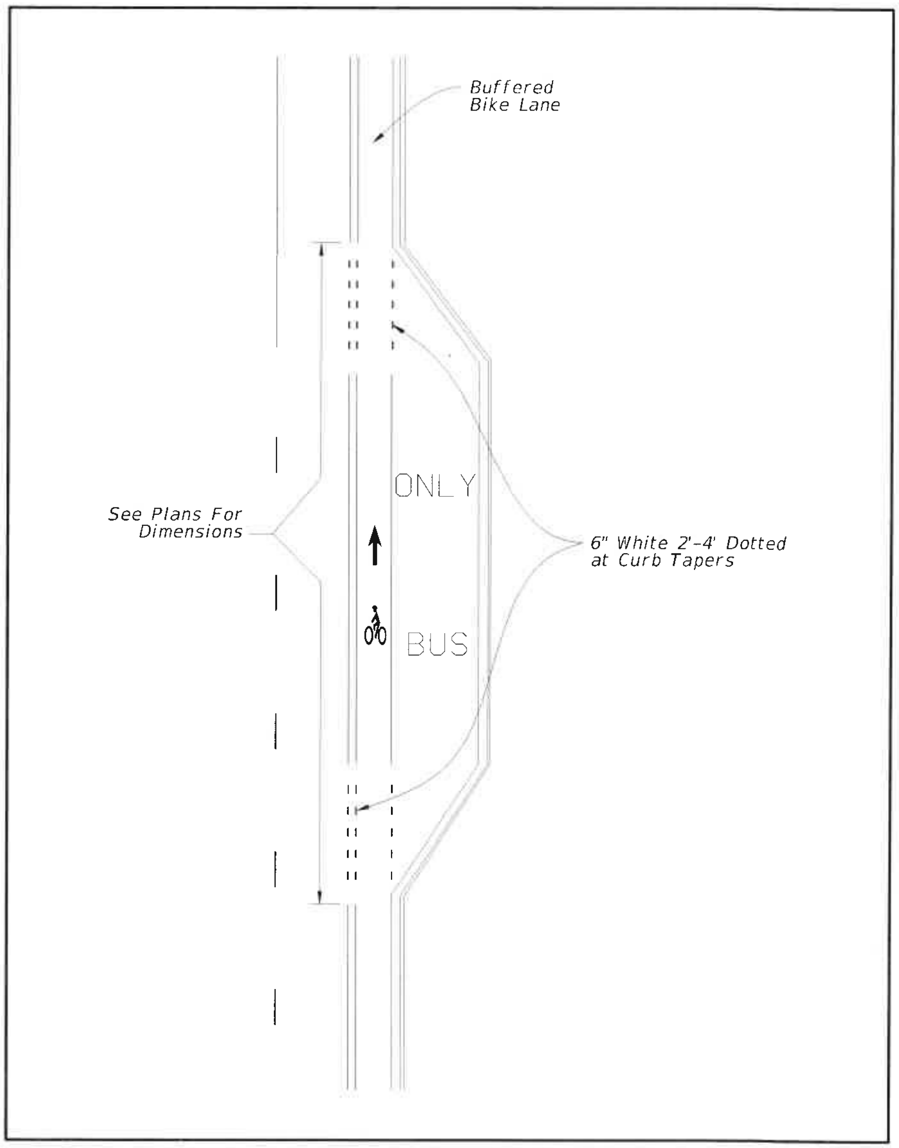
Figure 9 – 18 Buffered Bicycle Lane Markings with On-Street Parking



B.3 Bicycle Lane with Bus Bay

When a bus bay is provided on roadways with bicycle lanes, the bicycle lane shall be continued adjacent to the bus bay. Figure 9 – 19 Buffered Bicycle Lane with Bus Bay Marking provides an example of a buffered bicycle lane with a bus bay.

Figure 9 – 19 Buffered Bicycle Lane with Bus Bay Marking (Curb and Gutter)



B.4 Green Colored Bicycle Lanes

The Federal Highway Administration (FHWA) has issued an Interim Approval for the use of green colored pavement in bicycle lanes and in extensions of bicycle lanes through intersections and other traffic conflict areas. Colored pavements shall not replace or be used in lieu of required markings for bike lanes as defined in the ***MUTCD***, but shall only supplement such markings. Traffic conflict areas include where the:

- bicycle lane crosses a right turn lane,
- traffic in a right turn lane crosses a bike lane, or
- bicycle lane is adjacent to a dedicated bus bay.

The Interim Approval may be found at the following website and provides further information on how to submit a written request to use green colored pavement:

http://mutcd.fhwa.dot.gov/res-interim_approvals.htm

The effectiveness of green colored pavement may be maximized if the treatment is used only where the path of bicyclists and other road users cross and yielding must occur. Because colored pavements are addressed in the 2009 MUTCD, they are by definition a traffic control device whose need should be demonstrated before they are used. A need for this treatment can be demonstrated by either of the following:

1. A history of 3 or more motor vehicle-bicycle crashes exists at or adjacent to the traffic conflict area over the most recent three-year period, or
2. A government agency has observed and documented conflicts (failure of the motor vehicle to yield to the bicyclist) between cyclists and motor vehicles at an average rate of two per peak hour. The documentation for conflicts shall include observations from a minimum of two separate data collection periods, conducted on different days in a one month period, and include at least one weekday and one weekend count period during peak bicycle travel times. Each period should be at least 2 hours in duration. Peak times vary by region and surrounding land use, but are typically:

    - Weekday, 11:00 AM to 1:00 PM
    - Weekday, 5:00 PM to 7:00 PM
    - Saturday, 8:00 AM to 2:00 PM

When used in conjunction with white skip lines, such as when extending a bike lane across a right turn lane or access to a bus bay, the transverse colored marking shall match the 2'-4' white skip line pattern of the bike lane extension. The green colored pavement should begin as a solid pattern 50 feet in advance of the skip striping, match the 2' 4' skip through the conflict area, and then resume the solid color for 50' after the conflict area, unless such an extent is interrupted by a stop bar or an intersection curb radius. Details of each installation and associated pavement markings shall be shown in the plans. Figures 9 – 20, 21, 22 and 23 illustrate how the green portion of the bicycle lane may be marked.

Materials permitted to color the bike lane green shall be non-reflective and fall within the color parameters defined by FHWA in their interim approval. Materials which have been tested to meet these requirements can be found in ***FDOT's Approved Product List for Specification 523, Patterned Pavement.***

Figure 9 – 20 Green Bicycle Lane with Separate Right Turn Lane

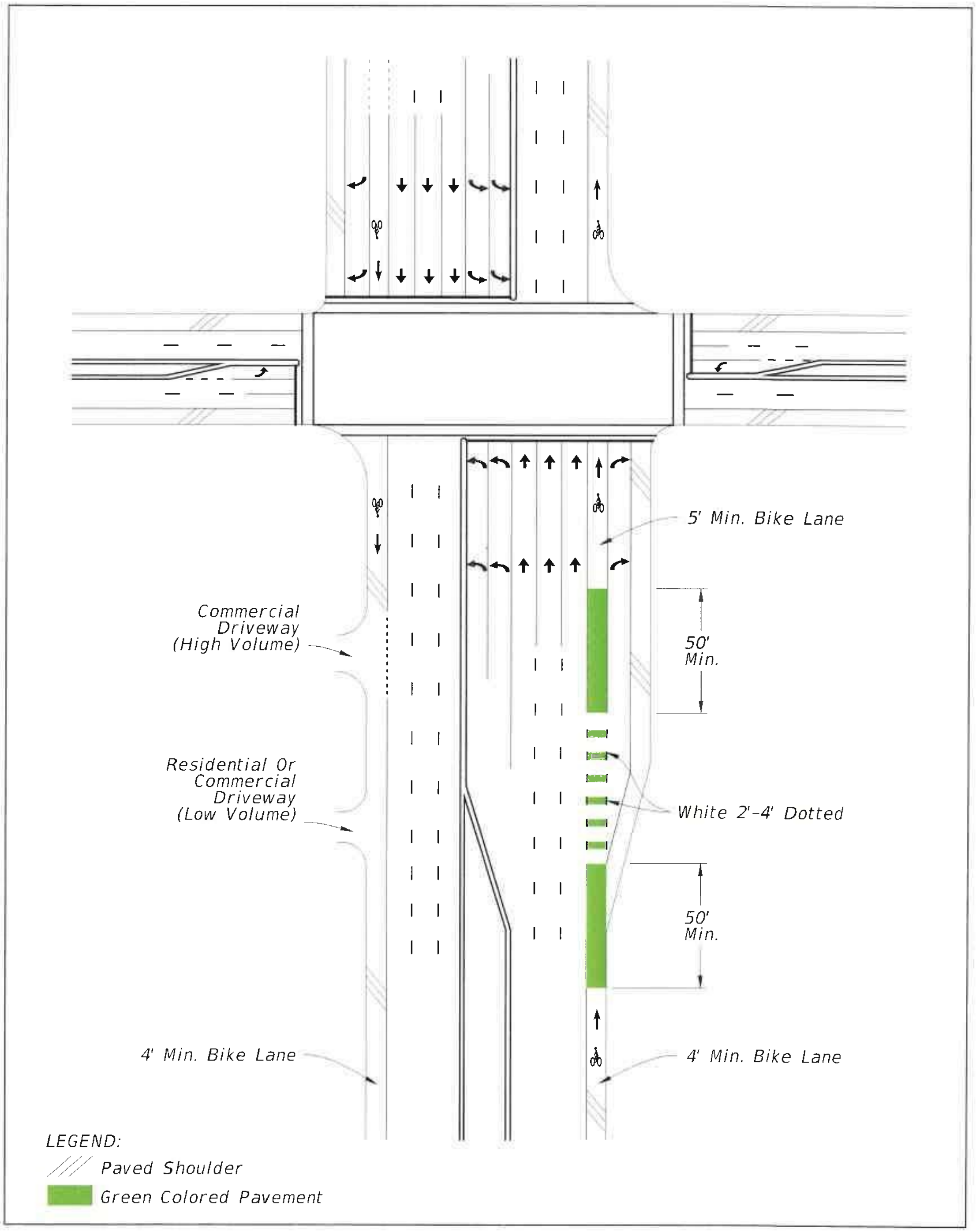


Figure 9 – 21 Green Bicycle Lane with Right Turn Drop Lane

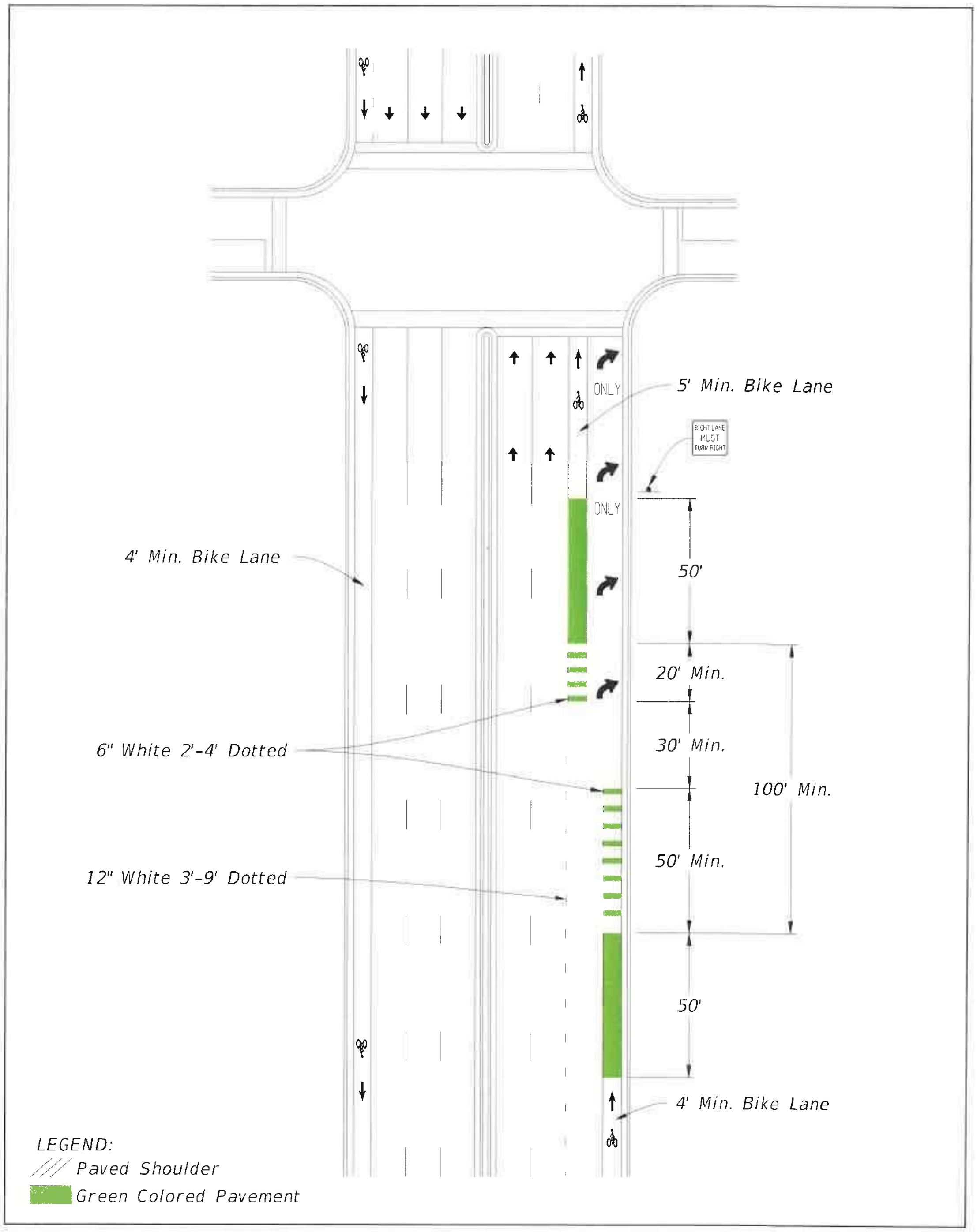


Figure 9 – 22 Green Bicycle Lane with Channelized Right Turn Lane

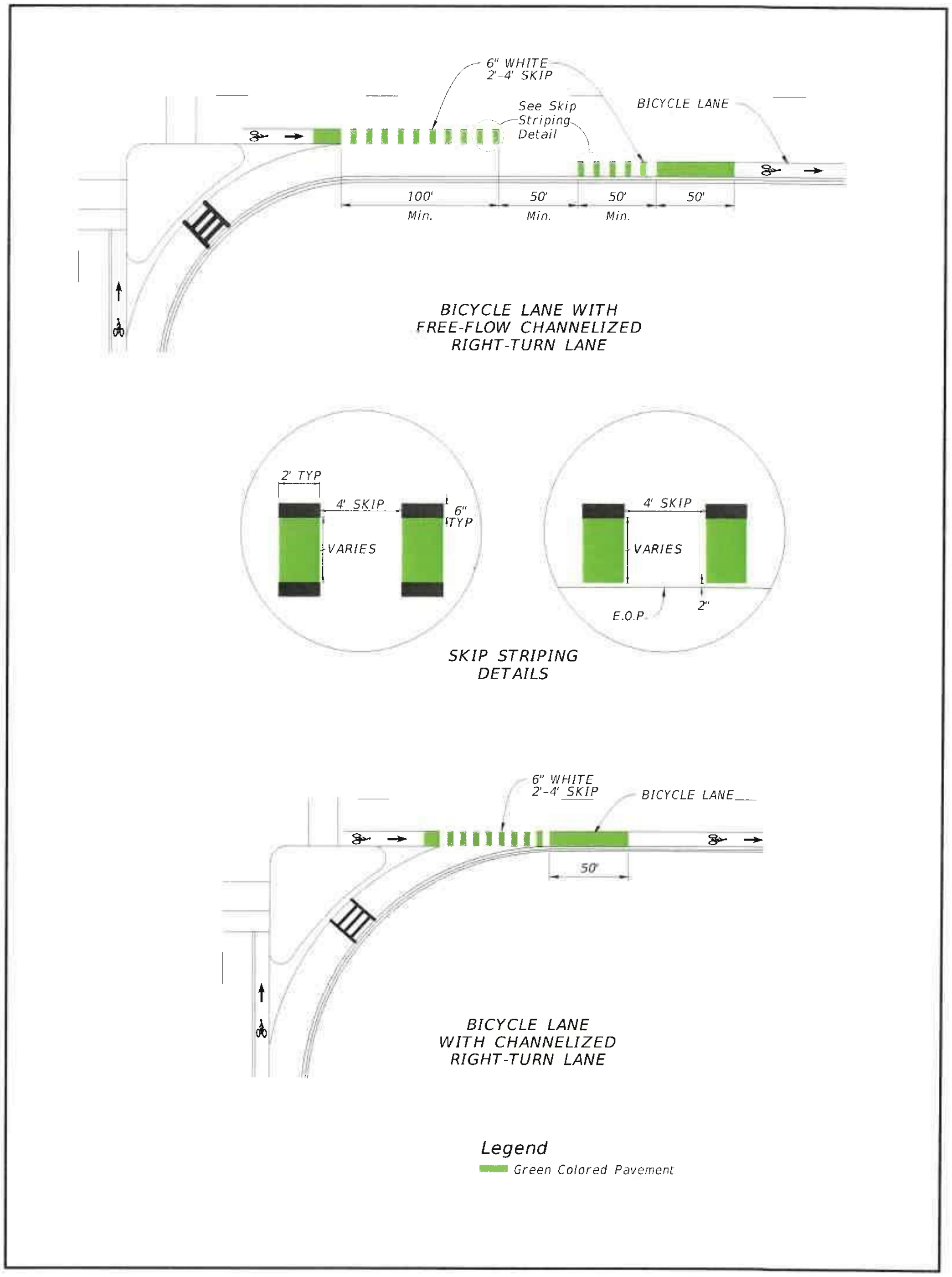
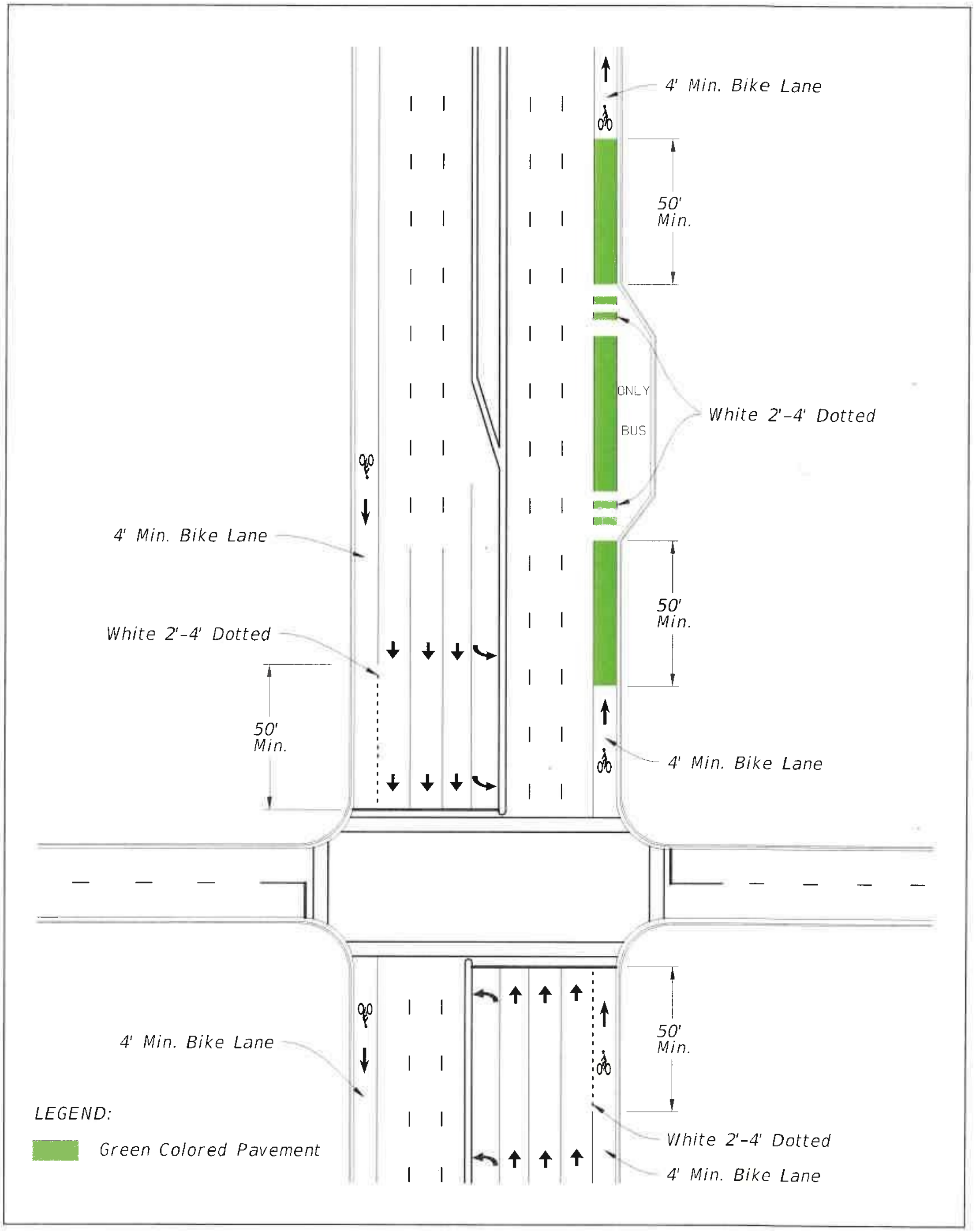


Figure 9 – 23 Green Bicycle Lane with Bus Bay



B.5 Paved Shoulders

A paved shoulder is a portion of the roadway which has been delineated by edge line striping. Adding, widening or improving paved shoulders often can be an acceptable way to accommodate bicyclists. However, when a shoulder is intended to serve as a bicycle facility and is adjacent to a curb, guardrail or other roadside barrier, a minimum 5-foot clear width between the traveled way and the face of the barrier is required. Additional shoulder width is desirable if the posted speed exceed 50 mph, or the percentage of trucks, buses, or recreational vehicles is high (>10%).

Ground-in rumble strips should not be included in paved shoulders if a minimum clear width of 4 feet outside of the rumble strip cannot be provided.

B.6 Wide Outside Lanes

Wide outside lanes on curbed roadways are through lanes that provide a minimum of 14 feet in width, which allows most motor vehicles to pass cyclists safely within the travel lane. Bicycle lanes are preferred for arterial and collector roadways, however, in some conditions, such as resurfacing projects, wide outside lanes may be the only practical option for a bicycle facility.

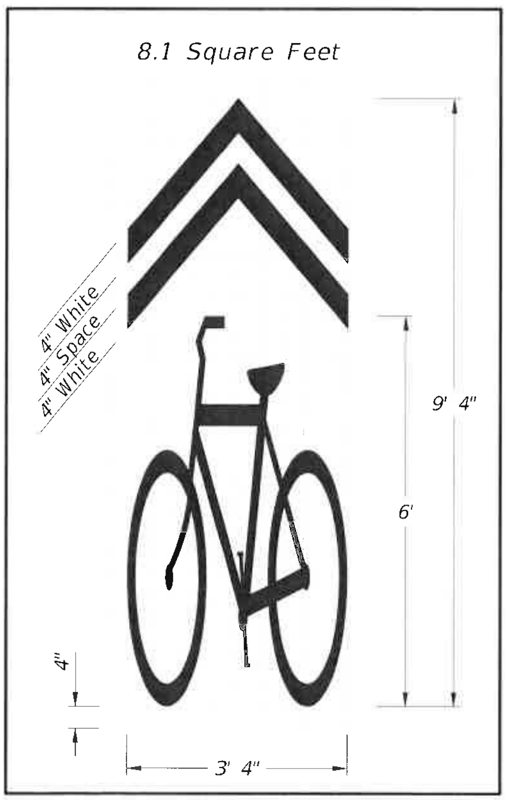
B.7 Shared Lane Markings

The shared lane marking is an optional pavement marking for roadways where bicyclists and motor vehicles are intended to share the lane and no bicycle lane or paved shoulder exists or is feasible. Shared lane markings should be limited to roadways with a posted speed of 35 mph or less. They are not intended to be placed on every roadway without bicycle facilities or on shared use paths.

Shared lane markings provide guidance to cyclists on their lateral positioning, especially on roadways with on-street parking or lanes that are too narrow to share side by side with a motor vehicle. They also help to discourage wrong way riding and encourage safer passing of bicyclists by motorists. Shared lane markings may be used to identify an alternate route as part of an approved temporary traffic control plan. Figure 9 – 24 provides the dimensions for shared lane markings.

Shared lane markings should be placed as follows:

Figure 9 – 24 Shared Lane Marking



- If used on a roadway without on-street parking that has an outside travel lane that is 14 feet wide or less, the Shared Lane Markings should be centered in the travel lane (Figure 9 – 25).
- If used on a roadway with on-street parking, the Shared Lane Markings should be centered in the travel lane (Figure 9 – 26).
- Shared Lane Markings should be placed immediately after an intersection and spaced at intervals not greater than 250 feet thereafter.

Figure 9 – 25 Shared Lane Marking Placement
(No Designated Parking, Lane Width ≤ 14 Feet)

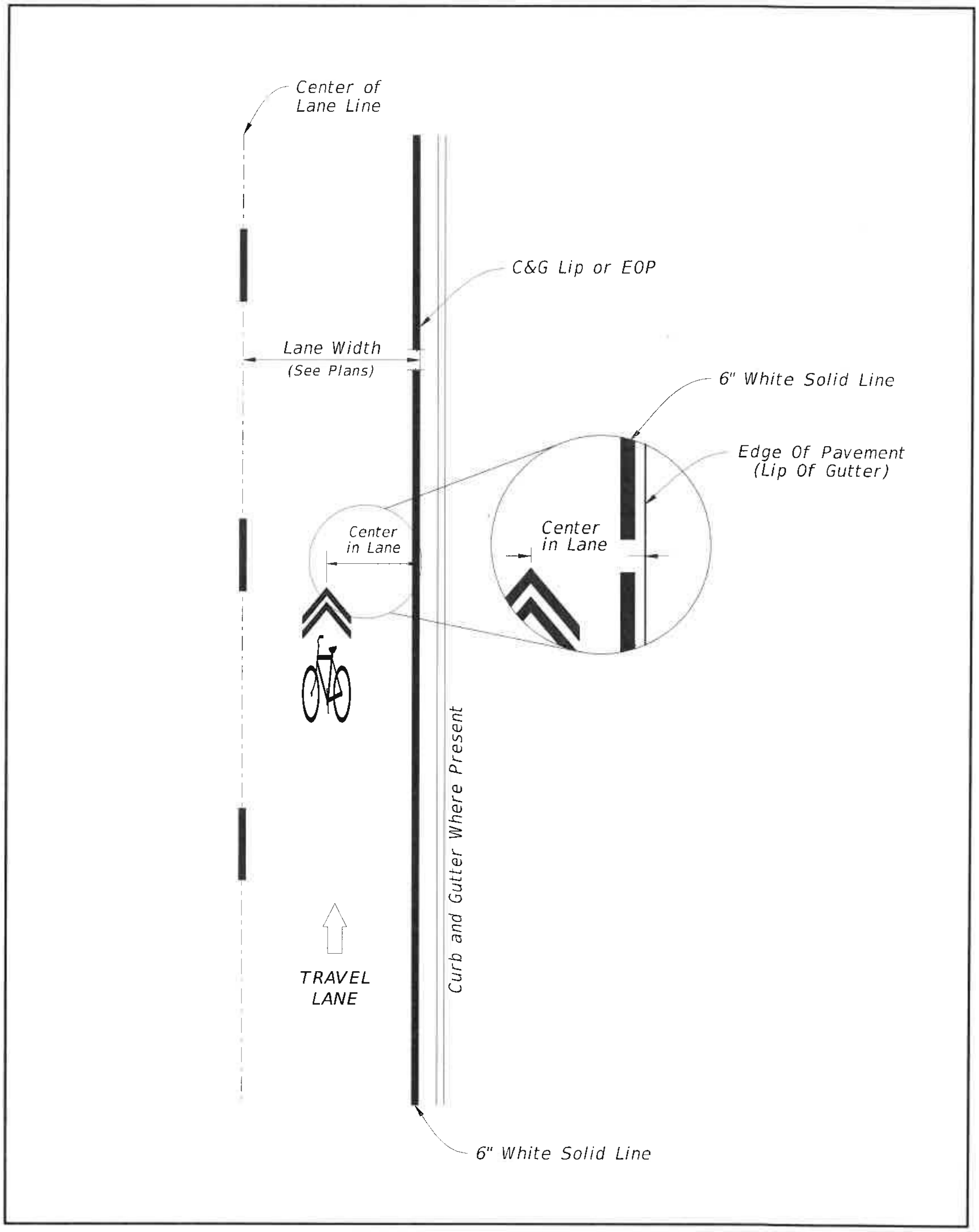
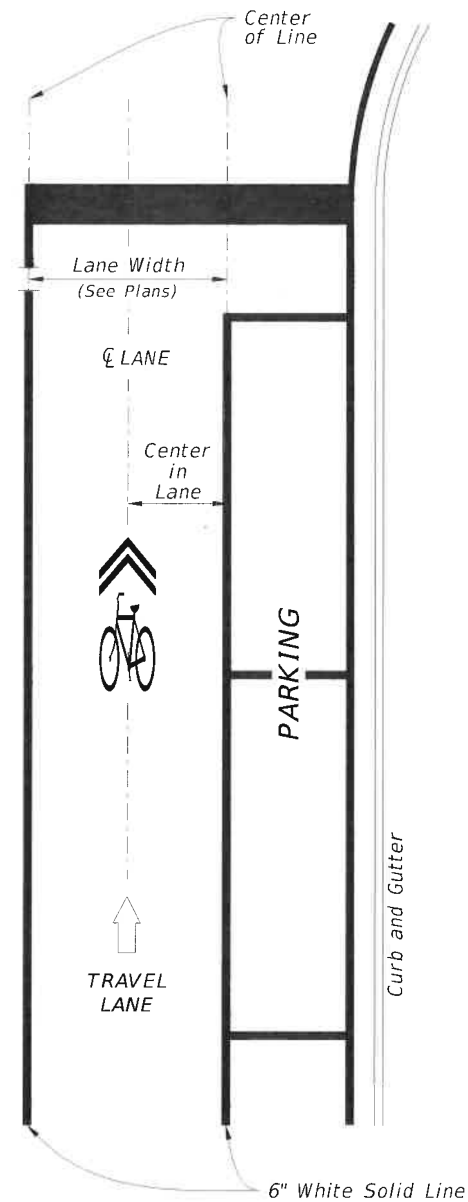


Figure 9 – 26 Shared Lane Marking Placement (With On-Street Parking)



B.8 Bicycles May Use Full Lane Sign

The Bicycle May Use Full Lane sign (R4-11) may be used on roadways where no bicycle lanes or adjacent shoulders useable by bicyclists are present and where travel lanes are less than 14' wide. The ***MUTCD*** provides additional information on the use of the sign.

C SHARED USE PATHS

Shared use paths are paved facilities physically separated from motorized vehicular traffic by an open space or barrier and either within the highway right of way or an independent right of way, with minimal cross flow by motor vehicles. They are used by bicyclists, pedestrians, runners, skaters, and in some cases equestrians. The bicycle's operating characteristics will govern the design of shared use paths. The ***2006 Americans with Disabilities Act – Standards for Transportation Facilities*** and the ***2012 Florida Accessibility Code*** impose additional requirements for the design and construction of shared use paths since they serve as pedestrian facilities.

Shared use paths serve a variety of purposes. They can provide a school age child, a recreational cyclist, or a person with a disability an alternative to busy roadways. Shared use paths can be located along former rail corridors, the banks of rivers or canals, and through parks and forests. Shared use paths can also provide access to areas otherwise served only by limited access highways. For transportation purposes, they should be thought of as an extension of the roadway network for non-motorized users. The inclusion of a shared use path should not be considered as an alternative to providing on-street facilities, but, rather, as a supplement.

For additional information on shared use path design, refer to the ***AASHTO Guide for the Development of Bicycle Facilities (2012, 4th Edition).***

C.1 Width and Clearance

The useable width and horizontal clearance for a shared use path are primary design considerations. The minimum paved width for a two-way path is 10 feet. Typically, widths range from 10 to 14 feet, with the wider values applicable to areas with high use or a wider variety of users, on steep grades, through curves, or used by larger maintenance vehicles.

In very rare circumstances, a reduced width of 8 feet may be used where the following conditions prevail:

- Bicycle traffic is expected to be low, even on peak days or during peak hours.
- Pedestrian use of the facility is not expected to be more than occasional.
- Horizontal and vertical alignments provide frequent, well-designed passing and resting opportunities.

- The path will not be regularly subjected to maintenance vehicle loading conditions that would cause pavement edge damage.

In addition, a path width of 8 feet may be used for a short distance due to a physical constraint such as an environmental feature, bridge abutment, utility structure, or fence.

A minimum 2 foot wide graded area with a maximum 1:6 slope should be maintained adjacent to both sides of the path; however, 3 feet or more is desirable to provide clearance from trees, poles, walls, fences, guardrails or other lateral obstructions. See Chapter 8, Section D Barrier Separation and Chapter 4, Figure 4 –8 Location of Guardrail for information on when and how longitudinal barriers should be utilized,

Where the path is adjacent to canals, ditches, or slopes steeper than 1:3, a wider separation should be considered. A minimum 5 foot separation from the edge of the path pavement to the top of the slope is desirable. Depending on the height of embankment and condition at the bottom, a physical barrier, such as a railing or chain link fence may need to be provided.

Where a recovery area is less than 5 feet, physical barriers or rails are recommended in the following situations:

- Slopes 1:3 or steeper, with a drop of 6 feet or greater;
- Slopes 1:3 or steeper, adjacent to a parallel body of water or other substantial obstacle
- Slopes 1:2 or steeper, with a drop of 4 feet or greater; and
- Slopes 1:1 or steeper, with a drop of 1 foot or greater.

The ***AASHTO Guide for the Development of Bicycle Facilities (2012, 4th Edition)*** provides additional information on the design of barriers or railings.

The desirable vertical clearance to obstructions is 10 feet. Fixed objects should not be permitted to protrude within the vertical or horizontal clearance of a shared use path. The recommended minimum vertical clearance that can be used in constrained areas is 8 feet. In some situations, vertical clearance greater than 10 feet may be needed to permit passage of maintenance and emergency vehicles.

C.2 Separation Between Shared Use Paths and Roadways

When shared use paths are located adjacent to a roadway, a separation shall be provided. This demonstrates to both path users and motorists that the shared use path is a separate facility.

The minimum distance between a path and the face of curb or edge of traveled way (where there is no curb) should be 5 feet. On roadways with flush shoulders, this separation is measured from the outside edge of the shoulder to the inside edge of the path. Where the separation is less than 5 feet, a physical barrier or railing should be provided between the path and the roadway.

A barrier or railing between the path and adjacent highway should not impair sight distance at intersections, and should be designed to limit the potential for injury to errant motorists or bicyclists. The barrier or railing need not be of size and strength to redirect errant motorists toward the roadway, unless other conditions indicate the need for a crashworthy barrier.

Barriers or railings at the outside of a structure or steep fill embankment that not only define the edge of the path but also prevent bicyclists from falling over the rail to a substantially lower elevation should be a minimum of 42" high. Barriers at other locations that serve only to separate the area for motor vehicles from the path should generally have a minimum height equivalent to the height of a standard guard rail.

When a path is placed along a high-speed highway, a separation greater than 5 feet is desirable.

C.3 Design Speed

For paths in relatively flat areas (grades less than or equal to 4%), a design speed of 18 mph shall be used. When a sustained downgrade greater than 4% exists, refer to the ***AASHTO Guide for the Development of Bicycle Facilities (2012, 4th Edition)*** for further guidance,

C.4 Horizontal Alignment

The typical adult bicyclist is the design user for horizontal alignment. Please refer to the ***AASHTO Guide for the Development of Bicycle Facilities (2012, 4th Edition)*** for further information on determining the minimum radius of curves on shared use paths.

Shared use paths should be transitioned as necessary towards the roadway at intersections to provide a more functional crossing location that also meets driver expectation.

C.5 Accessibility

Since nearly all shared use paths are intended to be used by pedestrians, they fall under the accessibility requirements of the Americans with Disabilities Act.

Pull boxes, manholes (and other utility covers), and other types of existing surface features in the location of a proposed curb ramp or detectable warning should be relocated when feasible. When relocation is not feasible, the feature shall be adjusted to meet the ADA requirements for surfaces (including the provision of a nonslip top surface, and adjustment to be flush with and at the same slope as the adjacent surface).

The detectable warning systems are designed to work with concrete surfaces. In areas where the path has an asphalt surface, the engineer must specify an appropriate detectable warning system. In these cases, consider including a short section of concrete that will accommodate any system.

If curb ramps are included in the path design, they should be parallel to and the full width of the approaching path width. Shared use path crossings shall meet the same grade and cross slope requirements as sidewalks where the grade should not exceed 5%, and the maximum cross slope shall be no more than 2%.

Project design shall include an evaluation of existing driveways to determine if it is feasible to upgrade nonconforming driveway turnouts to meet maximum cross slope criteria. Nonconforming driveways are not required to be upgraded if it is not feasible within the scope of the project.

Chapter 8 – Pedestrian Facilities provides additional information regarding accessible design of shared use paths.

C.6 Structures

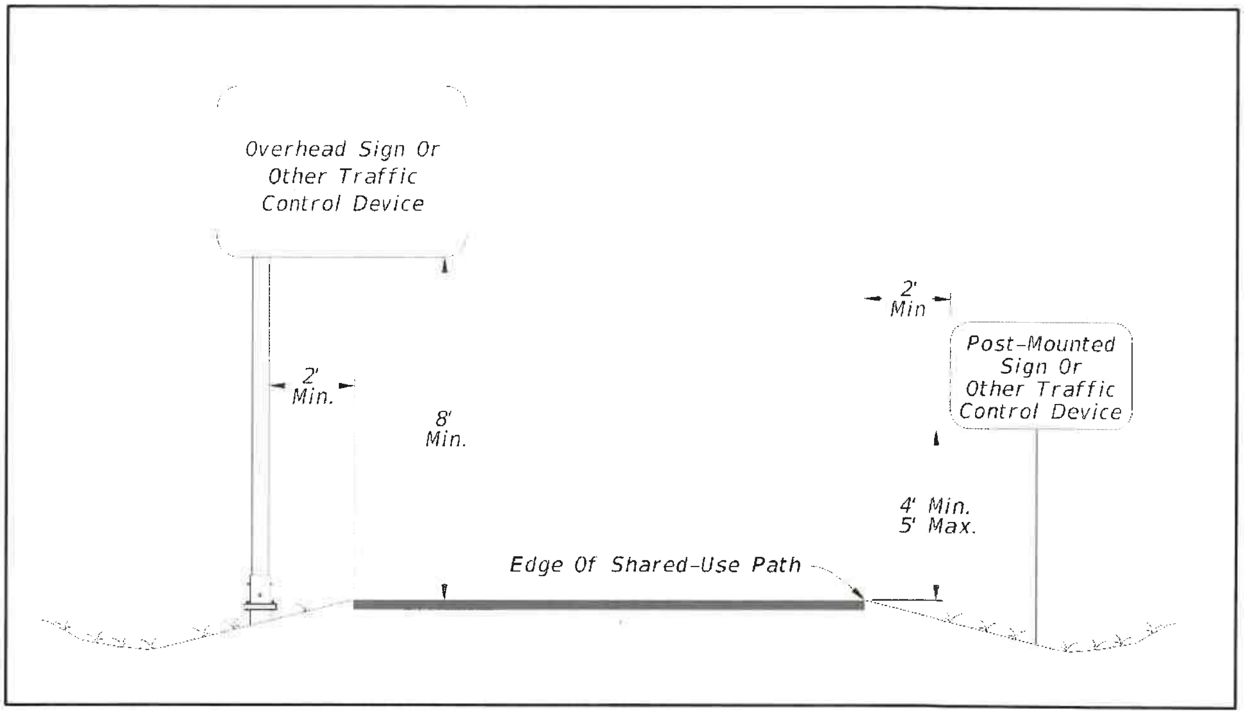
The minimum clear width on structures should be the same as the approach shared use path, plus the minimum 2 foot wide clear areas. Access by emergency, patrol and maintenance vehicles should be considered in establishing the design clearances of structures on shared use paths. Where practical, a path vertical clearance of 10 feet (on the structure) is desirable for adequate vertical shy distance.

Ramps on new structures that are part of a shared use path and serve as the accessible route shall have a running slope not steeper than 1:12 and cross slope not steeper than 1:48. Landings are required at the top and the bottom of each ramp run.

C.7 Pavement Markings and Signage

The MUTCD regulates the design and use of all traffic control devices on shared use paths. Figure 9 – 27 Sign Placement on Shared Use Paths provides the minimum criteria for the placement of signs along or over a shared use path. The maximum height from the outside edge of the path to the bottom elevation of a sign is five feet. Signs on shared use paths should follow the dimensions provided in ***Table 9B-1 Bicycle Sign and Plaque Sizes, MUTCD***. Guidance on the placement of stop or yield lines and crosswalks on roadways intersecting with shared use paths is provided in the ***MUTCD, Part 3***.

Figure 9 – 27 Sign Placement on Shared Use Paths



D RAILROAD CROSSINGS

Railroad-highway grade crossings should ideally be at a right angle to the rails. This can be accomplished either as a separate path or a widened shoulder. The greater the crossing deviated from this ideal crossing angle, the greater is the potential for a bicyclist's front wheel to be trapped in the flangeway, causing loss of steering control. If the crossing angle is less than approximately 45 degrees, an additional paved shoulder of sufficient width should be provided to permit the bicyclist to cross the track at a safer angle, preferable perpendicularly. Where this is not possible, and where train speeds are low, commercially available compressible flangeway fillers may enhance bicyclist operation. It is also important that the roadway approach be at the same elevation as the rails. For more information, see Figure 4 – 28 Correction for Skewed Railroad Grade Crossing – Separate Pathway in the ***AASHTO Guide for the Development of Bicycle Facilities***.

E STRUCTURES

All new bridges over roadways and shared use paths shall be designed to meet the vertical clearance standards specified in ***Chapter 3, Section C.7.j.4.(b)***, and ***Chapter 17, Section C.3.b.***

All bridges that include provisions for pedestrians shall provide pedestrian accommodations and design considerations that meet the provisions of the ADA.

Bridges over roadways should be covered or screened to reduce the likelihood of objects being dropped or thrown below. If the bridge is enclosed, the visual tunnel effect may require widening the bridge to provide a feeling of security for all bridge users. The area adjacent to overpasses may be fenced to prevent unsafe crossings and to channel pedestrians to the vertical separation structure.

F REFERENCES FOR INFORMATIONAL PURPOSES

- USDOT/FHWA ADA Standards for Accessible Design (ADAAG)
  http://www.access-board.gov/guidelines-and-standards/buildings-and-sites/about-the-ada-standards/ada-standards
- AASHTO – Guide for the Development of Bicycle Facilities, 2012, 4th Edition
  https://bookstore.transportation.org/
- NACTO Urban Streets Design Guide
  http://nacto.org/usdg
- FHWA Policy Memo for Flexibility in Pedestrian and Bicycle Facility Design
  http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/design_guidance/design_flexibility.cfm
- Storm Drain Handbook, Florida Department of Transportation, October 2014
  http://www.dot.state.fl.us/rddesign/Drainage/files/StormDrainHB.pdf
- Manual on Uniform Traffic Control Devices, May 2012
  http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 10

MAINTENANCE AND RESURFACING

FIGURES

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 10

MAINTENANCE AND RESURFACING

A INTRODUCTION

In order to provide for the safe and efficient movement of all modes of traffic, it is essential to maintain all aspects of the road and right of way at the highest reasonable level of safety. Improvements consistent with upgrading safety standards or accommodating changes in traffic are also required to maintain the facility in a quality condition. Maintenance and resurfacing are costly operations; therefore, every effort should be made to provide the maximum safety benefit from each operation. The fact that a major portion of the maintenance effort is necessary to merely preserve the economic investment in a facility should not be considered as justification for sacrificing the requirements for maintaining or improving the safety characteristics of a street or highway.

B MAINTENANCE

B.1 Objectives

The major objectives of a maintenance program include the following:

- Maintain all highway features and components in the best possible condition.
- Improve sub-standard features, with the ultimate goal to at least meet minimum standards.
- Provide for minimum disruptions and hazards to traffic during maintenance operations.
- Location and reporting of inadequate safety features.

B.2 Policy

Each highway agency responsible for maintenance shall develop and maintain a program of highway maintenance for the entire highway network under its jurisdiction. This program should include the following activities:

- Identify needs

- Establish priorities
- Establish procedures
- Establish and maintain a regular program of maintenance for all aspects

The program should be regularly evaluated and suitably modified to promote the maintenance of streets and highways that result in the best practicable condition.

B.3 Identification of Needs

The identification of maintenance needs is the first stage in the development of a successful maintenance program, and is required when any portion of the highway system is in a sub-standard condition. Action is also required to correct any situation which is hazardous or may become hazardous in the near future. This may be accomplished by both regular inspection of the highway network and proper analysis of crash records.

B.3.a Inspection

Periodic and systematic inspection of the entire highway network under each agency's jurisdiction is required to identify situations requiring improvements, and corrections or repairs. These inspections should be conducted by maintenance or traffic operations personnel, or other qualified personnel who are trained in the aspects of highway maintenance requirements.

B.3.b Crash Records

A regular program of crash investigations, record keeping, and analysis should be established to provide information for recommended highway modification and corrective maintenance requirements. Cooperation among maintenance, traffic operations, and police agencies is required, and activities of these agencies should be coordinated in accordance with the guidelines set forth in the ***National Highway Traffic Safety Administration (NHTSA) Program Guideline No. 21 (II), Identification and Surveillance of Crash Locations***. Inspection of the highway network and analysis of crash records should be utilized to provide feedback for modification of design and construction procedures.

B.4 Establishment of Priorities

The maintenance activities determined to be necessary by the identification program should be carried out on a priority basis. The establishment of priorities should be based, to a large extent, upon the objective of promoting highway safety. A high priority should be given to the improvement or correction of situations that may result in fatal or serious crashes. Preservation of highway investment and promotion of efficient traffic operations are important maintenance objectives. Every effort should be made to ensure the highest safety payoff from the maintenance dollar.

B.5 Establishment of Procedures

Standard procedures and methods for maintenance operations should be established for efficient, rapid, and safe completion of the required work. All maintenance work shall be conducted in accordance with the Standards set forth in ***Chapter 11 – Work Zone Safety***. Each maintenance agency should develop its own Maintenance Manual or utilize the Maintenance Manuals of the Department. Such manuals should specify the methods, procedures, equipment, personnel qualifications, and other aspects of the work necessary to ensure successful completion of maintenance operations. Procedures should be developed for emergency, routine, and special operations.

B.5.a Emergency Maintenance

Emergency maintenance operations are those required to immediately restore the highway to a safe condition. Emergency maintenance work should be carried out by personnel who are specially trained and qualified. Work units, which should be available on a twenty-four hour basis, should be connected with the emergency response communications system. Emergency operations would include the following:

1. The removal of debris from crashes, cargo spillage, or other causes. This activity should be conducted in accordance with the guidelines set forth in the ***NHTSA Program Guideline No. 16, Debris Hazard Control and Cleanup***.
2. Replacement of inoperative traffic control devices.
3. Repair or replacement of damaged highway safety components such as lighting, traffic control devices, redirection devices, and energy absorbing devices.

4. Repair or correction of any situation that provides an immediate or unexpected hazard to the public.
5. Assistance in any activity during emergency response operations.

B.5.b Routine Maintenance

Routine maintenance operations are those that may be predicted and planned in advance. These operations, which may be preventive or corrective in nature, should be conducted on a regularly scheduled basis using standard procedures. Proper scheduling of these operations should be utilized to provide minimum disruptions and hazards to the driving public. Routine maintenance may include operations such as:

1. Cleaning and debris removal from the pavement, shoulders, and roadside clear zones.
2. Mowing and other vegetation control operations to provide a smooth recovery area and to maintain proper sight distance.
3. Cleaning and inspection of gutters, ditches, and other drainage structures.
4. Structural inspection and preventive maintenance on bridges and other structures.
5. Cleaning, replacement, and maintenance of roadway lighting fixtures.
6. Replacement and maintenance of traffic control devices.
7. Inspection and maintenance of redirection and energy absorbing devices (***Chapter 4 – Roadside Design***).
8. Inspection and maintenance of emergency response communication systems and access facilities.
9. Inspection and maintenance of pavement and shoulders, with particular emphasis on maintaining shoulders flush with the pavement (***Chapter 5 – Pavement Design and Construction***).
10. Inspection and maintenance of all highway components and safety features.
11. Inspection and maintenance of pedestrian pavements, crossings, etc., with particular emphasis on sidewalk cracks, joint separations, accumulated debris, adjacent landscape materials, etc.).

12. Thin pavement overlay that is intended to preserve the pavement, retard its future deterioration and maintain its functional condition.

B.5.c Special Maintenance

Special maintenance operations are defined as those projects that are neither urgent nor routine in nature, but are occasionally required to improve or maintain a street or highway in a quality condition. Since these projects can be planned in advance of the initiation of any work, procedures that provide for efficient, rapid, and safe operations can be developed. To avoid continuing disruptions of traffic, the quality and durability of these improvements, corrections, and repairs should be maintained at the highest practicable level. Special maintenance should include the upgrading of the highway safety features, as well as the repair or replacement of damaged or deteriorated highway components. These operations should be designed to upgrade or maintain the street or highway in accordance with the Standards presented in this Manual.

B.5.d Pavement Maintenance

The primary purpose of pavement maintenance is to ensure the pavement characteristics prescribed in ***Chapter 5 – Pavement Design And Construction***, are reasonably maintained. Each agency with responsibility for maintenance of streets and highways shall establish a meaningful pavement maintenance system (including shoulders and drainage structures) for the entire system under its jurisdiction. This program should include:

1. A process that monitors the serviceability of the existing streets and highways and identifies the pavement sections that are inadequate.

2. A systematic plan of maintenance activities designed to correct structural deficiencies and to prevent rapid deterioration.

3. A preservation program, with assigned priorities, designed to resurface, reconstruct, or replace pavements when they are no longer structurally serviceable.

Pavement maintenance requires a substantial portion of the total maintenance budget for streets and highways. It is necessary to ensure highway safety. The reduction of hydroplaning and splashing is essential for promoting safe and efficient operation during wet weather conditions.

The elimination of driving discomfort, and vehicle damage caused by deteriorated pavements, provides additional economic justification for maintaining the pavement in a fully serviceable condition.

It is recognized that a comprehensive preservation program is expensive. Adequate financing is required to successfully carry out these activities. The establishment of appropriate budget priorities and careful planning can assist in developing and conducting a pavement maintenance and preservation program that will, within a reasonable number of years, bring substandard pavements up to the required level of serviceability and will maintain the adequacy of the entire system.

C RESURFACING

In addition to the design criteria provided in this chapter, the ***2006 Americans with Disabilities Act Standards for Transportation Facilities*** as required by ***49 C.F.R 37.41 or 37.43*** and the ***2017 Florida Accessibility Code for Building Construction*** as required by 61G20-4.002 impose additional requirements for the design and construction of resurfacing projects.

C.1 Accessibility Requirements

If new sidewalk and driveway construction or reconstruction is included on resurfacing projects they shall be designed to meet the requirements of ***Section C.7.d*** of ***Chapter 3 – Geometric Design*** and ***Chapter 9 – Pedestrian Facilities***. Project design should include an evaluation of existing driveways to determine if it is feasible to upgrade nonconforming driveways.

Existing detectable warnings and curb ramps shall be brought into compliance. This includes installing new detectable warnings for both flush shoulder and curbed roadway connections and signalized driveways where none exist or do not meet current requirements. New curb ramps shall be provided on curbed roadways where none exist and existing substandard curb ramps shall be replaced. Existing ramps not meeting detectable warning requirements which otherwise comply with orientation, slope and width criteria shall be retrofitted with detectable warnings.

Where existing right of way is inadequate or conflicts occur with existing features that cannot be practicably relocated or adjusted (e.g. driveways, drainage inlets, signal poles, pull boxes, utility poles, etc.), pedestrian accessibility shall be provided to the maximum extent feasible, with appropriate documentation signed and sealed by a Professional Engineer (EOR). Other than meeting detectable warning and curb ramp requirements, existing sidewalks and driveways are not required to be upgraded for the sole purpose of meeting requirements for accessibility unless included in the project scope.

C.2 Railroad-Highway Grade Crossing Near or Within Project Limits

Federal-aid projects must be reviewed to determine if a railroad-highway grade crossing is within the limits of or near the terminus of the project. If such railroad-highway grade crossing exists, the project must be upgraded to meet the requirements of the ***Manual on Uniform Traffic Control Devices (2009 Edition with Revision Numbers 1 and 2, May 2012) (MUTCD)*** in accordance with ***Title***

23, United States Code (U.S.C), Chapter 1, Section 109(e) and 23 C.F.R. 646.214(b). Please refer to Section C of ***Chapter 7 – Rail-Highway Crossings*** for further information.

C.3 Safety Improvements

Local agencies should strive to upgrade the safety of their facilities during scheduled maintenance intervals especially during pavement resurfacing projects. Particular attention should be paid to improving pedestrian and bicyclist safety using strategies such as crosswalks and bicycle facilities. Investments should also be made in improved guardrail end treatments and bridge-end transitions on high speed facilities.

C.3.a Pavement Safety Edge

Many low-cost strategies exist to improve the long-term safety of streets and highways. One such strategy is the pavement Safety Edge. The Safety Edge provides a higher probability of a vehicle returning safely to the travel lane when it drifts off the pavement. The Safety Edge is a wedge-shaped transition of the structural pavement to the unpaved shoulder. The wedge shape eliminates tire scrubbing against the pavement edge and improves vehicle stability as it crosses a drop-off.

The Safety Edge is particularly effective when providing a smooth transition from pavement to shoulder when vertical drop-offs exceed 2 inches. Construction of the Safety Edge typically includes initially pulling the unpaved shoulder for pavement structural course, and then backfilling onto the Safety Edge with installation of sod or turf. The Safety Edge is very effective in mitigating the severity of road-departure crashes should the unpaved shoulder erode away between maintenance intervals.

Details for the Safety Edge are included in Figures 10 – 1 Two Lane Road with Safety Edge and 10 – 2 Safety Edge Detail (No Paved Shoulder). Safety Edge should be constructed adjacent to the pavement edge on rural roadways with no paved shoulder and posted speeds 45 mph and above.

Figure 10 – 1
Two Lane Road with Safety Edge

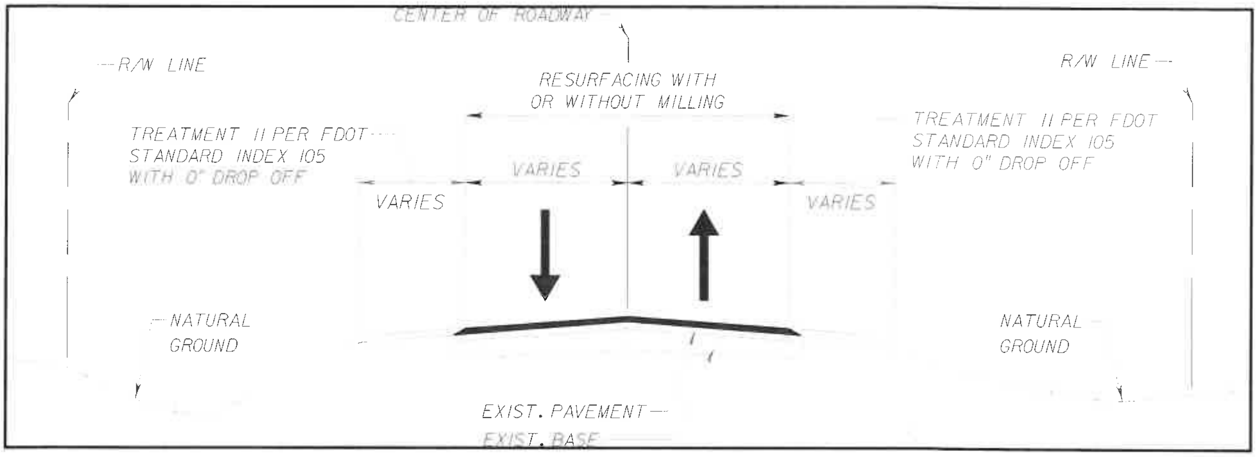
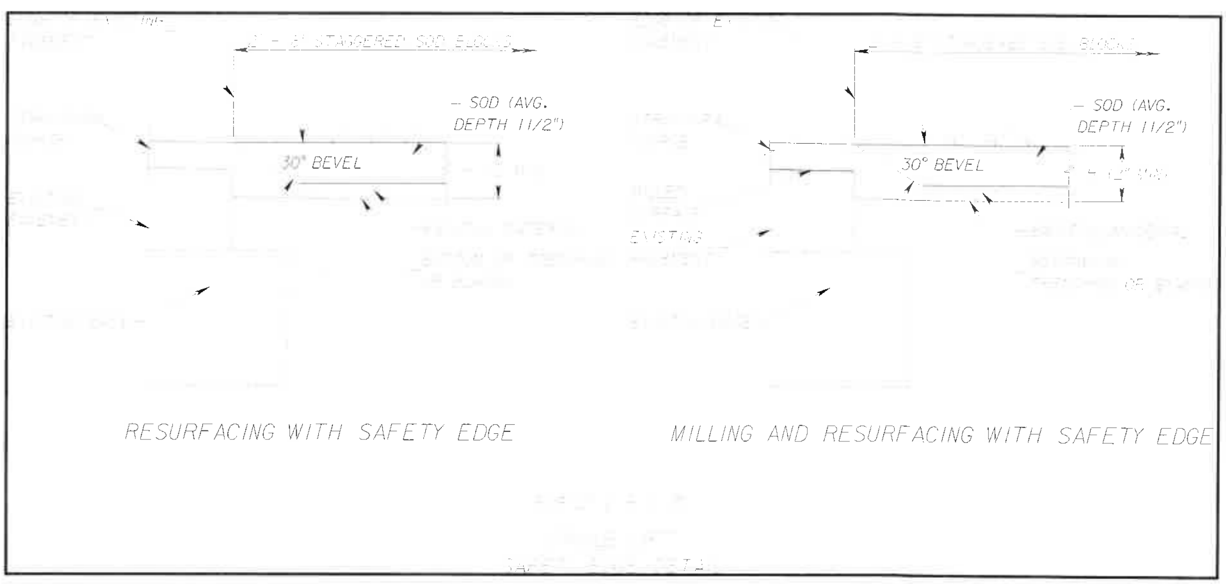


Figure 10 – 2
Safety Edge Detail (No Paved Shoulders)



C.4 Federal Aid Project Requirements

The following are the minimum requirements that a local highway resurfacing project scope must contain for federal-aid assistance including projects in the Local Agency Program (LAP):

1. Rework shoulders to be flush with the pavement and establish turf along the pavement edge.

2. Upgrade or replace existing roadside hardware (guardrail) as necessary for compliance with Federal criteria for 3R projects (as summarized in the ***Department's Design Manual, Chapter 215 Roadside Safety***).

3. Meet the latest ***Manual on Uniform Traffic Control Devices (2009 Edition with Revision Numbers 1 and 2, May 2012) (MUTCD)*** standards for signing and pavement marking.

4. Construct or reconstruct, as appropriate, curb cuts and ramps to meet current accessibility requirements.

5. Upgrade the safety of the project by mitigating the impact of crashes involving vehicles, bicycles and pedestrians.

   Note: The local agency may contact the FDOT District Safety Office and determine locations within the project with crash rates higher than average for similar facility type. The local agency may then identify the causes of the crashes from a review of crash report data provided by the FDOT District Safety Office. Based on this analysis, the local agency may then specify the appropriate crash mitigation measures (additional guardrail, signing, vibratory/audible pavement marking, designated crosswalks or other prudent safety-enhancing strategies).

6. Upgrade railroad crossings to meet the latest ***Manual on Uniform Traffic Control Devices (2009 Edition with Revision Numbers 1 and 2, May 2012) (MUTCD)*** requirements in accordance with ***Title 23, United States Code (U.S.C), Chapter 1, Section 109(e)*** and ***23 C.F.R. 646.214(b)***. Please refer to ***Section C*** of ***Chapter 7 – Rail-Highway Crossings*** for further information.

D REFERENCES FOR INFORMATIONAL PURPOSES

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

- FHWA Pavement Preservation Definitions, HIAM-20, September 12, 2005, http://www.fhwa.dot.gov/pavement/preservation/091205.cfm
- NCHRP Synthesis 417: Geometric Design Practices for Resurfacing, Restoration, and Rehabilitation, http://www.nap.edu/

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 11

WORK ZONE SAFETY

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 11

WORK ZONE SAFETY

A INTRODUCTION

Construction, maintenance, and utility work, along with traffic incident management, are roadwork operations that create highway safety challenges. The changes to normal traffic flow and the introduction of unexpected travelling conditions at many work zones may generate hazardous situations and serious traffic conflicts. A comprehensive plan for work zone safety is required to minimize the risks and effects of these roadwork operations. Any activity within the highway right of way shall be subjected to the requirements of work zone safety.

B BACKGROUND

Section 316.0745, Florida Statutes, mandates the Department of Transportation compile and publish a manual of traffic control devices for use on the streets and highways of the state. To comply with this statute, the *Federal Highway Administration's (FHWA) Manual on Uniform Traffic Control Devices (MUTCD)* has been adopted for use in *Rule 14-15.010, Florida Administrative Code (F.A.C.)*.

The intent of this chapter is to require conformance to the *MUTCD, Part 6*.

C OBJECTIVES

Managing traffic during roadwork operations is necessary to complete roadwork or resolve traffic incidents in a timely manner while minimizing traffic delays, maintaining access to travelers, and most importantly maintaining an acceptable level of safety. The general objective of a program of work zone safety is to protect workers, traffic incident responders, pedestrians, bicyclists, and motorists during roadwork operations. This general objective may be achieved by meeting the following specific objectives:

- Provide adequate advance warning and information about upcoming work zones
- Provide the pedestrians, bicyclists and motorists clear information to understand how to navigate through or around the work zone
- Reduce the consequences of an out-of-control vehicle

- Provide safe access and storage for equipment and material
- Promote the speedy completion of projects (including thorough cleanup of the site)
- Promote the use of the appropriate traffic control and protection devices
- Provide safe passageways for pedestrians through, in, and/or around construction or maintenance work zones, including persons with disabilities in compliance with the ***2006 Americans with Disabilities Act Standards for Transportation Facilities*** as required by ***49 C.F.R 37.41 – Construction of Transportation Facilities by Public Entities*** or ***37.43 - Alteration of Transportation Facilities by Public Entities*** and the ***2017 Florida Accessibility Code*** as required by ***61G20-4.002***.

D POLICY

Each agency with responsibilities for construction, maintenance, utility, or traffic incident management, or any roadwork operations on streets and highways shall develop and maintain a program of work zone safety, as set forth in the ***MUTCD, (Chapter 6A)***. Additional requirements related to all highway construction projects financed in whole or in part with federal-aid highway funds are provided in ***Title 23 Code of Federal Regulations (CFR) 630 Subpart J***, more commonly known as the ***Work Zone Safety and Mobility Rule*** impose additional requirements for the design and construction of projects financed in whole or in part with federal-aid highway funds.

E PLANNING OF ROADWORK OPERATIONS

The achievement of work zone safety requires careful and complete planning prior to the initiation of any roadwork. The planning objective is to develop a comprehensive temporary traffic control plan that includes the following considerations:

E.1 Project Requirements

E.1.a Type of Operation

Roadwork operations may be further classified as routine, unplanned, or planned operations.

E.1.a.1 Routine Operations

Routine operations would involve projects such as mowing, street cleaning, and preventive maintenance operations conducted on a regularly scheduled basis.

E.1.a.2 Unplanned Operations

Unplanned operations require prompt, efficient action to restore the roadway to a safe condition. These include traffic incident management such as clearing vehicle crash or storm debris, addressing hazardous materials spills, repairing or replacing damaged highway safety components and restoring inoperative traffic control devices.

E.1.a.3 Planned Operations

Planned operations are scheduled roadwork projects, neither routine nor time-sensitive in nature, that are occasionally required to maintain or upgrade a street or highway.

E.1.b Nature of the Roadwork

The development of the temporary traffic control plan for work zone safety should include consideration of the following factors:

- Time span required
- Requirements for continuous operation or occupation of the work zone
- Capability of clearing the site during cessation of work activity
- The various construction methods, equipment, and procedures that may be utilized. Evaluation of alternate methods should be undertaken to determine the safest and most efficient procedures
- The necessity for storing equipment or material in the highway right of way
- Roadwork operations that may expose workers to hazards from through traffic
- Hazards to out of control vehicles such as excavations or unguarded structures or equipment
- Equipment inspection and preventive maintenance program

E.1.c Nature of the Work Zone

The nature of the work zone and the prevailing traffic conditions should, to a large degree, influence the procedures incorporated into the plan for work zone safety. The development of the temporary traffic control plan should include consideration of the following factors:

- Location of the work zone in relation to the proximity to side streets, driveways, bus stops, schools, parks, places of worship, etc.
- Determination of the design vehicle, normal vehicle travelling speed, and traffic volumes.
- Distribution of traffic with respect to peak traffic periods (seasonal, day of week, time of day, etc.)
- Truck percentage, frequency of transit vehicles, and direction of traffic is also important for establishing traffic control procedures.
- Presence of Intelligent Transportation Systems (ITS) such as dynamic message boards.
- Site conditions that may be confusing or distracting to the motorist, pedestrian, or bicyclist.
- Limitations on sight distance.
- Decreased visibility associated with nighttime roadwork operations.
- Impacts of detours and diversions to business and residential communities.
- Pedestrian and bicycle accommodations.
- Reasonableness of detour length and complexity.

E.2 Work Scheduling

Proper work scheduling and sequencing of roadwork operations will not only promote efficiency, but also improve the safety aspects. Where feasible, routine operations and special projects should be conducted during periods of low traffic volume to reduce conflicts. Projects that may be carried out concurrently at the same site should be scheduled simultaneously to eliminate successive disruptions of traffic. Major projects that impede or restrict traffic flow should be coordinated and sequenced with similar projects in adjacent areas, to produce a minimum of disruption to orderly traffic flow in the overall highway network. The scheduling of work at a given location should include consideration of traffic generation (including special events), as well as traffic restrictions by work activities on the surrounding highway network.

E.3 Traffic Control and Protection

Plans for traffic control around or through work zones should be developed with safety receiving a high priority. Plans should include protection at work zones when work is in progress and when operations have been halted (such as during the night). Provisions for the protection of work crews, traffic control personnel, bicyclists, pedestrians (in areas of high pedestrian use, construction of temporary facilities should be considered), and motorists shall be included in the operation plans. The plan for traffic control and protection should consider provisions for the following:

- Advance warning devices
- Work zone traffic signs
- Clear view of work zone
- Roadway delineation and channeling devices
- Clear zone (***Chapter 4 – Roadside Design***)
- Regulatory information
- High visibility safety apparel for workers
- Traffic control officers and law enforcement
- Hazard warning
- Barriers

- Pedestrian and bicyclist safety
- Access for pedestrians, bicyclists, and vehicles
- Access to adjacent properties by the public during construction
- Location of construction vehicles and equipment, including access into and out of the work zone
- Night safety (***Chapter 6 – Lighting***)
- Personnel training
- Traffic control and protective devices – including transverse rumble strips (***Chapter 18 – Signing and Marking)***
- Transit Stops – including passenger access
- Abrupt changes in geometry (lane narrowing, lane drop, transitions)
- Turning restrictions
- Temporary traffic signals

E.4 Coordination with Others

To ensure safe and efficient roadwork operations, the temporary traffic control plan should be developed and executed in cooperation with interested individuals and agencies, which may include the following:

- Highway agencies
- Police agencies
- Emergency agencies
- Contractors
- Utilities
- Building departments
- Mass transit agencies
- Traffic generators
- Local residents and businesses
- Neighboring jurisdictions
- School Boards

- Postal Services
- Media
- Trash and recycling pick ups

F WORK ZONE MANAGEMENT

Roadwork operations shall follow an appropriate temporary traffic control plan.

F.1 Public Information

All reasonable effort should be made to inform the public of the location, duration, and nature of impending roadwork operations. Transit agencies should be given advanced notice of planned operations so they can be responsible for notifying their passengers.

F.2 Contracts and Permits

For construction and reconstruction projects, the general work zone layout; traffic control and protection procedures; occupational safety and health requirements; and specific traffic control devices required should be incorporated in the contract plans and specifications.

New utility installations in public rights of way are prohibited unless a permit by the appropriate highway agency is issued. Permits for routine maintenance (e.g., deteriorated pole/equipment replacement), minor alterations (e.g., changes in cable, wire, or transformer size), service drops, or emergency work should generally not be required. ***Occupational Safety and Health Administration (OSHA)*** regulations for work zone safety should be reviewed prior to any construction by utility companies involving encroachment of the highway right of way by workers, equipment or material.

F.3 Inspection and Supervision

A regular program of inspection and supervision of all construction and maintenance projects shall be established and executed.

G EVALUATION OF PROGRAM

The entire program for work zone safety should be periodically evaluated and revised to provide the safest practicable environment for workers, pedestrians, and motorists during roadwork operations.

CHAPTER 12

CONSTRUCTION

CHAPTER 12

CONSTRUCTION

A INTRODUCTION

The purpose of this chapter is to establish guidelines for field procedures, as they pertain to control of construction projects, supervision, and contract administration. All construction projects require an inspection process to administer the contract, to certify the project has been constructed within reasonable conformance with the plans/specifications, and the materials which were incorporated into the project were properly tested/certified.

All construction projects require:

- An inspection procedure to administer the contract
- Certification

B OBJECTIVES

Construction of street and highway facilities is the result of the effort, of the engineer, the contractor, and the owner. Minimum construction standards shall be followed to provide for proper implementation of the design. The following general objectives for roadway construction should be followed to ensure proper construction:

- All construction performed and all materials utilized shall be in reasonably close conformity with the construction plans and contract documents.
- The responsibilities and obligations of the owner, engineer, and contractor should be clearly defined.
- A safe working environment shall be provided in accordance with ***Chapter 11 – Work Zone Safety***.
- Adequate procedures through established methods of sampling and testing shall be implemented to provide for the control and placement of materials.

C CONTROL OF THE WORK

C.1 Plans and Contract Documents

The Contractor will be furnished an appropriate number of copies of the plans and special provisions as required for the particular project. The Contractor shall have available at the work site, at all times, one copy each of the plans (including relevant Design Standards), Specifications, and Special Provisions.

C.1.a Plans

The plans furnished consist of general drawings showing such details which are necessary to give a comprehensive idea of the construction contemplated. Roadway plans will show, in general, alignment, profile grades, typical cross sections, and general cross sections as necessary. Structure plans, in general, will show in detail all dimensions of the work contemplated.

C.1.b Alterations in Plans

No changes shall be made on any plan or drawing after it is approved by the Engineer, except as authorized in writing by the Engineer. All authorized alterations affecting the requirements and information given on the approved plans shall be in writing.

C.1.c Working Drawings (for Structures)

C.1.c.1 General

The Contractor shall furnish such working, shop, and erection drawings, as may be required, to complete the structure in compliance with the design shown on the plans.

C.1.c.2 Submission of Working, Shop, and Erection Drawings

All working, shop, and erection drawings prepared by the Contractor or his agents (subcontractor, fabricator, supplier, etc.) shall be reviewed, dated, stamped, approved, and signed by the Contractor prior to submission to the Engineer of Record for review. The Contractor's signed approval of drawings submitted shall confirm he/she has verified the work requirements, field measurements, construction criteria, sequence of assembly and erection, access and clearances, catalog numbers, and other similar data. Each series of drawings shall indicate the specification section and page or drawing number of the contract plans to which the submission applies. The Contractor shall indicate on the working, shop, and erections drawings all deviations from the contract drawings and shall itemize all deviations in his letter of transmittal.

C.1.c.3 Responsibility for Accuracy of Working Drawings

It is understood that approval by the Engineer of the Contractor's working drawings does not relieve the Contractor of any responsibility for accuracy of dimensions and details, or for conformity of dimensions and details. The Contractor shall be responsible for agreement and conformity of his working drawings with the approved plans and specifications.

C.2 Coordination of Plans, Specifications, and Special Provisions

The specifications, plans, special provisions, and all supplemental documents are integral parts of the contract, and a requirement occurring in one is as binding as though occurring in all. They are to be complementary and to describe and provide for a complete work.

In cases of discrepancy, the governing order of the documents shall be as follows:

- Special Provisions
- Plans
- Standard Drawings
- Specifications

C.3 Conformity of Work with Plans

All work performed and all materials furnished shall be in reasonably close conformity with the lines, grades, cross sections, dimensions, and material requirements, including tolerances, shown on the plans or indicated in the specifications.

In the event the Engineer finds the materials or the finished product in which the materials are used not within reasonably close conformity with the plans and specifications, but reasonably acceptable work has been produced, he/she shall then make a determination if the work shall be accepted and remain in place. In this event, the Engineer will document the basis of acceptance by contract modification which will provide for an appropriate adjustment in the contract price for such work or materials as he deems necessary to conform to his determination based on engineering judgment.

In the event the Engineer finds the materials, or the finished product in which the materials are used, or the work performed, are not in reasonably close conformity with the plans and specifications and have resulted in an inferior or unsatisfactory product, the work or materials shall be removed and replaced or otherwise corrected by and at the expense of the Contractor.

C.4 Conformity of Work Shown in Regulatory Permits

All work shall be accomplished in accordance with special conditions of the regulatory permits.

C.5 Authority of the Engineer

All work shall be performed to the satisfaction of the Engineer.

C.6 Engineering and Layout

C.6.a Control Points Furnished

Horizontal and vertical control points are required at appropriate intervals along the line of the project to facilitate the proper layout of the work. The Contractor shall preserve all control points furnished.

C.6.b Layout of Work

Utilizing the control points furnished, all horizontal and vertical controls shall be established as necessary to construct the work in conformance with the plans and specifications. The work shall include performing all calculations required and setting all stakes needed, such as grade stakes, offset stakes, reference point stakes, slope stakes, and other reference marks or points necessary to provide lines and grades for construction of all roadway, bridge, and miscellaneous items.

C.6.c Personnel, Equipment, and Record Requirements

The Contractor shall employ only competent personnel and utilize only suitable equipment in performing layout work.

Adequate field notes and records shall be kept as layout work is accomplished. These field notes and records shall be available for review by the Engineer as the work progresses and copies shall be furnished to the Engineer at the time of completion of the project. Any inspection or checking of the Contractor's field notes or layout work by the Engineer, and the acceptance of all or any part thereof, shall not relieve the Contractor of his responsibility to achieve the lines, grades, and dimensions shown in the plans and specifications.

C.7 Contractor's Supervision

C.7.a Prosecution of Work

The Contractor shall give the work the constant attention necessary to assure the scheduled progress and shall cooperate fully with the Engineer and with other contractors at work in the vicinity.

C.7.b Contractor's Superintendent

The Contractor shall at all times have on the work site, as his/her agent, a competent superintendent capable of thoroughly interpreting the plans and specifications and thoroughly experienced in the type of work being performed, and who shall receive the instructions from the Engineer or his/her authorized representatives. The superintendent shall have full authority to execute the orders or directions of the Engineer and to supply promptly any materials, tools, equipment, labor, and incidentals which may be required. Such superintendence shall be furnished regardless of the amount of work sublet.

C.7.c Supervision for Emergencies

The Contractor shall have a responsible person available at or reasonably near the work site on a twenty-four hour basis, seven days a week, in order that he/she may be contacted in emergencies and in cases where immediate action must be taken to maintain traffic or to handle any other problems that might arise. The Contractor shall be responsible for initiating, installing, and maintaining all traffic control devices as described in ***Chapter 11 – Work Zone Safety*** and in the plans.

C.8 General Inspection Requirements

C.8.a Cooperation by Contractor

No work shall be done nor materials used without suitable supervision or inspection by the Engineer. The Contractor shall furnish the Engineer with every reasonable facility for ascertaining whether the work performed and materials used are in accordance with the requirements and intent of the plans and specifications.

C.8.b Failure of Engineer to Reject Work During Construction

If, during or prior to construction operations, the Engineer should fail to reject defective work or materials, whether from lack of discovery of such defect or for any reason, such initial failure to reject shall in no way prevent his/her later rejection when such defect is discovered.

C.9 Final Construction Inspection Maintenance until Final Acceptance

The Contractor shall maintain all work in first-class condition until it has been completed as a whole and has been accepted by the Engineer. When all materials have been furnished, all work has been performed, and the construction contemplated by the contract has been satisfactorily completed, the Engineer will make the final inspection.

D CONTROL OF MATERIALS

D.1 Source of Supply and Quality Requirements

D.1.a Only Approved Materials to be Used

Only materials conforming to the requirements of the specifications and approved by the Engineer shall be used in the work. Any materials proposed for use may be inspected or tested at any time during their preparation and use. No material which, after approval, has in any way become unfit for use, shall be used in the work.

D.2 Inspection and Tests at Source of Supply

D.2.a General

The Engineer may undertake the inspection of materials at the source of supply.

D.2.b Cooperation by Contractor

The Contractor shall assure the Engineer has free entry at all times to such parts of the plant as concern the manufacture or production of the materials ordered, and shall bear all costs incurred in providing all reasonable facilities to assist in determining whether the material furnished complies with the requirements of the specifications.

D.3 Control by Samples and Tests

D.3.a Materials to be Tested, Samples

The Engineer may require any or all materials to be subjected to tests by means of samples or otherwise, at production points, after delivery, or both, as he/she may determine.

D.3.b Applicable Standards

Methods of sampling and testing materials shall conform to the Engineer's requirements and should be in accordance with ***Florida Sampling and Testing Methods (FSTM)*** so far as covered therein. Otherwise, they should be in accordance with Standards of AASHTO, ASTM, or other criteria as specifically designated by the Engineer. Where an AASHTO, ASTM, or other non-Florida Method is designated, but a Florida Method which is similar exists, sampling and testing should be in accordance with the Florida Method.

Whenever in these Specifications, FSTM, AASHTO, ASTM, or other standards are referenced without identification of the specific time of issuance, the reference should be construed to mean the most current issuance, including interims or addendums thereto, at the time of advertisement for bids for a project.

D.4 Quality Control System

D.4.a General Requirements

The Contractor shall furnish and maintain a quality control system that will provide reasonable assurance that all materials and products submitted for acceptance conform to the contract requirements, whether manufactured or processed by the Contractor or procured from suppliers or subcontractors. The Contractor shall perform or have performed the inspection and tests required to substantiate product conformance to contract requirements and shall also perform or have performed all inspections and tests otherwise required by the contract.

D.4.b Documentation

The Contractor shall maintain adequate records of all inspections and tests. The records shall indicate the nature and number of tests made, the number and type of deficiencies found, the quantities approved and rejected, and the nature of corrective action taken, as appropriate.

D.4.c Corrective Actions

The Contractor shall take prompt action to correct any errors, equipment malfunctions, process changes, or other assignable causes which have resulted or could result in the submission of materials, products, and completed construction which do not conform to the requirements of the specifications.

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 13

PUBLIC TRANSIT

FIGURES

CHAPTER 13

PUBLIC TRANSIT

A INTRODUCTION

All modes of transportation (autos, trucks, transit vehicles, rails, aircraft, water craft, bicyclists, and pedestrians) should be considered when planning, designing, and constructing the surface transportation system. Where there is a demand for highways to serve vehicles, there could also be a demand for public transit or public transportation. Public transit should be considered in all phases of a project, including planning, preliminary design and engineering, design, construction, and maintenance. Coordination with the appropriate public transit provider(s) will help determine the need for transit related infrastructure on a project-by-project basis. The integration of public transit street side facilities along with pedestrian and bicycle facilities furthers the implementation of this goal.

Planning and designing for public transit is important because it is an integral part of the overall surface transportation system. Public transit is defined as passenger transportation service, local or regional in nature, which is available to any person. It operates on established schedules along designated routes or lines with specific stops and is designed to move relatively large numbers of people at one time. Public transit includes bus, light rail, street cars, bus rapid transit and paratransit.

With rising levels of congestion resulting in the use of new strategies to effectively and efficiently manage mobility, there is an increased demand for accessible and user friendly public transit. New strategies include increased emphasis on public transit and new emphasis on Transportation System Management (TSM), as well as Transportation Demand Management (TDM). TSM is the use of low cost capital improvements to increase the efficiency of roadways and transit services such as retiming traffic signals or predestinating traffic flow. TDM focuses on people reducing the number of personal vehicle trips, especially during peak periods. TDM includes the promotion of alternatives to the single occupant vehicle, including public transportation, carpooling, vanpooling, bicycling, walking, and telecommuting, as well as other methods for reducing peak hour travel.

Federal and State legislation provide the stimulus for planning, designing, and constructing a fully integrated transportation system benefiting the traveling public and the environment. Examples of legislation include ***Fixing America's Surface Transportation Act (FAST Act)***, ***Americans with Disabilities Act of 1990 (ADA)***, and ***Clean Air Act Amendment of 1990 (CAAA)***. In response to this legislation, the surface transportation system should provide for concurrent use by automobiles, public transit and rail, bicycles and pedestrians.

B OBJECTIVE

There are a number of methods to efficiently develop a coordinated surface transportation system. Coordination among agencies is necessary during the planning and design stages to:

- incorporate transit needs and during the construction phase for re-routing bus (and complementary pedestrian) movements, and
- for actual transit agency specific requirements (e.g., bus stop sign replacement, shelter installations, etc.).

For planning purposes, the state and local Transportation Improvement Program (TIP) should be referenced. Additionally, individual transit authorities have ten-year Transit Development Plans (TDPs) that are updated annually. The TDP can be used as a guide for planned transit needs along existing and new transportation corridors so transit consideration and transit enhancements can be incorporated where appropriate.

C TRANSIT COMPONENTS

C.1 Boarding and Alighting (B&A) Areas

Boarding and Alighting (B&A) areas help to create an accessible bus stop by providing a raised platform that is compatible with a bus that kneels or extends a ramp. A B&A area has a firm, stable and slip-resistant surface with a minimum clear length of 8.0 feet (measured perpendicular to the curb or roadway edge), and a minimum clear width of 5.0 feet (measured parallel to the roadway). Firm, stable, and slip resistant B&A areas are required if amenities such as benches or shelters are added to a bus stop. B&A areas are not required at bus stops on flush shoulder roadways where only a bus stop sign is provided. Coordinate with the appropriate public transit provider(s) to determine compatibility with equipment and transit vehicles.

The slope of the B&A area parallel to the roadway shall to the extent practicable, be the same as the roadway. For water drainage, a maximum slope of 1:50 (2%) perpendicular to the roadway is allowed. Benches and other site amenities shall not be placed on the B&A area. The B&A area can be located either within or outside the shelter, and shall be connected to streets, sidewalks, or pedestrian circulation paths by an accessible route.

On flush shoulder roadways, a B&A area may be constructed at the shoulder point (or edge of shoulder pavement on roadways with a design speed of 45 mph or less) as shown in Figures 13 – 1 and 13 – 2 Boarding and Alighting Area for Flush Shoulder Roadways. A Type "E" curb (5" curb height) should be used.

A sidewalk and/or ramp provided with the B&A area shall be a minimum of 5 feet in width, and the ramp shall not exceed a slope of 1:12. A detectable warning is required where a sidewalk associated with a B&A area connects to the roadway at grade. Except for the area adjacent to the 5" curb, the areas surrounding the B&A area shall be flush with the adjacent shoulder and side slopes and designed to be traversable by errant vehicles. On the upstream side of the platform, a maximum slope of 1:12 should be provided, and may be grass or a hardened surface. The B&A area (and ramp and level landing if needed) should be constructed with 6" thick concrete.

Figure 13 – 1 Boarding and Alighting Area for Flush Shoulder Roadways with Connection to the Roadway

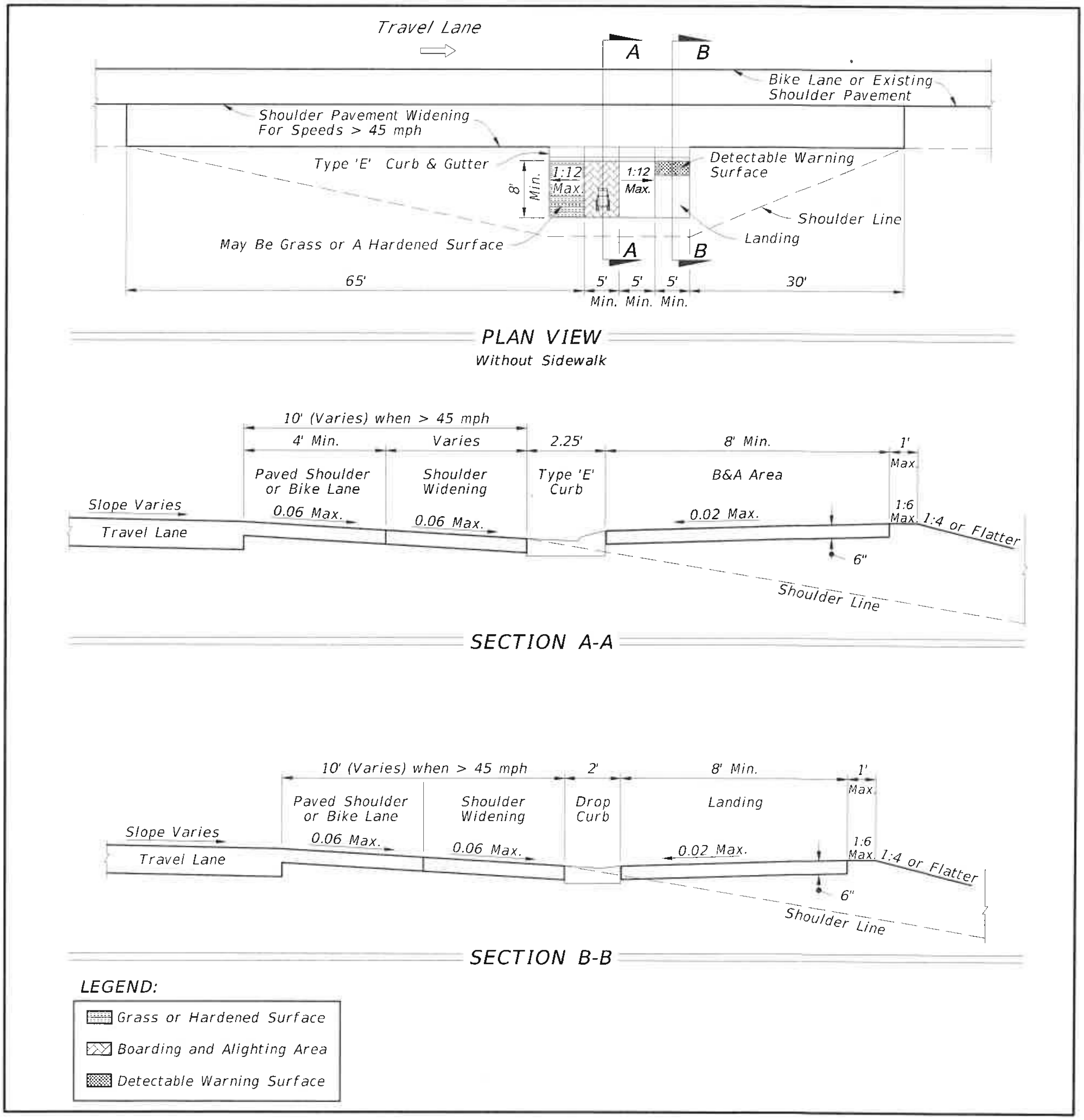
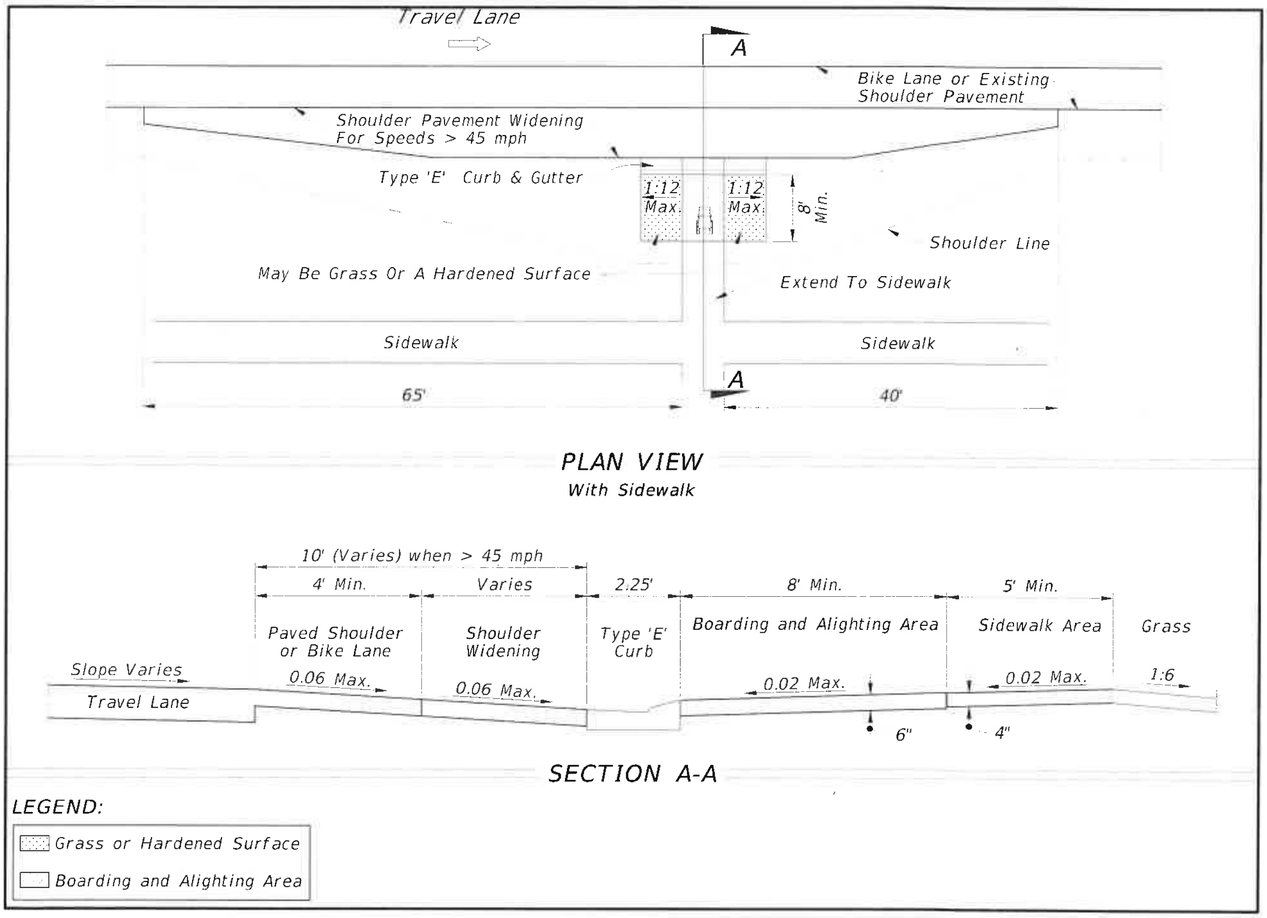


Figure 13 – 2 Boarding and Alighting Area for Flush Shoulder Roadways with Connection to the Sidewalk

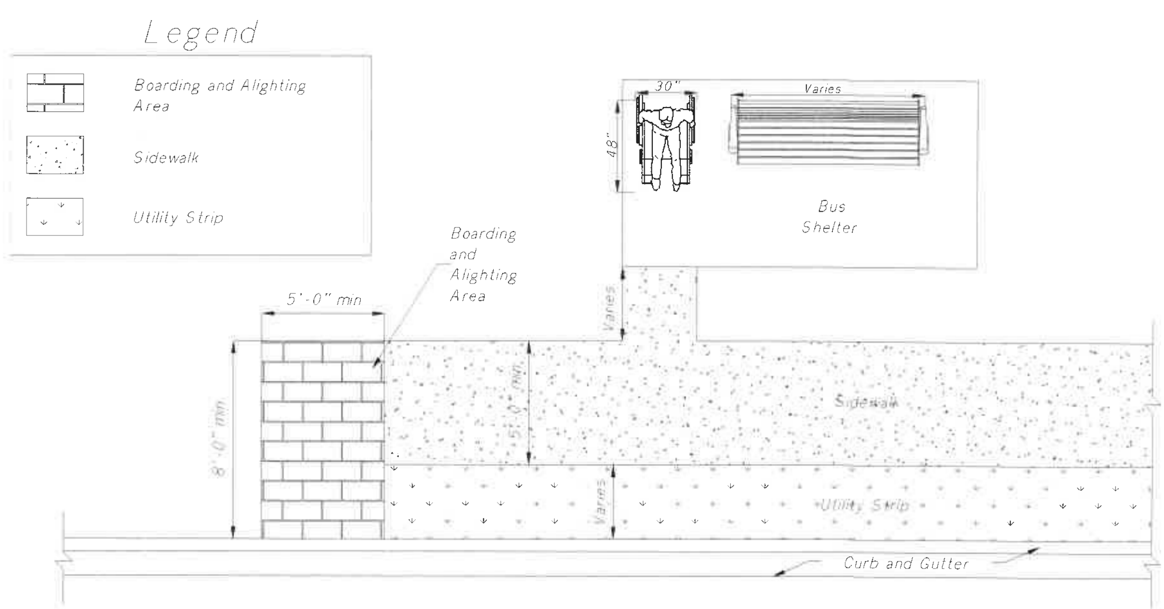


C.2 Shelters

Every public transit system has different needs with regards to shelters and corresponding amenities (e.g., benches, information kiosks, leaning posts, trash receptacles, etc.). Shelter foundation and associated pad size vary from stop to stop based on right of way availability, line of sight, and facility usage. New or replaced bus shelters shall be installed or positioned to provide an accessible route from the public way (sidewalk or roadway) to reach a location that has a minimum clear floor area of 30 inches by 48 inches, entirely within the perimeter of the shelter.

Shelters shall be connected by an accessible route to a B&A area. Coordinate with the appropriate public transit provider(s). Where feasible, shelters should provide a location for a bicycle rack. Shelters should be installed at locations where demand warrants installation and in accordance with clear zone criteria in ***Chapter 3 – Geometric Design, Section C.10.e*** Bus Benches and Transit Shelters and Chapter 4 – Roadside Design, Table 4 – 1 Minimum Width of Clear Zone of this Manual.

Figure 13 – 3 Bus Shelter Location



C.3 Benches

If a bench is provided, it should be on an accessible route, out of the path of travel on a sidewalk. Benches shall have an adjacent firm, stable and slip-resistant surface at least 30 inches wide and 48 inches deep to allow a user of a wheelchair to sit next to the bench, permitting the user shoulder-to-shoulder seating with a companion. Connection between the bench, sidewalk and/or bus B&A area shall be provided. Coordinate with the local public transit provider(s).

C.4 Stops and Station Areas

Transit stops should be located so that there is a level and stable surface for boarding vehicles. Locating transit stops at signalized intersections increases the usability for pedestrians with disabilities.

C.5 Bus Bays (Pullout or Turnout Bays)

Bus bays for transit vehicles may be necessary (e.g., extended dwell time, layover needs, safety reasons, high volumes or speed of traffic.). Bus bays can be designed for one or more buses. Coordinate with the local public transit provider(s) to determine the need for bus bays. When possible, bus bays should be located on the far side of a signalized intersection. The traffic signal will create the critical gap needed for bus re-entry into traffic. There are several publications available which provide additional design information for transit system applications. The Department District Public Transportation Office(s) maintains a library of these publications.

D PUBLIC TRANSIT FACILITIES

When a project includes a public transit route, curb-side and street-side transit facilities for bus stops should be considered in the roadway design process. Transit facilities shall comply with ***Chapter 14-20, Florida Administrative Code***.

The "Accessing Transit: Design Handbook for Florida Bus Passenger Facilities" provides guidance relating to provisions for curb-side and street-side facilities.

D.1. Curb-Side Facilities

Curb-side facilities are the most common, simple and convenient form of facilities at a bus stop. These include bus stop signs, shelters, bus stop B&A areas, benches, bike racks, leaning rails, and shelter lighting. "Accessing Transit" provides additional details and guidelines for each type of transit facility. Coordinate with the appropriate public transit provider(s) to determine the appropriate type and placement of amenities.

D.2 Street-Side Facilities

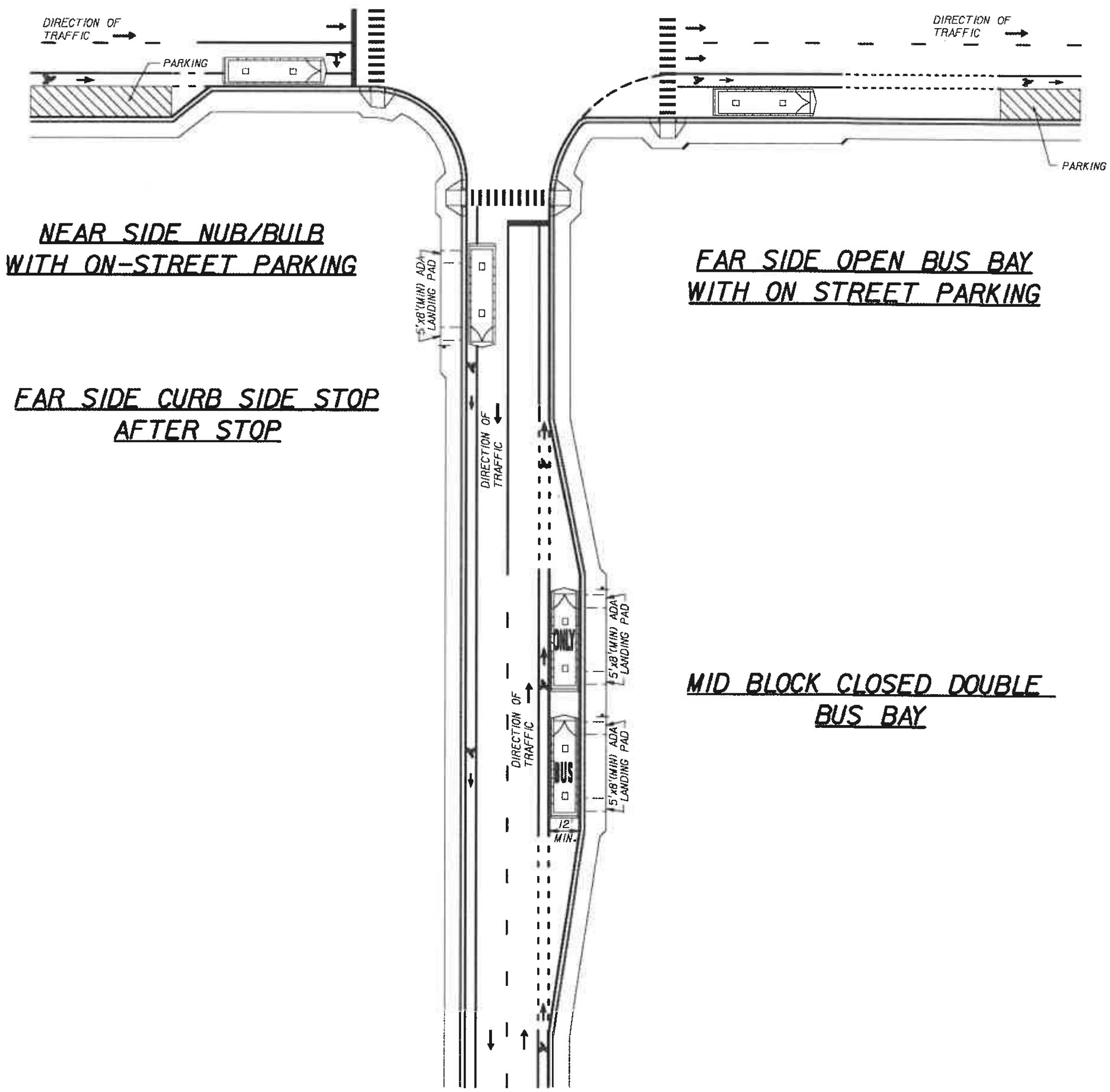
Bus stop locations can be categorized as far side, near side and mid-block stops. Bus stops may be designed with a bus bay or pullout to allow buses to pick up and discharge passengers in an area outside of the travel lane. This design feature allows traffic to flow freely without the obstruction of stopped buses. Far side bus stops and bays are preferred. See ***Accessing Transit, Version 3(2013)*** for a more detailed discussion of the location of the bus stop or bay.

Bus bays can be closed-ended, open-ended, or nubs/bulbs, and can be positioned near-side, far-side, or mid-block in relation to an intersection, as illustrated in Figure 13 – 3 Bus Shelter Location. The total length of the bus bay should allow room for an entrance taper, a stopping area, and an exit taper as a minimum. However, in some cases it may be appropriate to consider providing acceleration and deceleration lanes depending on the volume and speed of the through traffic. This decision should be based upon site specific conditions. "Accessing Transit" provides detailed bus bay dimensions for consideration with various right of way and access conditions.

D.3 Bus Stop Lighting

Lighting design for bus stops should meet the same criteria for minimum illumination levels, uniformity ratios and max-to-min ratios that are being applied to the adjoining roadway based on ***Chapter 6 – Lighting*** of this Manual. If lighting is not provided for the adjoining roadway, coordinate with the transit agency to determine if lighting should be provided for the bus stop area, particularly when night transit services are provided. A decision to install lighting for the adjoining bus stop area may include illumination of the bus bay pavement area. The use of solar panel lighting for bus stops is another option that should be considered.

Figure 13 – 4 Bus Stop Locations



E REFERENCES FOR INFORMATIONAL PURPOSES

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

- FDOT's Accessing Transit, Design Handbook for Florida Bus Passenger Facilities, Version III, 2013
  http://www.fdot.gov/transit/

- TCRP Report 155 – Track Design Handbook for Light Rail Transit, Second Edition
  http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_155.pdf

- Central Florida Commuter Rail Transit Project, Design Criteria – Phase 2 South RFP
  http://corporate.sunrail.com/wp-content/uploads/2015/06/P2S-RFP-Design-Criteria-06-15-15.pdf

- Transit facilities shall comply with Chapter 14-20, Florida Administrative Code, Private Use of Right of Way
  https://www.flrules.org/gateway/ChapterHome.asp?Chapter=14-20

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 14

DESIGN EXCEPTIONS AND VARIATIONS

EXHIBITS

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 14

DESIGN EXCEPTIONS AND VARIATIONS

A GENERAL

Uniform minimum standards for design, construction, and maintenance for streets and highways are contained in this Manual and meet or exceed the minimum values established by AASHTO. Consequently, the values given govern the design process. When it becomes necessary to deviate from the Manual's criteria, early documentation and approval are required.

Design Exceptions are required when proposed design elements are below both the criteria in this Manual and AASHTO's new construction criteria for the following Controlling Design Elements.

The 10 Controlling Design Elements for high speed (Design Speed ≥ 50 mph) roadways are:

- Design Speed
- Lane Width
- Shoulder Width
- Horizontal Curve Radius
- Superelevation Rate
- Stopping Sight Distance
- Maximum Grade
- Cross Slope
- Vertical Clearance
- Design Loading Structural Capacity

The 2 Controlling Design Elements for low speed (Design Speed < 50 mph) roadways are:

- Design Speed
- Design Loading Structural Capacity

When proposed design elements other than the Controlling Elements do not meet the criteria contained in this Manual, sufficient detail and justification of such deviations must be documented by the Responsible Professional Engineer as a Design Variation and submitted to the municipality or county.

This chapter provides the process for documentation and approval of Design Exceptions and Variations. The approved Design Exception or Variation submittal should be included in the project file to clearly document the action taken and the approval given.

Projects that comply with design criteria for local subdivision roads and/or residential streets adopted by ordinance do not require a Design Exception or Variation.

B RECOMMENDATIONS FOR APPROVAL

Design Exceptions and Variations are recommended by the Professional Engineer responsible for the project design element (Responsible Professional Engineer). All Design Exceptions and Variations require approval from the Maintaining Authority's Professional Engineer or Designee.

For additional information on the process to be followed for a Design Exception or Variation that involves a state facility or located on the National Highway System (NHS), please see FDOT's ***Design Manual, Chapter 122 Design Exceptions and Design Variations***

C COORDINATION

In order to allow time to research alternatives and begin analysis and documentation activities, it is critical that Design Exceptions and Variations be identified as early in the process as possible. This is preferably done during the planning phases of projects or as soon as possible during initial design.

When the need for a Design Exception or Variation has been determined, the Responsible Professional Engineer must coordinate with the Maintaining Authority's Professional Engineer or Designee and the Department (if applicable), to obtain conceptual concurrence and provide any requested documentation.

The Department will be involved only if the proposed design on the local (Non-State Highway System (SHS)) roadway is part of a Department project. For example, a Department project for a roadway on the SHS includes work on the adjacent local roads, or a Department project is exclusively on a local (Non-SHS) roadway. In these cases, the District Design Engineer will be listed for "concurrence" in the Design Exception or Variation request letter.

D JUSTIFICATION FOR APPROVAL

Sufficient detail and explanation must be given in order for the Maintaining Authority's Professional Engineer or Designee to approve the request for a Design Exception or Variation. The 10 Controlling Design Elements are considered to have significant effects on safety and the strongest case possible must be made if the designer is not able to meet these requirements. All deviations below the minimum criteria and standards in this Manual must be uniquely identified, located, and justified.

A strong case can be made if it can be shown that:

- The required criteria are not applicable to the site specific conditions.
- The project can be as safe by not following the criteria.
- The environmental or community needs prohibit meeting criteria.

Most often a case is made by showing the required criteria are impractical and the proposed design wisely balances all design impacts. The impacts required for documentation are:

- Safety and Operational performance
- Level of Service
- Right of Way impacts
- Community impacts
- Environmental impacts
- Costs
- Usability by all modes of transportation
- Long term and cumulative effects on adjacent sections of roadway

A case should not be made based solely on the basis that:

- The Department can save money.
- The Department can save time.
- The proposed design is similar to other designs.

E DOCUMENTATION FOR APPROVAL OF DESIGN EXCEPTIONS

Supporting documentation that is generated during the approval process is to accompany each submittal. Design Exceptions should include the following documentation:

1. Submittal/Approval Letter (Example shown in Exhibit 14-A)

2. Project Description:

    a) General project information, location map, existing roadway characteristics, project limits (mileposts), county section number, work mix, objectives, and obstacles.
    b) Associated or future limitations that exist as a result of public or legal commitments.

3. Project Schedule and Lifespan:

    a) Letting date and other important production dates associated with the project.
    b) Discussion of whether the deficiency is a temporary or permanent condition.
    c) Future work planned or programmed to address the condition.

4. Exception Description:

    a) Specific design criteria that will not be met (AASHTO, Florida Greenbook) and a detailed explanation of why the criteria or standard cannot be complied with or is not applicable.
    b) Proposed value for the project or location and why it is appropriate.
    c) Plan view, plan sheet, or aerial photo of the location, showing right of way lines and parcel lines of adjacent property.
    d) Photo of the area of the deficiency.
    e) Typical section or cross-section.
    f) Milepost or station location.

5. Alternative Designs Considered:

    a) Meeting AASHTO or Florida Greenbook criteria, partial correction, and the no-build (existing) condition.

6. Impacts of the Exception:

   a) Safety Performance:

      • Anticipated impact on safety, long and short term effects and of any anticipated cumulative effects.

      • Summary of the most recent 5-year crash history including any pertinent crash reports.

   b) Operational Performance:

      • Description of the anticipated impact on operations (long and short term effects) and any anticipated cumulative effects.

      • Summary of the amount and character of traffic using the facility.

      • Compatibility of the design with adjacent sections of roadway.

      • Effects on capacity and Level of Service (proposed criteria vs. AASHTO)

   c) Right-of-way

   d) Community

   e) Environment

   f) Usability by all modes of transportation

7. Anticipated Costs:

   a) Description of the anticipated costs (design, right of way, construction, maintenance).

8. Mitigation Measures:

   a) Practical mitigation measures or alternatives that were considered and any selected treatments implemented on the project.

9. Summary and Conclusions

When preparing a Design Exception, the Responsible Professional Engineer should consider potential mitigation strategies that may reduce the adverse impacts to highway safety and traffic operations. Please refer to the ***FHWA Mitigation Strategies for Design Exceptions*** ***(July 2007)*** for examples of mitigation strategies. The ***Highway Safety Manual (HSM)*** and ***Highway Capacity Manual*** provide information on quantifying and evaluating highway safety performance.

Benefit/Cost Analysis:

Calculate a benefit/cost analysis which estimates the cost effectiveness of correcting or mitigating a substandard design element. The "benefit" is the expected reduction in future crash costs and the "cost" is the direct construction and maintenance costs associated with the design. These costs are calculated and annualized so that direct comparison of alternate designs can be made.

A benefit/cost ratio equal to or greater than 1.0 indicates it may be cost effective to implement a particular design; however, the final decision is a management decision which considers all factors and applies sound engineering judgement. Key factors in the analysis are:

a) Evaluation of crashes by type and cause

b) Estimate of crash costs (based on property damage and severity of injuries)

c) Selection of a crash reduction factor based on proposed mitigation strategy

d) Selection of a discount rate (typically 4% for roadway projects)

e) Estimate of construction and maintenance costs

f) Selection of service life of the improvements

NOTE: The Department's ***Design Manual, Chapter 122 Design Exceptions and Design Variations*** provides guidance for the benefit/cost analysis, and may be used. The Department provides a useful tool, called ***Benefit Cost Analysis Spreadsheet Tool*** (BCAnalysis.xlsm), to aid in determining the benefit/cost ratio.

Conclusion and Recommendation:

a) The cumulative effect of other deviations from design criteria

b) Safety mitigating measures considered and provided

c) Summarize specific course of action

F DOCUMENTATION FOR APPROVAL OF DESIGN VARIATIONS

When proposed design elements other than the Controlling Elements do not meet the criteria contained in this Manual, sufficient detail and justification of such deviations must be documented by the Responsible Professional Engineer as a Design Variation and submitted to the municipality or county. The documentation, submittal and approval requirements for Design Variations are similar to that for Design Exceptions described in this chapter.

Design Variations should include:

a) Design criteria versus proposed criteria.

b) Reason the design criteria are not appropriate.

c) Justification for the proposed criteria.

d) Review and evaluation of the most recent 5 years of crash history where appropriate.

e) Background information which documents or justifies the request.

G FINAL PROCESSING OF DESIGN EXCEPTIONS AND VARIATIONS

After receiving conceptual approval from the designated Professional Engineer representative of the municipality or county, the documentation justifying the Design Exception or Variation shall be signed and sealed by the Responsible Professional Engineer and delivered to the municipality or county. ***Exhibit 14-A Sample Request Letter for Design Exception or Variation*** provides an example of an appropriate format and should be included with the signed and sealed supporting documents. The Design Exception or Variation will be reviewed for completeness and adherence to the requirements of this Chapter.

If the Design Exception satisfies all requirements, the acknowledgment of receipt will be signed by the Maintaining Authority's Professional Engineer or Designee, and, if applicable, forwarded to the Department's District Design Engineer for concurrence.

When all signatures are obtained, the Design Exception or Variation will be returned to the Responsible Professional Engineer. The original will be retained by the municipality or County and a copy kept by the Department, if applicable.

Exhibit 14-A Sample Request Letter for Design Exception or Variation

TO: ______________________________ DATE: __________________

SUBJECT: ☐ **DESIGN EXCEPTION or** ☐ **DESIGN VARIATION**

Local road number or street name: ______________________________
Project description (limits): ______________________________
Type construction (new, rehabilitation, adding lanes, resurfacing, etc.) ____________
Design Speed ______________________________
State and/or Federal road number (if applicable): ____________________
FDOT Financial Project ID No. (if applicable): ____________________

DESIGN EXCEPTION OR VARIATION FOR THE FOLLOWING ELEMENT:

( ) Design Speed
( ) Lane Width
( ) Shoulder Width
( ) Horizontal Curve Radius
( ) Superelevation Rate
( ) Stopping Sight Distance
( ) Maximum Grade
( ) Cross Slope
( ) Vertical Clearance
( ) Design Loading Structural Capacity
( ) Other (explain):
____
____

Include a brief statement concerning the project and items of concern.

Attach all supporting documentation to this exhibit in accordance with Chapter 14.

Recommended by: ______________________________
(Responsible Professional Engineer)

Approval: ______________________________
(Maintaining Authority's Professional Engineer or Designee)

Concurrence: ______________________________
FDOT (if applicable)

Concurrence: ______________________________
FHWA (if applicable)

CHAPTER 15

TRAFFIC CALMING

TABLES

FIGURES

CHAPTER 15

TRAFFIC CALMING

A INTRODUCTION

As Florida continues to grow, more and more of the major highways in its communities are becoming congested. This has caused many drivers to seek less crowded local residential streets as alternatives to get to their destinations. In many cases, this has meant the use of local residential streets as bypasses. The increase in traffic intrusion, volume, and speeds on residential streets has degraded the livability standards of various neighborhoods in Florida and as a result many residents complain about their environment (noise, air pollution), livability (quality of life, traffic intrusion, excessive volume, and speed of traffic), safety (as well as safety of their children, pets, and property) and physical characteristics (absence of sidewalks, etc). This chapter provides some guidance to Florida roadway planners, designers, and traffic engineers on how to address concerns about maintaining or enhancing the quality of life in residential neighborhoods by balancing the need for safety for all roadway users and adjacent property owners of the street network and maintaining the integrity of the highways networks as a whole.

B PLANNING CRITERIA

Traffic calming is the combination of mainly physical measures that reduce the negative effects of motor vehicle use, alter driver behavior, and improve conditions for non-motorized street users.

Communities undertaking a traffic calming program shall have a procedure for planning which neighborhoods and roadways qualify for participation in the program. Specifics of these methods shall be developed by the local jurisdictions. The methods will likely vary from locality to locality. However, some issues should be addressed in all communities:

- Through the public involvement process, adjacent residents and road users who are impacted by the situation should be included in identifying the concern(s).
- The need for traffic-calming measures should be confirmed by appropriate studies (license plate survey, speed, volume, crash analyses) studied.
- Once the concerns are clearly identified and confirmed by traffic studies, and documented, it will provide the focus for possible solution, prioritizing, and development of appropriate traffic calming measures. It will also help determine the best approach to address the concerns.
- When developing traffic calming measures, in addition to the affected property owners, emergency response, transit, school, and sanitation officials and any other entities impacted by the installation of such devices should be included in the review process.

Traffic calming may not be the appropriate method in all cases to address vehicle speeds, volumes, and safety. Alternative solutions or educational tools may be considered, as well as coordinated effort with law enforcement.

The application of traffic calming measures should consider possible network and access issues. A system impact analysis should be performed as part of the development process. Vehicular and pedestrian counts, speed data, and crash history of the streets under evaluation should be reviewed. Storm water and environmental impacts also need to be addressed, as well as facility type, urban and rural design factors, and driveway densities.

Design details for each traffic calming measure may vary depending on local conditions. Factors to be considered include both horizontal and vertical deflection, ease of use, emergency vehicle accessibility, ease of maintenance, and facility type. Operational considerations and geometrics are critical factors to consider as well. A list of references and resources to consider in providing more detailed design factors and information can be found at the end of this section. It may be desirable to begin with less restrictive measures and progress to more restrictive ones in stages.

Listed below are some "Do's" and "Don'ts" of the planning process for traffic calming which may be helpful in working through the design process.

Do's and Don'ts of the Planning Process

Do the following:

- Install temporary traffic calming features and monitor them for a period of time before installing the permanent features. Testing features on site prior to permanent installation will relieve resident anxiety about the impact on their own driving patters and driving behaviors will adjust to the new route circumstances.
- Have an organized program including public involvement. Plans and policies should be approved and supported by the local government. Emphasize the selected treatments(s) will be initially in a "test" mode, with permanency pending the outcome measurement. Be able to describe what is being done to keep traffic off residential streets.
- Channel public resources by prioritizing traffic calming request according to documentable criteria, setting thresholds of volume, speed, etc., to merit treatment.
- Involve the local service agencies, including fire, police, and emergency medical services personnel, from the start.
- Consult with fire department and EMS personnel to develop the preferred design, particularly with speed humps and traffic circles. Set up traffic circles with cones and have fire trucks and other emergency vehicles drive around them; this will help determine what radius is best for the vehicles used in a given area. The same process can be used in the design of speed humps.
- Review traffic patterns in the neighborhood as a whole. Avoid solving the problem on one neighborhood street by just shifting the traffic to another neighborhood street.
- Consider appropriate landscape treatments as part of the traffic calming design and implementation.

- Make certain that all signing, pavement markings, and channelization is in accordance with the Manual on Uniform Traffic Control Devices (MUTCD), the AASHTO Policy on Geometric Design of Highways and Streets, and Roundabouts: An Informational Guide, Second Edition, National Cooperative Highway Research Program (NCHRP 672).
- Check sight distances for vehicles, pedestrians, and bicyclists. Sight distance should be consistent with the dimensions shown in Chapter 3 – Geometric Design or Chapter 16 – Residential Street Design.
- Become familiar with the traffic calming features used in other communities and assemble references so that residents can be directed where to see them.
- Decide on a safe design speed beforehand and in consultation with neighborhood residents.
- Check sight distances by visiting the site before and after installation. Do parked cars obstruct sight distances? Do landscaping or other features obstruct sight distance?
- Review the illumination at night. Are additional street lights needed? Does landscaping block the light? Is there a shadow on one side of a median or traffic circle that might hide pedestrians from view?
- Review the channelization during the day and night. Is it a clear approach from all directions? Can it be seen at night? Watch the traffic: Is the driving public confused by the signing and channelization? Make adjustments as needed.
- Review the site for utility conflicts. Is there a fire hydrant? Does it need to be moved? Are there existing utilities in the way?
- Check the storm water drainage. Will the storm drain system need to be moved or revised? Can the runoff flow through or around the device?
- Review on-street parking. Will parked cars block the access of emergency vehicles through or around the proposed neighborhood traffic control devices? Add additional no parking zones where needed. Additional enforcement of parking restrictions may be required to keep the traveled path clear.
- Include weekends in traffic counts, as residential streets may have unique travel patterns and high use periods.

Don't do the following:

- Install neighborhood traffic calming features without a well-engineered program supported by the local government and public.
- Install neighborhood traffic calming features on arterial streets (See Section 1.C.2 for a discussion of roadway classifications). Typically, physical devices are not installed on streets with volumes greater than 3,000 vehicles per day, or with posted or operating speeds of greater than 30 MPH.
- Install neighborhood traffic calming features on streets without curbs unless supplemental features or other design considerations are included to keep vehicles within the traveled way.
- Install neighborhood traffic calming features on street with grades of greater than 10 percent.
- Install neighborhood traffic calming features on major truck routes.
- Install neighborhood traffic calming features on primary emergency routes. Contact local fire, emergency service, and police departments to determine these routes. Secondary access routes should be considered on a case-by-case basis.
- Install neighborhood traffic calming features on curving or winding roads with limited sight distance, unless reduced speed limits and adequate warning signs are used in conjunction with the devices.
- Place neighborhood traffic calming features in front of driveways.
- Neglect to check for conflicting utilities or drainage considerations.
- Install physical features on adjacent parallel routes, unless feasible design alternatives have been agreed upon, as this prevents or hinders emergency response.

C INAPPROPRIATE TRAFFIC CALMING TREATMENTS

C.1 Stop Signs

Unwarranted stop signs should not be used for traffic calming for the following reasons:

- Increase midblock speeds along the street because of drivers trying to make up for lost time
- Increase noise because of quick accelerations and decelerations
- Increase pollution
- Reduce drivers' expectation of a uniform flow
- Relocate the problem
- Cause disrespect for stop signs by drivers and bicyclists

Stop signs shall be used only when warranted per the ***MUTCD***.

C.2 Speed Bumps

Speed bumps shall not be used on public streets. Speed bumps are severe treatments 3 to 6 inches high and 1 to 2 feet long that slow drivers to speeds of less than 10 mph. Due to their abrupt rise and required low speed they can be a hazard to motorists and bicyclists. Speed *humps*, as described in Section D under vertical deflection, should not be confused with speed *bumps*.

C.3 Other Inappropriate Treatments

There are some other treatments that have been shown to be ineffective at reducing the speed and volume of traffic on local roadways. While a temporary improvement may result, long-term improvement is not likely; consequently, their use is discouraged. These treatments include the following:

- Novelty signs -While signs such as CHILDREN AT PLAY, SENIORS CROSS HERE and SLOW DEAF CHILD may make an infrequent roadway user aware of a specific local population, most regular users of the roadway are unaffected by the signs.

- Odd speed limit - NEIGHBORHOOD SPEED LIMIT 23 MPH and other odd speed limit signs place a high dependence on police to monitor speeders and are not consistent with the national practice required by the ***MUTCD*** of posting speeds limits in 5 mph increments.
- Crosswalks – Standard crosswalks marked only with signs and pavement markings do not affect motorists' speeds and should not be used by themselves as traffic calming treatments.
- Bicycle lanes – Standard bicycle lanes are not traffic calming treatments. They can be used to provide space for bicyclists between the sidewalk and travel lanes but should not be used by themselves for traffic calming.
- Speed trailers – While speed trailers can be used as part of a traffic calming program for educational awareness, they have no lasting effect on motorists' behavior.
- Reduced speed limit signs – Reduced speed limits without physical traffic calming measures do not slow drivers and should not be used for traffic calming.
- Rumble strips – These applications have high maintenance requirements and can cause severe noise problems. Also, they can be an obstacle to bicyclists.

D APPROPRIATE TRAFFIC CALMING TREATMENTS

The following sections describe some of the available traffic calming strategies. This list is not exhaustive, nor do the treatments necessarily fall exclusively into only one category.

In a typical traffic calming plan various types of treatments will be used. These plans will be based upon neighborhood preferences combined with engineering judgment.

Design details for traffic calming treatments will vary with application. Specific designs will need to be determined based upon the objective of the installations.

D.1 Vertical Treatments

Vertical treatments are those that depend upon a change in vertical alignment to cause drivers to slow down. When properly used, these treatments can be effective in reducing speeds and crashes. However, consideration should be given to impacts on emergency responders, buses, and, to some extent, bicyclists and motorcyclists.

Traffic calming features that alter the vertical alignment should not be installed near fire hydrants or mailboxes.

Information on signing and pavement markings for vertical deflections can be found in the *Manual on Uniform Traffic Control Devices (MUTCD)*.

Table 15 – 1 Vertical Treatments

Treatment	Description	Effect	Concerns	Cost
Raised Intersection	A raised plateau where roads intersect. Plateau is generally 4 inches above surrounding street.	Slows vehicles entering intersection and improves pedestrian safety.	Increases difficulty of making a turn.	Medium to High
Raised Crosswalk	Raised pedestrian crossing used in mid-block locations. Crosswalks installed on flat-top portion of speed table. See Figure 15 - 1	Reduces speed and is an effective pedestrian amenity makes pedestrians more visible.	May be a problem for emergency vehicles and vehicles with trailers.	Low to Medium
Speed Humps	Speed humps are parabolic, curved, or sinusoidal in profile, 3 to 4 inches in height and to 14 feet long. Comfortable speeds limited to 15 to 20 mph. See Figure 15 - 2.	Reduces speed.	May cause delays for emergency vehicles and impact patient comfort. May have greater impacts on longer wheelbase cars.	Low
Speed Tables	Speed tables are flat-topped speed humps, also 3 to 4 inches high but with a sloped approach taper on each side of a flat top. They are generally 20 to 24 feet long. Comfortable speeds limited to 20 to 25 mph.	Reduces speed.	May cause delays for emergency vehicles and impact patient comfort.	Low
Speed Cushions/ Pillows	Signed speed humps as described above.	Reduces speed.	May not slow all vehicles.	Low

Figure 15 – 1 Raised Crosswalk

Suwannee Street, Tallahassee, Florida

Figure 15 – 2 Speed Hump

Inside Loop Road, Orange County, Florida

D.2 Horizontal Treatments

Horizontal deflection treatments are often more expensive than vertical deflection treatments. However, they have less of an impact on emergency responders and large vehicles with multiple axles. They generally do not create problems for bicyclists and motorcyclists. Because pavement area is usually reduced, additional landscaping may be possible, making horizontal deflection treatments useful as part of neighborhood beautification projects.

Information on striping and signing roundabouts can be found in the ***MUTCD***.

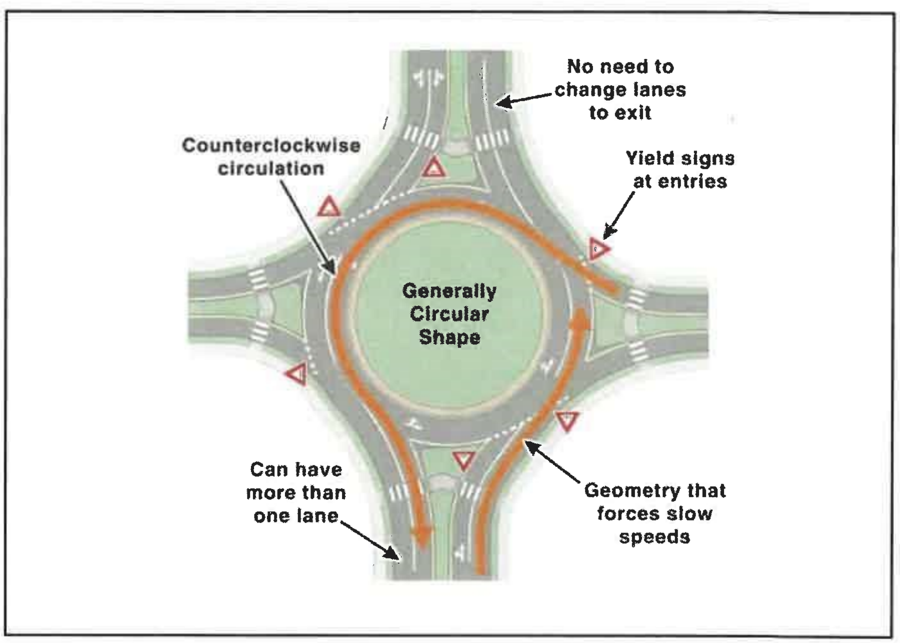
Table 15 – 2 Horizontal Treatments

Treatment	Description	Effect	Concerns	Cost
Angled Slow Point	Angled deviation to deter the path of travel so that the street is not a straight line	Reduces speed and pedestrian crossing distance.	Landscaping must be controlled to maintain visibility. Conflicts may occur with opposing drivers.	Medium to High
Chicanes	Mainline deviation to deter the path of travel so that the street is not a straight line. See Figure 15 - 3.	Reduces speed and pedestrian crossing distance.	A chicane design may warrant additional signing and striping to ensure that drivers are aware of a slight bend in the roadway. Increases the area possible for landscaping.	Medium to High
Mini-Circles	A raised circular island in the center of an existing intersection, typically 15 to 20 feet in diameter. May have mountable truck apron to accommodate large vehicles.	Reduces speed and both the number and severity of crashes.	May restrict larger vehicles. May cause some confusion when not signed properly. Some communities have documented increased crashes when mini-circles replaced all-way stop intersections.	Low to Medium
Roundabouts	A circular intersection with specific design and traffic control features, including yield control of all entering traffic, channelized approaches, geometric curvature. May be appropriate at locations as an alternative to a traffic signal. See Figure 15 - 4.	Reduces vehicle speeds and reinforces a change in the driving environment in transition areas.	May require more space at the intersection itself than other intersection treatments. While Roundabouts have sometimes been considered traffic calming features, they are primarily traffic control measures.	High

Figure 15 – 3 Chicanes

NACTO Urban Street Design Guide, National Association of City Transportation Officials

Figure 15 – 4 Key Roundabout Characteristics



NCHRP Report 672: Roundabouts: An Informational Guide, Second Edition

D.3 Neighborhood Entry Control

Neighborhood entry control treatments include partial street closures and gateway type tools. They are used to reduce speeds and volume at neighborhood access points and may be used in conjunction with neighborhood beautification or enhancement projects and residential area identification.

Table 15 – 3 Neighborhood Entry Control

Treatment	Description	Effect	Concerns	Cost
Chokers	Midblock reduction of the street to a single travel lane for both directions.	Reduces speed and volume.	Costs increase if drainage needs to be rebuilt.	Medium to High
Gateway Treatment or Entrance Features	Treatment to a street that includes a sign, banner, landscaping, and roadway narrowing or other structure that helps to communicate a sense of neighborhood identity.	Reduces entry speed and pedestrian crossing distance. Discourages intrusion by cut through vehicles and identifies the area as residential.	Maintenance responsibility. May lose some on street parking.	Medium to High
Curb Extensions or Bulb-outs	Realignment of curb at intersection or mid-point of a block to decrease pavement width. See Figure 15 - 5.	Visually and physically narrows the roadway, shortens pedestrian crossing distance, increases space for plantings, street furniture.	May impact sight distance, parking, and drainage.	Medium to High
Midblock Median, Slow Point	An island or barrier in the center of a street that separate traffic.	Provides refuge for pedestrians and cyclists.	Landscaping may impede sight distance.	Varies
Lane Narrowing	Street physically narrowed to expand sidewalks and landscaping areas. Could include median, on street parking etc.	Improved pedestrian safety.	May create conflict with opposing drivers in narrow lanes.	Medium to High
One-Way In or One-Way Out Channelization	Intersection reduction of the street to single travel lane with channelization. Also called half road closure.	Reduces speed and traffic.	Costs increase if drainage must be rebuilt. Transfers additional vehicles to other ingress/egress points.	Medium to High
Textured Pavement	A change in pavement texture, and color (e.g., asphalt to brick), that helps make drivers aware of a change in driving environment.	Enhances pedestrian crossings, bike lanes, or on street parking.	Increase maintenance. May increase noise.	Low to Medium

Figure 15 – 5 Curb Extension or Bulb Out

First and Lee Streets, Ft. Myers, Florida

D.4 Diverters

A diverter consists of an island or curbed closure, which prevents certain movements at intersections, and reduces speeds and volumes. By diverting motorists within a neighborhood they can significantly reduce cut through traffic.

Diverters must be planned with care because they will impact the people who live in the neighborhood more than anyone else. Trip lengths increase, creating inconvenience to residents. Emergency responders must also be considered when diverting traffic.

Bicyclists and pedestrians should be provided access through traffic diverters.

Table 15 – 4 Diverters

Treatment	Description	Effect	Concerns	Cost
Diagonal Diverters	Barrier placed diagonally across an intersection, interrupting traffic flow forcing drivers to make turns.	Eliminates through traffic.	May inhibit access by emergency vehicles and residents and increase trip lengths.	Medium
Forced Turn Barrier/Diverters	Small traffic islands installed at inter-sections to restrict specific turning movements.	Reduces cut through traffic.	Could impact emergency vehicles response time.	Low to Medium
Road Closures, Cul-de-sac	One or more legs of the intersection closed to traffic.	Eliminates through traffic improving safety for all street users.	May increase volumes on other streets in the area. Access restriction may cause concerns for emergency responders. Additional right of way for proper turnaround at dead ends may be required.	Low to Medium
Median Closures	Small median islands installed at cross streets to prevent through movements and restrict left turns.	Reduces cut through traffic.	Could impact emergency vehicle responses, inhibit access, and increase trip lengths or transfer volumes to other streets.	Low to Medium

D.5 Other Treatments

These treatments are most effective when used in combination with other physical traffic calming features, and should be used as supplements.

Table 15 – 5 Other Treatments

Treatment	Description	Effect	Concerns	Cost
Pavement Markings	Highlighting various area of road to increase driver's awareness of certain conditions such as bike lanes or crosswalks. See Figure 15 - 6.	Inexpensive and may reduce speed.	May not be as effective as a structure such as curb.	Low
Traversable Barriers	A barrier placed across any portion of a street that is traversable by pedestrians, bicycles, and emergency vehicles but not motor vehicles.	Eliminates cut-through traffic.	Inconvenience to some residents.	Medium
Colored Bike Lanes or Shoulders	A bike lane or shoulder painted, covered with a surface treatment or constructed of a pigmented pavement designed to contrast with the adjacent pavement.	Visually narrows the roadway and may reduce speeds.	May not be effective on roadways with 12 foot lanes.	Low to medium

Figure 15 – 6 Bicycle Lane, Advance Yield Bar and Crosswalk

Franklin Blvd, Tallahassee, Florida

E REFERENCES FOR INFORMATIONAL PURPOSAES

The publications listed below are additional sources, of information related to topics presented in this chapter. Search the Internet Web for up-to-date resources using "traffic+calming" as key words.

- Manual on Uniform Traffic Control Devices, with Revisions 1 and 2, May 2012 (MUTCD). US Department of Transportation, Federal Highway Administration http://mutcd.fhwa.dot.gov/kno_2009r1r2.htm

- Code of Practice for the Installation of Traffic Control Devices in South Australia, July 2013. Traffic and Operational Standards Section, Department Transportation, P.O. Box. 1, Walkerville, South Australia, 5081. (updated in 2013)

- National Cooperative Highway Research Program (NCHRP) Report 672, Roundabouts: An Informational Guide, Second Edition, (2010) http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_672.pdf

- The Florida Intersection Design Guide. Florida Department of Transportation, http://www.dot.state.fl.us/officeofdesign/publicationslist.shtm

- Traffic Calming Measures - Speed Hump, Institute of Transportation Engineers, http://www.ite.org/traffic/

- New York State Supplement (2001) to the Manual of Uniform Traffic Control Devices, 2009. Transportation Planning, Highway Safety, and Traffic Engineering Division, New York State Department of Transportation, 1220 Washington Avenue, Albany, NY 12232-0204. https://www.dot.ny.gov/divisions/operating/oom/transportation-systems/repository/B-2011Supplement-adopted.pdf

- New York State Vehicle & Traffic Law, (latest edition). New York State Department of Motor Vehicles, Swan Street Building, Empire State Plaza, Albany, NY, 12228.

- Roundabout Design Guidelines, Supplement to the NCHRP 672 (October 2012). Maryland Department of Transportation, State Highway Administration http://sha.md.gov/OHD2/MDSHA_Roundabout_Guidelines.pdf

- Traffic Control Systems Handbook, Revised Edition, 2005, Federal Highway Administration, DC 20590. (Updated in 2013) http://ops.fhwa.dot.gov/publications/fhwahop06006/

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 16

RESIDENTIAL STREET DESIGN

TABLES

CHAPTER 16

RESIDENTIAL STREET DESIGN

A INTRODUCTION

The street is a public way designed for the purposes of serving motor vehicles, bicycles, pedestrians, and transit vehicles. The primary function of residential streets is to provide access to homes that front those streets. The primary consideration, therefore, of residential street design should be to foster a safe and pleasant environment for the residents that live along the street, and safe traveling conditions for motorists, bicyclists and pedestrians. The convenience of motorists is a secondary consideration.

The street design should create an environment that cautions drivers that they are in a residential area where they must safely share the traveling space with pedestrians and bicyclists, both child and adult. Visual cues such as meandering streets, sidewalks, landscaping, signage, narrowed streets, changes in pavement texture (such as brick, stamped, or textured surfaces), and raised crosswalks all serve to heighten drivers' awareness for the need to maintain lower speeds. Incorporating such features into residential street design at inception will reduce or eliminate the need for traffic calming retrofits.

Section B of this chapter discusses the primary objectives of Residential Street Design in more detail, to aid the designer in the selection of proper criteria. ***Section C*** sets forth specific design criteria for residential streets.

B OBJECTIVES

The basic principles of residential street design are based on four factors:

1. Safety
2. Efficiency of Service
3. Livability and Amenities
4. Economy of Land Use, Construction, and Maintenance

The following 17 principles incorporate these factors. These principles are not intended as absolute criteria, since instances may occur where certain principles conflict. The principles should therefore be used as concepts for layout of proper street systems.

1. Adequate vehicular and pedestrian access should be provided to all parcels.
2. Local street systems should be designed to minimize through traffic movements unless it is specifically desired by the County or municipality to connect residential developments.
3. Street patterns should minimize excessive vehicular travel through connectivity between adjacent residential developments, and to larger street networks.
4. Local street systems should be logical and comprehensible, and systems of street names and house numbers should be simple, consistent, and understandable.
5. Local circulation systems and land-development patterns should not detract from the efficiency of adjacent major streets due to lack of connectivity.
6. Elements in the local circulation system should not have to rely on extensive traffic regulations and enforcement in order to function efficiently and safety.
7. Traffic generators within residential areas should be considered in the local circulation pattern.
8. The planning and construction of residential streets should clearly indicate their local function. The street's residential nature should be obvious to those driving on them.
9. The street system should be designed for a relatively uniform low volume of traffic.
10. Local streets should be designed to discourage excessive speeds.

11. Pedestrian-vehicular conflict points should be minimized.
12. The amount of space in the land development devoted to motor vehicle uses should be minimized.
13. Smaller block sizes may be used to encourage walking or bicycling. See ***Chapter 19 – Traditional Neighborhood Development*** for more information.
14. The arrangement of local streets should permit economical and practical patterns, shapes, and sizes of development parcels and provide interconnectivity without using arterials or collectors.
15. Local streets should consider and utilize topography from the standpoint of both economics and amenities.
16. Appropriate provisions for transit service within residential areas should be included.
17. Street design should consider horizontal and vertical compatibility and connectivity with sidewalks, bicycle lanes, and pedestrian walkways.

C DESIGN ELEMENTS

C.1 Design Speed

For local residential streets, design speeds of 15 to 30 mph are appropriate, depending on the adjacent development, terrain, available right of way, and other area controls. Alleys and narrow roadways intended to function as shared spaces (that is, could be used to access driveways, for garbage pickup, and travel by walking or bicycling) may have design speeds as low as 10 mph. Design speeds greater than 30 mph in residential areas require increased sight distances and radii which are contrary to the function of a local residential street.

C.2 Sight Distance

C.2.a Stopping Sight Distance

The minimum stopping sight distance is shown in Table 16 – 1 Minimum Stopping Sight Distance for Residential Streets.

Table 16 – 1 Minimum Stopping Sight Distance for Residential Streets

Design Speed (mph)	Stopping Sight Distance (feet)
10	45
15	75
20	125
25	150
30	200

C.2.b Passing Sight Distance

Passing should not be encouraged on local residential streets, and design for passing sight distance is seldom applicable on these streets. If longer straight sections and higher design and posted speeds support passing, the street shall be designed under the design criteria established in ***Chapter 3 – Geometric Design***.

C.2.c Intersection Sight Distance

Intersections shall be designed with adequate corner sight distance as set forth in Table 16 – 2 Minimum Corner Intersection Sight Distance for Residential Streets. Intersection design should take into consideration growth of landscaping and other amenities. Where a local residential street intersects a higher-order street, the design criteria of the higher-order street shall control within the right of way of the higher-order street.

Table 16 – 2 Minimum Corner Intersection Sight Distance for Residential Streets

Design Speed (mph)	Corner Intersection Sight Distance * (feet)
10	110
15	160
20	210
25	260
30	310

* Corner sight distance measured from a point on the minor road at least 14.5 feet from the edge of the major road pavement and measured from a height of eye at 3.5 feet on the minor road to a height of object at 3.5 feet on the major road.

Where stop or yield control is not used, the corner sight distance should be a minimum of 300 feet. If restrictions are unavoidable, a minimum of 200 feet is allowed with proper warning signage found in the ***Manual on Uniform Traffic Control Devices (MUTCD)*** such as an intersection warning sign (W2 series) or cross traffic does not stop here plaque (W4-4P). To maintain the minimum sight distance, restrictions on height of embankments, locations of buildings, and screening fences may be necessary. Any landscaping in the sight distance triangle should be low growing, and should not be higher than 3 feet above the level of the intersecting street pavements. Tree overhangs should be trimmed to at least 8 feet above the level of the intersections.

Intersecting streets should meet at approximately right angles. Angles of less than 60 degrees should be avoided.

C.3 Horizontal Alignment

C.3.a Minimum Centerline Radius

The minimum radii for horizontal curves are given in Table 16 – 3 Minimum Centerline Radii for Residential Streets. Typically, superelevation should not be utilized on local residential streets. Where superelevation is appropriate or required, the street shall be designed under the design criteria established in ***Chapter 3 – Geometric Design***.

Table 16 – 3 Minimum Centerline Radii for Residential Streets

Design Speed (mph)	Min. Centerline Radius (feet)
10	25
15	50
20	89
25	166
30	275

C.3.b Minimum Curb Return Radius

Where there are substantial pedestrian movements, the minimum radius of curb return where curbs are used, or the outside edge of pavement where curbs are not used shall be 15 feet. A minimum radius of 25 feet is desirable to accommodate turning movements of service vehicles.

C.4 Vertical Alignment

C.4.a Vertical Curves

Vertical curves shall be designed for a minimum stopping sight distance using the design criteria of 30 mph established in ***Chapter 3 – Geometric Design.***

C.5 Cross Section Elements

C.5.a Width of Roadway

The minimum width of a two-way residential roadway should be 20 feet from edge-of-pavement to edge-of-pavement (excluding curbs and gutters). Travel lanes should be a minimum of 10 feet wide, and wider where practicable. Under constrained conditions or in some very rural areas, lanes 9 feet or narrower may be used. Refer to ***Chapter 4*** of the ***AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400)***. Lanes narrower than 9 feet are prohibited in the absence of a Design Exception as provided for in ***Chapter 14 – Design Exceptions***.

When parking lanes are provided on one or both sides of the roadway, they shall be at least 7 feet wide including the gutter section where applicable.

Where curb and gutter sections are used, the roadway may be narrowed to the travel lane width (plus bike lane if present) at intersections. This will prevent parking close to the intersection, reduce crossing distances for pedestrians, provide space for curb ramps, and reduce turning speeds. By providing intersection curb extensions, the visual width of the roadway can be reduced.

C.5.b Medians

When used in residential areas, medians or traffic separators should conform to ***Chapter 3*** or ***Chapter 19***.

C.6 Cul-de-sacs and Turnarounds

C.6.a Turning Area

A residential street more than 100 feet long and open at one end only shall have a special turning area at the closed end. This turning area should be circular and have a radius appropriate to the types of vehicle expected. The minimum outside radius of a cul-de-sac shall be 30 feet. In constrained circumstances, other turning configurations such as a "hammerhead" may be considered. Cul-de-sacs can detract from connectivity if used excessively or inappropriately.

C.7 Pedestrian Considerations

C.7.a Sidewalks

In residential areas, sidewalks should be provided on both sides of the street. The sidewalks should be located as far as practicable from the travel lanes and usually close to the right of way line. In certain circumstances, such as where lots are very large or there are environmental limitations, sidewalk on only one side may be considered. Along collector roadways shared use paths may be provided in lieu of sidewalks. Connectivity to and between existing public sidewalk or shared use path facilities is desired.

Pedestrian access should be provided to schools, day care facilities, parks, churches, shopping areas, and transit stops within or adjacent to the residential development. Pedestrian access to these destinations and throughout the neighborhood shall be designed for safe and convenient pedestrian circulation. Sidewalks or shared use paths between houses or to connect cul-de-sacs may be used where necessary to provide direct access.

Sidewalks, crosswalks and mid-block crossings shall be constructed under the criteria set forth in ***Section C.7.d*** of ***Chapter 3 – Geometric Design***, and ***Chapter 8 – Pedestrian Facilities***.

C.8 Bicyclist Considerations

C.8.a Bicycle Facilities

Residential roadways are generally sufficient to accommodate bicycle traffic. When specific bicycle facilities are desired they should connect to existing facilities and be designed in accordance with ***Chapter 3 – Geometric Design*** and ***Chapter 9 – Bicycle Facilities***. For bike lane transitions, see ***Chapter 9***.

C.9 Shared Use Paths

Shared use paths may be provided in lieu of sidewalks along collector roads in accordance with ***Section C.7.a***. When shared use paths are desired, they should connect to other pedestrian and bicycle facilities within or adjacent to the residential area, and connect to schools, day care facilities, parks, churches, shopping areas, and transit stops. Shared use paths shall be designed in accordance with ***Section C*** of ***Chapter 9 – Bicycle Facilities***. Shared use paths may be used by golf carts in certain areas, under certain circumstances in accordance with ***Sections 316.212, 316.2125 and 316.2126, F.S***.

C.10 Clear Zone

Clear zone requirements for residential streets shall be based on ***Chapter 3 – Geometric Design***, Table 3 – 15 Minimum Width of Clear Zone.

D REFERENCES FOR INFORMATIONAL PURPOSES

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

- AASHTO Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400):
  https://bookstore.transportation.org/

- Manual on Uniform Traffic Control Devices (MUTCD)
  http://mutcd.fhwa.dot.gov/pdfs/2009r1r2/pdf_index.htm

CHAPTER 17

BRIDGES AND OTHER STRUCTURES

EXHIBITS

CHAPTER 17

BRIDGES AND OTHER STRUCTURES

A INTRODUCTION

Bridges provide safe passage for multimodal traffic over various obstacles along a road or path. This chapter presents guidelines and standards for designing, constructing, inspecting, and maintaining bridges as well as other structures such as walls and supports for signs, lights, and traffic signals. These standards and criteria are necessary due to the critical function these structures serve to communities throughout their lifespan. This chapter establishes uniform minimum standards and criteria for all bridges used by the public for vehicular and/or pedestrian traffic as well as other structures such as walls and supports for signs, lights, and traffic signals. The geometry of structures shall follow the standards and criteria set forth in ***Chapters 3, 8, 9***, and ***13***. Exceptions to these standards and criteria must be processed in accordance with the procedures described in ***Chapter 14***.

In addition to the design criteria provided in this chapter, the ***2006 Americans with Disabilities Act Standards for Transportation Facilities*** as required by ***49 C.F.R 37.41 or 37.43*** and the ***2017 Florida Building Code – Accessibility, 6th Edition*** as required by 61G20-4.002 impose additional requirements for the design and construction of pedestrian facilities on bridges or other structures. Examples of facilities include sidewalks and shared use paths, and drainage grates and inlets in or near the accessible route. Significant ADA design considerations exist for all facilities with grades that exceed 5%.

Note: This chapter applies to all bridges under local control, except for bridges constructed on or over the Department's system. For bridges constructed on and over the Department's system, as well as all bridges that will be maintained by the Department, the Department's policies, procedures, standards and specifications will apply.

B OBJECTIVES

The objectives of this chapter are as follows:

- To prescribe uniform criteria with respect to bridge and miscellaneous structures design and geometric layout.
- To alert owners to the various federal and state requirements to be included in the design, construction, maintenance, and inspection of their bridges and other structures.
- To provide practical suggestions specific to Florida on prudent structural engineering based on past experience with statutes, standards, and criteria.

C DESIGN

The design of bridges and other structures shall be led by a licensed professional engineer who shall assume responsible charge of the work. The standards and criteria included here are directed only toward specific considerations that shall be followed. Other considerations are necessary to create a comprehensive bridge design allowing owners and their engineer's flexibility in design. All bridges and other structures shall be designed in accordance with specifications (including guide specifications) published by the American Association of State Highway and Transportation Officials (AASHTO).

C.1 Bridges - General

All bridges and other structures shall be designed in accordance with specifications (including guide specifications) published by the American Association of State Highway and Transportation Officials (AASHTO). At a minimum, the ***AASHTO Load and Resistance Factor Design (LRFD) Bridge Design Specifications, 8th Edition (2017)*** shall be used. Any bridge reconstruction (i.e., lengthening, widening, and/or major component replacement) shall be designed as specified in this section. Record of such reconstruction shall be maintained as specified in Section D of this chapter. The remaining design life should be considered in the design.

C.2 Bridge Live Loads

In addition to the notional (HL - 93) design load specified in ***LRFD***, bridges shall also require a FL 120 permit load rating greater than 1 as defined in the Department's ***Structures Manual, Volume 1 – Structures Design Guidelines, 2018 (SDG)***. This vehicle allows for a more consistent load rating comparison considering the current bridge inventory.

C.3 Bridge Superstructure

The superstructure of a bridge is that portion of the structure that spans between its supports or piers. Considerations that shall be incorporated into the design of all superstructures will include the following:

C.3.a Girder Transportation

The Engineer of Record (EOR) is responsible for investigating the feasibility of transportation for heavy, long and/or deep girder field sections. In general, the EOR should consider the following during the design phase:

- Whether or not multiple routes exist between the bridge site and a major transportation facility.
- The transportation of field sections longer than 130 ft or weighing more than 160,000 pounds requires coordination through the Department's Permit Office during the design phase of the project. Shorter and/or lighter field sections may be required if access to the bridge site is limited by roadway(s) with sharp horizontal curvature or weight restrictions.
- On steel superstructures, where field splice locations required by design result in lengths greater than 130 feet, design and detail "Optional Field Splices" in the plans.
- For curved steel box girders, prefabricated trusses, and integral pier cap elements, size field pieces such that the total hauling width does not exceed 16 feet.

C.3.b Vertical Clearance

All new bridges over roadways and shared use paths shall be designed to meet the vertical clearance standards specified in ***Chapter 3, Section C.7.j.4.(b)***, and ***Chapter 9, Section C.6***.

All new bridges over water shall be designed to meet the following vertical clearance standards:

- To allow debris to pass without causing damage, the clearance between the design flood stage and the low member of bridges shall be a minimum of two feet. This standard does not apply to culverts and bridge-culverts.

- For crossings subject to boat traffic, the minimum vertical navigation clearance should be:

Tidewater bays and streams	6 feet above Mean High Water *
Freshwater rivers, streams, non-regulated/controlled canals, and lakes	6 feet above Normal High Water
Regulated/controlled lakes and canals	6 feet above control elevation

* For locations subject to tidal salt / brackish water splashing, a 12-foot vertical clearance above Mean High Water should be considered for bridge durability reasons.

Higher clearances apply for crossings over legislated channels under the control of the U.S. Coast Guard (USCG). Designers should also consider future navigation demands and future shared use path demands in setting the vertical clearance of a bridge.

C.3.c Railings

All traffic, pedestrian, and bicycle railings shall comply with the requirements in ***Section 13*** of ***LRFD***. Traffic railings shall meet the crash requirements of at least Test Level 3 (TL-3) for bridges with design speeds greater than 45 mph and at least TL-2 for design speeds less than or equal to 45 mph.

For pedestrian/bicycle railings, two-pipe guiderails and details similar to the Department's ***Standard Plans, Indexes 515-070 and 515-080*** may be mounted on walls or other structures where drop-off hazards are 5 feet or less. Concrete, aluminum or steel railing and details similar in strength and geometry to the Department's ***Standard Plans, Indexes 515-021 thru 515-080 and 521-820 thru 521-825*** shall be used (or modified to suit environmental runoff concerns) where drop-off hazards are greater than 5 feet. See ***Standard Plans Instructions*** for more information.

C.3.d Expansion Joints

The number of joints should be minimized to reduce the inspection and maintenance needs of the bridge.

C.3.e Drainage

All bridge designs shall include a drainage design that is specific to its site. Conveyance of drainage off the bridge roadway should be designed to meet spread standards contained in the Department's ***Drainage Manual, (2019)*** and may include open systems (i.e., scuppers) or closed systems (i.e., inlets and pipes) based on environmental permitting restrictions. Drainage from the bridge should not drop onto traffic below. Longitudinal conveyance piping attached to bridges is expensive and maintenance-intensive, and should be avoided whenever possible.

Conveyance of drainage off pedestrian facilities shall be designed to provide an accessible route for pedestrians. Further guidance on the design of bridge deck drainage may be found in the current version of ***FHWA Publication HEC-21, "Design of Bridge Deck Drainage."***

C.3.f End Treatments

Requirements for end treatments of structures are given in ***Chapter 4 – Roadside Design***. Bridge barriers shall be designed to accommodate connection of a guardrail transition or energy absorbing system.

C.4 Bridge Substructure

The substructure of a bridge consists of all elements below the superstructure including its bearings, piers, and foundations. For guidance on bridges vulnerable to coastal storms, see ***SDG, Section 2.5***. Considerations that shall be incorporated into the design of all substructures include the following:

C.4.a Scour

A hydrologic/hydraulic analysis shall be performed to quantify expected stages and flows at the bridge site. Anticipated substructure scour shall be developed for the following conditions:

Hydraulic Design Flood Frequency	Scour Design Flood Frequency	Scour Design Check Flood Frequency
Q_{10}	Q_{25}	Q_{50}
Q_{25}	Q_{50}	Q_{100}
Q_{50}	Q_{100}	Q_{500}
Notes: "Q" is the common term used for flow rate, an expression of volume of fluid which passes per unit of time. "x" is the return period in years (10, 25, 50, 100, 500).		

Any exceptions to the standards above hydrologic/hydraulic and scour analysis requirements shall be approved in writing by the Department's local District Drainage Engineer. Methodology for computing bridge hydrology/hydraulics and bridge scour should follow the guidelines set forth in the Department's ***Drainage Manual (2019).*** Further guidance and training may be obtained through ***FHWA Hydraulic Engineering Circulars (HEC) "HEC-18"*** and ***"HEC-20"*** and the Department's training courses on these topics. Additionally, for larger bridges (>120,000 sq. ft.), hydraulic designers may wish to consult with the local Department District Drainage Engineer for case-specific guidance. The ***SDG, Section 2.11*** and ***2.12*** and the Department's ***Drainage Manual, (2019)*** provide guidance on scour load combinations with other loads.

C.4.b Navigation Aids and Vessel Collision

All bridges over USCG designated navigable waterways shall include bridge fender systems and consideration for potential vessel collision.

For guidance on navigation aids and bridge fender system design, see SDG Section 314. For guidance on vessel collision design see ***SDG, Section 2.11*** and ***LRFD, Section 3.14***.

C.4.c Pier Locations

All bridges over roadways shall have substructures supports set back from vehicular traffic lanes in accordance with ***Chapter 3, Section C.7.j.4.(a)***.

All bridges over water shall have substructure supports located with horizontal clearance requirements as listed below. In this case, horizontal clearance is defined as the clear distance between piers, fender systems, culvert walls, etc., projected by the bridge normal to the flow.

- For crossings subject to boat traffic a minimum horizontal clearance of 10 feet shall be provided.
- Where no boat traffic is anticipated, horizontal clearance shall be provided consistent with debris conveyance needs and structure economy.

C.5 Retaining and Noise Walls

The design of conventional, anchored, mechanically stabilized, and prefabricated modular retaining wall structures shall meet the requirements of ***LRFD Section 11***. Local agencies should consider using only wall types approved by the Department. These are described in ***Section 3.12*** of the ***SDG***. Local agencies should also follow the design criteria for retaining walls found in ***Section 3.13*** of the ***SDG***.

The design of noise walls should meet the requirements of the ***SDG, Section 3.16***. For noise walls within the clear zone, their design and/or protection should comply with the following:

- For noise walls attached to the top of traffic railings only use crash tested systems consistent with the design speed of the facility. The Department has standards for TL-4 systems that meet the requirements of ***NCHRP Report 350 or the Manual for Assessing Safety Hardware (MASH)***.
- Non-crash tested noise walls may be attached to structures if located behind an approved traffic railing and mounted at least five feet from the face of the traffic railing at deck level.

Potential existing off-site stormwater 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 ***Section C.3.c. Railings.***

C.6 Sign, Lighting, and Traffic Signal Supports

The design of sign, lighting, and traffic signal support structures shall meet the requirements of ***AASHTO's LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals, 1st Edition, 2018 Interim Revisions***, and the Department's ***Structures Manual Volume 3 - FDOT Modifications to LRFD Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals (LRFDLTS-1)***.

C.7 Pedestrian Bridges

For guidance on pedestrian bridges, see ***SDG Chapter 10***.

D CONSTRUCTION

During the construction of a bridge or any structure at, over, or near a public facility, safety awareness is necessary and precautions shall be taken to protect the public. Provisions for protecting the public during construction shall be in accordance with the ***MUTCD (2009 Edition with Revision Number 1 and 2, May 2012)*** work zone traffic control procedures and the standards and criteria described in ***Chapter 11 – Work Zone Safety***. Worker safety is the responsibility of the contractor. Temporary barriers shall be installed on all bridges being widened or whose new construction is phased. Spread of stormwater on the bridge deck should be considered in planning temporary traffic routing.

During the construction of a bridge or any structure, records to be kept and maintained throughout its life shall include foundation construction records (pile driving records, shaft tip elevations, borings) and as-built plans. These records provide critical information necessary for future inspection, maintenance, emergency management, enhancement, reconstruction, and/or demolition of these structures. These records shall be delivered to the Department's local District Structures Maintenance Engineers.

Any proposed changes to the construction details or specifications shall be signed, sealed, and dated by a professional engineer licensed in the State of Florida.

E ROUTINE INSPECTION AND MAINTENANCE

Title 23, Code of Federal Regulations, Part 650, Subpart C, sets forth the ***National Bridge Inspection Standards (NBIS)*** for bridges on all public roads. ***Section 650.3*** defines bridges, specifies inspection procedures and frequencies, and indicates minimum qualifications for personnel. Each state is permitted to modify its bridge inspection standards to deviate from the NBIS standards but only following approval from the FHWA.

Section 335.074, F.S., mandates safety inspection of bridges. Bridge inspectors shall be certified in accordance with ***Chapter 14-48, F.A.C***. Safety inspection of bridges shall be conducted in accordance with ***Chapter 14-48, F.A.C***.

The Department inspects all bridges in Florida, both on-system and off-system. The Department provides each local government with copies of its inspection reports. Each local government should maintain these reports to be responsive to Metropolitan Planning Organization requests for bridge rehabilitation, replacement, or enhancement designations. Please see the following for further information: ***Bridge and Other Structures Reporting Manual 850-010-030***

All on-system and off-system bridges are assigned a Bridge Number by the Department. For new bridges, local agencies shall contact the Department's local District Structures Maintenance Engineers to have a number assigned.

F BRIDGE LOAD RATING AND POSTING

Section 335.074, F.S. Safety Inspection of Bridges requires that bridges on a public transportation facility be inspected for structural soundness and safety at regular intervals. The inspection shall consider age, traffic characteristics, state of maintenance, and known deficiencies of the bridge. The governmental entity having maintenance responsibility for any such bridge shall be responsible for having inspections performed and reports prepared.

As required by ***Section 335.074, F.S***., each inspection shall be reported to the Department, using the Bridge Load Rating Summary Table form shown in Exhibit A. Further information for preparing a bridge load rating summary and fillable form may be found on the Department's ***Office of Maintenance, Bridge Load Rating*** web site.

Upon receipt of an inspection report that recommends reducing the weight limit on a bridge, the governmental entity having maintenance responsibility for the bridge shall load post the bridge within 30 days in accordance FS 335.074(5). Further requirements for reporting and posting of weight, size or speed limits on bridges are found in this statute, ***Section 316.555 F.S. Weight, load, speed limits may be lowered***. The appropriate signage shall be promptly installed in accordance with the ***MUTCD***.

For new construction or reconstruction projects, the bridge owner is responsible for providing the Department with a load rating and completed Bridge Load Rating Summary Table (see Exhibit A – Bridge Load Rating Summary Table) within 90 days of opening for on-system bridges or 180 days for off-system bridges. The bridge owner should consider requiring the engineer of record to perform the load rating.

EXHIBIT A Bridge Load Rating Summary Table

Bridge No.	**Analysis Method:** LRFR-LRFD	**FDOT Bridge Load Rating Summary Form (Page 1 of 1)**
Bridge Name		
Description		

Rating Type	Rating Type	Gross Axle Weight (tons)	Moment/Shear/Service		Dead Load Factor	Live Load Factor	Live Load Distrib. Factor (axles)	Rating Factor	Span No. - Girder No., Interior/Exterior, %Span-L	Pontis RF·Weight (tons)
Level	**Vehicle**	**Weight**	**Member Type**	**Limit**	**DC**	**LL**	**LLDF**	**RF**	**Governing Location**	**RATING**
Inventory	HL93	36	Member Type	Limit Test	NA	NA				
Operating	HL93	36	Member Type	Limit Test	NA	NA				
Permit	FL120	60	Member Type	Limit Test	NA	NA				
Max Span	FL120	60	Member Type	Limit Test	NA	NA				
Legal	SU2	17	Member Type	Limit Test	NA	NA				
	SU3	33	Member Type	Limit Test	NA	NA				
	SU4	35	Member Type	Limit Test	NA	NA				
	C3	28	Member Type	Limit Test	NA	NA				
	C4	36.7	Member Type	Limit Test	NA	NA				
	C5	40	Member Type	Limit Test	NA	NA				
	ST5	40	Member Type	Limit Test	NA	NA				

Original Design Load	enter Original Design Load	Performed by:	Date:
Rating Type, *Analysis*	enter Rating Type	Checked by:	Date:
Distribution Method	enter Distribution Method	Sealed By:	Date:
Impact Factor	enter IM (axle loading)	FL P.E. No.:	
FL120 Gov. Span Length	enter Gov Lengtł (feet)	Cert. Auth. No.:	
Recommended Posting	enter Posting (70)	Phone & email:	
Rec. SU Posting	enter SU posting (tons)	Company:	
Rec. C Posting	enter C posting (tons)	Address:	
Rec. ST5 Posting	enter ST5 postin| (tons)		
Floor Beam Present?	FLOOR BEAM PRESENT?		
Segmental Bridge?	SEGMENTAL BRIDGE?		
Project No. & Reason	FIN No. Update		
Status	Status		
Software Name, Version	Enter Software Name & Version		

COMMENTS BY THE ENGINEER

Page 1/XX. Contents: summary, narrative, plans, calcs, check.

This 04-24-2015 table is based on requirements within the 2015 FDOT Bridge Load Rating Manual, and the BMS Coding Guide; see http://www.dot.state.fl.us/statemaintenanceoffice/LoadRating.shtm

G RECOMMENDATIONS

- Involve the public in determining "*the appropriate aesthetics based upon scale, color, and architectural style, materials used to construct the facility, and the landscape design and landscape materials around the facility...*" (Section 336.045, F.S.).
- Resist the temptation to enhance the aesthetics of a bridge with non-structural appurtenances and features that are novel and therefore may have safety challenges (otherwise, consult with the Department on these safety issues).
- Consider the potential for future expansion of a bridge's capacity (vehicular transit and pedestrian) in its layout and bridge-type selection.
- Use the Department's objective construction unit prices (contained in the Structures Design Guidelines, Sections 9.2 and 9.3) to select bridge type(s) to consider for final design.
- Consider the use of alternative designs (i.e., steel superstructures vs. concrete superstructures) to increase bidding competition on very large bridge construction projects.
- Invest in a comprehensive subsurface investigation of the site before any significant design of the bridge occurs (which will also help avoid unforeseen conditions during construction).
- Consult with other local officials on experiences relating to construction of other bridges in the area.
- Consider using the Department's Standard Specifications for Road and Bridge Construction with notes on the plans referencing the Owner as the local governmental agency and the Engineer as the owner's engineer.
- Consider the constructability, inspectability, and maintainability of all bridge components before they are incorporated into the project's final design.
- Include drainage pass-throughs in wall designs.
- Provide qualified construction inspection personnel for all phases of bridge construction.
- Maintain all design and construction records in a safe, protected, and secure location throughout the life of the bridge.

H REFERENCES FOR INFORMATIONAL PURPOSES

The publications referenced in this chapter can be obtained from the following websites.

- FDOT Publications may be found at:
  http://www.fdot.gov/publications/
- AASHTO, all publications may be ordered from:
  bookstore.transportation.org
- FHWA "HEC-18" and "HEC-20" may be found at:
  http://www.fhwa.dot.gov/engineering/hydraulics/library_listing.cfm
- 2006 Americans with Disabilities Act Standards for Transportation Facilities
  http://www.access-board.gov/guidelines-and-standards/transportation/facilities/ada-standards-for-transportation-facilities
- 2017 Florida Accessibility Code for Building Construction
  https://codes.iccsafe.org/public/document/FAC2017

CHAPTER 18

SIGNING AND MARKING

TABLES

FIGURES

CHAPTER 18

SIGNING AND MARKING

A INTRODUCTION

Signing and pavement markings help improve highway safety by providing guidance information to road users. Both signs and pavement markings should provide sufficient visibility to meet the user's needs. The design of signs and pavement markings should complement the basic highway design. Designers and engineers should also be aware of the capabilities and needs of seniors, and consider appropriate measures to better meet their needs and capabilities.

Sections C and D of this chapter specifically discuss traffic control devices for both signing and pavement marking that accommodate not only the needs of all types of road users, but also the special needs of seniors.

B BACKGROUND

Section 316.0745, F.S., requires the Department compile and publish a manual of uniform traffic control devices for use on the streets and highways of the state. To comply with this statute, the Federal Highway Administration's (FHWA) ***Manual on Uniform Traffic Control Devices (MUTCD)*** has been adopted for use in ***Rule 14-15.010, F.A.C.:*** All references in this chapter are in conformance with the ***MUTCD***:

The ***Manual on Speed Zoning for Highways, Roads, and Streets in Florida (2019)***, is adopted for use by the State of Florida under ***Rule 14-15.012, F.A.C***. This manual is prepared by the Department in compliance with ***Chapter 316, F.S***., to promote uniformity in the establishment of state, municipal, and county speed and school zones throughout the State.

C SIGNS

C.1 Advance Street Name Signs

The use of advance street name signs provides advance notification to road users to assist them in making safe roadway decisions. Signs should be used for signalized or non-signalized intersections that are classified as a minor arterial or higher, or a cross street that provides access to a traffic generator or possesses other comparable physical or traffic characteristics deemed to be critical or significant.

C.1.a Standards

The words Street, Boulevard, Avenue, etc., may be abbreviated, deleted or reduced in size to conserve sign panel length. However, if confusion would result due to similar street names in the area, the deletion should not be made.

Use of the local name is preferred on advance street name signs. When a cross street has a different name on each side of the intersection, both names shall be shown with an arrow beside each name to designate direction. Additional legend such as NEXT SIGNAL or XX FEET may be added.

C.1.b Installation

Advance street name signs should be installed in advance of the intersection in accordance with the distances shown in "Condition A" of ***Table 2C-4. Guidelines for Advance Placement of Warning Signs of the MUTCD***. These distances are to be considered the minimum for a single lane change maneuver, and should be measured from the begin taper point for the longest auxiliary lane designed for the intersection. The degree of traffic congestion and the potential number of lane change maneuvers that may be required should also be considered when determining the advance placement distance.

C.1.c Sign Design

Advance street name signs shall be designed in accordance with *Part 2 Signs* of the *MUTCD*. The lettering for the signs shall be composed of a combination of lower case letters with initial upper case letters.

Letter height should conform to Table 18 – 1 Design Guidelines for Advance Street Name Signs. Various layouts for advance street name signs are shown in Figure 18 – 1 Examples of Advance Street Name Signs.

Table 18 – 1
Design Guidelines for Advance Street Name Signs

Posted Speed Limit	Street Name Legend	Next Signal or Intersection
	Letter Size (inches) Series E Modified (EM) Upper/Lower Case Letters	Letter Size (inches) Series D (D) Upper Case Letters
35 mph or less	8 EM	6 D
40 mph or greater	10.67 EM	8 D

Figure 18 – 1
Examples of Advance Street Name Signs

C.2 Advance Traffic Control Signs

Advance Traffic Control signs, i.e., Stop Ahead (W3-1), Yield Ahead (W3-2), and Signal Ahead (W3-3) signs, shall be installed on an approach to a primary traffic control device that is not visible for a sufficient distance to permit the driver to respond to the device. The visibility criteria for traffic signals shall be based on having a continuous view of at least two signal faces for the distance specified in ***Table 4D-2. Minimum Sight Distance for Signal Visibility*** of the ***MUTCD***.

An Advance Traffic Control sign may be used for additional emphasis of the primary traffic control device, even when the visibility distance to the device is satisfactory.

C.3 Overhead Street Name Signs

Overhead street name signs with mixed-case lettering should be used at major intersections (with multi-lane approaches) as a supplement to post mounted street name signs.

C.3.a Standards

Overhead street name signs shall only be used to identify cross streets, not destinations such as cities or facilities. To avoid the need for lighting of overhead signs, they should have a minimum maintained retroreflectivity value as shown in ***Table 2A-3. Minimum Maintained Retroreflectivity Levels, MUTCD***. Roadway geometry and forward sight distance will also influence the need for overhead sign lighting.

The words Street, Boulevard, Avenue, etc., may be abbreviated, deleted or reduced in size to conserve sign panel length. The border should be eliminated on overhead street name signs to minimize sign panel size. When a cross street is known by both a route number and a local name, use of the local name is preferred.

When a cross street has a different name on each side of the intersection, two options are permitted:

- When two sign panels are used, install one sign panel on the left and the other sign panel on the right side of the signal heads; or
- When one sign panel is used, the left name should be displayed over the right name. Arrows should be provided to indicate which side of the

intersection the street name applies.

C.3.b Installation

Due to the possibility of hurricane strength winds, overhead street name signs should not be installed on span wire but should be mounted to the strain pole or mast arm.

The location of the overhead street name sign on a signal strain pole and/or mast arm may vary. However, it shall not interfere with the motorist's view of the signal heads. The preferred location is shown in the Department's ***Standard Plans, Index 700-050***.. In the case of separate street names on each side of the street, where separate signs are used, one sign should be placed to the right of the signal heads and the other sign to the left of the signal heads.

C.3.c Sign Design

On roadways with speeds of 40 mph or above, the sign panel should be at least 24 inches in height with the length determined by text. At a minimum, use 8-inch upper case and 6-inch lower case lettering for the street name. If block numbering text is included, use 6-inch all upper case lettering on the second line. The preferred font is Series E-Modified; however, Series E may be used to accommodate the amount of legend so as not to exceed the 96-inch maximum length.

Where structurally possible, overhead street name signs should be designed in compliance with the FHWA recommendations for older drivers using a minimum lettering size of 10-inch upper case with 9-inch lower case.

C.3.d Internally Illuminated Overhead Street Name Signs

An internally illuminated overhead street name sign may be used to improve night-time visibility. Internally illuminated overhead street name signs should have a standardized height of 24-inches and a length not to exceed 108-inches (nine feet).

A Series E Modified or Series E font, which may vary to accommodate the amount of text on the panel should be used.

The sign design shall be in accordance with the ***MUTCD.*** When possible, the text should utilize the following text attributes in descending order to limit the maximum width:

- 10-inch upper case with 8-inch lower case, Type EM font
- 10-inch upper case with 8-inch lower case, Type E font
- 8-inch upper case with 6-inch lower case, Type EM font
- 8-inch upper case with 6-inch lower case, Type E font

Internally illuminated overhead street name signs shall be on the Department's ***Approved Products List (APL)***.

C.4 Community Wayfinding Guidance

Community wayfinding guide signs should be developed and approved through local resolution with criteria for the destinations shown on the community wayfinding guide sign system plan. Any wayfinding guide sign should be used in accordance with ***Rule 14-51.030, F.A.C.*** The intent is to provide guidance and navigation information to local cultural, historical, recreational, and tourist activities. No destination should be displayed for the purpose of advertising.

C.5 DMS Overview

The main purpose of dynamic message signs (DMS) is to convey timely and important en-route and roadside information to motorists and travelers. Further information on how DMS signs may be used can be found in FDOT's policy on ***Displaying Messages on Dynamic Message Signs Permanently Mounted on the State Highway System.***

C.6 Design Details for Signs

The ***MUTCD*** shall govern all sign details. At a minimum, the "Conventional Road" size shall be used on signs intended for motor vehicle operators.

Shared use path sign sizing for traffic control shall follow the "Shared-Use Path" sizing and height shown in the MUTCD. See ***Chapter 9 – Bicycle Facilities*** for additional requirements on the signing of shared use paths.

D PAVEMENT MARKINGS

D.1 6-inch Pavement Markings

6-inch pavement markings should be used for all pavement center line, lane separation line and edge line markings.

D.2 Reflective Pavement Markers

To provide greater emphasis and increase visibility, reflective (raised) pavement markers (RPM) may be placed at 40-foot spacings along the centerline markings of roadways.

E AUDIBLE AND VIBRATORY TREATMENTS

E.1 Longitudinal Audible Vibratory Treatments

Longitudinal audible and vibratory treatments are a countermeasure to reduce the severity and frequency of roadway departure crashes. They include cylindrical ground-in rumble strips, sinusoidal ground-in rumble strips and profiled thermoplastic. They are most effective on high speed roadways with flush shoulders. They should not be placed within the limits of intersections or crosswalks.

Audible vibratory treatments are designed to improve the opportunity for a safe recovery for distracted, drowsy, or otherwise inattentive drivers who may unintentionally drift over the edge or center line. Due to the difficulty in determining where a driver will depart the lane, it is recommended that treatments be installed system-wide or in corridors, Their use should be determined on the suitability of the cross-section and appropriateness in the surrounding land use context.

Considerations that may limit the acceptability and effectiveness include low speeds, noise for adjacent residences, and pavement width. More information on these types of treatments are shown in the Department's ***Standard Plans, Index 546-010*** and ***Design Manual, Chapter 210 Arterials and Collectors***.

E.2 Transverse Rumble Strips

Transverse rumble strips may be used to alert the driver to upcoming stop conditions or abrupt changes in alignment. Factors influencing their use include crash history, roadway geometry and surrounding land use (noise pollution). They should not be placed in crosswalks or bicycle facilities. If placed on roadways open to bicycle travel, a minimum clear path of 4 feet on the outside edge should be provided. ***Sections 3J.02 Transverse Rumble Strip Markings*** and ***6F.87 Rumble Strips, MUTCD*** provide further information on the use of transverse rumble strips.

CHAPTER 19

TRADITIONAL NEIGHBORHOOD DEVELOPMENT

TABLES

FIGURES

CHAPTER 19

TRADITIONAL NEIGHBORHOOD DEVELOPMENT

A INTRODUCTION

Florida is a national leader in planning, design and construction of Traditional Neighborhood Development (TND) communities, and in the renovation of downtown neighborhoods and business districts. TND refers to the development or redevelopment of a neighborhood or town using traditional town planning principles. Projects should include a range of housing types and commercial establishments, a network of well-connected streets and blocks, civic buildings and public spaces, and include other uses such as stores, schools, and worship within walking distances of residences.

They represent patterns of development aligned with the state's growth management, smart growth and sprawl containment goals. This approach, with its greater focus on pedestrian, bicycle and transit mobility; is distinct from Conventional Suburban Development (CSD). CSDs are comprised largely of subdivision and commercial strip development.

TND communities rely on a strong integration of land use and transportation. A TND has clearly defined characteristics and design features that are necessary to achieve the goals for compact and livable development patterns reinforced by a context-sensitive transportation network. The treatment of land use, development patterns and transportation networks necessary for successful TND communities is a major departure from those same elements currently utilized in other Greenbook chapters.

To provide a design that accomplishes the goals set out in this chapter, designers will be guided by the context of the built environment, established or desired, for a portion of the communities because TND communities rely on a stronger integration of land use and transportation than CSD communities. This chapter provides criteria that may be used for the design of streets within a TND when such features are desired, appropriate and feasible. This involves providing a balance between mobility and livability. This chapter may be used in planning and designing new construction, urban infill, and redevelopment projects.

Section B of this chapter discusses the primary objectives of TND in more detail to aid the designer in the selection of proper criteria. Section C sets forth specific design criteria for the transportation system within TND.

The Department's ***Traditional Neighborhood Development Handbook (2011)*** provides designers guidance in the successful application of this Chapter.

B APPLICATION

A project or community plan may be considered a TND when at least the first seven of the following principles are included:

1. Has a compact, pedestrian-oriented scale that can be traversed in a five to ten-minute walk from center to edge.
2. Is designed with low speed, low volume, interconnected streets with short block lengths, 150 to 500 feet, and cul-de-sacs only where no alternatives exist. Cul-de-sacs, if necessary, should have walkway and bicycle connections to other sidewalks and streets to provide connectivity within and to adjacent neighborhoods.
3. Orients buildings at the back of sidewalk, or close to the street with off-street parking located to the side or back of buildings, as not to interfere with pedestrian activity.
4. Has building designs that emphasize higher intensities, narrow street frontages, connectivity of sidewalks and paths, and transit stops to promote pedestrian activity and accessibility.
5. Incorporates a continuous bike and pedestrian network with wider sidewalks in commercial, civic, and core areas, but at a minimum has sidewalks at least five feet wide on both sides of the street. Accommodates pedestrians with short street crossings, which may include mid-block crossings, bulb-outs, raised crosswalks, specialty pavers, or pavement markings.
6. Uses on-street parking adjacent to the sidewalk to calm traffic, and offers diverse parking options, but planned so that it does not obstruct access to transit stops.
7. Varies residential densities, lot sizes, and housing types, while maintaining an average net density of at least eight dwelling units per acre, and higher density in the center.
8. Integrates at least ten percent of the developed area for nonresidential and civic uses, as well as open spaces.
9. Has only the minimum right of way necessary for the street, median, planting strips, sidewalks, utilities, and maintenance that are appropriate to the adjacent land uses and building types.
10. Locates arterial highways, major collector roads, and other high-volume corridors at the edge of the TND and not through the TND.

The design criteria in this chapter shall only be applicable within the area defined as TND.

C PLANNING CRITERIA

Planning for TND communities occurs at several levels, including the region, the city/town, the community, the block, and, finally, the street and building. Planning should be holistic, looking carefully at the relationship between land use, buildings, and transportation in an integrated fashion. This approach, and the use of form based codes, can create development patterns that balance pedestrian, bicycling, and transit with motor vehicle transportation.

C.1 LAND USE

In addition to its importance in calculating trip generation, the Institute of Transportation Engineers (ITE) recognizes land use as fundamental to establishing context, design criteria, cross-section elements, and right of way allocation. The pedestrian travel that is generated by the land uses is also important to the design process for various facilities.

A well-integrated, or "fine grained", land use mix within buildings and blocks is essential. These buildings and blocks aggregate into neighborhoods, which should be designed with a mix of uses to form a comprehensive planning unit that aggregates into larger villages, towns, and regions. Except at the regional scale, each of these requires land uses to be designed at a pedestrian scale and to be served by "complete streets" that safely and attractively accommodate many modes of travel.

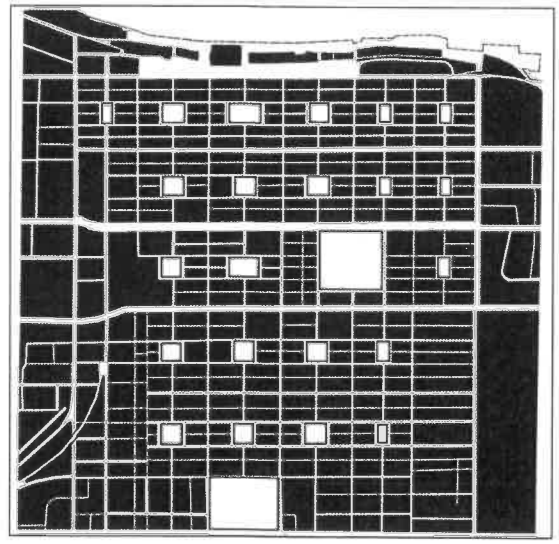
The proposed land uses, residential densities, building size and placement, proposed parking (on-street and off-street) and circulation, the location and use of open space, and the development phasing are all considerations in facility design for TNDs. ITE recommends a high level of connectivity, short blocks that provide many choices of routes to destinations, and a fine-grained urban land use and lot pattern. Higher residential density and nonresidential intensity, as measured by floor area ratios of building area to site area, are required for well-designed TNDs.

C.2 NETWORKS

Urban networks are frequently characterized as either traditional or conventional. Traditional networks are typically characterized by a relatively non-hierarchical pattern of short blocks and straight streets with a high density of intersections that support all modes of travel in a balanced fashion.

Figure 19 – 1 Traditional Network

New York, NY



Savannah, GA

(Source: VHB)

The typical conventional street network, in contrast, often includes a framework of widely-spaced arterial roads with limited connectivity provided by a system of large blocks, curving streets and a branching hierarchical pattern, often terminating in cul-de-sacs.

Figure 19 – 2 Conventional Network

Walnut Creek, CA
(Source: VHB)

Traditional and conventional networks differ in three easily measurable respects: (1) block size, (2) degree of connectivity and (3) degree of curvature. While the last does not significantly impact network performance, block size and connectivity create very different performance characteristics.

Advantages of traditional networks include:

1. Distribution of traffic over a network of streets, reducing the need to widen roads;
2. A highly interconnected network providing a choice of multiple routes of travel for all modes, including emergency services;
3. More direct routes between origin and destination points, which generate fewer vehicle miles of travel (VMT) than conventional suburban networks;
4. Smaller block sizes in a network that is highly supportive to pedestrian, bicycle, and transit modes of travel;
5. A block structure that provides greater flexibility for land use to evolve over time.

It is important in TND networks to have a highly interconnected network of streets with smaller block sizes than in conventional networks. There are several ways to ensure that these goals are achieved.

One method is based upon the physical dimensions used to layout streets and blocks. The following list identifies those parameters:

1. Limit block size to an average perimeter of approximately 1,320 feet.
2. Encourage an average intersection spacing for local streets of 300-400 feet.
3. Limit maximum intersection spacing for local streets to approximately 600 feet.
4. Limit maximum spacing between pedestrian/bicycle connections to approximately 300 feet (that is, it creates mid-block paths and pedestrian shortcuts).

D OBJECTIVES

The basic objectives of a Traditional Neighborhood Development are:

1. Safety
2. Mobility of all users (vehicles, pedestrians, bicyclists and transit)
3. Compact and livable development patterns
4. Context-sensitive transportation network

TND features are based upon the consideration of the following concepts. These concepts are not intended as absolute criteria since certain concepts may conflict. The concepts should therefore be used for the layout of proper street systems.

1. Strong integration of land use and transportation.
2. Very supportive of pedestrian, bicycle, and transit modes.
3. Smaller block sizes to improve walkability, and to create a fine network of streets accommodating bicyclists and pedestrians, and providing a variety of routes for all users.
4. On-street parking is favored over surface parking lots.
5. Limited use of one way streets.
6. Speeds for motor vehicles are ideally kept in the range of 20-35 mph through the design of the street, curb extensions, use of on-street parking, the creation of enclosure through building and tree placement.
7. Street geometry (narrow streets and compact intersections), adjacent land use, and other elements within a TND must support a high level of transit, pedestrian and bicycle activity.
8. Provide access to emergency services, transit, waste management, and delivery trucks.
9. Provide access to property.

This approach to street design requires close attention to the operational needs of transit, fire and rescue, waste collection, and delivery trucks. For this reason, early coordination with transit, fire and rescue, waste collection, and other stakeholder groups is essential. For fire and rescue, determination of the importance of that corridor for community access should be determined, e.g. primary or secondary access.

More regular encroachment of turning vehicles into opposing lanes will occur at intersections. Therefore, frequency of transit service, traffic volumes, and the speeds at those intersections must be considered when designing intersections.

When designing features and streets for TND communities, creativity and careful attention to safety for pedestrians and bicyclists must be balanced with the operational needs of motor vehicles.

Finally, it is very important when designing in TND communities to ensure that a continuous network is created for pedestrians, bicyclists, and transit throughout the community to create higher levels of mobility that are less dependent on automobile travel.

E DESIGN ELEMENTS

The criteria provided in this chapter shall require the approval of the maintaining authority's designated Professional Engineer representative with project oversight or general compliance responsibilities. Approval may be given based upon a roadway segment or specific area.

The criteria provided in this chapter are generally in agreement with AASHTO guidelines with a special emphasis on urban, low-speed environments. Design elements within TND projects not meeting the requirements of this chapter are subject to the requirements for Design Exceptions found in ***Chapter 14*** of this manual.

E.1 Design Controls

E.1.a Design Speed

The application of design speed for TND communities is philosophically different than for conventional transportation and CSD communities. Traditionally, the approach for setting design speed was to use as high a design speed as practical.

In contrast to this approach, the goal for TND communities is to establish a design speed that creates a safer and more comfortable environment for pedestrians and bicyclists, and is appropriate for the surrounding context.

Design speeds of 20 to 35 mph are desirable for TND streets. Alleys and narrow roadways intended to function as shared spaces may have design speeds as low as 10 mph.

E.1.b Movement Types

Movement types are used to describe the expected driver experience on a given thoroughfare, and the design speed for pedestrian safety and mobility established for each of these movement types. They are also used to establish the components and criteria for design of streets in TND communities.

Yield: Has a design speed of less than 20 mph. Drivers must proceed slowly with extreme care, and must yield to pass a parked car or approaching vehicle. This is the functional equivalent of traffic calming. This type should accommodate bicycle routes through the use of shared lanes.

Slow: Has a design speed of 20-25 mph. Drivers can proceed carefully, with an occasional stop to allow a pedestrian to cross or another car to park. Drivers should feel uncomfortable exceeding design speed due to the presence of parked cars, enclosure, tight turn radii, and other design elements. This type should accommodate bicycle routes through the use of shared lanes.

Low: Has a design speed of 30-35 mph. Drivers can expect to travel generally without delay at the design speed, and street design supports safe pedestrian movement at the higher design speed. This type is appropriate for thoroughfares designed to traverse longer distances, or that connect to higher intensity locations. This type should accommodate bicycle routes through the use of bike lanes.

Design speeds higher than 35 mph should not normally be used in TND communities due to the concerns for pedestrian and bicyclist safety and comfort. There may be locations where planned TND communities border, or are divided by, existing corridors with posted/design speeds higher than 35 mph. In those locations, coordination with the regulating agency should occur with a goal to re-design the corridor and reduce the speed to 35 mph or less. The increase in motorist travel time due to the speed reduction is usually insignificant because TND communities are generally compact.

When the speed reduction cannot be achieved, measures to improve pedestrian safety for those crossing the corridor should be evaluated and installed when appropriate.

E.1.c Design Vehicles

There is a need to understand that street design with narrow streets and compact intersections requires designers to pay close attention to the operational needs of transit, fire and rescue, waste collection, and delivery trucks. For this reason, early coordination with transit, fire and rescue, waste collection, and other stakeholder groups is essential.

Regular encroachment of turning vehicles into opposing lanes will occur at intersections. Therefore, frequency of transit service, traffic volumes, and the speeds at those intersections must be considered when designing intersections. For fire and rescue, determination of the importance of the street for community access should be determined, e.g. primary or secondary access.

The designer should evaluate intersections using turning templates or turning movement analysis software to ensure that adequate operation of vehicles can occur. Treatment of on-street parking around intersections should be evaluated during this analysis to identify potential conflicts between turning vehicles and on-street parking.

E.2 Sight Distance

See ***Chapter 3 – Geometric Design, C.3 Sight Distance.***

E.2.a Stopping Sight Distance

See ***Chapter 3 – Geometric Design, C.3.a Stopping Sight Distance***.

E.2.b Passing Sight Distance

Due to the importance of low speeds and concerns for pedestrian comfort and safety, passing should be discouraged or prohibited.

E.2.c Intersection Sight Distance

Sight distance should be calculated in accordance with ***Chapter 3, Section C.9.b***, using the appropriate design speeds for the street being evaluated. When executing a crossing or turning maneuver after stopping at a stop sign, stop bar, or crosswalk, as required in ***Section 316.123, F.S.***, it is assumed that the vehicle will move slowly forward to obtain sight distance (without intruding into the crossing travel lane) stopping a second time as necessary.

Therefore, when curb extensions are used, or on-street parking is in place, the vehicle can be assumed to move forward on the second step movement, stopping just shy of the travel lane, increasing the driver's potential to see further than when stopped at the stop bar. The resulting increased sight distance provided by the two step movement allows parking to be located closer to the intersection.

The ***MUTCD*** requires that on-street parking be located at least 20 feet from crosswalks. The minimum stopping sight distance is 60 feet for low volume (< 400 ADT) streets. Even on slow speed, low volume urban streets, the combination of curb return, crosswalk width and 20-foot setback to the first parking space may not meet the minimum stopping distance. Justification for locating parking spaces 20 feet from crosswalks may be achieved based on community history with existing installations.

E.3 Horizontal Alignment

E.3.a Minimum Centerline Radius

See ***Chapter 3 – Geometric Design, C.4 Horizontal Alignment*** and Table 3 – 12 Minimum Radii (feet) for Design Superelevation Rates Low Speed Local Roads ((e_{max} = 0.05) .

E.3.b Minimum Curb Return Radius

Curb return radii should be kept small to keep intersections compact. The use of on-street parking and/or bike lanes increases the effective size of the curb radii, further improving the ability of design vehicles to negotiate turns without running over the curb return.

Table 19 – 1 Curb Return Radii

Movement Type	Design Speed	Curb Radius w/Parallel Parking*
Yield	Less than 20 mph	5-10 feet
Slow	20-25 mph	10-15 feet
Low	30-35 mph	15-20 feet

* Dimensions with parking on each leg of the intersection. Both tangent sections adjacent to the curb return must provide for on-street parking or else curb radii must be evaluated using "design vehicle" and either software or turning templates.

E.4 Vertical Alignment

See ***Chapter 3 – Geometric Design, C.5 Vertical Alignment***.

E.5 Cross Section Elements

E.5.a Introduction

As discussed earlier in this chapter, TND street design places importance on how the streets are treated since they are part of the public realm. The street portion of the public realm is shaped by the features and cross section elements used in creating the street. For this reason, it is necessary the designer pay more attention to what features are included, where they are placed, and how the cross section elements are assembled.

E.5.b Lane Width

Travel lane widths should be based on the context and desired speed for the area where the street is located. Table 19-2 shows travel lane widths and associated appropriate speeds. It is important to note that in low speed urban environments, lane widths are typically measured to the curb face instead of the edge of the gutter pan. Consequently, when curb sections with gutter pans are used, the motor vehicle and parking lanes include the width of the gutter pan.

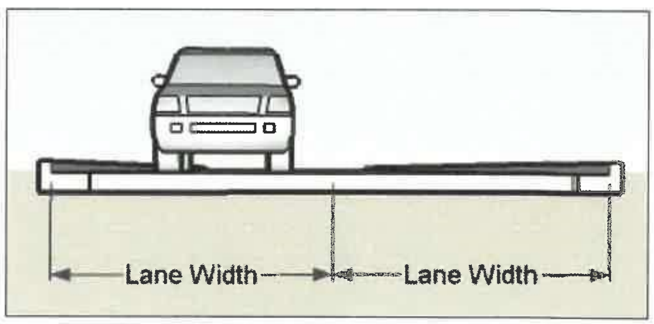
Table 19 – 2 Minimum Lane Width

Movement Type	Design Speed	Travel Lane Width
Yield*	Less than 20 mph	N/A
Slow	20-25 mph	9-10 feet
Low	30-35 mph	10-11 feet

* Yield streets are typically residential two-way streets with parking on one or both sides. When the street is parked both sides, the remaining space between parked vehicles (10 feet minimum) is adequate for one vehicle to pass through. Minimum width for a yield street with parking on both sides should be 24 feet curb face to curb face. Minimum width for a yield street with parking on one side should be 20 feet curb face to curb face, allowing for two 10-foot lanes when the street is not parked.

Figure 19 – 3 Lane Widths shows a typical measurement.

Figure 19 – 3 Lane Width



(Source: VHB)

In order for drivers to understand the appropriate driving speeds, lane widths should create some level of discomfort when driving too fast. The presence of on-street parking is important in achieving the speeds shown in Table 19 – 2 Minimum Lane Widths. When bicycle lanes or multi-lane configurations are used, there is more room for vehicles, such as buses, to operate. However car drivers may feel more comfortable driving faster than desired.

Alleys and narrow roadways that act as shared spaces can have design speeds as low as 10 mph, as noted in ***Chapter 16 – Residential Street Design***.

Alleys can be designed as either one way or two way. Right of way width should be a minimum of 20 feet with no permanent structures within the right of way that would interfere with vehicle access to garages or parking spaces, access for trash collection, and other operational needs. Pavement width should be a minimum of 12 feet. Coordination with local municipalities on operational requirements is essential to ensure that trash collection and fire protection services can be completed.

E.5.c Medians

Medians used in low-speed urban thoroughfares provide for access management, turning traffic, safety, pedestrian refuge, landscaping, lighting, and utilities. These medians are usually raised with raised curb.

Landscaped medians can enhance the street or help create a gateway entrance into a community. Medians can be used to create tree canopies over travel lanes for multi-lane roadways contributing to a sense of enclosure.

Medians vary in width depending on available right of way and function. Because medians require a wider right of way, the designer must weigh the benefits of a median with the issues of pedestrian crossing distance, speed, context, and available roadside width.

Table 19 – 3 Recommended Median Width

Median Type	Minimum Width	Recommended Width
Median for access control	4 feet	6 feet
Median for pedestrian refuge	6 feet	8 feet
Median for trees and lighting	6 feet [1]	10 feet [2]
Median for single left turn lane	10 feet [3]	14 feet [4]

Table Notes:

[1] Six feet measured curb face to curb face is generally considered the minimum width for the proper growth of small caliper trees (less than 4 inches),

[2] Wider medians provide room for larger caliper trees and more extensive landscaping,

[3] A ten foot lane provides for a turn lane without a concrete traffic separator,

[4] Fourteen feet provides for a turn lane with a concrete traffic separator.

E.5.d Turn Lanes

The need for turn lanes for vehicle mobility should be balanced with the need to manage vehicle speeds and the potential impact on the border width, such as sidewalk width. Turn lanes tend to allow through vehicles to maintain higher speeds through intersections, since turning vehicles can move over and slow in the turn lane.

Left turn lanes are considered to be acceptable in an urban environment since there are negative impacts to roadway capacity when left turns block the through movement of vehicles. The installation of a left turn lane can be beneficial when used to perform a road diet such as reducing a four lane section to three lanes with the center lane providing for turning movements. In urban areas, no more than one left turn lane should be provided.

Right turns from through lanes do not block through movements, but do create a reduction in speed due to the slowing of turning vehicles. Right turn lanes are used to maintain speed through intersections, and to reduce the potential for rear end crashes. However, the installation of right turn lanes increases the crossing distance for pedestrians and the speed of vehicles, therefore the use of exclusive right turn lanes are rarely used except at "T" intersections.

E.5.e Parking

On-street parking is important in the urban environment for the success of those retail businesses that line the street, to provide a buffer for the pedestrian, and to help calm traffic speeds. When angle parking is proposed for on-street parking, designers should consider the use of back in angle parking in lieu of front in angle parking.

Table 19 – 4 Parking Lane Width

Movement Type	Design Speed	Parking Lane Width
Slow	20-25 mph	(Angle) 17-18 feet
Slow	20-25 mph	(Parallel) 7 feet
Low	30-35 mph	(Parallel) 7-8 feet

E.6 Cul-de-sacs and Turnarounds

Cul-de-sacs should only be used where no other alternatives exist. Cul-de-sacs should have walkway or bicycle connections to other sidewalks and streets to provide connectivity within and to adjacent neighborhoods.

E.6.a Turning Area

A residential street open at one end only should have a special turning area at the closed end. A residential street more than 100 feet long and open at one end only shall have a special turning area at the closed end. This turning area should be circular and have a radius appropriate to the types of vehicle expected. The minimum outside radius of a cul-de-sac shall be 30 feet. In constrained circumstances, other turning configurations such as a "hammerhead" may be considered.

E.7 Pedestrian Considerations

In urban environments, the "border," or area between the face of a building or right of way line and the curb face, serves as the pedestrian realm because it is the place for which pedestrian activity is provided, including space to walk, socialize, places for street furniture, landscaping, and outdoor cafes. In an urban environment, the border consists of the furniture, walking and shy zones.

Figure 19 – 4 Border

(Source: VHB)

E.7.a Furniture Zone

The furniture zone can be located adjacent to the building face, but more commonly is adjacent to the curb face. The furniture zone contains parking meters, lighting, tree planters, benches, trash receptacles, magazine and newspaper racks, and other street furniture. The furniture zone is separate from the walking/pedestrian and shy zones to keep the walking area clear for pedestrians, including proper access to transit stops.

E.7.b Walking/Pedestrian Zone

Chapter 8 addresses considerations for pedestrians. In a properly designed urban environment, where buildings are at the back of the sidewalk and vehicle speeds are low, the separation from traffic is normally provided by on-street parking, which also helps to calm traffic. The width of the walking/pedestrian zone should be at least four feet and should be increased based on expected pedestrian activity.

E.7.c Shy Zone

The shy zone is the area adjacent to buildings and fences that pedestrians generally "shy" away from. A minimum of one foot is provided as part of the sidewalk width. This space should not be included in the normal walking zone of the sidewalk.

E.7.d Mid-Block Crossings

Properly designed TND communities will not normally require mid-block crossings due to the use of shorter block size. When mid-block crossings are necessary, the use of curb extensions or bulbouts should be considered to reduce the crossing distance for pedestrians.

E.7.e Curb Extensions

Curb extensions are helpful tools for reducing the crossing distance for pedestrians, providing a location for transit stops, managing the location of parking, providing unobstructed access to fire and rescue, and increasing space for landscaping and street furniture.

Designers should coordinate with public works staff to ensure that street cleaning can be achieved with their equipment, and adequate drainage can be provided to avoid ponding at curb extensions.

E.8 Bicyclist Considerations

E.8.a Bicycle Facilities

Chapter 9 contains information on bicycle facilities. This section is directed to designing bike facilities in TND communities. Designing for bicycles on thoroughfares in TND communities should be as follows: bicycles and motor vehicles should share lanes on thoroughfares with design speeds of twenty five mph or less. It is important to recognize that the addition of bike lanes does increase roadway widths and can increase the tendency for drivers to speed.

When bicycle lanes are used in TND communities, they should be a minimum of 5 feet wide and designated as bike lanes. On curb and gutter roadways, a minimum 4-foot width measured from the lip of the gutter is required. The gutter width should not be considered part of the rideable surface area, but this width provides useable clearance to the curb face. Drainage inlets, grates, and utility covers are potential problems for bicyclists. When a roadway is designed, all such grates and covers should be kept out of the bicyclists' expected path. If drainage inlets are located in the expected path of bicyclists, they should be flush with the pavement, well seated, and have bicycle compatible grates.

Where parking is present, the bicycle lane should be placed between the parking lane and the travel lane, and have a minimum width of 5 feet. Designers should consider increasing the bicycle lane to 6 feet in lieu of increasing parallel parking width from 7 to 8 feet. This helps encourage vehicles to park closer to the curb, and provides more room for door swing, potentially reducing conflict with bicyclists.

Shared lane markings, or "sharrows," can be used instead of bicycle lanes adjacent to on-street parking. The sharrow allows the bicyclist to occupy the lane and therefore avoids placing bicyclists in the "door zone", and does not require an increase in lane width or ROW width for the thoroughfare. Guidance for use of the shared lane marking is included in ***Chapter 9 – Bicycle Facilities*** and the ***MUTCD***. See Figure 9 –24 – Shared Lane Marking in ***Chapter 9*** for a detailed drawing of a shared lane marking.

E.8.b Shared Use Paths

Greenways, waterfront walks, and other civic spaces should include shared use paths, and provide for bicycle storage or parking. Bicycle storage or parking should also be included in areas near transit facilities to maximize connectivity between the modes.

E.9 Transit

See ***Accessing Transit, Design Handbook for Florida Bus Passenger Facilities, Version III, 2013*** for information.

E.10 Clear Zone

In urban areas, horizontal clearances, based on clear zone requirements for rural highways, are not practical because urban areas are characterized by lower speed, more dense abutting development, closer spaced intersections and accesses to property, higher traffic volumes, more bicyclists and pedestrians, and restricted right of way. The minimum horizontal clearance shall be 1.5 feet measured from the face of curb.

Streets with curb, or curb and gutter, in urban areas where right of way is restricted do not have roadsides of sufficient widths to provide clear zones; therefore, while there are specific horizontal clearance requirements for these streets, they are based on clearances for normal operation and not based on maintaining a clear roadside for errant vehicles. It should be noted that curb has essentially no redirectional capability; therefore, curb should not be considered effective in shielding a hazard.

F REFERENCES FOR IMFORMATIONAL PURPOSES

The following publications were either used in the preparation of this chapter, or may be helpful in designing TND Communities and understanding the flexibility in AASHTO design criteria:

- Designing Walkable Urban Thoroughfares: A Context Sensitive Approach: An ITE Recommended Practice, 2010

- http://www.ite.org/css/

- SmartCode 9.2
  http://www.smartcodecentral.org/

- A Guide for Achieving Flexibility in Highway Design, AASHTO, May, 2004
  https://bookstore.transportation.org/

- Accessing Transit, Design Handbook for Florida Bus Passenger Facilities, 2008, FDOT Public Transit Office :
  http://www.dot.state.fl.us/transit/NewTransitPlanning.shtm

- Safe Routes to Schools Program, FDOT Safety Office:
  http://www.dot.state.fl.us/safety/2A-Programs/Programs.shtm

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 20

DRAINAGE

TABLES

THIS PAGE INTENTIONALLY LEFT BLANK

CHAPTER 20

DRAINAGE

A INTRODUCTION

This chapter recognizes that Florida is regularly affected by adverse weather conditions. As such, the proper design of a roadway's drainage system is critical to its function and to the safety of the motoring public as well as pedestrians, bicyclists and other users of these facilities. Standing water on a roadway can not only create a hazard but could also impede the flow of traffic.

This chapter represents the minimum standards that should be used when designing roadway drainage. As is the case for all elements in a facility's design, the designer must consider site specific conditions and determine the proper level of service the facility's drainage system should provide. The design of drainage facilities should not only consider the system's ability to handle the design storm, but also consider the system's recovery time during an event which exceed the design storm.

B OBJECTIVES

The objective of this chapter is to establish the minimum standards to which a roadway's drainage system is to be designed. In order for the drainage system to function properly, the below guidelines should be used in the design, construction and maintenance of these systems.

- Design and maintain drainage systems to quickly move water out of the travel lanes in order provide a safer environment for users of a facility during adverse weather conditions.
- Design drainage systems by taking into consideration the future maintenance of said system in order to avoid creating hazardous conditions to drivers and maintenance staff during routine servicing.

C OPEN CHANNEL

This section presents minimum standards for the design of natural or manmade open channels, including roadside ditches, swales, median ditches, interceptor ditches, outfalls, and canals.

C.1 Design Frequency

Open channels shall be designed to convey and to confine storm water within the ditch. Standard design frequencies for stormwater flow are shown in Table 20 – 1 Stormwater Flow Design Frequencies.

Table 20 – 1 Stormwater Flow Design Frequencies

Facility Types	Frequency
Major roadway	10-year
All other road types	5-year

Site-specific factors may warrant the use of an atypical design frequency. Any increase over pre-development stages shall not significantly change land use values, unless flood rights are acquired.

C.2 Hydrologic Analysis

Hydrologic data used for the design of open channels shall be based on one of the following methods as appropriate for the particular site:

1. A frequency analysis of observed (gage) data shall be used when available. If insufficient or no observed data is available, one of the procedures below shall be used as appropriate. However, the procedures below shall be calibrated to the extent practical with available observed data for the drainage basin, or nearby similar drainage basins.

    a. Regional or local regression equation developed by the United States Geological Survey (USGS).

b. Rational Equation for drainage areas up to 600 acres.

c. For outfalls from stormwater management facilities, the method used for the design of the stormwater management facility may be used.

2. For regulated or controlled canals, hydrologic data shall be requested from the controlling entity. Prior to use for design, this data shall be verified to the extent practical.

C.3 Hydraulic Analysis

The Manning's Equation shall be used for the design of open channels.

C.3.a Manning's "n" Values

Recommended Manning's n values for channels with bare soil, vegetative linings, and rigid linings are presented in the ***Department's Drainage Manual (2019)***, Table 2.2 Manning's "n" Values for Artificial Channels with Bare Soil and Vegetative Linings and Table 2.3 Manning's 'n" Values for Artificial Channels with Rigid Linings. The manual is incorporated by reference in ***Rule 14-86.003, F.A.C., Permit, Assurance Requirements, and Exceptions***.

The probable condition of the channel when the design event is anticipated shall be considered when a Manning's n value is selected.

C.3.b Slope

Roadside channels should be designed to have self-cleaning velocities, where possible. Channels should also be designed to avoid standing water in the roadway right-of-way.

C.3.c Channel Linings and Velocity

The design of open channels shall consider the need for channel linings. When design flow velocities do not exceed the maximum permissible for bare earth, the standard treatment of ditches may consist of grassing and mulching. For higher design velocities, sodding, ditch paving, or other form of lining shall be provided. Tables for maximum velocities for bare earth and the various forms of channel lining can be found in the ***Department's Drainage Manual (2019)***, Tables 2.4 Maximum Shear Stress Values and Allowable Velocities for Different Soils and Table 2.5 Maximum Velocities for Various Lining Types.

C.3.d Limitations on Use of Linings

Grassing or sodding should not be used under the following conditions:

1. Continuous standing or flowing water
2. Areas that do not receive the regular maintenance necessary to prevent overgrowth by taller vegetation
3. Lack of nutrients
4. Excessive soil drainage
5. Areas excessively shaded

To prevent cracking or failure, concrete lining must be placed on a firm, well-drained foundation. Concrete linings are not recommended where expansive clays are present.

When concrete linings are to be used where soils may become saturated, the potential for buoyancy shall be considered. Acceptable counter-measures may include:

1. Increasing the thickness of the lining to add additional weight.
2. For sub-critical flow conditions, specifying weep holes at appropriate intervals in the channel bottom to relieve the upward pressure on the channel.
3. For super-critical flow conditions, using subdrains in lieu of weep holes.

C.4 Construction and Maintenance Considerations

The type and frequency of maintenance that may be required during the life of drainage channels should be considered during their design, and allowances should be made for the access of maintenance equipment.

C.5 Safety

The design and location of open channels shall comply with roadside safety and clear zone requirements. See ***Chapter 3 – Geometric Design*** for clear zone requirements, including special clearance criteria for canals.

C.6 Documentation

For new construction, design documentation for open channels shall include the hydrologic and the hydraulic analyses, including analysis of channel lining requirements

.

D STORM DRAIN HYDROLOGY AND HYDRAULICS

This section presents minimum standards for the design of storm drain systems.

D.1 Pipe Materials

See Section G for pipe material requirements.

D.2 Design Frequency

The minimum design storm frequency for the design of storm drain systems shall be 3 years.

Site-specific factors may warrant the use of an atypical design frequency. Any increase over pre-development stages shall not significantly change land use values, unless flood rights are acquired.

D.3 Design Tailwater

For most design applications where the flow is subcritical, the tailwater will either be above the crown of the outlet or can be considered to be between the crown and critical depth. To determine the energy grade line (EGL), begin with either the tailwater elevation or $(d_c + D)/2$, whichever is higher, add the velocity head for full flow and proceed upstream, adding appropriate losses (e.g., exit, friction, junction, bend, entrance).

An exception to the above procedure is an outfall with low tailwater. In this case, a water surface profile calculation would be appropriate to determine the location where the water surface will either intersect the top or end of the barrel and full-flow calculations can begin. In this case, the downstream water surface elevation would be based on critical depth or the tailwater, whichever is higher.

D.4 Hydrologic Analysis

The Rational Method is the most common method in use for the design of storm drains when the momentary peak-flow rate is desired.

D.4.a Time of Concentration

Minimum time of concentration shall be 10 minutes.

D.5 Hydraulic Analysis

Hydraulic calculations for determining storm drain conduit sizes shall be based on open channel and pressure flow as appropriate. The Manning's equation shall be used.

D.5.a Pipe Slopes

The minimum physical slope should be that which will produce a velocity of 2.5 feet per second (fps) when the storm drain is flowing full.

D.5.b Hydraulic Gradient

If the hydraulic grade line (HGL) does not rise above the top of any manhole or above an inlet entrance, the storm drainage system is satisfactory. Standard practice is to ensure that the HGL is below the top of the inlet for the design discharge (some local agencies may add an additional safety factor which can be up to 12 inches).

D.5.c Outlet Velocity

When discharge exceeds 4 fps, consider special channel lining or energy dissipation. For computation of outlet velocity the lowest anticipated tailwater condition for the given storm event shall be assumed.

D.5.d Manning's Roughness Coefficients

Standards Manning's Roughness Coefficients can be found in the ***Department's Drainage Manual (2019)*** Section 3.6.4.

D.6 Hydraulic Openings

If the hydraulic grade line does not rise above the top of any manhole or above an inlet entrance, the storm drainage system is satisfactory. Standard practice is to ensure that the HGL is below the top of the inlet for the design discharge.

D.6.a Entrance Location and Spacing

Drainage inlets and other hydraulic openings are sized and located to satisfy hydraulic capacity, structural capacity, safety (pedestrians, cyclists and motor vehicles), and durability requirements.

Grate inlets and the depression of curb opening inlets should be located outside the through traffic lanes to minimize the shifting of vehicles attempting to avoid them. All grate inlets shall be bicycle safe where used on roadways that allow bicycle travel.

The ***Department's Drainage Manual (2019)***, ***Section 3.7*** provides guidance on hydraulic openings and protective treatments. Table 3.3 Curb and Gutter Inlet Application Guidelines, Table 3.4 Ditch Inlet Application Guidelines and Table 3-5 Drainage End Treatment – Lateral Offset Criteria in the ***Drainage Manual (2019)*** provide guidance for inlet selection.

Inlet spacing shall consider the following:

- Regardless of the results of the hydraulic analysis, inlets on grade should be spaced at a maximum of 300 ft for 48 inches or smaller pipes.
- Inlets on grade should be spaced at a maximum of 600 ft for pipes larger than 48 inches.
- Inlets should be placed on the upstream side of bridge approaches.
- Inlets should be placed at all low points in the gutter grade.
- Inlets should be placed upstream of intersecting streets.
- Inlets should be placed on the upstream side of a driveway entrance, curb-cut ramp, or pedestrian crosswalk even if the hydraulic analysis places the inlet further down grade or within the feature.
- Inlets should be placed upstream of median breaks.

- Inlets should be placed to capture flow from intersecting streets before it reaches the major highway.
- Flanking inlets in sag vertical curves are standard practice.
- Inlets should be placed to prevent water from sheeting across the highway (i.e., place the inlet before the superelevation transition begins).
- Inlets should not be located in the path where pedestrians walk.

D.6.b Grades

D.6.b.1 Longitudinal Gutter Grade

The minimum longitudinal gutter grade shall be 0.3%. Minimum grades can be maintained in very flat terrain by use of a rolling profile.

D.7 Spread Standards

The spread, in both temporary and permanent conditions, resulting from a rainfall intensity of 4.0 inches per hour shall be limited as shown in Table 20 – 2 Spread Criteria.

Table 20 – 2 Spread Criteria

Design Speed (mph)	Spread Criteria*
Design Speed ≤ 30	Crown of Road
30 < Design speed ≤ 45	Keep ½ of lane clear
45 < Design Speed ≤ 55	Keep 8' of lane clear
Design Speed > 55	No encroachment

* The criteria in this column apply to travel, turn, or auxiliary lanes adjacent to barrier wall or curb, in normal or super elevated sections.

In addition to the above standards, for sections with a shoulder gutter, the spread resulting from a 10-year frequency storm shall not exceed 1' 3" outside the gutter in the direction toward the front slope. This distance limits the spread to the face of guardrail posts.

D.8 Construction and Maintenance Considerations

Proper design shall also consider maintenance concerns of adequate physical access for cleaning and repair.

D.8.a Pipe Size and Length

Consider using a minimum pipe size of 18" for trunk lines and laterals. 15" hubcaps commonly block smaller pipes resulting in roadway flooding. The minimum pipe diameter for all proposed exfiltration trench pipes (french drain systems) within a drainage system is 18".

The maximum pipe lengths without maintenance access structures are as follows:

<u>Pipes without French Drains:</u>

18" - 42" pipe	300 feet
48" and larger and all box culverts	600 feet

French Drains that have access through only one end:

18" to 30" pipe	150 feet
36" and larger pipe	200 feet

French Drains that have access through both ends:

24" to 30" pipe	300 feet
36" and larger pipe	400 feet

D.8.b Minimum Clearances

A minimum cover of 1 ft should be provided between the top of pipe and the top of subgrade. A minimum clearance of 1 ft should be provided between storm drainage pipes and other underground facilities (e.g., sanitary sewers). Check with local utility companies, as their clearance requirements may vary from the 1' minimum.

D.9 Protective Treatment

Drainage designs shall be reviewed to determine if some form of protective treatment will be required to prevent unauthorized entry to long or submerged storm drain systems, steep ditches, or water control facilities. If other modifications, such as landscaping or providing flat slopes, can eliminate the potential hazard and thus the need for protective treatment, they should be considered first. Areas provided for retention and detention, for example, can often be effectively integrated into parks or other green spaces.

Vehicular and pedestrian safety are attained by differing protective treatments, often requiring the designer to make a compromise in which one type of protection is more completely realized than the other. In such cases, an evaluation should be made of the relative risks and dangers involved to provide the design that gives the best balance. It must be remembered that the function of the drainage feature will be essentially in conflict with total safety, and that only a reduction rather than elimination of all risk is possible.

The three basic types of protective treatment are shown in Table 20 – 3 Protective Treatments.

Table 20 – 3 Protective Treatments

Feature	Typical Use
Grates	To prevent persons from being swept into long or submerged drainage systems.
Guards	To prevent entry into long sewer systems under no-storm conditions, to prevent persons from being trapped.
Fences	To prevent entry into areas of unexpected deep standing water or high velocity water flow, or in areas where grates or guards are warranted but are unsuitable for other reasons.

When determining the type and extent of protective treatment, the following considerations should be reviewed:

- The nature and frequency of the presence of children in the area, e.g., proximity to schools, school routes, and parks, should be established.
- Highway access status should be determined. Protective treatment is usually not warranted within a limited access highway; however, drainage facilities located outside the limited access area or adjacent to a limited access highway should be considered unlimited access facilities.
- Adequate debris and access control would be required on all inlet points if guards or grates are used at outlet ends.
- Hydraulic determinations such as depth and velocity should be based on a 25-year rainfall event.
- The hydraulic function of the drainage facility should be checked and adjusted so the protective treatment will not cause a reduction in its effectiveness.
- Use of a grate may cause debris or persons to be trapped against the hydraulic opening. Grates for major structures should be designed in a manner that allows items to be carried up by increasing flood stages.

- Use of a guard may result in a person being pinned against it. A guard is usually used on outlet ends.
- A fence may capture excessive amounts of debris, which could possibly result in its destruction and subsequent obstruction of the culvert. The location and construction of a fence shall reflect the effect of debris-induced force.

D.10 Documentation

For new construction, supporting calculations for storm sewer system design shall be documented and provided to facility owner.

E CROSS DRAIN HYDRAULICS

This section presents standards and procedures for the hydraulic design of cross drains including culverts, bridge-culverts[1], and bridges.

E.1 Design Frequency

The recommended minimum design flood frequency for culverts is shown in Table 20 – 4 Recommended Minimum Design Flood Frequency. The minimum flood frequency used to design the culvert can be adjusted based on:

- An analysis to justify the flood frequencies greater or lesser than the minimum flood frequencies listed below; and
- The culvert being located in a National Flood Insurance Program mapped floodplain.

Table 20 – 4 Recommended Minimum Design Flood Frequency

Roadway Classification	Exceedance Probability (%)	Return Period (Year)
Local Roads and Streets, ADT >3,000 VPD	4%	25
Local Roads and Streets, ADT ≤ 3,000 VPD*	20-10%	5-10

*At the discretion of the local agency

[1] A culvert qualifies as a bridge if it meets the requirements of Item 112 in the FDOT "***Bridge Management System (BMS) Coding Guide.***"

E.2 Backwater

Allowable headwater is the depth of water that can be ponded at the upstream end of the culvert during the design flood. The allowable headwater for the design frequency should:

- Have a level of inundation that is tolerable to upstream property and roadway for the design discharge;
- Consider a duration or inundation that is tolerable to the upstream vegetation to avoid crop damage; and
- Be lower than the upstream shoulder edge elevation at the lowest point of the roadway within the drainage basin.

If the allowable headwater depth to culvert height ratio (HW/D) is established to be greater than 1.5, the inlet of the culvert will be submerged. Under this condition, the hydraulics designer should provide an end treatment to mitigate buoyancy.

E.3 Tailwater

For the sizing of cross drains and the determination of headwater and backwater elevations, the highest tailwater elevation which can be reasonably expected to occur coincident with the design storm event shall be used.

E.4 Clearances

To permit the passage of debris, a minimum clearance of 2 ft should be provided between the design approach water surface elevation and the low chord of the bridge where practical. Where this is not practicable, the clearance should be established by the hydraulics engineer based on the type of stream and level of protection desired. Additional vertical clearance information can be found in ***Chapter 3 – Geometric Design***.

E.5 Bridges and Other Structures

See ***Chapter 17, Section C.3.e*** for Drainage Criteria.

F STORMWATER MANAGEMENT

F.1 Regulatory Requirements

F.1.a Chapter 62-25, Florida Administrative Code

Chapter 62-25. F.A.C., rules of the Florida Department of Environmental Protection specifies minimum water quality treatment standards for new development.

F.1.b Chapter 62-40, Florida Administrative Code

Chapter 62-40, F.A.C., rules of the Florida Department of Environmental Protection outlines basic goals and requirements for surface water protection and management to be implemented and enforced by the Florida Department of Environmental Protection and Water Management Districts.

F.1.c National Pollutant Discharge Elimination System

The ***National Pollutant Discharge Elimination System*** (***NPDES***) permit program is administered by the U. S. Environmental Protection Agency and delegated to the Florida Department of Environmental Protection in Florida. This program requires permits for stormwater discharges into waters of the United States from industrial activities; and from large and medium municipal separate storm sewer systems (MS4s). Construction projects are within the definition of an industrial activity.

G CULVERT MATERIALS

The evaluation of culvert materials shall consider functionally equivalent performance in three areas: durability, structural capacity, and hydraulic capacity.

G.1 Durability

Culverts shall be designed for a design service life (DSL) appropriate for the culvert function and highway type. The design service life should be based on factors such as:

- Projected service life of the facility
- Importance of the facility
- Economics
- Potential inconvenience and difficulties associated with repair or replacement, and projected future demands on the facility.

In estimating the projected service life of a material, consideration shall be given to actual performance of the material in nearby similar environmental conditions, its theoretical corrosion rate, potential for abrasion, and other appropriate site factors. Theoretical corrosion rates shall be based on the environmental conditions of both the soil and water. At a minimum, the following corrosion indicators shall be considered:

1. pH
2. Resistivity
3. Sulfates
4. Chlorides

The Department provides a program called ***Culvert Service Life Estimator*** for estimating the service life of culverts based on the above criteria

To avoid unnecessary site specific testing, generalized soil maps may be used to delete unsuitable materials from consideration. The potential for future land use changes which may change soil and water corrosion indicators shall also be considered to the extent practical.

G.2 Structural Capacity

AASHTO design guidelines and industry recommendations should be considered in pipe material selection.

G.3 Hydraulic Capacity

The hydraulic evaluation shall establish the hydraulic size for the particular culvert application. For storm drains and cross drains, the design shall use the Manning's roughness coefficient associated with the pipe material selected.

THIS PAGE INTENTIONALLY LEFT BLANK