User Guide for Roadway Speed Limit Review Forms

This guide includes a glossary of terms used in the Roadway Speed Limit Review Packet as well as reference documents. The document uses bookmarks to allow the user to quickly jump to the desired section. To access the bookmarks, click 🔖

If that image is not available, right click on the document and select “Show Navigation Pane Buttons”.

Attachments

1. Example Strip Analysis
2. Example Features Report
3. Example 85% Speed Raw Data
4. Ball Bank Study Form
5. *FHWA Highway Functional Classification Concepts, Criteria, and Procedures*
6. *NCDOT Complete Streets Planning and Design Guidelines*
7. *North Carolina Pedestrian Crossing Guidance*

Data Collection Terms

TERM	DEFINITION
Attachments	
Strip Analysis	Check box if strip analysis was conducted and included as an appendix to the data collection form
Features Report	Check box if a features report was conducted and included as an appendix to the data collection form
Neighborhood Petition	Check box if neighborhood petition was submitted and included as an appendix to the data collection form
Photographs	Check box if site photographs were taken and included as an appendix to the data collection form
85% Speed Raw Data	Check box if a speed study was conducted and raw data included as an appendix to the data collection form
Ball Bank Study Form	Check box if ball bank study was conducted and study form included as an appendix to the data collection form
Bicycle Activity Observed/Expected	Note the level of bicycle activity observed relative to similar roadways in the area. For expected activity, consider any traffic generator which may have high bicycle peaking by time of day (e.g. designated commuter bike route)
Completed By	Name of person completing the worksheet
County	County in which roadway segment is located

Current Speed Limit	Current posted or statutory speed limit of the study segment
Date	Date the worksheet is being completed
DOT Route ID	Full 10 digit route code for the study road as defined by NCDOT
Driving Investigation	Drive the segment and note any areas with potentially inadequate sight distance, vertical alignment, or horizontal alignment.
Lanes	
# of Thru Lanes	At a representative area away from an intersection
Average Width	Measured along a continuous through lane from edge of lane line to edge of lane line
TWLTL Present	Note if two way left turn lane is present
Length	Length of roadway for which speed limit is being studied
Mile posted Crashes	Use data from Strip Analysis or other crash data source
Multimodal Facilities	
Are schools present along the segment	In the note, detail what level(s) of schools (e.g. middle, high, community)
Are parks or recreation areas present along the segment	In the note, detail type of facility (e.g. playground, garden, sports complex)
Are pedestrian facilities present along the segment	In the note, detail type of facility (e.g. sidewalk, shared use path, crosswalk)
Are transit facilities present along the segment	In note, detail type of facility (e.g. light rail tracks, bus stop)
Are bicycle facilities present along the segment	In note, detail type of facility (e.g. shared use path, cycle track, sharrows). Make note if it is a designated bike route.
Is on-street parking permitted	In note, detail type of parking (e.g. short term, long term, loading zone)

Municipality	Municipality in which roadway segment is located; If the roadway is not within municipality limits, leave blank. This can be used for coordinating with local agencies.
NCDOT Complete Street Area Type	Use the *NCDOT Complete Streets Planning and Design Guidelines* to determine the area type found in the chapter on Understanding Context and Designing for All Users. Possibilities include: CBD, Urban Center, Urban Residential, Suburban Center, Suburban Corridor, Suburban Residential, Rural Developed, Rural Village, Countryside
Number of Driveways by Type	Count of all business and residential driveways within the study segment on both sides of the road
Number of Intersections by Type	Count of all intersections within the study segment on both sides of the road. Intersections which restrict movement (e.g. right in – right out) should be included.
Pavement	
Width	Measured from edge of pavement to edge of pavement
Type	Check one or more boxes as appropriate
Condition	Check one or more boxes as appropriate. This should be used to determine if pavement condition is impacting operating speeds. Pavement conditions that reduce speeds below what the typical operator would travel on adequate pavement conditions are of particular interest (e.g. overall roughness or excessive cracking/potholes).
Marking Condition	Check one or more boxes as appropriate
Median Type	Check one or more boxes as appropriate
Median Width	Measured from edge of median to edge of median in a representative area away from an intersection.
Pedestrian Activity Observed/Expected	Note the level of pedestrian activity observed relative to similar roadways in the area. For expected activity, consider any traffic generator which may have high pedestrian peaking by time of day (e.g. retail shopping area, school). See *NCDOT Pedestrian Crossing Guidance* for “low” threshold.
Photographs	Describe any photographs taken on site and attach the same to the report
Plan-view sketch of road segment with major intersecting roads	Include any major landmarks as well as major intersecting roads. Include curves as necessary
Reference #	OPTIONAL, for internal use only

Result of 85% Speed Study	Speed (mph) at which 85th percentile fastest driver is traveling in uncongested conditions
Road Classification	Use Route ID or *FHWA Highway Functional Classification Concepts, Criteria, and Procedures document* to determine the functional roadway classification. Possibilities include: Interstate, Freeway/Expressway, Principal Arterial, Minor Arterial, Major Collector, Minor Collector, Local
Shoulders	
Width	At a representative area away from an intersection. Select "none" if no shoulder is present or "curb" if curb is present.
Type	Check one or more boxes as appropriate
Condition	Check one or more boxes as appropriate
Typical Distance to Roadside Hazards	At a representative area away from an intersection, measure the lateral distance from the edge of pavement to the nearest hazard
Signs	Note any warning or regulatory signs in need of replacement or repair, with particular attention to speed limit and advisory speed limit signs
Speed limit downstream of starting point	Speed limit of roadway being studied downstream of the start of the study segment (downstream as defined in the plan-view sketch)
Speed limit upstream of starting point	Speed limit of roadway being studied upstream of the start of the study segment (upstream as defined in the plan-view sketch)
Study Motivation	State the factor which initiated the study (e.g. citizen request, statutory review, crash history)
Study Road	Road for which the speed limit is being studied
Study segment begins	Starting point of the study segment, recorded as a distance and direction from a road intersecting the study roadway
Study segment ends	Ending point of the study segment, recorded as a distance and direction from a road intersecting the study roadway
Traffic Composition	Check one or both boxes depending on the surrounding area and likelihood for either local/commuter drivers familiar with the area and/or drivers unfamiliar with the area
Typical Building Offset to Roadway	Typical average distance between the roadway and the face of buildings along the roadway

North Carolina Department of Transportation
Traffic Engineering Accident Analysis System
Strip Analysis Report

Study Criteria Summary

County: CHATHAM **City:** All and Rural

Date: 6/1/2011 **to** 5/31/2016 **Study:** 06292016001SR1972

Location: SR 1972 (Pea Ridge Road) from SR 1008 (Beaver Creek Road) to SR 1910 (Merry Oaks Church Road).

Report Details

Acc No	Crash ID	Milepost	Date	Accident Type	Total Damage	Injuries				Condition			Road		Trfc Ctl	
						F	A	B	C	R	L	W	Ch	Ci	Dv	Op
1	**103350242**	0.000	01/09/2012 07:00	SIDESWIPE, OPPOSITE DIRECTION	$ 250	0	0	0	0	2	5	3	1	0	13	1
Unit	**1 : 2**	**Alchl/Drgs:** 0		**Speed:** 55 MPH	**Dir:** E	**Veh Mnvr/Ped Actn:** 4							**Obj Strk:**			
Unit	**2 : 32**	**Alchl/Drgs:** 7		**Speed:** 55 MPH	**Dir:** W	**Veh Mnvr/Ped Actn:** 4							**Obj Strk:**			
2	**104374752**	0.000	05/11/2015 10:59	FIXED OBJECT	$ 12000	0	0	1	1	1	1	1	1	0	13	1
Unit	**1 : 4**	**Alchl/Drgs:** 0		**Speed:** 55 MPH	**Dir:** SW	**Veh Mnvr/Ped Actn:** 4							**Obj Strk:** 33			
3	**104451393**	0.000	08/04/2015 04:20	FIXED OBJECT	$ 5500	0	0	0	0	1	5	1	1	0	1	1
Unit	**1 : 4**	**Alchl/Drgs:** 1		**Speed:** 55 MPH	**Dir:** E	**Veh Mnvr/Ped Actn:** 7							**Obj Strk:** 42			
4	**103448178**	0.105	05/11/2012 10:35	FIXED OBJECT	$ 4000	0	0	0	0	1	1	1	7	0	13	1
Unit	**1 : 1**	**Alchl/Drgs:** 0		**Speed:** 65 MPH	**Dir:** S	**Veh Mnvr/Ped Actn:** 4							**Obj Strk:** 33			
5	**103546765**	1.000	09/06/2012 04:41	FIXED OBJECT	$ 20000	0	0	0	0	1	5	1	1	0	13	1
Unit	**1 : 1**	**Alchl/Drgs:** 7		**Speed:** 60 MPH	**Dir:** N	**Veh Mnvr/Ped Actn:** 4							**Obj Strk:** 33			
6	**104434063**	1.155	07/12/2015 08:13	FIXED OBJECT	$ 2500	0	0	0	0	1	1	1	1	0	0	
Unit	**1 : 1**	**Alchl/Drgs:** 0		**Speed:** 45 MPH	**Dir:** S	**Veh Mnvr/Ped Actn:** 4							**Obj Strk:** 33			
7	**103467698**	1.655	05/23/2012 13:00	FIXED OBJECT	$ 4000	0	0	0	0	1	1	1	1	0	13	1
Unit	**1 : 1**	**Alchl/Drgs:** 7		**Speed:** 15 MPH	**Dir:** N	**Veh Mnvr/Ped Actn:** 9							**Obj Strk:** 64			
8	**103967049**	1.967	01/30/2014 09:09	FIXED OBJECT	$ 2000	0	0	0	2	4	1	1	1	0	13	1
Unit	**1 : 2**	**Alchl/Drgs:** 0		**Speed:** 45 MPH	**Dir:** N	**Veh Mnvr/Ped Actn:** 4							**Obj Strk:** 33			
9	**103855110**	2.117	09/23/2013 06:34	ANIMAL	$ 1500	0	0	0	0	1	3	1	7	0	13	1
Unit	**1 : 1**	**Alchl/Drgs:** 0		**Speed:** 55 MPH	**Dir:** E	**Veh Mnvr/Ped Actn:** 4							**Obj Strk:** 17			

North Carolina Department of Transportation
Traffic Engineering Accident Analysis System
Strip Analysis Report

Acc No	Crash ID	Milepost	Date	Accident Type	Total Damage	Injuries				Condition			Road		Trfc Ctl	
						F	A	B	C	R	L	W	Ch	Ci	Dv	Op
22	**103649831**	2.942	01/12/2013 18:27	ANIMAL	$ 5000	0	0	0	0	1	5	5		0		
Unit	**1 : 2**	**Alchl/Drgs:** 0		**Speed:** 0 MPH **Dir:** N		**Veh Mnvr/Ped Actn:** 4							**Obj Strk:** 17			
23	**104318786**	3.041	02/22/2015 16:23	FIXED OBJECT	$ 1000	0	0	0	0	1	1	2	5	0	13	1
Unit	**1 : 2**	**Alchl/Drgs:** 0		**Speed:** 45 MPH **Dir:** N		**Veh Mnvr/Ped Actn:** 4							**Obj Strk:** 38			
24	**104718683**	3.042	04/25/2016 23:28	OVERTURN/ROLLOVER	$ 2000	0	0	0	0	1	5	1	5	0	13	1
Unit	**1 : 2**	**Alchl/Drgs:** 7		**Speed:** 25 MPH **Dir:** N		**Veh Mnvr/Ped Actn:** 7							**Obj Strk:**			

Legend for Report Details:

Acc No - Accident Number
Injuries: F - Fatal, A - Class A, B - Class B, C - Class C
Condition: R - Road Surface, L - Ambient Light, W - Weather
Rd Ch - Road Character
Rd Ci - Roadway Contributing Circumstances
Trfc Ctl - Traffic Control: Dv - Device, Op - Operating
Alchl/Drgs - Alcohol Drugs Suspected
Veh Mnvr/Ped Actn - Vehicle Maneuver/Pedestrian Action
Obj Strk - Object Struck

Summary Statistics

High Level Crash Summary

Crash Type	Number of Crashes	Percent of Total
Total Crashes	24	100.00
Fatal Crashes	0	0.00
Non-Fatal Injury Crashes	3	12.50
Total Injury Crashes	3	12.50
Property Damage Only Crashes	21	87.50
Night Crashes	12	50.00
Wet Crashes	4	16.67
Alcohol/Drugs Involvement Crashes	1	4.17

Crash Severity Summary

Crash Type	Number of Crashes	Percent of Total
Total Crashes	24	100.00
Fatal Crashes	0	0.00
Class A Crashes	0	0.00
Class B Crashes	1	4.17
Class C Crashes	2	8.33
Property Damage Only Crashes	21	87.50

Vehicle Exposure Statistics

Annual ADT = 2000

Total Length = 3.042 (Miles) **4.896 (Kilometers)**

Total Vehicle Exposure = 11.12 (MVMT) **17.89 (MVKMT)**

Crash Rate	Crashes Per 100 Million Vehicle Miles	Crashes Per 100 Million Vehicle Kilometers
Total Crash Rate	215.92	134.16
Fatal Crash Rate	0.00	0.00
Non Fatal Crash Rate	26.99	16.77
Night Crash Rate	107.96	67.08
Wet Crash Rate	35.99	22.36
EPDO Rate	415.64	258.26

Miscellaneous Statistics

Severity Index =	1.92
EPDO Crash Index =	46.20
Estimated Property Damage Total = $	91000.00

Accident Type Summary

Accident Type	Number of Crashes	Percent of Total
ANIMAL	11	45.83
FIXED OBJECT	11	45.83
OVERTURN/ROLLOVER	1	4.17
SIDESWIPE, OPPOSITE DIRECTION	1	4.17

Injury Summary

Injury Type	Number of Injuries	Percent of Total
Fatal Injuries	0	0.00
Class A Injuries	0	0.00
Class B Injuries	1	16.67
Class C Injuries	5	83.33
Total Non-Fatal Injuries	6	100.00
Total Injuries	6	100.00

Monthly Summary

Month	Number of Crashes	Percent of Total
Jan	6	25.00
Feb	2	8.33
Mar	1	4.17
Apr	1	4.17
May	3	12.50
Jun	0	0.00
Jul	1	4.17
Aug	1	4.17
Sep	2	8.33
Oct	1	4.17
Nov	2	8.33
Dec	4	16.67

Daily Summary

Day	Number of Crashes	Percent of Total
Mon	6	25.00
Tue	2	8.33
Wed	1	4.17
Thu	5	20.83
Fri	6	25.00
Sat	1	4.17
Sun	3	12.50

Hourly Summary

Hour	Number of Crashes	Percent of Total
0000-0059	0	0.00
0100-0159	1	4.17
0200-0259	0	0.00
0300-0359	0	0.00
0400-0459	2	8.33
0500-0559	0	0.00
0600-0659	2	8.33
0700-0759	4	16.67
0800-0859	1	4.17
0900-0959	1	4.17
1000-1059	4	16.67
1100-1159	0	0.00
1200-1259	0	0.00
1300-1359	1	4.17
1400-1459	0	0.00
1500-1559	0	0.00
1600-1659	1	4.17
1700-1759	0	0.00
1800-1859	2	8.33
1900-1959	4	16.67
2000-2059	0	0.00
2100-2159	0	0.00
2200-2259	0	0.00
2300-2359	1	4.17

Light and Road Conditions Summary

Condition	Dry	Wet	Other	Total
Day	6	3	1	10
Dark	10	1	1	12
Other	2	0	0	2
Total	18	4	2	24

Object Struck Summary

Object Type	Times Struck	Percent of Total
ANIMAL	11	50.00
DITCH	2	9.09
GUARDRAIL FACE ON SHOULDER	1	4.55
OFFICIAL HIGHWAY SIGN BREAKAWAY	1	4.55
OTHER FIXED OBJECT	1	4.55
TREE	6	27.27

Vehicle Type Summary

Vehicle Type	Number Involved	Percent of Total
PASSENGER CAR	12	48.00
PICKUP	8	32.00
SPORT UTILITY	2	8.00
UNKNOWN	1	4.00
VAN	2	8.00

Yearly Totals Summary

Accident Totals

Year	Total Accidents	Fatal Accidents	Injury Accidents	Property Damage Only Accidents
2011	0	0	0	0
2012	7	0	0	7
2013	5	0	0	5
2014	3	0	1	2
2015	6	0	1	5
2016	3	0	1	2
Total	24	0	3	21

Injury Totals

Year	Fatal Injuries	Class A, B, or C Injuries
2011	0	0
2012	0	0
2013	0	0
2014	0	2
2015	0	2
2016	0	2
Total	0	6

Miscellaneous Totals

Year	Property Damage	EPDO Index
2011	$ 0	0.00
2012	$ 34950	7.00
2013	$ 14000	5.00
2014	$ 5500	10.40
2015	$ 26000	13.40
2016	$ 10550	10.40
Total	$ 91000	46.20

Type of Accident Totals

Year	Left Turn	Right Turn	Rear End	Run Off Road & Fixed Object	Angle	Side Swipe	Other
2011	0	0	0	0	0	0	0
2012	0	0	0	3	0	1	3

Year	Left Turn	Right Turn	Rear End	Run Off Road & Fixed Object	Angle	Side Swipe	Other
2013	0	0	0	0	0	0	5
2014	0	0	0	2	0	0	1
2015	0	0	0	4	0	0	2
2016	0	0	0	2	0	0	1
Total	0	0	0	11	0	1	12

Strip Diagram

Features	Milepost	Crash IDs
SR 1008	0.00	103350242 104374752 104451393
	0.01	
	0.02	
	0.03	
	0.04	
	0.05	
	0.06	
	0.07	
	0.08	
	0.09	
	0.10	103448178
	0.11	
	0.12	
	0.13	
	0.14	
	0.15	
	0.16	
	0.17	
	0.18	
	0.19	
	0.20	
	0.21	
	0.22	
	0.23	
	0.24	
	0.25	
	0.26	
	0.27	
	0.28	
	0.29	
	0.30	
	0.31	
	0.32	
	0.33	
	0.34	
	0.35	
	0.36	
	0.37	
	0.38	
	0.39	
	0.40	
	0.41	
	0.42	

Features	Milepost	Crash IDs
	0.43	
	0.44	
	0.45	
	0.46	
	0.47	
	0.48	
	0.49	
	0.50	
	0.51	
	0.52	
	0.53	
	0.54	
	0.55	
	0.56	
	0.57	
	0.58	
	0.59	
	0.60	
	0.61	
	0.62	
	0.63	
	0.64	
	0.65	
	0.66	
	0.67	
	0.68	
	0.69	
	0.70	
	0.71	
	0.72	
	0.73	
	0.74	
	0.75	
	0.76	
	0.77	
	0.78	
	0.79	
	0.80	
	0.81	
	0.82	
	0.83	
	0.84	
	0.85	
	0.86	
	0.87	
	0.88	

Features	Milepost	Crash IDs
	0.89	
	0.90	
	0.91	
	0.92	
	0.93	
	0.94	
	0.95	
	0.96	
	0.97	
	0.98	
	0.99	
	1.00	103546765
	1.01	
	1.02	
	1.03	
	1.04	
	1.05	
	1.06	
	1.07	
	1.08	
	1.09	
	1.10	
	1.11	
	1.12	
	1.13	
	1.14	
SR 1907	1.15	104434063
	1.16	
	1.17	
	1.18	
	1.19	
	1.20	
	1.21	
	1.22	
	1.23	
	1.24	
	1.25	
	1.26	
	1.27	
	1.28	
	1.29	
	1.30	
	1.31	
	1.32	
	1.33	

Features	Milepost	Crash IDs
	1.34	
	1.35	
	1.36	
	1.37	
	1.38	
	1.39	
	1.40	
	1.41	
	1.42	
	1.43	
	1.44	
	1.45	
	1.46	
	1.47	
	1.48	
	1.49	
	1.50	
	1.51	
	1.52	
	1.53	
	1.54	
	1.55	
	1.56	
	1.57	
	1.58	
	1.59	
	1.60	
	1.61	
	1.62	
	1.63	
	1.64	
	1.65	103467698
	1.66	
	1.67	
	1.68	
	1.69	
	1.70	
	1.71	
	1.72	
	1.73	
	1.74	
	1.75	
	1.76	
	1.77	
	1.78	
	1.79	

Features	Milepost	Crash IDs
	1.80	
	1.81	
	1.82	
	1.83	
	1.84	
	1.85	
	1.86	
	1.87	
	1.88	
	1.89	
	1.90	
	1.91	
	1.92	
	1.93	
	1.94	
	1.95	
	1.96	
	1.97	103967049
	1.98	
	1.99	
	2.00	
	2.01	
	2.02	
	2.03	
	2.04	
	2.05	
	2.06	
	2.07	
	2.08	
	2.09	
	2.10	
	2.11	
	2.12	103855110
	2.13	
	2.14	
	2.15	104207528
	2.16	
	2.17	
	2.18	
	2.19	
	2.20	
	2.21	
	2.22	
	2.23	
	2.24	

Features	Milepost	Crash IDs
	2.25	
	2.26	
SR 1974	2.27	
	2.28	
	2.29	
	2.30	
	2.31	
	2.32	
	2.33	
	2.34	
	2.35	
	2.36	
	2.37	104277807
	2.38	
	2.39	
	2.40	
	2.41	
	2.42	
	2.43	
	2.44	
	2.45	
	2.46	
	2.47	103887968
	2.48	
	2.49	
	2.50	
	2.51	
	2.52	
	2.53	103933517
	2.54	
	2.55	
	2.56	
	2.57	103369677 | 104239724
	2.58	
	2.59	
	2.60	
	2.61	104686725
	2.62	
SR 1988	2.63	
	2.64	
	2.65	
	2.66	
	2.67	
	2.68	
	2.69	104621265

Features	Milepost	Crash IDs
	2.70	
	2.71	
	2.72	
	2.73	103638575
	2.74	
	2.75	
	2.76	
	2.77	
	2.78	
	2.79	
	2.80	
	2.81	
	2.82	
	2.83	
	2.84	103658302 | 104589346
	2.85	
	2.86	
	2.87	
	2.88	
	2.89	
	2.90	
	2.91	
	2.92	
	2.93	
	2.94	103608254 | 103649831
	2.95	
	2.96	
	2.97	
	2.98	
	2.99	
	3.00	
	3.01	
	3.02	
	3.03	
SR 1910	3.04	104318786 | 104718683

North Carolina Department of Transportation
Traffic Engineering Accident Analysis System
Strip Analysis Report

Study Criteria

Study Name	Log No.	PH No.	TIP No.	K/A Cf.	B/C Cf.	ADT	ADT Route
06292016001SR1972				76.8	8.4	2000	

Request Date	Courier Service	Phone No.	Ext.	Fax No.
6/27/2016				

County			Municipality					
Name	Code	Div.	Name	Code	Y-Line Ft.	Begin Date	End Date	Years
CHATHAM	19	8	All and Rural		150	6/1/2011	5/31/2016	5.00

Location Text	Requestor
SR 1972 (Pea Ridge Road) from SR 1008 (Beaver Creek Road) to SR 1910 (Merry Oaks Church Road).	Ms. Anita Becker (919)642-0441

Fiche Roads

Name	Code
	40001972

Strip Road

Name	Code	Begin MP	End MP	Miles	Kilometers
	40001972	0.000	3.042	3.042	4.896

North Carolina Department of Transportation
Traffic Engineering Accident Analysis System
Features Report

County	Inventoried Route ID	Begin Milepost	End Milepost
CHATHAM	40001972	0.0	6.453

MP No	Feature ID	Feature Name/Type	Special Type	Distance to Next	Direction to Next	Loop	Beyond Route Limits
0.000	40001008	SR 1008	At grade intersection, 3 legs	1.155	South and East		
1.155	40001907	SR 1907	At grade intersection, 3 legs	1.112	South and East		
2.267	40001974	SR 1974	At grade intersection, 3 legs	0.363	South and East		
2.630	40001988	SR 1988	At grade intersection, 3 legs	0.412	South and East		
3.042	40001910	SR 1910	At grade intersection, 3 legs	2.090	South and East		
5.132	20400001	US 1 SB COUPLET	At grade intersection, 3 legs	0.010	North and East		
5.142	20000001	US 1	At grade intersection, 3 legs	0.000	South and East		
5.142	180063	Structure	Bridge	0.106			
5.248	40001964	SR 1964	At grade intersection, 3 legs	1.205	South and East		
6.453	40001011	SR 1011	At grade intersection, 3 legs	0.000	South and East		

SPOT SPEEDS-FIELD-RADAR

County: B D N [✓ O] P S City/Town/Area: Jacksonville

On Road: SR1211 - Firetower Road

Looking S From: 1.5 mile S of NC111

Target area: —

Day/Date: Wed. 8/17/16

Weather: Sunny 86°

Speed Limit 55mph

By: M. Bass, Jr.

		mph	Time: Start: 11:00 a.m; End: 11:45 a.m																Total	Cumul.	%	N	85th%ile	Widths
		Dir-->	[✓ N]	NE	E	SE	S	SW	W	NW-bound	N	NE	E	SE	[✓ S]	SW	W	NW- Bound						
N	85th%ile	<25																				72	61.2	
20	17.0	25																				73	62.1	
21	17.9	26																				74	62.9	
22	18.7	27																				75	63.8	
23	19.6	28																				76	64.6	
24	20.4	29																				77	65.5	
25	21.3	30																				78	66.3	
26	22.1	31																				79	67.2	
27	23.0	32																				80	68.0	
28	23.8	33																				81	68.9	
29	24.7	34																				82	69.7	
30	25.5	35																				83	70.6	
31	26.4	36																				84	71.4	
32	27.2	37																				85	72.3	
33	28.1	38																				86	73.1	
34	28.9	39																				87	74.0	
35	29.8	40																				88	74.8	
36	30.6	41																				89	75.7	
37	31.5	42																				90	76.5	
38	32.3	43	|								|								2	2		91	77.4	
39	33.2	44	|								||								3	5		92	78.2	
40	34.0	45	||								||								4	9		93	79.1	
41	34.9	46	||								||								4	13		94	79.9	
42	35.7	47									||||								4	17		95	80.8	
43	36.6	48	|								||								3	20		96	81.6	
44	37.4	49	|								|								2	22		97	82.5	
45	38.3	50																				98	83.3	
46	39.1	51	||||								||								6	28		99	84.2	
47	40.0	52	||||								|||||								9	37		100	85.0	
48	40.8	53	|||								||								5	42		101	85.9	
49	41.7	54	||								|||								5	47		102	86.7	
50	42.5	55	|								|								2	49		103	87.6	
85th%ile 51	43.4	[✓ 56]	|||																3	52		104	88.4	
52	44.2	57									|								1	53		105	89.3	
53	45.1	58																				106	90.1	
54	45.9	59									|								1	54		107	91.0	
55	46.8	60									|								1	55		108	91.8	
56	47.6	61	|								|								2	57		109	92.7	
57	48.5	62																				110	93.5	
58	49.3	63	|																1	58		111	94.4	
59	50.2	64																				112	95.2	
60	51.0	65									|								1	59		113	96.1	
61	51.9	66																				114	96.9	
62	52.7	67																				115	97.8	
63	53.6	68																				116	98.6	
64	54.4	69																				117	99.5	
65	55.3	70																				118	100.3	
66	56.1	71									|								1	60		119	101.2	
67	57.0	72																				120	102.0	
68	57.8	73																				121	102.9	
69	58.7	74																				122	103.7	
70	59.5	75																				123	104.6	
71	60.4	>75																				124	105.4	
																						125	106.3	
																						126	107.1	
																						127	108.0	

To find the 85th %ile speed for "N" observations from 20 to 127, see left or right columns.

form SSFR-1 25-75 Revised: 10/10/08

SPOT SPEEDS-FIELD-RADAR

County: B D N [✓ O] P S City/Town/Area: Jacksonville

On Road: SR 1211 - Firetower Road

Looking W From: 0.5 mile W of SR 1212 - Pony Farm Road

Target area:

Day/Date: Wed. 8/17/16

Weather: Sunny 87°

Speed Limit 55 mph

By: M. Bass, Jr.

mph Time: Start: 11:48 a.m; End: [redacted] 12:25 p.m

N	85th%ile	Dir-->	N	NE	[✓ E]	SE	S	SW	W	NW-bound	N	NE	E	SE	S	SW	[✓ W]	NW-bound	Total	Cumul.	%
		<25																			
20	17.0	25																			
21	17.9	26																			
22	18.7	27																			
23	19.6	28																			
24	20.4	29																			
25	21.3	30																			
26	22.1	31																			
27	23.0	32																			
28	23.8	33																			
29	24.7	34																			
30	25.5	35																			
31	26.4	36																			
32	27.2	37																			
33	28.1	38																			
34	28.9	39																			
35	29.8	40									ǀ								1	1	
36	30.6	41																			
37	31.5	42																			
38	32.3	43																			
39	33.2	44																			
40	34.0	45																			
41	34.9	46									ǀǀ								2	3	
42	35.7	47	ǀǀǀ								ǀǀǀ								6	9	
43	36.6	48	ǀǀ								ǀǀ								4	13	
44	37.4	49	ǀ								ǀ								2	15	
45	38.3	50									ǀǀ								2	17	
46	39.1	51	ǀ																1	18	
47	40.0	52	ǀǀǀ								ǀǀ								5	23	
48	40.8	53									ǀ								1	24	
49	41.7	54	ǀǀǀǀ								ǀǀǀ								7	31	
50	42.5	55	ǀǀ																2	33	
51	43.4	56									ǀǀ								2	35	
52	44.2	57	ǀǀǀ																3	38	
53	45.1	58	ǀ								ǀǀǀǀǀ								6	44	
54	45.9	59									ǀ								1	45	
55	46.8	60	ǀǀ								ǀ								3	48	
56	47.6	85th% → 61									ǀ								1	49	
57	48.5	62	ǀǀǀ								ǀǀ								5	54	
58	49.3	63																			
59	50.2	64																			
60	51.0	65									ǀ								1	55	
61	51.9	66	ǀ																1	56	
62	52.7	67																			
63	53.6	68	ǀ																1	57	
64	54.4	69									ǀ								1	58	
65	55.3	70																			
66	56.1	71																			
67	57.0	72																			
68	57.8	73																			
69	58.7	74																			
70	59.5	75																			
71	60.4	>75																			

N	85th%ile	Widths
72	61.2	
73	62.1	
74	62.9	
75	63.8	
76	64.6	
77	65.5	
78	66.3	
79	67.2	
80	68.0	
81	68.9	
82	69.7	
83	70.6	
84	71.4	
85	72.3	
86	73.1	
87	74.0	
88	74.8	
89	75.7	
90	76.5	
91	77.4	
92	78.2	
93	79.1	
94	79.9	
95	80.8	
96	81.6	
97	82.5	
98	83.3	
99	84.2	
100	85.0	
101	85.9	
102	86.7	
103	87.6	
104	88.4	
105	89.3	
106	90.1	
107	91.0	
108	91.8	
109	92.7	
110	93.5	
111	94.4	
112	95.2	
113	96.1	
114	96.9	
115	97.8	
116	98.6	
117	99.5	
118	100.3	
119	101.2	
120	102.0	
121	102.9	
122	103.7	
123	104.6	
124	105.4	
125	106.3	
126	107.1	
127	108.0	

To find the 85th %ile speed for "N" observations from 20 to 127, see left or right columns.

form SSFR-1 25-75 Revised: 10/10/08

Ball Bank Indicator Worksheet **Version 1**

Date: M M / D D / Y Y Reference #: ____________ Completed By: ________________

County: ______________________________ Municipality: __________________

Study Road: ____________________________ Current Speed Limit: ________________

Plan-view sketch of road segment
with major intersecting roads

Number each horizontal curve (HC1, HC2, HC3, etc)
Also note any areas with questionable sight distance

Presence of Advisory Speed Signs
& Ballbank Indicator Readings

For each curve, note the posted advisory speed limit or that such sign is not present (NP)

For each curve, note if the BBI has a reading less than or greater than 12.0

Horizontal Curve	1	2	3	4	5	6	7	8	9	10	11	12
Advisory Speed Limit	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS

	Posted Speed											
Curve	1	2	3	4	5	6	7	8	9	10	11	12
1st Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
2nd Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
3rd Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓

	Posted Speed +5 MPH											
Curve	1	2	3	4	5	6	7	8	9	10	11	12
1st Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
2nd Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
3rd Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓

	Posted Speed -5 MPH											
Curve	1	2	3	4	5	6	7	8	9	10	11	12
1st Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
2nd Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
3rd Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓

Ball Bank Indicator Worksheet

Version 1

Date: M M / D D / Y Y

Reference #: ____________

Completed By: ____________

County: ____________

Municipality: ____________

Study Road: ____________

Current Speed Limit: ____________

Plan-view sketch of road segment with major intersecting roads

Number each horizontal curve (HC1, HC2, HC3, etc)
Also note any areas with questionable sight distance

Presence of Advisory Speed Signs & Ballbank Indicator Readings

For each curve, note the posted advisory speed limit or that such sign is not present (NP)

For each curve, note if the BBI has a reading less than or greater than 12.0

Horizontal Curve	1	2	3	4	5	6	7	8	9	10	11	12
Advisory Speed Limit	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS	AS

	Posted Speed											
Curve	1	2	3	4	5	6	7	8	9	10	11	12
1st Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
2nd Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
3rd Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓

	Posted Speed +5 MPH											
Curve	1	2	3	4	5	6	7	8	9	10	11	12
1st Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
2nd Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
3rd Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓

	Posted Speed -5 MPH											
Curve	1	2	3	4	5	6	7	8	9	10	11	12
1st Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
2nd Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓
3rd Drive Thru	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓	↑ ↓

U.S. Department of Transportation
Federal Highway Administration

Highway Functional Classification Concepts, Criteria and Procedures

2013 Edition

U.S. Department of Transportation
Federal Highway Administration

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SECTION 1. INTRODUCTION

The *Highway Functional Classification: Concepts, Criteria and Procedures, 2013 Edition*, describes the procedures and processes for assigning functional classifications to roadways and adjusting urban area boundaries. This document builds upon and modifies prior guidance documents.

Our nation's roadway system is a vast network that connects places and people within and across national borders. Planners and engineers have developed elements of this network with particular travel objectives in mind. These objectives range from serving long-distance passenger and freight needs to serving neighborhood travel from residential developments to nearby shopping centers. The functional classification of roadways defines the role each element of the roadway network plays in serving these travel needs.

Over the years, functional classification has come to assume additional significance beyond its purpose as a framework for identifying the particular role of a roadway in moving vehicles through a network of highways. Functional classification carries with it expectations about roadway design, including its speed, capacity and relationship to existing and future land use development. Federal legislation continues to use functional classification in determining eligibility for funding under the Federal-aid program. Transportation agencies describe roadway system performance, benchmarks and targets by functional classification. As agencies continue to move towards a more performance-based management approach, functional classification will be an increasingly important consideration in setting expectations and measuring outcomes for preservation, mobility and safety.

As a result of the decennial census, the US Census Bureau issues urban area boundary maps. Transportation agencies should review these census boundaries and either accept them as is or adjust them for transportation planning purposes.

This guidance document provides recommended practices for assigning functional classifications and adjusting urban area boundaries concerning roadways that Federal, State and local transportation entities own and operate. Assigning functional classifications and adjusting urban area boundaries requires work elements common to many large-scale business enterprises: there are technical methods and tools to create an efficient and cost-effective end product; there are also procedural elements that require coordination and negotiation across agencies and individuals. This guidance document encompasses both of these elements.

This guidance document also recognizes and describes the implications of how our roadway systems are configured, used and planned for today:

- The Federal-aid system has matured significantly. A significant proportion of new functional classification designations are likely to occur from improvements and modifications to existing roads and corridors, rather than from designations on new roadways and corridors.

- In conducting functional classification updates, State departments of transportation (DOTs) strive for consensus with potentially dozens of agencies, including metropolitan and rural planning agencies, local officials and FHWA Division Offices.
- Geospatial technologies and travel demand forecasting capabilities have advanced significantly, greatly lowering the cost of data storage and increasing analysis capabilities.
- Planners and engineers have expanded roadway design options significantly, especially in areas where providing for non-motorized travel is a priority. Transportation agencies have developed their own classification terms to describe these options.

1.1 Overview

This guidance document builds upon and updates the two most recent guidance documents circulated by FHWA, namely:

- Highway Functional Classification: Concepts, Criteria and Procedures, March 1989
- Updated Guidance for the Functional Classification of Highways Memorandum, October 14, 2008[1]

1. All functional classification categories will now exist in both urban and rural areas. Specifically, all Principal Arterial sub-categories and all Collector sub-categories will be recognized in both urban and rural forms. The following revised functional classification categories should be used:
    a. Principal Arterial
        i. Interstate
        ii. Other Freeways & Expressways (OF&E) (**Figure 1-1**)
        iii. Other (OPA)
    b. Minor Arterial
    c. Collector
        i. Major Collector
        ii. Minor Collector
    d. Local
2. States should assign functional classifications according to how the roadway is functioning in the current year only. With regard to future routes, roads should be functionally classified with

Figure 1-1: Principal Arterial - Other Freeways & Expressways

Source: Ohio Statewide Imagery Program

---

[1] http://www.fhwa.dot.gov/policy/ohpi/hpms/fchguidance.cfm

Roadways that fall into the Principal Arterials- Other Freeways & Expressways category are limited-access roadways that serve travel in a similar way to the Interstates.

Transportation agencies apply a variety of treatments to preserve mobility and increase the person throughput of Urban Arterials, including ramp metering, high-occupancy-vehicle (HOV) lanes and high-occupancy toll lanes.

Figure 1-2: HOV Lane on Interstate 95 in Woodbridge, VA

Source: www.roadstothefuture.com

the existing system if they are included in an approved Statewide Transportation Improvement Program (STIP) and are expected to be under construction within the STIP timeframe of 4 years or less. Use the current classification for roadways, even replacement roadways that will upgrade the roadway, until construction is complete. Reclassify the new roadway once it has been constructed.

3. Ramps and other non-mainline roadways are to be assigned the same functional classification as the highest functional classification among the connecting mainline roadways served by the ramp. (**Figure 1-2**)
4. Principal Arterial roadways (**Figure 1-3**) serve a large percentage of travel between cities and other activity centers, especially when minimizing travel time and distance is important. For this reason, Arterials typically are roadways with high traffic volumes and are frequently the route of choice for intercity buses and trucks. The spacing of Arterials in urban areas is closely related to the trip-end density characteristics of activity centers in urban areas. The spacing of these facilities (in larger urban areas) may vary from less than 1 mile in highly developed central business areas to 5 miles or more in the sparsely developed urban fringes.

Figure 1-3: Other Principal Arterial in California

Source: Akos Szoboszlay

Principal Arterials play a unique role in providing a high degree of mobility and carrying a high proportion of travel for long distance trips. These facilities carry the major portion of trips entering and leaving an activity center, as well as the majority of through movements that either go directly through or bypass the area.

SECTION 2. CONCEPTS

2.1 Introduction

This section of the guidance document presents the concepts underlying the functional classification of roadways. It first introduces the two primary transportation functions of roadways, namely mobility and access, and describes where different categories of roadways fall within a continuum of mobility-access. In addition to mobility and access, other factors that can help determine the proper category to which a particular roadway belongs — such as trip length, speed limit, volume, and vehicle mix — are discussed in this section.

While Arterials, Collectors and Locals span the full range of roadway functions, the Federal functional classification scheme uses additional classification categories to describe these functions more precisely. Distinctions between access-controlled and full-access roadways; the urban and rural development pattern; and subtleties between "major" and "minor" sub-classifications are key considerations when determining the Federal functional classification category to which a particular roadway belongs. The process of determining the correct functional classification of a particular roadway is as much art as it is science. Therefore, a real-world example is presented to help make the discussion of functional classification more readily understood.

The flow of traffic throughout a roadway network is similar to the flow of blood through the human circulatory system or the trunk and branch system of a tree. The units moving through the system (blood cells, nutrients, vehicles, etc.) move through progressively smaller network elements as they approach their destination.

2.2 Functional Classification Concepts

Most travel occurs through a network of interdependent roadways, with each roadway segment moving traffic through the system towards destinations. The concept of functional classification defines the role that a particular roadway segment plays in serving this flow of traffic through the network. Roadways are assigned to one of several possible functional classifications within a hierarchy according to the character of travel service each roadway provides. Planners and engineers use this hierarchy of roadways to properly channel transportation movements through a highway network efficiently and cost effectively.

2.2.1 Access versus Mobility

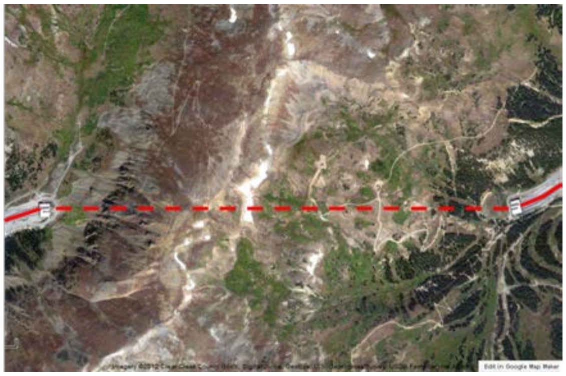
Roadways serve two primary travel needs: access to/egress from specific locations and travel mobility. While these two functions lie at opposite ends of the continuum of roadway function, most roads provide some combination of each.

- Roadway mobility function: Provides few opportunities for entry and exit and therefore low travel friction from vehicle access/egress
- Roadway accessibility function: Provides many opportunities for entry and exit, which creates potentially higher friction from vehicle access/egress

These two roles can be best understood by examining two extreme examples (**Figure 2-1** and **Figure 2-2**).

First, consider the Eisenhower Tunnel west of Denver, CO. Located along Interstate 70, the Eisenhower Tunnel runs under the Continental Divide in the Rocky Mountains and is one of the longest tunnels in the United States. Motorists that travel through the tunnel are en route to a distant location and are using the roadway completely to serve their "mobility" needs. There is no location that is immediately "accessible" to the roadway.

Figure 2-1: Aerial View of the Eisenhower (and Johnson) Tunnels along I-70, west of Denver, CO



Source: Google Earth Pro, June 27, 2012

Figure 2-2: View from Inside the Eisenhower Tunnel

Source: Creative Commons Attribution-Share Alike 2.0 generic license; Benjamin Clark

Next, consider the example of Eisenhower Court in North Platte, NE (**Figure 2-3**). This roadway is travelled almost exclusively by the individuals that live along the roadway. Hence, the roadway entirely provides "accessibility" and offers almost nothing in terms of mobility.

Figure 2-3: Aerial View of Eisenhower Court, North Platte, NE

Source: Google Earth Pro, June 27, 2012

Figure 2-4 depicts the neighborhood around Eisenhower Street in Carrollton, TX. This roadway serves both mobility needs (the residents that live along the side streets that intersect Eisenhower Street use it for some level of north/south mobility) and land access needs (there are both residential and commercial properties located along the roadway).

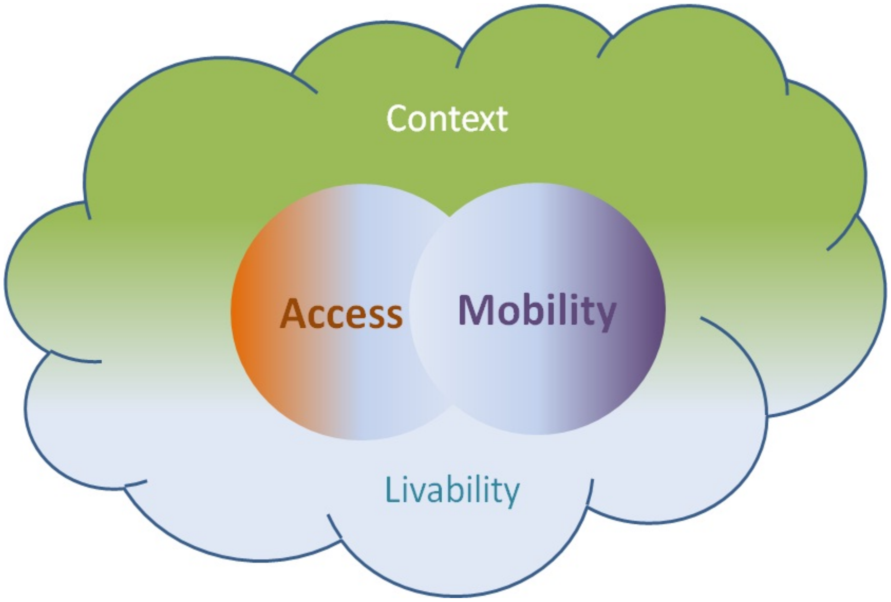
Figure 2-4: Aerial View of Eisenhower Street in Carrollton, TX

Source: Google Earth Pro, June 28, 2012

For nomenclature purposes, those roadways that provide a high level of mobility are called “Arterials”; those that provide a high level of accessibility are called “Locals”; and those that provide a more balanced blend of mobility and access are called “Collectors.”

The relationship between mobility and land access is illustrated in **Figure 2-5**. Arterials provide mostly mobility; Locals provide mostly land access; and Collectors strike a balance between the two. Context Sensitivity and Livability form the environment through which Mobility and Access should be considered. These concepts are discussed in greater detail in Chapter 5.

Figure 2-5: Illustration of Access-Mobility Dynamic



Source: FHWA

While most roadways offer both “access to property” and “travel mobility” services, it is the roadway’s primary purpose that defines the classification category to which a given roadway belongs.[2]

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[2] The use of the term “Local” roadway in the context of functional classification is separate from the use of the term in a jurisdictional context. While it is true that roadways functionally classified as “Local” are often under the jurisdiction of a “local” entity (i.e., incorporated city), Local Roads are not always under local jurisdiction. Other roadway classifications, including Arterials, may also be under the jurisdiction of a local (i.e., non-state) entity.

A route is a linear path of connected roadway segments, all with the same functional classification designation. For example, the roadways along a given Arterial route may — and often do — comprise multiple named roadways or state numbered facilities. Similarly, different segments of a given named roadway, or even more likely a given state numbered route, may belong to different functional classification categories, depending on the character of travel service that each segment provides. In the example to the right, the minor Arterial "route" consists of a portion of Tyler Street and a portion of Dalton Avenue (shown in green). East of Dalton Avenue, Tyler Street (shown in brown) is a Minor Collector.

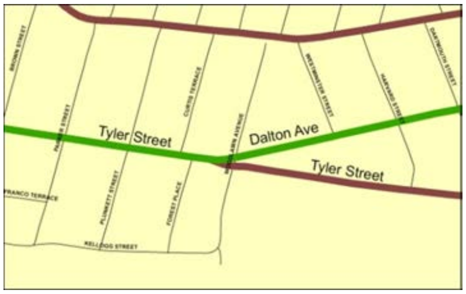
2.3 Other Important Factors Related to Functional Classification

The distinction between "mobility and accessibility" is important in assigning functional classifications to roadways. There are a few additional factors to consider, and these are discussed here.

Efficiency of Travel: Trip makers will typically seek out roadways that allow them to travel to their destinations with as little delay as possible and by the shortest travel time. Arterial roadways provide this kind of service, often in the form of fully or partially controlled access highways, with no or very few intersecting roadways to hinder traffic flow. Therefore, a high percentage of the length of a long-distance trip will be made on Arterials. In contrast, travelers making shorter trips tend to use Local and/or Collector roadways for a much higher proportion of the trip length than Arterial roads.

Collectors: As their name implies, Collectors "collect" traffic from Local Roads and connect traffic to Arterial roadways. Collector routes are typically shorter than Arterial routes but longer than Local Roads. Collectors often provide traffic circulation within residential neighborhoods as well as commercial, industrial or civic districts (see **Figure 2-6**).

Figure 2-6: Collector Example



Source: CDM Smith

Access Points: Arterials primarily serve long-distance travel and are typically designed as either access controlled or partially access controlled facilities with limited locations at which vehicles can enter or exit the roadway (typically via on- or off-ramps). In instances where limited or partial access control is not provided, signalized intersections are used to control traffic flow, with the Arterial given the majority of the green time.

In growing urban areas, Arterial roadways often experience an ever-increasing number of driveway access points. This high degree of accessibility decreases mobility. To address this issue and restore the carrying capacity of through traffic on these roadways, transportation agencies apply access management principles, such as driveway consolidation and median installations (see **Figure 2-7**).

Figure 2-7: Example of Access Points

Source: Ohio DOT, http://www.ahtd.info/basic_bike-

In contrast, roadways classified as "Local" provide direct access to multiple properties.

Speed Limit: In general, there is a relationship between posted speed limits and functional classification. Arterials typically have higher posted speed limits as vehicles encounter few or no at-grade intersections. The absence of cross-traffic and driveways allows for higher rates of speed, which provides mobility, especially for long-distance travel. In contrast, because their primary role is to provide access, Locals are lined with intersecting access points in the form of driveways, intersecting roadways, cross walks and transfer points for buses and other modes. Due to the frequency of traffic turns, speed limits are kept low to promote safe traffic operations. Speed limits on any non-access controlled roadways are also influenced by the mix of vehicles and modes that use them.

Route Spacing: Directly related to the concept of channelization of traffic throughout a network is the concept of distance (or spacing) between routes. For a variety of reasons, it is not feasible to provide Arterial facilities to accommodate every possible trip in the most direct manner possible or in the shortest amount of time. Ideally, regular and logical spacing between routes of different classifications exists. Arterials are typically spaced at greater intervals than Collectors, which are spaced at much greater intervals than Locals. This spacing varies considerably for different areas; in densely populated urban areas, spacing of all routes types is smaller and generally more consistent than the spacing in sparsely developed rural areas. Geographic barriers greatly influence the layout and spacing of roadways.

Usage (Annual Average Daily Traffic [AADT] Volumes and Vehicle Miles of Travel [VMT]): Arterials serve a high share of longer distance trips and daily vehicle miles of travel. In rural areas, Arterials typically account for approximately half of the daily vehicle miles of travel; in urban areas, this percentage is often higher. Collectors account for the next largest percentage of travel. Urban Area Collectors account for somewhat less (5 to 15 percent), while the percentage for Rural Area Collectors is typically in the 20 to 30 percent range. Lastly, by definition, Local Roads in rural areas typically serve very low density, dispersed developments with relatively low traffic volume. In contrast, the Urban Local Road network, with higher roadway centerline miles and higher density spacing, serves denser land uses and therefore accounts for a larger proportion of travel than its rural counterpart.

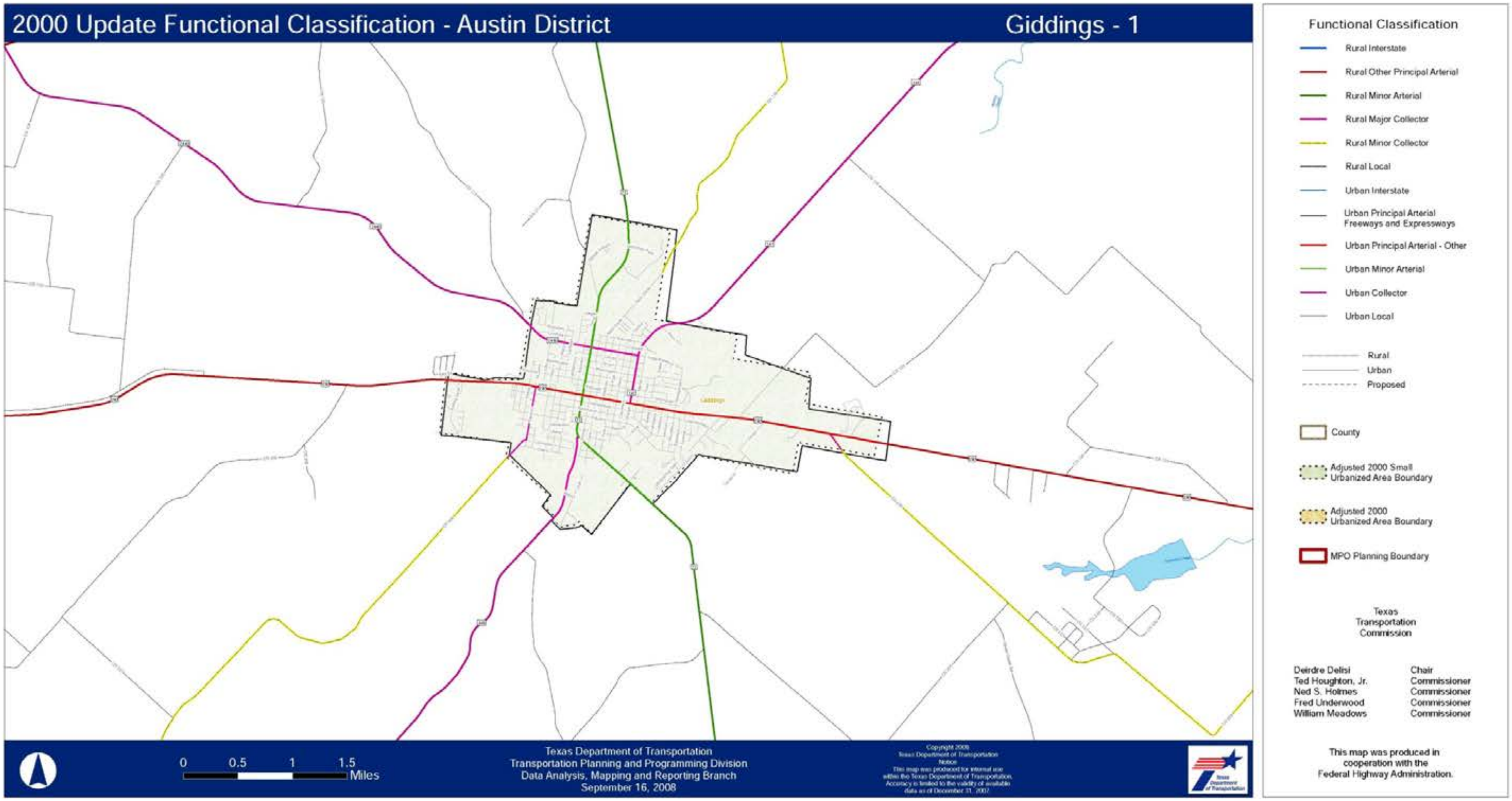
While there is a general relationship between the functional classification of a roadway and its annual average daily traffic volume, two roads that carry the same traffic volume may actually serve very different purposes and therefore have different functional classifications. Conversely, two roadways in different parts of a State may have the same functional classification but carry very different traffic volumes. This is particularly applicable among urban areas with very different populations — an Arterial within a remote city with a population of 50,000 is likely to have a much lower traffic volume than an Arterial within a city of 1 million people.

Traffic volumes, however, can come into play when determining the proper functional classification of a roadway "on the border" of a functional classification group (for example, trying to determine whether a roadway should be classified as a Collector or Local). Furthermore, AADT can often be used as a "tie-breaker" when trying to determine which of two (or more) similar and roughly parallel roadways should be classified with a higher (or lower) classification than the other. For example, suppose that two parallel roadways appear to serve the

When determining the functional classification of a given roadway, no single factor should be considered alone. For example, US 290 runs through the heart of Giddings, TX. Within the city, the roadway has many intersecting roadways, provides direct access to a number of densely developed commercial and residential properties and has speed limits as low as 35 mph. However, because the roadway is one of the two most direct routes of travel between Austin and Houston and a large percentage of its traffic consists of longer distance trips, the roadway is best classified as an Arterial.

function of a Collector. Classifying both of them as a Collector could lead to undesirable redundancy in the functional classification network. All other things being equal, the roadway with the higher AADT would generally be given the Collector classification, while its companion would be given a Local classification (**Figure 2-8**).

Figure 2-8: Functional Classification Map of Giddings, TX and Surrounding Unincorporated Territory



Source: Texas DOT, Transportation Planning and Programming Division, Data Analysis, Mapping and Reporting Branch, September 16, 2008

Number of Travel Lanes: Roadways are designed and constructed according to their expected function. If a roadway is expected to function as an Arterial, it is designed for high capacity, with multiple travel lanes. In general, Arterials are more likely to have a greater number of travel lanes than Collectors, and Collectors are more likely to have a greater number of travel lanes than Locals. It should also be noted that the relationship between functional classification and number of lanes is stronger in urban areas than it is in rural areas.

Regional and Statewide Significance: Highly significant roadways connect large activity centers and carry longer-distance travel between and through regions and States. Arterials carry the vast majority of trips that travel through a given State, while Local Roads do not easily facilitate statewide travel.

Table 2-1 summarizes the relationship between the factors previously described and the three broad categories of functional classification.

Table 2-1: Relationship between Functional Classification and Travel Characteristics

Functional Classification	Distance Served (and Length of Route)	Access Points	Speed Limit	Distance between Routes	Usage (AADT and DVMT)	Significance	Number of Travel Lanes
Arterial	Longest	Few	Highest	Longest	Highest	Statewide	More
Collector	Medium	Medium	Medium	Medium	Medium	Medium	Medium
Local	Shortest	Many	Lowest	Shortest	Lowest	Local	Fewer

2.4 System Continuity

Because the roadway system is an interconnected network of facilities channeling traffic in both directions from Arterials to Collectors, then to Locals and back again, the concept of continuity of routes is important to recognize. A basic tenet of the functional classification network is continuity — a roadway of a higher classification should not connect to a single roadway of a lower classification.[3] Generally speaking, Arterials should only connect to other Arterials. However, there are exceptions to this guideline. Arterials can end or link to very large regional traffic generators or can connect to multiple parallel roads of lower functional classification that, together, provide the same function and capacity as an Arterial.

In **Figure 2-9**, the Arterials (represented by black lines) only connect to other Arterials. Collectors (represented by the red lines), only connect to Arterials or other Collectors. Lastly, Local Roads (represented by the green lines) can connect to any type of roadway.

Exceptions to the "connectivity" guideline exist. A Collector can serve a major residential community and — for topological or other constraining reasons —not connect at one end to another similar or higher classified roadway. Other examples can also be found, especially within coastal communities. Wings Neck Road in Bourne, MA (**Figure 2-10**) is a good example. **Figure 2-11** is an example of an Interstate spur terminating at a city street in Holyoke, MA.

*Exceptions to the "connectivity" guideline exist. There are locations where an Arterial can "dead end" and not connect to another Arterial. A common example is when an Arterial terminates at a regionally significant land use (such as an airport or military installation). Another example is a Collector that serves a major residential community and, for topological or other constraining reasons, does not connect at one end to another similarly or higher classified roadway. Many other examples can also be found within coastal communities. Wings Neck Road in Bourne, MA (**Figure 2-10**) is a good example. Other obvious examples are Interstate spur routes (the highest type of Arterial, to be discussed in the following section) that terminate at a city street in the downtown of an urban area.*

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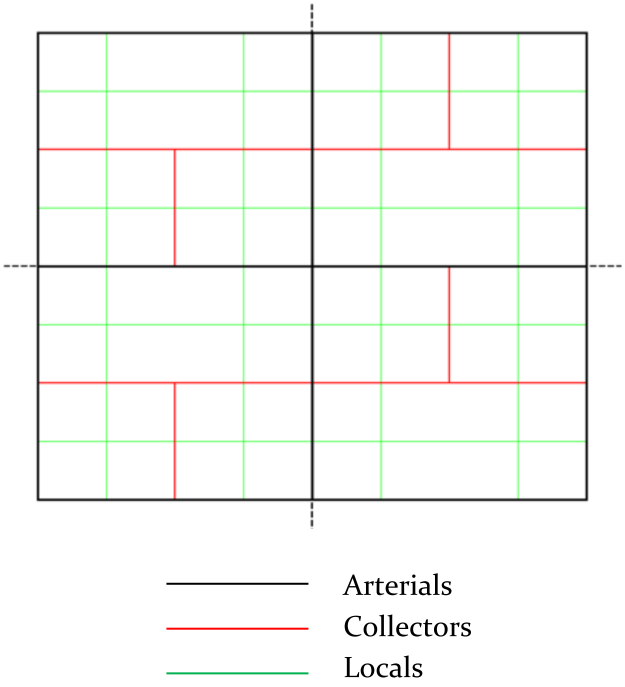
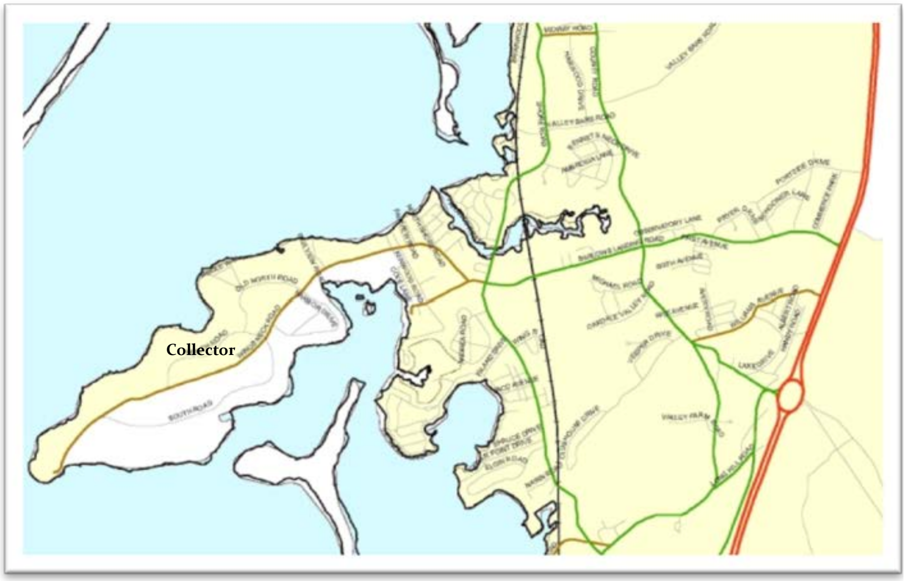
[3] A higher functionally-classified road can "split" its traffic between two lower-level roads, with different levels of access and mobility.

Figure 2-9: Schematic Illustrating the Concept of Continuity



Source: CDM Smith

Figure 2-10: Example of an Exception to the Connectivity Guidelines
Wings Neck Road, Bourne, MA



Source: MassDOT, Office of Transportation Planning, Functional Classification Map

Figure 2-11: Example of an Interstate Spur Terminating at a City Street in Holyoke, MA

Source: Google Earth Pro, June 29, 2012

SECTION 3. CRITERIA

3.1 Definitions and Characteristics

The previous section provided a general overview of the functional classification categories of Arterial, Collector and Local. For Federal functional classification purposes, this section breaks these categories down further to stratify the range of mobility and access functions that roadways serve. Additionally, the physical layout and the official designation of some roadways dictate the classification of certain roadways.

3.1.1 Interstates

Interstates are the highest classification of Arterials and were designed and constructed with mobility and long-distance travel in mind. (**Figure 3-1**) Since their inception in the 1950's, the Interstate System has provided a superior network of limited access, divided highways offering high levels of mobility while linking the major urban areas of the United States.

Figure 3-1: Example of Interstate

Source: CDM Smith

Determining the functional classification designation of many roadways can be somewhat subjective, but with the Interstate category of Arterials, there is no ambiguity. Roadways in this functional classification category are officially designated as Interstates by the Secretary of Transportation, and all routes that comprise the Dwight D. Eisenhower National System of Interstate and Defense Highways belong to the Interstate functional classification category and are considered Principal Arterials.

3.1.2 Other Freeways & Expressways

Roadways in this functional classification category look very similar to Interstates. While there can be regional differences in the use of the terms 'freeway' and 'expressway', for the purpose of functional classification the roads in this classification have directional travel lanes are usually separated by some type of physical barrier, and their access and egress points are limited to on- and off-ramp locations or a very limited number of at-grade intersections. Like Interstates, these roadways are designed and constructed to maximize their mobility function, and abutting land uses are not directly served by them.

Access control is a key factor in the realm of functional classification. All Interstates are "limited access" or "controlled access" roadways. The use of the word "access" in this context refers to the ability to access the roadway and not the abutting land use—these roadways provide no "access" to abutting land uses. Access to these roadways is controlled or limited to maximize mobility by eliminating conflicts with driveways and at-grade intersections that would otherwise hinder travel speed. Access to these roadways is limited to a set of controlled locations at entrance and exit ramps. Travelers use a much lower functionally classified roadway to reach their destination.

3.1.3 Other Principal Arterials

Figure 3-2: Example of Other Principal Arterial

Source: CDM Smith

These roadways serve major centers of metropolitan areas, provide a high degree of mobility and can also provide mobility through rural areas. Unlike their access-controlled counterparts, abutting land uses can be served directly. Forms of access for Other Principal Arterial roadways include driveways to specific parcels and at-grade intersections with other roadways. (**Figure 3-2**) For the most part, roadways that fall into the top three functional classification categories (Interstate, Other Freeways & Expressways and Other Principal Arterials) provide similar service in both urban and rural areas. The primary difference is that there are usually multiple Arterial routes serving a particular urban area, radiating out from the urban center to serve the surrounding region. In contrast, an expanse of a rural area of equal size would be served by a single Arterial.

Table 3-1 presents a few key differences between the character of service that urban and rural Arterials provide.

Table 3-1: Characteristics of Urban and Rural Arterials

Urban	Rural
• Serve major activity centers, highest traffic volume corridors and longest trip demands • Carry high proportion of total urban travel on minimum of mileage • Interconnect and provide continuity for major rural corridors to accommodate trips entering and leaving urban area and movements through the urban area • Serve demand for intra-area travel between the central business district and outlying residential areas	• Serve corridor movements having trip length and travel density characteristics indicative of substantial statewide or interstate travel • Connect all or nearly all Urbanized Areas and a large majority of Urban Clusters with 25,000 and over population • Provide an integrated network of continuous routes without stub connections (dead ends)

3.1.4 Minor Arterials

Minor Arterials provide service for trips of moderate length, serve geographic areas that are smaller than their higher Arterial counterparts and offer connectivity to the higher Arterial system. In an urban context, they interconnect and augment the higher Arterial system, provide intra-community continuity and may carry local bus routes. (**Figure 3-3**)

Figure 3-3: Example of Urban Minor Arterial

Source: Unsourced photo

In rural settings, Minor Arterials should be identified and spaced at intervals consistent with population density, so that all developed areas are within a reasonable distance of a higher level Arterial. Additionally, Minor Arterials in rural areas are typically designed to provide relatively high overall travel speeds, with minimum interference to through movement. The spacing of Minor Arterial streets may typically vary from 1/8- to 1/2-mile in the central business district (CBD) and 2 to 3 miles in the suburban fringes. Normally, the spacing should not exceed 1 mile in fully developed areas (see **Table 3-2**).

Table 3-2: Characteristics of Urban and Rural Minor Arterials

Urban	Rural
• Interconnect and augment the higher-level Arterials • Serve trips of moderate length at a somewhat lower level of travel mobility than Principal Arterials • Distribute traffic to smaller geographic areas than those served by higher-level Arterials • Provide more land access than Principal Arterials without penetrating identifiable neighborhoods • Provide urban connections for Rural Collectors	• Link cities and larger towns (and other major destinations such as resorts capable of attracting travel over long distances) and form an integrated network providing interstate and inter-county service • Be spaced at intervals, consistent with population density, so that all developed areas within the State are within a reasonable distance of an Arterial roadway • Provide service to corridors with trip lengths and travel density greater than those served by Rural Collectors and Local Roads and with relatively high travel speeds and minimum interference to through movement

3.1.5 Major and Minor Collectors

Collectors serve a critical role in the roadway network by gathering traffic from Local Roads and funneling them to the Arterial network. Within the context of functional classification, Collectors are broken down into two categories: Major Collectors and Minor Collectors. Until recently, this division was considered only in the rural environment. Currently, all Collectors, regardless of whether they are within a rural area or an urban area, may be sub-stratified into *major* and *minor* categories. The determination of whether a given Collector is a Major or a Minor Collector is frequently one of the biggest challenges in functionally classifying a roadway network.

In the rural environment, Collectors generally serve primarily intra-county travel (rather than statewide) and constitute those routes on which (independent of traffic volume) predominant travel distances are shorter than on Arterial routes. Consequently, more moderate speeds may be posted.

The distinctions between Major Collectors and Minor Collectors are often subtle. Generally, Major Collector routes are longer in length; have lower connecting driveway densities; have higher speed limits; are spaced at greater intervals; have higher annual average traffic volumes; and may have more travel lanes than their

Minor Collector counterparts. Careful consideration should be given to these factors when assigning a Major or Minor Collector designation. In rural areas, AADT and spacing may be the most significant designation factors. Since Major Collectors offer more mobility and Minor Collectors offer more access, it is beneficial to reexamine these two fundamental concepts of functional classification. Overall, the total mileage of Major Collectors is typically lower than the total mileage of Minor Collectors, while the total Collector mileage is typically one-third of the Local roadway network (see **Table 3-3**).

Table 3-3: Characteristics of Major and Minor Collectors (Urban and Rural)

MAJOR COLLECTORS	
Urban	**Rural**
• Serve both land access and traffic circulation in higher density residential, and commercial/industrial areas • Penetrate residential neighborhoods, often for significant distances • Distribute and channel trips between Local Roads and Arterials, usually over a distance of greater than three-quarters of a mile • Operating characteristics include higher speeds and more signalized intersections	• Provide service to any county seat not on an Arterial route, to the larger towns not directly served by the higher systems and to other traffic generators of equivalent intra-county importance such as consolidated schools, shipping points, county parks and important mining and agricultural areas • Link these places with nearby larger towns and cities or with Arterial routes • Serve the most important intra-county travel corridors
MINOR COLLECTORS	
Urban	**Rural**
• Serve both land access and traffic circulation in lower density residential and commercial/industrial areas • Penetrate residential neighborhoods, often only for a short distance • Distribute and channel trips between Local Roads and Arterials, usually over a distance of less than three-quarters of a mile • Operating characteristics include lower speeds and fewer signalized intersections	• Be spaced at intervals, consistent with population density, to collect traffic from Local Roads and bring all developed areas within reasonable distance of a Collector • Provide service to smaller communities not served by a higher class facility • Link locally important traffic generators with their rural hinterlands

3.1.6 Local Roads

Locally classified roads account for the largest percentage of all roadways in terms of mileage. They are not intended for use in long distance travel, except at the origin or destination end of the trip, due to their provision of direct access to abutting land. Bus routes generally do not run on Local Roads. They are often designed to discourage through traffic. As public roads, they should be accessible for public use throughout the year.

Local Roads are often classified by default. In other words, once all Arterial and Collector roadways have been identified, all remaining roadways are classified as Local Roads (see **Table 3-4**).

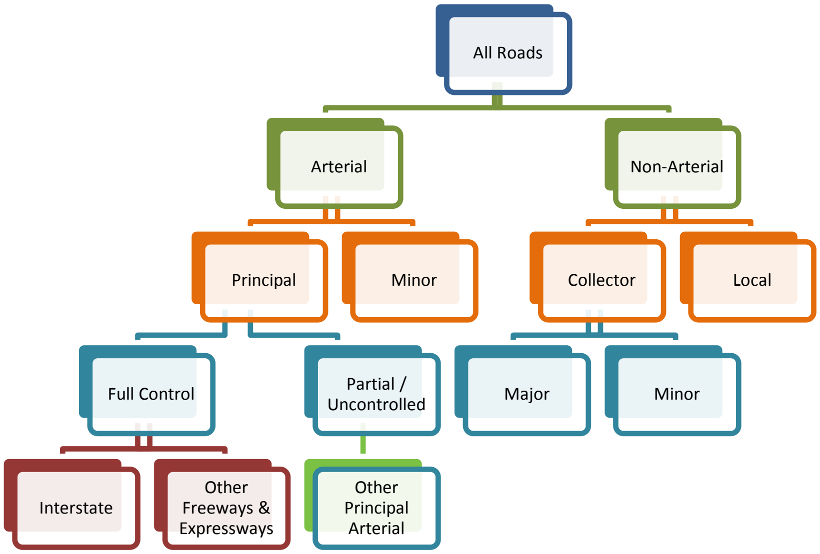
Table 3-4: Characteristics of Urban and Rural Local Roads

Urban	Rural
• Provide direct access to adjacent land • Provide access to higher systems • Carry no through traffic movement • Constitute the mileage not classified as part of the Arterial and Collector systems	• Serve primarily to provide access to adjacent land • Provide service to travel over short distances as compared to higher classification categories • Constitute the mileage not classified as part of the Arterial and Collector systems

3.2 Putting it all Together

The functional classification system groups roadways into a logical series of decisions based upon the character of travel service they provide. **Figure 3-4** presents this process, starting from assigning the function of an Arterial by its level of access (limited or full) or Non-Arterial (full access).

Figure 3-4: Federal Functional Classification Decision Tree



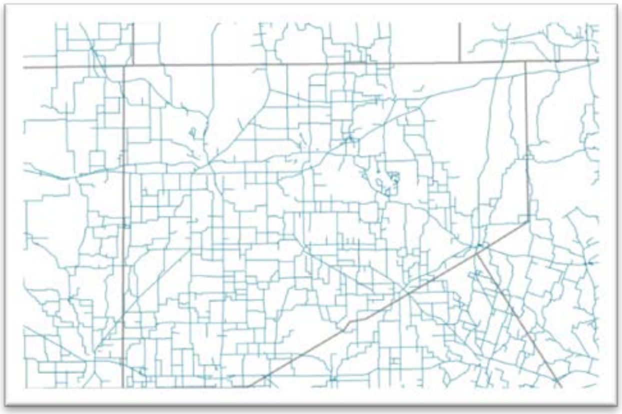
Source: FHWA and CDM Smith

While this document emphasizes the importance of function and service over the urban/rural distinction when classifying roads, the classification process is still influenced by the intensity and distribution of land development patterns. Classification of roadways in urban areas is typically guided by the local comprehensive planning and design process, or the fundamental principles of roadway functional classification. In comparison, rural development patterns are often more diverse, if not less orderly, thereby making the functional classification determination of some rural roadways more challenging (see **Figure 3-5** and **Figure 3-6**).

Figure 3-5: Map of an Urban Area's Roadway Network (Functional Classification more evident)

Source: CDM Smith

Figure 3-6: Map of a Rural Area's Roadway Network (Functional Classification less evident)



Source: CDM Smith

When comparing urban and rural areas, perhaps the most relevant characteristic is the density of the roadway network. Even with a cursory view of a map of an urban area's roadway network, the functional classification of many roadways can be discerned due the differences in roadway size. In contrast, the functional classification of the roadway network in many rural areas is less readily apparent, primarily due to the relatively inconsistent roadway spacing.

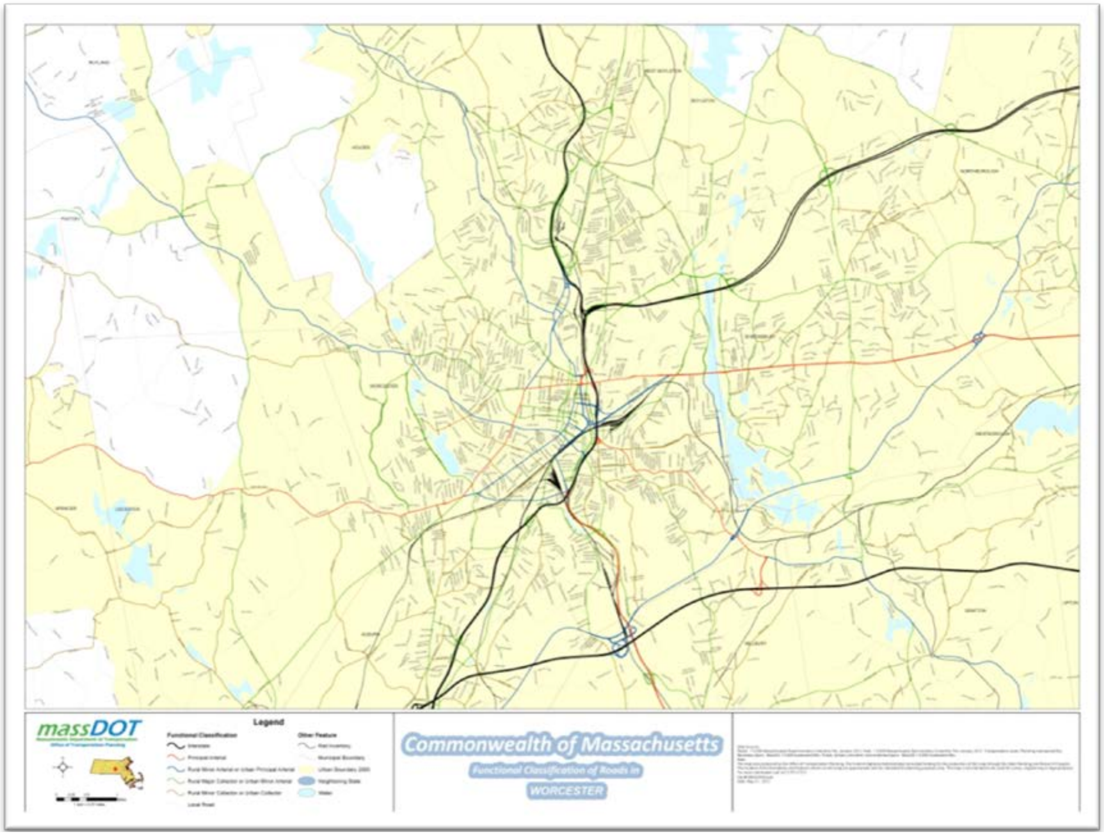
Nevertheless, functional classifications should be assigned based on actual functional criteria, rather than the location of the roadway within an urban or rural context.

3.3 A Real World Example

At this point, the concepts, criteria and definitions of all Federal functional classification categories have been presented. However, to strengthen the functional classification practitioner's understanding of these topics, the real world example of the city of Worcester, MA is presented below (**Figure 3-7**).

Figure 3-7: Worcester, MA Roadway System

Shaded area depicts the Urbanized Area



1. The city of Worcester is served by two interstate routes, Interstate 190 and Interstate 290 (shown in black). These Interstates provide high mobility service to residential communities to the north, northeast and south sides of the city.

2. A handful of Other Freeways & Expressways and Other Principal Arterials (shown in red and blue) radiate out from the central core of the city and provide direct service into, out of and through the city, offering connections to the surrounding areas not served by the Interstates.

3. An even larger number of Minor Arterials (shown in green) provide connectivity between the Interstate, Other Freeways & Expressways and Other Principal Arterials and are rather evenly spaced. Note that only a few of these Minor Arterial routes actually extend outside of the city border, as most of them terminate at Arterials within the city limits.

4. The Collector roadway system (shown in brown) consists of relatively shorter routes that mainly connect to Minor Arterials.

5. All other roadways (shown in gray) are Local Roads and comprise the vast majority of the mileage of the city's roadway network.

3.4 Final Considerations

In many instances, assigning a functional classification to a roadway is straightforward, especially for Interstates and Locals. However, there is flexibility when deciding between adjacent classifications. For example, deciding whether a given roadway acts as a Minor Arterial or Major Collector can be subject to debate. Deciding between a Major Collector and Minor Collector assignment can be even more challenging.

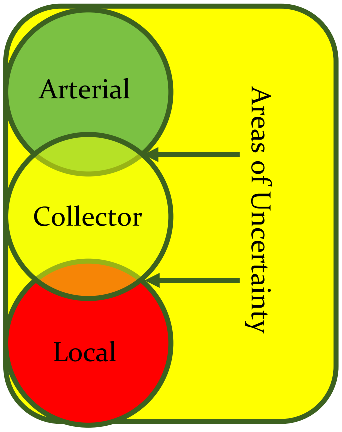
To assist transportation planners responsible for determining the functional classification of roadways, this guidebook offers a helpful tool that can make the classification process of classifying "borderline" roadways a bit easier. **Table 3-5** illustrates the range of lane width, shoulder width, AADTs, divided/undivided status, access control and access points per mile by functional classification categories.

Table 3-5 also presents guidelines for mileage and VMT ranges for Federal functional classifications of roads. These guidelines are based on an analysis of 2008 HPMS data and are adjusted to represent reasonable ranges. The table presents mileage and VMT extents for rural states, urban states and all states. For this purpose rural states are defined as having 75 percent or less of their population in urban areas. Research determined this was a natural breakpoint that approximated the geographic difference between the States.

As expected, Interstates account for the lowest portion of total system miles, but the greatest portion of travel. Conversely, Local Roads comprise the greatest portion of system mileage with Collectors carrying the lowest percentage of travel volume. Therefore, as a primary consideration in functional classification, planners and engineers can use mileage as a guideline. Where roadway systems significantly deviate from these ranges, State DOTs should consider adjusting their roadway assignments during the functional classification review process and at least every 10 years as part of the response to Census defined Urban Boundary changes. FHWA intends to review these guideline ranges for mileage and VMT periodically.

Lastly, as a result of variances within the functional classification system, the guidelines have overlapping ranges of values. This allows greater flexibility in determining functional classification (see **Figure 3-8**).

Figure 3-8: Classification Overlap



Source: FHWA

Table 3-5: VMT and Mileage Guidelines by Functional Classifications - Arterials

	Arterials			
	Interstate	**Other Freeways & Expressway**	**Other Principal Arterial**	**Minor Arterial**
Typical Characteristics				
Lane Width	12 feet	11 - 12 feet	11 - 12 feet	10 feet - 12 feet
Inside Shoulder Width	4 feet - 12 feet	0 feet - 6 feet	0 feet	0 feet
Outside Shoulder Width	10 feet - 12 feet	8 feet - 12 feet	8 feet - 12 feet	4 feet - 8 feet
AADT[1] (Rural)	12,000 - 34,000	4,000 - 18,500[2]	2,000 - 8,500[2]	1,500 - 6,000
AADT[1] (Urban)	35,000 - 129,000	13,000 - 55,000[2]	7,000 – 27,000[2]	3,000 - 14,000
Divided/Undivided	Divided	Undivided/Divided	Undivided/Divided	Undivided
Access	Fully Controlled	Partially/Fully Controlled	Partially/Uncontrolled	Uncontrolled
Mileage/VMT Extent (Percentage Ranges)[1]				
Rural System				
Mileage Extent for Rural States[2]	1% - 3%	0% - 2%	2% - 6%	2% - 6%
Mileage Extent for Urban States	1% - 2%	0% - 2%	2% - 5%	3% - 7%
Mileage Extent for All States	1% - 2%	0% - 2%	2% - 6%	3% - 7%
VMT Extent for Rural States[2]	18% - 38%	0% - 7%	15% - 31%	9% - 20%
VMT Extent for Urban States	18% - 34%	0% - 8%	12% - 29%	12% - 19%
VMT Extent for All States	20% - 38%	0% - 8%	14% - 30%	11% - 20%
Urban System				
Mileage Extent for Rural States[2]	1% - 3%	0% - 2%	4% - 9%	7% - 14%
Mileage Extent for Urban States	1% - 2%	0% - 2%	4% - 5%	7% - 12%
Mileage Extent for All States	1% - 3%	0% - 2%	4% - 5%	7% - 14%
VMT Extent for Rural States[2]	17% - 31%	0% - 12%	16% - 33%	14% - 27%
VMT Extent for Urban States	17% - 30%	3% - 18%	17% - 29%	15% - 22%
VMT Extent for All States	17% - 31%	0% - 17%	16% - 31%	14% - 25%
Qualitative Description (Urban)	• Serve major activity centers, highest traffic volume corridors, and longest trip demands • Carry high proportion of total urban travel on minimum of mileage • Interconnect and provide continuity for major rural corridors to accommodate trips entering and leaving urban area and movements through the urban area • Serve demand for intra-area travel between the central business district and outlying residential areas			• Interconnect with and augment the principal arterials • Serve trips of moderate length at a somewhat lower level of travel mobility than principal arterials • Distribute traffic to smaller geographic areas than those served by principal arterials • Provide more land access than principal arterials without penetrating identifiable neighborhoods • Provide urban connections for rural collectors
Qualitative Description (Rural)	• Serve corridor movements having trip length and travel density characteristics indicative of substantial statewide or interstate travel • Serve all or nearly all urbanized areas and a large majority of urban clusters areas with 25,000 and over population • Provide an integrated network of continuous routes without stub connections (dead ends)			• Link cities and larger towns (and other major destinations such as resorts capable of attracting travel over long distances) and form an integrated network providing interstate and inter-county service • Spaced at intervals, consistent with population density, so that all developed areas within the State are within a reasonable distance of an arterial roadway Provide service to corridors with trip lengths and travel density greater than those served by rural collectors and local roads and with relatively high travel speeds and minimum interference to through movement

1- *Ranges in this table are derived from 2011 HPMS data.*

2- *For this table, Rural States are defined as those with a maximum of 75 percent of their population in urban centers.*

Table 3-6: VMT and Mileage Guidelines by Functional Classifications – Collectors and Locals

	Collectors		Local
	Major Collector[2]	**Minor Collector[2]**	
Typical Characteristics			
Lane Width	10 feet - 12 feet	10 - 11 feet	8 feet - 10 feet
Inside Shoulder Width	0 feet	0 feet	0 feet
Outside Shoulder Width	1 feet - 6 feet	1 feet - 4 feet	0 feet - 2 feet
AADT[1] (Rural)	300 - 2,600	150 - 1,110	15 - 400
AADT[1] (Urban)	1,100 - 6,300[2]		80 - 700
Divided/Undivided	Undivided	Undivided	Undivided
Access	Uncontrolled	Uncontrolled	Uncontrolled
Mileage/VMT Extent (Percentage Ranges)[1]			
Rural System			
Mileage Extent for Rural States[3]	8% - 19%	3% - 15%	62% - 74%
Mileage Extent for Urban States	10% - 17%	5% - 13%	66% - 74%
Mileage Extent for All States	9% - 19%	4% - 15%	64% - 75%
VMT Extent for Rural States[3]	10% - 23%	1% - 8%	8% - 23%
VMT Extent for Urban States	12% - 24%	3% - 10%	7% - 20%
VMT Extent for All States	12% - 23%	2% - 9%	8% - 23%
Urban System			
Mileage Extent for Rural States[3]	3% - 16%	3% - 16%[2]	62% - 74%
Mileage Extent for Urban States	7% - 13%	7% - 13%[2]	67% - 76%
Mileage Extent for All States	7% - 15%	7% - 15%[2]	63% - 75%
VMT Extent for Rural States[3]	2% - 13%	2% - 12%[2]	9% - 25%
VMT Extent for Urban States	7% - 13%	7% - 13%[2]	6% - 24%
VMT Extent for All States	5% - 13%	5% - 13%[2]	6% - 25%
Qualitative Description (Urban)	• Serve both land access and traffic circulation in higher density residential, and commercial/industrial areas • Penetrate residential neighborhoods, often for significant distances • Distribute and channel trips between local streets and arterials, usually over a distance of greater than three-quarters of a mile	• Serve both land access and traffic circulation in lower density residential, and commercial/industrial areas • Penetrate residential neighborhoods, often only for a short distance • Distribute and channel trips between local streets and arterials, usually over a distance of less than three-quarters of a mile	• Provide direct access to adjacent land • Provide access to higher systems • Carry no through traffic movement
Qualitative Description (Rural)	• Provide service to any county seat not on an arterial route, to the larger towns not directly served by the higher systems, and to other traffic generators of equivalent intra-county importance such as consolidated schools, shipping points, county parks, important mining and agricultural areas • Link these places with nearby larger towns and cities or with arterial routes • Serve the most important intra-county travel corridors	• Be spaced at intervals, consistent with population density, to collect traffic from local roads and bring all developed areas within reasonable distance of a minor collector • Provide service to smaller communities not served by a higher class facility • Link locally important traffic generators with their rural hinterlands	• Serve primarily to provide access to adjacent land • Provide service to travel over short distances as compared to higher classification categories • Constitute the mileage not classified as part of the arterial and collectors systems

1- *Ranges in this table are derived from 2011 HPMS data.*

2- *Information for Urban Major and Minor Collectors is approximate, based on a small number of States reporting.*

3- *For this table, Rural States are defined as those with a maximum of 75 percent of their population in urban centers.*

Mileage and Daily Vehicle - Miles of Travel (DVMT) Ranges: While these guidelines should be considered general rules of thumb, FHWA encourages State DOTs to generate similar statistics for their roadway network and evaluate whether they fall within the normal ranges presented here. States should also apply the urban and rural guidelines as appropriate to their urban and rural areas.

Annual Average Daily Traffic: Roadway traffic volumes are typically expressed as annual average daily traffic (AADT) and represent one of the most objective characteristics of a roadway's usage, providing a standard, easy to understand and simple metric for comparing the relative importance of roadways. In general, the higher the traffic volume is, the higher the functional classification will be (relative to the norms in the surrounding area). Therefore, examining the AADT with other roadways in both the immediate vicinity (and in the region as a whole) is helpful when deciding a "borderline" roadway classification. If, for example, when trying to determine whether a given roadway with an AADT of 3,500 should be classified as a Minor Arterial or Major Collector, most of the Minor Arterials (in the immediate area and the region at large) fall within the 4,000 to 10,000 range, and the Major Collectors fall within the 2,000 to 4,000 range, the roadway should be classified as a Major Collector.

State DOTs are required to collect, analyze and publish traffic data on the roadways within their borders. Specifically, through the Highway Performance Monitoring System, each roadway segment on the Federal-aid highway (e.g., urban roadways classified as Minor Collectors and above and rural roadways classified as Major Collectors and above) is required to have an AADT value that is based on an actual traffic count within the last3 years. Therefore, AADT is a readily available and objective metric that can be brought into the functional classification determination process.

The Big Picture: If there still remains some ambiguity surrounding what classification should be applied to a given roadway, it is often helpful to examine the roadways in close proximity to it and to consider the spacing. For example, if trying to determine whether a roadway should be classified as a Minor Arterial or Major Collector, it is useful to take a "step back" and determine whether any functional classification is under- or over-represented. If the area has a significant number of Minor Arterials, then the roadway could very well be best classified as a Major Collector. Alternatively, if there is not another Minor Arterial within a few mile radius of the roadway (assuming an urban context), then the roadway may best be designated as a Minor Arterial.

Even after careful review of a given roadway's attributes, a small set of roadway segments that are difficult to classify can remain. For this reason, the set of mileage guidelines in Tables 3-5 and 3-6 can help provide high-level guidance regarding both the extent (mileage) and usage (daily vehicle miles of travel [DVMT]) of the roadway system that should fall into the different functional classification categories. While these guidelines have been developed for application at the State level, they can also be applied within regions.

SECTION 4. PROCEDURES

4.1 Introduction

This section of the guidance outlines suggested procedures for assigning functional classifications to highways, including a discussion of the specific technical tasks that describe the detailed technical "how to" tasks, as well as the collaborative efforts with partner agencies to ensure the functional classification of the roadway network considers State, regional and local needs. Currently, each State maintains a categorized roadway network consistent with the Federal functional classification system. While functional classifications of some roadways can and do change over time, the functional classification of the vast majority of roadways remains stable. Consequently, the focus of each State's efforts should be to identify roadways where the functionality has changed. These changes can take the form of newly constructed, re-aligned, extended, widened or otherwise reconfigured roadways. Equally important are changing land use and development patterns — growing residential areas, newly developed commercial or industrial centers and construction of isolated traffic generators can all have a profound impact on the roadway network serving these developments. State DOTs should establish, with local planning partners, a collaborative process of monitoring development and roadway usage patterns to ensure that the functional classification system is kept current.

While the nation's roadway system is mature in comparison to the 1960's-era highway system, the concepts and processes pertaining to the original Federal functional classification system are still relevant. The following section briefly presents an adaptation of the key recommendations of the 1989 guidance document, which is based on an earlier 1960's era document.

Many State DOTs have generated their own functional classification guidance documents. For the most part, these State-specific documents are based upon FHWA's 1989 document, augmented with additional details as necessary. To obtain a complete understanding of functional classification procedures in a particular State, these supporting documents should be reviewed as well.

Agencies can use travel demand models to validate or update their functional classification assignments. These models and the software they use produce estimates of the number of trips that travel between activity centers as well as the flows of travel on roadway segments. A particularly useful feature is "select link analysis" that shows the origin and destination location of travel from a roadway segment, and select zone analysis, which shows the path of trips from or to an activity center. Travel demand model "activity centers" represent collections of smaller areas such as block groups, census tracts or even counties, so their ability to track the path of travel from smaller areas is often limited.

4.2 Identifying the Functional Classification of a Roadway Network

A primary objective of the functional classification system is to connect traffic generators (population centers, schools, shopping areas, etc.) with a roadway network that channelizes trips logically and efficiently. As classification proceeds from identifying Arterials to Collectors to Locals, the perspective (and size) of traffic generators also moves from a larger to a smaller scale (or from a smaller to a larger scale, if starting from the local development).

When developing a functional classification network in a given area, the same basic procedures should be followed, whether the functional classification is applied in a rural or an urban area. However, due to the differences in population and land development intensity between rural and urban areas, the process and considerations used to classify roadways may be different. Because functional classification is part art and part science, these procedures are a blend of detailed, task-oriented steps and qualitative guidelines. These procedures do not eliminate judgment from the classification process, but when used as a guide, they help to apply judgment in a sound and orderly fashion.

1. **Identify traffic generators.** In rural areas, traffic generators may be population centers (cities and towns); recreational areas such as lakes, national and State parks; military facilities; consolidated schools; and shipping points. In urban areas, traffic generators may be business districts; air, rail, bus and truck terminals; regional shopping centers; colleges and universities; hospital complexes; military bases; industrial and commercial centers; stadiums; fairgrounds; and parks. Regional traffic generators adjacent, but outside of the area of interest, should also be identified.

2. **Rank traffic generators.** Traffic generators should be categorized based on their relative ability to generate trips and be first stratified into urban and rural groupings. Traffic generators thought to be significant enough to be served by a Major Collector or higher should be categorized into five to eight groups (it is better to have too many groups than to have too few, especially toward the lower end of the scale). Traffic generators with similar significance should be placed in the same group. These groups will be used to identify the functional classification of connecting roadways. Population, sales tax receipts, retail trade, visitation and employment are some examples of factors to consider when ranking traffic generations according to their significance.

3. **Map traffic generators.** Traffic generators should be mapped using graduated symbols of varying sizes and/or colors according to the group to which the generator belongs. This will produce a visual representation of the ranking. For example, the group of generators ranked highest should all be symbolized with the largest symbol.

4. **Determine the appropriate functional classification to connect traffic generators.** To determine the functional classification of roadways, work from the highest mobility facilities first by identifying Interstates, Other Freeways & Expressways, Other Principal Arterials, then Minor Arterials and Collectors (Major, then Minor). Then, by definition, Local Roads will be all of the roadways that were not classified as Arterials or Collectors. In other words, begin with a wide, regional perspective to identify Principal Arterials, then gradually move to smaller, more localized perspectives as Minor Arterials, Major Collectors and Minor Collectors are identified. In this process, consider the size of the traffic generators connected and the predominant travel distances and "travel shed"[4] served.

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[4] "Travel shed" refers to the general area from which most travelers originate.

4.2.1 Arterial Considerations

Arterials serve a wide range of functions across the access-mobility spectrum. Some considerations and rules of thumb for designating roads as Arterials include:

- Start with Interstates and Other Freeways & Expressways. Control of access is perhaps the easiest criterion to apply, since roadways with full or partial control of access will most always be in the Arterial classification category. It is therefore advantageous to identify these roadways first, providing a convenient starting point in defining the Arterial system.
- Preserve the continuity of Principal Arterials (Interstates, Other Freeways & Expressways and Other Principal Arterials). Continuity of Principal Arterial routes traveling from rural areas, then into and through urban areas, should be preserved.
- Arterials should avoid neighborhoods. They often serve as buffers between incompatible land uses and should avoid penetration of residential neighborhoods.
- Most high volume roadways in urban areas function as Arterials. Notable exceptions to this rule in intensely developed area exist in cases where high volume roadways actually function as Collectors that serve traffic movements between Locals and Arterials or provide a high degree of direct access service to abutting land uses. For example, roadways that border on high-activity, low-land area generators may carry proportionally high volumes of traffic while functioning as Collectors.
- The network of Minor Arterial roadways will usually intersect roadways in all other classifications.
- In urban areas, guidance for distinguishing between Principal and Minor Arterials includes:
    - *Principal Arterials typically serve:*
        - *Activity centers, from CBDs to larger town centers*
        - *Important air, rail, bus and truck terminals*
        - *Regional shopping centers*
        - *Large colleges, medical complexes, military bases and other institutional facilities*
        - *Major industrial and commerce centers*
        - *Important recreational areas*
    - Principal Arterials provide more mobility; Minor Arterials provide more access. The land access function of Principal Arterials is subordinate to their primary function of providing mobility for traffic not destined to land adjacent to the roadway. Minor Arterials, on the other hand, have a slightly more important land access function (although even for this classification category, this is a secondary consideration).
    - In general, the spacing between Principal Arterials should be greater than the spacing between Minor Arterials. In most cases, Minor Arterials will be located between Principal Arterials.

- Minor Arterials in urban areas should provide service to all remaining major traffic generators not served by a Principal Arterial, and they provide adequate area-wide circulation.
- Location matters when assigning functional classification. Because traffic volumes in the outlying portions of an urban area are generally lower than in the more densely populated central areas, the traffic volume on a Minor Arterial in the central city may be greater than the volume on a Principal Arterial in a suburban area.

  Note: Under MAP-21, the National Highway System (NHS) was expanded on October 1, 2012, to include the Principal Arterials at that time. This one-time event did not create a link between the NHS and Principal Arterials. A change to the Principal Arterials does not automatically change the NHS.

4.2.2 Collector Considerations

Collectors, which may have an important land access function, serve primarily to funnel traffic between Local to Arterial roadways. In order to bridge this gap, Collectors must and do provide access to residential neighborhoods.

When deciding between Major and Minor Collectors, the following guidelines should be considered:

- A road that is not designated as an Arterial but that connects larger generators to the Arterial network can be classified as a Major Collector. Major Collectors generally are busier, have more signal-controlled intersections and serve more commercial development.
- Identify Minor Collectors for under-served residential areas. After Major Collectors have been identified, Minor Collectors should be identified for clustered residential areas that have yet to be served by a roadway within higher classification categories.
- In rural areas, Minor Collectors should have approximately equal distance between Arterial or Major Collector routes for equal population densities, such that equitable service is provided to all rural areas of the State. The population density within each area bounded by an Arterial and/or Major Collector route can be determined, and the existing spacing of routes already selected can be measured. Areas with poor service can then be identified by comparing the data with a table of desirable Collector spacing (mileage between routes) versus population density. Additional routes can be added to the system as necessary.

4.2.3 General Rules of Thumb for All Categories and the System as a Whole

While working down through the functional classification system of roadway classifications, the following additional considerations should be kept in mind:

- Roadways that connect to and allow for the interchange of traffic with Principal Arterials are most likely to be Other Principal Arterials, Minor Arterials or Collectors.

- Avoid, if possible, within spacing guidelines, assigning the same functional classification to parallel routes. In the event that parallel routes are determined to provide identical functions, a determination should be made as to which of the routes is more important (as perhaps indicated by traffic volumes); the other parallel route(s) will be assigned the next lower functional classification.
- In general, the more intense the development, the closer the spacing of roadways within the same functional classification category. In less dense suburban locations within an urban area, neighborhoods tend to be larger than in the more dense central parts of cities. These less dense areas generally do not require the same close spacing of facilities to serve traffic as the areas closer to the central business district.
- For the most part, a single connection between two generators is all that is required. However, in some instances, an additional alternative route might be included where:
    - *Two apparently alternative routes are separated by geographic barriers and each is needed for connection to another intermediate generator or another intersecting route within the same classification category*
    - *One roadway excludes commercial vehicles*
    - *Total traffic volume is not adequately handled by one of the roadways*
    - *One roadway is tolled*
- Ensure that each route terminates at a route of the same or higher functional classification. As each subsequent category in the functional classification hierarchy is identified and added to the system, the continuity of the system must be maintained.
- In rural, sparsely developed areas, the spacing of various functional classification categories is often not a helpful criterion in determining functional classification.

    In most cases, the most direct, most improved and most heavily traveled route should be chosen for connecting medium and small size traffic generators.

FHWA encourages States to develop their own more detailed and more quantifiable guidelines. The state of Wisconsin has developed robust algorithms taking into account factors of the population of the areas connected by a roadway, land use, spacing and current AADT volumes.

4.3 Good Practices

The following section discusses and recommends a series of good practices that State DOTs may follow to keep the functional classification of its roadways as accurate as possible.

4.3.1 Ongoing Maintenance of the Functional Classification System

State DOTs are charged with ensuring that the functional classification of their roadways is kept up-to-date. In addition, FHWA recommends that States update their functional classification system continually as the roadway system and land use developments change. States should also consider reviewing their systems every 10 years to coincide with the decennial census and the adjusted urban area boundary update cycle.

This maintenance process involves ongoing coordination with local planning partners to identify roadways that require changes to their functional classification, due to changes in transportation network and/or land use patterns.

These changes can involve:

- Adding newly constructed or extended roadways to the network, which can in turn affect the functional classification of connecting or nearby roadways
- Upgrading the functional classification of an existing roadway due to land use changes or an improvement made to the roadway
- Downgrading the functional classification of an existing roadway due to land use changes, traffic controls that discourage through traffic or other controls that limit the speed and capacity of a road

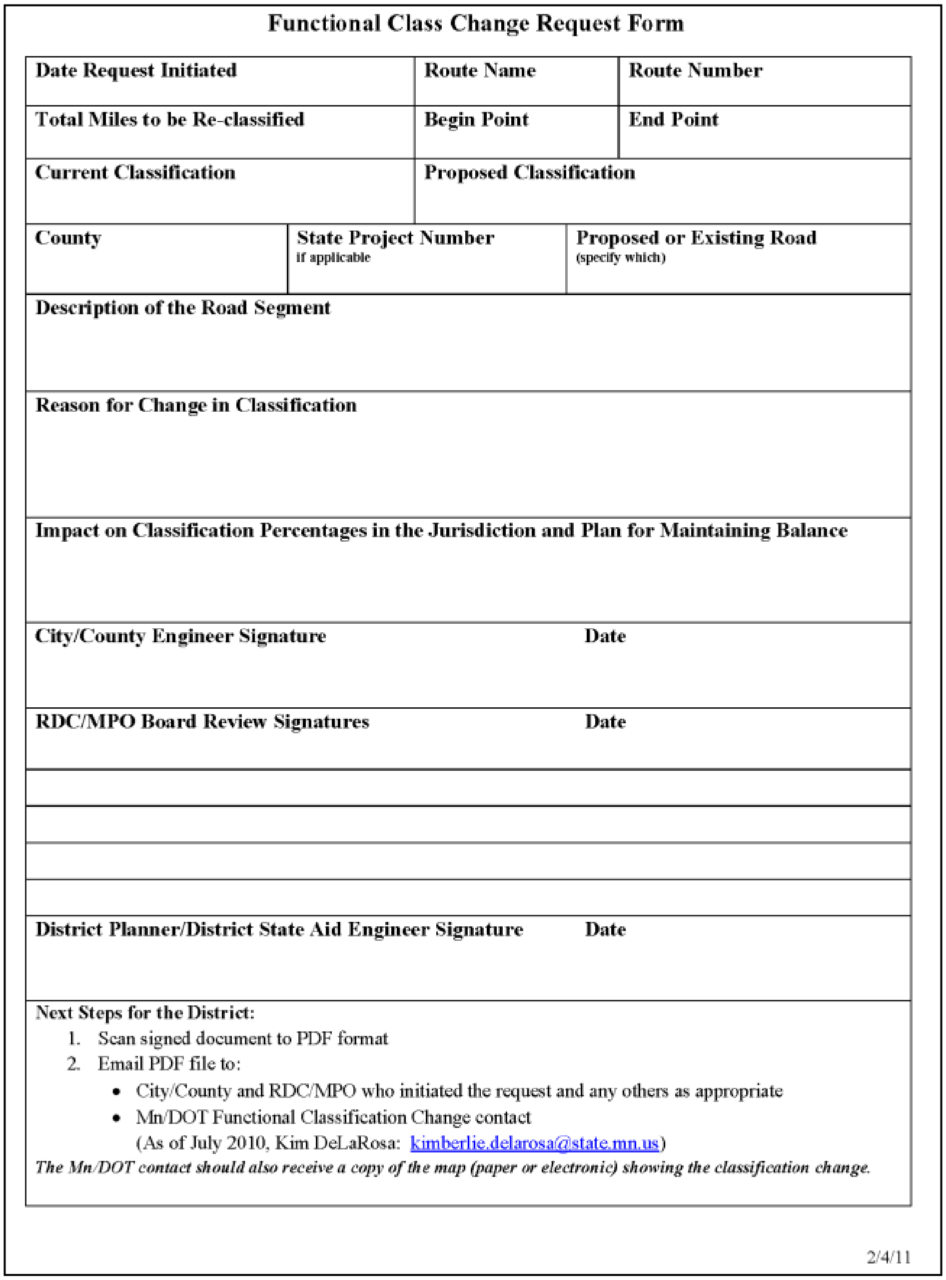
Actively maintaining the functional classification attributes of roadways will reduce the level of effort needed for the periodic updates. As State DOTs work with their local transportation planning partners on various initiatives such as long-range planning activities and project programming and development, issues related to the functional classification should be kept in mind. Useful questions to ask are the following:

- Have new significant roadways been constructed that may warrant Arterial or Collector status?
- Has any previously non-divided Principal Arterial roadway been reconstructed as a divided facility?
- Has any new major development (such as an airport, regional shopping center major medical facility) been built in a location that has caused traffic patterns to change?
- Has there been significant overall growth that may have caused some roadways to serve more access or mobility needs than they have previously?
- Have any Arterial or Collector roadways been extended or realigned in such a way to attract more through trip movements?
- Has a particular roadway experienced a significant growth in daily traffic volumes?

A key success factor for State DOTs is to have a well-documented process for changing the functional classification of an existing roadway. This process, along with a description of what the functional classification is and why it is important, should be readily accessible on the internet.

Many State DOTs have developed a functional classification change request form (see **Figure 4-1**). These forms ensure that consistent information and evidence supporting such a change are provided. Typically, information — such as the roadway location, the justification for the change and letters or signatures expressing local support — is required.

Figure 4-1: Minnesota DOT Functional Classification Change Request Form



Functional Class Change Request Form

Date Request Initiated	**Route Name**	**Route Number**
Total Miles to be Re-classified	**Begin Point**	**End Point**
Current Classification	**Proposed Classification**	
County	**State Project Number** if applicable	**Proposed or Existing Road** (specify which)

Description of the Road Segment

Reason for Change in Classification

Impact on Classification Percentages in the Jurisdiction and Plan for Maintaining Balance

City/County Engineer Signature **Date**

RDC/MPO Board Review Signatures **Date**

District Planner/District State Aid Engineer Signature **Date**

Next Steps for the District:

1. Scan signed document to PDF format
2. Email PDF file to:
   - City/County and RDC/MPO who initiated the request and any others as appropriate
   - Mn/DOT Functional Classification Change contact
     (As of July 2010, Kim DeLaRosa: kimberlie.delarosa@state.mn.us)

The Mn/DOT contact should also receive a copy of the map (paper or electronic) showing the classification change.

2/4/11

Source: Minnesota DOT, Functional Classification, Request to Change Classification; *http://www.dot.state.mn.us/roadway/data/docs/Single_FC_Change_Form.pdf*

When new Local Roads get added to the State's roadway inventory databases, as a good practice, State DOTs should evaluate how closely their roadways fit within each functional classification category based on the percentage guidelines found in Tables 3-5 and 3-6. If any significant differences are found, steps may be taken to either correct or explain them. However, this refinement process should not be conducted simply to keep adding or removing roadways until certain percentage guidelines are met. Bearing in mind that the classification process is as much art and science, it should still be as systematic, reproducible and logical as possible. Additionally, states and their planning partners (to be discussed later) should document their methodology and attempt to follow it as consistently as possible.

4.4 Geographic Information Systems

Transportation agencies rely on a variety of up-to-date spatial data to carry out their planning, maintenance and operations responsibilities. The most important element of this, for functional classification purposes, is an accurate GIS-based inventory of all roadways for a given area. This inventory contains the current functional classification of all roadways and AADT estimates to calculate daily VMT.[5] Total mileage and total DMVT can then be calculated for the entire network, independent of functional classification, thereby providing the denominator for the mileage and DVMT percentages by functional classification.

State DOTs identify new roadways and roadway improvements in their Statewide Transportation Improvement Program (STIP). DOTs should maintain basic information such as mileage, functional classification, lanes and traffic forecasts in a Linear Referencing System/GIS format. A variety of other GIS data can be useful in the functional classification evaluation process — this includes land use, major traffic generators and digital ortho-photography.

As DOTs move toward integrated, enterprise-wide GIS-based asset management systems, it is becoming increasingly important to ensure consistency between traditional tabular roadway inventory data and geospatial databases representing the physical roadway network. Some State DOTs have been maintaining tabular databases that contain information on the numerous attributes of a roadway (e.g., number of lanes, speed limit and functional classification).

Figure 4-2 illustrates the potential consequences of an inconsistency between databases. The example shows the merging of a GIS network and an underlying database containing functional class information. Because the network, as represented in the GIS system, does not correlate completely with the roadway section representation of the non-GIS database, the displayed non-GIS database information appears to be inaccurate.

Figure 4-2: Example of Shifting due to Inconsistency between Tabular Event Data and Geospatial Data

Source: CDMSmith

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[5] Vehicle miles of travel can be calculated as: DVMT = length in miles * annual average daily traffic volume.

Today's geospatial technologies allow this data to be easily "viewed" in the context of a spatially accurate map display. Therefore, it is important that the linearly referenced tabular data, when integrated into a state DOT's traditionally separated databases, be dynamically segmented on a routed roadway network and be spatially correct.

This issue may become apparent when roadways are mapped and symbolized according to their functional classification. The mapped functional classification designations often stop short or slightly overshoot their proper terminal location.

As shown above, GIS systems enable roadway segment color coding for validation and public display. An example of a color coding scheme for roadways by functional classification is shown in **Figure 4-3**. If followed, this suggestion would improve future mapping consistency.

Figure 4-3 Sample Roadway Color Scheme

🟦	Interstate	1
🟪	Other Freeways and Expressways	2
🟥	Other Principal Arterial	3
🟫	Minor Arterial	4
🟧	Major Collector	5
🟩	Minor Collector	6
◼	Local	7

4.4.1 Proactive Communication and Accessibility of Information

State DOTs should create a 2-way communication network with internal and external users of functional classification information. The unit within the State DOT responsible for maintaining the official functional classification network should keep a list of internal and external users of functional classification information and provide them with guidance and a mechanism for updating functional classifications. Increasingly, enterprise-wide databases and information provided over the internet (either with static PDF maps or more sophisticated interactive, dynamic online mapping applications) allow end-users quick and convenient access to roadway attribute information, including functional classification. Additionally, internal linkages and strong lines of communication with the DOT offices responsible for asset management, system inventories and operations can ensure that updates and changes to their roadway databases are transferred to a master GIS inventory which the functional classification process has access.

4.5 Partners in the Functional Classification Process

Whether processing a single functional classification change request or conducting a comprehensive statewide functional classification review in response to the establishment of the updated Adjusted Census Urban Boundaries, a variety of planning partners should be involved to ensure informed consent of the functional classification designation for a State's roadways.

4.5.1 Metropolitan Planning Organizations

MPOs are the primary local contact for the DOTs in Urbanized Areas. MPOs may initiate requests for revising the functional classification of a roadway within their planning area, either on their own initiative or on behalf of member jurisdictions. For requests originating from a member jurisdiction, the MPO may conduct an initial review to ensure compliance with functional classification criteria. Typically, MPOs will forward requests along with their recommendation for approval or disapproval to the State DOT unit responsible for maintaining the functional classification information. In some cases, local governments work directly with the State DOT, with concurrence from the MPO.

4.5.2 State DOTs

For the sake of efficiency, a single specific unit with the DOT should be responsible for maintaining the official functional classification designation of all roads within the State. This unit should also be in charge of coordinating with FHWA on matters related to functional classification and be the final State decision-maker for all functional classification issues. The unit should also ensure that all submissions for changes to the functional classification of a roadway have followed the appropriate documented procedures. If the State DOT approves a change, the unit should submit the change, along with supporting information, to the FHWA Division Office for their review and approval. Upon receipt of FHWA approval (or disapproval), the DOT should notify the affected local jurisdiction of the decision.

DOT regional or district offices may be responsible for submitting system revisions for all State highways outside an MPO's planning area and coordinating proposed system revisions for areas within the planning jurisdiction of an MPO.

Once a change has been approved by the FHWA Division Office, the State DOT may revise the official repository of functional classification information and update ancillary systems and work products to reflect the change.

State DOTs should complete the adjusted urban area boundary process within 2 years of the boundary release date.

The functional classification update should be completed within 3 years following the approval of the adjusted urban area boundaries.

4.5.3 Counties and Other Agencies

Counties may be responsible for initiating functional classification changes on roadways under their jurisdiction but outside of an MPO planning area. Counties within an MPO's planning area should coordinate proposed system revisions with the MPO and submit any proposed changes to the State DOT.

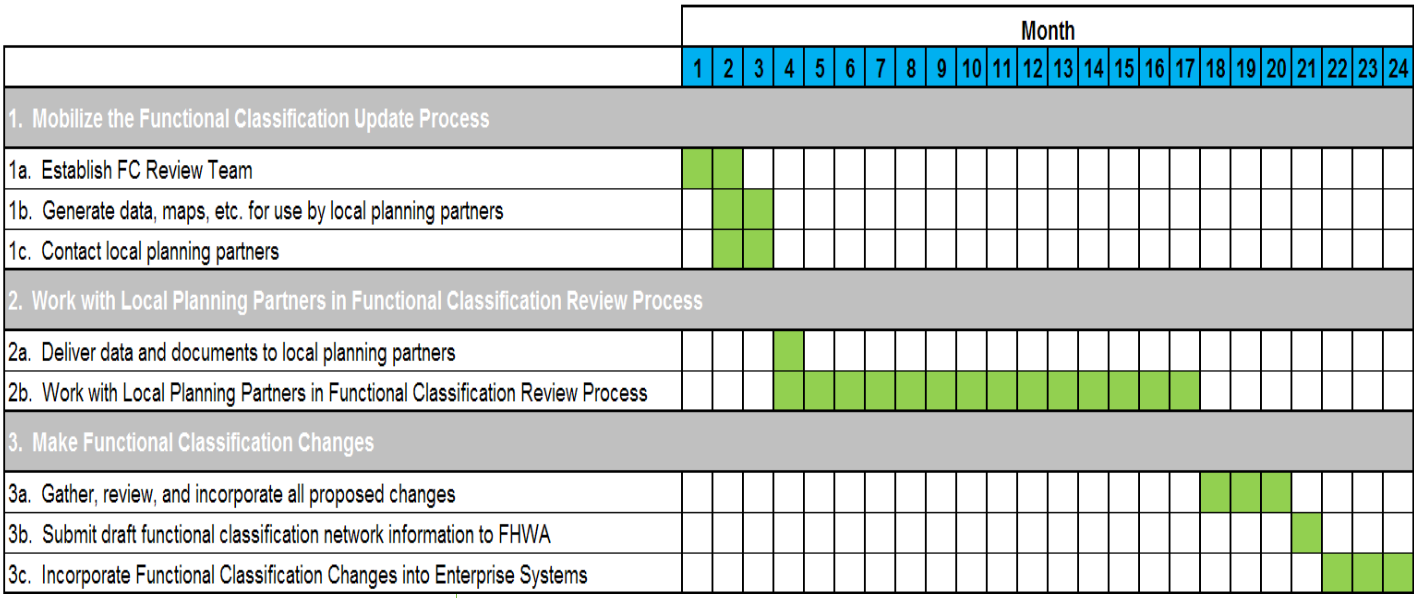
In addition to MPOs, counties and State DOTs, other local government and regional entities — such as cities, rural transportation planning organizations, regional development commissions, councils of government, etc. — may also submit changes and participate in the update process.

4.6 Suggested Procedural Tasks

This section of the guidance outlines a series of recommended technical and procedural steps to review the functional classification of a State's roadway network. These tasks should be conducted through a collaborative effort between each State DOT and its local planning partners. In an ideal setting, the State and its partners should assess whether its roadways are properly classified on a continuous basis. Because new roads and major land development projects take years of advance planning, State DOTs should anticipate and respond to functional class adjustments in tandem with development activity. Additionally, the entire network of roadways should be reviewed after the development of the adjusted urban area boundaries. For those State DOTs that actively maintain and update the functional classifications of their roadway system, this formal process should be rather straightforward.

The following suggested procedures offer the most robust and detailed steps in the update process (**Figure 4-4**). Even for the most challenging of circumstances, the process of official review and submittal of the updated functional classification system can take less than 36 months to complete from the time of FHWA approval of the adjusted urban area boundaries.

Figure 4-4: Good-Practice Timeframe for Functional Classification Updates in Months



	Month																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Mobilize the Functional Classification Update Process																								
1a. Establish FC Review Team	🟩	🟩																						
1b. Generate data, maps, etc. for use by local planning partners		🟩	🟩																					
1c. Contact local planning partners		🟩	🟩																					
2. Work with Local Planning Partners in Functional Classification Review Process																								
2a. Deliver data and documents to local planning partners				🟩																				
2b. Work with Local Planning Partners in Functional Classification Review Process				🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩							
3. Make Functional Classification Changes																								
3a. Gather, review, and incorporate all proposed changes																		🟩	🟩	🟩				
3b. Submit draft functional classification network information to FHWA																					🟩			
3c. Incorporate Functional Classification Changes into Enterprise Systems																						🟩	🟩	🟩

Source: CDM Smith

States and their partners should re-evaluate the functional classification of the road system at least every 10 years, coinciding with the decennial census. FHWA highly recommends that this process be completed within 3 years of the formal approval of the adjusted urban area boundaries so that all States are coordinated with the same census. FHWA considers the State DOT to be the authority during this process and relies upon it to take an active leadership role.

FHWA Division Offices may correspond with State DOTs to formally launch the functional classification system review. This notice, which can accompany the approval of the adjusted urban area boundaries, reminds the State DOTs of their responsibilities and provide information regarding how and when the functional classification information should be submitted.

The following listing presents a good practice level functional classification review process with a 24 month completion timeframe, following approval of the adjusted urban area boundaries.

1. **Mobilize the Functional Classification Update Process**
    a. **Form a team to specifically guide the functional classification review and update process.** Establish a functional classification review team composed of State and regional planners that have a vested interest in the final delineation of the functional classification designations. Individuals with experience in Federal transportation funding, highway design, traffic operations and the metropolitan transportation planning process should have a seat on the committee. This review team should be responsible for reviewing proposed changes to the functional classification network from local planning partners.

   b. **Generate data, maps, etc. for use by local planning partners.** Incorporate approved adjusted urban area boundaries in the enterprise GIS system and produce functional classification maps at a variety of scales that are relevant to local planning partners. These may include statewide, district, county and municipal scales.

   c. **Contact local planning partners.** Contact various local planning partners to explain the task at hand and request their participation. MPO staff should be key partners, and other regional planning agencies, counties and/or local municipalities should be consulted as necessary. For many areas in which engaging local partners can be difficult, it is appropriate for State DOTs to be responsible for reviewing the functional classification of roadways.

2. **Work with Local Planning Partners in the Functional Classification Review Process**

   a. **Deliver data and documents to local planning partners.** Transmit the maps described in #1b (and/or GIS data used to make such maps) to local planning partners. This transmittal should include specific instructions in terms of data formats, spatial accuracy, update processes and expected completion dates. The functional classification guidance document should also be shared with everyone involved in this process. A strong emphasis should be placed on transmitting the data in a timely fashion. In-person or video conference meetings can be extremely valuable to ensure proper communication and mutual understanding.

   b. **Work with Local Planning Partners.** As necessary, a State DOT will work with the local planning partners to ensure that the functional classification review and update process meets their expectations. In urban areas, close collaboration with MPOs is extremely important. Regional workshops hosted by MPOs can be valuable in ensuring that there is a common understanding of the process and the schedule for delivery. While the exact details surrounding information exchange may vary from state to state, the local planning partners are generally expected to review the current functional classification network, in the context of the newly revised adjusted urban area boundaries, and submit a set of proposed changes to the functional classification of roadways in their area. Whether a large or minimal number of changes, sufficient explanation should be provided to justify each recommended functional classification change (see Table 3-1: Characteristics of Urban and Rural Arterials for examples). In many areas, proposed functional classification changes require formal MPO approval.

3. **Make Functional Classification Changes**

    a. **Gather, review and incorporate all proposed changes.** The State DOT must review a local or regional transportation agency's proposed changes to ensure that they are reasonable. Special attention should be paid to the consistency of classifications at regional boundaries, overall route continuity, spacing and mileage and DVMT percentage guidelines. In addition, DOTs should coordinate with neighboring States to ensure consistency at State boundaries. If possible, potential system-wide changes should be made in a "test" environment to avoid affecting the official enterprise system during the analysis of proposed changes. Follow-up meetings may be necessary to resolve issues discovered by the DOT.

    b. **Submit draft functional classification network information to FHWA.** Once the State DOT has successfully reviewed and concurred with all recommend functional classification changes, it should submit the draft final functional classification network to its FHWA Division Office for final approval. The specific geospatial format of data delivery should be worked out between the State DOT and its FHWA Division. Separately, hard copy maps at a scale sufficiently small enough to evaluate the functional classification network should be provided. Should the Division Office have any issues with the proposed functional classification network, the State DOT and the affected local planning entities should meet to decide upon a mutually agreeable solution. *Note: Any changes to the National Highway System (NHS) will need to be coordinated with FHWA HQ Office of Planning, Environment and Realty. Approval of changes to the NHS happens in FHWA HQ, and the procedures for modifications are detailed in 23 CFR 470.*

    c. **Incorporate Functional Classification Changes into Enterprise Systems** Once FHWA approval has been received, any proposed functional classification changes should be made into the enterprise database systems that house the official records of roadway functional classification. These functional classification changes should be forwarded to FHWA HEPP for inclusion into the HEPGIS database and also be incorporated into the June 15th HPMS data transmittal.

An example functional classification table from Massachusetts can be found in **Table 4-1.**

Table 4-1: Example Massachusetts Roadway Functional Classification Table

Ref #	City/Town	Roadway	From	To	Existing Classification	Proposed Classification	Distance (Miles)	Map
1	Blandford	Huntington Rd	Chester Rd / North St	Huntington Town Line	Rural Major Collector	Local Road	3.80	1
	Huntington	Blandford Hill Rd	Route 20	Blandford Town Line	Rural Major Collector	Local Road	0.83	
2	Blandford	Cobble Mountain Rd	Russell Town Line	Birch Hill Rd	Rural Major Collector	Local Road	2.80	
	Blandford	Birch Hill Rd	Route 23	Cobble Mountain Rd	Rural Major Collector	Local Road	0.24	
	Granville	Wildcat Rd	Cobble Mountain Rd	Old Westfield Rd	Rural Major Collector	Local Road	1.94	
	Granville	Phelon Rd	North Lane #2	Cobble Mountain Rd	Rural Minor Collector	Local Road	1.78	
	Granville	Cobble Mountain Rd	Phelon Rd	Russell Town Line	Rural Minor Collector	Local Road	1.30	
	Russell	Cobble Mountain Rd	Blandford Town Line	Granville Town Line	Rural Major Collector	Local Road	0.33	
3	Chester	Bromley Rd	Huntington Town Line	Skyline Trail	Local Road	Rural Minor Collector	7 3.14	
	Huntington	Bromley Rd	Chester Town Line	Route 112	Local Road	Rural Minor Collector	1.79	
4	Huntington	Country Rd	Route 112	Route 66	Local Road	Rural Major Collector	3.04	
5	Holyoke	Bobala Rd	Whitney Ave	West Springfield Town Line	Local Road	Urban Minor Collector	0.83	2
	West Springfield	Interstate Dr	Holyoke Town Line	Prospect Ave	Local Road	Urban Minor Collector	0.53	
6	West Springfield	Prospect Ave	Westfield Town Line	Bernie Ave	Urban Minor Collector	Local Road	2.18	
	West Springfield	Morgan Rd	Prospect Ave	Amostown Rd	Urban Minor Collector	Local Road	1.24	
	West Springfield	Amostown Rd	Morgan Rd	Pease Ave	Urban Minor Collector	Local Road	0.65	
	Westfield	Old Holyoke Rd	East Mountain Rd	West Springfield Town Line	Urban Minor Collector	Local Road	0.60	

Description of Changes

1. *Huntington Road in the Town of Blandford and Blandford Hill Road in the Town of Huntington no longer provide access to through traffic. Additionally, portions of this roadway are unsurfaced. For this reason, it is recommended that this roadway be downgraded from a Rural Major Collector to a Local Road.*
2. *The Department of Homeland Security recently closed access to Cobble Mountain Road in the Town of Blandford in order to increase security of the Cobble Mountain Reservoir. Consequently, it is recommended that all roadways discussed in Reference #2 in Table 1 be downgraded to Local Roads due to the inaccessibility and lack of continuity of the roadway functional classification system.*

Sample functional classification changes listed, with examples of supporting justification

Table 4-2 presents good practice milestones for the overall development and submittal process.

Table 4-2: Key Milestones for Development and Submittal of the Functional Classification Network

Event	Month Following FHWA Adjusted Urban Area Boundary Approval
State DOT launches the formal functional classification update process after FHWA approves the State's adjusted urban area boundaries	Month 1
State DOT works with planning partners to review and propose changes to the functional classification of its roadways	Months 2-17
State DOT gathers and processes all proposed function classification changes and submits draft final data and/or maps to FHWA Division Office for review	Months 18-20
DOT incorporates updates into planning process and related databases to ensure submittal of updated functional classification in upcoming June 15th HPMS submittal	Months 22-24

SECTION 5. APPLICATIONS

5.1 Performance

This section of the guidance document details a variety of ways functional classification data may be used by Federal, State, local and other entities. Transportation agencies organize many of their administrative, budgetary, operations and maintenance activities around functional classification. Functional classification is also an important organizing element in data management and highway statistics reporting.

Currently, Federal and State funding programs assign a substantial share of capital and operating resources to the Principal Arterial system, in comparison to lower functional classifications. Likewise, expectations for condition and performance tend to be higher for the higher functional classifications. There is risk associated with not investing in and maintaining the system that carries the most people and goods.

5.2 Data Needs and Reporting

Statistics derived from the Federal roadway databases are organized around functional classification. This data are used in a number of ways, including reporting on the condition of the nation's roadways to Congress and in other highway statistics reports and studies.

5.2.1 Impact of Functional Classification Changes

The changes brought about in the functional classification categories with this updated guidance document will lead to more uniform and more accurate classification of roadways across the country. This will improve the tracking, monitoring and reporting on the performance of the system and specific system elements at a national and State level.

5.3 Secondary Functional Classification Uses

Functional classification is used by transportation agencies in a number of ways, from design to maintenance. The hierarchal system correlates the purpose of a roadway with all the external factors transportation agencies handle. The functional classification of a roadway is often a factor in decision-making by transportation agencies.

- **Program and Project Prioritization** – In a climate of constrained resources, functional classification often plays a role in the prioritization of expenditures. Several transportation agencies have developed separate funding programs to support the roadway systems that serve their longest distance travel, a large proportion of which comprises the Principal Arterial system.
- **Asset Management** – Functional classification plays a role in transportation agencies' asset management programs, as agencies generally work to preserve

and protect their most important assets — those that serve the most people and goods.

- **Safety Programs** – Functional classification is used by transportation agencies to evaluate the safety of their roadways and implement safety improvement programs. Agencies consider the type of roadway in evaluating the significance of crash rates. The typical safety improvement may also vary widely depending on the functional classification of a roadway. For example, speed reduction or signage improvements may be more effective in reducing crashes on a Local Road than on an Arterial.
- **Highway Design** – There is a correlation between functional classification and design. As an illustration, lower class roadways have lower speed limits, narrower lanes, steeper curves, etc., while higher class roadways have higher speed limits, wider lanes and fewer sharp curves. The relationship between functional classification and highway design is discussed in the following section (Subsection 5.4.1).
- **Bridge programs** – Functional classification often plays a key role in a States' bridge program. For example, some States have set thresholds, such as a functional classification of Local with low traffic volume, at which 1-lane bridges are acceptable.
- **Traffic control** – Some transportation agencies may look to functional class to determine the most appropriate intersection control measure to use.
- **Maintenance** – Functional classification often plays a role in resurfacing cycles, which is related to asset management and project prioritization. The classification of a roadway also impacts general maintenance and snow/ice removal in inclement weather.

5.4 Highway Design

5.4.1 The Relationship between Functional Classification and Design

Functional classification does not dictate design; however, the two influence one another. There is a great deal of latitude in the design of a roadway relative to its functional classification.

Transportation agencies may maintain their own roadway typology. But it is also important that the Federal functional classification system (e.g., FHWA reporting guidelines) be followed. Secondary roadway typologies developed by transportation agencies can be descriptive of how an agency wants vehicles to interact in different settings. Some States, for example, allow for local control over design standards in roadway-dense areas. This is essentially a form of context sensitive solutions (CSS).[6]

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[6] Context sensitive design describes a process and practice that considers the both the immediate environment of the roadway and the transportation needs of the communities it serves. For more information, see http://contextsensitivesolutions.org.

The following presents a summary of key resources available on how functional classification can work in concert with livable and walkable communities.

5.4.1.1 AASHTO Green Book and Flexibility in Highway Design

Although States' design standards are often based on the AASHTO Green Book, FHWA's *Flexibility in Highway Design* document illustrates flexibility options for States to tailor their designs to incorporate community values while safely and efficiently moving people and goods.

The AASHTO Green Book and other design manuals recognize the relationship between highway functional classification and design criteria. The AASHTO Green Book states that, "The first step in the design process is to define the function that the facility is to serve. The level of service required to fulfill this function for the anticipated volume and composition of traffic provides a rational and cost effective basis for the selection of design speed and geometric criteria within the range of values available to the designer (for the specified functional classification). The use of functional classification as a design type should appropriately integrate the highway planning and design process."

The Green Book explains that functional classification decisions are made well before an individual project is selected to move into the design phase. This decision is made on a system-wide basis by cities, counties or State DOTS or MPOs as part of their transportation planning process. Because these decisions require considerable lead time, the functional classification of a roadway often represents a decision made years before the road is built. After a functional classification has been assigned to a roadway, however, there is still a degree of flexibility in the major controlling factor of design speed. There are no "cookie-cutter" designs for roadways. Instead, there is a range of geometric design options available.

5.4.1.2 Livability

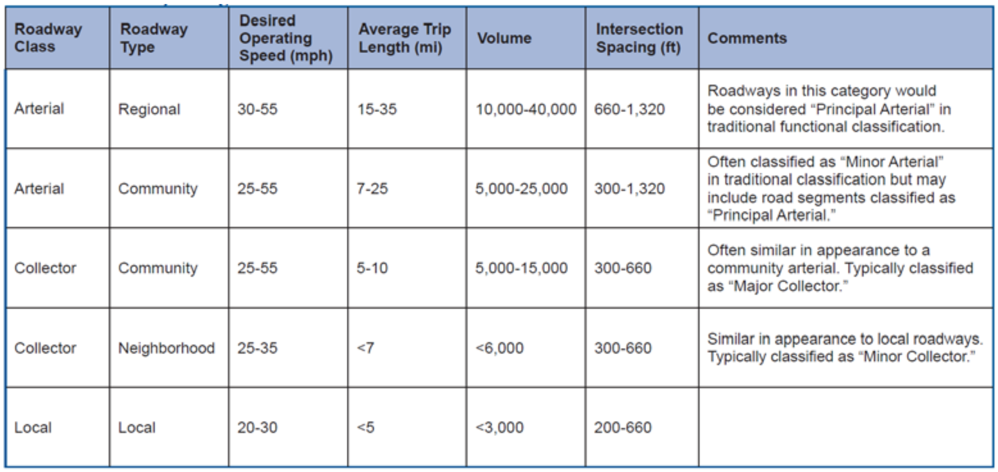
By FHWA definition, "Livability is about tying the quality and location of transportation facilities to broader opportunities such as access to good jobs, affordable housing, quality schools, and safe streets." The term captures and recognizes the pervasive influence of transportation in our daily lives and provides a justification for transportation investments that address broader social goals such as quality of life. Specific investments include expanding the use of Intelligent Transportation System (ITS) technologies, quiet pavements and Travel Demand Management approaches in system planning and operations.

FHWA's *Livability in Transportation Guidebook* cautions that functional classification based designs may not be responsive to context. The report notes the traditional association of functional classification with the movement of vehicles, but it also notes the historical lack of recognition regarding the influence of land use density and mix on the feasibility and desirability of walking, as well as the influence of land use density and mix on setting operating speeds that are appropriate for the level of pedestrian activity present. The report describes corridor re-design initiatives that have preserved mobility for vehicles and enhanced access for travel by foot. These initiatives have produced, when considering all modes, including bicyclists, pedestrians, transit users, a more optimal outcome on the mobility-access continuum.

5.4.1.3 Smart Transportation Guidebook

The *Smart Transportation Guidebook: Planning and Designing Highways and Streets that Support Sustainable and Livable Communities, New Jersey and Pennsylvania Departments of Transportation, March 2008*, recommends an approach to roadway planning and design that tailors transportation investments to the specific needs of each project. The ultimate goal of the guidebook is to integrate the planning and design of streets and highways in a manner that fosters development of sustainable and livable communities. The guidebook proposes a new roadway typology to design roadways that better reflect their role in the community and the larger transportation network. The typology (Table 5.1 in the Smart Transportation Guidebook) is shown below as **Figure 5-1**. This scheme focuses more narrowly on the characteristics of access, mobility and speed. And, the guidebook emphasizes that this typology should be used only as a planning and design "overlay" for individual projects and should not replace the traditional functional classification system.

Figure 5-1: "Table 5.1 Roadway Categories"
from the Smart Transportation Guidebook, March 2008



Roadway Class	Roadway Type	Desired Operating Speed (mph)	Average Trip Length (mi)	Volume	Intersection Spacing (ft)	Comments
Arterial	Regional	30-55	15-35	10,000-40,000	660-1,320	Roadways in this category would be considered "Principal Arterial" in traditional functional classification.
Arterial	Community	25-55	7-25	5,000-25,000	300-1,320	Often classified as "Minor Arterial" in traditional classification but may include road segments classified as "Principal Arterial."
Collector	Community	25-55	5-10	5,000-15,000	300-660	Often similar in appearance to a community arterial. Typically classified as "Major Collector."
Collector	Neighborhood	25-35	<7	<6,000	300-660	Similar in appearance to local roadways. Typically classified as "Minor Collector."
Local	Local	20-30	<5	<3,000	200-660	

Source: Pennsylvania Department of Transportation

The guide addresses design options for roadway attributes such as:

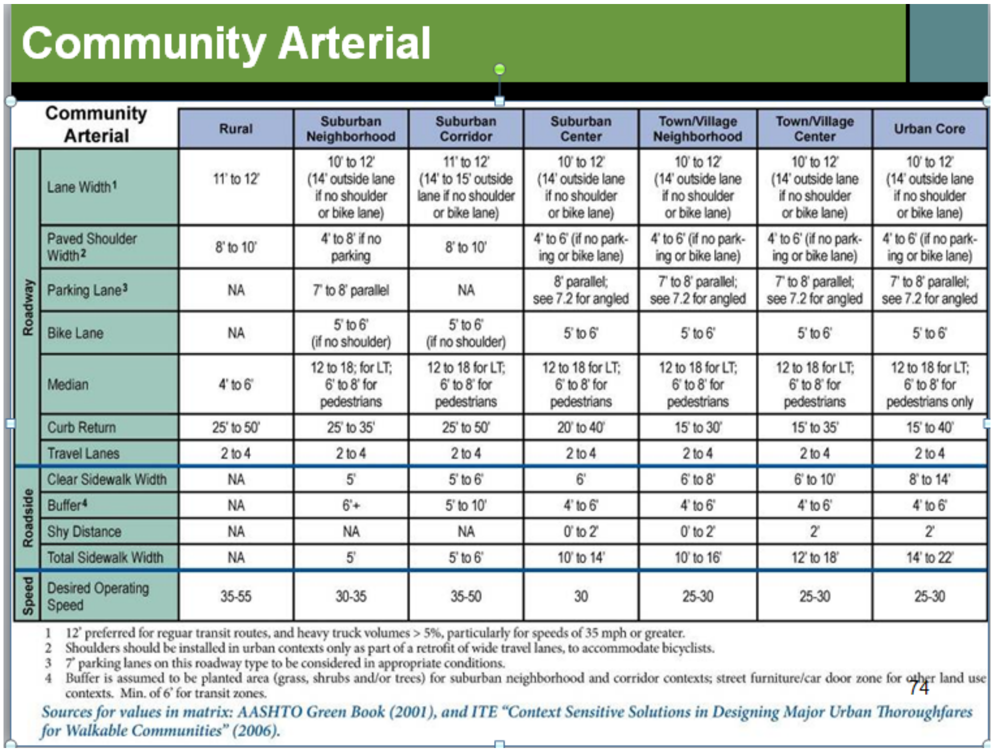
- Travel lane width
- A shift to designing for desirable operating speed versus design speed
- Shoulder width
- On-street parking
- Bicycle facilities
- Medians
- Intersections (including turn radii)
- Pedestrian facilities
- Landscaping
- Access and spacing

The guidebook describes seven prototypical development types and the design attributes appropriate for each, by roadway classification. The design options for a Community Arterial (row 2 from Figure 5-1 above) are shown in **Figure 5-2.**

Many States and localities have adopted policies that aim to consider the needs of all roadway users. Such policies have been referred to as 'Complete Streets' policies. The PennDOT Smart Transportation Guide has been identified as a good example of addressing Complete Streets issues in the American Planning Association Report #559, "Complete Streets: Best Policy and Implementation Practices."

This guidance document can be found at: http://contextsensitivesolutions.org/content/reading/dots_release_smart_transportation_guidebook/resources/smart_transportation_guidebook/

Figure 5-2: Community Arterial Roadway Design Guidelines in Smart Transportation Guidebook



Community Arterial

	Community Arterial	Rural	Suburban Neighborhood	Suburban Corridor	Suburban Center	Town/Village Neighborhood	Town/Village Center	Urban Core
Roadway	Lane Width[1]	11' to 12'	10' to 12' (14' outside lane if no shoulder or bike lane)	11' to 12' (14' to 15' outside lane if no shoulder or bike lane)	10' to 12' (14' outside lane if no shoulder or bike lane)	10' to 12' (14' outside lane if no shoulder or bike lane)	10' to 12' (14' outside lane if no shoulder or bike lane)	10' to 12' (14' outside lane if no shoulder or bike lane)
	Paved Shoulder Width[2]	8' to 10'	4' to 8' if no parking	8' to 10'	4' to 6' (if no parking or bike lane)	4' to 6' (if no parking or bike lane)	4' to 6' (if no parking or bike lane)	4' to 6' (if no parking or bike lane)
	Parking Lane[3]	NA	7' to 8' parallel	NA	8' parallel; see 7.2 for angled	7' to 8' parallel; see 7.2 for angled	7' to 8' parallel; see 7.2 for angled	7' to 8' parallel; see 7.2 for angled
	Bike Lane	NA	5' to 6' (if no shoulder)	5' to 6' (if no shoulder)	5' to 6'	5' to 6'	5' to 6'	5' to 6'
	Median	4' to 6'	12 to 18; for LT; 6' to 8' for pedestrians	12 to 18 for LT; 6' to 8' for pedestrians	12 to 18 for LT; 6' to 8' for pedestrians	12 to 18 for LT; 6' to 8' for pedestrians	12 to 18 for LT; 6' to 8' for pedestrians	12 to 18 for LT; 6' to 8' for pedestrians only
	Curb Return	25' to 50'	25' to 35'	25' to 50'	20' to 40'	15' to 30'	15' to 35'	15' to 40'
	Travel Lanes	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4	2 to 4
Roadside	Clear Sidewalk Width	NA	5'	5' to 6'	6'	6' to 8'	6' to 10'	8' to 14'
	Buffer[4]	NA	6'+	5' to 10'	4' to 6'	4' to 6'	4' to 6'	4' to 6'
	Shy Distance	NA	NA	NA	0' to 2'	0' to 2'	2'	2'
	Total Sidewalk Width	NA	5'	5' to 6'	10' to 14'	10' to 16'	12' to 18'	14' to 22'
Speed	Desired Operating Speed	35-55	30-35	35-50	30	25-30	25-30	25-30

1 12' preferred for reguar transit routes, and heavy truck volumes > 5%, particularly for speeds of 35 mph or greater.
2 Shoulders should be installed in urban contexts only as part of a retrofit of wide travel lanes, to accommodate bicyclists.
3 7' parking lanes on this roadway type to be considered in appropriate conditions.
4 Buffer is assumed to be planted area (grass, shrubs and/or trees) for suburban neighborhood and corridor contexts; street furniture/car door zone for other land use contexts. Min. of 6' for transit zones.

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Sources for values in matrix: AASHTO Green Book (2001), and ITE "Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities" (2006).

Source: Pennsylvania Department of Transportation

5.4.1.4 CSS in Designing Major Urban Thoroughfares for Walkable Communities

ITE's Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities, 2006 is another valuable resource for practitioners. This report advances the successful use of context sensitive solutions in the planning and design of major urban thoroughfares for walkable communities. The document, which can be found at http://www.ite.org/bookstore/RP036.pdf, provides guidance on how to apply CSS concepts and principles to create roadway improvement projects consistent with their physical settings.

Specifically, this work describes the principles, benefits and importance of CSS in transportation projects; identifies how CSS principles can be applied in the planning and development of improvements to major urban thoroughfares; describes the relationship, compatibility and tradeoffs that may be appropriate when balancing the needs of users, adjoining land uses, environment and community interests; presents guidance on how to identify and select appropriate thoroughfare types and corresponding design parameters to best meet the needs of a particular context; and provides criteria for specific roadway elements along with guidance on balancing stakeholder, community and environmental needs and constraints.

5.5 Assessment of Functional Classification Systems

While the Federal functional classification categories play an important role in Federal, State, regional and local transportation planning, there is an emerging trend in transportation to develop new classification categories with which to group and describe roadways. At the heart of this trend is the recognition that roadways do more than move traffic. Roadways are the basic skeleton of a community and are travelways for other modes of transportation, including walking, bicycling and public transportation. The following section describes other functional classification systems in use and touches upon emerging concepts in the realm of roadway functional classification.

5.6 Emerging/Other Functional Classification Systems

While most States only use the FHWA functional classification scheme, several States have developed additional or alternative classification systems to suit their planning and engineering needs. Reasons for developing alternative functional systems include the need to incorporate unique roadway types or roadways that are not part of the Federal-aid system and the need to develop a system to meet the unique administrative or jurisdictional requirements of a State.

Oregon DOT is one State that has employed a separate classification system. This alternate system has only four categories (Interstate, Statewide, Regional and District). While there is not a single translation to convert the Federal functional classification categories to the four State categories, **Table 5-1** represents a general "rule of thumb" that Oregon DOT uses for the translation between the two systems.[7]

Table 5-1: Oregon DOT's Classification System

State Classification System (SCS)	Description	Corresponding Functional Classifications
Interstate Highways	Provide connections to major cities, regions or other states; regional trips within metro areas.	• Urban or Rural Interstate
Statewide Highways	Provide connection to larger urban areas, ports and recreational areas that are not directly served by interstate highways	• Principal Arterial – Other • Urban Principal Arterial – Other Freeway Expressway • Urban or Rural Other Principal Arterial
Regional Highways	Provide links to regional centers, statewide or interstate highways or economic or activity centers of regional significance	• Urban or Rural Minor Arterial
District Highways	Facilities of county-wide significance function largely as county and city Arterials or Collectors	• Urban or Rural Minor Arterial • Urban or Rural Major Collector • Rural Minor Collector

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[7] Department of Transportation, Guidelines for Updating Federal Aid Urban Boundaries and Functional Classification, July 2003 http://www.oregon.gov/ODOT/TD/TDATA/rics/docs/InstructionsForFCReview.pdf?ga=t

With the institutionalization of new concepts such as sustainability, smart growth, new urbanism and complete streets comes a different perspective on transportation as a whole and on roadways in particular. These movements have shifted the dialogue from the movement of automobiles to the mobility of persons. Some States have developed roadway design guidelines that decouple the Federal functional classification system from the specific design needs of a roadway that are determined through a project development process.

The MassDOT Project Development and Design Guide[8] provides designers with options that reflect the needs of a considerable range of prevailing land uses and roadway user types. While the guide notes the role that the Federal functional classification system plays in ensuring mobility, access and connectivity, as well as its role in determining funding eligibility, it also points out that MassDOT's guidance on access control, cross-sections, sight distance, design speeds etc. reflect the appropriate level of flexibility that the department applies to roadway design. As an example, MassDOT provides ranges of acceptable design speeds based on roadway type (Arterial, Collector) and subtype, as well as area type (Rural, Suburban and Urban) and subtype.

The Idaho DOT also embraces this new concept. The DOT's August 2009 Technical Report 5 entitled "Highway System Classification (Functional Classification)"[9] states that the department has come to a new understanding that *"streets should connect to their surrounding environment through adjustments in highway/street elements and functions."* This approach bucks the traditional 'one size fits all' approach to roadway design that has been effective in supporting vehicular mobility.

The new approach of multimodal street design encompasses four distinct elements or zones (the travelway zone, the pedestrian zone, the context zone and the intersection zone). Each element works with the others to accommodate the needs of multiple modes in harmony their abutting land uses, taking into account environmental, historical preservation and economic development objectives. Idaho's new functional street classification system is consistent with other national good practices which recognize the importance of the different transportation functions that are accommodated within the roadway's right of way. Increasingly, municipal thoroughfare plans are breaking the traditional "Arterial, Collector, Local" mold and using alternate typology. These typologies expand the rural/urban construct into more granular categories that recognize aesthetic and neighborhood-level concerns and explicitly account for all modes of transportation.

Idaho's proposed functional street classification system is consistent with other national practices, which are often found at the local level. **Figure 5-3** illustrates the proposed multimodal functional street classification system (which includes

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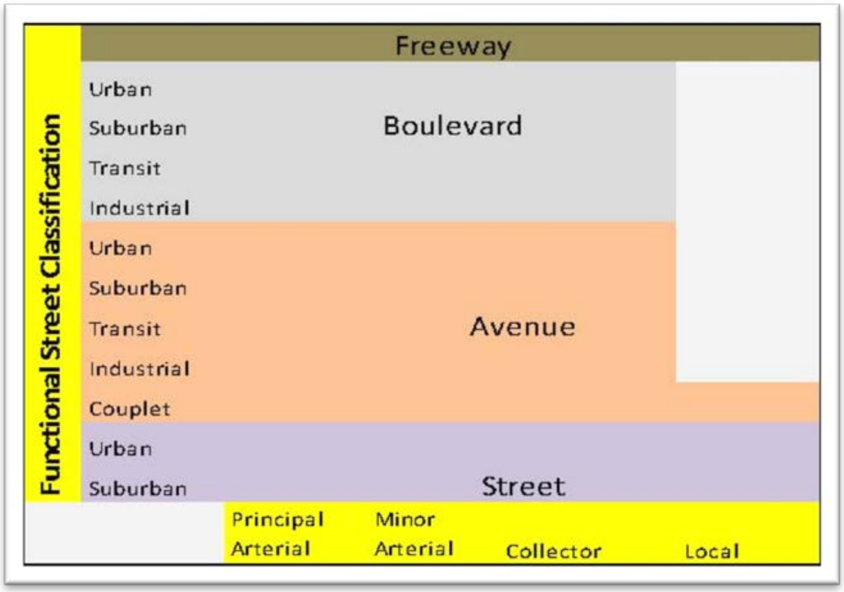
[8] The MassDOT Project Development and Design Guide, http://www.massdot.state.ma.us/highway/DoingBusinessWithUs/ManualsPublicationsForms/ProjectDevelopmentDesignGuide.aspx

[9] Technical Report 5, Highway System Classification, August 12, 2009, http://itd.idaho.gov/transportation-performance/lrtp/reports/Tech%20Rept%205-Highway%20Systems%20Classification.pdf

the categories of Freeways, Boulevards, Avenues and Streets) and relates it to the conventional street classification system. Idaho has other classes as well.

Figure 5-3: Idaho DOT's Proposed Redefinition of Functional Street Classifications

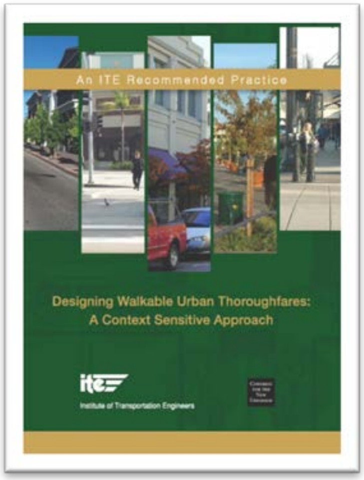


Source: Idaho Department of Transportation

Idaho Department of Transportation Statewide Transportation Systems Plan

The broadening of road typologies and design options within the context of functional classification is not limited to a few DOTs. The Institute of Traffic Engineers' *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities* [10] supports and extends this way of thinking. (**Figure 5-4**) In addition, the ARTIST (Arterial Streets Toward Sustainability)[11] concept and the United Kingdom's *Manual for Streets* [12] offer new ways of categorizing roadways that support short-distance mobility and access with design options to accommodate a variety of modes and roadway treatment options.

Figure 5-4: ITE Report: Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities



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10 Institute of Traffic Engineers, Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities, March, 2010.

11 Lund University, Department of Technology and Society, Arterial Streets Toward Sustainability, Sweden, http://www.tft.lth.se/english/research/traffic_safety/artists/?L=2

12 Department for Transport, Manual for Streets, March 29, 2007 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/3891/pdfmanforstreets.pdf

5.7 Future Trends

Additionally, a significant change is occurring in the transportation industry related to the development of improvement projects focusing on the performance of the facility. Roadway performance can be measured in a number of ways, including mobility, speed, safety and surface condition, as well as by person throughput and the accommodation of multiple transportation modes. Increasingly, the character and context of the environment within which the roadway is located, as well as the expectation of its performance on a number of measures, are driving the design of roadway improvement projects. Gone are the days of simply verifying a roadway's functional classification and applying a "one-size-fits-all" approach to the application of design standards of a roadway improvement project.

This movement in transportation planning to categorize roadways beyond the traditional "Arterial, Collector, Local" spectrum will continue to evolve. Continuing research and dialogue among transportation practitioners will deepen the understanding of what these alternatives can offer to a functional classification system that is relevant and meaningful at the national level.

SECTION 6. URBAN BOUNDARIES

6.1 Introduction

Many Federal transportation programs and policies rely upon a clear and well-documented distinction between urban and rural areas. Urban and rural areas are explicitly defined by the Census Bureau according to specific population, density and related criteria. From these technical definitions, irregularities and boundaries that are separated from or inconsistent with transportation features may result. For transportation purposes, States have the option of using census-defined urban boundaries exclusively, or they may adjust the census-defined boundaries to be more consistent with transportation needs. States, in coordination with local planning partners, may adjust the urban area boundaries so fringe areas having *"…residential, commercial, industrial, and/or national defense significance"* (as noted in the December 9, 1991 Federal-Aid Policy Guide), are included.

The authority to establish the geographic definitions is set forth in Section 101(a) of Title 23 U.S.C. and subsequent guidance has been provided in 23 CFR 470 and in FHWA policy documents.

Reasons for adjusting urban area boundaries for transportation planning purposes often relate to a need for consistency or geographic continuity. For example, it may be logical to include, as part of an urban area, a roadway that is used by urban residents but is located just outside the official Census Bureau urban area boundary. Or, it may make sense to designate as urban a rural pocket in the middle of an urban area (or to address alternating patterns of rural and urban-designated areas). Additionally, large, low density land uses on the urban fringe that serve the urban population such as airports, industrial parks, regional shopping centers and other urban attractions may also be included in an urban area.

On October 14, 2008, FHWA issued the memorandum "Updated Guidance for the Functional Classification of Highways" which stated, "Functional classification should not automatically change at the rural/urban boundary." This extended the 1991 Addendum to the 1989 guidance *Highway Functional Classification: Concepts, Criteria and Procedures,* which provided "greater flexibility for deciding on an appropriate place for changing the functional classification when rural routes cross an urban boundary." The 2008 memorandum proposed further study of functional classification and urban area boundary adjustment which led to this document.

This section is intended to assemble and complete all previous policy given by FHWA for establishing urban area boundaries. It has three main objectives:

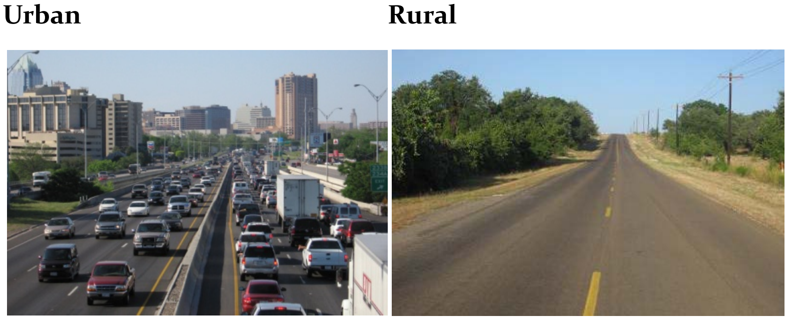
1. To provide a clear definition of adjusted urban area boundaries and other related boundaries
2. To define a set of technical and administrative processes by which States, working in conjunction with local planning partners, could develop adjusted urban areas based upon urban areas as defined by the US decennial census
3. To establish data delivery protocols from the States to FHWA

6.2 Defining Urban and Rural

The terms “urban” and “rural” mean different things to different people, and in many cases, their definitions differ depending upon the context in which they are used. At their core, the concepts of urban and rural are clear; urban areas are considered to have *dense* development patterns, while rural areas are considered to have *sparse* development patterns (see **Figure 6-1**). What has changed over the years, however, is the terminology used and the technical definitions of “dense” and “sparse”.

The concept of adjusted urban areas has evolved since the issuance of the Federal guidance on the topic in Chapter 4 of FHWA’s Federal-Aid Policy issued in December 1991.

Figure 6-1: Prototypical Urban and Rural Areas



Source: CDM Smith

6.2.1 Census Definitions

For the 2010 Census, the Census Bureau classified as urban, all territory, population, and housing units located within urbanized areas (UAs) and urban clusters (UCs), both defined using the same criteria. The Census Bureau delineates UA and UC boundaries that represent densely developed territory, encompassing residential, commercial, and other non-residential urban land uses. An urban area comprises a densely settled core of census tracts and/or census blocks that meet minimum population density requirements, along with adjacent territory containing non-residential urban land uses as well as territory with low population density included to link outlying densely settled territory with the densely settled core. To qualify as an urban area, the territory identified according to criteria must encompass at least 2,500 people, at least 1,500 of which reside outside institutional group quarters.

For the 2010 Census the urban and rural classification was applied to the 50 states, the District of Columbia, Puerto Rico, American Samoa, Guam, the Commonwealth of the Northern Mariana Islands, and the U.S. Virgin Islands.

For classification purposes, the Census Bureau identified two types of urban areas for the 2010 Census:

Urbanized Areas (UAs)—An urbanized area consists of densely developed territory that contains 50,000 or more people. The Census Bureau delineates UAs to provide a better separation of urban and rural territory, population, and housing in the vicinity of large places.

Urban Clusters (UCs)—An urban cluster consists of densely developed territory that has at least 2,500 people but fewer than 50,000 people. The Census Bureau first introduced the UC concept for Census 2000 to provide a more consistent and

According to definitions in 23 U.S.C. 101(a)(33), areas of population greater than 5,000 qualify as urban for transportation purposes in contrast to the Census Bureau’s threshold of 2,500.

accurate measure of urban population, housing, and territory throughout the United States, Puerto Rico, and the Island Areas.

In general, this territory consists of areas of high population density and urban land use resulting in a representation of the "urban footprint." Rural consists of all territory, population, and housing units located outside of UAs and UCs.

Geographic entities, such as metropolitan areas, counties, minor civil divisions (MCDs), places, and census tracts often contain both urban and rural territory, population, and housing units.

A full description of the final 2010 Census urban area delineation criteria can be found in the August 24, 2011, Federal Register (76 FR 53030):

http://www.census.gov/geo/reference/frn.html.

Additional information regarding the 2010 Census urban area program can be found:

http://www.census.gov/geo/reference/ua/urban-rural-2010.html.

6.2.2 FHWA Definitions

There are differences in the way FHWA and the Census Bureau define and describe urban and rural areas. The Census Bureau defines urban areas solely for the purpose of tabulating and presenting Census Bureau statistical data. A number of Federal agency programs use the census definitions as the starting point (if not the basis) for implementing and determining eligibility for a variety of their funding programs.

According to 23 U.S.C. 101(a)(33), areas of population greater than 5,000 can qualify as urban, in contrast to the Census Bureau's threshold of 2,500. There are also differences in the terminology used to describe sub-categories of urban areas. FHWA refers to the smallest urban area as a *Small Urban Area*[13], while the Census Bureau refers to *Urban Clusters*. This and other differences are presented in **Table 6-1** and **Table 6- 2**.

Table 6-1: US Census Bureau Urban Area Types Defined by Population range

Census Bureau Area Definition	Population Range
Urban Area	2,500+
Urban Clusters	2,500-49,999
Urbanized Area	50,000+

Table 6 2: FHWA Urban Area Types Defined by Population Range

FHWA Area Definition	Population Range	Allowed Urban Area Boundary Adjustments
Urban Area	5,000+	Yes
Small Urban Area (From Clusters)	5,000-49,999	Yes
Urbanized Area	50,000+	Yes

Federal transportation legislation allows for the outward adjustment of Census Bureau defined urban boundaries (of population 5,000 and above) as the basis for development of adjusted urban area boundaries for transportation planning purposes, through the cooperative efforts of State and local officials. By Federal rule, these adjusted urban area boundaries must encompass the entire census-designated urban area (of population 5,000 and above) and are subject to

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[13] FHWA has traditionally used this term to describe Urban Areas with a population greater than or equal to 5,000 and less than 50,000, derived from Urban Clusters

approval by the Secretary of Transportation (23 USC 101(a) (36) - (37) and 49 USC 5302(a) (16) - (17)).

For the purposes of the boundary adjustment process, the term "adjusted urban area boundaries" refers to the FHWA boundary adjustment process in all areas of 5,000 population and above.

During the time between the release of the Census Bureau boundaries and the formal approval of the new adjusted boundaries, the previously-developed and approved adjusted urban area boundaries remain in effect. For FHWA and State DOT planning purposes, if a State DOT chooses not or is unable to adjust the urban area boundaries, the most recent unadjusted census boundaries will take effect. This could cause a roadway previously considered to be urban to now be considered rural, which may affect Federal aid funding eligibility.

To avoid this situation, States are encouraged to work with their FHWA Division Office and their local planning partners to go through the process of developing the adjusted urban area boundaries within the recommended timeframe.

6.3 Relationship to Functional Classification

While the urban/rural designation is independent of the functional classification, it is important to recognize that the adjusted urban area boundary is a significant factor in developing the functional classification of a road in an urban/rural context.

Recent changes to FHWA policy have normalized[14] the concepts of urban boundaries and functional classification to improve consistency. The seven functional classifications each for urban and rural areas create 14 possible combinations of functional class and area type. As an example, a roadway classified as a Minor Arterial that happens to be in an urban area has a combined classification of Urban Minor Arterial. There is no change in the definitions of the functionally classified roads; nor does this in any way change the eligibility of rural and urban-classified roads for Federal programs and policies, or how highway statistics are reported.

This change in policy provides an opportunity to clarify how functional classifications at the boundaries of urban/rural areas should be treated. The previous practice in some States of automatically changing the functional classification of a route that crosses into or out of an adjusted urban area boundary can be phased out and eliminated. Upgrading due to an actual change in function should be the operative criterion.

Special attention should be paid to locations at which roadways and boundaries are in close proximity. The adjusted urban area boundary should be designed to eliminate or minimize a roadway's snaking in and out of the boundary. In these cases, as the boundary is adjusted, it needs to be clearly defined that the road is either in or out. This adjustment serves to maintain consistent designation of these peripheral routes and avoids the situation of a roadway alternating between urban and rural designations. Special care should be taken when developing the

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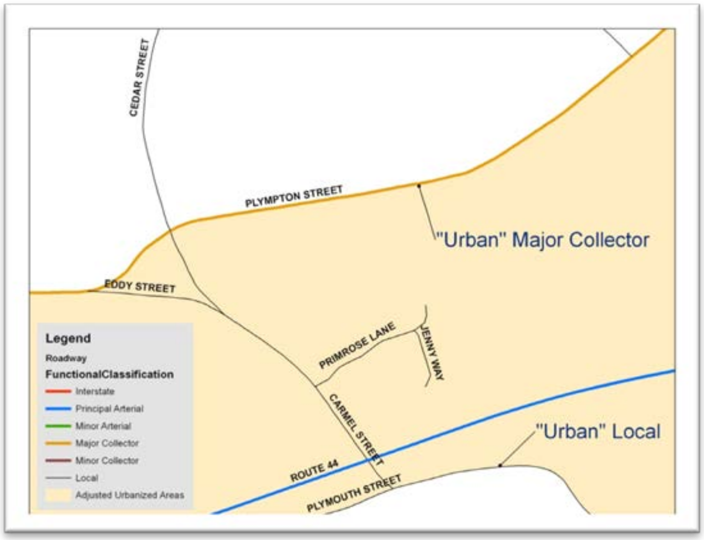
[14] Normalization here means simplifying the functional classification so that a roadway is classified with one meaning while urban/rural is a separate context in which the road is located.

boundary so that spatial consistency is maintained with the roadways and associated attributes.

Roads that define a boundary should be considered consistently urban or rural, and it is strongly recommended that these roadways be carefully evaluated before they are included in or out of the adjusted urban area boundary. For example, in **Figure 6-2**, Plympton Street (a Major Collector) defines the adjusted urban area boundary and is considered to be an Urban Major Collector, while Plymouth Street (a Local Road) is considered to be an Urban Local Road.

Figure 6-2: Example of Roadway Coinciding with Adjusted Urban Area



Source: CDM Smith 2012; Data provided by Massachusetts DOT

6.4 Developing Adjusted Urban Area Boundaries

This section outlines a series of recommended technical and procedural steps to develop adjusted urban area boundaries. These tasks are typically conducted through a collaborative effort between State DOTs and local planning partners. The process begins with the release of the urban area boundaries by the Census Bureau and concludes with the approval of the appropriate FHWA Division Office. Overall, the process typically takes between six months and a year to complete from the time that the census boundaries are released.

As described previously, there is no requirement to adjust the census urban boundaries. States may adopt the census boundaries as is, or they may adjust them for transportation planning purposes. The only official requirement is that an adjusted boundary includes the original urban area boundary defined by the Census Bureau in its entirety. In other words, any adjustment must expand, not contract, the Census Bureau urban area boundary.

6.4.1 Adjusted Urban Area Boundaries – Technical Tasks

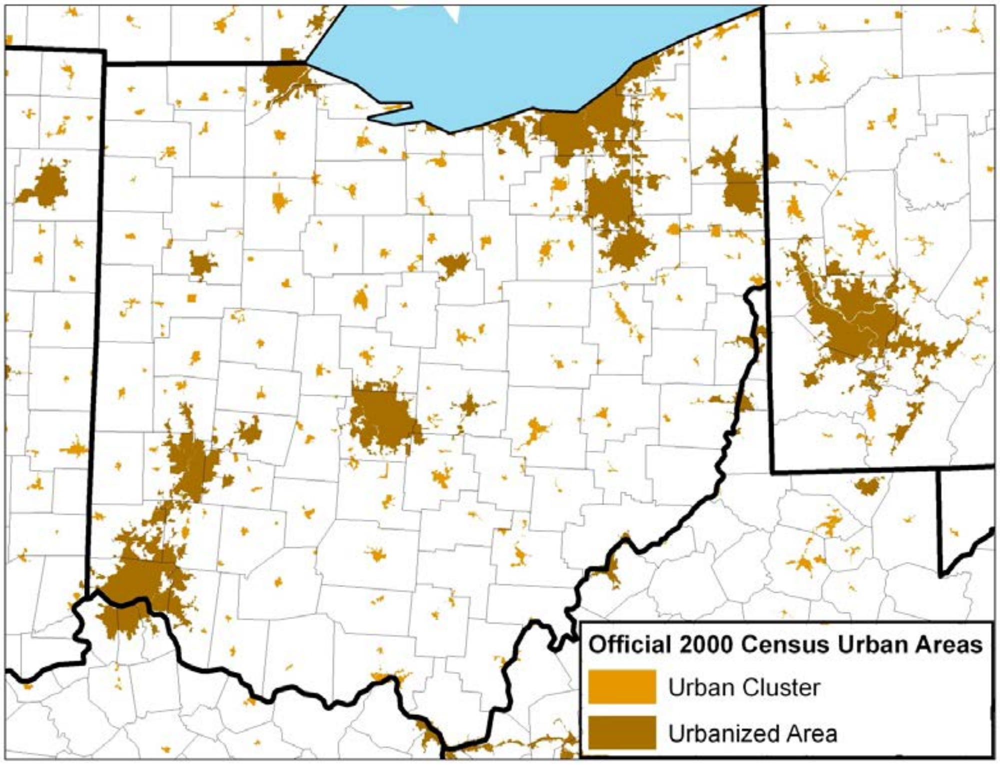
The first step in defining adjusted urban area boundaries is to obtain the census urban area geospatial boundary files from the Census Bureau. These files are available from FHWA's HEPGIS website www.hepgis.fhwa.dot.gov or from the Census Bureau in a variety of GIS-compatible formats, including Arc/Info export, Arc View shape file and Arc/Info format. Historical cartographic boundary files from previous censuses are available for download at:

www.census.gov/geo/www/cob/bdy_files.html.

These urban area boundary files should be edited in GIS. Additional GIS layers should also be gathered from the same year as the decennial census (e.g., 2010) or of similar vintage (see **Figure 6-3**). Potentially useful GIS layers include:

- Land use, including areas of recent growth
- Roadway network
- Railroads
- Transit routes
- Ports (e.g., airports, seaports)
- Military installations
- Other significant traffic generators
- Hydrography
- Municipal boundaries (i.e., incorporated areas)
- Digital ortho-photography

Figure 6-3: 2000 Census Urban Cluster and Urbanized Areas (Ohio and Vicinity)



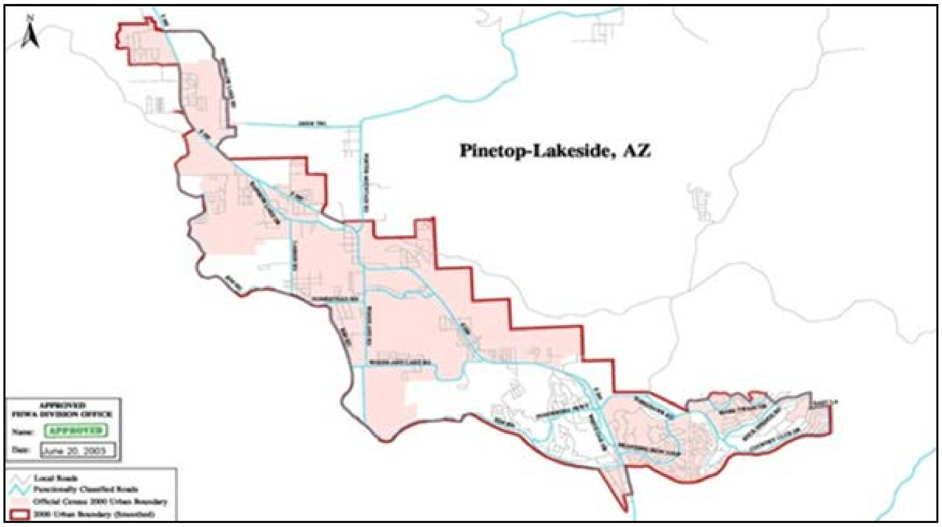
Source: 2000 US Census

6.4.2 Consideration Factors for Adjusting Urban Areas

When adjusting the urban areas, a variety of factors should be considered. The list below describes these factors and includes an example for each. All examples are courtesy of the Arizona or Massachusetts departments of transportation.

- The adjusted urban area boundary will encompass the entire urban area (of population 5,000 or greater) as designated by the Census Bureau. In **Figure 6-4**, no part of the original urban area was removed.

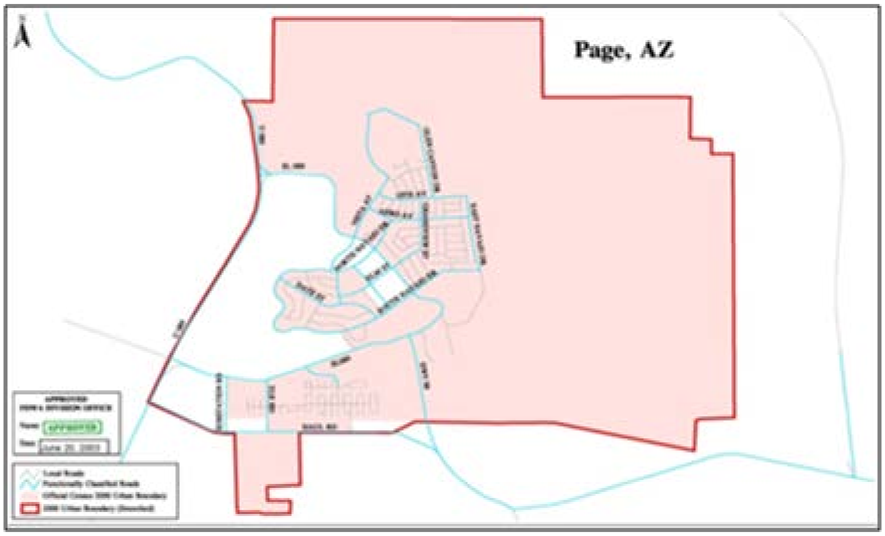
Figure 6-4: Example Original Urban Area



Source: Arizona DOT; http://azdot.gov/mpd/gis/fclass/urban.asp

- The adjusted urban area boundary will be one, single contiguous area. In **Figure 6-5**, the new boundary, like the original census boundary, is a single contiguous area without any holes or discontinuities, such that there is no rural area contained within the outer urban boundary.

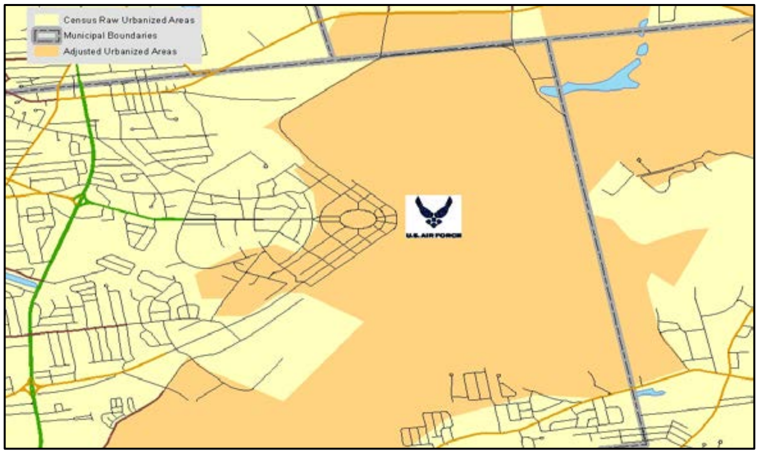
Figure 6-5: Example Single Contiguous Area



Source: Arizona DOT; http://azdot.gov/mpd/gis/fclass/urban.asp

- The adjusted urban area boundary often is designed to encompass areas outside of municipal boundaries that have urban characteristics with residential, commercial, industrial or national defense land uses that are consistent with or related to the development patterns with the boundary. The adjusted urban area boundary should include terminals and their access roads, if such terminals lie within a reasonable distance of the urban area (e.g. airports, seaports). In **Figure 6-6**, the urban area was expanded to cover the nearby Air Force base.

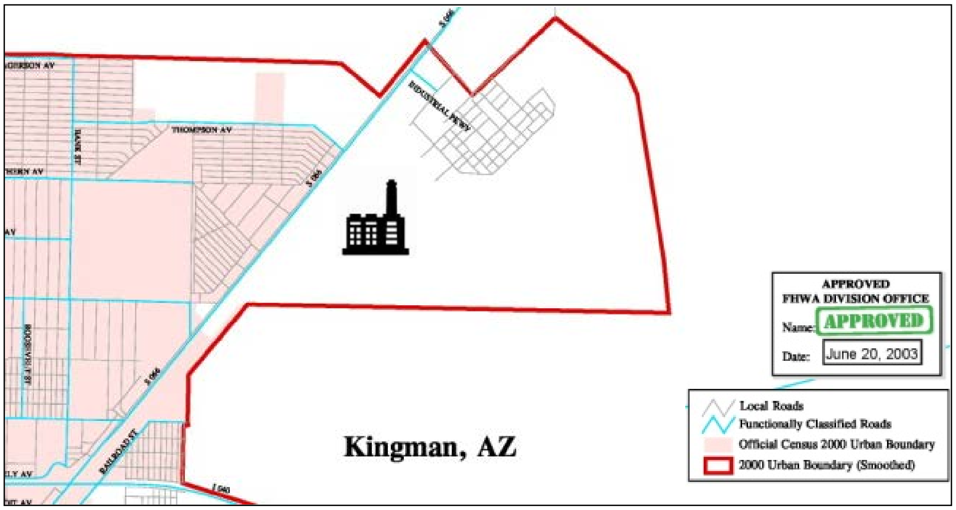
Figure 6-6: Example Area Expanded to Cover Air Force Base



Source: Map created by CDM Smith, using data provided by Massachusetts DOT and US 2000 Census.

- The adjusted urban area boundary is adjusted in many instances to encompass all large traffic generators that are within a reasonable distance from the urban area (e.g., fringe area public parks, large places of assembly, large industrial plants, etc.). In **Figure 6-7**, the urban area was expanded to include the industrial area east of the census urban area boundary.

Figure 6-7: Example Area Expanded to Include Industrial Area

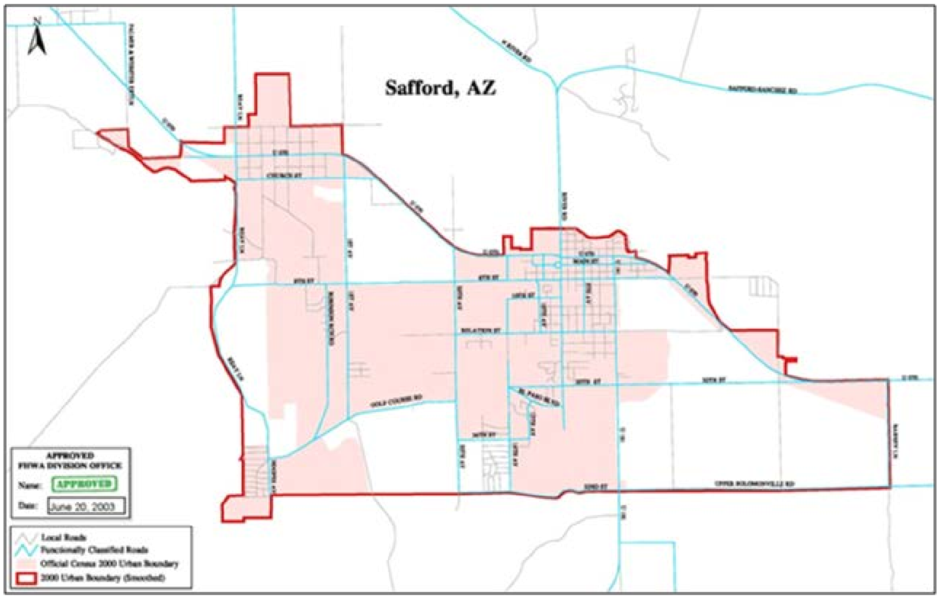


Source: Arizona DOT; http://azdot.gov/mpd/gis/fclass/urban.asp with overlay graphic by CDM Smith to identify industrial plant.

- The adjusted urban area boundary should consider transit service routes (e.g., bus route, passenger rail line) in the placement of a boundary location. However, their inclusion should not unduly distort the shape or composition of the original census-defined urban area boundary.
- The adjusted urban area boundary should be defined so that its physical location is easy to discern in the field from data shown on the map. Whenever possible, if the boundary is going to deviate from political jurisdictional boundaries, it should follow physical features (e.g., rivers, streams, irrigation canals, transmission lines, railroads, streets or highways). In instances where physical features are lacking, the boundary should cross at

roadway intersections which are readily identifiable in the field. In **Figure 6-8**, the boundary was adjusted to align with the major east-west roadway to the south.

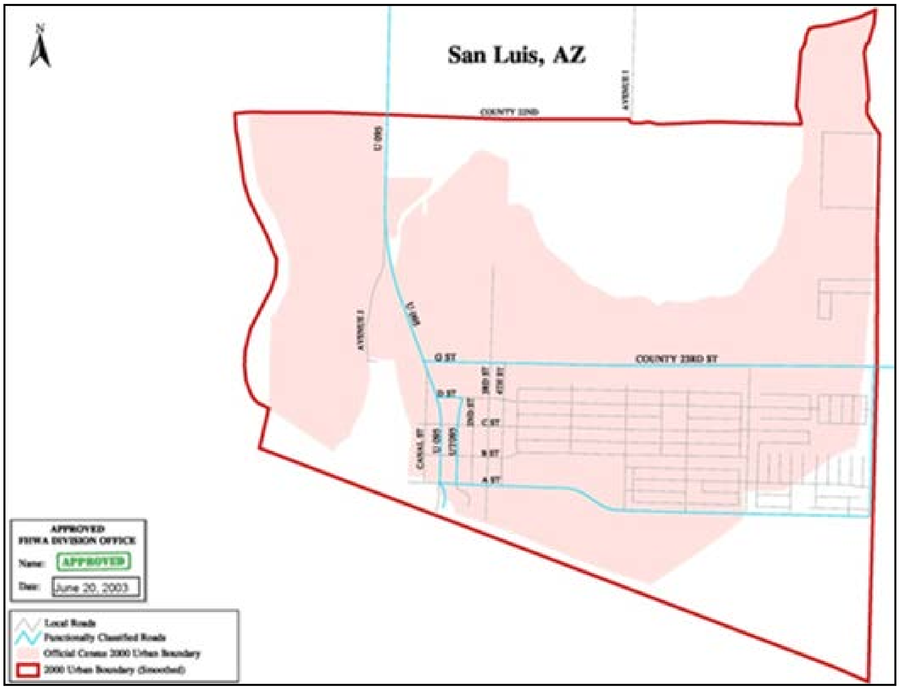
Figure 6-8: Example Boundary Adjusted to Align with Major Roadway



Source: Source: Arizona DOT; http://azdot.gov/mpd/gis/fclass/urban.asp

- After the adjusted urban area boundary has been defined using all the factors previously listed, remaining boundary irregularities should be minimized to avoid the confusion that irregular boundaries can create. In **Figure 6-9**, the boundary was adjusted to be considerably less complex than the original irregular census boundary.

Figure 6-9: Example Boundary Adjusted for Simplicity



Source: Arizona DOT; http://azdot.gov/mpd/gis/fclass/urban.asp

Additional recommendations regarding the adjustment of the urban area boundaries include:

- Adjusted urban area boundaries should be defined so that confusion or ambiguity is minimized. For example, a boundary should not be drawn in the middle of a divided highway. The divided highway should be either completely in or completely out of the urban area boundary.
- In instances where a roadway defines the boundary between two urban areas, the roadway should be clearly assigned to the urban area it primarily serves. If the roadway serves each urban area equally, a business rule should be developed that assigns the roadway appropriately.
- If access controlled roadways are used to define the adjusted urban area boundary, all ramps and interchanges should be either included or excluded concerning the adjusted urban area boundary and interchanges should not be divided by the boundary.
- For coastal areas, if the intent of the adjusted urban area boundaries is to be reflective of the shoreline, then the generally accepted coastal boundaries most commonly used for geospatial processes, such as spatial analysis or map-making, should be used.

6.5 Adjusted Urban Area Boundaries – Procedural Tasks

If States and their local partners choose to adjust the urban area boundaries, then they must be reviewed, at a minimum, in conjunction with the census urban area boundary release.[15] FHWA recommends that this process be completed within 1 year of the release of the census urban area GIS datasets. FHWA considers a State's DOT, working with the appropriate local government entities, to be the authority during this process and relies upon State DOTs to take an active leadership role.

6.5.1 Risk Factors to Urban Area Adjustment Schedule

There are several risk factors that could potentially arise and impact the amount of time it takes to complete the adjustment process. Therefore each State should develop a carefully planned approach for addressing these potential risk factors, which include:

- A large number of urban areas within a State
- Newly created urban areas
- Merging of previously separate urban areas
- Urban areas that cross State boundaries
- A large number of local planning partners with which to coordinate
- Inconsistency in the application of adjustment criteria across the State
- Inconsistent interim data submittal formats
- Lack of active engagement by local planning partners

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[15] Although there is no specific FHWA policy on how often adjustments to urban area boundaries can be made, states are encouraged to make such adjustments as infrequently as possible and only when deemed absolutely necessary.

- Lack of DOT resources to complete the process in a timely fashion

6.5.2 Urban Area Adjustment Schedule

FHWA Division Offices will correspond with State DOTs to launch the effort of developing the adjusted urban area boundaries. This transmittal is expected to be delivered soon after the Census Bureau releases its urban area boundaries, which typically occurs about 12 to 18 months following the decennial census. FHWA's transmittal will remind the State DOTs of their responsibilities; include notification of the availability of the Census Bureau's urban area boundary files; and provide information regarding how and when the updated boundary data should be submitted.

Figure 6-10 and the list that follows present a good practice level of procedural steps that should be completed within 12 months of the release of the Census Bureau's urban area boundary files.

Figure 6-10: Good Practice Level of Procedural Steps for an Urban Boundary Update Process

	Month											
	1	2	3	4	5	6	7	8	9	10	11	12
1. Mobilize the Adjusted Urban Area Boundary Update Process												
1a. Obtain Urban Area Boundaries from U.S. Census	🟩											
1b. Establish AUAB Review Team	🟩	🟩										
1c. Generate data, maps, etc. for use by local planning partners		🟩	🟩									
1d. Contact local planning partners		🟩	🟩									
2. Work with Local Planning Partners in Adjusted Urban Area Boundary Review Process												
2a. Deliver data and documents to local planning partners				🟩								
2b. Work with Local Planning Partners in Adjusted Urban Area Boundary Review Process				🟩	🟩	🟩	🟩	🟩	🟩			
3. Make Adjusted Urban Area Boundary Changes												
3a. Gather, review, and incorporate all proposed changes										🟩		
3b. Submit draft Adjusted Urban Area Boundary information to FHWA											🟩	
3c. Incorporate Adjusted Urban Area Boundary Changes into Enterprise Systems												🟩

1. **Mobilize the Urban Area Boundary Adjustment Process**
   a. **Acquire newly developed urban area boundaries from US Census.** Obtain the latest decennial census urban area boundaries from the Census Bureau.

   b. **Form a team to guide the urban area boundary update process.** Staff the team with FHWA Division personnel, along with State and regional transportation planners who have a vested interest in the final delineation of the boundaries. Individuals with experience in functional classification, Federal transportation funding, highway design, traffic operations and the metropolitan transportation planning process should have a role in this process. This review team should be responsible for reviewing draft adjusted urban area boundary submittals from local planning partners.

c. **Generate data, maps, etc. for use by local planning partners.** Incorporate urban area boundaries from the census into data and maps that that are relevant to local planning partners. These may include statewide, district, county and municipal scales.

d. **Contact local planning partners.** Contact the impacted local planning partners to explain the task at hand and request their participation. For Urbanized Areas contained and/or very proximate to metropolitan planning areas, the MPO should be a key partner. For Urban Clusters, regional planning agencies, counties and/or local municipalities should be consulted. However, for many of these urban areas, additional effort may be required to properly engage these partners. In these instances, it is appropriate for State DOTs to make urban area adjustments in these areas. Finally, in some instances, regional transit service providers should also be consulted to understand their short-term routing plans.

2. **Work with Local Planning Partners in the Adjusted Urban Area Boundary Update Process**

   a. **Deliver data and documents to local planning partners.** Share the original decennial census-based urban boundary maps and/or GIS data (including both Urbanized Areas and Small Urban Areas) with the local planning partners. In addition, to inform the partners and the process more completely, it helps if maps and/or GIS data representing both the previous unadjusted and adjusted urban area boundary are shared in a timely manner. This transmittal should include specific instructions in terms of data formats, spatial accuracy, update processes and expected completion dates, as well as this guidance document. In-person or video conference meetings are encouraged to enhance communication and mutual understanding. Creation of adjusted urban area boundaries should follow each State's GIS data editing and quality control procedures (e.g., issues of scale) and performed by qualified GIS users.

   b. **Work with local planning partners.** As necessary, each State DOT will need to work with the local planning partners to ensure that the urban area adjustment process is meeting their expectations. Close collaboration with MPOs is extremely important, and regional workshops hosted by MPOs can be very valuable in ensuring there is a common understanding of the process and schedule. While the exact details surrounding information exchange may vary from state to state, the expectation is that local planning partners will review the US census urban area boundaries in the context of the existing adjusted urban area boundaries (based upon the previous census) and determine the extent to which the boundaries should be adjusted for transportation planning purposes. The local planning partners should submit a set of proposed adjustments to the current US Census urban area boundaries in their area to their State DOT.

3. **Make Adjusted Urban Area Boundary Changes**

    a. **Gather, review and incorporate proposed changes from local planning partners.** As local planning partners submit their recommendations for adjusted urban area boundaries, the State DOT must review the proposed adjustments to ensure that they are reasonable. At the very least, the DOT must ensure that no territory considered urban by the Census Bureau be left out of the adjusted urban area boundary. In addition, the State DOT should review all proposed adjusted urban area boundaries paying particular attention to locations where the adjusted urban area boundaries are co-located with another feature such as a roadway, a municipal boundary or a hydrographic feature. Some follow-up meetings may be necessary to resolve issues discovered by the DOT. The updated GIS adjusted urban area boundaries need to be incorporated into the master urban boundary layer and subjected to the DOT's GIS quality control checks with the metadata for the layer updated.

    b. **Submit draft adjusted urban area boundary information to FHWA Division Office.** Once the State DOT has successfully reviewed and concurred with all recommend adjusted urban area boundaries, the State DOT should submit the draft final adjusted urban area boundaries to its FHWA Division Office for final approval. The specific format of data delivery should be worked out between the State DOT and their FHWA Division Office. Various geospatial formats will be acceptable, and as developed, FHWA systems such as HPMS or HEPGIS may be used. As a final resort, hard copy maps at a scale sufficient to identify the adjusted urban area boundaries can be submitted.

    c. **Incorporate adjusted urban area boundary changes into Enterprise Systems.** Once FHWA has approved the adjusted urban areas, the State DOT should incorporate the adjusted urban area boundary changes into the enterprise geospatial database systems that house the official record of the adjusted urban area boundaries. States are required to submit their adjusted urban area boundaries to FHWA when changes are made to the boundaries. In most cases, this submittal should only occur once after the State has completed its adjustment process.

Table 6-3 presents key milestones for the overall development and submittal process (for example, using submitted data based upon the 2010 US Census data.

Table 6-2: Key Milestones for Development and Submittal of Adjusted Urban Area Boundaries

Event	Months Following Decennial Census Data Release (CDR)
Census releases urban area boundaries and FHWA issues transmittal letter	Month 24
Begin adjusted urban area boundary update process	Month 24
DOT works with planning partners to define adjusted urban area boundaries	Month 27-Month 33
Provide draft final data and/or maps to FHWA Division Office for review	Month 34
DOT incorporates updates	Month 35
DOT submits adjusted urban area boundaries via annual HPMS submittal	Month 36

Each State should submit only boundaries for the HPMS submittal that have been approved by their FHWA Division Office.

Table 6-4 lists the attributes that are required within the FHWA geospatial database.

Table 6-3: Geospatial Database Required Attributes

Field Name	Description
Year_Record	Year for which the data apply
Urban_Code	Census urban code
Urban_Name	Urban name
Census_Pop	Census population ("recalculated" based upon the adjusted urban area boundary)
Census_Land_Area	Census land area (in square miles)
Shape	Polygon feature

6.6 Adjusted Urban Area Boundaries – Data Transmittal Process

Each State DOT should coordinate with its local FHWA Division Office to discuss the data transmittal process. To the extent possible, all draft final boundaries should be submitted electronically in the form of GIS data and/or PDF maps. If GIS data are provided, appropriate metadata delineating the spatial accuracy, projection and definition/domain of all attributes should also be provided, as well as supporting documentation that briefly describes the process by which the boundaries were adjusted. In addition, each adjusted urban area boundary should be a single (multi-part, if necessary) polygon GIS feature. Feature names and codes should follow Federal Information Processing Standards (FIPS) conventions as well as any applicable State naming and coding standards.

SECTION 7. GRAPHICS SOURCES

Akos Szoboszlay

Arizona DOT

CDM Smith

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Department for Transport, United Kingdom

FHWA

Google Earth Pro

Lund University, Department of Technology and Society

Idaho DOT

Institute of Transportation Engineers

Idaho DOT

Massachusetts DOT

Minnesota DOT

Ohio DOT

Ohio Statewide Imagery Program

Oregon DOT

Smart Transportation Guidebook

Texas DOT

US Census (2000)

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North Carolina Department of Transportation

Complete Streets Planning and Design Guidelines

July 2012

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Preface

The North Carolina Board of Transportation adopted a Complete Streets policy in July 2009. The policy directs the North Carolina Department of Transportation (NCDOT) to consider and incorporate all modes of transportation when building new projects or making improvements to existing infrastructure. Under the new policy, NCDOT will collaborate with cities, towns, and communities during the planning and design phases of new streets or improvement projects. Together, they will decide how to provide the transportation options needed to serve the community and complement the context of the area.

The policy adopted by the Board of Transportation directed NCDOT to develop planning and design guidelines. The following chapters represent the planning and design guidelines, and are the result of a collaborative effort between NCDOT and representatives of metropolitan planning organizations, cities, towns, transit agencies, and the Federal Highway Administration. Development of the guidelines included public comment periods to gain feedback from cities, towns, transit agencies, advocacy groups, and other interested parties; the input gained informed the planning and design guidelines.

The following, included in this preface for reference, is NCDOT's adopted complete streets policy.

Under the Complete Streets policy, NCDOT is to collaborate with communities during the planning and design phases of new streets or improvement projects to decide how to provide transportation options needed to serve the community.

North Carolina Department of Transportation Complete Streets Policy

A. Definition

Complete Streets is North Carolina’s approach to interdependent, multi-modal transportation networks that safely accommodate access and travel for all users.

B. Policy Statement

Transportation, quality of life, and economic development are all undeniably connected through well-planned, well-designed, and context-sensitive transportation solutions. To NCDOT the designations “well-planned’, “well-designed” and “context-sensitive” imply that transportation is an integral part of a comprehensive network that safely supports the needs of the communities and the traveling public that are served.

The North Carolina Department of Transportation, in its role as steward over the transportation infrastructure, is committed to:

- providing an efficient multi-modal transportation network in North Carolina such that the access, mobility, and safety needs of motorists, transit users, bicyclists, and pedestrians of all ages and abilities are safely accommodated;
- caring for the built and natural environments by promoting sustainable development practices that minimize impacts on natural resources, historic, businesses, residents, scenic and other community values, while also recognizing that transportation improvements have significant potential to contribute to local, regional, and statewide quality of life and economic development objectives;
- working in partnership with local government agencies, interest groups, and the public to plan, fund, design, construct, and manage complete street networks that sustain mobility while accommodating walking, biking, and transit opportunities safely.

This policy requires that NCDOT’s planners and designers will consider and incorporate multimodal alternatives in the design and improvement of all appropriate transportation projects within a growth area of a town or city unless exceptional circumstances exist. Routine maintenance projects may be excluded from this requirement if an appropriate source of funding is not available.

C. Purpose

This policy sets forth the protocol for the development of transportation networks that encourage non-vehicular travel without compromising the safety, efficiency, or function of the facility. The purpose of this policy is to guide existing decision making and design processes to ensure that all users are routinely considered during the planning, design, construction, funding and operation of North Carolina’s transportation network.

D. Scope and Applicability

This policy generally applies to facilities that exist in urban or suburban areas; however, it does not necessarily exclude rural setting; and is viewed as a network that functions in an interdependent manner.

There are many factors that must be considered when defining the facility and the degree to which this policy applies, e.g., number of lanes, design speeds, intersection spacing, medians, curb parking, etc. Therefore, the applicability of this policy, as stated, should be construed as neither comprehensive nor conclusive. Each facility must be evaluated for proper applicability.

Notwithstanding the exceptions stated herein, all transportation facilities within a growth area of a town or city funded by or through NCDOT, and planned, designed, or constructed on state-maintained facilities, must adhere to this policy.

E. Approach

It is the Department's commitment to collaborate with cities, towns, and communities to ensure pedestrian, bicycle, and transit options are included as an integral part of their total transportation vision. As a partner in the development and realization of their visions, the Department desires to assist localities, through the facilitation of long-range planning, to optimize connectivity, network interdependence, context sensitive options, and multimodal alternatives.

F. Related Policies

This policy builds on current practices and encourages creativity for considering and providing multi-modal options within transportation projects, while achieving safety and efficiency. Specific procedural guidance includes:

- Bicycle Policy (adopted April 4, 1991)
- Highway Landscape Planting Policy (dated 6/10/88)
- Board of Transportation Resolution: Bicycling & Walking in North Carolina, A Critical Part of the Transportation System (adopted September 8, 2000)
- Guidelines for Planting within Highway Right-of-Way
- Bridge Policy (March 2000)
- Pedestrian Policy Guidelines – Sidewalk Location (Memo from Larry Goode, February 15, 1995)
- Pedestrian Policy Guidelines (effective October 1, 2000 w/Memo from Len Hill, September 28, 2000)
- NCDOT Context Sensitive Solutions Goals and Working Guidelines(created 9-23-02; updated 9-8-03)

G. Exceptions to Policy

It is the Department's expectation that suitable multimodal alternatives will be incorporated in all appropriate new and improved infrastructure projects. However, exceptions to this policy will be considered where exceptional circumstances that prohibit adherence to this policy exist. Such exceptions include, but are not limited to:

- facilities that prohibit specific users by law from using them,
- areas in which the population and employment densities or level of transit service around the facility does not justify the incorporation of multimodal alternatives.

It is the Department's expectation that suitable multimodal alternatives will be incorporated as appropriate in all new and improved infrastructure projects within a growth area of a town or city.

As exceptions to policy requests are unique in nature, each will be considered on a case-by- case basis. Each exception must be approved by the Chief Deputy Secretary.

Routine maintenance projects may be excluded from this requirement if an appropriate source of funding is not available.

H. Planning and Design Guidelines

The Department recognizes that a well- planned and designed transportation system that is responsive to its context and meets the needs of its users is the result of thoughtful planning. The Department further recognizes the need to provide planners, designers and decision-makers with a framework for evaluating and incorporating various design elements into the planning, design, and construction phases of its transportation projects. To this end, a multi-disciplinary team of stakeholders, including transportation professionals, interest groups, and others, as appropriate, will be assembled and charged with developing comprehensive planning and design guidelines to support this policy.

These guidelines will describe the project development process and incorporate transparency and accountability where it does not currently exist; describe how (from a planning and design perspective) pedestrians, bicyclists, transit, and motor vehicles will share roads safely; and provide special design elements and traffic management strategies to address unique circumstances.

An expected delivery date for planning and design guidelines will be set upon adoption of this policy.

I. Policy Distribution

It is the responsibility of all employees to comply with Departmental policies. Therefore, every business unit and appropriate private service provider will be required to maintain a complete set of these policies. The Department shall periodically update departmental guidance to ensure that accurate and up-to-date information is maintained and housed in a policy management system.

Approved by North Carolina Board of Transportation, July 9, 2009

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1. Implementing Complete Streets in North Carolina

Even before the founding of the Interstate Highway System, transportation planning and design was focused on the safe movement of cars and trucks from point A to point B, alleviating bottlenecks along the way, and increasing access and capacity in response to increasing traffic. It didn't matter whether the facility was an interstate highway, a freeway, a community main street, or a rural road, the automobile was an emerging mode of transportation and getting motorists from their origins to their destinations as quickly and smoothly as possible was the role of the transportation planner and engineer. This seemed an appropriate response to the desires of the times—a growing country wanting quick access to commerce and connectivity from city to city and region to region.

Over time, though, the demand for transportation services has changed, and this auto-only focus has had unintended consequences for communities, for those needing or wanting to use other transportation modes, and even for motorists. For the past 50 years, streets have been designed to serve motor vehicles and often have not included sidewalks or bicycle facilities. As a result, it is difficult to walk, bicycle, or use transit in many places due to incomplete streets. People seeking to travel by modes other than the automobile need more transit services and better access to those services. Our residents also desire more pedestrian and bike friendly choices for mobility. These mobility choices will increase the level of independence for all users. Motorists are also facing increasingly congested roadways that have resulted from an auto-only emphasis. For all of these reasons, there is a growing need to ensure that streets provide safety and mobility for all users. Well-planned, well-designed, context-based streets are an integral part of a comprehensive transportation network that safely supports the needs of the communities and the traveling public, no matter how they are traveling.

Complete streets represent North Carolina's approach to interdependent, multimodal transportation networks that safely accommodate access and travel for all users of all ages and abilities.

The North Carolina Board of Transportation adopted a complete streets policy in July 2009. The purpose of the policy is to "guide existing decision making and design processes to ensure that all users are routinely considered during the planning, design, construction, funding and operation of North Carolina's transportation network." The adoption of the policy and subsequent formation of detailed guidance represents a significant shift in North Carolina's approach to street design. Meeting the mobility requirements of the 21st century requires collaborative, local context decision making and a shift away from designing an auto-focused highway system toward designing and operating a street network that safely and conveniently accommodates all transportation modes.

What are Complete Streets?

It is possible to find many examples of incomplete streets—streets that were designed primarily for vehicular throughput and that made it more difficult to move about using other modes. Conversely, and as defined by the National Complete Streets Coalition:

> *"Complete streets are designed and operated to enable safe access for all users. Pedestrians, bicyclists, motorists and transit riders of all ages and abilities must be able to safely move along and across a complete street."*

Therefore, a complete streets philosophy means that NCDOT and its partners will provide a network of streets that safely and comfortably accommodate all users, including bicyclists, pedestrians, and transit users. Typical elements that make up a complete street include sidewalks, bicycle lanes, appropriate street widths and speeds, and transit stops with benches, shelters, and access points that comply with Americans with Disabilities Act requirements.

Complete street design elements that emphasize safety, mobility, and accessibility for those using a variety of travel modes may also include crosswalks, bus lanes, adequate separation between sidewalks and streets, street trees and other landscaping, lighting, and signal systems. Though complete streets may initially be designed or built as apparently disconnected segments, the intent is to incrementally grow and develop extensive networks of complete streets. This will require systematic application of the complete streets principles and designs included in these guidelines.

When defining complete streets, NCDOT recognizes that streets are different from highways and, therefore, should be designed differently from highways. Highways operate at much higher speeds and function differently than streets. Highways serve an important function, focusing on providing the highest level of efficiency for very high traffic volumes, typically over longer distances, and providing connections between towns and cities. As such, they are more auto oriented and provide more access control than streets, and traditional highway design is appropriate and necessary for these types of facilities.

On the other hand, streets predominately serve to provide connectivity within communities and access to surrounding land uses. This requires a focus on providing design treatments for all modes so that people can move about within their communities by car, transit, bicycle, or on foot. It requires moving toward an understanding and expectation that "functionality" does not just apply to motor vehicles—streets should be evaluated and designed with an eye to functionality for all users. Streets also represent a significant portion of the public realm and play an important role in community livability. Therefore, street design practices and principles should differ from highway design practices and principles. These guidelines are intended to provide the direction for establishing those street design practices.

Finally, although freeways and expressways are not a part of a complete street framework, their intersections with surface streets, as well as bridges or underpasses crossing them, should be designed to safely and comfortably accommodate bicyclists, pedestrians, and transit users. This will further ensure the long-term development of complete street networks that support all users.

Why Are Complete Streets Important for North Carolina?

The adoption of NCDOT's Complete Streets policy and the formation and ongoing implementation of these guidelines will represent a significant change in the approach to street design for North Carolina. At the heart of this transition to complete streets is the understanding that "transportation" is not only about moving cars, but also about moving people and connecting, supporting, and building communities. This includes the recognition that streets contribute to the quality of life and the economic vitality of places and are meant to serve all users. It is about providing North Carolinians with safe, comfortable, and viable options for how they move about their communities. This will be increasingly important as North Carolina continues to grow and urbanize, and as its residents continue to demand and require transportation choices, whether they live in large cities or in small towns.

Complete streets also provide healthier transportation options to North Carolina residents. Complete streets provide opportunities for physical activity that promote walking, biking, and transit use. In 2009, the Centers for Disease Control and Prevention recommended that communities adopt complete streets policies to fight against obesity, as over 100 recent studies have shown a connection between obesity and automobile dependence. By providing more facilities for walking, biking, and active transportation, North Carolina is helping to combat a major public health crisis.

North Carolina is diverse in its geography, communities, land uses, and the needs and expectations of its people. It offers a quality of life that draws people to live here and encourages businesses to grow here. Our population reflects the importance of this quality of life as retirees, young workers, and families choose to stay in North Carolina or to come here from other places. As the state continues to grow, it must

Streets that were primarily designed for vehicular throughput can make it difficult to move about using other modes.

Complete streets provide for and encourage use by all users.

address the interconnection between transportation and economic development in a manner that maintains and enhances the quality of life that is paramount to the communities throughout this state. Serving our citizens, our businesses, and our communities will require the emphasis on viable transportation choices that are provided by complete streets.

For many years, the practice of street design was driven by functional considerations for motor vehicles, such as engineering criteria, cost, and user benefits. More recently, it has been recognized that while these represent legitimate reasons for pursuing street improvements, functional considerations must extend to all users of the street as well as the broad array of contextual factors that may affect a proposed street project. Understanding context is a critical element for designing a street that functions well in its surroundings. NCDOT recognizes that its complete street approach will help to better match streets with the many communities and contexts represented across the state.

As stewards of the state's transportation infrastructure, NCDOT is committed to providing an efficient transportation network, caring for the built environment by promoting sustainable development practices and working in partnership with local and regional government agencies, interest groups and the public to create a network of complete streets. There are many benefits of this complete streets approach including:

- Making it easier for travelers to get where they need to go;
- Providing for, and encouraging, the use of all modes of transportation;
- Increasing accessibility and mobility for the disabled, children, our aging population, and those without motor vehicles;
- Improving safety for pedestrians, cyclists, transit users, and motorists;
- Supporting public health goals by increasing opportunities for physical activity through active transportation;
- Building more sustainable communities;
- Increasing connectivity between neighborhoods, streets, commercial areas, and transit systems; and
- Adding value to communities and neighborhoods.

Complete streets provide a framework under which NCDOT and our local communities can use resources efficiently through a multimodal approach to providing infrastructure. This is an approach that serves more users. By creating efficiency in the use of the infrastructure we build and maintain, complete streets also serve to protect and enhance quality of life. Complete streets can assist with the creation of healthy communities that can sustain our generation, as well as the generations that follow ours.

Why is NCDOT Changing Its Approach?

North Carolina is a growing state, with a variety of communities and varying needs of its residents, businesses, and visitors. A common element amidst this diversity is that transportation provides an integral link between the quality of life and the economic development of the state. If we are to maintain and enhance the quality of life that encourages business to grow here, and people to want to live, work, and play here, NCDOT must change its approach to meet the needs of this growing, changing population and business environment.

NCDOT's complete streets guidelines also reflect the direction from the Board of Transportation's policy to engage in a collaborative process with cities, towns, and communities toward integrating pedestrian, bicyclist, and transit facilities and services into its total state transportation vision. The approach emphasizes NCDOT's partnership with localities in the planning, design, construction and maintenance of an interconnected, interdependent network of context-based streets that provide for all modes. This complete streets approach aligns with the U.S. Department of Transportation's (USDOT) 2010 policy statement for complete streets, which states that "Transportation programs and facilities should accommodate people of all ages and abilities, including people too young to drive, people who cannot drive, and people who choose not to drive." The policy also states that "The establishment of well-connected walking and bicycling networks is an important component for livable communities, and their design should be a part of Federal-aid project developments." Complete streets represent an efficient approach to providing these emerging networks across North Carolina.

Given this, complete streets are an investment in the future of North Carolina's communities and citizens through a commitment to creating sustainable transportation networks that support livable communities. Creating a network of complete streets provides choices beyond the automobile and allows citizens to walk, bike, and use transit, resulting in improved public health and livability. NCDOT's commitment to complete streets represents its ongoing commitment to providing a safe and functional street network by recognizing that complete streets provide those essential benefits to all users, including motorists, pedestrians, bicyclists, and transit users.

How Will NCDOT Implement Complete Streets?

Complete streets implementation actually began with the adoption of the Complete Streets Policy. With that adoption came the responsibility to plan and implement all future street projects to provide for the safe travel of all users, but also recognition that NCDOT's transportation divisions and districts, planners, and engineers need processes and guidelines to apply this new philosophy and approach.

The challenge that transportation planners and designers face is to balance the interests of each mode of travel when designing street projects. This approach recognizes that complete street designs are not “one size fits all.” If streets are to reflect their local and surrounding contexts, then a variety of street types are required, as well as the understanding that there are a variety of ways to provide for all users, depending on the context. Each street’s design should be tailored to the context of the area in which the street is located and should address the needs and desires of those living, working, and traveling on that street. Therefore, NCDOT’s planners, designers, and construction and maintenance engineers will consider and incorporate, through collaborative processes, multimodal solutions in the design and improvements of all transportation projects.

These planning and design guidelines represent a significant step towards implementing complete streets in planning, design, and construction activities undertaken by NCDOT and the jurisdictions with which they collaborate. The processes, street types, and recommendations included in the planning and design guidelines are intended to support the concept of collaboratively-designed and context-based complete streets. The purpose of the guidelines is to provide direction in the decision making and design processes to ensure that all users are considered during the planning, design, construction, funding, and operations of North Carolina’s transportation network. The philosophy of stronger partnerships in the provision of the network of streets to accommodate all users requires a change in the processes for incorporating multiple modes into both existing and future transportation improvement projects.

To that end, the long-range planning and project development processes described in Chapter 2 are intended to provide an approach for planning and designing complete streets to provide a multimodal transportation network that adds value to the community. This approach provides flexibility to apply complete streets that will reflect local input, existing and future context, and the overall street network. Chapter 3 describes the importance of understanding context and identifies various area types that reflect the diverse land use mixes and patterns found across North Carolina. Chapter 3 also includes a discussion about how to provide for quality of service for pedestrians, bicyclists, and transit users. Chapter 4 provides additional information about land use context, and also describes a variety of street types, cross-sections, and design elements for creating a network of complete streets. Intersections are the point at which two or more streets meet, and thus represent a point of opportunity and conflict for street users. Chapter 5 details principles for complete streets intersections, quality of service for all modes, and intersection design for different street types (main streets, parkways, boulevards and avenues). Chapter 6 outlines transit considerations with complete streets, including facility access, placement, and elements. Structures such as bridges and tunnels can provide key links within a transportation system; thus, Chapter 7 describes recommended design for complete streets facilities on bridges and underpasses. Chapter 8 describes various street elements within maintenance and operations projects, which constitute a large percentage of roadway projects that NCDOT implements each year. Finally, Chapter 9 covers design considerations for various elements including clear zones, super elevations, utilities and stormwater facilities.

How Will These Guidelines Be Implemented?

These guidelines are intended to provide comprehensive guidance for incorporating complete streets into everyday practice (including new construction, widening, modernization projects, and maintenance projects) so that North Carolina's streets increasingly support mobility for those using all travel modes. To accomplish this, these guidelines apply to all North Carolina's streets (not including freeways and interstates, which are not considered or treated as streets). These guidelines also apply to all processes and practices that affect those streets.

These guidelines are effective with the publication of this document. To facilitate implementation of the guidelines, the following is provided:

1. Beginning as early in a new project or TIP request as practical, a collaborative process between NCDOT and the local government will be initiated to evaluate existing and future context and purpose of the street and determine how to make it safe and accessible for all users. This collaborative process (discussed further in Chapter 2), should provide maximum opportunities for project collaboration and project scope development.
2. Existing projects that have not progressed to the "design public hearing stage" are to follow the same collaborative process as new projects to identify and determine the feasibility of appropriate complete street designs and the revised project scope, cost, and project schedule, if applicable.
3. For operations and maintenance work by NCDOT, local governments are encouraged to review and comment on upcoming resurfacing projects and other project lists for the opportunities to recommend complete streets features. When requested and determined by the Division Engineer to be feasible within the scope and budget for the project, such features will be considered for inclusion. If it is not feasible to include these features due to scope, funding, timing or other reasons, the features may need to be considered as a new or future project request.
4. NCDOT will partner with local governments in the development of local transportation visions. Local transportation visions, adopted policies and plans should promote and identify projects that work toward an interconnected network of context sensitive and multimodal complete streets. NCDOT will collaborate with the local area to develop projects that strive toward achieving the purposes of the Complete Streets Policy.

The guidelines provide a bridge between the adopted policy and the broad variety of policies, manuals, and practices currently used for planning, designing, constructing, and managing North Carolina's streets. (As this guidance evolves into standard principles and practices within NCDOT, current policy and guidelines will be reviewed and updated over time.) In the meantime, where existing policy and guidance conflicts with the Complete Streets Planning and Design Guidelines, NCDOT should be flexible and collaborate with local government to reach an agreeable solution that safely and efficiently provides the various travel components of complete streets.

What Will These Changes Mean for Communities and Stakeholders Across the State?

NCDOT recognizes that streets contribute to the mobility, quality of life, and the economic vitality of our communities. Therefore, NCDOT will be seeking the active support of, and collaborative involvement from, local communities, citizens, and stakeholders in planning, designing, and implementing streets that provide safe and comfortable access to all users. Crucial to the success of complete streets will be the stronger partnerships forged between NCDOT and local jurisdictions, Metropolitan Planning Organizations (MPOs), Rural Planning Organizations (RPOs), transit agencies, and other agencies and stakeholders across the state.

The process described in these guidelines provides many opportunities for community and stakeholder involvement in the decision making process. Local direction should initially be provided through discussion with local staff regarding the community's plans and policies. As described in the following chapter, community representatives' and stakeholders' ideas and thoughts will be further sought at appropriate milestones as projects are planned and designed. Planning and designing complete streets requires an understanding of the local area's vision for land use and transportation in order to plan ahead for the transportation system instead of reacting to change in potential needs of the transportation users.

Ultimately, these changes mean that NCDOT will work in partnership with communities to provide a network of complete streets throughout the state—streets that reflect the communities and contexts they serve, and that allow the state and those communities to safely and efficiently meet the mobility needs of current and future North Carolinians, whether they are driving, using transit, walking, or bicycling.

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2: Incorporating Complete Streets in the Planning Process

North Carolina's transportation planning, design, construction, and maintenance processes will change as NCDOT's approach to street design shifts to an emphasis on providing a safe network of facilities to accommodate access and travel for all users. The intent of these guidelines is to establish a collaborative process with cities, towns, and communities for designing complete street networks that are in harmony with the context of the diverse communities throughout North Carolina.

The type of land uses adjacent to the street will have a primary effect on the street design. Three broad categories of land use types (described further in Chapter 3) exist within North Carolina: urban, suburban, and rural. It is also important to consider the transitions between these types. To create context-based complete streets, the adjacent land use context needs to be integrated with the street function so that each street contains appropriate elements to address the needs of existing and future land uses. Several different street types are identified and addressed in this document: main street, avenue, boulevard, parkway, and rural road. Information provided in the guidance will help planners, designers, and others match the land use area and sub-area type with the street type to create streets that address the needs and desires of those living, working, or traveling on the street.

The challenge that transportation planners and designers face is to balance the interests of each mode of travel. To do so, our processes must be collaborative, involving Metropolitan Planning Organizations (MPOs), Rural Planning Organizations (RPOs), advocacy groups and local communities in the consideration and incorporation of all modes in the design and improvements of all streets. The purpose of this chapter is to provide guidance on the process for planners, designers, construction and maintenance engineers to follow in integrating complete streets into the decision making process.

This chapter outlines the project development process from the earliest phases of project definition through final design and construction. The Complete Street Planning and Design Guidelines will be integrated into other NCDOT planning processes, including the North Carolina Statewide Long Range Transportation Plan (2040 Plan), Program and Resource Plan, State Transportation Improvement Program (STIP), Five Year Work Program, Comprehensive Transportation Plan (CTP), the Long-Range Transportation Plan (LRTP) and other plans including local land use plans, small area plans, comprehensive bicycle and pedestrian plans, regional bicycle plans, county, urban, and regional bicycle routes and maps and greenway plans. It is NCDOT's intent for these planning processes and documents to use the complete street types described in Chapter 4, so that accommodation of all users continues to be integrated into each of these existing processes.

Transportation Planning Process

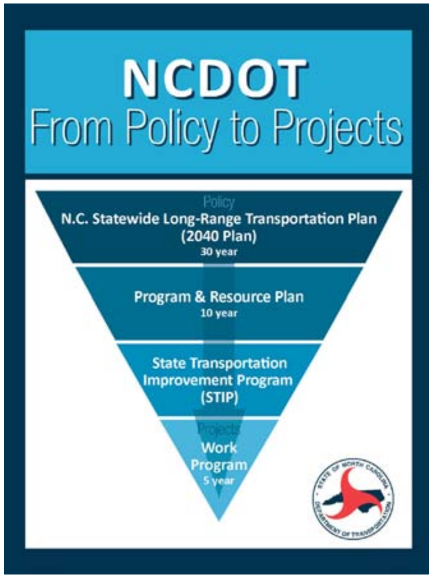
Transportation planning as a process in North Carolina generally includes elements/plans that are driven internally by NCDOT in collaboration with MPOs and RPOs (as shown in Figure 1), and elements/plans that are driven by MPOs or RPOs, in collaboration with NCDOT (as shown in Figure 1A). For example, the NCDOT defines its transportation policies and priorities in the North Carolina Transportation Plan (2040 Plan). For MPOs, on the other hand, the planning process begins with the Comprehensive Transportation Plan (CTP), which should reflect local priorities and policies. These overarching processes converge as identified projects in the State Transportation Improvement Program (STIP). All are completed under the umbrella of Federal requirements that apply to state departments of transportation and local or regional entities. The following sections describe the purpose and content of each of these documents, as well as the inter-relationship between them, whether state, regional or local. Planning for Complete Streets should begin as a project is included in each of these documents.

North Carolina Transportation Plan (2040 Plan)

The North Carolina Transportation Plan is a 30 year document that defines the mission and goals of the NCDOT and sets out key objectives and strategies to achieve them. These elements guide decision making, including investment decisions. The plan outlines the resources needed to support the Program and Resource Plan and sets forth an investment strategy that embraces all modes. This plan is developed by transportation professionals at NCDOT with input from regional and local bodies, based on significant public input. The plan undergoes a complete revision every eight years, with data updates every four years.

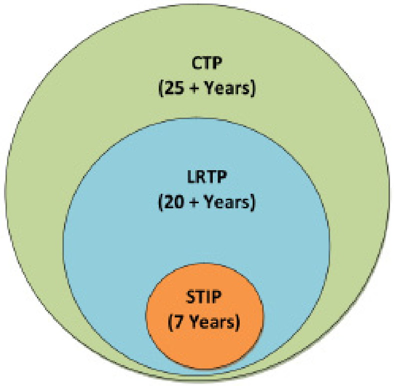
The existing North Carolina Transportation Plan (also known as The Statewide Plan) was last updated in 2004. In 2010, NCDOT began a major update called the "2040 Plan." The 2040 Plan (and subsequent Statewide Plan updates) is intended to reflect changes that have occurred since the previous Statewide Plan in terms of broad economic and social developments, internal governance and program delivery mechanisms, and changes in the State's goals for mobility, growing the multi-modal network, and freight logistics. It is being developed with broad input from Metropolitan and Rural Planning Organizations (MPOs, RPOs) local governments and other stakeholders. The 2040 Plan and subsequent updates will include complete streets as a priority for future project and program planning, in order to ensure that all streets are planned and constructed to support safety and mobility for all users.

Figure 1: From Policy to Projects



Comprehensive Transportation Plan and Long Range Transportation Plan

Figure 1A: Transportation Planning Process



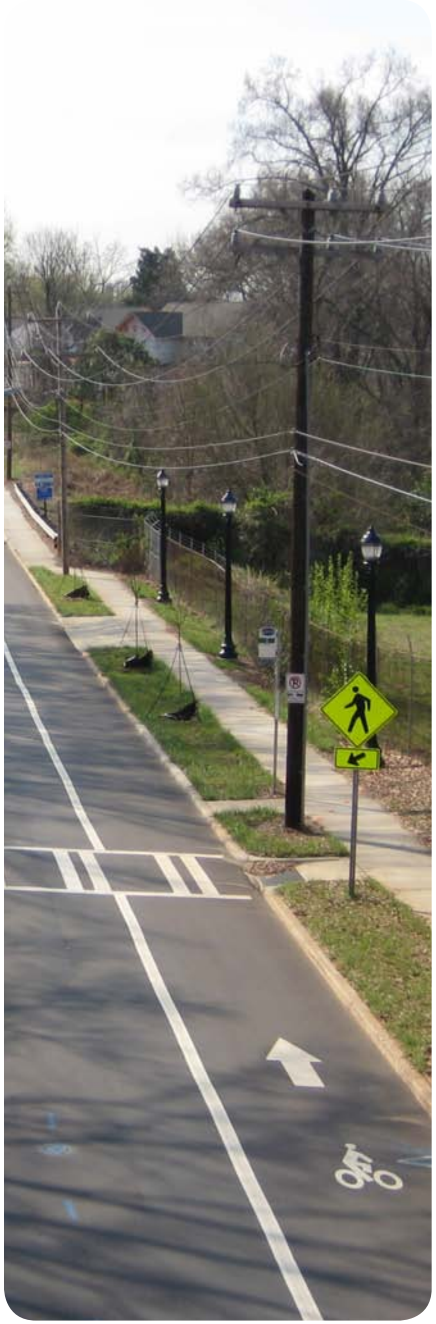
Long range transportation planning identifies anticipated deficiencies and needs for a 25-50 year time frame. It is a collaborative process with MPOs and local governments working in partnership with NCDOT. As shown in Figure 1A, the Comprehensive Transportation Plan (CTP) lays the very long-range vision for the transportation system with specific consideration given to multimodal facilities and is developed to reflect the community's land use vision and context. The CTP essentially serves as an "inventory" of potential projects that could be used to address network deficiencies for motorists, pedestrians, bicyclists, and/or transit users and inter-city rail service.

The CTP consists of maps and a report that provides additional information about the potential projects shown on the maps. The maps for the CTP are mutually adopted by the MPO/RPO and NCDOT. During development and prior to adoption of the CTP, NCDOT will work with the MPO/RPO to ensure that the CTP considers statewide and regional objectives and strategies that have been identified in the North Carolina Transportation Plan. MPOs and RPOs should work with NCDOT to ensure that their CTP promotes their community's vision for complete streets, both through the maps, the accompanying report development, and through the formation of problem statements to be included as part of the report. The problem statement helps to bridge the gap between undefined projects and the eventually-defined projects and their federally-required purpose and need statements.

For MPOs, the long range transportation plan (LRTP), as required by Federal law, should address at least a 20 year timeframe and must be financially-constrained as well as meeting other Federal planning requirements. As such, it serves as a "subset" of the CTP, where specific projects are first defined. RPOs do not have an LRTP and the STIP (described below) serves as their plan. Unlike the CTP, the LRTP should only include projects that are feasible or buildable from an environmental, engineering, and cost/benefit perspective. It is important to recognize that while a project may not be financially feasible within the LRTP timeframe, it may be needed to handle travel demand within the longer timeframe of the CTP. Due to continued development, demands on the transportation system are growing more rapidly than improvements to the transportation infrastructure. During CTP updates it is critical that elements of the CTP beyond the timeframe of the LRTP are reexamined to ensure they are still needed based on either projected travel demand or deficiencies as complete streets. MPOs rank identified projects from their financially-constrained LRTPs and submit them into the prioritization process for inclusion in the STIP.

Program and Resource Plan

The Program and Resource Plan is a 10 year plan that addresses both transportation needs, as identified through the North Carolina Transportation Plan, the CTPs, and LRTPs, and fiscal constraints. The plan is based on a process called "Strategic Prioritization," which enables NCDOT to apply limited transportation resources to the projects that will best meet the NCDOT's mission and goals in a data-driven and transparent way. Under Prioritization, professional staff from NCDOT, regional MPOs, and RPOs prioritize their transportation needs. Those needs



are categorized by the three goals of safety, mobility and infrastructure health, and then ranked based on objective criteria such as crash data, congestion levels, pavement and bridge conditions, etc. Moving forward, these goals and criteria will be expanded to ensure that the concepts of safety, mobility, and infrastructure health extend to all users and that projects are envisioned as complete streets. The result of the prioritization process is a list of North Carolina's transportation needs, unconstrained by fiscal or other considerations. The document also identifies 10-year performance targets for the goals of safety, mobility, and infrastructure health. A technical analysis shows how various investment mixes will yield differing outcomes in meeting the goals.

The Program and Resource Plan also includes a "cash-constrained" 10 year budget for the Department. It is based on forecasted expenditures, revenues (state and federal), cash balances and includes trend analyses of revenues, commitments, reimbursements, payout rates, etc.

A critical step in the Program and Resource Plan is the convergence of the strategic prioritization outputs and the cash-constrained 10 year budget to the previously unconstrained needs list. NCDOT applies funding levels and additional constraints such as eligibility, equity, etc. The outcome is a 10-year plan (the "Project List") that shows the prioritized projects and programs NCDOT plans to carry out with the projected available funds to achieve defined performance targets. It should be emphasized that the 10-year Program and Resource Plan is a fluid document that is based on projections that will change, especially in the latter years.

Five Year Work Program

The Work Program derives from the Program and Resource Plan. It contains both program and project-level information. The Work Program is an accounting of the state's annual transportation program grouped by five categories:

- Construction & Engineering
- Maintenance
- Operations
- Administration
- Transfers

The Work Program is NCDOT's commitment to the projects we plan to build and the services we plan to offer over the next five years. Work Program projects are found in the first five years of the (10 year) Project List. The Five Year Work Program is produced and reviewed by the Board of Transportation every year. The first two years of the Work Program are aligned with the biennial budget cycle.

State Transportation Improvement Program (STIP)

The state also publishes the State Transportation Improvement Program (STIP), which is a 7 year subset of the (10 year) Project List included in the Program and Resource Plan and is required under federal and state law. The STIP describes the projects to be programmed during the upcoming 7 years (note that NCDOT reviews the draft STIP annually and publishes the STIP every two years). The project list in this strategic planning document also includes smaller projects, called division-managed construction projects. Moving forward, the STIP will increasingly incorporate complete streets, as MPOs, RPOs, and NCDOT continue to identify and prioritize projects based on their ability to serve all users, while meeting the other broad goals described in the North Carolina Transportation Plan.

Project Development Process

Once a project is defined and prioritized through the planning and programming processes described above, it moves into the project development process which will ultimately result in a specific street design to be constructed. As with the CTP and LRTP, the project development process will also incorporate complete streets concepts and designs. The project development process begins in NCDOT's Project Development and Environmental Analysis (PDEA) Branch. PDEA leads the formation of a National Environmental Policy Act (NEPA) document. The NEPA process consists of an evaluation of the environmental effects of a federal undertaking (in this case, a street or roadway project), including its alternatives. The NEPA document makes a definitive recommendation as to how motor vehicle, bicycle, pedestrian, and transit use is to be accommodated (i.e., number of lanes, separate bike lanes, multi-use paths, sidewalk width, transit shelter locations).

The NEPA process requires a "purpose and need statement" for each project. As the foundation for subsequent decision making, the development of the purpose and need chapter of the NEPA document should consider all modes of travel. It should focus not only on the traditional aspects of safety and capacity for motor vehicular traffic, but rather on the safe movement of people. During the project development process, the CTP and LRTP vision should be referenced to ensure consistency and that the appropriate and necessary multimodal facilities are considered throughout the planning process. For example, moving forward (and as CTPs increasingly reflect complete streets), the problem statements developed as part of the CTP can serve to help define the purpose and need statement for projects going through the project development process.

The following section describes how localities, MPOs/RPOs, and others will work with NCDOT through project development. The project development process entails a series of steps (shown in Figure 2) to collaboratively define the ultimate design for a street. This process is compatible with and enhances the NEPA process, particularly the intent to carefully consider alternatives and select the appropriate design. The key to the process is to evaluate the existing and future context and users of a street, examine potential alternatives, and select the design that will make the facility safe, functional, and accessible for all users.

Because complete streets are not a "one size fits all" design, the selected solution will depend on the surrounding context, goals and objectives defined by project stakeholders, as well as careful analysis of tradeoffs of different solutions. The intent is to design the best complete street for a given context. The questions that are asked in each step of the process have been transformed into a checklist that should be revisited throughout the planning process (the checklist is included in the Appendix).

Formation of the Design Input Team

The recommended project development process begins with formation of a design input team that meets throughout the life of the project to ensure that all users are considered on a facility. This design input team should include both internal and external team members. Internal members may include the NCDOT Roadway Design Project Engineer, Division Construction Engineer, and a PDEA Group Supervisor, with a number of NCDOT Branches and Units, including Transportation Planning Branch (TPB), PDEA, Pre-Construction, Bicycle and Pedestrian Division, Public Transportation, Transportation Mobility and Safety, and the Program Development Branch. Some members may play more critical roles at different stages over the life of a project. For example, a member of TPB would be invited to participate in the early phase of project planning, but would typically not be involved through final design and right-of-way acquisition. External members should include city or county jurisdiction staff and MPO or RPO representatives.

Figure 2: Project Development Process

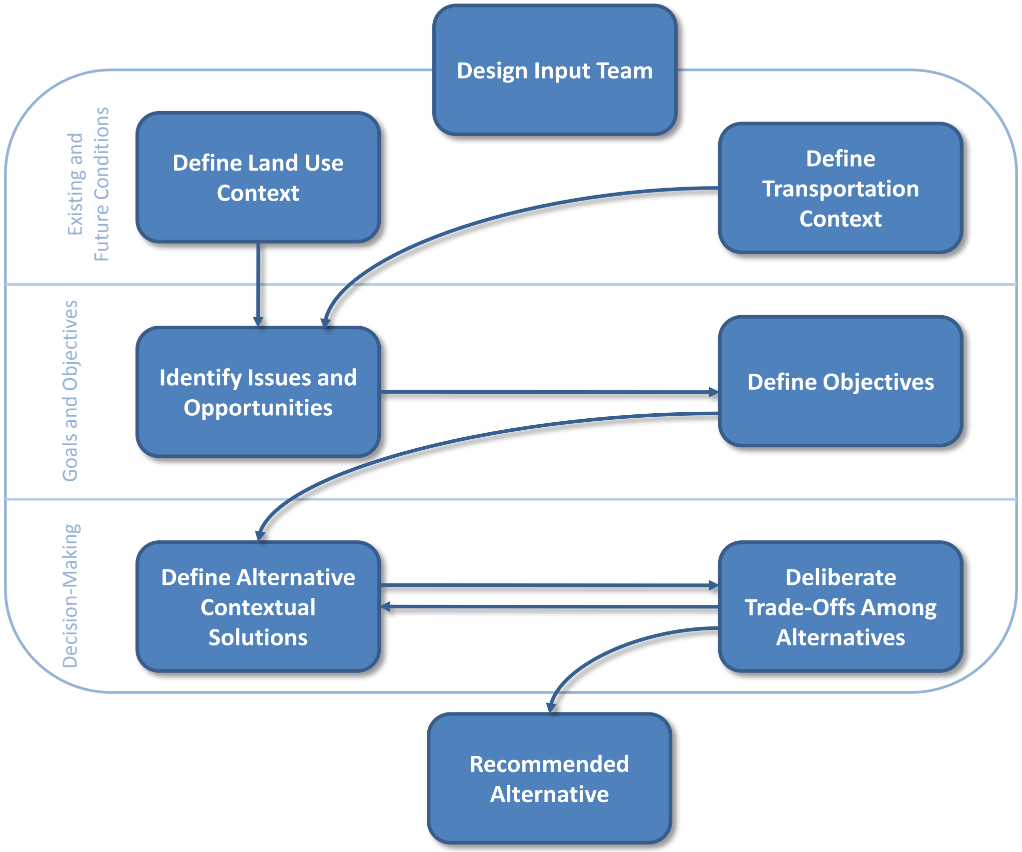
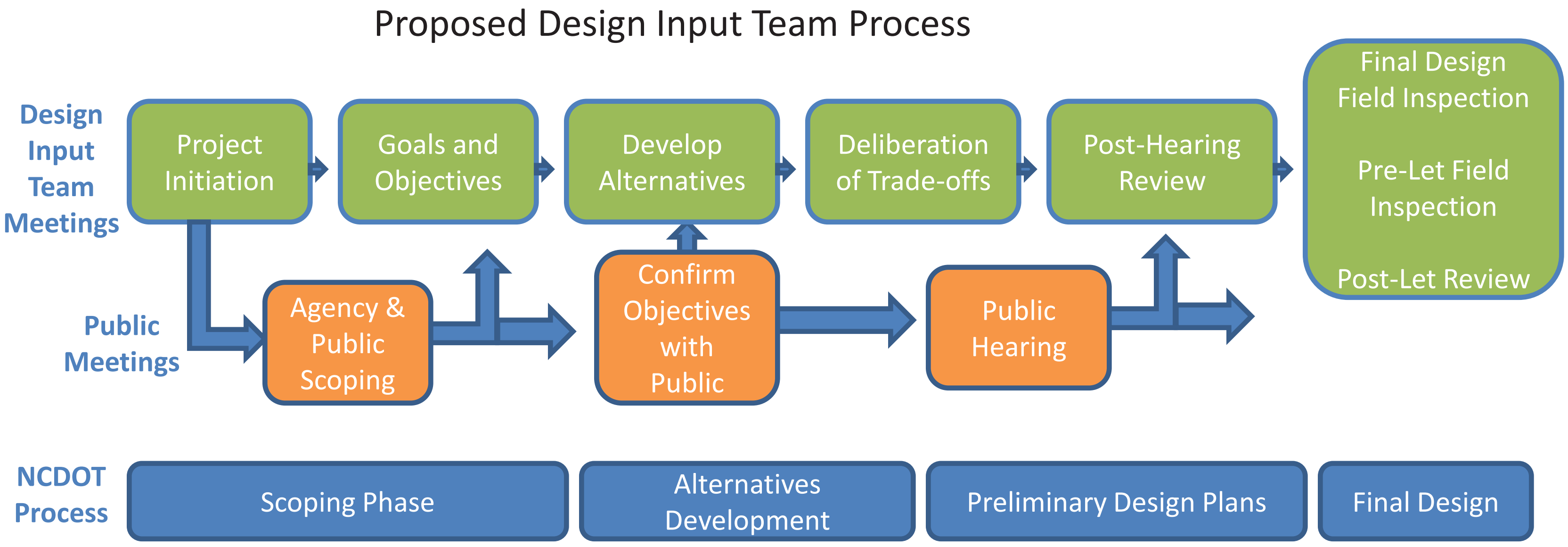


Figure 3: Relationship Between Project Development Process and Milestones



The key with the design input team is to bridge the project definition phase (CTP and LRTP) with the project development phase. The design input team begins meeting at the start of the project (after the project moves to PDEA). The design input team carries out the steps outlined in Figure 2, and also meets at the key milestones identified in Figure 3. The steps in Figure 2 are described in the following sections.

Evaluation of Existing and Future Conditions

With all stakeholders at the table as a team, the initial steps for evaluating existing and future conditions involves defining the land use context and the transportation context. This initial meeting of the design input team should take place in conjunction with the project initiation meeting. The land use context assesses the existing and future land use along a corridor. It is important to note that the land use context may vary along the same corridor; it may be urban on one end and rural on the other, and different street solutions for the same corridor may be appropriate. In any case, it is critical that the context be considered both in terms of the areas adjacent to the street, and the broader context beyond the street and corridor.

Define Land Use Context

The following are questions to consider in defining the existing and future land use context:

Existing Conditions:

- Is this an urban area, a rural area, or an area of transition (urban to rural or rural to urban)?
- What is the jurisdiction land use and zoning for the area?
- What is the existing land use mix and density?
- What are the typical building types, their scale, setbacks, urban design characteristics, relation to the street?

Future conditions:

- Are there any development pressures on the area? What is the nature of the emerging land use context?
- What is the jurisdiction's future land use vision (as identified in a comprehensive plan, corridor plan, policies, or other sources)?
- Does the adopted plan(s) make specific recommendations regarding density, setbacks, urban design, etc. through the project area?

Define Transportation Context

The team will also discuss the existing and future transportation context for both the surrounding street/roadway network and the street itself. These questions will require research and study of all documented plans and policies affecting the street. It will be a collaborative discussion among stakeholders to assess what the street looks like today (or what the area looks and feels like if this is a new street), and an assessment of plans and policies for the future corridor. The discussion should address the following:

Existing Conditions:

- What is the character of the street? What does the area look and feel like?
- How does the street currently function? What are the daily and hourly traffic volumes? Operating and posted speeds?
- How does this corridor function within the larger transportation network?
- What design features and accommodations for bicyclists, pedestrians, and transit users are included on the corridor (number of lanes, sidewalk availability, bicycle facilities, transit service and stops, traffic control, etc.)?
- What is the existing quality of service (safety and accessibility) for each mode? What is the general crash history for motorists, bicyclists, and pedestrians (are there any specific safety issues to be addressed)?

Future Conditions:

- What are the projected traffic volumes along the corridor?
- What trip generators (existing and future) are in the vicinity of the proposed project that might affect travel patterns and connections in and around the corridor?
- What are the locally adopted multimodal plans or policies affecting bicycle, pedestrian, or transit use?
- Are there any planned transportation projects in the larger area that would affect the street segment?

Chapter 3 provides detailed descriptions of urban, suburban, and rural area types that can help to define the existing and future land use and transportation contexts. The design input team should reference and note these area types during this phase in the process and as they discuss goals and objectives for the project.

Establish Goals and Objectives

Once the broader land use context and transportation context are evaluated and agreed upon as a team, the goals and objectives for the project can be defined at a second meeting of the design input team. This phase includes analysis of the project issues and opportunities and definition of the objectives, both of which are conducted at the time of scoping. Public feedback is gathered during this phase through separate citizens' information workshops. The purpose of the workshops is to solidify the vision for the project and confirm the assumptions moving forward.

Identify Issues and Opportunities

This step in the process takes all of the observations about the past and present function of the corridor together to define issues and opportunities. The team should evaluate:

- What are the deficiencies/problems with the street today?
    - Are there gaps in the bicycle or pedestrian network near or along the street?
    - Are there gaps in the overall street network (connectivity, capacity, etc.)?
    - Are there inconsistencies between the amount or type of transit service provided along the street and the types of facilities and/or land uses adjacent to the street?
- What are the key opportunities with this project (i.e. a tool for economic development or improved community health, a missing link in the bicycle, pedestrian, or vehicular system, improving the level or quality of service for a particular mode, etc.)?

Define Objectives

The assessment of issues and opportunities leads to the definition of the objectives for the project, with the surrounding context as a basis for decision making. The design input team should evaluate:

- How do the local government, community, and all users want the street and neighborhood to change, if at all?
- What are the existing functions that need to remain in place?
- How can those functions be balanced with new users of the street?
- How would this project increase the connectivity of the larger network?
- How would this project improve the mobility and safety of all potential users of the street?
- How would this project meet the needs of the community?

Public input is important in ensuring that important objectives are not overlooked and are verified, and that all transportation and environmental concerns are addressed as the project moves forward. This is particularly critical if major changes have taken place with the project planning or substantial time has elapsed.

Decision making

Once the framework for the project is devised by defining the issues, opportunities, goals, and objectives, the design input team is ready to focus on developing alternative design solutions at the third meeting, evaluating those alternatives, and moving towards the recommended design. \

Develop Alternatives

The development of alternatives occurs after initial public outreach and prior to the preparation of preliminary design plans and public hearings. This step should rely on the street typologies included in Chapter 4 to help determine the range of solutions. Each street type defines a zone for every street component. Flexibility is built into the street cross-sections in terms of width of these zones (green zone, motor vehicle travel zone, median zone). Some alternatives may include the same street zones but differ in their dimensions. The design input team should ask:

- How will the proposed project accommodate existing and planned bicycle, pedestrian, and transit facilities?
- What modes does each alternative scenario serve and how?
- How do the alternatives fit within the land use and transportation context and defined objectives?
- How will the alternative scenarios under consideration meet the needs of stakeholders?

Deliberate Tradeoffs

All of the scenarios identified should be tested against the land use and transportation context and the objectives for the project to determine any inconsistencies or constraints. The solutions within various alternative scenarios will likely vary by cost, right-of-way needs and/or how various modes are accommodated. This requires an evaluation and description of tradeoffs prior to selection of the recommended alternative. This evaluation and description of tradeoffs is a necessary part of the NEPA process and should occur prior to publication of the NEPA document, with input gathered at a public hearing. During this phase, the preliminary design plans are under development which allows for comparison of tradeoffs in street cross-sections, right-of-way needs, ability of the alternatives to meet the identified objectives, etc. At the end of this process, the reasons behind the selected cross-section should be transparent and understood. Items to be considered include, but are not limited to:

- Consistency with local context, land use and transportation plans and policies, and project objectives, as defined through this process;
- Balanced modal capability (to achieve functionality for all users);
- Accessibility to achieve functionality for all users;
- Right-of-way availability;
- Environmental (natural and human) considerations; and
- Overall cost.

Recommended Alternative

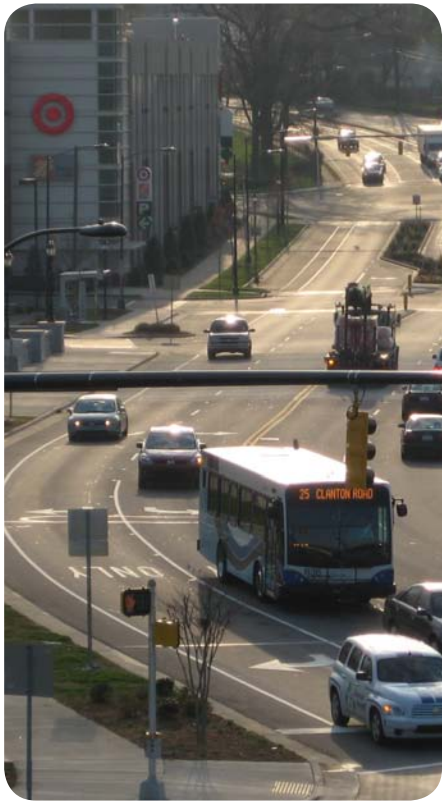
Once tradeoffs have been evaluated and described among alternatives, the team will come to a recommended alternative. The recommended alternative should reflect the ultimate design for the project with specific design features and dimensions.

The design input team should continue meeting beyond the public hearing and definition of a recommended alternative to ensure that the proposed improvements are incorporated into final design and construction. Specific meetings for design input team follow-up include a post-hearing meeting, a final design field inspection, a pre-let field inspection, and a post-let review. At the pre-let field inspection, the team will review the contract documents before a contractor bids on the project. A checklist that summarizes all of these steps is included in Appendix A of these guidelines.

It is important to note that the intent of the project development process outlined in this chapter could apply to other types of NCDOT projects, such as resurfacing or bridge projects, to ensure that treatments for all users are considered. The key is to help streamline and assist in the decision making process and to foster collaboration with stakeholders early in the process.

This chapter has explained that complete streets will be integrated into the long-range planning, programming, and project development processes. The current approach to planning is based on traditional functional classification of streets. This approach recognizes functional classifications for streets that address function for all users of the street network. The approach also focuses on the existing and future land use and transportation contexts, and agreed-upon goals and objectives for the street. This approach will be based on identification of area types and street types as defined in Chapters 3 and 4.

3: Understanding Context and Designing for All Users



Context Factors

Planning and designing complete streets requires a fundamentally different design approach and philosophy. It requires both an understanding of the existing and future land use and transportation contexts, and an understanding of how different design treatments affect peoples' ability to safely and comfortably use the street, whether on foot, bike, or by transit. Designing streets requires that those concepts be considered integral to the design from the beginning, rather than as "additional" or "special" design elements simply added onto a more traditional highway design. This context-based approach recognizes that complete streets are not "one size fits all" and ensures the most efficient, inclusive, and appropriate application of complete streets designs on a wide variety of streets.

As described in Chapter 2, one of the first steps when developing complete streets is evaluating the existing and future land use and transportation contexts. Done properly, land use should never be considered in isolation, nor should the transportation solution be developed without a full understanding of the uses of surrounding land, both existing and future.

This chapter describes urban, suburban, and rural area types that reflect the diverse land use mixes and patterns found across North Carolina. While "streets" are more typical to cities, suburbs, and towns than to rural areas, it is important to recognize the need to provide design recommendations for rural areas as well. This chapter also discusses quality of service levels by various modes of travel. Quality of service emphasizes that street designs affect the functionality of the street for each mode, including those other than the automobile. Designing complete streets requires moving away from a highway-oriented emphasis to balancing motorist level of service with the quality of service for other users.

Designing complete streets requires both an understanding of the future and existing land use and transportation contexts, and an understanding of how different design treatments affect peoples' ability to safely and comfortably use the street.

Understanding the Built Environment and Street Type

The design of a practical, functioning street depends on a clear understanding of the application of the context-based approach in designing complete streets in a particular setting. Once the context for an area is understood, the function of each street can be established and design parameters can be selected to achieve a balance between land use and street design.

This relationship between land use and street design also affects the character of the street. Character is reflected not only in the travel lanes but also in the overall dimensions and design treatments from building face to building face along the street. Character is also reflected in the space between a building's edge, a street tree, or a parked car. This aspect of character is influenced by the location and quality of street elements. Also, character can be defined by its surface qualities. The manner in which the elements are applied to streets creates its formal character and consists of qualities such as the shape, material, colors, textures, pattern, and compilation of the street elements.

Typical street elements may include street furniture, medians, lighting, landscaping, street trees, signage, parking, pavement markings, and paving material. These elements not only provide function, but contribute to the character of the street.

The character of a street is defined by both land use and street design.

Area Types

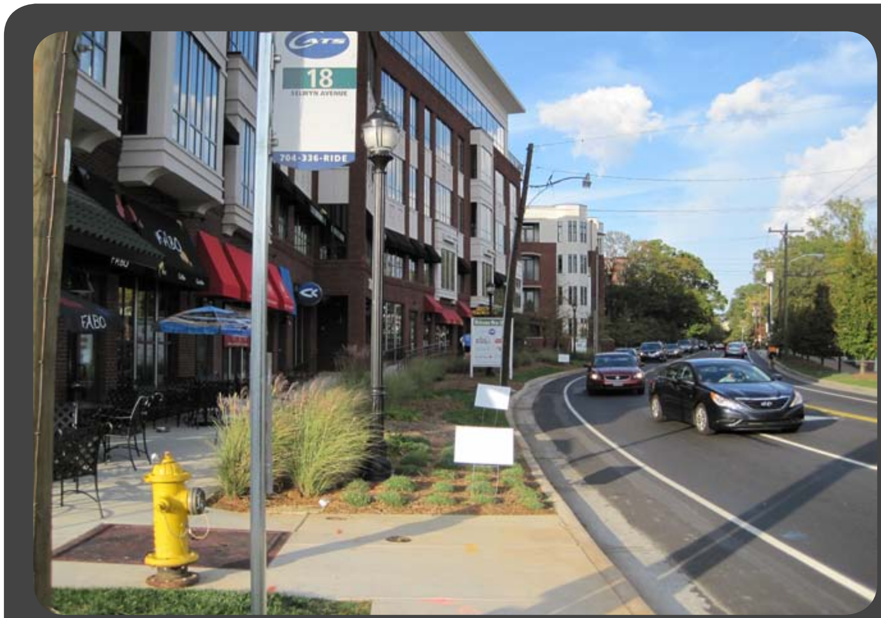
Within North Carolina, three broad categories of land use types exist: urban, suburban, and rural. These categories can be further divided into nine sub-area types (three in each area) to aid in more specifically identifying the context of the area through which a transportation facility passes. These nine sub-areas are described further in the following sections. While the current land use context may be readily apparent, land use and transportation plans and policies for the area must be reviewed to determine anticipated changes over time. As described previously, this review is a collaborative process that incorporates local areas' land use information in the project development process. In the review of these plans, one should consider whether the area is transitioning from a rural area to a suburban one or from a suburban area to an urban one. Generally speaking, the urban, suburban, and town contexts represent the greatest need for street designs to be treated distinctly different from highway designs. Chapter 2 describes the project development process and series of steps to follow to help create a shared solution for the transportation facility.

Urban Area Types

Urban areas usually represent a heavy mix of commercial, residential, and civic activity for a region. Development is typically most intense in terms of the density and the mix of uses. Within urban areas, the intensity of land use often decreases with the distance from the urban core. Open areas exist but are generally limited to parks, school playgrounds, or large lawns or wooded areas associated with institutional sites. Common elements include a high level of pedestrian interaction, as many buildings front directly onto a sidewalk. There is transit availability, bicycle activity, and grid or modified grid street patterns. In general, urban areas are experiencing renewed growth in residential and mixed-use activities, thus requiring greater attention to accommodating all modes of transportation. In the following section urban areas are divided into central business district, urban center, and urban residential sub-areas.

Central Business District

Central business districts are the most intensely developed area of a city. As the “downtown” or employment center of an urban area, development is typically commercial or mixed-use and vertically dense. Right of way may be constrained by existing adjacent land uses. Driveway access to parking and commercial uses may be frequent. Building setbacks are normally uniform and close to the street. On-street parking is common, but employment centers and large destinations are typically served by structured parking. Pedestrian, bicycle, and transit activity is nearly always present and of substantial volume. A network of streets, sidewalks, pedestrian and bicycle routes that link dense development is usually found, and the transportation system is dependent upon this network of modes. Transit centers where multiple bus routes converge are often present. Rail stations and intermodal facilities may also exist. Central business districts can range in size, depending on the overall size of the community.



Urban Center

Urban centers are areas that are developed at moderate to high levels of intensity, including areas outside the central business district in larger cities and the downtowns of small to mid-sized municipalities. The urban center will typically contain a mix of land uses, including commercial and institutional uses that support neighborhoods within its vicinity. Typical commercial uses may include grocery and drug stores, department stores, restaurants, and movie theaters. Institutional uses such as schools, libraries, and post offices may be found in these areas. Professional or medical offices are common. Building lot sizes will vary, but are usually relatively narrow. Buildings traditionally have a common setback relatively close to the street. Access points are limited through the consolidation of driveways. Land uses may be mixed vertically and horizontally. Urban centers vary in size. The transportation network should allow for access to the center by a variety of modes, as well as provide for high levels of connectivity within the center, particularly for pedestrians, cyclists, and transit (where appropriate). This can allow urban centers to develop into “park once” destinations.

Urban Residential

Urban residential districts typically consist of single-family residential developments at a common scale and setback from the street, often interspersed with multi-family development such as duplexes and quad-plexes. Larger multi-family buildings, such as apartments or condo buildings, may also be present. Sidewalks are usually present and on-street parking is common. Access points may be limited through the consolidation of driveways, though shared driveways may be less frequent in single-family residential areas. Off-street parking is common for single-family houses and duplexes, with parking lots provided for larger multi-family buildings. High levels of pedestrian, bicycle, and transit activity are usually found in these areas.

Suburban Area Types

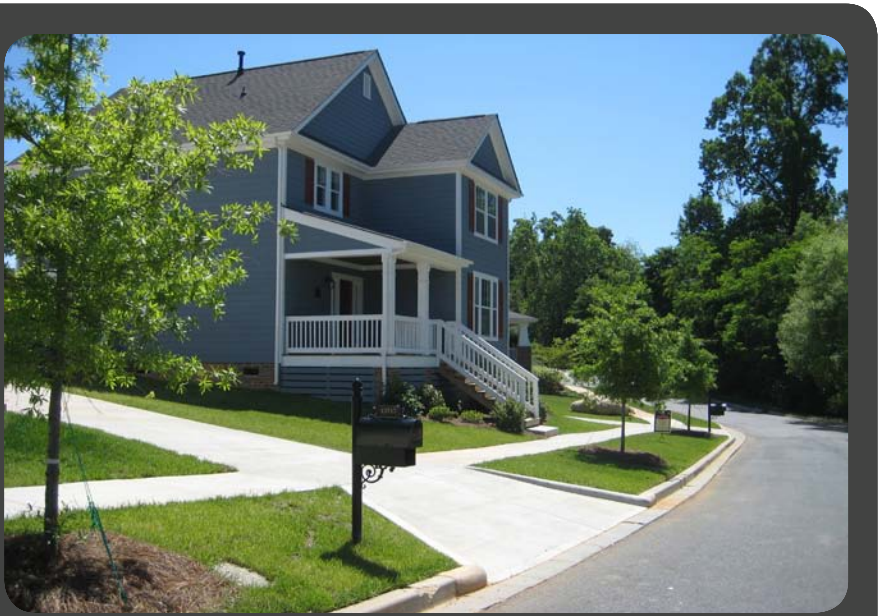
Suburban areas are usually found at the periphery of an urbanized area and are characterized by pockets of development that are often disconnected and contain structures that are generally consistent in height and aesthetics. Suburban areas can vary widely in character, appearing more rural in areas further removed from the metropolitan core and more urban in areas with denser populations and development. Suburban areas offer different challenges than urban areas, but also present opportunities (and the need) for providing more streets and street networks, as well as more complete street designs. Suburban areas are divided into suburban center, suburban corridor, and suburban residential.

Suburban Center

The suburban center is distinguished from the suburban corridor due to its (typically) higher density, greater mix of uses, and nodal form. Suburban centers are characterized by concentrations of commercial and residential uses. The commercial uses are usually grouped together and are notable for a uniform building setback. Residential development in this area is often a mix of single family and multi-family units. Residential development often defines the edge of a suburban center, with areas of predominantly residential development patterns punctuated by non-residential centers at key points along main roads. Pedestrian and bicycle activity are highest nearby or in the suburban center and sidewalks are usually present. Access points will vary from numerous driveways to shared access points. On-street parking is common in these areas, but surface parking lots are predominant. The transportation network should allow for access to the center by a variety of modes, as well as provide for high levels of connectivity within the center, particularly for pedestrians, bicyclists, and transit (where appropriate). This can allow suburban centers to develop into a “park once” destination, even when accessed by car.

Suburban Corridor

Suburban corridors are characterized by auto-oriented development. The development pattern is typically linear and may span for miles along the same street, containing numerous commercial and retail destinations along with medium- to high-density residential development located adjacent to (or very nearby) commercial properties, perhaps along perpendicular residential streets. The residential and non-residential developments are, however, usually disconnected (i.e., they lack direct access between the two). Bicycle and pedestrian facilities are often present, but the volume of these users is typically lower than in suburban centers. Transit services are often present in the suburban corridor. The auto-oriented network typical to the suburban corridor presents the need to provide more and better streets—streets that allow for better access for bicyclists, pedestrians, and transit users.



Suburban Residential

Generally located on the outermost periphery of an urbanized area, suburban residential areas have transitioned from rural developed but remain a mix of developed, undeveloped, and natural areas. Development pockets are typically segregated, disjointed, and are predominantly residential (low to moderate density) with intermittent, isolated commercial and other non-residential properties between. Building setbacks may be deeper than in urban areas. Internal streets in these suburban areas typically carry a lower volume of vehicular traffic (though streets connecting subdivisions often carry very high volumes due to lack of connectivity in the street network) and contain a mixture of direct driveway access, subdivision street access and public street intersections. Pedestrian and bicycle activity in these areas is higher than in rural areas, and public transit service is occasionally encountered.

Rural Area Types

Rural areas are characterized by natural areas, agricultural uses, and limited development, except in towns, villages, or crossroads. Rural areas are distinguished from other area types by their separation from other developed areas and by an intent or desire of residents to retain the natural or rural character of the area in the future. The rural area type can be subdivided into three different sub-areas: rural village, rural developed, and countryside.

Rural Developed

Rural developed areas are characterized by scattered, very low-density development. The development is primarily residential with occasional other uses. Rural developed areas may include a limited number of residential subdivisions or isolated commercial/industrial uses. Linear large-lot residential development is common along rural secondary routes. They are distinguished from the suburban area in that there is an intention or desire to retain the rural character of the area in the future. In rural developed areas, buildings generally have deep setbacks from roadways. Occasional driveways require a driver to be more alert for entering and exiting vehicles than in natural rural areas, and present potential conflicts with pedestrians and bicyclists. Pedestrian and bicycle activity is more frequent than in the countryside, but may be of modest volume, due in part to lack of facilities and connectivity. Touring or weekend bicycling may be common (especially if it is a designated bike route).

Rural Village

A rural village is a concentrated area of development within a rural area with businesses and civic uses, and may include adjacent or interspersed housing. A village is often an incorporated municipality, but not always. A rural village is distinguished from an urban center or a suburban center by its isolation, size, and separation from other areas of development. There are varied building setbacks in a rural village and frequent driveways and intersections are common. Pedestrian activity can be moderate to high. Bicycle activity is variable. Transit activity may be present, but is not common.

Countryside

Countryside reflects the traditional concept of rural open space and includes farmland, forestland, park land, and other open space. There are few access points along the roadway and little development. Building setbacks from the roadway are large and there are infrequent access points. Pedestrian and transit activity is usually infrequent and of low volume; however, bicyclists, and to some extent pedestrians, may be attracted to roadways that traverse scenic rural areas and/or connect more intensive development types.

Quality of Service

What is Quality of Service?

Engineers and planners have long used level of service (LOS) to describe how transportation facilities function for motorists. Planning and designing complete streets also requires understanding how well transportation facilities function for bicyclists, pedestrians, and transit users. These guidelines describe how to provide for quality of service for these users. Quality of service is based on street design elements that make using a facility safe and comfortable for bicyclists, pedestrians, and transit users, thereby improving streets' functionality for all users. In contrast to LOS, which is a quantified measure of how effectively transportation facilities move cars, quality of service is a qualitative measure of how well transportation facilities serve other users.

Quality of service also takes into consideration the ways in which buildings, circulation, parking, and landscaping are arranged on an adjacent site and the effect that site has on where a street contextually falls in the continuum of street networks. Streets should strive to provide high quality of service for bicyclists, pedestrians, and transit users, as described in this section and in Chapter 4.

Elements of Quality of Service

Quality of service emphasizes the safety and accessibility of travel, rather than a quantifiable measure of throughput of travel. For walking, biking, and transit to be attractive travel options, the experience of using non-motorized transportation must be convenient, comfortable and safe. Quality of service applies to the design elements provided along streets, but can also be assessed within the context of the street network, as part of the collaborative process described in Chapter 2. Street, transit, rail, bicycle, and pedestrian facility planning lays the vision for street improvements with consideration of multimodal facilities and connections to the surrounding street network. This vision is developed through collaborative dialog with local jurisdictions and reflects the community's land use vision and context. Transportation projects will often have tradeoffs among design elements that provide higher quality of service for different users. But in every instance, the solution must strive toward connectivity of a complete streets network, and the design input team should strive to improve quality of service for all users when designing new or modified streets.

The following section describes the types of facilities that contribute to quality of service for bicyclists, pedestrians, and transit users. For each element, an image is shown demonstrating good quality of service. This quality of service concept is built into Chapter 4 and is incorporated into each of the street type cross-section diagrams.

Quality of service is based on street design elements that improve street functionality for bicyclists, pedestrians, and transit users.

Bicycle Quality of Service

Providing for bicycle quality of service may vary based on context. The surrounding land use, the speed of cars on the street, and the directness of the route connecting destinations are all important factors in identifying the appropriate elements for bicycle facilities. In addition, there are different types of bicyclists with varying levels of expertise. While bicyclists have the legal right to use the traffic lanes, some cyclists will be more comfortable than others riding in mixed traffic. Creating viable transportation options means that a variety of types of facilities should be provided to create a bicycling network. Creating bicycling networks is often an incremental process, and facilities should be provided where appropriate.

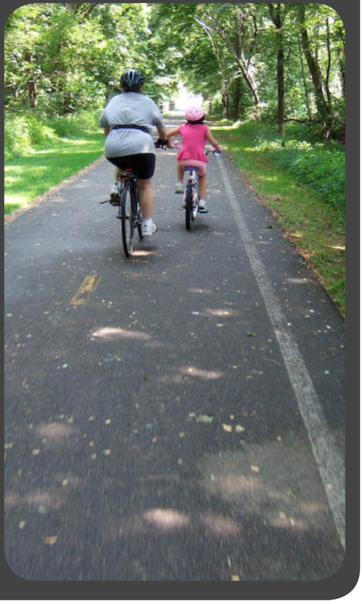
Bicycle Lanes

Dedicated bicycle lanes are the preferred option to provide for the greatest variety of cyclists on streets, particularly those streets with higher volumes and speeds. The most recognizable form of a bicycle lane is a striped lane with a painted arrow and cyclist icon. Bicycle lanes are the backbone of a complete bicycle network, as they visually distinguish a bicycle-only travel lane in which a cyclist does not have to maneuver around motor vehicles and vice versa. Bicycle lane widths are typically four feet to six feet of pavement. The gutter pan on an urban street is not to be considered part of the bicycle lane. When bicycle lanes are adjacent to on-street parking or on higher-speed streets, the minimum width of a bike lane is five feet. The bicycle lane shown below is in excellent condition: it is clearly marked and well-maintained. To maintain a high quality of service in bicycle lanes, pavement markings should be re-striped regularly, streets and bicycle lanes should be kept clean of debris, and bicycle lane signage should be present and visible.

Shared-Lane Markings

In streets where bicycle lanes cannot be accommodated, shared lanes provide an alternative to bicycle lanes. Shared-lane markings are lane markings that indicate a shared-use lane for motorists and cyclists. Shared-lane markings increase a motorist’s awareness of the presence of cyclists (by raising the motorists’ expectation that they will encounter cyclists), reduce the incidence of wrong-way bicycling, and indicate to both drivers and cyclists the ideal lateral positioning of the cyclist In the lane. However, the use of markings is limited to lower-speed streets. The shared lane marking shown in the image below is well-maintained and clear to motorists. To maintain a high quality of service in shared-lane markings, “Share the Road” signs or “Bicycles May Use Full Lane” signs should be present and pavement markings should be re-striped regularly.

Multi-Use Path



On streets where physical separation of bicycle traffic from motoring traffic is appropriate (such as on very low-access, high-speed facilities like parkways and potentially rural roads), multi-use paths should be considered. Multi-use paths are paved pathways that accommodate both cyclists and pedestrians. The image shows an off-road multi-use path in excellent condition that accommodates two-way pedestrian and bicycle traffic. In order to maintain a high quality of service on multi-use paths, paths should be well lit, clear of debris, and have appropriate signage. Intersections of multi-use paths with streets and roadways also must be carefully designed (see Chapter 5) to provide a high quality of service.

Signage

Bicycle signage is an important element that alerts motorists to the presence of bicycle traffic while providing information to bicyclists. Both bicycle lanes and shared lane markings should include signage, but bicycle signage that identifies a designated bicycle route can be a stand-alone element. Signed bicycle routes often help bicyclists to navigate lower-volume street networks, for example. The signage shown depicts a designated bicycle route. To maintain a high quality of service, signs should be posted at regular intervals in high-visibility locations. Offering additional wayfinding information with bike route signs as appropriate can enhance quality of service.

Paved Shoulders

In many rural areas, four foot wide paved shoulders are the typical treatment for accommodating bicyclists. Four foot wide paved shoulders allow bicyclists to travel on a paved surface adjacent to through traffic, if desired. Where speeds are 55 mph and above, five foot wide paved shoulders should be considered. In the image, both sides of the street have paved shoulders to accommodate pedestrians and cyclists. To maintain a high quality of service, it is extremely important that shoulders are kept free from debris, and any drainage structures have bicycle safe grates. If rumble strips are necessary, they should be designed to allow passage of bicycles.

Cycling Elements at Intersections

There are a number of other treatments that can improve bicyclists' ability to safely navigate high-conflict areas like intersections. Bicycle boxes, bicycle stop bars and lead signal indicators position the cyclist ahead of motorists at intersections and improve visibility between bicyclists and motorists. In addition, bicycle detection at intersections improves network and intersection function for bicyclists. Additional treatments not specified above and included in AASHTO, NACTO, or other guidance, will be considered.

Pedestrian Quality of Service

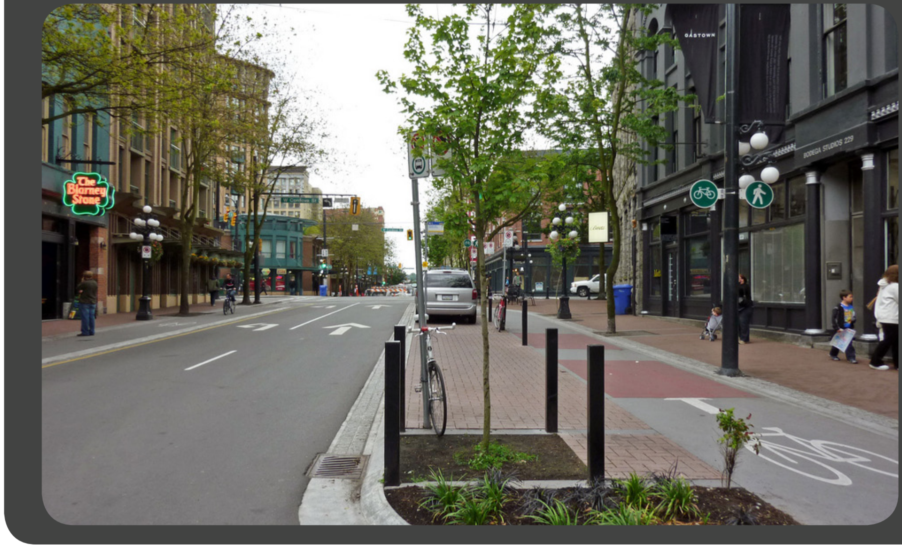
Safety of the pedestrian and separation from high speed traffic is of the utmost importance in planning for pedestrian quality of service. Complete streets need to provide for a range of passive and active uses including, but not limited to walking, waiting for transit, and crossing the street. While specific treatments or dimensions may vary by context, the goal in any environment is to have a continuous pedestrian network that provides dedicated space for pedestrians and separation from vehicles. In urban areas, this network exists or can be created. However, in rural areas, the pedestrian network may not be continuous or may utilize shoulders of high-traffic roads. Pedestrian facilities should be encouraged in all environments, with the specific treatment based on the context and the street type.

Sidewalks

Sidewalks are the primary mode of pedestrian travel and are a crucial element in any pedestrian network. Sidewalks should be part of a continuous network, connected with crosswalks and separated from traffic with a buffer (see next treatment). To maintain a high quality of service, sidewalks should be kept level, smooth, and free of debris, and they should be kept continuous across driveways and other entrances. They should also be kept free of conflicts, such as utility poles or fire hydrants, with sidewalk dimensions that allow for appropriate unobstructed walking space. The minimum unobstructed walking space for a sidewalk on a street is five feet, with six feet or wider applications for higher-volume, higher-speed streets, and/or more intensive land uses (as described in Chapter 4). The sidewalk shown below exceeds this minimal width, reflecting the context. Such treatment should be encouraged where possible, particularly in urban areas.

Buffer

Providing a buffer between pedestrians and traffic is important for providing good quality of service. A buffer is a strip of land that separates vehicular traffic from the sidewalk or other pedestrian facility. Buffers typically are planting strips or, in more intensive areas of development, hardscaped amenity zones. For most street types, these types of buffers are also planted with trees to provide shade and for additional (vertical) buffering. A buffer greatly enhances the pedestrian experience by providing additional separation from traffic. Other elements of complete streets can also contribute to a buffer, such as bicycle lanes and on-street parking. The buffer pictured below includes both a planting strip with street trees and a cycle track. To maintain a high quality of service, these buffers should be kept clear of debris and be of sufficient width to separate the sidewalk from fast-moving vehicles.

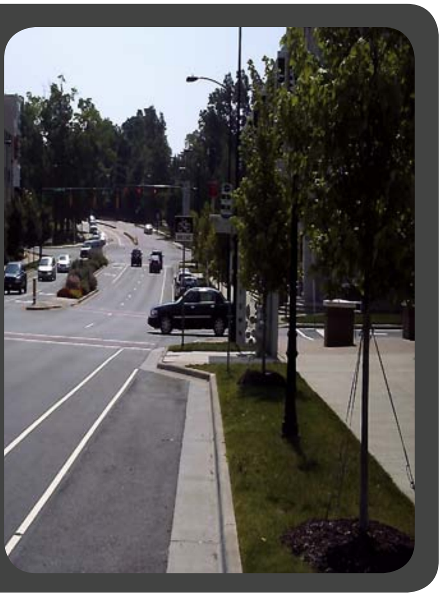


Pedestrian Crossings

Pedestrian crossings and/or crosswalks are another crucial element in any pedestrian network. Designing complete streets means understanding that pedestrians must be able to cross the street. Providing well-designed crossings, whether at intersections or mid-block (marked and unmarked), encourages walking and helps to complete the pedestrian network. Crossing treatments vary depending on a number of factors, including nearby land uses, transit stop locations, and characteristics of the street. Crossing treatments range from signage to marked crosswalks at intersections, marked mid-block crossings or, where appropriate, pedestrian beacon signals. Crosswalks provide for pedestrian visibility and also serve to assign the right of way. Well-designed and located mid-block crossings can help shorten blocks and connect destinations more directly. The image below shows a high-visibility striped pedestrian crossing, an important element in a pedestrian network. To maintain a high quality of service, pedestrian crossings should be well-marked with appropriate signage and located in areas without sight distance issues or constraints.

Curb Extensions

Curb extensions (also called nubs or bulb-outs) are extensions of sidewalks that narrow the street, increase pedestrian visibility, and decrease pedestrian crossing distance. They are also an element of traffic calming that prioritizes pedestrian safety, can reduce vehicle speeds, and can serve to protect on-street parking. The curb extensions in the image show a high quality of service in a small town environment.



Signage

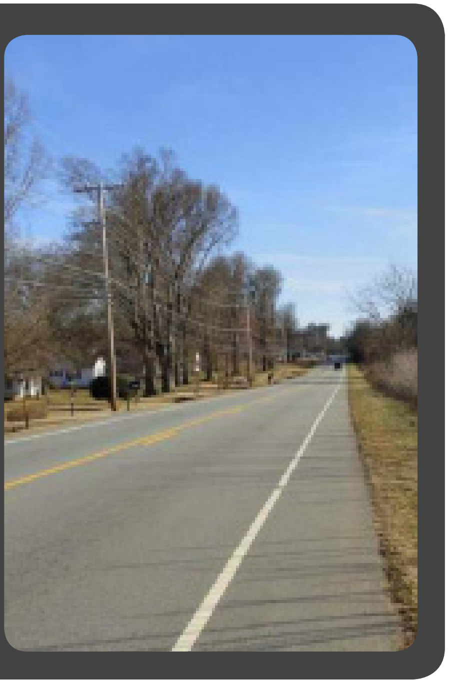
Signage helps to improve pedestrian safety by alerting motorists that pedestrians may be present. Signage can also improve the visibility of pedestrian facilities at pedestrian crossings, such as a marked crosswalk. The signage in the adjacent image serves as a reminder that motorists must stop for pedestrians in a crosswalk. To maintain a high quality of service, crosswalks at mid-block locations, and under some circumstances at unsignalized intersections, should include signage placed to allow enough distance to allow a motorist to react and slow down if necessary.

Multi-Use Path

A multi-use path separates pedestrian and bicycle traffic from vehicular traffic on streets with less frequent access or higher speeds, such as parkways or some rural roads. Multi-use paths are popular with recreational walkers or runners and commuters, and in places where destinations are spaced further apart. The multi-use path in the image below is of excellent quality, providing enough width to accommodate pedestrians and cyclists in two directions. In order to maintain a high quality of service for multi-use paths, they should be lit, kept free of debris, and appropriately signed. Intersections of multi-use paths with streets and roadways also must be carefully designed (see Chapter 5) to provide a high quality of service.

Shoulders

In rural areas, shoulders may be the only pedestrian facility. Wide shoulders on rural roads allow pedestrians to travel along a paved surface in a separate space from traffic. To maintain a high quality of service, shoulders should be kept free of debris, be of sufficient width to accommodate pedestrians, and be connected with crosswalks where needed, such as at a major off-road trail crossing.



Lighting

In order to allow for pedestrian quality of service during evening hours, lighting should be provided near transit stops, commercial areas, or other locations where night-time pedestrian activity is likely. Pedestrian-scale lighting such as street lamps helps to illuminate a sidewalk, and improves pedestrian safety and security. In order to maintain a high quality of service, lighting should be regularly maintained, equally spaced, and focused downward to reduce glare.

ADA Requirements

Pedestrian quality of service is especially important for persons with limited mobility. The Americans with Disabilities Act (ADA) requires certain elements like curb ramps and minimum clearance widths to make the pedestrian network accessible to all users. The image below shows a high-quality crosswalk that includes ADA ramps, detectable warning pads, and level landings.

Photo source: Dan Burden, www.pedbikeimages.org

Other Pedestrian Amenities

There are other elements that can enhance an individual's experience on a complete street and improve the function of the street for pedestrians and other users. For example, street trees provide shade, additional buffering from the street, and an element of traffic calming. Street furniture, such as benches, and enhanced walking surface texture can provide a better pedestrian experience. To maintain a high quality of service, these pedestrian elements should be regularly maintained.

Transit Quality of Service

Transit modes may include commuter, light rail, streetcars, or buses. As a street user, transit can take many forms, including operating in vehicle travel lanes or within dedicated lanes. Some transit, such as light rail, can operate outside of the street right-of-way and merge with the street for needed connections. Pedestrian access is an essential component in the success of transit networks. Proper circulation of pedestrians and bicyclists adjacent to transit stations and transit stops is important to ensure safe and convenient access.

Streets that are well-designed for transit can encourage more people to get out of their cars and onto the bus. Such streets provide accessible bus stops and assist buses in moving through traffic. Transit systems have realized that bicycling and transit go well together. Most transit agencies now provide bicycle parking at bus and rail stops, and more than 100 transit systems in the United States (and a growing number in North Carolina) carry passengers' bicycles on buses and trains.

Complete street concepts and initiatives ensure safe and convenient access to public transit for all users. Creating safe and comfortable bus stops and smooth, predictable transit trips help make transit an attractive option.

Transit Service

The frequency of transit service greatly affects the perceived quality of service. A transit system with a reliable, accurate schedule has the potential to attract additional choice riders and increase demand for more frequent service.

Transit service varies greatly across different land use types. In an urban area, high-frequency transit service is typical and has a variety of connected transit routes. However, in a more suburban area, limited transit service is more typical, and often the frequency is approximately one bus per hour. Because the service is infrequent, long waits can occur. Long headways and unpredictable schedules will not lead to additional riders, regardless of the quality of facilities at a bus stop. Therefore, the reliability of transit service is an integral element in transit quality of service.

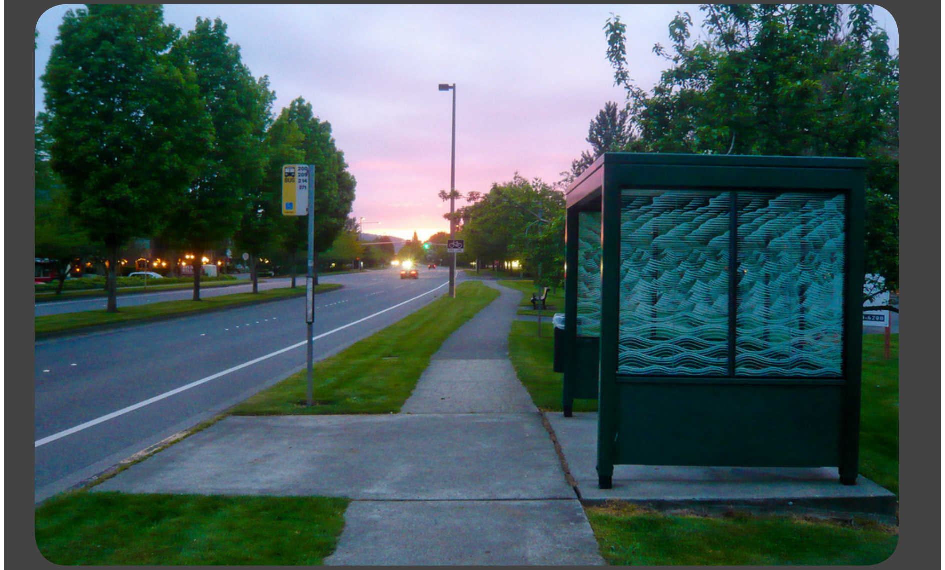
Bus Shelters

Bus shelters provide a place protected from the elements for transit users to wait for a transit vehicle. Bus shelters should include seating, lighting, and bus information. The bus shelter in the image below is well maintained and includes seating for waiting passengers. In order to maintain a high quality of service, bus shelters should be maintained regularly, kept secure, and kept free of debris and graffiti. Bike racks at shelters can provide multimodal connections.

Adequate Connections to Transit

Transit stops are only one element in a transportation network, and every transit user is also a pedestrian or cyclist at the beginning or end of their trip. For that reason, connections to transit stops are an essential element in a complete transportation network. Sidewalks and pedestrian crossing treatments should connect transit to the surrounding area, and bicycle facilities should connect to transit where possible. To maintain a high quality of service, sidewalks should be kept clear, with wayfinding and signage if necessary, and crosswalks should be well-marked.

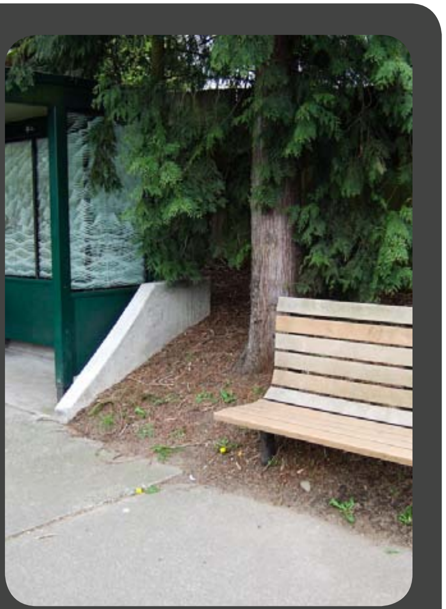
ADA considerations at transit stops include a flat, stable landing pad that allows individuals of all abilities to safely get on or off the bus. Clear zones inside shelters and around other stop amenities also improve ADA access.



Schedules & Routes

Transit schedules and posted routes are an essential element of transit service. Schedules provide information to transit users on bus routes, transfers, and timetables. A variety of schedule types are available, from printed timetables to interactive bus displays, which indicate when the next bus will be arriving. In order to maintain a high quality of service, schedules should be kept up to date and include any service advisories for special circumstances.

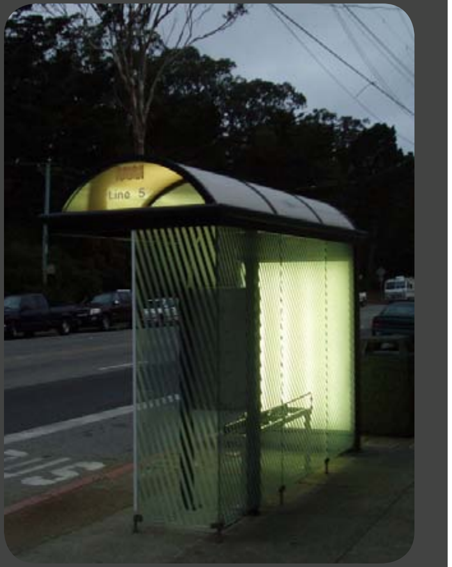
Seating



In places where there is not enough demand or usage to justify a complete bus shelter, seating alone can improve the experience of waiting for a bus. Seating typically includes one or more benches near a bus stop. The image below includes a wide sidewalk, a bus shelter, and a bench in a rural area. To maintain a high quality of service, seating should be kept clean and well maintained.

Lighting

Lighting enhances the visibility and safety of a transit stop. Lighting also improves the readability of transit features such as schedules. Lighting should be provided at bus stops that are served by routes in the evening and early morning. Connecting sidewalks should also be well lit. Lighting should be maintained regularly and checked to be in good working order to maintain a high quality of service.



Signage

A bus stop post is a basic element of transit quality of service. This post can identify the route serving a stop and provide any additional information on the route and schedule. Signage helps transit users locate the bus stop. In the image to the right, bright colors and clear printing allow transit users to quickly see which routes serve the bus stop. To maintain a high quality of service, signage should be well lit and located in high-visibility locations.

Transit Design

Elements such as bus pull-out lanes allow buses to stop without blocking traffic and provide easier and safer boarding. It is important for the practitioner to understand the dimensions and capabilities of the type of transit using the street, and the ramifications that their operation and stops and stations will have on the design of the street. In many street contexts, bus pull-out lanes, for example, would not be appropriate since the emphasis may be less on vehicular throughput and more on pedestrian and transit access.

The purpose of this chapter was to identify urban, suburban, and rural area types that reflect a variety of land use types across North Carolina. The chapter described quality of service levels by various modes of travel to show the importance of providing functionality for those modes other than the automobile. Chapter 3 laid the foundation for Chapter 4, in which appropriate street types are described based on the surrounding context and functional criteria. These context-based and functional criteria (classification, speed, volume, and access density) assist in the decision making process to identify the preferred street design solution.

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4: Planning and Design Elements

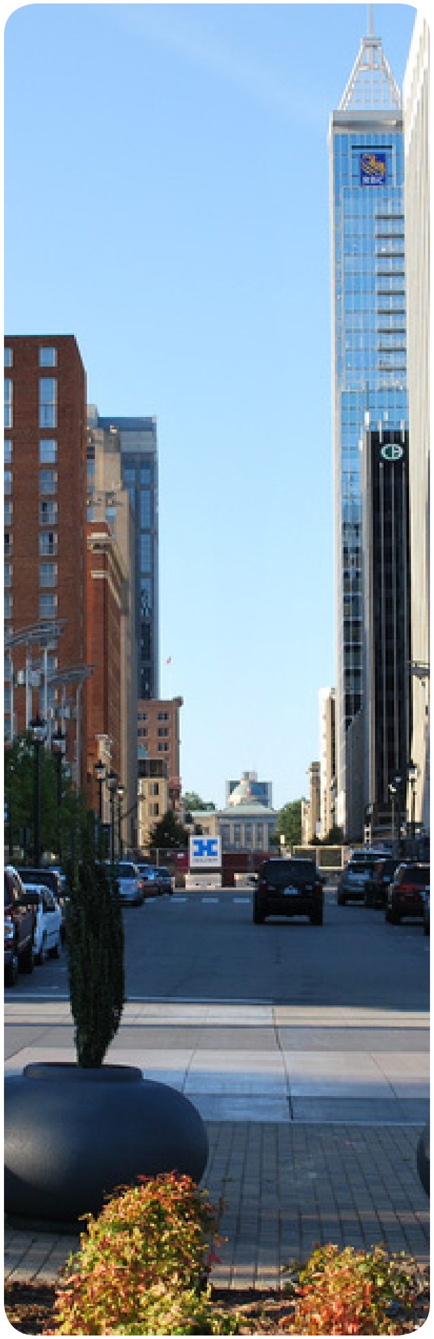
North Carolina's complete streets approach is intended to be flexible enough to apply to streets in communities across the state. When selecting the planning and design features for a particular street, the design input team must consider the current and future land use context of the corridor and its desired purpose and function.

Once the initial land use context had been identified, the design input team can collaborate on the design solutions that are appropriate for the street. A range of street types are described in detail in this chapter. A conceptual plan view, summary list of key elements, applicable street zones, and a street cross-section are shown for each. The design input team should use a variety of context-based land use, transportation, and functional criteria to refine the street type and design. These street sections should be used as guidance for the design in creating a complete street design that supports a transportation network that integrates motorists, bicyclists, pedestrians, and transit users and services.

Planning and Design Considerations

Land Use Context and Street Network

In defining the context of a complete street, an initial step is to identify the existing and future land use context where the street is located. Elements of land use context include the pattern, use, and density of development, both current and future.



Complete street design should be based on a collaborative discussion about local needs and the role of the street in the region's transportation network. The network should be planned to support the transportation needs generated by the planned or anticipated land uses while being compatible with characteristics of the surrounding neighborhoods and communities.

The structure of the network, the ability of the streets to serve traffic and provide mobility for non-motorists, provide access and accessibility, the spatial relationship of the street elements, and other elements of the right of way should encourage and support the development pattern, land-use, and development intensity in accordance with the community's vision. The total street network should improve the integration of land-use and transportation by avoiding mismatches between land uses and streets, and by creating the right combination of land uses and streets to facilitate the anticipated growth.

Area Type Considerations

The type of area the street is adjacent to will have a primary effect on the design of the street. While areas and sub-areas are defined in Chapter 3, it is important to understand the range of issues that should be considered in each area, as well as the importance of considering the future land use expectations of the community.

Urban

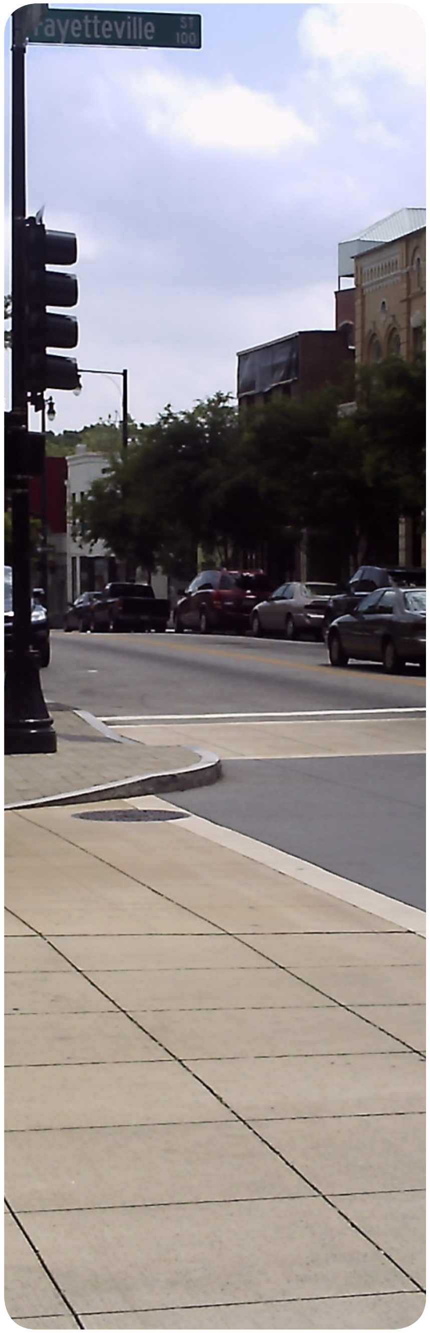
Urban areas have the most intense street use by the widest range of users. These streets may have to accommodate various modes with dedicated facilities, separate bike lanes for bicyclists, on-street parking to serve local businesses, and transit areas, with either dedicated travel lanes or dedicated loading and multi-modal connection areas. The transition areas between the different uses require special attention. For instance, planting strips and other buffers that separate the curb from the sidewalk should safely accommodate passenger access in areas where on-street parking or a transit stop is provided. In these types of areas, a hardscaped amenity zone may provide the better treatment.

Suburban

Suburban areas are located at the periphery of more urban areas or may be transitioning to urban areas. These areas may have a limited street network and be less intensively developed, creating challenges for providing pedestrian connections and accommodations for bicyclists as well as transit users. Bicycle lanes are the preferred treatment for accommodating bicyclists on higher volume and higher speed suburban streets. Along auto-oriented commercial strip areas, driveways can sometimes account for more than half of the sidewalk length within a block, creating potential bicycle/pedestrian-auto conflicts. Suburban areas are often expected to transition through time into more urban conditions. Therefore, they represent the greatest opportunities and needs for establishing better street networks (by providing more streets), lower target speeds, and better street designs to serve current and future users, who will be driving, walking, bicycling, and using transit. Additional streets and better networks should be provided as these areas develop to help achieve these objectives.

Rural

While recognizing that most streets (and complete streets) are in cities and towns, it is also important to consider how appropriate facilities can be provided in more rural environments. Rural areas may have the least network connectivity and, therefore, might have the most demand on single facilities. Travel lanes often need to accommodate motor vehicles, bicyclists, and transit with pedestrian access provided on shoulders or off-street. While rural areas can provide challenges to accommodating a full range of users, many times the provision of paved shoulders, multi-use paths or other facilities can safely and comfortably address user needs and provide complete streets. Different design treatments will be appropriate for different contexts and constraints.



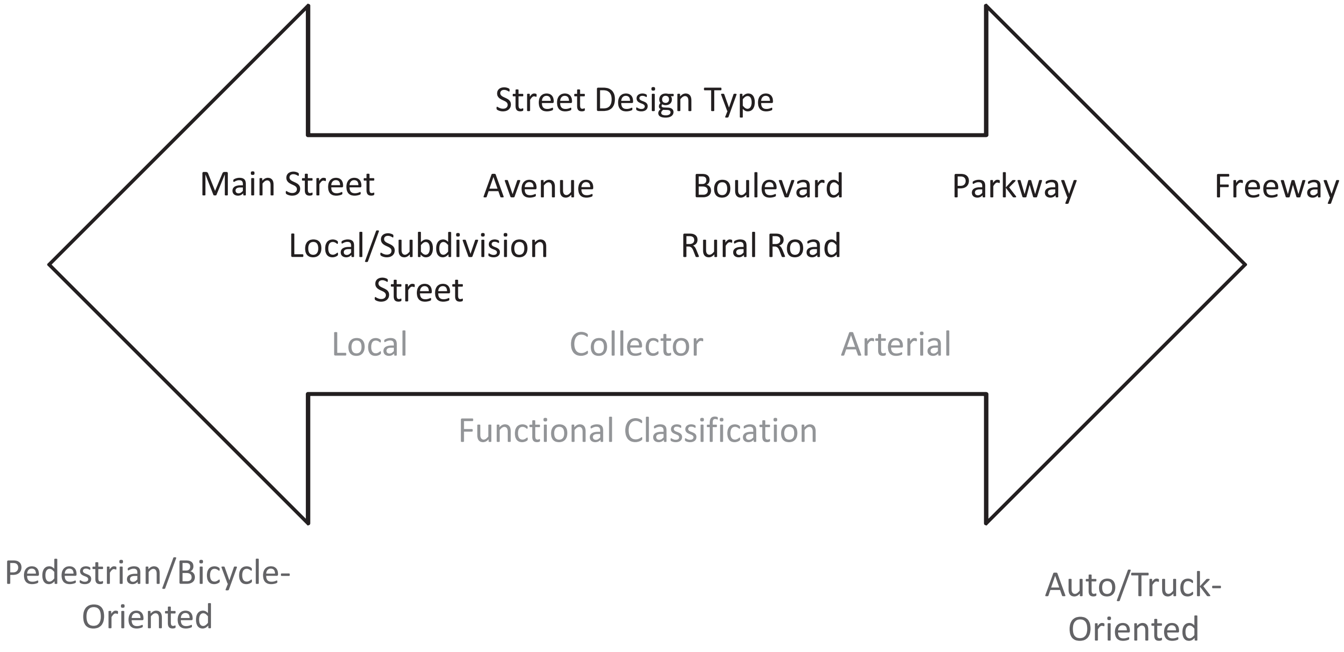
Street Types

Street Types: Integrating Land Use & Street Function

In order to develop complete street networks in communities throughout North Carolina, a variety of street types have been defined and will be applied as complete streets. They represent a spectrum ranging from very pedestrian-oriented to very auto-oriented but, as described in this chapter, each can and should include ways to provide for the safe and comfortable travel of motorists, bicyclists, pedestrians, and transit users. Street design decisions and land use decisions should complement one another and achieve a pleasant balance between land use and street design. As illustrated in Figure 4, the following street types have been identified for the application of complete streets:

- Main Street
- Avenue
- Boulevard
- Parkway
- Rural Road
- Local/Subdivision Street

Figure 4: Arrow Showing Complete Street Types



Each street type’s relative location on Figure 4 indicates the general function of the street within the complete street network. For example, the main street is the most pedestrian-oriented of these streets, and the parkway is the most auto/truck oriented. It should be noted that even a parkway provides design elements that improve safety and operation for bicyclists, pedestrians, and transit. While all of the street types should be designed to provide functionality for all users, the modal emphasis shifts. Rural roads serve as the primary connection and access to numerous towns and communities throughout the state. As such, they serve all types of road users, including bicyclists, pedestrians, and, in some places, rural transit. As a result, rural roads are also included in these guidelines.

The street types are defined on the following pages.

Main Street

- May function as an arterial, collector, or local street. May function as a collector serving as a primary thoroughfare for traffic circulation in a limited area. May function as a local destination street for an outlying business district.
- Designed to carry vehicles at low speeds (under 30 mph).
- A destination street for a city or town, serving as a center of civic, social, and commercial activity.
- Serves substantial pedestrian traffic as well as transit and bicycles.
- Includes wide sidewalks, crosswalks, and pedestrian facilities due to the emphasis on pedestrian travel.
- Bicycle lanes are allowed, but typically not necessary on these streets due to lower speeds and volumes, and the desire to keep pedestrian crossing distances to a minimum.

Avenue

- May function as an arterial, collector, or in a rural setting as a local route, but generally at low to moderate speeds.
- An urban street serving a range of traffic levels within and between various area types.
- Characterized by wide sidewalks (scaled to the surrounding land uses) and on-street bicycle facilities.
- May have on-street parking.
- Transit stops, shelters, and other amenities are located along the street, preferably within the right of way.

Boulevard

- Most often functions as an arterial designed to carry vehicles at moderate speeds.
- Thoroughfare characterized by multiple lanes and includes a street median.
- Wide sidewalks with appropriate planting strips and on-street bicycle lanes are necessary to accommodate pedestrians and bicyclists due to higher speeds and higher traffic volumes for motor vehicles.
- Building setbacks will typically be deeper than on avenues.
- Transit stops and shelters may be located within the right of way, requiring connections to sidewalks.
- On-street parking is not required. It is allowed where appropriate, but rare due to the nature of the street. If provided, parking should typically be placed on a separate, parallel frontage street separated with a side median.

Parkway

- Most often functions as an arterial designed with control of access to carry vehicles at moderate to high speeds.
- Urban or rural thoroughfare often characterized by landscaping or natural vegetation along roadsides and medians.
- Land uses are set back from the street and are typically not oriented toward the parkway.
- Pedestrian and bicycle traffic usually provided for on separate multi-use paths ideally located adjacent to the facility.
- Convenient access to off-street transit stations, stops, and park-and-ride lots.
- Tractor trailer and semitrailer truck traffic is frequently present.

Rural Road

- May function as an arterial, collector or local route, but with a range of speeds.
- A road outside of cities and towns serving a range of traffic levels in a country setting.
- Wide paved shoulders can be used to provide bicycle and pedestrian accommodations.
- Multi-use paths separated from the roadway may also be an appropriate treatment for bicycle and pedestrian accommodations.
- Accommodates bus facilities, including turnouts as appropriate. Public transit stops and shelters should be clearly marked and placed within the right of way.

Local/Subdivision Streets

Local/subdivision streets serve as a critical element in the street network, linking residential and business areas. Local streets are not defined by ownership or maintenance responsibility, but by the fact they functionally provide direct access to land uses within subdivisions. These streets typically have low speeds and very low traffic volumes, and have a strong focus on access and pedestrian/bicycle movements. Local/subdivision streets are subdivided into two types: residential and office/commercial/industrial. Characteristics similar to each include:

- Carries traffic at low speed.
- Provides direct access to local land uses.
- Provides linkages and connections to the overall street network.
- Street widths are based on land use, density, and lot size.
- On-street parking typically occurs, though at different levels, depending on land use characteristics.
- Bicycle lanes are typically not necessary due to low traffic volumes and low speeds.
- Pedestrian activity is expected, and should be accommodated on these streets.

Local streets are treated differently than the other street types in this document for several reasons. First, these are the streets that are typically built through the land development process, rather than as capital/public projects. Therefore, the local/subdivision street cross-sections are meant to be applied more prescriptively than are the cross-sections for the other street types. This offers predictability to those creating these streets. Second, even though these cross-sections are more prescriptive, there are several different cross-sections, to allow for the flexibility to establish the "right" street for a wide variety of land development types and intensities. This provides for both predictability and flexibility as land uses are being developed. These street types are offered here as examples to communities seeking to apply complete streets through their ordinances. Moving forward, NCDOT will accept these street types for maintenance in communities that implement complete streets, provided the street types are appropriately applied and have prior approval from NCDOT.

Why Multiple Cross-Sections?

The multiple cross-sections described for local/subdivision streets reflect the likelihood that on-street parking will be utilized. The intent is to ensure enough space for parking where needed, but to not create overly-wide streets that make it more difficult to maintain low operating speeds. The narrower cross-sections for both residential and commercial developments are meant to be applied where there is a low likelihood of on-street parking, due to the amount or placement of on-site parking. For example, a large-lot residential neighborhood with long driveways and rear-access parking will likely not require much on-street parking, and an overly wide cross-section is neither necessary nor in keeping with expected speeds. Likewise, a commercial development (such as a traditional "office park") with a large amount of surface parking, and little short-term parking turnover will also not require on-street parking.

At the other end of the spectrum, higher density or mixed-use types of development usually result in frequent and heavy utilization of on-street parking. For example, residential densities above a certain threshold or commercial mixed-use developments will need to apply the wider cross-sections. These cross-sections provide space for full-time on-street parking, while leaving travel lanes open – all of which supports an accessible, but calmed street environment. Further, the sidewalk width is scaled to reflect the context, which will include higher levels of parking turnover and resulting pedestrian activity along the street front.

The medium cross-section for residential developments is generally meant to be applied in residential neighborhoods where there will be some utilization of on-street parking, but not heavy parking on both sides of the street. This cross-section is similar to the "default" for many communities because it reflects the current NCDOT subdivision street cross-section.

Box 1 shows an example of how ordinance language can be used to apply similar local street cross-sections to the appropriate context. The local residential streets in this example are defined as:

- narrow (20 ft., measured face of curb to face of curb),
- medium (25 ft.), or
- wide (34 ft.).

All include 8 ft. planting strips and 5-8 ft. sidewalks.

The local office/commercial streets are defined as:

- narrow (24 ft.) or
- wide (40 ft.),

with 8 ft. planting strips and 5 or 8 ft. minimum sidewalks.

The local industrial street is 34 ft. wide, with an 8 ft. planting strip and 5 ft. sidewalk.

Box 1 – Sample Application of Complete Street Cross-Sections in Subdivision Ordinance (Charlotte, NC).

Land Use Conditions	**USDG Street Type/Cross-Section**
Residential Land Uses	
Default: except in conditions 1-4 below, use:	Local Residential Medium
1. If mixed use development:	Local Office/Commercial Wide
2. If all lots are greater than 10,000 square feet with all of the following conditions: • Lot frontage greater than 80 feet • More than one street connection • Parallel street located within one connected block	Local Residential Narrow
3. If the street is abutted only by lots fronting adjacent perpendicular streets with the following condition: • More than one street connection	Local Residential Narrow
4. If greater than 8 dwelling units per acre	Local Residential Wide
Industrial Land Uses	Local Industrial Street
Office/Commercial/Retail Land Uses	
Default: except in conditions 1-2 below, use:	Local Office/Commercial Wide
1. A conditional zoning district or small area plan prescribes the use of the Local Office/Commercial Narrow	Local Office/Commercial Narrow
2. The developer can reasonably demonstrate to city staff that the anticipated development will not create parking demand on the street.	Local Office/Commercial Narrow

Network and Local Streets

Throughout this document, there are references to the importance of both using and creating street "network" to create better, more complete streets. This is particularly important to consider as local/subdivision streets are being planned and constructed. These streets create vital connections between thoroughfares (avenues and boulevards, e.g.) and the neighborhoods or commercial developments that access them. Good network provides more direct (shorter) routes for bicyclists and pedestrians to gain access to the thoroughfares and to the land uses along them (or allows them to avoid the thoroughfare altogether). Likewise, good connections can also allow short-range, local vehicular traffic more direct routes and access, resulting in less traffic and congestion on the thoroughfares. This can, in turn, help make the thoroughfare itself function as a better, more complete street. For all of these reasons, a complete local street network should generally provide for multiple points of access, short block lengths, and as many connections as possible.

Box 2 shows one example of how block lengths are used to help create complete street networks in a community. The example shows how Charlotte applies block length expectations based on land use context. Generally, the more dense or intensive the expected

Box 2 – Example of Block Length Expectations for Local Streets, Based on Land Use Context (Urban Street Design Guidelines, Charlotte, NC).

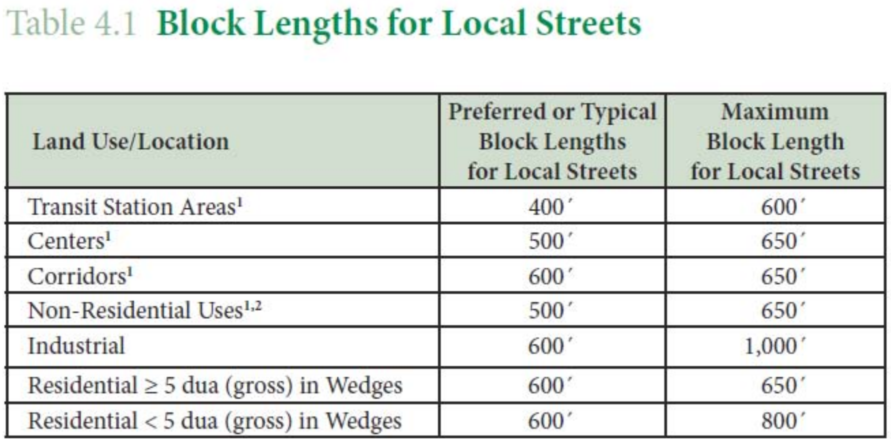


Table 4.1 **Block Lengths for Local Streets**

Land Use/Location	Preferred or Typical Block Lengths for Local Streets	Maximum Block Length for Local Streets
Transit Station Areas[1]	400′	600′
Centers[1]	500′	650′
Corridors[1]	600′	650′
Non-Residential Uses[1,2]	500′	650′
Industrial	600′	1,000′
Residential ≥ 5 dua (gross) in Wedges	600′	650′
Residential < 5 dua (gross) in Wedges	600′	800′

land use, the shorter the expected block lengths to support those land uses. This is broadly applied to Charlotte's Centers, Corridors, and Wedges growth framework and also to specific types of land uses. Centers and Transit Station Areas represent the highest density location/context and have shorter block lengths. Lower-density land uses in the Wedges represent the lowest density location/context and can have longer block lengths. Charlotte's Subdivision Ordinance includes a flexible approach to applying these block lengths to developments.

Freeway/Expressway

Freeways and certain expressways are not considered part of the complete street types previously described. Planning and design of these facilities will focus on the capacity and safety requirements of motor vehicle traffic. However, streets at interchanges and grade separations should incorporate complete streets elements, and interchanges, expressway intersections with surface streets, and their bridges and underpasses will be designed to safely and comfortably accommodate bicyclists, pedestrians, and transit users. Along freeways and expressways, pedestrian space may consist of a multi-use path provided outside of the control of access.

Figure 5: Street and Area Type Matrix

Area Type	**Land Use**	**Main Street**			**Avenue**			**Boulevard**	**Parkway**	**Rural Road**		
		Arterial	Collector	Local	Arterial	Collector	Local	Arterial	Arterial	Arterial	Collector	Local
Urban	Central Business District (CBD)	*Urban/Suburban Main Street*			*Urban/Suburban Avenue*			*Urban/Suburban Boulevard*	*Urban/Suburban Parkway*			
	Urban Center											
	Urban Residential											
Suburban	Suburban Center											
	Suburban Corridor											
	Suburban Residential											
Rural	Rural Village	*Rural Main Street*			*Rural Avenue*			*Rural Boulevard*	*Rural Parkway*			
	Rural Developed											
	Countryside									*Rural Road*		

Street Type Selection

By defining and implementing complete street designs that meet the intent of different street types and a variety of land use contexts, NCDOT has a better chance of meeting the multiple objectives of the different users of our streets. This section identifies planning and design criteria that represent both land use and street function.

As described in the previous section, different street types have been defined: main street, avenue, boulevard, parkway, rural road, and local/subdivision street. These street types are meant to represent the range of state-maintained streets throughout North Carolina.

The matrix shown in Figure 5 lets the planner/designer see the area type, land use, and street type together. The matrix provides initial guidance about appropriate street types for general contexts, but should not be applied without more information. With this selection made, the design input team should consider other functional and context-based criteria to help select the appropriate cross-section for the street.

Functional Criteria

Once the appropriate street type has been initially identified, the design input team can refer to the more detailed functional criteria shown in Figure 6. These functional criteria include classification, target speed, traffic volume, and access density, all of which assist in defining the ultimate cross-section. As with Figure 5, this information is intended to provide guidance to the design input team and is not intended to replace the project development process described in Chapter 2.

Functional Classification – Traditionally, functional classification is divided into arterial, collector, and local routes. An arterial is typically a higher volume facility serving longer regional trips (as well as local trips), may have high truck volumes, and connects to local collector routes. At the other end of the spectrum, local routes typically carry lower traffic volumes and primarily provide access to adjacent land uses. Collectors connect these two functional types by “collecting” traffic from the local routes and conveying it to the arterials. The street types defined in these guidelines also describe a functional classification, but one that is expanded to include functional considerations for all users. Therefore, the traditional functional classifications described in this section represent one type of useful design parameter to be considered in planning and designing complete streets.

Target Speed – Target speed refers to the preferred travel speed on the street. Speed is a critical component in improving motorist, bicycle, and pedestrian safety on a street and the target speeds for streets are typically lower than would be applied in most applications of traditional highway design.

Traffic Volume – Traffic volume represents the amount of motor vehicle traffic on a street, with ranges for low, moderate, and high. These ranges for traffic volumes overlap to allow flexibility in the number of lanes required based on area type, land use, and street type. Two-lane streets carry low to moderate traffic volumes. The general range for application is:

- Low: Less than 8,000 vehicles per day;
- Moderate: Between 6,000 and 24,000 vehicles per day; and
- High: More than 20,000 vehicles per day.

Access Density – Access density provides a relative measure of the amount of development and interaction along a street. Generally, more dense spacing of access is a reflection of the need for lower speeds in a corridor. However, there can be exceptions on roads with heavy access management. Denser access spacing also generally provides more network flexibility for pedestrians, bicyclists, transit users, and motorists. As shown in the Street Type Matrix (Figure 6), two measures can be used for access density:

1. Traffic Signal spacing:

- Low: Up to 1 signal per mile;
- Moderate: 1 to 3 signals per mile; and
- High: More than 3 signals per mile.

Figure 6: Street Type Matrix

Urban / Suburban	Street Type	Main Street			Avenue			Boulevard	Parkway
	Target Speed (MPH)	20-25	20-25	20-25	25-35	25-35	25-35	25-40	> 35
	Traffic Volume	H / M	M	M / L	H	M	L	H	H
	Access Density	H	H	H	M	H / M	H	L/M	L
	Functional Classification	Arterial	Collector	Local	Arterial	Collector	Local	Arterial	Arterial

Rural	Street Type	Main Street			Avenue			Boulevard	Parkway	Rural Road		
	Target Speed (MPH)	20-25	20-25	20-25	25-35	25-35	25-35	30-40	> 35	45-55	35-55	25-55
	Traffic Volume	M	L	L	M	L	L	M	H / M	M	L	L
	Access Density	M	M	M	L/M	M	M	L/M	L	L	L	L
	Functional Classification	Arterial	Collector	Local	Arterial	Collector	Local	Arterial	Arterial	Arterial	Collector	Local

Suggested Ranges:

Traffic Volume	L - Low	Less than 8,000 vpd		
	M - Moderate	6,000-24,000 vpd		
	H - High	Greater than 20,000 vpd		
Access Density (Traffic Signal Spacing and Access Point Spacing)	L - Low	Up to 1 signal per mile	OR	Greater than 1000 ft. average spacing between access points (less than 5 access points per mile on each side of the street)
	M - Moderate	1 - 3 signals per mile	OR	400 -1000 ft. average spacing between access points (5-15 access points per mile on each side of street)
	H - High	More than 3 signals per mile	OR	Less than 400 ft. average spacing between access points (more than 15 access points per mile on each side of street)

Note: Access points include street intersections and commercial access points (excluding single family residential).
Access points should be counted on both sides of the street when determining the number of access points.

2. Access Point spacing:

- Low: greater than 1,000-foot spacing between access points (approximately 0-10 access points per mile);
- Moderate: 400- to 1,000-foot spacing between access points (approximately 10-30 access points per mile); and
- High: less than 400 foot spacing between access points (greater than 30 access points per mile).

Access points include street intersections and commercial access points. Access points should be counted on both sides of the street when determining the number of access points.

Street Cross-Sections

This section describes the characteristics of each street type using cross-sections and recommended dimensions. The cross-sections described in this section reflect the design elements that provide for good quality of service, as described in Chapter 3. Street quality of service focuses on a consideration of all modes of travel, including cyclists, pedestrians, and transit users. Therefore, streets have design treatments to provide access and accessibility for all modes. This section illustrates the requirements in a graphic format. As shown in the Street Type Matrix (Figure 6), there are nine basic street cross-sections, not including local/subdivision streets (main street, avenue, boulevard, and parkway in both urban/suburban and rural sections) as well as rural roads. In addition, a section is included for a multi-use path, since this is a recommended way to improve quality of service for some street types or contexts.

For each of these street types, a two-page summary is included. One page shows a conceptual plan view of a typical street (graphical and not to scale), a summary list of the key elements of each street type, and a discussion of the street zones within each section. The second page illustrates a street cross-section with ranges and, where necessary, explanatory notes.

Plan View

An illustrated plan view is provided for each typical street section. The purpose of the illustration is to provide a general understanding of the intended spatial relationships of the various street elements. The illustration serves as a diagram of one or more possible street configurations.

Key Elements

Key elements describe the overall characteristics of each street type. Since these typical street sections represent an integration of area type with street type, the key elements should be a confirmation that the design input team is considering the appropriate street section for the proposed application.

Street Cross-section Zones

Each of the street cross-sections is described as a series of zones to clarify the purpose of specific areas of the street, and to provide flexibility when defining the necessary components or their recommended dimensions for a specific context. Each of the street zones accommodate specific street design elements.

Development Zone

This is the area outside the street right of way (ROW) where public or private property is located or may be planned in the future. The relationship of the buildings in the development zone to the street is an important component of the character of the street, as well as how it functions for the street users. In a downtown area, it is likely that this zone includes buildings fronting or very near the back of the sidewalk. In suburban or rural areas, the development zone is more likely to include a deeper setback between the street and the developed portion of the street front (the buildings). Depending on context, this area could be a parking lot, a front lawn to a residence, or undeveloped land. In some cases, ROW for a utility strip is required behind a sidewalk which effectively shifts the development zone farther from the street.

Since the development zone is outside the street ROW, the types of street elements in this area can vary widely. Elements specific to the transportation network may include:

- Bicycle or pedestrian paths;
- Transit stops or facilities;
- Public parking lots; or
- Driveway connections between private parcels.

Green Zone

The green zone is generally a landscaped area between the street pavement (or curb) and the sidewalk. In general, the street designs provide a minimum of 6 to 8 feet in this area to allow space for street trees. Street trees buffer pedestrians and other street users from vehicular traffic, as well as providing for shade and an attractive public realm. Within a high-density urban area, the green zone may be hardscaped with trees in planters. It is important to note that the design needs to account for safe offset of stationary objects from the through traveled way.

In addition to street trees, green zone elements may include features such as other landscaping, signs, benches, fire hydrants, street and pedestrian light poles, and utility poles. Transit amenities such as bus shelters can be considered, but would typically be accommodated behind the green zone.

Sidewalk Zone (or Multi-Use Path Zone)

This area is reserved primarily for a paved sidewalk to carry pedestrians and provide access to transit and to adjacent land uses. In urban and suburban areas, the expectation is to provide sidewalks on both sides of the street unless there are site-specific constraints that make this impossible. When planning for, or accommodating, transit, safe and accessible pedestrian connections are needed between adjacent land uses and transit stops.

Detached sidewalks (located behind the green zone) are preferred because they separate (or buffer) pedestrians from moving traffic and allow for a planting area between the sidewalk and travel lanes. Sidewalk widths vary based on the street type and context. Recommended sidewalk widths range from 6 to 12 feet. Narrower sidewalks (5 feet) may be sufficient for local/subdivision streets in areas with low to medium land use densities. Wider sidewalks (up to 12 feet) are preferred in urban or main street settings with higher levels of pedestrian activity.

In urban areas or other areas with intensive development, it may be necessary to provide wider sidewalks extending to the face of existing buildings. Generally, the sidewalk zone should allow for unobstructed sidewalk width. Street and transit furniture (such as benches, trash cans, and newspaper racks), should be placed within the green zone or development zone, rather than the sidewalk zone, if there is sufficient width and offset from the curb.

On parkways or rural roads, instead of a sidewalk, the pedestrian space may consist of a multi-use path zone set back from the roadway. Multi-use paths are separate facilities that serve pedestrians and bicyclists. The multi-use path should be wide enough to serve bicyclists and pedestrians safely. The preferred cross-section is 10 to 12 feet with two-foot gravel shoulders on each side. A green zone and natural zone help provide a buffer from the main travel way.

Motor Vehicle Zone (or Shared Vehicle Zone)

The motor vehicle zone is generally considered the paved travel way of a street. Motor vehicle zone elements include the travel lanes, turn lanes and tapers, and channelized or striped pavement areas, and, in some circumstances, the gutter pans. Travel lanes are important for vehicular movement and capacity along a corridor. Travel lane considerations include the number and width of lanes, the street direction (one-way or two-way), and the width and incorporation of turn lanes. It is also important to consider these elements from the standpoint of their impact on other users. Street width, for example, can affect the ability of pedestrians to cross the street or the potential provision of bike lanes. The majority of street cross-sections in these guidelines show a range of lane widths from 10 to 12 feet. The recommendation for 10- to 11-foot lanes reflects that, for most urban and suburban street types, lanes less than 12 feet wide are both safe and appropriate, can help to reduce the overall footprint of the street, and/or allow space for other users of the street. Additional considerations include the need for turn lanes at intersections. Sufficient width and need for turn lanes should be evaluated within the context of the larger corridor.

A shared vehicle zone allows for both motorized and non-motorized vehicles, and typically includes additional pavement for bicycles. The preferred treatment for bicycles on higher volume and speed streets is a separate bicycle lane. If a shared vehicle zone is used instead, it might consist of additional space for a shared lane, additional space with shared lane markings, or on very low-volume, low-speed streets, a regular travel lane. The gutter pan is not considered part of the bicycle facility.

Parking may or may not be provided along a street. The relationship between parking lane width and vehicular lane width should be evaluated (in corridors with parking, vehicular lanes may need to be wider, depending on the street type and context). If a parking zone is adjacent to the traveled way, additional offset may be provided. Transit vehicles will often utilize the motor vehicle zone for bus stops if bus pull-offs are not provided or appropriate.

Parking/Transit Stop Zone

The parking zone is typically an 8 to 10-foot wide section allowing for parallel parking adjacent to traffic flow. Parallel parking should be limited to corridors with lower speed limits (35 mph or lower). Parking zones are not provided on parkways. Under certain circumstances, parking can be applied on boulevards. Parking zones are more typical on avenues and almost always included on main streets. Angle parking is allowed, preferably reverse angle parking. The parking/transit zone is a paved area. The gutter pan can be included as part of this zone without increasing the width of the parking zone. This zone can also be used as a bus pullout, where appropriate, or can serve as an extension of the green zone when providing bulb-outs to protect parking and improve pedestrian accommodations.

Bicycle Zone (Bicycle Lane)

A bicycle zone is an area reserved for a striped bicycle lane adjacent to the motor vehicle lane. The width is typically four to six feet of pavement. The gutter pan should not be considered part of the bicycle lane. When placed adjacent to a parking zone, the bike lane should be 5 to 6-feet wide. As described in the description of the shared vehicle zone, if separate bicycle lanes cannot be accommodated, shared lanes are allowed if the outside vehicular lanes are 14 feet and shared lane markings may be considered when travel speeds are 35 mph and below. On streets with limited right of way, shared-lane markings (without a wide outside lane) may be sufficient with travel speeds of 35 mph and below.

Median Zone

The median zone typically provides a landscaped buffer between traffic moving in opposing directions. Medians can also help to provide for pedestrian refuge opportunities in some contexts. Parkways and boulevards typically have a median, avenues may have a median, and main streets may have a median, though it is atypical. Rather than continuous medians, avenues may typically include intermittent landscaped islands to allow for more access, breaks in center turn lanes, and provide pedestrian refuge opportunities. Most two-lane streets do not have a median.

The primary considerations with medians include width and treatment. Median widths vary from 8 feet to 46 feet depending on street type and context. In most urban and suburban locations, curbs will be used to delineate the median from the traveled way. Median breaks should be identified early in the design and should be located to allow for access and to maintain network connectivity. The median zone typically includes street trees and shrubbery. Hardscaping may be provided at narrow points and at specified crossing points to facilitate pedestrian use. At crossing points, landscaping and limbs should be maintained to allow visibility for the pedestrian and motorist.

Another median type is a side median, which is used in a multi-way boulevard configuration. Side medians separate the primary thoroughfare traffic from traffic on the adjacent access street. Side medians are typically 8 feet or less in width.

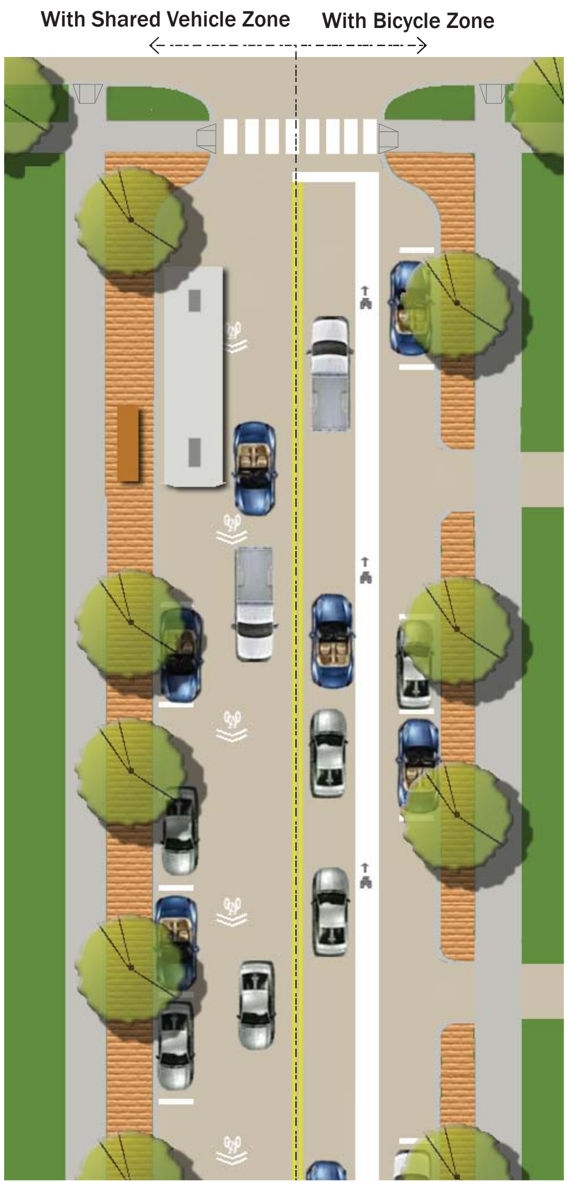
Street Cross-sections and Guidelines

The following pages illustrate street cross-sections for each street type. The purpose of the illustrations is to provide a general understanding of the intended spatial relationships of the various street components for each street type. These illustrations serve as a diagram of one or more possible street configurations.

Dimensional guidelines are provided for the appropriate combinations of street types with subarea type. The guidelines provide ranges that allow the design input team the flexibility to respond to particular conditions. **These cross-sections should not be used in isolation.** Consideration of the context and the elements discussed previously in this guideline document must be brought into the decision making process, as described in Chapter 2. Please also note that all pavement markings and placement of pavement markings should follow the guidelines specified in the current edition of the Manual on Uniform Traffic Control Devices (MUTCD).

URBAN/SUBURBAN MAIN STREET

PLAN VIEW



Not all traffic control devices shown

KEY ELEMENTS

- May function as an arterial, collector or local street. May function as a collector serving as a primary thoroughfare for traffic circulation in a limited area. May function as a local street for an outlying business district.
- Designed to carry vehicles at low speeds.
- A destination street for a city or town, serving as a center of civic, social and commercial activity.
- Serves substantial pedestrian traffic as well as transit and bicycles.
- Characterized by wide sidewalks, crosswalks and pedestrian amenities, due to emphasis on pedestrian travel.
- Bicycle lanes are allowed but typically not necessary on these streets due to lower speeds and volumes and the desire to keep pedestrian crossing distances to a minimum.

STREET CROSS-SECTION ZONES

● *Sidewalk Zone*: The pedestrian walk area is of sufficient width to allow pedestrians to walk safely and comfortably. Pedestrians are the priority on a main street.

● *Green Zone:* Consists of the area between the sidewalk zone and curb. Includes street trees and other landscaping, as well as interspersed street furnishings and pedestrian-scale lighting in a hardscaped amenity zone.

● *Parking/Transit Zone*: Accommodates on-street parking and transit stops. Width and layout may vary.

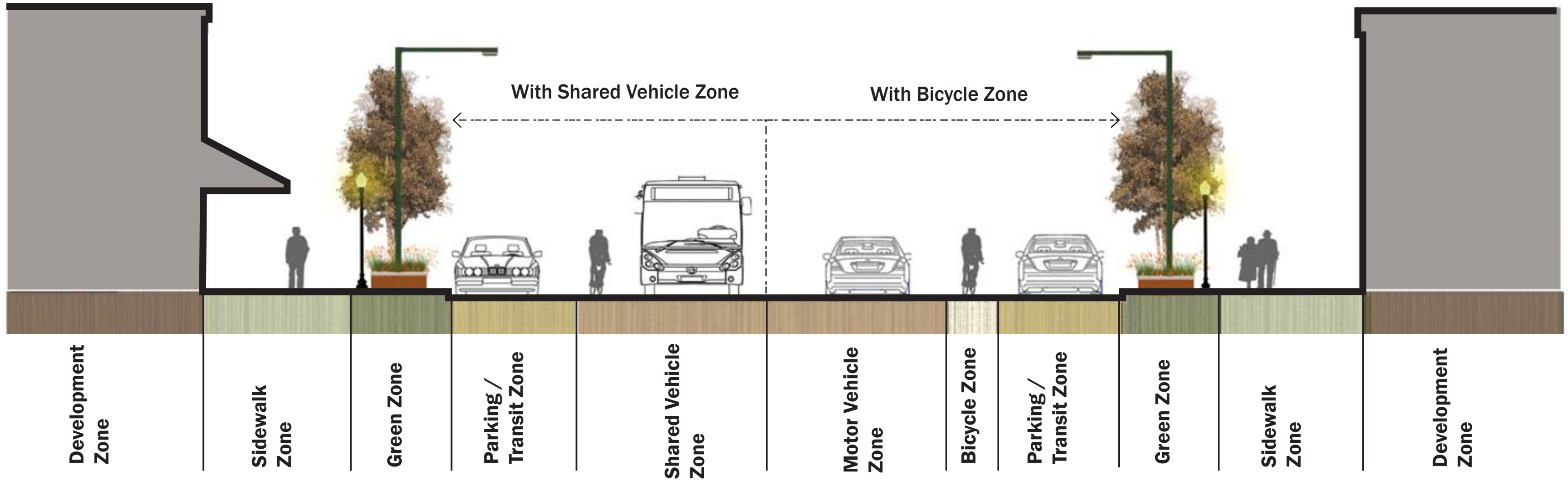
● *Bicycle Zone*: A zone for bicyclists separate from vehicular traffic.

● *Motor Vehicle / Shared Vehicle Zone:* The primary travel way for vehicles. A shared vehicle zone has mixed traffic (cars, trucks, buses and bicycles).

● *Development Zone:* Development should be pedestrian-oriented with narrow setbacks and an active street environment.

URBAN/SUBURBAN MAIN STREET

ILLUSTRATIVE STREET CROSS-SECTION



STREET COMPONENT DIMENSIONAL GUIDELINES

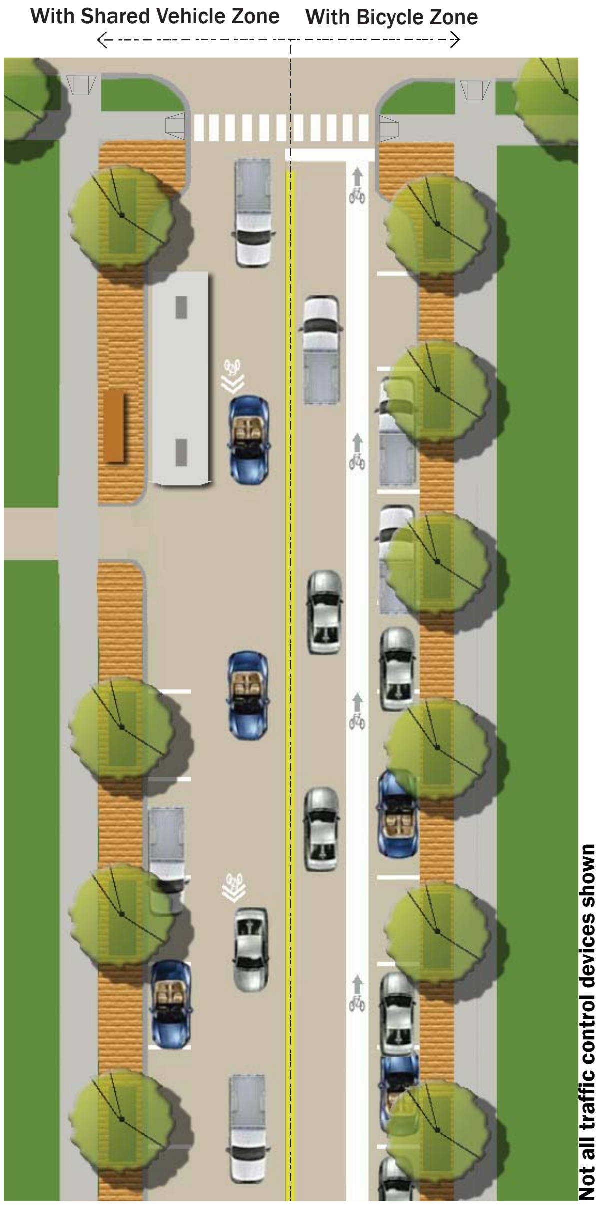
	Sidewalk Zone *(feet)*	Green Zone *(feet)*	Parking /Transit Zone *(feet)*	Motor Vehicle / Shared Vehicle Zone *(lane width- feet)*	Bicycle Zone *(feet)*
Central Business District	10' - 12' 12' - 20' in high volume pedestrian areas	6' - 8'	8' - 10'	10' - 13' (see note 4)	6' lanes (see note 4)
Urban Center / Suburban Center	8' - 12' 12' - 20' in high volume pedestrian areas	6' - 8'	8' - 10'	10' - 13' (see note 4)	6' lanes (see note 4)
Suburban Corridor / Urban Residential / Suburban Residential	8' - 10' 12' - 20' in high volume pedestrian areas	6' - 8'	8' - 10'	10' - 13' (see note 4)	6' lanes (see note 4)

NOTES

1. **Sidewalk zone should typically extend to the front of buildings. Sidewalks are the most important element on a main street, because pedestrians are the priority. Therefore, the sidewalk width should typically be at least 10', unobstructed.**
2. **Green zone may include hardscaping, landscaping, street trees, lighting, and related pedestrian/bicycle/transit amenities. Hardscaping (with street trees in appropriately-designed planters) is typical for access to on-street parking and transit.**
3. **Parking is expected on main streets. Parking zone dimension may vary depending upon type of parking provided. Angle parking is allowed, preferably reverse angle parking. Angle parking will require a wider dimension than shown.**
4. **Shared lanes are the preferred treatment, due to the low speeds. In this case, travel lanes should be 13' to allow for maneuvering and opening car doors. Shared lane markings can be used on streets < 35 mph. If bicycle lane is provided, it should be 6' wide, and motor vehicle lane should be narrowed to 10'.**

RURAL VILLAGE MAIN STREET

PLAN VIEW



KEY ELEMENTS

- May function as an arterial, collector or local street. Could function as an arterial in rural communities. May function as a collector serving as a primary thoroughfare for traffic circulation in a limited area. May function as a local street for an outlying business district.
- Designed to carry vehicles at low speeds.
- Bicycle lanes are allowed but typically not necessary on these streets, due to lower speeds and volumes and the desire to keep pedestrian crossing distances to a minimum.
- A destination for a rural village serving as a center of civic, social and commercial activity.
- Serves substantial pedestrian traffic as well as transit and bicycles.
- Includes wide sidewalks, crosswalks and pedestrian facilities due to the emphasis on pedestrian travel.

STREET CROSS-SECTION ZONES

● *Sidewalk Zone*: The pedestrian walk area is of sufficient width to allow pedestrians to walk safely and comfortably. Pedestrians are priority on a main street.

● *Green Zone:* This zone consists of the area between the sidewalk zone and curb. It includes street trees and other landscaping, as well as interspersed street furnishings and pedestrian-scale lighting in a hardscaped amenity zone.

● *Parking/Transit Zone*: Accommodates on-street parking and transit stops. Parking zone widths and layout may vary.

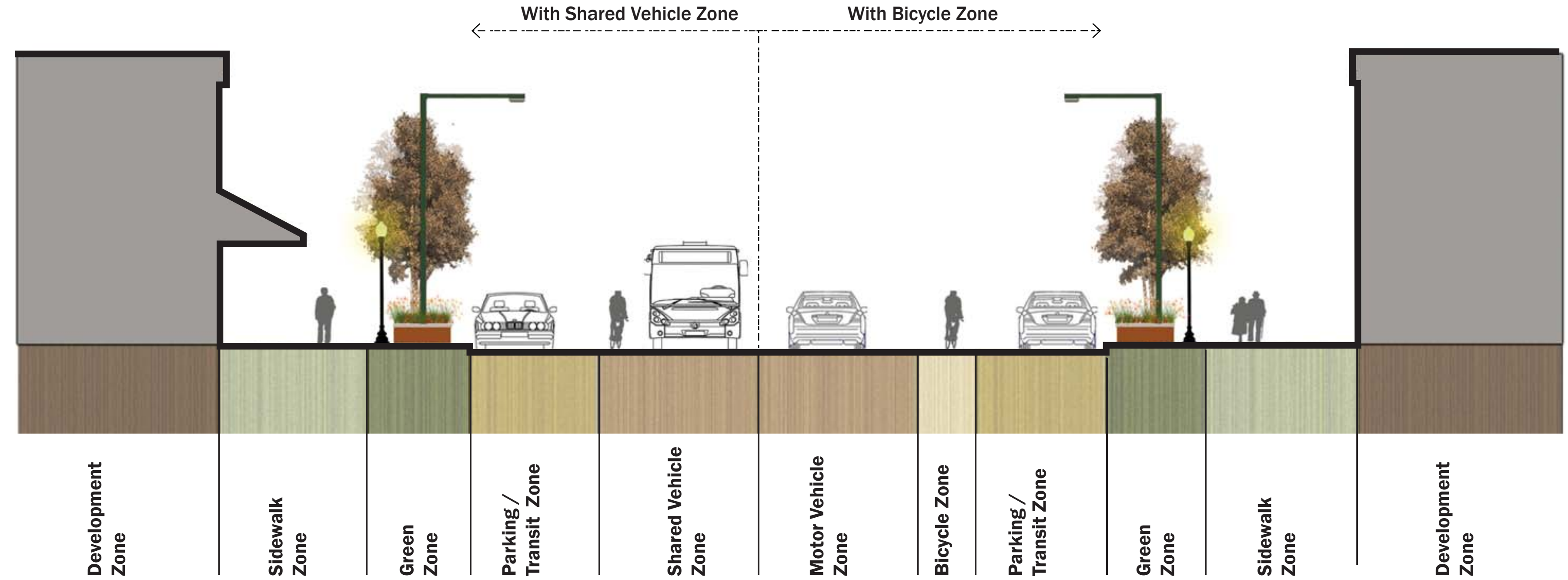
● *Bicycle Zone:* A zone for bicyclists separate from vehicular traffic.

● *Motor Vehicle /Shared Vehicle Zone:* The primary travel way for vehicles. A shared vehicle zone has mixed traffic (cars, trucks, buses, and bicycles).

● *Development Zone:* Development should be pedestrian-oriented with narrow setbacks and an active street environment.

RURAL VILLAGE MAIN STREET

ILLUSTRATIVE STREET CROSS-SECTION



STREET COMPONENT DIMENSIONAL GUIDELINES

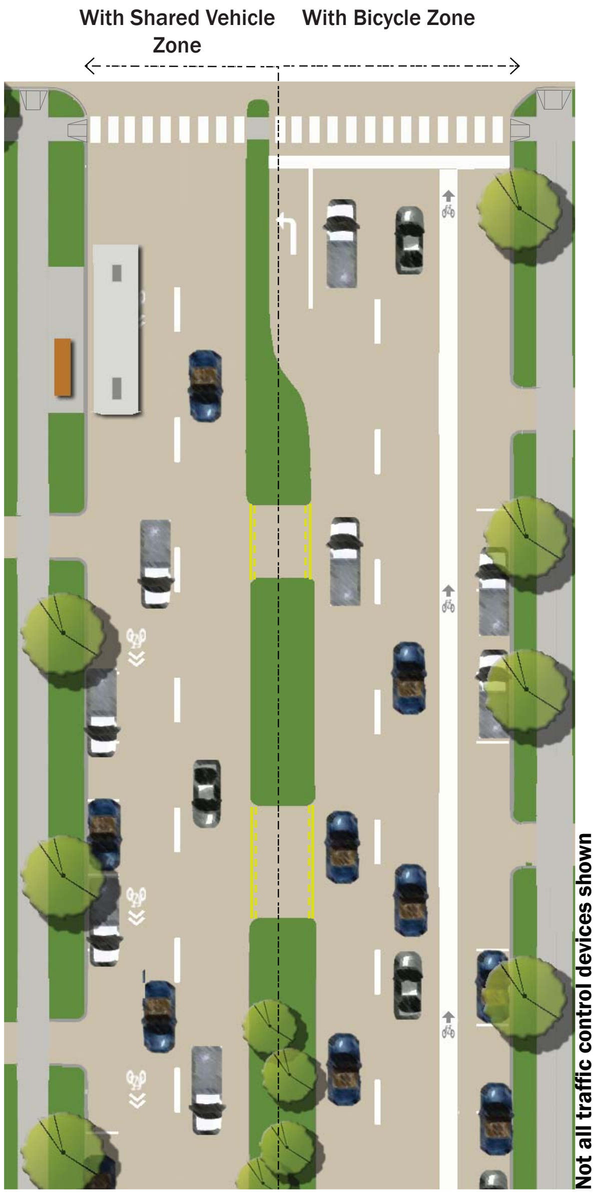
	Sidewalk Zone *(feet)*	Green Zone *(feet)*	Parking /Transit Zone *(feet)*	Motor Vehicle/ Shared Vehicle Zone *(lane width- feet)*	Bicycle Zone *(feet)*
Rural Village	10’ - 12’	6’ - 8’	8’ - 10’	10’ - 13’	4’ - 6’ lanes (see note 4)
Rural Developed	8’ - 10’	6’ - 8’	8’ - 10’	10’ - 13’	4’ - 6’ lanes (see note 4)

NOTES

1. Sidewalk zone should typically extend to the front of the building. Sidewalks are the most important element on a main street, because pedestrians are the priority. Therefore, the sidewalk width should typically be at least 10’ unobstructed.
2. Green zone may include hardscaping, landscaping, street trees, lighting, and related pedestrian /bike /transit amenities. Hardscaping (with street trees in appropriately-designed planters) is typical, for access to on-street parking and transit.
3. Parking is expected on main streets. Parking zone dimensions vary depending upon the type of parking provided. Angle parking is allowed, preferably reverse angle parking. Angle parking will require a wider dimension than shown.
4. Shared lanes are the preferred treatment, due to the low speeds. In this case, travel lanes should be 13’ wide to allow for maneuvering and opening car doors. Shared lane markings can be used on streets < 35 mph. If a bicycle lane is provided, it should be 6’ wide, and the motor vehicle lane should be narrowed to 10’.

URBAN / SUBURBAN AVENUE

PLAN VIEW



KEY ELEMENTS

- May function as an arterial or collector, but generally at low to moderate speeds.
- An urban street serving a range of traffic levels within and between various area types.
- Characterized by wide sidewalks (scaled to the surrounding land uses) and on-street bicycle facilities.
- May have on-street parking.
- Transit stops, shelters and other amenities are located along the street, preferably within the right of way.

STREET CROSS-SECTION ZONES

● *Sidewalk Zone*: The pedestrian walk area is of sufficient width to allow pedestrians to walk safely and comfortably.

● *Green Zone:* The landscaped or hardscaped area along the edge of a street. On avenues, this zone should include grass, landscaping, and shade trees in planting strips or, in some cases, hardscaped amenity zones. Pedestrian or decorative lighting may be provided when appropriate for adjacent land uses.

● *Parking/Transit Zone*: On-street parking is optional and should be considered in relation to providing convenient access to adjacent land uses. Parking zone width and layout may vary.

● *Bicycle Zone:* Accommodation for bicyclists in a zone separate from the motor vehicle zone.

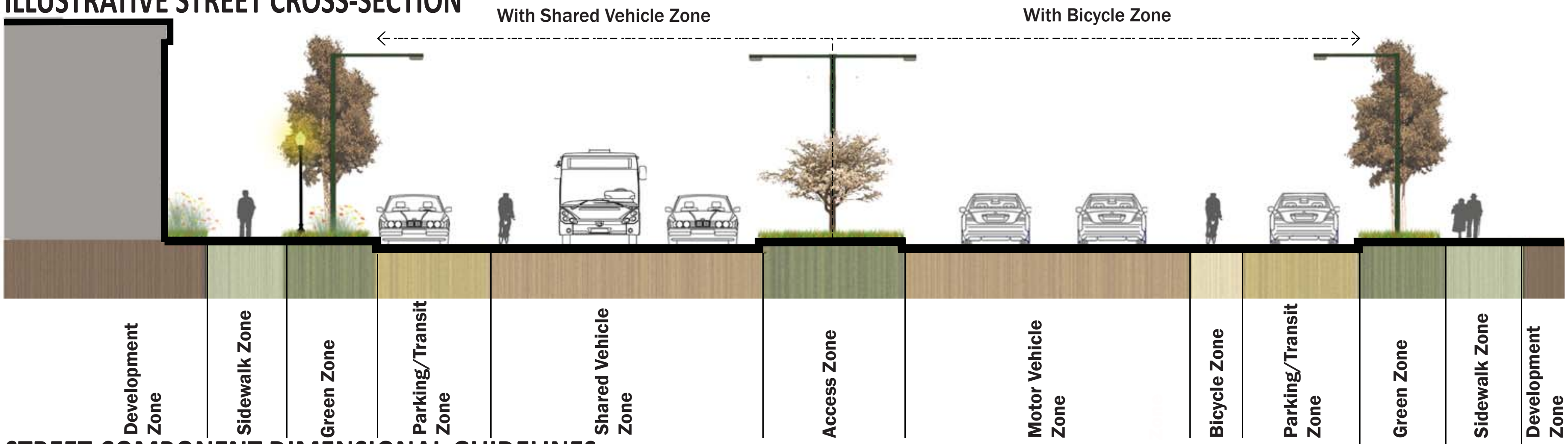
● *Motor Vehicle/Shared Vehicle Zone:* The primary travel way for vehicles. A shared vehicle zone has mixed traffic (cars, trucks, buses and bicycles).

● *Access Zone:* A landscaped zone or turning zone located between the travel lanes as a center median or turn lane. Avenues typically do not include a continuous median.

● *Development Zone:* Development should be oriented toward the street with good functional and visual connection to the street.

URBAN / SUBURBAN AVENUE

ILLUSTRATIVE STREET CROSS-SECTION



STREET COMPONENT DIMENSIONAL GUIDELINES

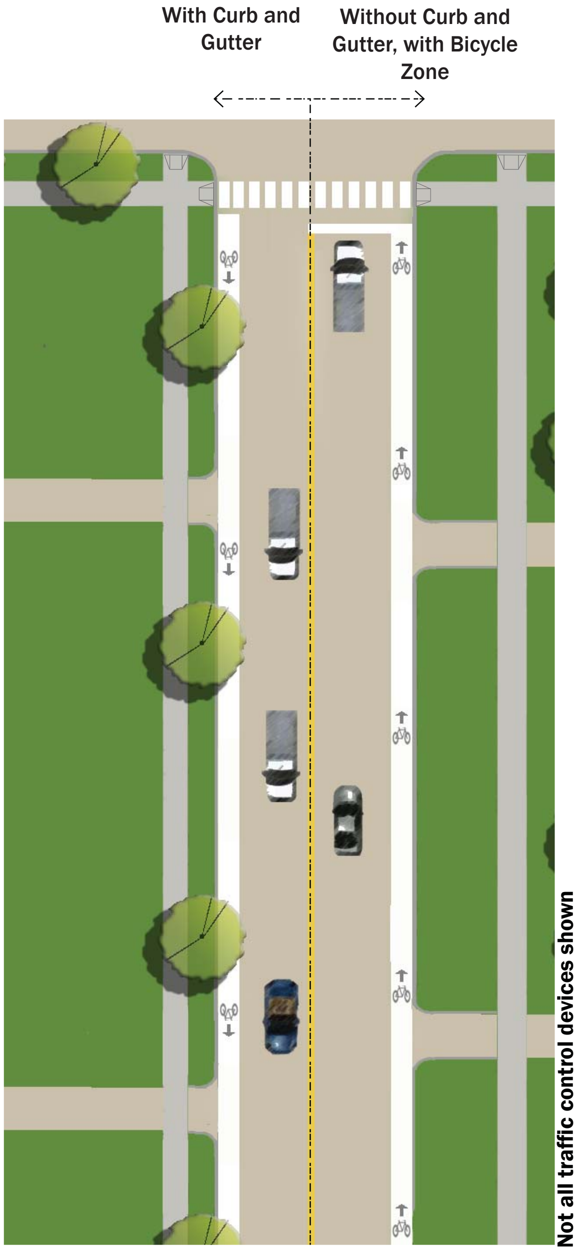
	Sidewalk Zone *(feet)*	Green Zone *(feet)*	Parking /Transit Zone *(feet)*	Motor Vehicle/ Shared Vehicle Zone *(lane width- feet)*	Bicycle Zone *(feet)*	Access Zone *(feet)*
Central Business District	**8' - 12' 12' - 20' in high volume pedestrian areas**	**6' - 8'**	**8' - 10'**	**10' - 11' (see notes 4 & 5)**	**4' - 6' lanes (see notes 4, 5 and 6)**	**0' - 17'6" (see note 7)**
Urban Center / Suburban Center	**6' - 10' 12' - 20' in high volume pedestrian areas**	**6' - 8'**	**8' - 10'**	**10' - 11' (see notes 4 & 5)**	**4' - 6' lanes (see notes 4, 5 and 6)**	**0' - 17'6" (see note 7)**
Suburban Corridor Urban Residential / Suburban Residential	**6' - 8' 12' - 20' in high volume pedestrian areas**	**6' - 8'**	**8' - 10'**	**10' - 11' (see notes 4 & 5)**	**4' - 6' lanes (see notes 4, 5 and 6)**	**0' - 17'6" (see note 7)**

NOTES

1. **Sidewalk zone should typically be a minimum unobstructed width of 6'. In areas that are currently or are planned to be pedestrian-oriented or mixed-use development, minimum 8' – 10' wide unobstructed sidewalks should be provided to allow for higher pedestrian priority and potential extension to the development zone.**
2. **Green zone may include landscaping, street trees, lighting, street furniture, hardscaping in some circumstances, and related pedestrian / bike/ transit amenities. 8' minimum green zone is preferred, to allow for separation between pedestrians and vehicles, and space for street trees.**
3. **Parking is an option on avenues. Parking zone dimension may vary depending upon type of parking provided. Angle parking is allowed, preferably reverse angle parking. Angle parking will require a wider dimension than shown.**
4. **5' bicycle lanes are the preferred treatment. Steep grades may call for wider bicycle lanes. If bicycle lanes are not possible, shared lanes may be allowed. For a shared lane, the outside lane should be a minimum of 14' wide. Shared lane markings can be used on streets ≤35 mph, with either shared lane or standard lane dimensions.**
5. **In the shared vehicle zone and the bicycle zone, the gutter pan is not considered part of the lane width or the bicycle lane width.**
6. **Bicycle lanes located next to on-street parking should be a minimum of 5' or 6' wide (generally, the combined dimension for parking and bicycle lane should be at least 13' from the face of curb).**
7. **Avenues may or may not include a center turn lane with intermittent landscaped islands. Avenues typically do not include a continuous median, but it may be allowed in some circumstances.**
8. **Pedestrian lighting should be considered at mid-block crossings, near transit stops, commercial areas, mixed-use areas or other locations where nighttime pedestrian activity is likely.**

RURAL AVENUE

PLAN VIEW



KEY ELEMENTS

- May function as an arterial, collector or local, route, but generally at low to moderate speeds and volumes.
- A rural street serving a range of traffic levels within and between various area types.
- Characterized by wide sidewalks (scaled to the surrounding land uses) and on-street bicycle facilities.
- May have on-street parking.
- Transit stops, shelters and other amenities are located along the roadway, preferably within the right of way.

STREET CROSS - SECTION ZONES

● *Sidewalk Zone*: The pedestrian walk area is of sufficient width to allow pedestrians to walk safely and comfortably.

● *Green Zone:* The landscaped or hardscaped area along the edge of a street. On avenues this zone should include grass, landscaping, trees in planting strips or, in some cases, hardscaped amenity zones. Pedestrian or decorative lighting may be provided when appropriate for adjacent land uses.

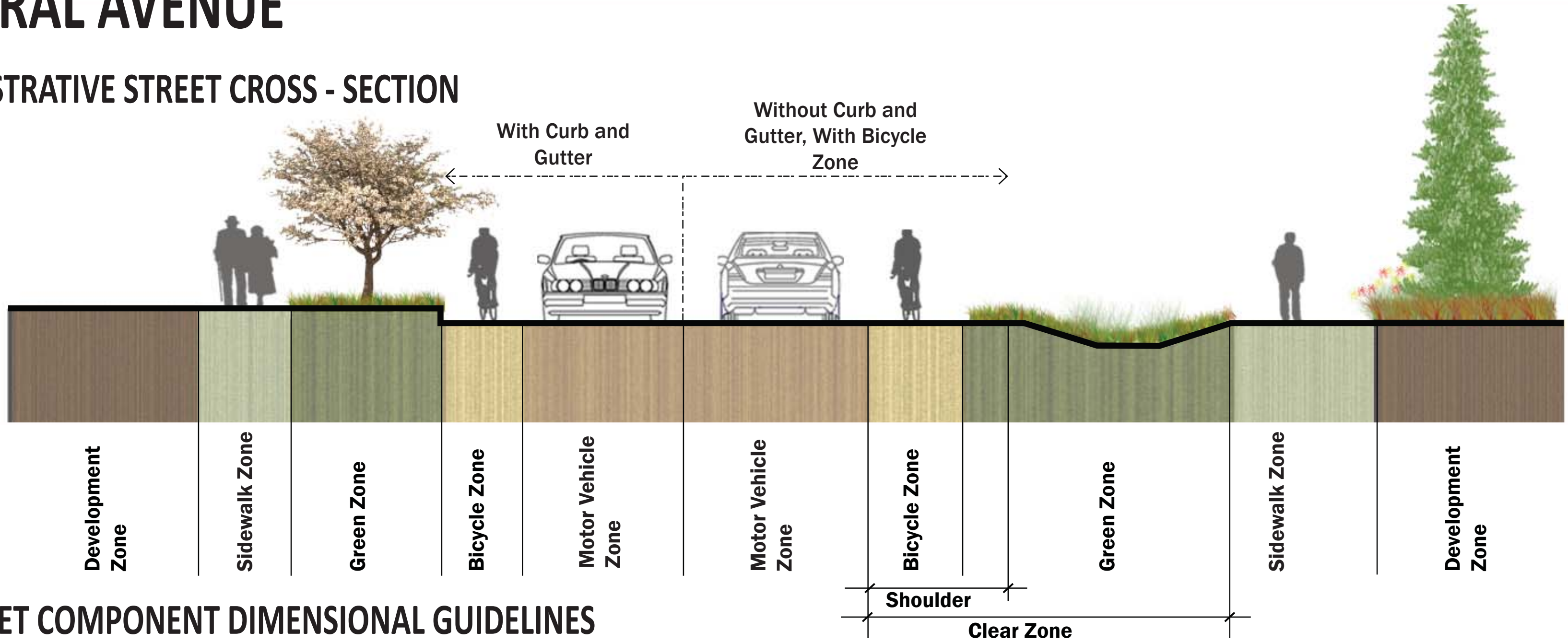
● *Bicycle Zone:* Accommodation for bicyclists in a zone separate from the motor vehicle zone.

● *Motor Vehicle Zone:* The primary travel way for motor vehicles. In a rural avenue without curb and gutter, the green zone would be relied on for drainage conveyance.

● *Development Zone:* Development should be oriented towards the street with good functional and visual connection to the street.

RURAL AVENUE

ILLUSTRATIVE STREET CROSS - SECTION



STREET COMPONENT DIMENSIONAL GUIDELINES

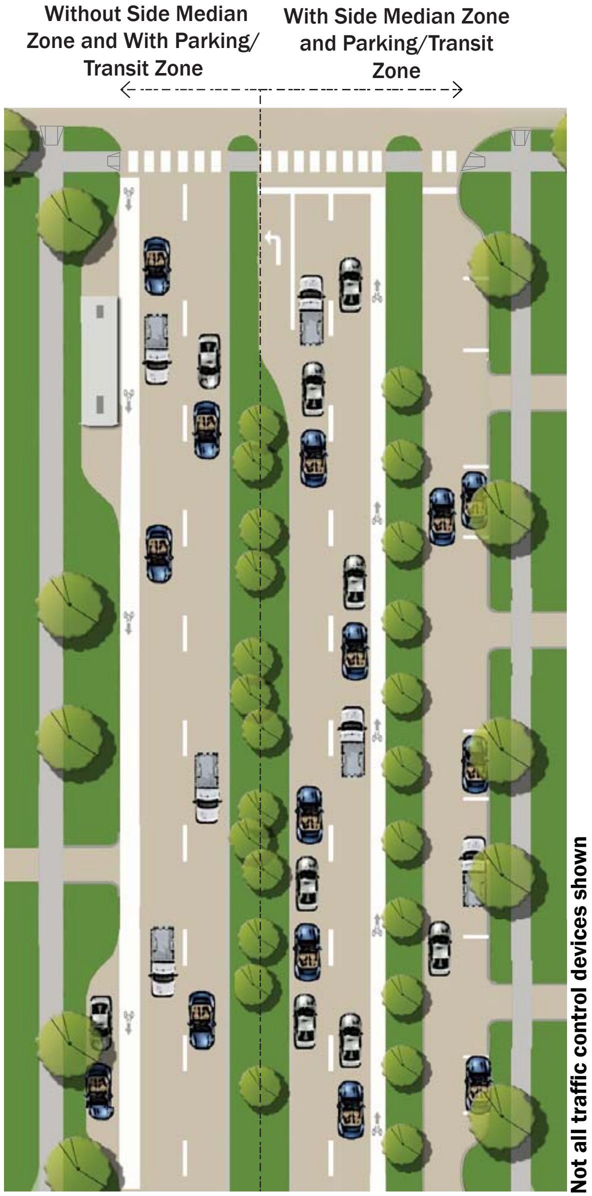
	Sidewalk Zone *(feet)*	Green Zone *(feet)*	Shoulder Zone *(feet)*	Bicycle Zone *(feet)*	Motor Vehicle Zone *(lane width-feet)*
Rural Village	6’ - 8’	4’ - 12’ (see notes 2 and 3)	8’ - 10’	4’ - 6’ bicycle lanes (see notes 5, 6 & 7)	10’ - 12’ lanes
Rural Developed	5’ - 8’	4’ - 12’ (see notes 2 and 3)	8’ - 10’	4’ - 6’ bicycle lanes (see notes 5, 6 & 7)	10’ - 12’ lanes

NOTES

1. Sidewalk zone should typically be a minimum unobstructed width of 6’. In areas that are currently or are planned to be pedestrian-oriented or mixed-use development, 8’ wide unobstructed sidewalks can be provided.
2. Green zone may include landscaping, street trees, lighting, street furniture, hardscaping in some circumstances and related pedestrian/bike/transit amenities. 8’ minimum green zone is preferred, to allow for separation between pedestrians and vehicles, and space for street trees.
3. For areas outside of towns and communities, wider green zones of 10’ to 12’ are preferred where street trees are provided.
4. Parking is an option on avenues. Parking zone dimensions vary depending upon the type of parking provided. Angle parking is allowed, preferably reverse angle parking. Angle parking will require a wider dimension than shown.
5. 5’ bicycle lanes are the preferred treatment. Steep grades may call for wider bike lanes. If bicycle lanes are not possible, shared lanes may be allowed. For a shared lane, the outside lane should be a minimum of 14’ wide. Shared lane markings can be used on streets $\leq$ 35 mph, with either shared lane or standard lane dimensions.
6. In the shared vehicle zone and the bicycle zone, the gutter pan is not considered part of the lane width or the bicycle lane width.
7. Bicycle lanes located next to on-street parking should be a minimum of 5’ wide (generally, the combined dimension for parking and a bicycle lane should be at least 13’ from the face of the curb).
8. Avenues may or may not include a center turn lane with intermittent landscaped islands. Avenues typically do not include a continuous median, but it may be allowed in some circumstances.
9. Pedestrian lighting should be considered adjacent to development.

URBAN / SUBURBAN BOULEVARD

PLAN VIEW



KEY ELEMENTS

- Most often functions as an arterial designed to carry vehicles at moderate speeds.
- Thoroughfare characterized by multiple lanes and including a street median.
- Wide sidewalks and on-street bicycle lanes are necessary to accommodate pedestrians and bicyclists due to higher speeds and higher traffic volumes for motor vehicles.
- Transit stops and shelters may be located within the right of way, requiring connections to sidewalks.
- On-street parking is not required. It is allowed where appropriate, but rare due to the nature of the street. If provided, parking should typically be placed on a separate, parallel frontage street separated with a side median.

STREET CROSS-SECTION ZONES

● *Sidewalk Zone*: The pedestrian walk area is of sufficient width to allow pedestrians to walk safely and comfortably.

● *Green Zone:* This zone serves to separate the sidewalk from the vehicles. This zone contains landscaping and trees or, in some circumstances, hardscape treatments.

● *Parking/Transit Zone*: Accommodates on-street parking and transit pull-outs. Parking on the street is rare, but may be separated from the motor vehicle zone by side medians. Width and layout may vary depending on the type of parking provided.

● *Bicycle Zone:* A zone for bicyclists separate from vehicular traffic.

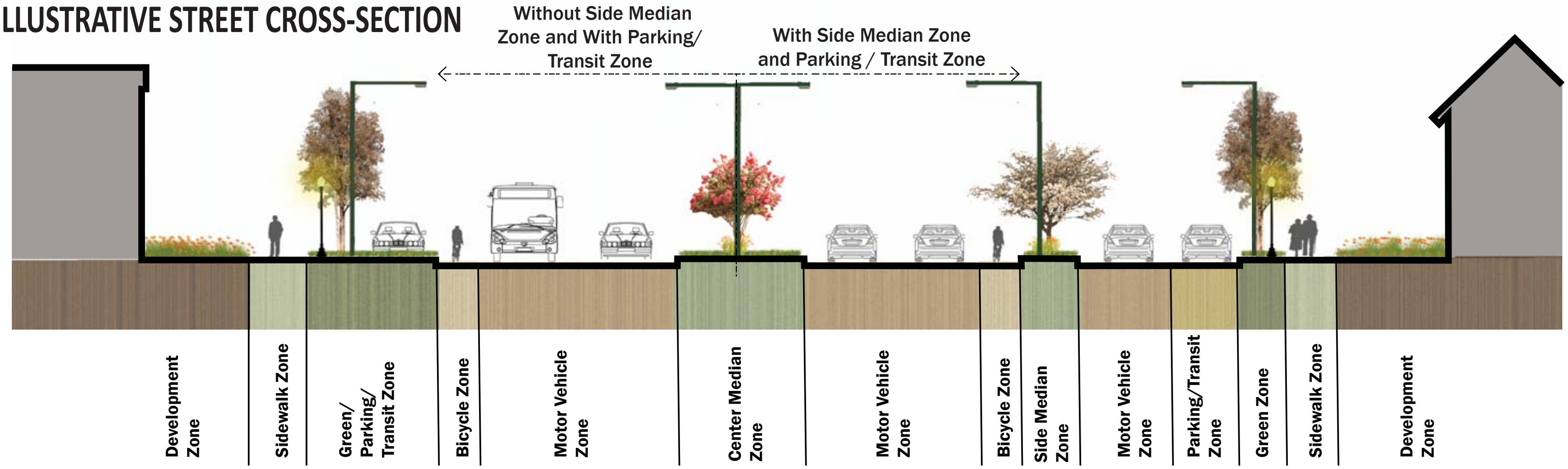
● *Motor Vehicle Zone:* The primary travel way for motor vehicles.

● *Median Zone:* A landscaped zone located between the travel lanes as a center median or as side medians that separate one-way parallel lanes. Median zones should consider provision for turn bays at intersections. May include hardscaping at pedestrian crossings.

● *Development Zone:* Building setbacks vary but are typically deeper than on avenues. Building frontage may not always be directed to the street but physical connections to the street from building entrances are important.

URBAN / SUBURBAN BOULEVARD

ILLUSTRATIVE STREET CROSS-SECTION



STREET COMPONENT DIMENSIONAL GUIDELINES

	Sidewalk Zone *(feet)*	Green Zone *(feet)*	Parking /Transit Zone *(feet)*	Bicycle Zone *(feet)*	Motor Vehicle Zone *(lane width- feet)*	Center Median Zone *(feet)*	Side Median Zone *(feet)*
Central Business District	6' - 10' 12' - 20' in high volume pedestrian areas	6' - 8'	8' - 10'	4' - 6' lanes (see notes 3 and 4)	10' - 11'	8' - 30'	8'+
Urban Center / Suburban Center	6' - 8' 12' - 20' in high volume pedestrian areas	6' - 8'	8' - 10'	4' - 6' lanes (see notes 3 and 4)	10' - 11'	8' - 30'	8'+
Suburban Corridor / Urban Residential / Suburban Residential	6' - 8' 12 '- 20' in high volume pedestrian areas	6' - 8'	8' - 10'	4' - 6' lanes (see notes 3 and 4)	10' - 11'	8' - 30'	8'+

NOTES

1. Sidewalk zone should typically be a minimum unobstructed width of 6'. In areas that are currently or are planned to be pedestrian-oriented or mixed-use development, minimum 8' wide unobstructed sidewalks should be provided.
2. Green zone may include landscaping, street trees, lighting, street furniture, and related pedestrian/bike/transit amenities. 8' minimum green zone is preferred, to allow for separation between pedestrians and vehicles, and space for street trees.
3. 5' bicycle lanes are the preferred treatment. Steep grades may call for wider bike lanes. If bicycle lanes are not possible, shared lanes may be allowed. For a shared lane, the outside lane should be a minimum of 14' wide. Shared lane markings can be used on streets ≤ 35 mph, with either shared lane or standard lane dimensions.
4. The gutter pan is not considered part of the bicycle lane width. Bicycle lanes located next to parking should be a minimum of 5' or 6' wide.
5. The gutter pan is not considered part of the motor vehicle lane width in most circumstances.
6. Median zone requirements vary depending upon appropriate treatment (hardscape, landscape, drainage, curb and gutter, or street trees). Though the median width may vary, the median will typically be 17' 6", to allow for a turn lane and pedestrian refuge at intersections. The minimal 8' width will allow for landscaping and pedestrian refuge at appropriate locations. A 30' wide median should be provided to accommodate double left turn lanes when multi-modal analysis confirms the need.
7. Continuous two-way left turn lanes are not permitted on a boulevard.
8. Parking/transit stop zone is rare, but is allowed where appropriate.

RURAL BOULEVARD

PLAN VIEW

KEY ELEMENTS

- Most often functions as an arterial designed to carry vehicles at moderate speeds.
- Thoroughfare characterized by multiple lanes and including a street median.
- Wide sidewalks and on-street bicycle lanes are necessary to accommodate pedestrians and bicyclists due to higher speeds and higher traffic volumes for motor vehicles.
- Building setbacks will typically be deeper than on avenues.
- Transit stops and shelters may be located within the right of way, requiring connections to sidewalks.
- On-street parking is not required. It is allowed where appropriate, but rare due to the nature of the street and adjacent land uses.

STREET CROSS - SECTION ZONES

● *Sidewalk Zone*: The pedestrian walk area is of sufficient width to allow pedestrians to walk safely and comfortably.

● *Green Zone:* This zone serves to separate the sidewalk from the vehicles. This zone contains landscaping and trees or, in some circumstances, hardscape treatments. The green zone may be wider if providing an intermittent parking / transit zone.

● *Bicycle Zone:* Accommodation for bicyclists either in a separate zone or within the shared vehicle zone.

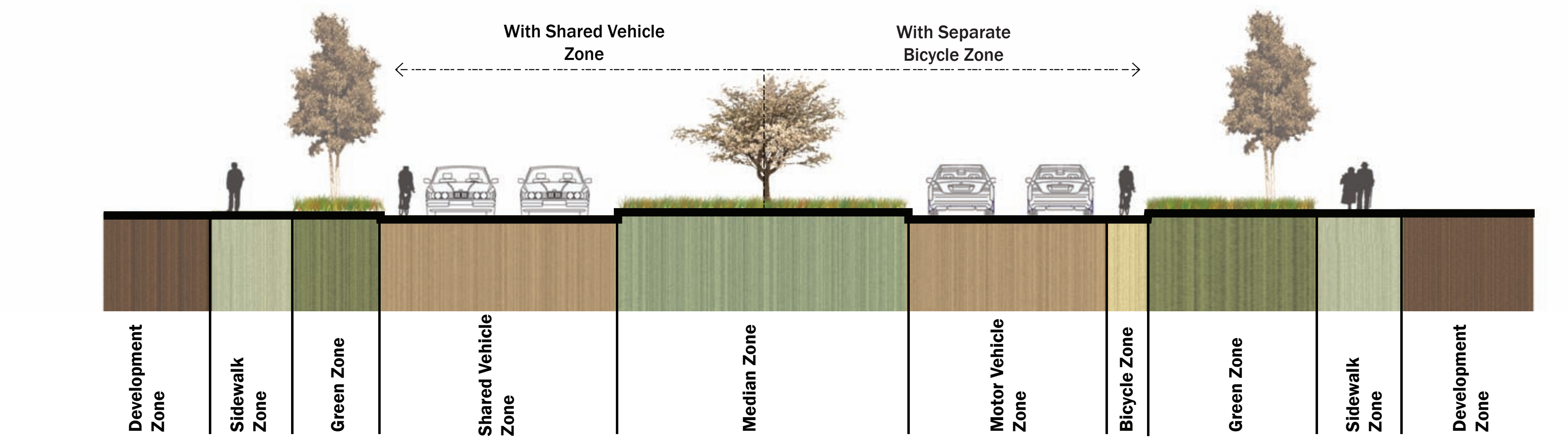
● *Motor Vehicle/Shared Vehicle Zone:* The primary travel way for vehicles. A shared vehicle zone has mixed traffic (cars, trucks, buses and bicycles).

● *Median Zone:* A landscaped zone located between the travel lanes as a center median. Median zones should consider provision of turn bays at intersections. The median zone may include hardscaping at pedestrian crossings.

● *Development Zone:* Building setbacks vary, but are typically deeper than avenues. Building frontage may not always be directed to the street, but physical connections to the street from building entrances are important.

RURAL BOULEVARD

ILLUSTRATIVE STREET CROSS - SECTION



STREET COMPONENT DIMENSIONAL GUIDELINES

	Sidewalk Zone *(feet)*	Green Zone *(feet)*	Motor Vehicle/ Shared Vehicle Zone *(lane width- feet)*	Median Zone *(feet)*	Bicycle Zone *(feet)*
Rural Village / Rural Developed	6' - 8'	6' - 10' (see note 2)	10' - 12'	17' 6" - 30'	4' - 6' bicycle lanes (see notes 3 & 4)

NOTES

1. Sidewalk zone should typically be a minimum unobstructed width of 6'. In areas that are currently or are planned to be pedestrian-oriented or mixed use development, 8' wide unobstructed sidewalks can be provided.
2. Green zone may include landscaping, street trees, lighting, street furniture, and related pedestrian/bike/transit amenities. 8' minimum green zone is preferred, to allow for separation between pedestrians and vehicles, and space for street trees. Green zone may be wider if providing intermittent parking / transit stop zone. Parking/transit stop zone is rare, but allowed where appropriate.
3. 5' bicycle lanes are the preferred treatment. Steep grades may call for wider bike lanes. If bicycle lanes are not possible, shared lanes may be allowed. For a shared lane, the outside lane should be a minimum of 14' wide. Shared lane markings can be used on streets ≤ to 35 mph, with either shared lane or standard lane dimensions.
4. The gutter pan is not considered part of the bicycle lane width. Bicycle lanes located next to parking should be a minimum of 5' wide.
5. The gutter pan is not considered part of the motor vehicle lane width, in most circumstances.
6. Median zone requirements vary depending upon appropriate treatment (hardscape, landscape, drainage, curb and gutter, or street trees). Though the width may vary, the median will typically be between 17'-6" - 30', to allow for a turn lane and pedestrian refuge at intersections.
7. Continuous two-way left turn lanes are not permitted on a boulevard.

URBAN/SUBURBAN PARKWAY

PLAN VIEW

Not all traffic control devices shown

KEY ELEMENTS

- Most often functions as an arterial designed with control of access to carry vehicles at moderate to high speeds.
- Urban or suburban thoroughfare often characterized by landscaping or natural vegetation along roadsides and medians.
- Land uses are set back from the street and are typically not oriented toward the parkway.
- Pedestrian and bicycle traffic usually provided for on separate multi-use paths ideally located adjacent to the facility.
- Convenient access to off-street transit stations, stops and park-and-ride lots.
- Trailer and semitrailer truck traffic is frequently present.

STREET CROSS - SECTION ZONES

● *Multi-Use Path Zone*: A zone for pedestrians and bicyclists in a multi-use path separate from the motor vehicle zone. Please see *Multi-Use Path Zone typology* for more details.

● *Green Zone:* Consists of a planting strip with trees to separate the multi-use path zone from the motor vehicle zone. On parkways, typically includes a clear zone.

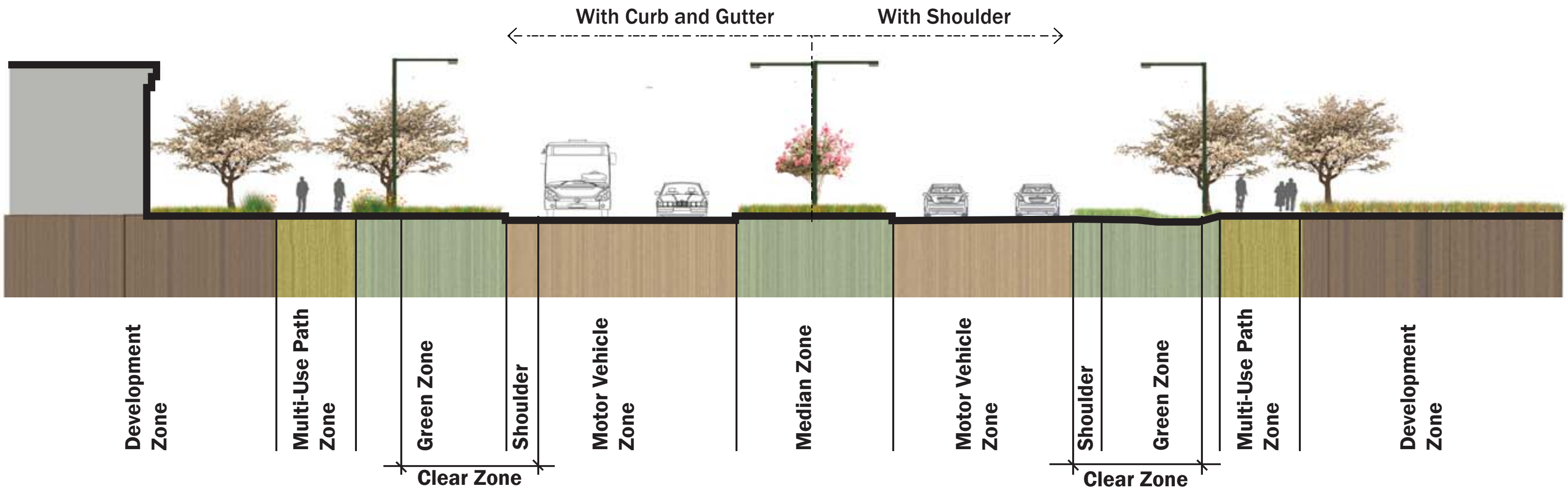
● *Motor Vehicle Zone:* The primary travel way for motor vehicles.

● *Median Zone:* A landscaped zone located between the travel lanes as a center median.

● *Development Zone:* Deep setbacks due to the typically auto-oriented nature of the street. Access to this zone is limited and controlled.

URBAN/SUBURBAN PARKWAY

ILLUSTRATIVE STREET CROSS - SECTION



STREET COMPONENT DIMENSIONAL GUIDELINES

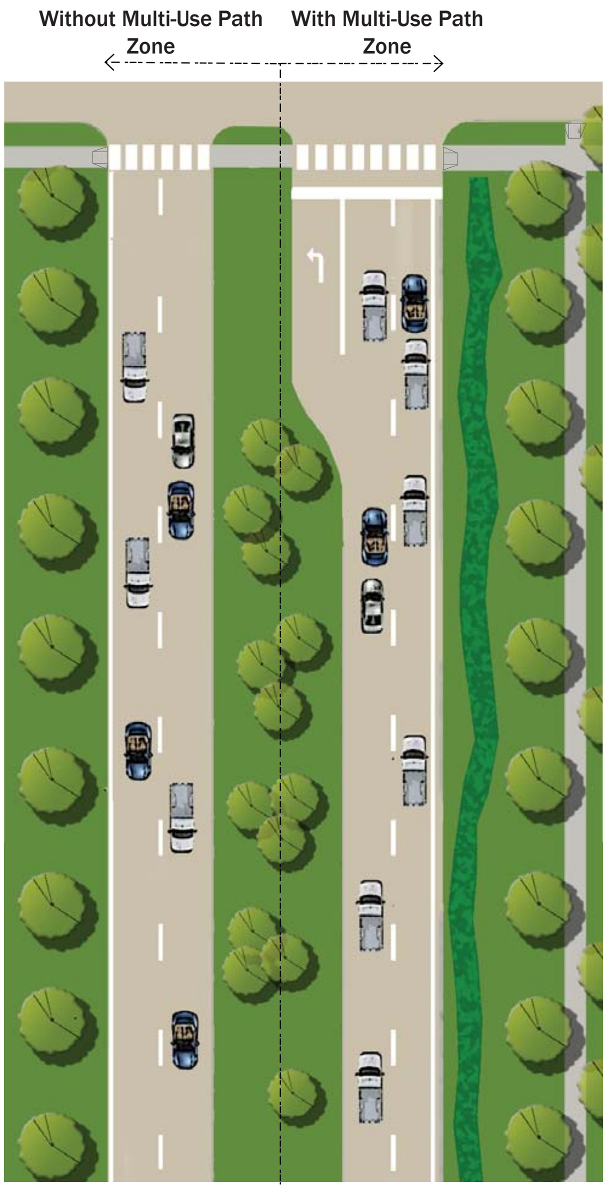
	Multi - Use Path Zone *(feet)*	Green Zone *(feet)*	Motor Vehicle Zone *(lane width- feet)*	Median Zone *(feet)*
Central Business District	**10' - 12' 12' - 20' in high volume pedestrian areas**	**See notes 1 and 2**	**11' - 12'**	**17' 6" - 32'**
Urban Center / Suburban Center	**10' - 12' 12' - 20' in high volume pedestrian areas**	**See notes 1 and 2**	**11' - 12'**	**17' 6" - 32'**
Suburban Corridor / Urban Residential / Suburban Residential	**10' - 12' 12' - 20' in high volume pedestrian areas**	**See notes 1 and 2**	**11' - 12'**	**17' 6" - 32'**

NOTES

1. **Green zone may include landscaping and, in areas beyond the clear zone, large-maturing trees.**
2. **Green zone should provide a minimum width equal to the clear zone requirement, typically 20' - 30'.**
3. **In the motor vehicle zone, the gutter pan is not considered part of the lane width.**
4. **Median zone requirements vary depending upon median treatment (landscaping, curb and gutter, or trees).**
5. **Continuous two-way left turn lanes are not permitted on a parkway.**
6. **Multi-use path is the preferred treatment for bicycles and pedestrians on a parkway. See multi-use path section.**
7. **Shoulders are allowable on an urban parkway, if deemed appropriate.**
8. **On shoulder sections the shoulder may be a combination of pavement and grass.**

RURAL PARKWAY

PLAN VIEW



Not all traffic control devices shown

KEY ELEMENTS

- Most often functions as an arterial designed with control of access to carry vehicles at moderate to high speeds.
- Rural thoroughfare often characterized by landscaping or natural vegetation along roadsides and medians.
- Land uses are set back from the street and are typically not oriented toward the parkway.
- Pedestrian and bicycle traffic usually provided on separate multi-use paths ideally located adjacent to the facility.
- Convenient access to on-street transit facilities and off-street stations and park and ride lots.
- Large truck traffic may be present.

STREET CROSS - SECTION ZONES

● *Green Zone:* Consists of a planting strip with trees to separate the multi-use path zone from the motor vehicle zone. A portion of the green zone is the roadway shoulder. Parkways typically include a clear zone.

● *Motor Vehicle Zone:* The primary travel way for through vehicles. A rural parkway would typically not have curb and gutter, and therefore the green zone would be relied on for drainage conveyance.

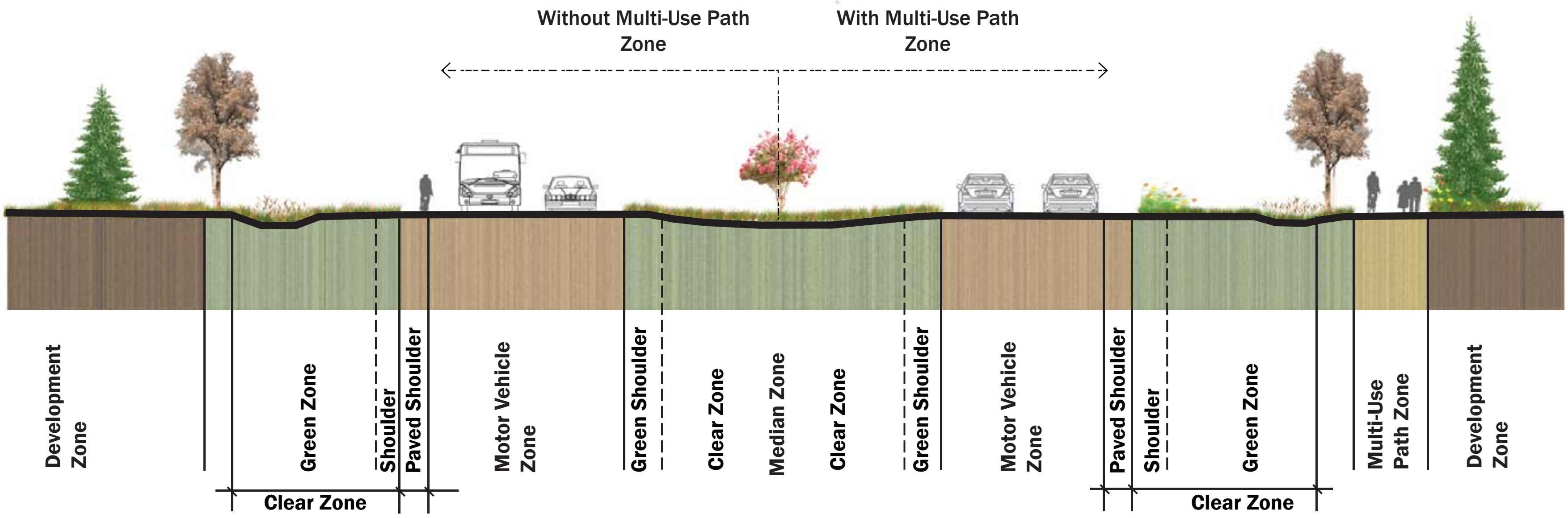
● *Median Zone:* A landscaped zone located between the travel lanes in the center of the street. A wide median would be needed for drainage conveyance.

● *Multi-Use Path Zone*: A zone for pedestrians and bicyclists in a multi-use path separate from the motor vehicle zone. Please see *Multi-Use Path Zone Typology* for more details.

● *Development Zone:* Deep setbacks due to the typically auto-oriented nature of the street. Access to this zone is limited and controlled.

RURAL PARKWAY

ILLUSTRATIVE STREET CROSS - SECTION



STREET COMPONENT DIMENSIONAL GUIDELINES

	Multi-Use Path Zone *(feet)*	Green Zone *(feet)*	Shoulder *(feet)*	Motor Vehicle Zone *(lane width- feet)*	Median Zone *(feet)*
Village / Developed	**10’ - 12’**	**see notes 3 and 4**	**8’ - 10’**	**11’ - 12’**	**32’ - 46’**
Countryside	**10’ - 12’**	**see notes 3 and 4**	**8’ - 10’**	**12’**	**32’ - 46’**

NOTES

1. Multi-use path is the preferred treatment for bicycles and pedestrians on a parkway. Multi-use path should be provided on each side behind the green zone, as appropriate. See multi-use path section.
2. Multi-use path may be in the right-of-way or in an easement.
3. Green zone may include landscaping and, in areas beyond the clear zone, large-maturing trees.
4. Median zone requirements vary depending upon median treatment (landscaping, curb and gutter, or trees).
5. Green zone should provide a minimum width equal to the clear zone requirement, typically 30’.
6. The shoulder may be a combination of pavement and grass. If a paved shoulder is provided, it may serve as a bicycle zone, though a multi-use path is preferred.

RURAL ROAD

PLAN VIEW

KEY ELEMENTS

- May function as an arterial, collector or local route, but with a range of speeds.
- A road outside of cities and towns serving a range of traffic levels in a country setting.
- Paved shoulders can be used to provide bicycles and pedestrians accommodation.
- Multi-use paths separated from the roadway may be appropriate treatment for bicycle and pedestrian accommodations.
- Accommodates bus facilities including turnouts as appropriate. Public transit stops and shelters should be clearly marked and placed within the right of way.

STREET CROSS-SECTION ZONES

Sidewalk Zone: Sidewalks on rural roads are rare. If sidewalk is provided it should be placed outside of the clear zone.

Green Zone: The landscaped area along the edge of a roadway and could include grass, landscaping or trees (as permitted). Serves as drainage conveyance.

Bicycle Zone: A zone for bicyclists separate from vehicular traffic.

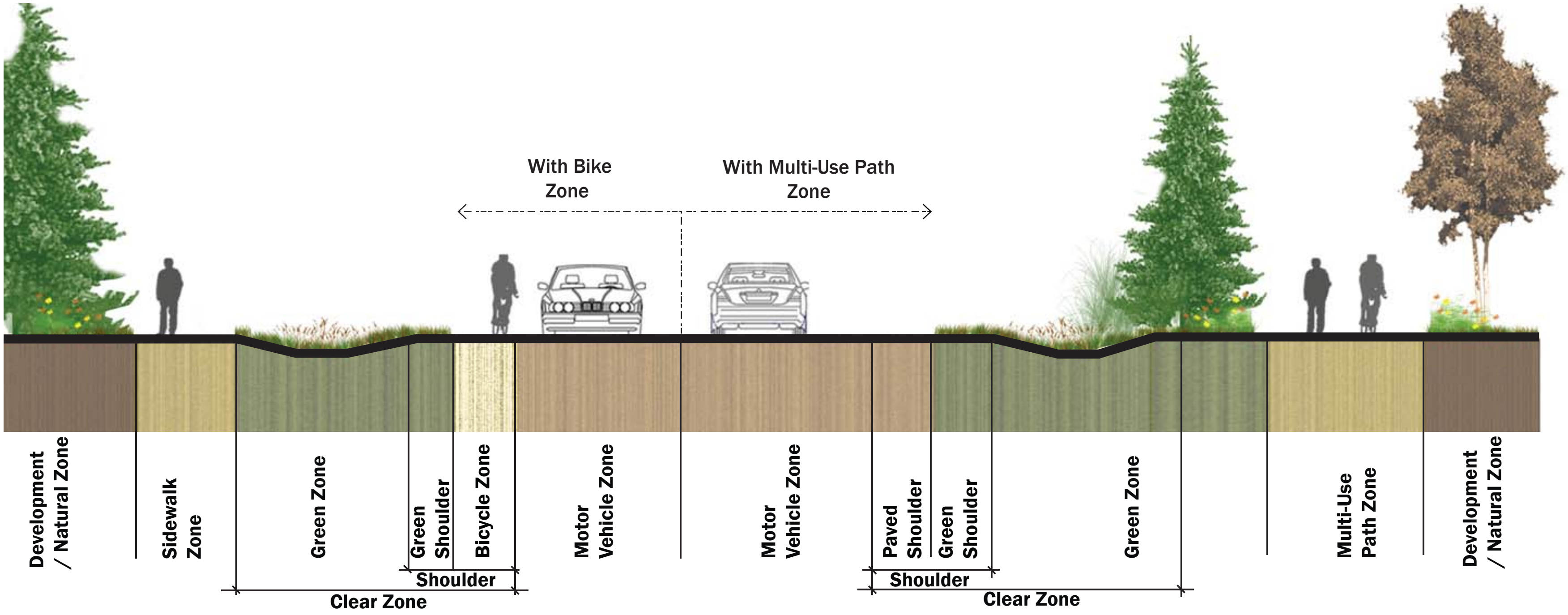
Motor Vehicle Zone: The primary travel way for vehicles.

Multi-Use Path Zone: A zone for pedestrians and bicyclists in a multi-use path separate from the motor vehicle zone. Please see *Multi-Use Path Zone Typology* for more details.

Development Zone / Natural Zone: Land uses are typically set back from the street. This zone may also consist of natural vegetation.

RURAL ROAD

ILLUSTRATIVE STREET CROSS-SECTION



STREET COMPONENT DIMENSIONAL GUIDELINES

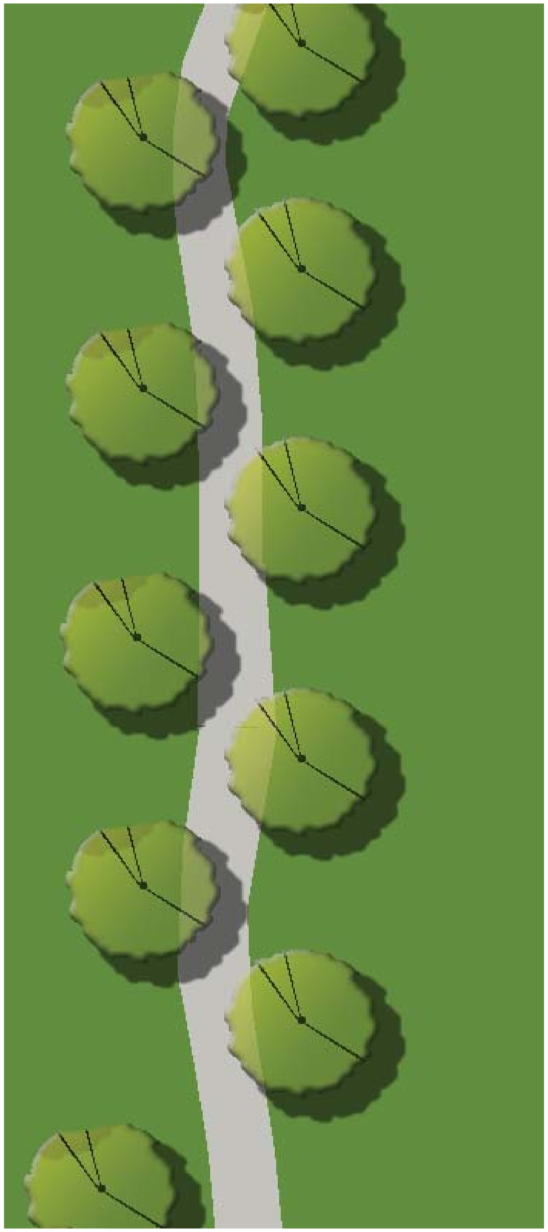
	Sidewalk Zone *(feet)*	Green Zone *(feet)*	Bicycle Zone *(feet)*	Motor Vehicle Zone *(lane width- feet)*	Shoulder Zone *(feet)*	Multi-Use Path Zone *(feet)*
Countryside	5’ minimum	See note 2	4’ - 6’ bicycle lanes (see note 3)	10’ - 12’	6’ - 8’	10’ - 12’

NOTES

1. Green zone is the grassed roadway shoulder and the ditch or fill slope. At intersections and intermediate locations it may include hardscaping to provide connectivity to pedestrian/bicycle/transit amenities.
2. The green zone and the shoulder for resurfacing, restoration, and rehabilitation (R-R-R) work on high-speed rural roads should be a minimum of 15’ in width. The green zone and the shoulder for new construction work on high-speed rural roads should be 30’ in width.
3. A 4’ paved shoulder without standard bicycle markings is commonly used in the place of bicycle lanes. A steep grade may require a slightly wider paved shoulder. On rural roads with lower access densities, higher speeds, and higher volumes, a separate 10-12’ multi-use path could be considered to provide pedestrians and bicycles accommodation.
4. In typical rural settings the roadway shoulder provides the pedestrian walking area.
5. If sidewalk is deemed appropriate, it should be located behind the ditch and outside of the clear zone.

MULTI-USE PATH

PLAN VIEW



Not all traffic control devices shown

KEY ELEMENTS

- Multi-use path can be provided as part of a parkway, rural road or greenway.
- Link multi-use paths (especially greenway trails) to make connections between homes, parks, schools, and shopping districts.
- Shade trees are recommended.
- Provide a green zone of 3’- 6’ on either side of the path.
- Pedestrian lighting should be considered in more urban environments.

PATH CROSS-SECTION ZONES

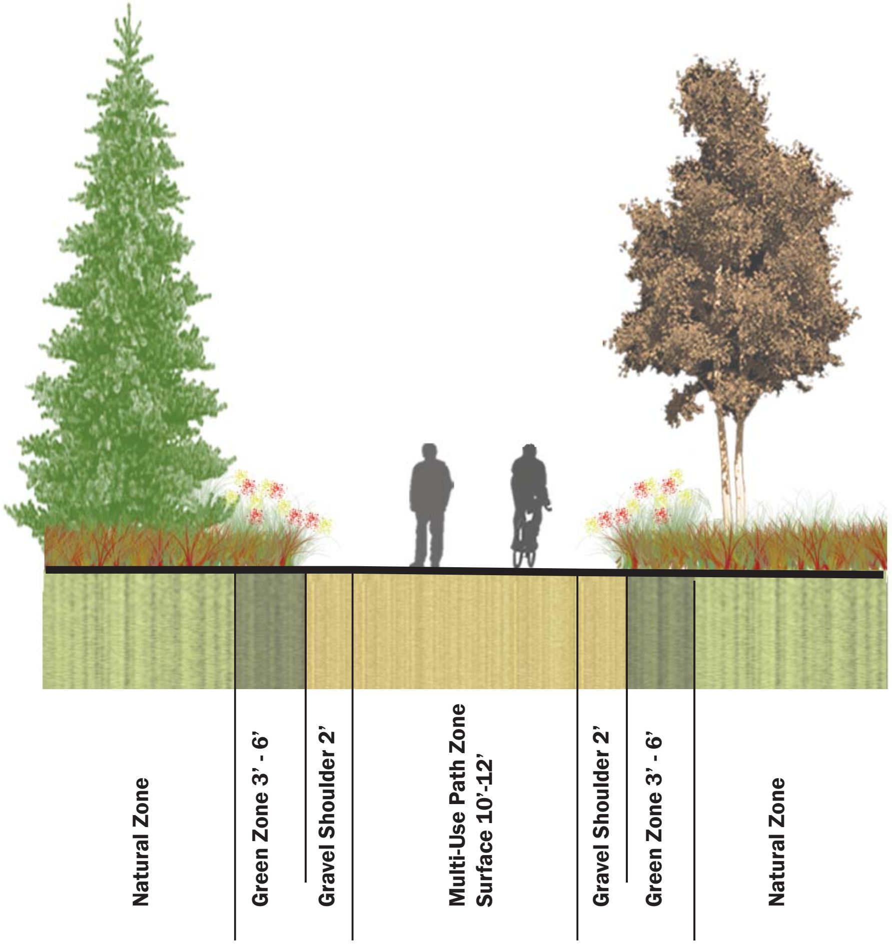
🟩 *Natural Zone*: Buffer and offset for trees and other vegetation.

🟩 *Green Zone:* This zone is a planting strip used to create lateral offset from edge of the multi-use path to trees and other objects.

🟨 *Multi-Use Path Zone*: A zone for pedestrians and bicyclists in a multi-use path separate from the motor vehicle zone. Please see *Multi-Use Path Typology* for more details.

MULTI-USE PATH

ILLUSTRATIVE PATH CROSS-SECTION



LOCAL / SUBDIVISION STREET: RESIDENTIAL

PLAN VIEW

KEY ELEMENTS

- Carries traffic at a low speed.
- Street within a neighborhood or residential development providing direct access to land use.
- Provides additional linkages and connections within and to the overall street network.
- On-street parking typically occurs at different levels depending on land use characteristics. Parking demand will affect street width.
- Pedestrian activity is expected, encouraged, and to be accommodated.
- Local streets provide important connections in the bicycle network.
- Bike lanes are typically not necessary due to low speed and volumes, but are allowed. In some cases, local streets can serve as parallel bicycle or transit route to heavier traveled streets.

STREET CROSS-SECTION ZONES

● *Development Zone:* Density and setbacks will vary, but all should be oriented to the street to support pedestrian access and activity along the street.

● *Sidewalk Zone*: The pedestrian walk area is of sufficient width to allow pedestrians to walk safely and comfortably.

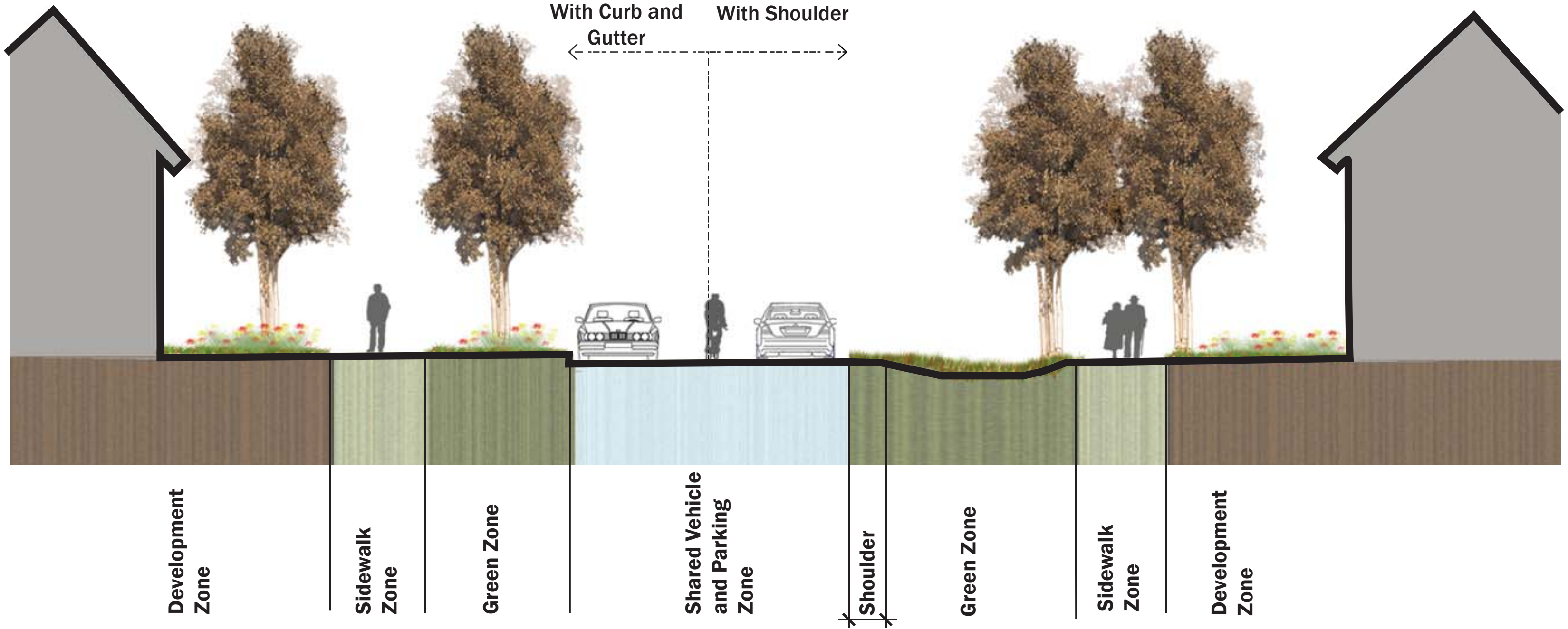
● *Green Zone:* Consists of a planting strip (or, in very urban areas, a hardscaped area), with street trees between the sidewalk zone and the edge of street.

● *Shared Vehicle and Parking Zone:* The primary travel way that includes mixed traffic (cars, trucks, buses and bicycles) and on-street parking. Local streets will be two lanes with varying provisions for parking.

* The discussion of local streets begins on page 59.

LOCAL / SUBDIVISION STREET: RESIDENTIAL

ILLUSTRATIVE STREET CROSS-SECTION



STREET COMPONENT DIMENSIONAL GUIDELINES

	Minimum Travelway F.O.C. to F.O.C. *(feet)*	Sidewalk Zone *(feet)*	Green Zone *(feet)*	Parking Zone *(feet)*	Lane Width *(feet)*	Shoulder *(feet)*
Local / Subdivision (Traditional Neighborhood Guidelines - Lane)	18’	5’ - 6’	4’ - 8’	very low demand	9’ with no parking	4’ - 6’
Local / Subdivision (Low Parking Demand)	24’	5’ - 6’	4’ - 8’	low demand	10’ with low demand parking	4’ - 6’
Local / Subdivision (Parking On 1 Side)	26’	5’ - 6’	4’ - 8’	7’ on one side	9’ with parking/ 13’ with no parking	4’ - 6’
Local / Subdivision (Parking On 2 Sides)	34’	5’ - 8’	4’ - 8’	7’ on both sides	10’ with one parked vehicle / 9’ with two parked vehicles	4’ - 6’

NOTES

1. Minimum travelway measured from Face of Curb (FOC) to FOC.
2. Median typically not provided on local streets unless for aesthetic reasons. If provided, lane widths will be increased by 2’ - 5’.
3. Shoulder zone on local street typically has grass.

LOCAL / SUBDIVISION: OFFICE, COMMERCIAL AND INDUSTRIAL

PLAN VIEW

Not all traffic control devices shown

KEY ELEMENTS

- Carries traffic at a low speed.
- Street providing local access to adjacent office, commercial, or industrial development.
- Provides additional linkages and connections within and to the overall street network.
- On street parking typically occurs although at different levels depending on land use characteristics. Parking demand will affect street width. In industrial areas, this can include parking for larger vehicles.
- Pedestrian activity is expected, encouraged, and to be accommodated on these streets.
- Bike lanes typically not required due to low parking volumes.

STREET CROSS-SECTION ZONES

● *Development Zone:* Development types and setbacks will vary, but all should be oriented to the street to support pedestrian access and activity. The most pedestrian oriented development types will have small setbacks, entrances directly onto the sidewalk zone, and will front streets that include on-street parking.

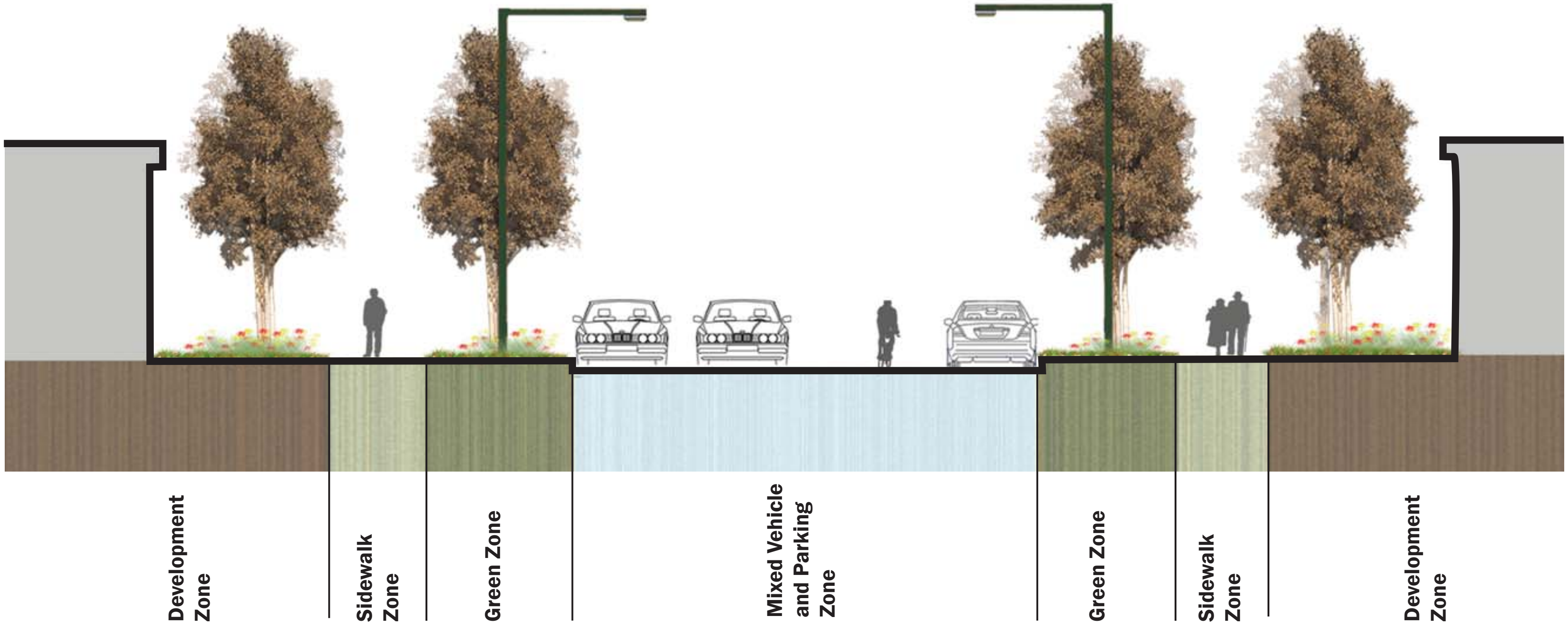
● *Sidewalk Zone*: The pedestrian walk area is of sufficient width to allow pedestrians to walk safely and comfortably.

● *Green Zone:* Consists of a planting strip (or, in very urban areas, a hardscaped area), with street trees between the sidewalk zone and the edge of street.

● *Shared Vehicle and Parking Zone:* The primary travel way that includes mixed traffic (cars, trucks, buses and bicycles) and on-street parking. Local streets will be two lanes with varying provisions for parking.

LOCAL / SUBDIVISION: OFFICE, COMMERCIAL AND INDUSTRIAL

ILLUSTRATIVE STREET CROSS-SECTION



STREET COMPONENT DIMENSIONAL GUIDELINES

	Minimum Travelway (FOC to FOC) *(feet)*	Sidewalk Zone *(feet)*	Green Zone *(feet)*	Parking Zone *(feet)*	Lane Width *(feet)*
Local Office / Commercial (Parking on 1 Side)	26’	5’ - 6’	4’ - 8’	7’ on one side	9’ with parking/ 12’ with no parking
Local Office / Commercial (Parking on 2 Sides)	40’	6’ - 8’	4’ - 8’	7’ on both sides	12’ with parking on both sides
Local Industrial Streets (Parking on One Side)	34’	5’ - 6’	4’ - 8’	8’ on one side	12’ marked

NOTES

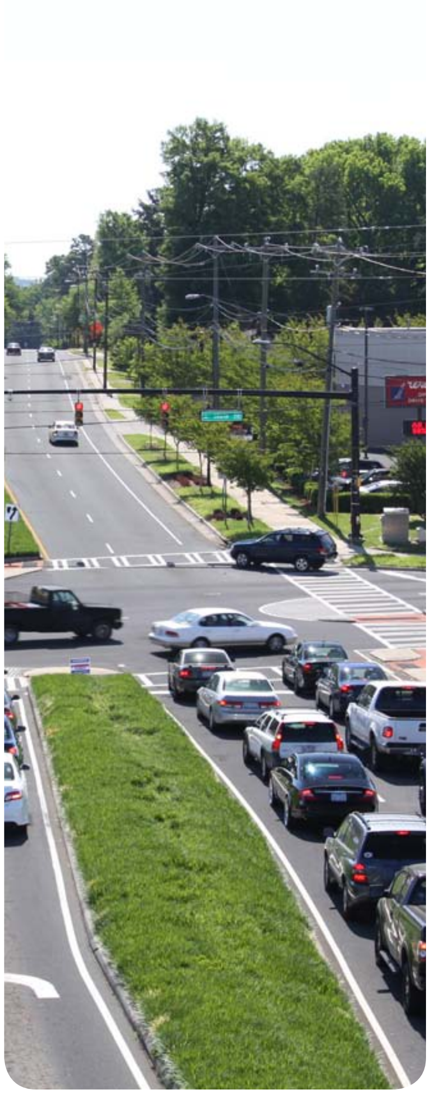
1. Minimum travelway measured from Face of Curb (FOC) to FOC.
2. The gutter pan can be used for parking, but not for vehicular or bicycle traffic.
3. Median typically not provided on local streets unless for aesthetic reasons. If provided, lane widths will be increased by 2’ to 5’.

5: Planning and Designing Complete Intersections

Complete intersections make it possible to achieve the goals of complete streets. A primary goal of planning, designing, and creating complete streets is to make it possible for motorists, pedestrians, bicyclists, and transit riders to all travel safely from their origins to their destinations. Another primary goal of complete streets is to incorporate safety, mobility, accessibility, quality of life, and sustainability perspectives into the planning, design, and operations of streets.

If motorists, pedestrians, bicyclists, and transit riders wanted or needed only to travel along streets, this chapter would not be necessary or important. However, people do want and need to travel not just along streets, but across them. Since each intersection is where two or more streets meet, each intersection represents a point of both opportunity and of conflict for street users. Congestion, and attempts to alleviate congestion by providing more lanes, typically occurs at intersections. Intersections are also the places where bicyclists and pedestrians are expected to cross streets. This is why intersections are particularly important for all users.

Intersection design is also typically more difficult because working through the design and quality-of-service tradeoffs among modes can be more difficult than along segments. ”Complete” intersections need to operate safely and comfortably for pedestrians, bicyclists, motorists, transit and, depending on the context, trucks. That is why NCDOT and communities throughout North Carolina will be changing stakeholders’ expectations about the physical and operational design of intersections.



Differing User Expectations

The sometimes competing interests of the different street users can be significant at intersections. At intersections all users will be competing for "time" to traverse the intersection. Motorists, bicyclists, transit users, and pedestrians all prefer to minimize their travel time across or through an intersection. Users may also be competing for "space" and different users may find that specific factors and design elements can make their crossing more or less comfortable. Specific expectations consist of the following:

- Motorists and bicyclists will be interested in maintaining a smooth flow through intersections without experiencing noticeable delays or even stopping.
- Pedestrians will also not want to have to wait long for an opportunity to safely cross the street.
- Pedestrians will be looking for short crossing distances and no or very few conflicts with turning vehicles to make the crossing quicker and more comfortable.
- Visually and physically impaired pedestrians will want to safely navigate the intersection.
- Bicyclists will also want short crossings, high visibility to motorists, and no or few conflicts with motor vehicles and pedestrians.

A key aspect of creating complete intersections is designing to promote safe and comfortable crossings for each travel mode, often by introducing "order" to the various crossings. Intersection users in urban and suburban settings will experience delays and conflicts between motor vehicles, pedestrians and bicyclists, and driver expectations need to shift toward taking turns with the other modes in these contexts. Given this, the speed and ease with which bicyclists and pedestrians move through an intersection is affected by signal timing, number of lanes, lane widths, presence or absence of pedestrian refuge islands, traffic calming features, landscaping, traffic volumes, and other factors. Appropriate pedestrian and bicycle signage, flashing beacons, crosswalks, and pavement markings should be used to indicate to motorists that they should see and expect to yield to pedestrians and bicyclists.

Principles for Creating Complete Intersections

When designing intersections, planners and designers should begin with an understanding of the objectives and priorities related to the land use context, network context, and any design trade-offs related to prevalent vehicle type, conflicts, pedestrian and bicyclist comfort, accessibility, and efficiency of public transit services. The safety of pedestrians and bicyclists is a key priority when designing and maintaining intersections. Designing "complete" intersections with appropriate treatments for all users is performed on a case-by-case basis, due to the many possible intersection configurations. A later section of this chapter describes principles and expectations for specific intersection types, but there are general principles that apply to all types of intersections. These general principles for designing intersections consist of the following:

- To encourage and support bicycle and pedestrian travel, intersections should be designed to minimize crossing distance, crossing time, and conflicts between motor vehicles and other users.
- The basic design parameters are set by the size (number of lanes) of the intersection and, therefore, intersections should be designed to be as small as practical, particularly in urban areas and towns.
- The design speed for the intersection should be appropriate for the area type and the context. Lower speeds allow the motorist more time to perceive and react to conflicts at intersections. If crashes do occur, they will generally be less severe if speeds are lower.
- Intersections should be designed so motorists learn to expect bicyclists and pedestrians.
- Because an intersection is part of the overall network and context, the design should extend beyond the actual intersection to the street approaches, with appropriate designs and facilities carried to and through the intersection.
- Intersection approaches should allow motorists, pedestrians, and bicyclists to observe and react to each other. Always ensure maximum visibility of pedestrians and bicyclists by providing adequate sight distance at crosswalks, weaving, and merging areas, and installing appropriate pedestrian and bicyclist pavement markings, signage and signals.
- Channelizing islands to separate conflicts can be important design features within intersection functional areas. Appropriately-designed islands can break up pedestrian crossing maneuvers, provide a pedestrian refuge area, minimize conflict points, and shorten the crossing distance.

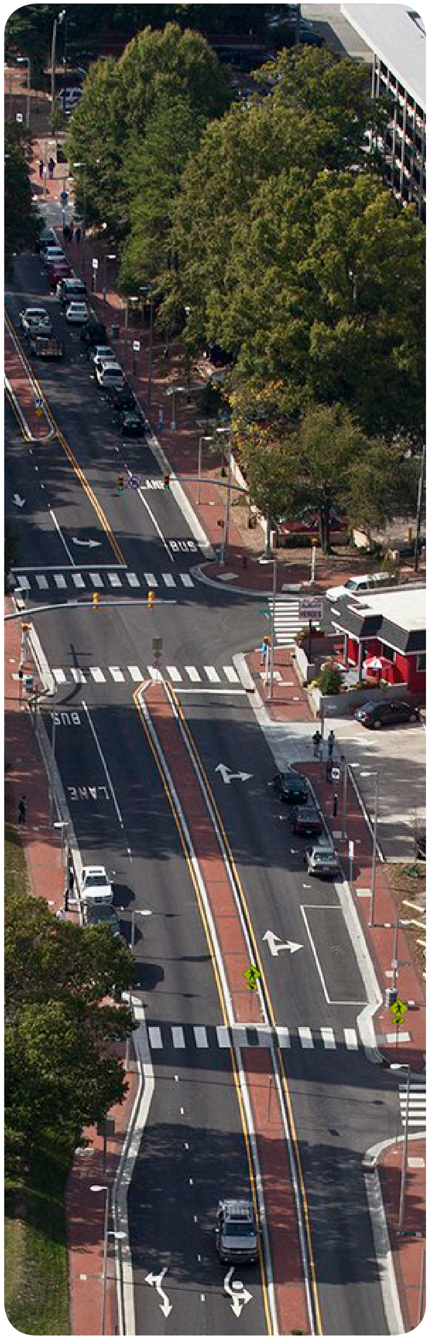
Level of Service and Quality of Service for Complete Intersections

Intersections should be designed to provide safe and adequate Level of Service (LOS) for motor vehicles and Quality of Service (QOS) for pedestrians and bicyclists. Factors affecting QOS for pedestrians and bicyclists consist of:

- crossing distance
- conflicts with turning vehicles
- motor vehicle volumes
- motor vehicle speeds

Motorist LOS at Intersections

Designing for higher QOS for pedestrians and bicyclists is described in the following sections, but the need to provide additional design elements often results first from how the intersection is designed from a motor vehicle LOS/capacity perspective (i.e., how many lanes does the intersection have?). Complete streets are expected to serve all users, including the motorist, and a significant aspect of designing good complete street networks is to identify the appropriate number of lanes needed for motor vehicle capacity, while keeping in mind the desire to keep intersections as small as possible for other users' QOS.



The amount of vehicular traffic that can approach and pass through an intersection depends on various physical and operational characteristics of the streets, characteristics of the traffic stream, and traffic control measures. The geometrics and dimensions of the street involved, the amount of pavement available, and the signal green time for moving traffic, and the manner in which the traffic is handled are all fundamental factors influencing the traffic-carrying capacity of intersections along those streets. Therefore, approach width in feet, parking conditions, type of operation (one-way or two-way), and signal phasing and timing are used in procedures to establish basic conditions in which intersection capacity can be evaluated.

Various procedures are used to analyze signalized intersection capacity and LOS. The Highway Capacity Manual (HCM) provides the basis for NCDOT's analysis. Both the morning peak (a.m.) and afternoon peak (p.m.) should be considered in this analysis. Intersections are evaluated based on vehicle delay, volume-to-capacity ratio (v/c), and queue lengths. NCDOT requires the use of a peak hour factor in this evaluation, because the HCM bases its analysis procedures on a 15 minute analysis period. When analyzing urban street intersections, the duration of traffic Level of Service (LOS) analysis may need to expand when congestion is projected to exceed one hour. This expanded analysis is intended to provide additional information about the nature of congestion at the intersection, to aid NCDOT and the local community in making capacity decisions for that intersection. Congestion will be considered in relation to the surrounding network, land use and urban design context, street type, constraints, and other variables to decide the appropriate amount of capacity.

In urban areas, if an intersection's v/c for both morning (a,m,) and afternoon (p.m.) peak hour (existing and future) conditions is less than 0.90 for each lane group, no further traffic analysis is usually necessary. Otherwise, additional analysis evaluating delays, queue lengths and v/c is expected. These analyses will help identify the critical lane groups, and determine whether operational or, particularly, physical capacity increases are necessary for those critical lane groups. **Note that the 0.90 v/c is specifically not intended as a "target" for each lane group – but rather a "trigger" for further analysis and collaborative decision making.**

Intersection size, and specifically the width of each street approach, affects functionality for all users. This is why the width, allocation to motor vehicles or bicyclists, and placement of channelization items within the pavement needs to be "managed" for 24-hour use. The results of the analysis described above (used to determine the need for physical capacity increases) should be considered in light of land use, network, and street context. This will allow the best utilization of the space available (or provided) and best match between the intersection, the context, and all users.

When deciding how many lanes for motor vehicles will be provided, the designers should consider network context, street type, and land uses or area type. This design philosophy will result in the following types of recommendations:

- For intersections near or at a freeway ramp, the overriding objective is simply to not degrade the freeway's flow. The most important consideration for the design input team will be to recommend the sufficient number of traffic lanes for each intersection affecting the flow of traffic from a freeway off-ramp to prevent traffic from queuing at the off-ramp into the freeway travel lanes. In these cases, there would be the least amount of flexibility in determining the number of lanes and capacity required, regardless of the surface street type – throughput for the freeway takes precedence. Each intersection would still be designed to provide high QOS for pedestrians and bicyclists, particularly in intensive urban areas, and particularly on avenues and boulevards (main streets would not typically be located adjacent to freeway ramps).
- For intersections on a Strategic Highway Corridor, the decision of "how much capacity is provided at an intersection?" will also consider the existing and future street network, area type, and context, while maintaining the objective of providing for adequate mobility/throughput function for motorists. Generally speaking, the more robust the surrounding network, the less emphasis placed on throughput for the corridor/intersection. In addition, the area/street type combinations shown in Table 1 will be considered and are described from the context with the highest emphasis on throughput to the context with the lowest emphasis on throughput.

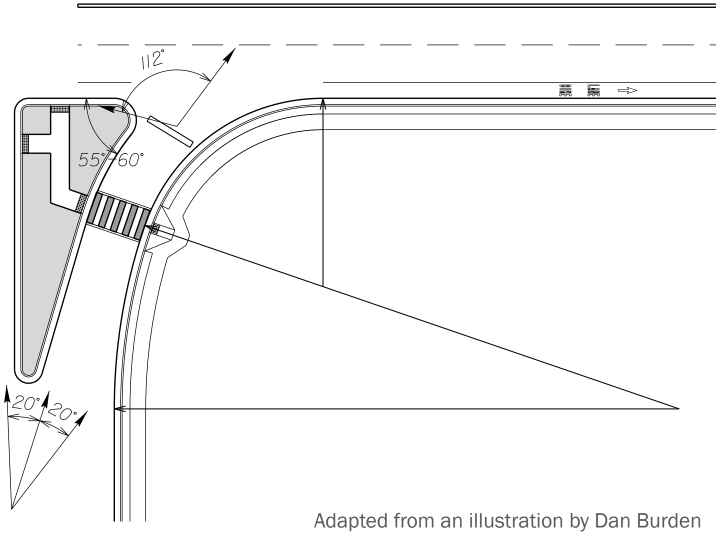
Table 1: Throughout Expectations for Different Contexts

Emphasis on Throughput	**Area Type or Context**	**Street Type**
Highest Emphasis on Motor Vehicles	Rural or outlying areas	Parkways and Rural Roads
	Outside urban loops	Parkways and Boulevards
	Suburban Corridors	Parkways
	Suburban Corridors	Boulevards
	Urban and Suburban Residential	Boulevards
	Corridors/Urban/ Suburban Residential	Avenues
Lowest Emphasis on Motor Vehicles	Centers/CBDs	Boulevards
	Centers/CBDs	Avenues
	Centers/CBDs	Main Streets (not typically on strategic highway corridors)

  Discussion/analysis, based on this chapter, between NCDOT and local agencies will be required when designing intersections. Throughput for motor vehicles is still an important objective, but is balanced to reflect the network and context, based on collaboration between NCDOT and the locality. As the capacity decisions that affect number of lanes are made, the design input team should also be working to ensure high QOS for bicyclists and pedestrians.
- Intersections not on a Strategic Highway Corridor or affecting a freeway ramp will also be designed based on their network, context and street type, as described above. The number and type of (through and turning) lanes will still result from collaborative decisions between NCDOT and local agencies and will predominantly reflect the local agencies' vision for the context and designation of street type. Based on local vision and expectations regarding throughput, planners and engineers will generally be striving to design main streets and avenues by carefully limiting the number of motor vehicle lanes, while providing more traditional emphasis on throughput for boulevards and, particularly, parkways.

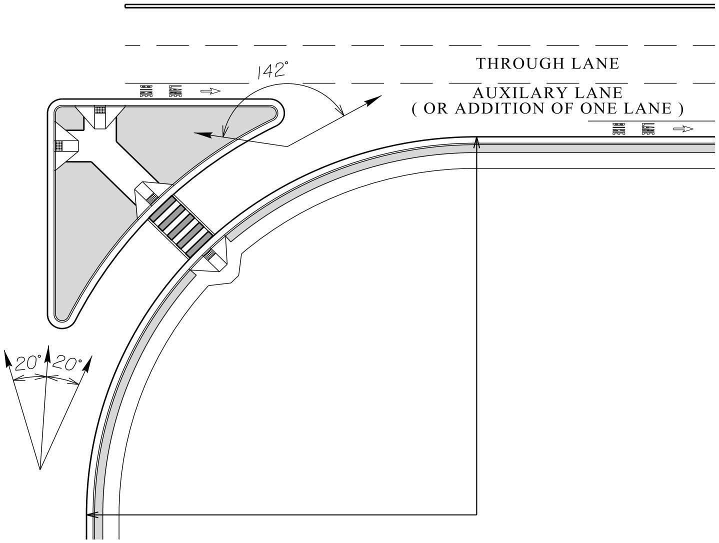
By applying the appropriate and necessary technical analyses and considering the facility type and context in decision making, design teams can provide for complete intersections that function appropriately for all users.

Figure 7: Tight Angle Channelization for Right Turns to Support Pedestrian Travel



Adapted from an illustration by Dan Burden

Figure 8: Wide Angle Channelization for Right Turns for Use on Parkways Only



Adapted from an illustration by Dan Burden

Pedestrian Quality of Service (QOS) at Intersections

When planning for and designing complete intersections, specific design elements will affect how well the intersection functions for pedestrians. As previously described, pedestrians will benefit from, among other things, shorter crossing distances and fewer conflicts with vehicles. For pedestrians, improving quality of service (providing safe and comfortable crossings) at signalized intersections can be achieved by applying the following designs:

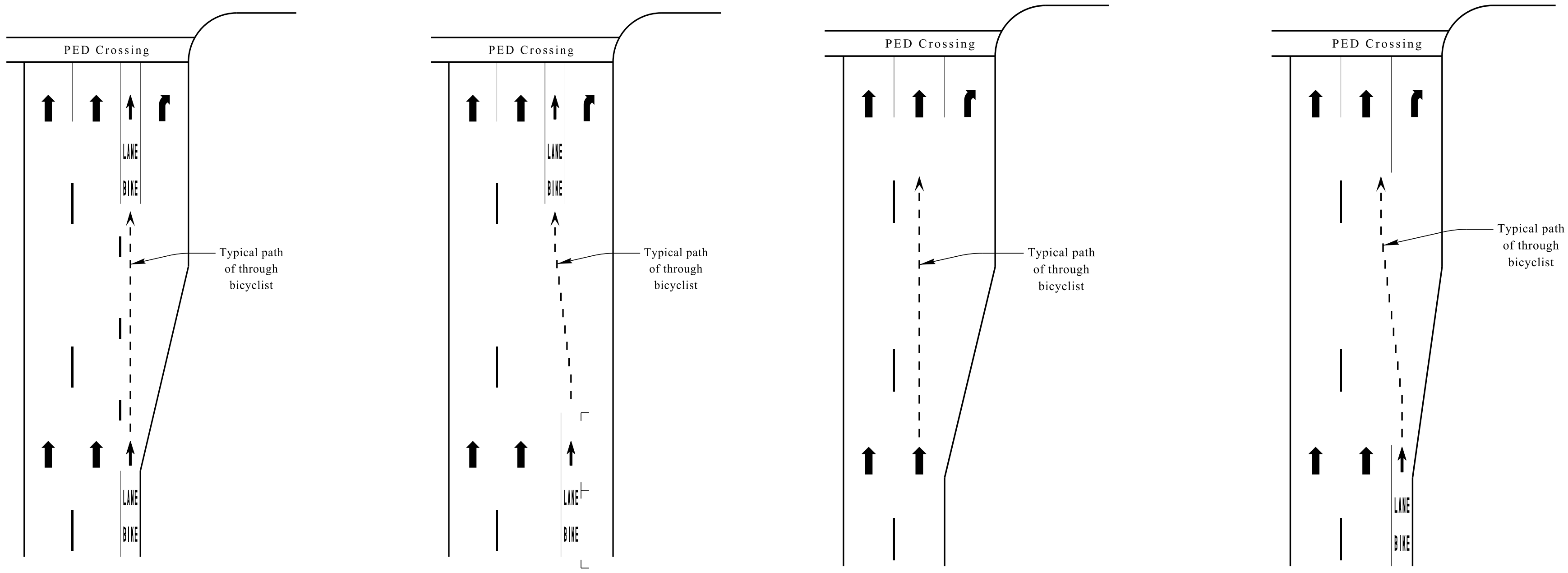
- If the street is four lanes or fewer traffic lanes wide, then a pedestrian refuge for the crossing is not required, but may be beneficial in some contexts.
- If the street is five or more traffic lanes wide, and the crossing distance is greater than 50 feet, construct a pedestrian refuge island in the median and/or in the right turn lane channelization. This is a total lane count, including through lanes, turning lanes and auxiliary lanes.
- If right turn lanes are provided, then include pedestrian refuge islands to separate right turn lanes from the through lanes (assuming the crossing is more than four lanes and is over 50 feet).
- When constructing channelized right turn lanes, design the curb radii and the channelization to reduce the turning angle (slowing the turning vehicles and increasing the visibility of pedestrians to turning motorists) and include a pedestrian refuge island (shown in Figure 7). Parkways may require the use of wide angle channelization for right turns (shown in Figure 8).
- If the street is seven or more lanes wide, construct multiple refuge islands. The location for multiple refuge islands will depend on the turn lane configuration, volumes, intersection geometry, etc. The intent is to ensure that pedestrians cross no more than five lanes and/or 50 feet without providing a refuge island to break up the crossing distance.
- Include high visibility crosswalks at signalized intersections.
- Manage cycle lengths and include adequate timing for pedestrian crossings.
- Include countdown pedestrian signals at signalized intersections.
- Include the smallest applicable curb radii (determined by prevalent design vehicle). See the section “Turning Paths for Design Vehicles” for more details on applicable curb radii.
- Provide curb extensions when appropriate to shorten the pedestrian crossing distance, and for on-street parking, traffic calming, bus stops, etc.

Bicyclist Quality of Service (QOS) at Intersections

Because they are an integral part of the street network, complete intersections must also provide for the safety and comfort of bicyclists, as they share space with motorists and pedestrians. For bicyclists, improving multi-modal quality of service at signalized intersections can be achieved by applying the following designs:

- Appropriately designed bicycle facilities (planned or existing) along the approaching street segments (as described below) should be extended across the intersection.
    - For avenues and boulevards, the preferred bicycle facilities are typically (in order of preference):
        - Bicycle lanes;
        - Edge lines;
        - Off-street multi-use (shared use) path (in rare circumstances where access is extremely limited along the street, e.g. where there are large parks with few or no driveways along the street); and
        - Wide outside lanes.
    - For main streets, the preferred bicycle treatment is a shared lane (typically with shared lane markings).
    - For parkways, the preferred bicycle treatment is an off-street multi-use (shared use) path.
- If the intersection project is relocating and/or moving the line of curb and gutter, then provide bicycle facilities in accordance with the street type, area context, objectives, plans, policies and priorities (as listed above, and described in Chapters 3 and 4).
- If the intersection project is not relocating/moving the line of curb and gutter, then provide sufficient setback or space in the green zone (planting strip or hardscaped area) for future bicycle lanes or other facility accommodations. The specific facility will be defined in accordance with street type, area context, objectives, plans and policies; therefore, providing for future continuity of the bicycle facility along the corridor.
- Provide bicycle sensitive detection at signalized intersections for the intersection approaches/movements that have lower motor vehicle volumes. NCDOT will work with local agencies to assess or identify priority locations for detection, for example: where signed bike routes cross an intersection, where nearby land uses serve as major destinations, or where there are no or few other, nearby network connections for bicyclists.
- Provide bicycle stop bars (which are located ahead of the motor vehicle stop bar) to allow motorists to see bicyclists at the intersection. NCDOT will collaborate with local agencies to identify appropriate locations for bicycle stop bars, for example: where there are bike lanes provided approaching the intersection, where there are right-turning motor vehicles.

Figure 9: Bicycle Treatments for Exclusive Right Turn Lanes



(A) Straight alignment - Cyclists travel straight and turning motorists yield to cyclists (BEST CONDITION)

(B) Alignment shift - Cyclists merge left and turning motorists merge right

(C) No bike lane - Cyclists share lane with motorists

(D) Bike lane ends - Cyclists shift into motor vehicle lane

- Consider providing bike boxes where there are bike lanes approaching the intersection, and for example there is likely to be frequent bicycle traffic, or the dominant motor vehicle traffic turns right and the bicycle traffic continues straight or turns left.
- Additional treatments not specified above and included in AASHTO, NACTO, or other guidance will be considered where appropriate (as determined through collaborative discussions between NCDOT and the locality).

Additional considerations for bicyclist QOS include designing for safer turning movements. For example, a left turn phase removes potential left turn conflicts from the path of a bicyclist. Left turns made on a green arrow only (protected phase only) provide a higher QOS than a green ball/ green arrow phase (protected-permitted phase).

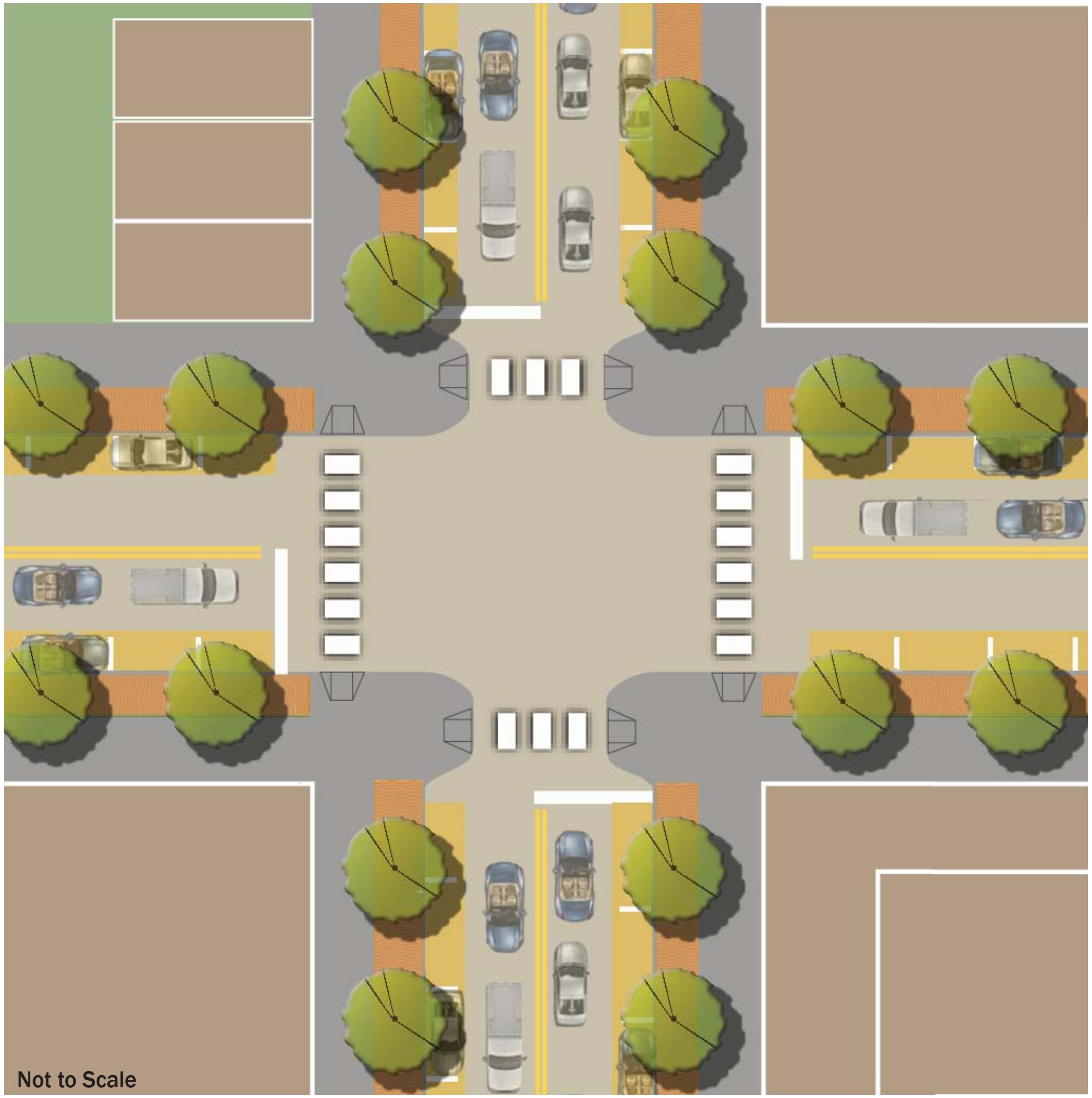
Another potential conflict exists where motor vehicles are turning right and bicyclists are traveling straight ahead on an intersection approach. The preferred method of resolving this conflict when there is a right turn lane and a bicycle lane, is by the motor vehicle merging right (with the cyclist traveling straight through and right turning vehicles yielding to the cyclist), as shown in A and B in Figure 9 above. If the bike lane ends, or there is no bike lane, the preferred method is for the bicyclist to “take” the lane, as shown in C and D above.

Intersection Design Expectations for Specific Street Types

This chapter has, thus far, described how to analyze and design intersections from the perspective of different users (to provide for motorist LOS and bicyclist and pedestrian QOS) and contexts. This section expands those concepts for direct application to the different complete street types, in order to ensure that the street type and context are adequately considered during collaborative design efforts.

Main streets and parkways represent the two “extremes” in terms of balancing users’ expectations. Between main street and parkway intersections are intersections for boulevards and avenues. Boulevards and avenues serve a wide variety of land uses and contexts while providing important travel functions and network connections for all users. The mix of possible land uses, cross-sections, and intersection types, along with the desire to provide a balance among all modes, makes boulevard and avenue intersections the most complicated to design.

MAIN STREET INTERSECTION



STREET ZONES

● *Development Zone:* Development should be pedestrian-oriented with narrow setbacks and an active street environment.

● *Sidewalk Zone:* The pedestrian walk area is of sufficient width to allow pedestrians to walk safely and comfortably. Pedestrians are the priority on a main street.

● *Green Zone:* Consists of the area between the sidewalk zone and curb. Includes street trees and other landscaping, as well as interspersed street furnishings and pedestrian-scale lighting in a hardscaped amenity zone.

● *Motor Vehicle/Shared Vehicle Zone:* The primary travel way for vehicles. A shared vehicle zone has mixed traffic (cars, trucks, buses and bicycles).

● *Parking/Transit Zone:* Accommodates on-street parking and transit stops. Width and layout may vary.

MAIN STREET INTERSECTION

KEY ELEMENTS

With the proper application of complete streets principles and practices, main street intersections will be located in a pedestrian-oriented context. Main street intersections will favor the pedestrian orientation of the main street leg, whether the intersecting street is a local/subdivision street, an avenue or a boulevard. Therefore, main street intersections:

- Place emphasis on pedestrian travel and their needs;
- Include high visibility crosswalks;
- Do not provide separate bicycle lanes due to lower speeds and volume of traffic;
- Provide countdown pedestrian signals;
- Generally do not include separate right or left turn lanes;
- Allow on-street parking;
- Have bus stops located at the far side of the intersection; and
- May include curb extensions (bulb-outs) to reduce crossing distances, increase visibility of pedestrians, allow for easier access to transit, and/or for recessed parking.

Main street intersections are typically not part of the State's strategic highway system. This allows maximum flexibility in the design, and capacity decisions can be based on local considerations and prevailing traffic conditions. Throughput for motor vehicles is less emphasized than is high pedestrian QOS to reflect the land use and street context.

PARKWAY INTERSECTION

→ *Development Zone is outside the limits of the area shown*

STREET ZONES

● *Development Zone:* Deep setbacks due to the typically auto-oriented nature of the street. Access to this zone is limited and controlled.

● *Multi-Use Path Zone:* A zone for pedestrians and bicyclists in a multi-use path separate from the motor vehicle zone.

● *Green Zone:* Consists of a planting strip with trees to seperate the multi-use path zone from the motor vehicle zone.

● *Motor Vehicle Zone:* The primary travel way for motor vehicles.

● *Median Zone:* A landscaped zone located between the travel lanes as a center median.

PARKWAY INTERSECTION

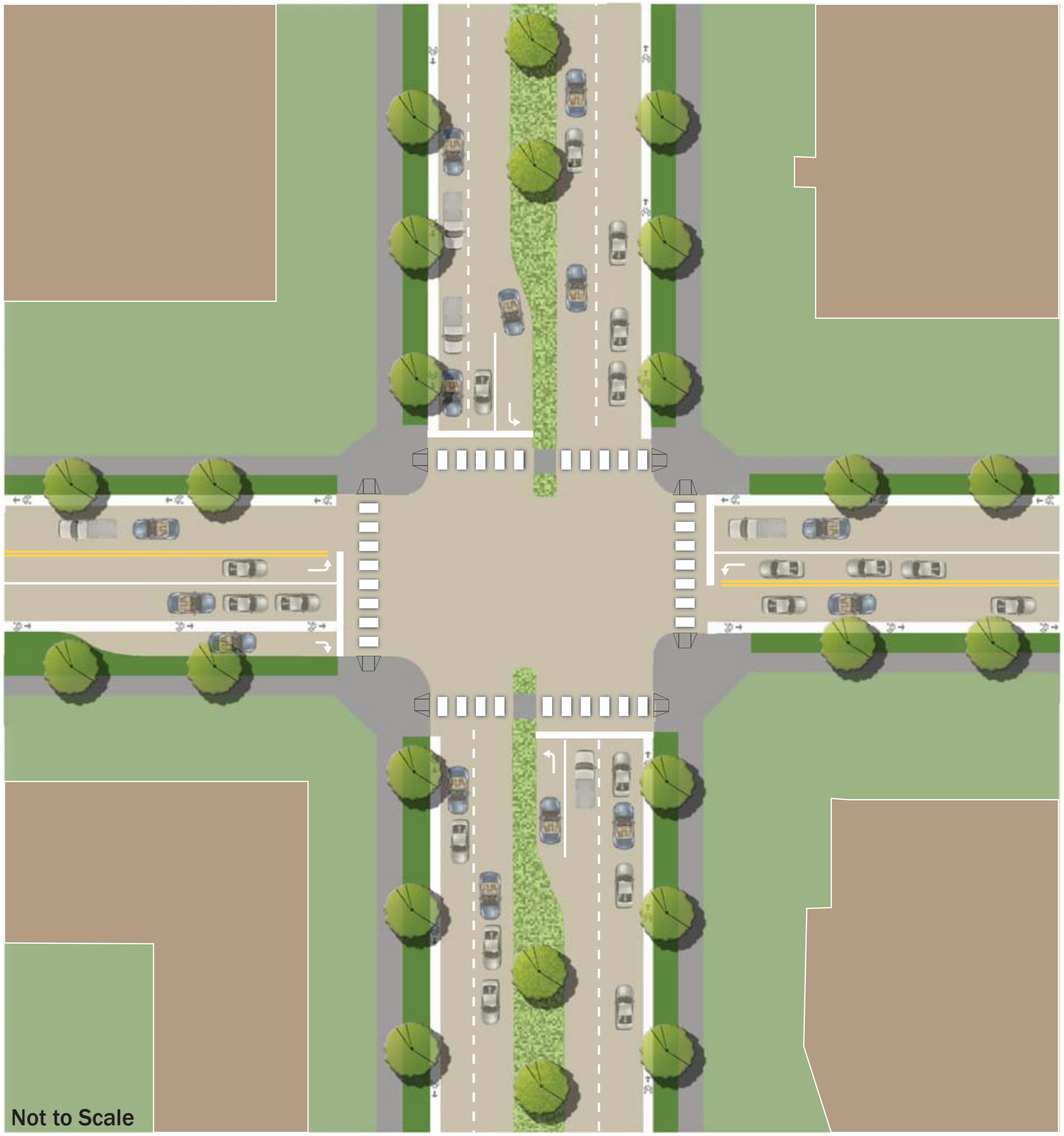
KEY ELEMENTS

Parkway intersections serve high volumes of motor vehicle traffic at relatively high speeds. Throughput and reduced travel delay for motorists is a key goal for designing parkway intersections. Adjacent land uses are generally auto-oriented in both type and design, with access control more prevalent than for any other street type. Therefore, parkway intersections:

- Will not typically intersect with main streets;
- Will have multiple lanes;
- Will always include a median;
- Include a refuge island within the pedestrian crossing (median and right lane channelization);
- Will allow dual left turn lanes;
- Will allow dual right turn lanes (parkway to parkway right-turn lanes will use the wide angle channelized right-turn design (Figure 8) and the parkway to boulevard/avenue will use the tighter angle channelized right turn design (Figure 7)). Dual right turns under signal control using the tight angle channelization design could be considered to provide additional capacity and improved pedestrian QOS;
- Are designed for the safety of all users, even though motor vehicle level of service is emphasized;
- Include multiple refuge islands if the street is 7 or more lanes wide. The location for multiple refuge islands will depend on the turn lane configuration, volumes, intersection geometry, etc. The intent is to ensure that pedestrians cross no more than 5 lanes and/or 50 feet without providing a refuge island to break up the crossing distance;
- Provide countdown pedestrian signals;
- Include high visibility crosswalks at locations where multi-use (shared use) paths cross through the intersection or where sidewalks on the intersecting street will connect destination land uses on either side of the parkway;
- Do not typically allow bicycle lanes because bicycle and pedestrian traffic is typically supported by a separate multi-use (shared use) path, ideally located adjacent to the parkway; and
- Will have longer distances between intersections than any other street type.

Parkway intersections are likely to be part of the State's strategic highway network. The intersection analysis and design for parkways will address future delays, queues and capacity. The recommended number of lanes, signal timing, and length of storage for future traffic conditions will typically favor throughput for motorists.

BOULEVARD INTERSECTION



STREET ZONES

● *Development Zone:* Building setbacks vary but are typically deeper than on avenues. Building frontage may not always be directed to the street but physical connections to the street from building entrances are important.

● *Sidewalk Zone:* The pedestrian walk area is of sufficient width to allow pedestrians to walk safely and comfortably.

● *Green Zone:* This zone serves to separate the sidewalk from the vehicles. This zone contains landscaping and trees or, in some circumstances, hardscape treatments.

○ *Bicycle Zone:* A zone for bicyclists separate from vehicular traffic.

● *Motor Vehicle Zone:* The primary travel way for motor vehicles.

● *Median Zone:* A landscaped zone located between the travel lanes as a center median or as side medians that separate one-way parallel lanes. Median zones should consider provision for turn bays at intersections. May include hardscaping at pedestrian crossings.

BOULEVARD INTERSECTION

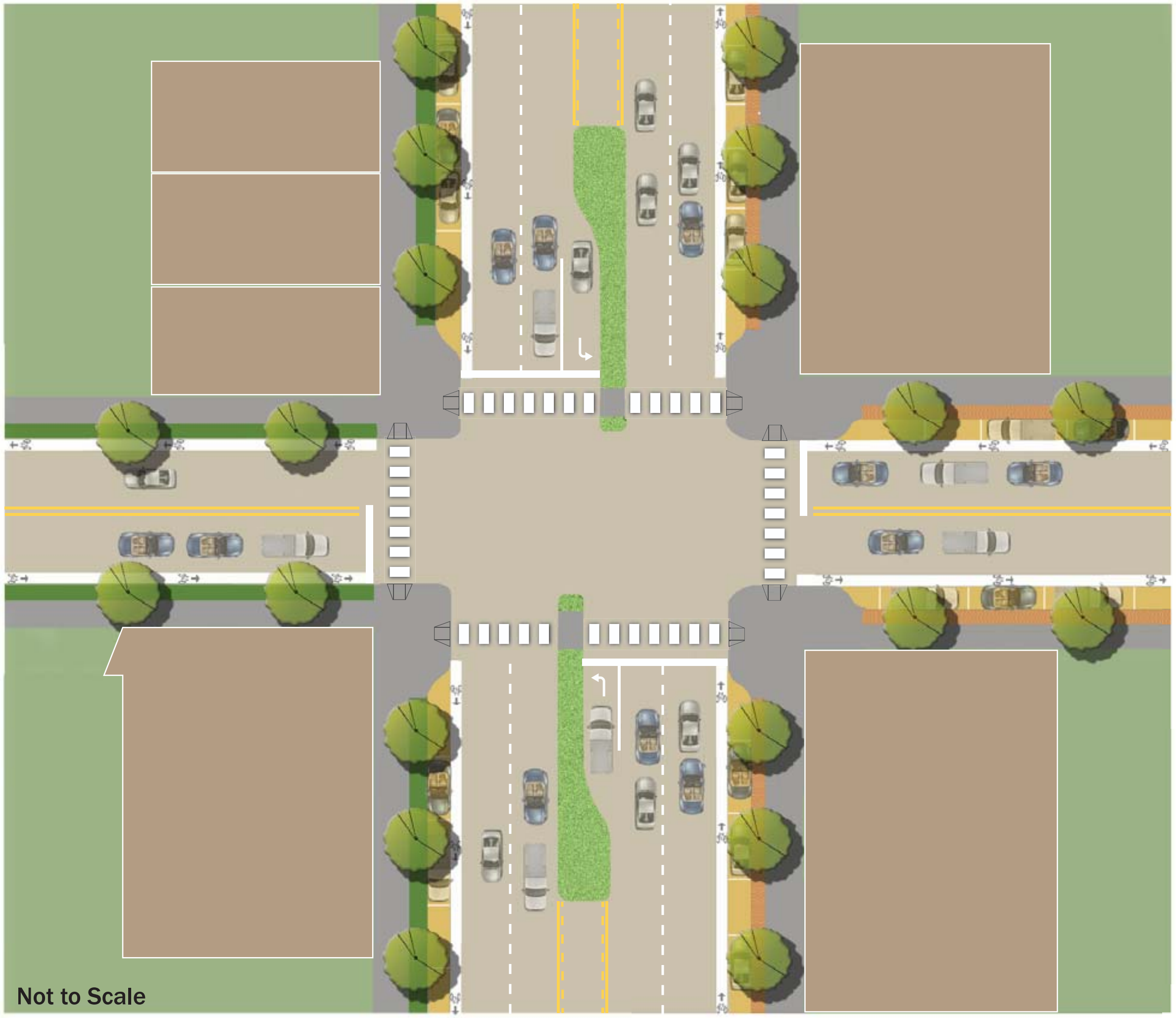
KEY ELEMENTS

Boulevard intersections serve moderate to high volumes of motor vehicle traffic but at low or moderate speeds to reflect context and to provide safety and comfort for bicyclists and pedestrians. Therefore boulevard intersections:

- Are likely to have more lanes than avenues;
- Will always have a median, but the distance between median openings and intersections will be closer than on parkways;
- Must be designed with care, because higher speeds and volumes of the boulevard must not overwhelm the needs of the pedestrians and bicyclists along the other legs of the intersection;
- Will typically have left-turn lanes;
- Will allow right turn lanes and right turn corner islands (boulevard to avenue/boulevard will use the tighter angle channelized right turn design (Figure 7));
- Allow dual left turn lanes onto parkways (dual left turn lanes should be avoided onto avenues and other boulevards). The preferred option is to try the longest possible storage lane and green time (carefully evaluating the tradeoffs of extending the storage lane and green time) for a single left-turn lane first and/or provide additional connections in the surrounding street network;
- Include a refuge island within the pedestrian crossing (median and right lane channelization) if the street is five or more traffic lanes or the crossing distance is greater than 50 feet (this is a total lane count, including through lanes, turning lanes and auxiliary lanes);
- Include multiple refuge islands if the street is 7 or more lanes wide. The location for multiple refuge islands will depend on the turn lane configuration, volumes, intersection geometry, etc. The intent is to ensure that pedestrians cross no more than 5 lanes and/or 50 feet without providing a refuge island to break up the crossing distance;
- Will carry bicycle lanes through the intersection (5 foot minimum width or 6 foot preferred width bicycle lanes);
- Allow far side bus stops;
- Include high visibility crosswalks; and
- Include pedestrian countdown signals.

Boulevards can be part of the State's strategic highway system or part of the local street network (non-strategic highway system). Therefore, more analysis and discussion between NCDOT and local agencies will be required when determining the appropriate levels of physical and operational capacity. Throughput for motor vehicles is important on boulevards, but is balanced with bicycle and pedestrian QOS to reflect the context, based on collaboration and communication between NCDOT and the locality.

AVENUE INTERSECTION



STREET ZONES

● *Development Zone:* Development should be oriented toward the street with good functional and visual connection to the street.

● *Sidewalk Zone:* The pedestrian walk area is of sufficient width to allow pedestrians to walk safely and comfortably.

● *Green Zone:* The landscaped (shown in green) or hardscaped (shown in orange) area along the edge of a street. Pedestrian or decorative lighting may be provided when appropriate for adjacent land uses.

○ *Bicycle Zone:* Accommodation for bicyclists in a zone separate from the motor vehicle zone.

● *Motor Vehicle Zone:* The primary travel way for motor vehicles.

● *Parking/Transit Zone:* On-street parking is optional and should be considered in relation to providing convenient access to adjacent land uses. Parking zone width and layout may vary.

● *Access Zone:* A landscaped zone or turning zone located between the travel lanes as a center median or turn lane. Avenues typically do not include a continuous median.

AVENUE INTERSECTION

KEY ELEMENTS

Avenue intersections reflect a somewhat lower emphasis on throughput than boulevard intersections. Therefore, avenue intersections:

- Require careful review and analysis of potential capacity increases; design decisions will assess and compare the trade-offs of safe, efficient, and comfortable travel for motorists, pedestrians and bicyclists, with the decision sometimes allowing for longer queue lengths or delays as a tradeoff for providing better QOS for other users;
- Generally do not have medians, but when provided they should be a minimum width (at the intersection) of 6 feet or a preferred width of 8 feet along corridors with anticipated heavy pedestrian traffic; the more likely avenue design uses intermittent islands for pedestrian crossing opportunities, landscaping, and to “break up” long two-way-left-turn lanes;
- Will rarely have separate right-turn lanes;
- Will typically include left-turn lanes;
- Will have closer intersection spacing than either boulevards or parkways;
- Typically should not allow dual left-turn lanes. The preferred option is to try the longest possible storage lane and green time (carefully evaluating the tradeoffs of extending the storage lane and green time) for a single left-turn lane first and/or provide additional connections in the surrounding street network;
- Are not required to provide pedestrian refuge islands if the street is four or fewer travel lanes wide;
- Include a refuge island within the pedestrian crossing (median and/or right-turn channelization) if the street is five or more traffic lanes and the crossing distance is greater than 50 feet (this is a total lane count, including through lanes, turning lanes and auxiliary lanes);
- Will carry bicycle lanes through the intersection (5 foot preferred width, 4 foot minimum width), with a “receiving” bicycle lane (or accommodation) on the opposite side of the intersection. If there is no receiving lane or advanced bicycle stop bar, the bicycle lane should be dropped just prior to the actual intersection, to allow the bicyclist to safely merge;
- Allow for far side bus stops;
- Include high visibility crosswalks; and
- Include countdown pedestrian signals.

Avenues may or may not be part of the strategic highway system. Motor vehicle throughput is less emphasized than for boulevards, particularly for avenue to avenue/main street intersections. The number of through and turning lanes for avenue intersections will result from collaborative decisions and reflect the local agency’s vision for context and street type.

Unsignalized Intersections

The previous discussion described how to analyze and design signalized intersections to be “complete” and function well for all users. Unsignalized intersections present some challenges for bicyclists and pedestrians that are similar to those for signalized intersections, such as large turning radii and exclusive right turn lanes, which increase turning speeds and crossing distances (Caltrans Complete Street Intersections, California Department of Transportation, 2010). However, the unsignalized intersection of a minor street with a major street can provide additional challenges for pedestrians and bicyclists. For example (adapted from Caltrans, 2010):

- Because traffic on the major street is not controlled by signals, pedestrians and bicyclists might experience long delays before there is a large enough gap in traffic to allow them to cross the street. This can be particularly challenging for pedestrians who have difficulty judging gaps in traffic or who cannot move quickly.
- The major street, particularly if it is a boulevard, may not be designed to cue motorists to look for and/or expect pedestrians and bicyclists crossing at the minor street.
- Medians in the major street might not be designed to provide a refuge for crossing pedestrians. For example, the median would need to be wide enough to allow for a pedestrian refuge, even where there is a left turn lane. If the median does include a left turn lane, it may further complicate the crossing for pedestrians and bicyclists if it is continuously occupied by turning vehicles.
- Longer crossing distances, in conjunction with high motor vehicle volumes and speeds for some street types make it more difficult to cross an uncontrolled crossing.

In addition to the types of treatments described elsewhere for signalized intersections, the following types of design treatments should be applied to improve the comfort and safety of pedestrians and bicyclists at unsignalized intersections:

- For main streets, do not include separate right or left turn lanes to minimize the crossing distance for pedestrians;
- For avenues, do not include separate (exclusive) right turn lanes at unsignalized intersections, to help reduce speeds and crossing distances;
- For main streets, avenues, and boulevards construct the smallest applicable intersection curb radii to help slow turning traffic and reduce the crossing distance for pedestrians;
- For main streets and some avenues, include curb extensions to reduce the crossing distances;
- Depending on the traffic volumes and speeds on avenues, include pedestrian refuge islands even when there are 4 or fewer traffic lanes (as compared to the recommendations for signalized intersections, where refuges are recommended at 5 or more lanes);
- For boulevards, construct pedestrian refuge islands in the median and right turn corner islands for pedestrians to shorten the crossing distances and allow the crossing to occur in stages. Avenues will not typically include continuous medians or exclusive right turn lanes at unsignalized intersections;
- Minimize distances across the minor street by limiting the number of (turning) lanes on the minor leg and/or providing raised pedestrian refuges or medians that can serve as refuges;
- Include signing and striping to increase visibility and driver awareness of pedestrian crossings (include high visibility crosswalks on the minor legs, particularly in urban or center

contexts). For unsignalized main street intersections, include high visibility crosswalks on all legs; for unsignalized avenue intersections (and some boulevards) include high visibility crosswalks on the minor leg, and consider them for the major leg in urban and suburban centers, or where complementary land use types exist in close proximity (as described in the "Mid-Block Crossings" (p. 120) section of this chapter);

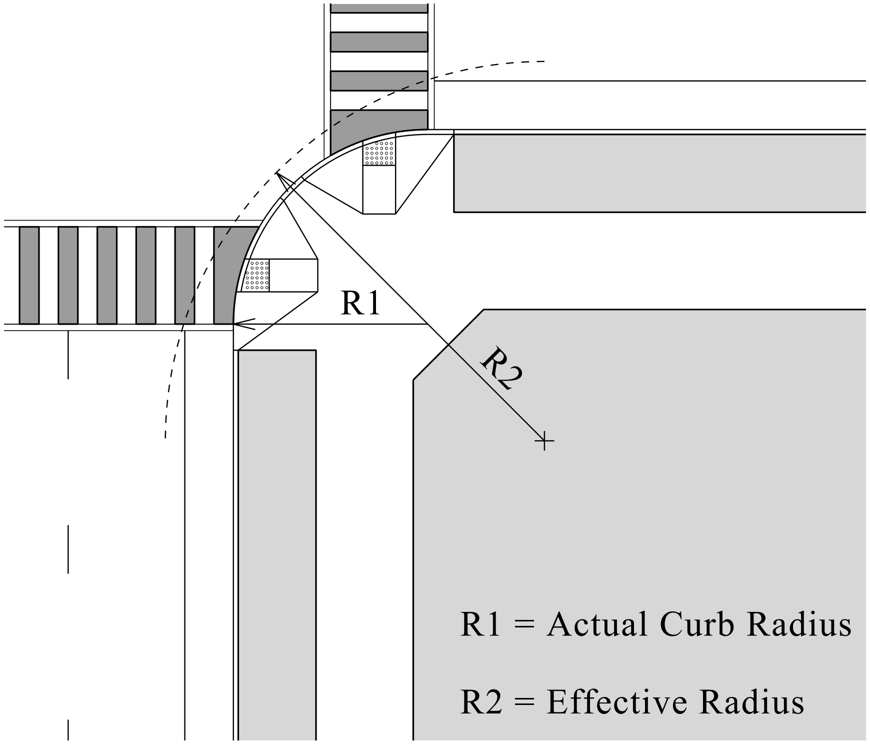
- On boulevards (or any avenues that might have medians), provide a bicycle passage through the median at the unsignalized intersection;
- Include pedestrian flashing beacons, as described in the section on "Mid-Block Crossings", (p. 120); and
- Improve visibility by restricting parking for at least one car length on each side of the crossing.

Turning Paths for Design Vehicles

Curb returns are the curved curb islands formed by the intersection of two streets. The curb return's purpose is to guide turning motor vehicles and separate vehicle traffic from pedestrian traffic at the intersection corners. The radius of the curve varies depending on the type of motor vehicle the designer is trying to accommodate. Radii should be minimized, to allow the necessary dimension for traffic, while minimizing impacts on pedestrians, bicyclists, and adjacent land uses. Smaller curb radii narrow the overall dimensions of the intersection, shortening pedestrian crossing distance and reducing the right-of-way requirements. The presence of a bike lane or parking lane creates an "effective radius" that allows a smaller curb radius to be constructed than otherwise would be required for some motor vehicles because they provide extra maneuvering space for the turning vehicles. On boulevards and parkways, large vehicles may encroach entirely on adjacent travel lanes (lanes that are in the same direction of travel).

The designer must consider lane widths, curb radii, location of parking spaces, grades and other factors while designing intersections. Designers are discouraged from using a combination of minimal dimensions unless the resulting design can be demonstrated to be operationally practical and safe. Key concepts for providing appropriate curb radii at intersections consist of:

Figure 10: Effective Curve Radius at an Intersection



Source: Kimley-Horn and Associates, Inc., adapted from the Oregon Bicycle and Pedestrian Plan

- Minimizing curb radii to reduce turning speeds, reduce crossing distances for pedestrians, improve visibility of pedestrians, and allow for the installation of the safest ramp at crosswalk locations;
- Using prevalent (expected under normal circumstances) vehicle type for the recommended design;
- Assuming the appropriate turning speeds for all design vehicles; and
- Allowing for encroachment into adjacent travel lanes on multi-lane streets and use of full street width on local streets.

Additional factors to consider for intersection design include:

- The overall street pattern – depending on the size and layout of the adjacent street system, it may be appropriate to design smaller radii at most intersections, while accommodating larger vehicles at fewer select locations along designated routes (at these locations consider using mountable curbs like those shown in the photo, to accommodate larger vehicles while maintaining smaller radii and lower turning speeds);
- The presence of raised median or pedestrian refuge island – may require larger radii to prevent vehicles from encroaching onto the median. Alternatively, particularly for "gateway" medians on local streets, medians may have aprons to allow larger vehicles to turn without damaging landscaping or curbs;
- Skewed or oddly shaped intersections – may dictate larger or smaller radii than the guidelines would otherwise indicate; and
- Lane configurations or traffic flow – intersections of one-way streets, locations where certain movements are prohibited (left or right turns), or streets with uneven number of lanes (two in one direction, one in the other) will also affect the design of curb radii.

The presence or absence of on-street parking will directly affect the curb radii required to accommodate the design vehicle. Table 2 may be used where full time on-street parking is allowed and accommodated on both streets at an intersection (assumes that the parking is not recessed by using curb extensions at the intersection).

Table 2: Curb Radii with Permanent Full-Time On-Street Parking (in feet)

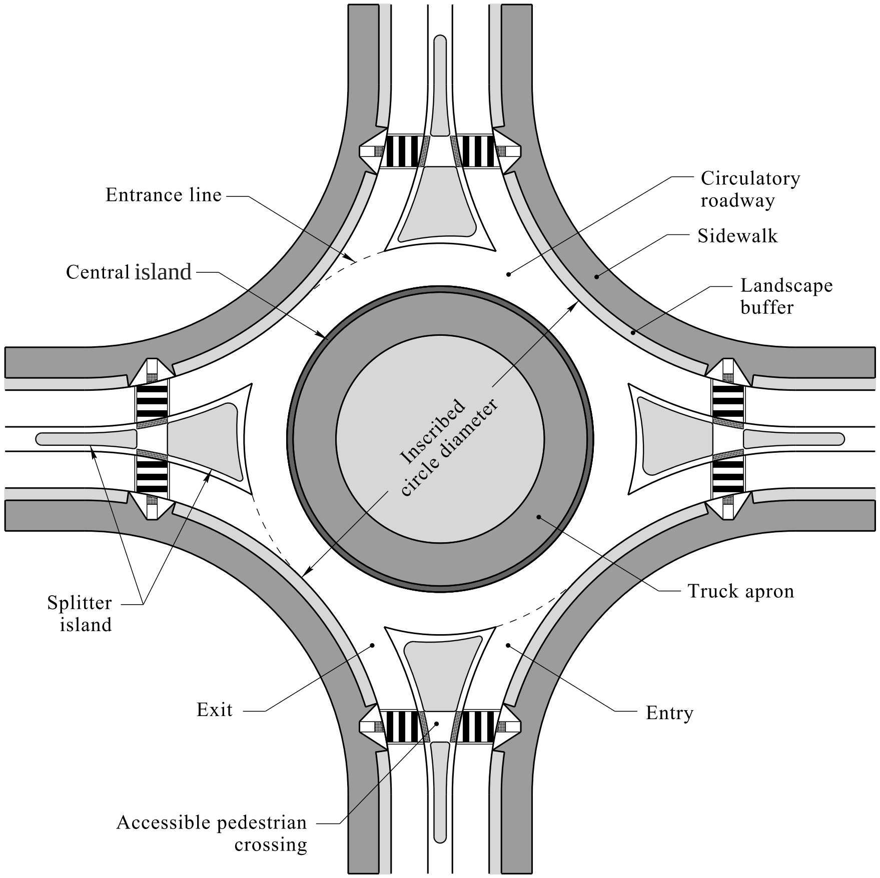
FROM/TO	Local	Main	Avenue	Boulevard	Parkway
Local	15	20	25	30	--
Main	20	20	25	30	--
Avenue	25	25	25	30	--
Boulevard	30	30	30	35	--
Parkway	--	--	--	--	--

This table should not be used where parking is either part-time only or occurs infrequently.

Other Types of Intersections

In addition to the signal-controlled and unsignalized intersections, other types of intersections may be included as part of a complete street network, and should be designed to both reflect the context and to be safe and comfortable for all users. These include, but are not limited to, roundabouts and grade-separated intersections (interchanges). In addition, mid-block crossings, at-grade rail crossings, and intersections with greenways are important for providing a network to support bicycling and walking. The following sections describe important design considerations for these types of intersections and crossings.

Figure 11: Single Lane Roundabout



Roundabouts

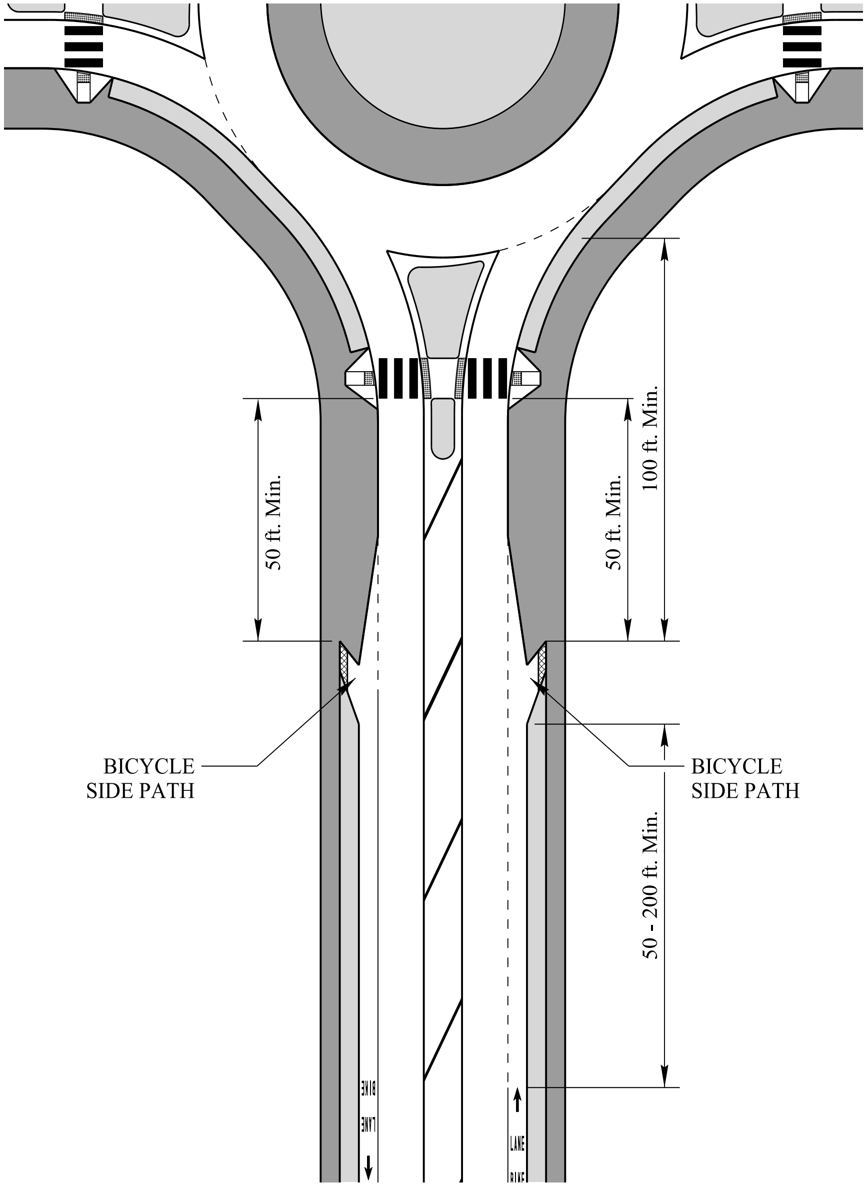
Roundabouts are a type of yield-controlled intersection characterized by a generally circular shape and design features that create a low-speed environment. A roundabout requires entering traffic to yield the right of way to traffic already in the roundabout. This yield control keeps traffic flowing and can prevent traffic backups as well as delays for motorists, bicyclists, and pedestrians. When operating within their capacity, roundabout intersections typically operate with shorter vehicle delays than other intersections, especially during non-peak traffic times. For this reason, roundabouts support motor vehicle capacity objectives and, when properly designed, also support bicyclist and pedestrian quality of service objectives. For example, certain traffic conflicts for bicyclists are reduced or eliminated, such as those that result in left and right-turn hook crashes. Likewise, conflicts for pedestrians are managed by breaking up the crossing and reducing traffic speeds.

The size, geometry, and applicability of a roundabout is determined by many variables, including: street and area type, available space, layout of the existing intersection, intended objectives (capacity improvements, traffic calming, e.g.), traffic volume (number of lanes), the sizes of the vehicles using the roundabout, and the need to design appropriately for speeds that provide safe accommodation for all users. Each roundabout must be designed to the dimensions and configuration that supports safety and mobility for all users while achieving the specific objectives described collaboratively by NCDOT and the local area representatives.

Roundabouts can help address safety and congestion concerns at intersections. They are designed to enhance traffic efficiency, safety and aesthetics, and minimize delay for all users including motorists, pedestrians and bicyclists. The benefits to bicyclists and pedestrians are easiest to obtain with single-lane roundabouts. Multiple-lane roundabouts can provide difficulties for pedestrians and bicyclists if not carefully designed. Therefore, single lane roundabouts are preferred to multi-lane roundabouts in most situations. When designing roundabouts, the design input team should strive to provide for (among other important design considerations) the following (portions taken or adapted from Caltrans 2010 report, pp. 71-75, and Los Angeles County “Model Design Manual for Livable Streets,” 2011):

- Apply roundabouts where the context and design objectives allow, but avoid their use for capacity improvements where there are very unequal traffic volumes between the intersecting streets (particularly where one has a very high volume);
- Construct crosswalks (and pedestrian refuges) at least one car length from the roundabout entrance (Los Angeles County, 2011, p. 5-23);

Figure 12: Roundabout with Bicycle Lanes on the Approach



1.) For Single Lane Roundabouts: Bicyclists take the lane at the roundabout.

2.) For Multi-Lane Roundabouts: Bicyclists either take the side path or take the lane and enter the roundabout.

- Construct the smallest diameter roundabout necessary, with the minimum number of lanes to meet capacity needs based on the context and street type (as described under “Motor Vehicle LOS” in this chapter). Single-lane roundabouts are preferred;
- Construct roundabouts to keep the internal circulation speed low enough to minimize the speed differential between motor vehicles and bicycles – the goal should be to keep approaches and internal circulation speeds low;
- Construct splitter islands at all entrances, and design them to slow vehicle speeds through deflection, guide motorists and cyclists properly into the roundabout, and to be wide enough to serve as pedestrian refuge islands at crosswalks;
- Particularly for multi-lane roundabouts, provide a separate bike path to allow bicyclists to leave the street prior to the roundabout and re-enter after the roundabout – design carefully to avoid bicyclist and pedestrian conflicts at these points; and note that bicyclists may also “take the lane” prior to entering the roundabout;
- For single lane roundabouts, the bicyclist should generally “take the lane”, so provide for a transition from any approaching bicycle lane prior to the roundabout;
- Consider reducing entrance speeds by providing speed tables at crosswalks (from Caltrans, 2010, p. 75);
- Particularly for multi-lane roundabouts, reduce “dual threat” conflicts for all pedestrians and crossing difficulties for elderly, disabled, or visually-impaired pedestrians by considering pedestrian hybrid signals at each approach to the roundabout;
- Even for single lane roundabouts, consider accessible pedestrian signals to make crossings safer and more comfortable for the elderly, disabled, and particularly the visually impaired;
- Provide a strong vertical element in the roundabout center, to help define the roundabout, reduce approach speeds; provide landscaping in the center for those reasons, and to make clear that pedestrians should not cross through the roundabout; and

- Provide for large vehicle movements by constructing a mountable apron for the roundabout center – ensure that the apron is not comfortably mountable by passenger cars.

Additional guidance for designing roundabouts can be found at: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_672.pdf

Interchanges

Interchanges, or other grade separated crossings, often provide the only connection across a freeway for long distances. Since these connections are critical parts of the transportation network, they should be designed to provide for comfortable and safe pedestrian and bicycle travel. In keeping with NCDOT's complete streets objectives, interchanges or other grade-separated intersections over freeways or parkways will include bicycle and pedestrian accommodations on the surface street, whether above or below the freeway or parkway. Furthermore, interchanges will be designed as multi-modal intersections where on-ramps and off-ramps intersect the surface street. Earlier sections of this chapter describe how motor vehicle capacity decisions are made at these types of intersections, as well as pedestrian and bicyclist QOS expectations for intersections, which will apply at interchanges' intersections with surface streets.

The types of challenges that pedestrians and bicyclists face at interchanges are generally related to high traffic speeds, multiple (and often changing or transitioning) lanes, and turning angles for motor vehicles that support higher speeds and also reduce driver visibility and awareness of bicyclists and pedestrians. Therefore, in keeping with the bicycle and pedestrian QOS objectives for complete streets, the following guidance should be applied:

- Include bicycle and pedestrian facilities on the surface street that intersects with freeways, interstates, or parkways (see Chapter 7, "Structures", for more information);
- Design interchanges as multi-modal intersections where on-ramps and off-ramps intersect the surface street, particularly for avenues and boulevards (main streets would not typically intersect at freeway ramps);

- Avoid free-flow on and off ramps, particularly at interchanges with avenues or boulevards;
- Consider channelized right turn lanes and/or dual right turn lanes under signal control, rather than free-flow right turn lanes;
- Construct turning angles onto and off of freeway ramps as close to 90-degrees as possible;
- Design for short pedestrian crossings and construct pedestrian refuge islands for longer crossings (3 or more lanes or multiple right-turn lanes, etc.);
- Provide high visibility crosswalks in urban and suburban areas;
- Where bicyclists travel among moving vehicles for more than 200 feet adjacent to auxiliary lanes, install a painted or raised buffer (adapted from Caltrans, 2010, p. 75); and
- Where bicyclists must change lanes or, in doing so, cross a traffic lane, allow flexibility to transition when and where it is safe (adapted from Caltrans, 2010, p. 75); generally, it is preferable to provide for highly visible transition areas, and to continue the through bicycle lane to the left of any turning (auxiliary) lane.

Mid-Block Crossings

When designing for complete street networks, it is vital to consider how pedestrians will be able to safely and comfortably cross those streets and to provide opportunities to do so. As described in the section on “unsignalized intersections”, there are many challenges that pedestrians face when trying to cross at locations that are not signalized intersections. These challenges increase as traffic speeds, traffic volumes, and the number of traffic lanes increase. For example, adequate gaps in traffic become scarce, crossing distances discourage pedestrians (particularly those who may not be able to walk as quickly as others), pedestrians may be less visible to motorists when there are multiple lanes, and multiple types of conflicts with through and turning vehicles may occur.

In recognition of the need for pedestrians to safely cross streets without major deviation from their direction of travel, complete street networks should typically provide for a greater number and variety of crossings. This can occur by providing more signalized intersections in the network and/or by providing other types of crossings, in support of the complete streets and area types described in these guidelines. This means that:

- Main streets typically will not need mid-block crossings because the block structure should support more closely spaced signals and the street widths and speeds lessen the need; mid-block crossings should, however, be strongly considered on main streets if the block is more than 600 feet long;
- Parkways will not include mid-block crossings due to higher speeds and volumes of traffic and land uses that are oriented away from the parkway. Crossings that are not at intersections or interchanges should be grade-separated;
- Avenues and boulevards may include mid-block crossings, particularly at or near locations that will likely generate higher than average pedestrian activity or where complementary types of land uses are located across the street from each other (and where the closest signalized intersection is more than 300 feet away). Examples of such locations and land uses include, but are not limited to:

  - Urban/suburban centers;
  - Transit stops, particularly those located across from neighborhood entrances or any of the types of land uses described below;
  - Where signed bicycle routes cross the street or are nearby;
  - Where greenways cross the street or are nearby;
  - Concentrations of neighborhood type retail uses such as restaurants, coffee shops, grocery stores, cafes, etc.
  - The above types of uses or neighborhood services such as dry cleaners, drugstores, and health clubs, particularly when these are located in close proximity to housing;
  - Higher density residential uses;
  - Vertical mixed-use or concentrated multi-use developments; and
  - Institutional uses such as parks, libraries, schools, places of worship, or concentrations of public service offices.

Once the NCDOT and the local area representatives have decided to further consider a mid-block crossing, then the designers should use the following guidance:

- Provide the crossing on the shortest path between the most likely pedestrian destinations, taking care to consider sight lines, offset intersection, driveways, etc.;
- Provide the appropriate treatment for the mid-block crossing, by generally providing additional elements, in combination, as volumes and speeds increase (note that this is guidance and each crossing should be designed to achieve the best crossing for the context; e.g. some crossings may require more treatments, even when volumes are below 12,000 AADT):
  - For traffic volumes up to 12,000 AADT, provide pedestrian crossing signs, pedestrian paddles, and high visibility pavement markings;
  - For traffic volumes up to 12,000 AADT, also consider adding curb extensions and/or raised crosswalks (take care that curb extensions do not block any bicycle facility on the street);

  - For traffic volumes above 12,000 AADT, a raised median or refuge island should also typically be provided with the crossing;
  - For traffic volumes above 15,000 AADT, consider providing rapid flashing beacons or pedestrian beacons in conjunction with raised medians, pedestrian refuges, and/or high visibility pavement markings (see MUTCD for additional information);
  - Design pedestrian refuges at designated mid-block crossings to be accessible;
  - Include a vertical element (such as landscaping, paddles, or other) on pedestrian refuges to ensure visibility to motorists;
  - Use the “z crossing” or angled crossing design for the pedestrian refuge to ensure that pedestrians are facing oncoming traffic.

Properly designed and visible midblock crossings, with signals and warning signs help to alert drivers to potential pedestrians, protect crossing pedestrians, and encourage and support walking. Mid-block crossings are, therefore, an important tool that NCDOT and communities can use to expand the complete street network.

Greenways and Multi-Use Paths

Greenways and other types of multi-use paths can contribute significantly to a "complete" transportation network. They can offer important connections for bicyclists and pedestrians in urban, suburban, and rural contexts. Unless they are located directly adjacent to a street, they should not be considered a substitute for a complete street, but rather a supplement to the complete street network. For example, parkways and rural roads would be the most likely street types to have a multi-use path alongside the roadway. Other types of streets, such as boulevards or avenues, occasionally have a greenway (or multi-use path) located adjacent to one side of the street (with appropriate facilities on the other side).

Where multi-use paths run parallel to (and nearby) an adjacent street, the following guidance should be applied at intersections:

- Bring the adjacent path as close as possible to the intersection to ensure visibility between the motorists and bicyclists and pedestrians;
- Provide as direct a path as possible for the bicyclists and pedestrians through the intersection;
- Use high visibility pavement markings at the crossings; and
- Provide adequate signal green time for crossing for signalized intersections.

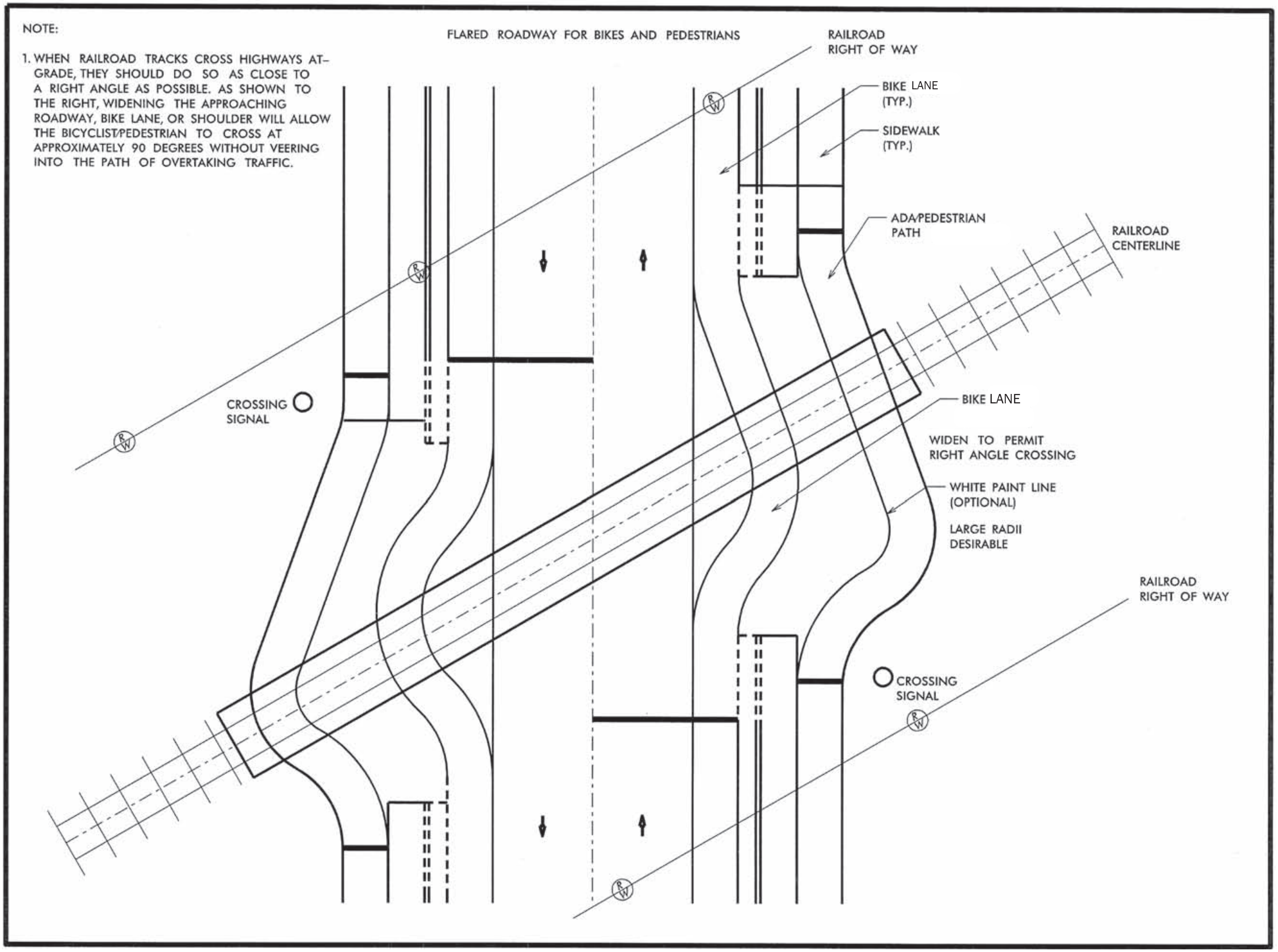
Where multi-use paths cross streets as intersections, the following guidance should be applied:

- Align crossing approaches as close to perpendicular to the street as possible, to improve visibility and sight lines;
- Carry the width of the multi-use path through the curb ramp and crosswalk to increase safety for pedestrians and bicyclists;
- Provide high visibility pavement markings at all crossings;
- Provide accessible curb cuts and tactile warnings;
- Consider raised crossings for low-volume streets;
- Provide refuges at the crossing for higher-volume streets;
- Design crossing refuges to be accessible and use the "z-crossing" or angled crossing design for visibility;
- Consider pedestrian/bicycle signals for streets with high traffic volumes or for crossings likely to have high pedestrian and/or bicycle activity;
- Provide for appropriate signage and wayfinding for those using the greenway and to alert motorists approaching the crossing;
- Ensure that grades approaching and leaving the surface street are appropriate for all levels of bicyclists and meet accessibility standards; and
- For crossings on high-volume streets, consider grade-separated crossings where appropriate for the context.

At-Grade Railroad Crossings

Commuter and light rail systems, as well as passenger and freight railroads cross streets at-grade, thereby affecting motorists, bicyclists, and pedestrians at the crossing. Proper care must be taken to provide a safe and convenient crossing for all users, particularly as opportunities (network) to cross the tracks might be limited in some locations. The appendix includes sample street cross-sections for the

Figure 13: Rail Crossing for Sidewalks and Bicycles



incorporation of sidewalks and bicycle lanes at level or at-grade railroad crossings. Note that the treatments, dimensions and cross-sections shown in the appendix may require modifications based on the specific street type and the context for each crossing. Specifically, the designer or design input team should strive to continue the approach cross-section (which is based on complete street type and context) through the crossing and not to taper or narrow the street (and sidewalk) width across the railroad tracks. If the sidewalk alignment shifts at the crossing, the taper (lateral shift) should be a minimum of 20:1.

The pedestrian and bicycle crossings should have clear lines of sight and good visibility so all users can see approaching trains. To ensure appropriate visibility, parking is not allowed in the railroad right of way. Sight triangles of 50 feet by 100 feet will be provided at the railroad and street right of way (sight triangles are measured from the centerline of the railroad track). Railroad gate placement will be coordinated with the placement of sidewalks and bicycle lanes at the crossing.

In addition to the need to continue the appropriate street cross-section across the tracks and to provide for safe crossings, there are two other main considerations for bicyclists and pedestrians with at-grade crossings. First is to consider the effect of the crossing angle, and second is to consider the roughness of the crossing. Pedestrian and bicycle crossings at such crossings should be designed to avoid situations in which wheels and tires do not hit the top of the rail and drop into the flange way. Pedestrians and bicyclists are better accommodated when the street crosses the tracks at 90 degrees. If the skew angle is less than 45 degrees, special attention should be given to the sidewalk and bicycle alignment to improve the approach angle to at least 60 degrees. This lessens the chance of bicycle wheels or any other wheels getting caught in the flange of the railroad tracks (see Figure 13).

The objective for “complete” crossings is to provide as smooth a surface as possible. Four common materials used for the railroad crossings are concrete, rubber, asphalt and timber. Concrete performs best, even under wet conditions.

For the sidewalk approaching the crossing, ADA detectable warning domes shall be provided 17 feet from the railroad track centerline. The sidewalk approaching the crossing will be asphalt within 13 feet of the railroad centerline.

Access Management

Access management is a set of techniques used to control access to streets. Specifically, access management refers to the regulation of intersections, driveways and median openings to or along a street. The benefits usually identified with access management include improved movement of through traffic, reduced crashes, and fewer vehicle conflicts. For implementing complete streets, however, these benefits should be considered in relation to the multiple objectives of improving access, safety and functionality for all users. Access management can be compatible with complete streets, but it must be applied to best match the street and context. Proper application is necessary to provide the intended benefits without unintended consequences for pedestrians, bicyclists, or motorists. For example, along some types of streets, the benefit of “improved movement of through traffic” should be balanced so as to not result in higher motor vehicle speeds (which can inhibit pedestrian and bicycle traffic and also result in more severe crashes). Some forms of access management can inhibit network connections across streets and result in the concentration of traffic through one, or a few, very large intersections thereby increasing congestion or making it difficult to comfortably serve pedestrians and bicyclists. Therefore, varying street types and contexts will assume varying levels or types of access management.

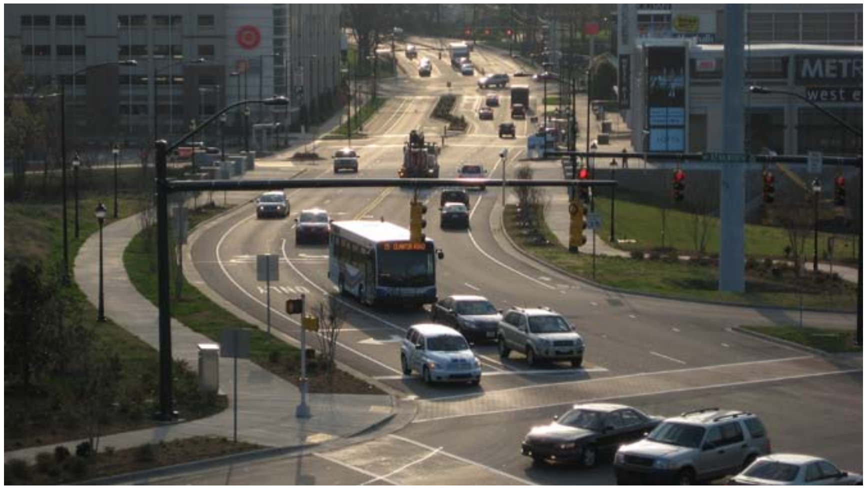
This means that:

- **For main streets**, the objective is to provide direct access to land uses, but with the focus on providing slow speeds for this pedestrian-oriented street. Therefore, main streets typically:
  - will have few driveways (due to relatively short blocks, good network structure, and the desire to limit conflicts between turning vehicles and pedestrians along the street);

    - Will never (or only in rare circumstances) have right-turn lanes, either into driveways or at intersections;
    - Will never (or only in rare circumstances) have medians; and
    - The distance between intersections should be shorter than for other street types.
- **For parkways**, the objective is to carry high volumes of motor vehicle traffic at relatively high speeds over longer distances through or within an urban or suburban area. Therefore, parkways will have high levels of access management. Parkways typically:
    - Will seldom (or only in rare circumstances) have driveways or entrances directly to land uses off of the parkway;
    - Will typically have right turn lanes at intersections and into any driveways;
    - Will always include a median; and
    - Will have longer distances between intersections than other street types.

Between these two street types are the avenues and boulevards, where the modal balance is more mixed and the application of access management techniques is more varied. This means that:

- **For avenues**, the objective is to provide for access to land uses, activity and friction along the street, and motor vehicle speeds that are not excessive. Therefore, avenues typically:
    - Will have driveways for direct access to land uses (although shared driveways are still encouraged);
    - Will almost never have right turn lanes into driveways/ entrances and rarely at intersections;
    - Will seldom have medians and are much more likely to include intermittent landscaped islands/pedestrian refuge islands in combination with a two-way left turn lane; and
    - Will have closer spacing of intersections than either boulevards or parkways.
- **For boulevards**, the goal is still to balance the modes, although the balance shifts more towards motor vehicle capacity while remaining safe and functional for pedestrians and cyclists.



Therefore, boulevards typically:
    - Will have fewer driveways than avenues (more shared driveways);
    - Will sometimes have right-turn lanes into driveways and at intersections;
    - Will always have medians; but
    - The distance between median openings and intersections will be shorter than for parkways.

The following section describes the typical approaches to providing access management. To most effectively blend the advantages of access management with other complete street objectives, NCDOT and the locality should work together to assess each street type and land use context to determine the most appropriate application.

Distance between traffic signals - Managing the distance between traffic signals can improve the flow of traffic and reduce congestion. “Managing the distance” means spacing the signals to provide the most appropriate pace of traffic through the corridor (with appropriateness determined by the street type and context). In some cases, as with parkways and many boulevards, this means longer distances between signals than for avenues. For main streets and avenues, this means shorter distances between signals than for boulevards to ensure that the "pace" of traffic supports access, safety, and mobility for pedestrians, bicyclists, and transit users, in addition to motorists.

Driveway spacing - Appropriate driveway spacing also affects pacing and access. Large numbers of driveways can increase the potential conflicts on the street, both in the vehicle lanes (for motorists and bicyclists) and across the sidewalk (for pedestrians). Fewer driveways spaced further apart present fewer challenges to drivers, but also tend to limit access to businesses and residences, which might be less desirable in some contexts than others. Therefore, avenues will have fewer limitations on driveways than will boulevards, and parkways will have the greatest limitation on driveways.

Exclusive turning lanes - Exclusive turning lanes for vehicles remove slowing or stopped vehicles from through traffic. Left-turn lanes at intersections substantially reduce rear-end crashes and help to increase the capacity of many streets. Right-turn lanes have a less substantial impact on crashes, other than rear-end crashes, because there are fewer motorist conflicts on right turns (although there may be significant conflicts between motor vehicles, bicyclists, and pedestrians at right turns). At intersections with substantial right-turn movements, a dedicated right-turn lane segregates turning vehicles from the through traffic and increases the capacity of the street. Right-turn lanes also have effects on pedestrians and bicyclists. Adding exclusive turn lanes into driveways, for example, can increase crossing distances and traffic speeds. At intersections, there may be more opportunities to mitigate for these effects (see the sections "Pedestrian QOS at Intersections" and "Bicyclist QOS at Intersections"). Generally, parkways and boulevards are most likely to have exclusive right-turn lanes, avenues will rarely have them (and only at intersections), and main streets will never have them.

Medians - Medians (either raised or grassed) represent one of the most effective means to regulate access along streets. They can also limit direct access to land uses and are, therefore, more appropriate for some street types than others. Treatments for median access range from a continuous median with defined median breaks, to intermittent islands in a center two-way left-turn lane (TWLTL), to continuous access with or without a center TWLTL. Intermittant islands are allowed on streets with center turn lanes.

In comparison to a center TWLTL, medians:

- Separate opposing traffic and significantly reduce a wide range of common crashes, including rear-end, right angle, head-on and left-turn;
- Reduce property damage, injuries, and fatalities related to these crashes;
- Reduce driver confusion by concentrating vehicular maneuvers to intersections where they are more expected and are typically controlled with traffic control devices;
- Limit direct access to land uses along the street;
- Increase the likelihood of u-turns; and
- May result in higher speeds, as motorists feel comfortable traveling at higher speeds and expect fewer impedances.

In comparison with medians, continuous TWLTLs:

- Remove left-turning vehicles from the through traffic;
- Provide for direct access into all land uses and all cross-streets;
- Can create driver confusion, particularly if used for long distances;
- Can be associated with higher frequency and severity of crashes (compared to median-divided);
- Provide little to no opportunity for pedestrian refuge; and
- At higher AADTs, motorists desiring to turn left from a five-lane section might have difficulty finding a safe gap in oncoming traffic.

Boulevards and parkways will always have medians (with more median breaks available on boulevards).

Main streets will almost never have medians and avenues will not typically include continuous medians. On avenues, continuous medians and long distances between intersections and full movement crossings interfere with logical route options and create a need for additional capacity at intersections. However, the TWLTL (particularly when used in a five lane cross-section) has safety implications for motorists, pedestrians, and bicyclists (as described above). **For avenues, the use of intermittent landscaped islands in a center turn lane can support access management strategies for complete streets by:**

- Maintaining access to properties;
- Separating turning movements from through lanes;
- Reducing driver confusion created by longer, continuous center turn lanes
- Allowing for landscaping on intermittent islands;
- Allowing for pedestrian refuge for multi-lane crossings and
- Generally, enabling better organization of the TWLTL space.

In closing, access management objectives are to enable access to land uses while maintaining street safety and mobility through controlling access location, design, spacing and operation. Specific objectives for each street type have been described above, and should be scaled to the relative importance of through traffic, local traffic, and direct access to land uses, as defined collaboratively by NCDOT and local representatives.

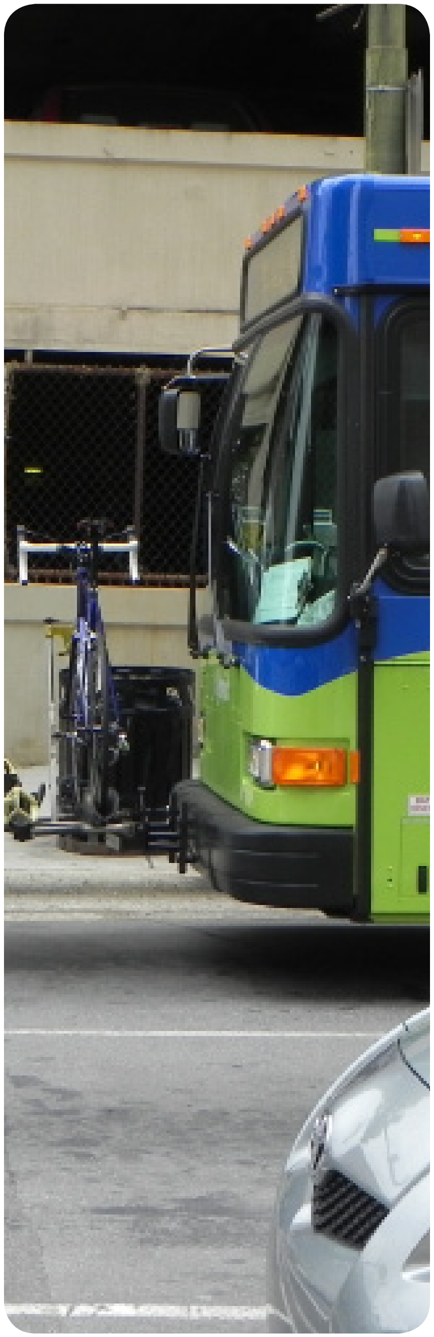
The information provided in this chapter is intended to provide guidance for NCDOT and communities to collaboratively evaluate the many tradeoffs associated with intersection design and to support the objective of providing safe, convenient and comfortable travel for all users. Planners and designers should keep in mind that, although this guidance focuses on pedestrians and bicyclists, designing complete intersections is all-inclusive and considers the context as well as the needs of all users, including bicyclists, pedestrians, transit users/operators, motorists and individuals of all ages and abilities.

6: Designing for Transit in Complete Streets

Transit services, both bus and rail, are an important part of the transportation network. Complete streets can provide opportunities to increase transit usage by ensuring good access and connections for pedestrians and bicyclists on either end of the transit trip, by providing adequate amenities at a transit stop, and by designing streets that accommodate transit vehicles and transit users safely. Nearly every transit trip begins and ends as a walking trip, and facilities to support bicycle and pedestrian access are important in creating a comprehensive transportation network.

Complete street concepts and initiatives ensure safe and convenient access to public transit for all users. As described in Chapter 3, many characteristics of a transit system improve the quality of service for transit users. For example:

- A transit system with a reliable schedule can attract additional riders and increase demand for more frequent service.
- Likewise, the frequency of transit service greatly affects the quality of service.
- Signal priority for transit vehicles improves reliability in many areas (cities that have initiated priority signal systems for transit have seen significant travel time decreases and large ridership increases in the past several years).
- Bus shelters provide a place protected from the elements for transit users to wait for a transit vehicle.
- Lighting enhances the visibility and safety of a bus shelter and/or transit stop.
- Transit schedules provide information to transit users on bus routes, transfers, and timetables.
- Seating can improve the experience of waiting for a bus in places where there is not enough usage or demand to justify a complete bus shelter.
- A bus stop post and sign can identify the route serving a stop and provide additional information on the route and schedule.



Throughout the complete streets planning and design process, transit agencies should be included as collaborative participants in the discussion and decision making process. Current transit services and future transit plans of the transit agencies are important considerations in planning complete street projects. Involvement of the local transit service provider is important in decisions regarding the design of the street, particularly in decisions regarding transit stop access and locations, stop spacing, and transit stop elements. The following sections describe and further discuss transit and quality of service.

Elements of Designing Complete Streets for Transit

As with other elements of complete streets, there is a lot to consider in designing for transit and transit stops. Traffic operations and passenger accessibility, passenger safety and security, traffic and pedestrian conflicts are just some of the issues that need to be considered in planning for and locating transit stops within the complete street design.

In addition to access and location of transit stations, spacing distance between stations, and the level of personal comfort and safety of the transit stop, the context should be considered when designing streets to include transit. In all environments, the goal should be to make the transit stop as safe and accessible as possible for the transit passenger and for the transit driver without compromising safety for other vehicles and activities within and around the transit stop or station.

Access to Transit

Connections to transit stops are an essential component in the success of transit networks and for the complete street network. Transit quality of service depends in part upon pedestrian quality of service. Circulation of pedestrians and bicyclists adjacent to transit stations and stops is important in ensuring safe and convenient access. Many of the same elements in pedestrian and bicycle quality of service are also important for transit quality of service:

- Sidewalks and pedestrian crossings should connect the stop with the surrounding area;
- Utility poles, fire hydrants, signage and other potential conflicts should be avoided in the direct access way to the transit stop;
- Pedestrian crossings should be located in close proximity to transit stops;

- Sidewalks should be kept clear of debris and other obstructions;
- Wayfinding and signage should be considered;
- Bicycle storage should be provided at stops (particularly for those transit systems that are not equipped with bicycle racks on buses); and
- A flat, stable landing pad should be provided at the stop for ease boarding by passengers of all abilities.

Transit Stop Spacing

Bus stop spacing is another important element to consider in the design of complete streets. While closely spaced stops are more convenient for pedestrian access, stops farther apart mean less frequent stops and potentially faster service. These tradeoffs for transit users should be considered by the design team in the planning process. Transit stop spacing also depends on the street type, for example:

- Main streets and avenues should have more frequent stop spacing and should be located in-street, typically at intersections but in some cases, mid-block stops are appropriate;
- Boulevards will likely have fewer stops than main streets and avenues, but usually more than parkways; and
- Parkways are more likely to have infrequent/distant spacing, and off-street stops are typical.

While some local jurisdictions may have their own standards for bus stop spacing, the Transportation Research Board, Transit Cooperative Research Program Report 10 (TCRP Report 10) provides guidance for bus stop spacing in different land use contexts (Table 3).

Table 3: Recommended Bus Stop Spacing (Source: TCRP Report 10)

Environment	Spacing Range	Typical Spacing
Central Core Areas of CBDs	300 – 1,000 feet	600 feet
Urban Areas	500 – 1,200 feet	750 feet
Suburban Areas	600 – 2,500 feet	1,000 feet
Rural Areas	650 – 2,640 feet	1,250 feet

Transit Stop Placement

Pedestrians typically want to take the shortest path to their destination; the challenge for the design input team is to designate and design the pedestrian trip to the transit stop to be as safe (and as short) as possible. Transit facilities should be placed in areas with good pedestrian access and as close to area trip generators as possible. When street projects are undertaken, the current stop placements, if any, should be assessed and provided at (or moved to) optimal locations. Elements the design input team should consider in the placement of transit stops include:

- The location of major trip generators;
- Traffic volume, through and turning vehicle and bicycle movements;
- Potential impacts on intersection operations;
- Potential conflicts between buses, other vehicles, bicyclists and pedestrians;
- Intersecting transit routes;
- Physical roadside constraints like utility poles, trees and driveways;

- Ability to restrict parking and/or truck delivery zones if needed;
- Traffic control devices;
- Available space for signage, shelters, benches, if applicable; and
- Accessibility for users of all capabilities.

Transit Stop Locations

Bus stops are placed in one of three locations (Figure 14: Typical Transit Stop Locations): near-side (located immediately before an intersection); far-side (located immediately after an intersection); and mid-block (located between intersections). Each of these locations offers advantages and disadvantages to vehicle drivers and pedestrians. Regardless of the location, the transit stop can affect the function of the street for motorists and transit users. However, the final decision on specific bus stop locations is dependent on ease of operation, transfer situations, space availability and amount of traffic.

The preferred location of a transit stop at a signalized intersection is the far side of the intersection. Locating the stop on the far-side minimizes the conflicts between turning vehicles, weaving of vehicles behind the transit vehicle, and improves sight distance and visibility for the transit driver, motor vehicles, bicyclists and pedestrians.

In circumstances in which a far side transit stop would be unsafe, or at busy transit stops with multiple bus arrivals at a time, a near-side transit stop may be appropriate. Near-side transit stops at signalized intersections will likely conflict with transit signal prioritization in urban contexts.

There may also be cases where a mid-block transit stop is the preferred location, such as when an activity generator is located in the middle of a longer block. For these types of mid-block stops, walking desire lines should be noted to identify likely pedestrian paths and appropriate mid-block crossings should be provided.

In determining where to locate transit stops, the design team should also consider the following:

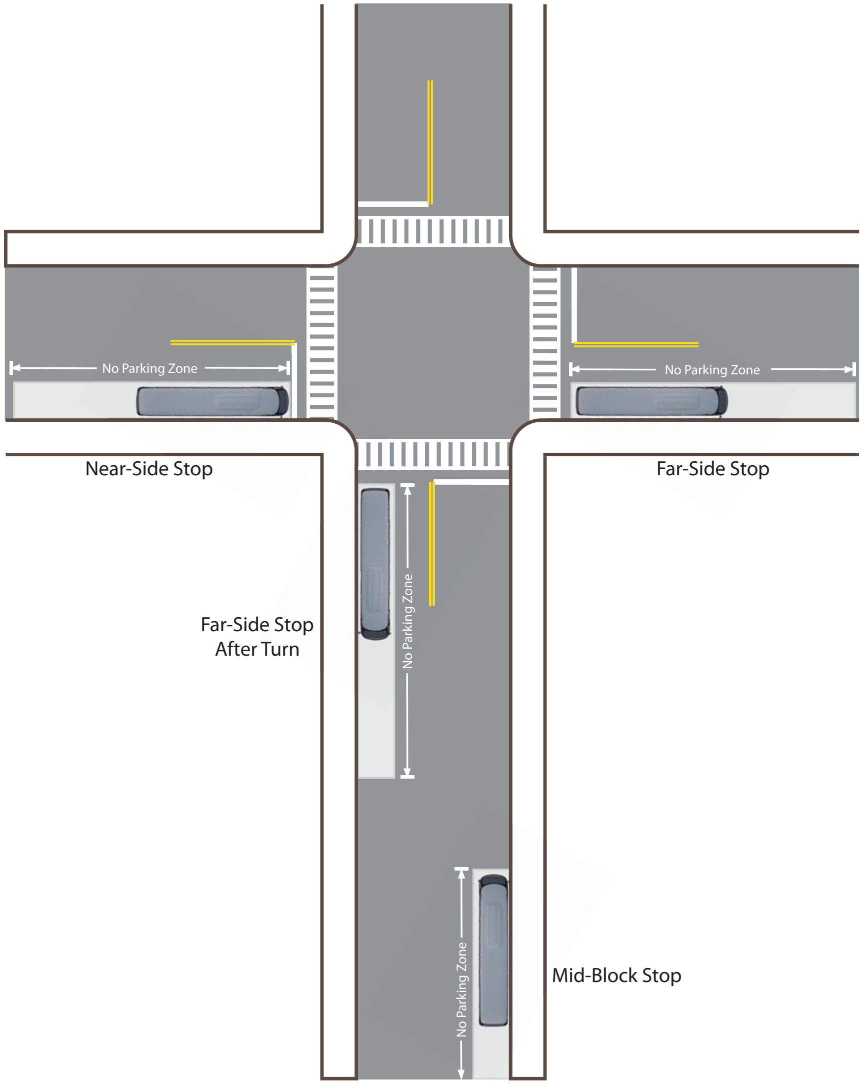
- Far-side of signalized intersections are the preferred locations for transit stops on main streets, avenues and boulevards;
- Near-side stops at unsignalized intersections under certain circumstances may be appropriate;
- Mid-block stop locations may be considered for avenues and boulevards, particularly if there are longer blocks or greater distances between signalized intersections. Include mid-block crossings appropriate to the context at these locations; and
- Off-street stops, or in some cases bus pull outs, are typical for parkways due to the speeds and context. Pullouts may be considered on boulevards, but are typically not preferred on avenues and main streets unless the stop is a staging point.

In all cases, priority should be given to the location that is most convenient and safe for transit passengers. Additionally, for stops at or near intersections (or located mid-block) along main streets and some avenues, curb extensions should be considered.

Marked crossings, curb ramps, pedestrian refuges, lighting, signage and other quality of service elements for transit users, pedestrians and bicyclists should also be considered.

Curb extensions, also known as bus bulbs or nubs, solve the problem of locating transit patron elements in dense urban environments with considerable pedestrian traffic. A curb extension essentially extends the sidewalk through the parking lane. Curb extensions create additional space at a bus stop for shelters, benches, and other transit patron improvements and provide enough space for patrons to comfortably board and depart from the bus away from nearby general pedestrian traffic. Curb extensions also shorten the pedestrian walking distance across a street, which reduces pedestrian exposure to on-street vehicles. Special consideration should be made for bicycle lanes where curb extensions are present to ensure bicyclists are not forced to merge into traffic without warning.

Figure 14: Transit Stop Locations



Transit Stop Elements

A well-designed transit stop is clearly defined, does not interfere with sidewalk travel, and provides a visual cue about where to wait for a transit vehicle. Transit stops can include a number of elements: shelters, benches, lighting, trash receptacles, and route or schedule information. Because transit stops should reflect the context, the necessary and optional elements of transit stops will vary according to the surrounding land use context, connections with other transportation networks, and frequency of transit service.

Frequently spaced street-side stops are typical in urban and suburban areas. In addition, transit stops in these areas can include hub stations (locations with bus-to-bus transfers), retail centers (a bus stop in a parking lot or access road to serve a major activity center), entrances to residential and commercial developments, and/or at park & ride lots (a bus stop in a parking lot to facilitate car-to-bus transfers). In urban/suburban areas well marked stations with transit signage and comfortable and safe waiting areas are important for the riders. Therefore, the following guidance should be applied when designing stops:

- Provide adequate space for appropriate transit stop types, intermodal transfer centers (a bus stop at a train station, for example), and hub stations (a transit stop that can accommodate bus-to-bus transfers).
- Clearly mark all bus stops.
- Site bus stops to provide passenger protection from passing traffic and facilitate safe parking lot and street pedestrian crossings.
- Provide shelters, benches, trash cans, and lighting where possible.
- Consider/provide bicycle storage at transit stops, particularly for those transit systems that are not equipped with bicycle racks on buses.
- Provide for a flat, stable landing pad that allows riders of all abilities to safely access the transit vehicle.

- Consider how to provide route schedules, transit maps, and possibly fare kiosks.
- Electronic transit arrival displays may be appropriate for stations and hubs.
- In hub stations, electronic bus arrival displays may be appropriate to facilitate bus-to-bus transfers.
- Where intermodal transfers occur, provide way finding signage to connecting bus routes and other modes of transit.

Rural transit stops include those in park & ride lots and those on roadways. Rural transit stops typically have less frequent transit service, so facilities should comfortably accommodate passengers who may face longer wait times than passengers at suburban and urban transit stops. Therefore:

- Stops should always include transit signage, and shelters and lighting are preferable.
- Stops should have clear information, including route schedules and transit maps, and should provide passenger protection from passing traffic.
- Rural bus stops should be sited close to pedestrian facilities such as crosswalks and sidewalks, with safe connections to trip generators.
- A rural transit stop might consist only of a waiting area (typically a pad) and clearly marked transit station sign.
- Bicycle storage at transit stops is also an important element, particularly for those transit systems that are not equipped with bicycle racks on buses.

In summary, the elements of transit service listed in this chapter are meant to provide guidance on transit considerations when designing complete streets. North Carolina includes both urban areas with bus and rail transit and rural areas with very limited bus transit service, but safely accommodating transit is an important element of complete streets no matter what the context. Safe and comfortable transfers, be it from walking to a bus stop, or taking transit to a personal vehicle, are a vital element in a complete streets network. North Carolina's streets should not only aim to accommodate transit vehicles, but to encourage transit ridership through highly functional and attractive street-side transit stops and easy connections to the rest of the complete streets network.

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7: Accommodating Pedestrians and Bicyclists on Structures

Sidewalks and Bicycle Lanes for Highway Bridges and Underpasses

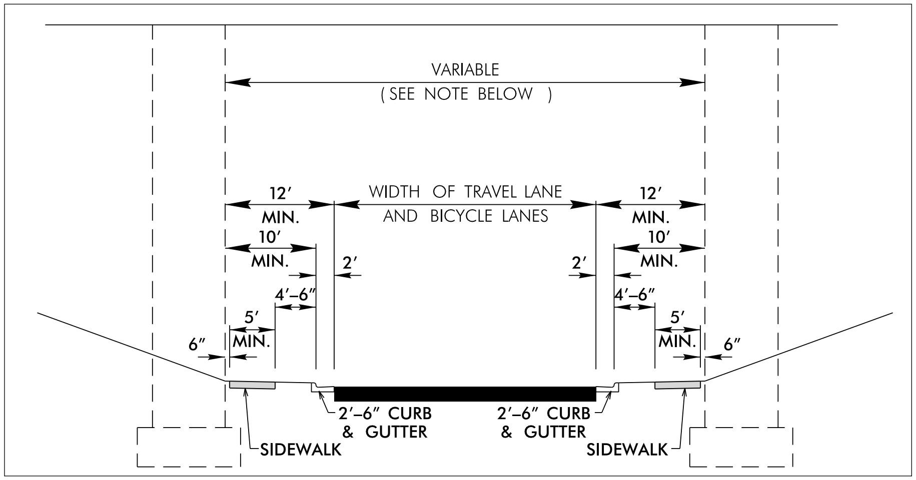
Structures like bridges and tunnels can provide key links in any type of walking facility or bicycle transportation system. Because they are unlikely to be replaced very often and because they are often the only network connections, it is critical to design bridges, tunnels and underpasses to support bicycle and pedestrian travel, particularly in urban and suburban areas. The determination of how to provide these accommodations should be made early in the planning and design process to minimize re-design and potential delay in the project schedule. Local governments and the public should be involved early in project development so appropriate decisions can be made and included in the overall planning and design.

Sidewalks, bicycle lanes, and shared vehicle zones, along and under bridges are more difficult to design than sidewalks and bicycle lanes along streets because the overall space is at a premium, and the edges of the bicycle lanes and sidewalk can be limited by travelway width, abutment wall or railing. However, they are often the only connection for pedestrians and bicyclists, so they should be designed to support each user.

On newly constructed bridges, the minimum clear street width (vehicle zone/shared vehicle zone, bicycle lane) and sidewalk width should be the same as the approach street cross-section and sidewalk width. For a street cross-section with 5 feet of sidewalk approaching the bridge the sidewalk on the bridge will be 5 feet, 6 inches with a bridge rail height of 42 inches.

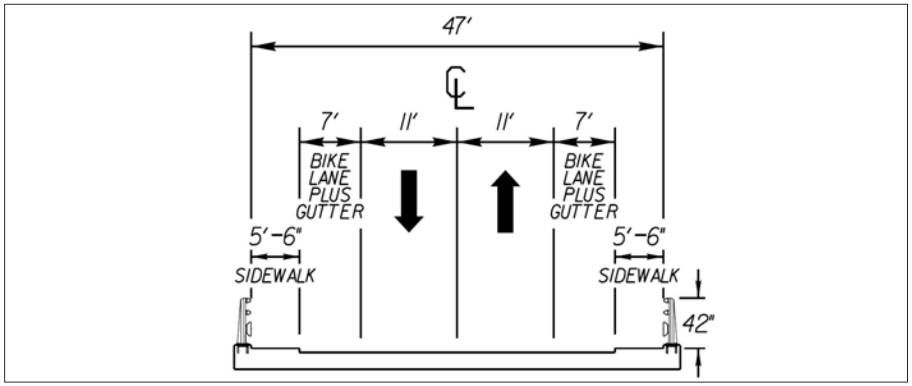
In urban and suburban contexts, where approach streets include curb and gutter, sample bridge typicals shown in Figures 17, 18, 19 and 20 can be used. Figure 17 demonstrates the requirements for a street with bike lanes, curb and gutter and sidewalks going under a bridge. The sidewalk under the bridge on Figure 20 can be increased to 9 foot 6 inches to minimize the maintenance of the 4 foot 6 inch vegetated strip behind the curb. In urban and suburban contexts, where curb and gutter is not present on the approach street, bridge shoulders are typically widened to 12 foot 6 inches or 9 foot 6 inches for the accommodation of either future bicycle lanes or wide outside lanes and sidewalks. A bridge rail height of 54 inches is used on bridges that are set up for future accommodations of pedestrians and bicyclists.

Figure 17: Sample Street Cross-Section Under an Overhead Bridge



Note: Any bridge with special design requirements such as long span lengths, locations with special significance, such as proximity to historic sites or public parks, bridge lengths greater than 200 feet or other special features, will be designed on an individual basis.

Figure 18: Sample Bridge Typical, 2-Lane Street Cross-section with Bicycle Lanes, Sidewalks and Curb and Gutter Approaches



In rural areas, other options are used for accommodating pedestrians and bicyclists on bridges. For rural roads with existing or planned bicycle routes or areas with high pedestrian and bicycle activity, a minimum 4 foot wide shoulder and 54 inch high bridge rail are provided in addition to the width of the vehicle zone. The pedestrians and bicyclists will use the edge of the vehicle zone (or bicyclists may choose to use any part of the vehicle zone/travel way) and/or the shoulder for travel. For rural roads where all users share the same space, traditional bridge widths, shoulder widths (as listed in the current edition of the NCDOT Bridge Policy) and bridge rail heights of 32 – 42 inches are used.

Guardrail on Streets Approaching Bridges

Guardrails on bridge approaches should be designed with the needs of pedestrians and bicyclists in mind. Where sidewalk is provided, the placement of guardrail should be behind the sidewalk and connected to the face of the bridge rail. As a general rule, the guardrail should be placed as far away from the vehicle zone as conditions permit. For streets with shoulders, the minimum offset from the edge of the vehicle zone to the face of the guardrail is 4 feet.

Bridge Decks

On all bridge decks, care should be taken to ensure that smooth bicycle safe expansion joints are used. In cases where expansion joints are uneven, covers should be considered. For lift span bridges (or other bridge types) with grate type decking, accommodations for providing smooth surfaces for bicyclist and pedestrians should be considered, particularly when context suggests this is a significant connection.

Greenways and Multi-Use Path Structures

When a multi-use path meets a barrier – such as a railroad, river or an interstate highway – some type of grade-separated crossing should be considered to provide connectivity. This crossing may take the form of a bridge, an underpass or a facility on a highway bridge. For a multi-use path constructed as part of a street bridge, the minimum clear width should be the same as the approach paved path width (usually 10 feet). The minimum width of a separate greenway or multi-use path bridge should be the same width as the approach path (usually 10 feet) plus an additional 2 foot wide clear area to provide an offset to the railing or barrier. For example, a 10 foot wide path requires a 14 foot wide bridge. The end of railings should be flared away from the adjacent path to minimize the danger of bicyclists running into them. On all bridge decks, special care should be taken to ensure that bicycle safe expansion joints are used. Railing, fences or barriers on both sides of a greenway or multi-use path bridge should be a minimum of 42 inches high. For railings higher than this, smooth rub rails should be attached to the barrier at the handlebar height of 42 inches.

In some cases, an underpass will be the suggested as a means to carry a greenway or multi-use path under a street corridor. The minimal underpass cross-section has a 14 feet (horizontal) by 10 feet (vertical) opening. However, the length of the underpass, lighting, grades, approaching curve design, visibility and maintenance should be carefully considered when using this type of treatment. This treatment may require drainage if the bottom of the underpass is lower than the surrounding land (terrain). Open designs that allow daylight or lighting from the outside to shine into the walking and riding area create a more comfortable and functional underpass.

Access by emergency, patrol and maintenance vehicles should be considered in establishing the design clearances of structures for multi-use paths. Also, service vehicles using the path may dictate the vertical clearance required. Typically, a vertical clearance of 10 feet is sufficient.

Figure 19: Sample Bridge Typical, 4-Lane Cross-section - Median Divided, Bicycle Lanes and Sidewalks

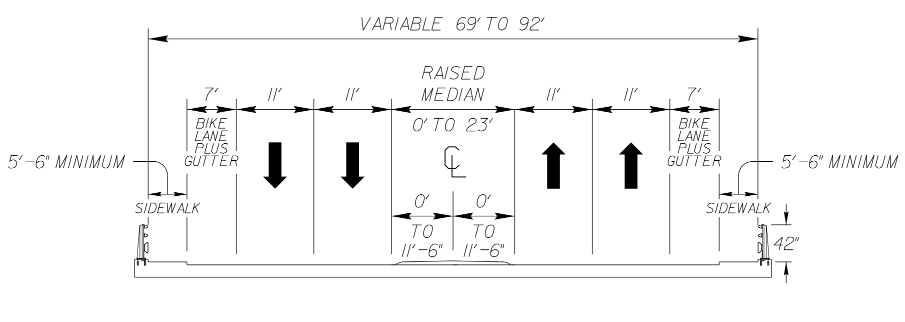
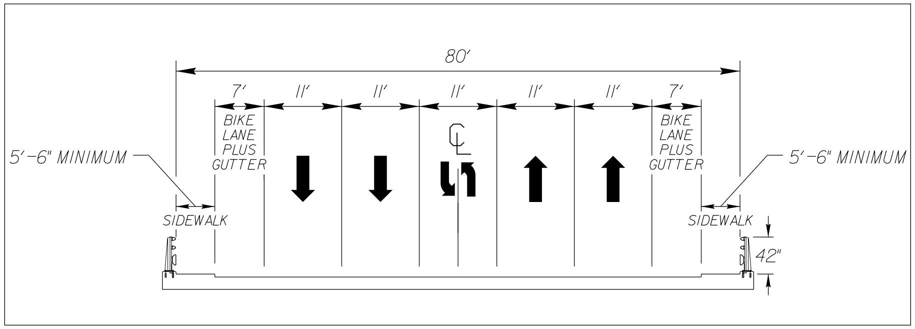


Figure 20: Sample Bridge Typical, 5-Lane Street Cross-section with Center Turn Lane, Bicycle Lanes, Sidewalks and Curb and Gutter



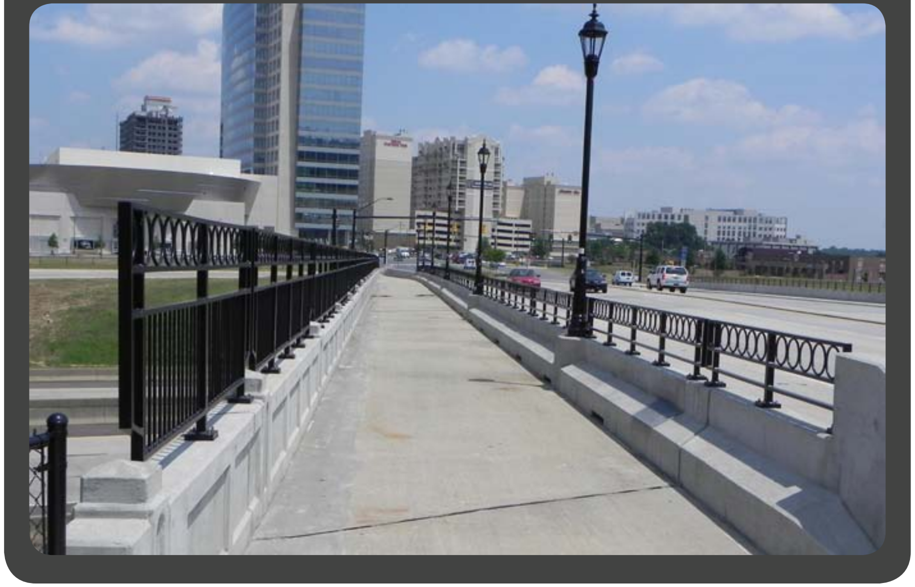
Multi-Use Path Under Street

Special Considerations

While it is not the intent of these guidelines to address requests for aesthetic bridge treatments, such as decorative lighting or bridge rails, such accommodations can be considered. Street type lights installed on bridges are intended to light the street and provide adequate lighting to vehicles and pedestrians. However in some cases, decorative post-top lighting or pedestrian lighting can be installed for either aesthetic purposes or to provide additional functionality. Post-top lights and street lights are mounted on pedestals on top of the bridge rail or on outriggers behind the bridge rail. For shorter bridges, where there is intent to light the street and sidewalk on the bridge, street lights can be installed on each end of the bridge, therefore not requiring any modifications to the bridge.

These considerations should be discussed early in the planning stages of project development to minimize re-design and potential delays to the project schedule. All lighting applications shall meet the latest version of the AASHTO Roadway Lighting Design Guide.

Multi-Use Path on Bridge



Multi-Use Path Under Street

Conclusions

There are many issues to consider as part of bridge, tunnel and underpass designs in regard to complete streets. Since it is important to create pedestrian and bicyclist connectivity and networks in urban and suburban areas, NCDOT will consider the needs of pedestrians and bicyclists on or under bridges as they are constructed, replaced or modified by maintenance. The determination of how to provide these accommodations should be made early in the planning and design processes. Local governments and the public should be involved early in the project development, so appropriate decisions can be made and included in the overall planning and design. Each bridge or underpass should safely accommodate the expected users and these considerations should incorporate future needs.

Bridge with Bike Lanes and Sidewalk

Multi-Use Path on Bridge

Crossing Underneath Overhead Bridges

8: Implementing Complete Streets in Maintenance & Operations

The State Transportation Improvement Plan (STIP) is the primary method for implementing complete street projects in North Carolina. However, the total dollars spent of the STIP is just a portion of NCDOT's overall budget. STIP projects cover only a small percentage of the 80,000-plus mile network of streets throughout North Carolina for which NCDOT is responsible for providing maintenance. As a result, maintenance and operations projects provide substantial opportunity to integrate complete streets. This Chapter describes keys to successful maintenance and operation projects and considerations for different project types.

Maintenance and operations projects typically have a defined scope and purpose; maintenance projects focus on items of work such as resurfacing and restriping, and operations projects focus on spot improvements and safety enhancements in specific geographic areas. However, there are ample opportunities for NCDOT and local governments to implement complete streets within both maintenance and operations projects. These changes may be on a more incremental basis, but can help meet larger complete streets goals.

Complete streets should not be considered as "additional" elements in maintenance and operations projects. Instead, they should be considered part of the project development process and incorporated early-on through close coordination between NCDOT (District and/or Maintenance staff), local municipalities, the MPO/RPO and private development community. The key is to view maintenance and operations projects as opportunities to integrate complete streets elements rather than to simply reconstruct the same roadway configuration.

Complete Streets in Maintenance Projects

Maintenance projects are a key component of the NCDOT transportation program. Hundreds of miles of roadway are resurfaced and restriped as part of maintenance projects each year. As such, they offer the opportunity to integrate complete streets throughout the state. Because maintenance projects are often restricted in terms of budget, right-of-way constraints, and the need to meet the schedule for annual repairs, coordination between agencies and municipalities should occur early in the project development process.

Design Elements & Features of Maintenance Projects

In general, most standard maintenance projects are resurfacing projects. These projects include the repair and preservation of the roadway pavement structure as well as upgrading pavement markings and signing to meet safety requirements. Opportunities to implement complete streets elements within standard maintenance or resurfacing projects include:

- Pavement restriping:
    - Reducing lane widths to provide a full bike lane;
    - Striping for shoulder/edge lines on streets with curb and gutter (may be in conjunction with a lane conversion or as a standalone maintenance project);
    - Striping for wide outside lanes;
    - Providing shared lane markings; and
    - Reallocating space on two-lane streets with inconsistent cross-sections to accommodate bicycle facilities (these reallocations do not necessarily take away vehicular travel lanes, and may add turn lanes).
- Street conversions or road diets by restriping and reassigning lanes;
- Widen or pave shoulder to provide striped bike lane, wider outside lane, or paved shoulder (note that shoulder widening can reduce future maintenance costs by protecting the roadway edge and provide safety benefits for bicyclists and motorists); and
- In addition, when completing these types of projects, curb ramp upgrades/additions should be provided as part of ADA compliance.

Process for Implementing Complete Streets Components in Maintenance Projects

A key component of implementing complete streets into maintenance projects is timely communication and coordination with local jurisdictions. Typically, each year a resurfacing schedule is developed down to the county level within each NCDOT division. Some counties even develop a tentative 3-year resurfacing list. Once these projects are identified, NCDOT and local agencies should meet to discuss the upcoming annual maintenance schedule and identify complete streets opportunities. It is important to meet early in the planning process to identify complete streets opportunities, find creative strategies and partnerships to implement the full improvements and assign roles and responsibilities. Open communication and subsequent follow-up are critical to successful implementation. The following is a potential process to review resurfacing projects for complete street improvements:

- NCDOT shares resurfacing list with local government as soon as possible;
- Local government reviews resurfacing list for potential revisions to striping, lane assignments, shoulder widening, etc;
- Local government or MPO/RPO as appropriate provides recommendations to NCDOT with supporting data, signal and pavement marking plans (if necessary);
- NCDOT reviews recommendations; then
- NCDOT and local government collaboratively develops a plan for implementation.

Since resurfacing schedules are developed annually and project priorities shift due to current roadway conditions, the project development process is often compressed. This highlights the need for earlier and more intensive coordination between NCDOT and the local government to ensure that maintenance projects realize complete streets opportunities.

Complete Streets in Operations Projects

Operations projects provide localized spot improvements and safety enhancements on specific segments of the existing roadway network, and provide a key opportunity to integrate complete streets elements incrementally. Operations projects are implemented throughout the state by NCDOT as well as local municipalities and agencies.

Design Elements & Features of Operations Projects

Operation projects can offer opportunities to include complete street elements as part of intersection improvements, traffic signal installation/upgrades, pavement restriping, and thoroughfare widening.

Specific opportunities to provide complete street elements for these types of projects include:

- Intersection projects that consist of providing an additional turn lane:
    - Restripe or slightly widen shoulder for bike lanes through intersections;
    - Install sidewalks for pedestrians (both at intersections and to connect different approaches);

    - Provide crosswalks;
    - Add pedestrian refuges or islands;
    - Install curb ramp upgrades/additions to comply with ADA; and/or
    - Incorporate other complete street amenities or technologies.
- Traffic signal installation/upgrades:
    - Install pedestrian signal heads and countdown equipment;
    - Retime signals to allow for pedestrian phases and/or improve pedestrian QOS;
    - Incorporate accessible pedestrian crossing signals;
    - Install curb ramp upgrades/additions to comply with ADA requirements; and/or
    - Incorporate other complete street amenities or technologies.
- Pavement restriping (similar to maintenance projects):
    - Convert streets or use road diets to provide a full bike lane;
    - Reduce lane widths to provide a full bike lane;
    - Stripe pavement for a shoulder/edge lines on streets with curb and gutter (may be in conjunction with a street conversion or as a standalone maintenance project);
    - Stripe pavement for wide outside lanes; and/or
    - Provide shared-lane markings.
- Thoroughfare widening:
    - Widen street for striped bike lane;
    - Widen/pave shoulders to provide wider outside lane, paved shoulder, or striped bike lane;
    - Construct sidewalks; and/or
    - Incorporate other complete street amenities or technologies.

Process for Implementing Complete Streets Components in Operations Projects

As with maintenance projects, a key component of implementing complete streets into operations projects is timely communication and coordination between all agencies involved. When an operations project is being defined, NCDOT and other agencies should meet to discuss the project requirements, timing, and investigate opportunities for implementing complete streets elements.

Given the typical smaller focus of many operational projects (as opposed to more expensive corridor widening or STIP projects), timing of the review and coordination between NCDOT and the local government can often be compressed. Open communication and subsequent follow-up are critical to successful implementation, especially with short schedules.

In terms of implementation, it is important to consider that NCDOT spot improvement and safety projects must match the requirements of the specific program (such as directly improving safety at an intersection). Safety is a multi-modal concept and can offer significant opportunities to incrementally improve the complete street network. These project types can be implemented independently or in combination with standard maintenance projects. The benefit to spot improvement and spot safety projects is the flexibility to include additional features beyond resurfacing and restriping. The same applies for municipal projects, which provide the opportunity for additional features beyond pavement overlays and marking revisions. In some cases, they can involve the implementation of full complete streets type sections with separated sidewalks and amenities.

Privately funded street improvement projects can encompass both new roadways and improvements to existing roadways. In many cases, private developers may have incentives for integrating complete streets into their development. In any case, developers need a set of complete street standards and minimum requirements. The NCDOT and local municipality need to communicate these as part of the planning and development review process. Continuous coordination between entities is needed over the life of a project to ensure that the shared goals for the roadway are met.

Lessons Learned and Technical Recommendations

As shown in many projects throughout North Carolina, the implementation of complete streets on existing streets can be successfully implemented as part of maintenance and operations projects. Several technical lessons have been learned based on project experience. The following recommendations have been developed for NCDOT maintenance and operations staff:

- Even the "easy" street conversions require appropriate analysis. Allow plenty of time for:
  - Traffic volume forecasting, traffic analysis, evaluation and design;
  - Public involvement and/or notification (especially if repaving and marking will impact parking for existing businesses); and
  - Pavement marking plan preparation.
- Street conversion for high volume facilities will require more time for each phase.
- Complete pavement marking plans well in advance of resurfacing:
  - Striping plans should be required since in very few projects does a simple typical section apply in all locations;
  - Pavement marking contractor needs to order pre-made legends and prepare for the new pavement marking plan. Conversions, especially those with an odd number of travel lanes, may be more difficult to lay out in the field and may require more experienced staff; and
  - Coordinate conversions with signal design. Signal timers, designers, and field crews (ground and aerial) need sufficient notice to prepare the plans, adjust detection and signal heads, and alert signal timing staff to observe and modify timing if necessary.
- Establish traffic control for conversions:
  - Provide for or consider additional traffic control during the pavement marking process to "transition" motorists into the new cross-section; and
  - Identify whether restriping would require revisions to the existing signal system.
- Specify lane widths:
  - Lane width and striping need to be coordinated with the NCDOT contract administration staff so that the pavement joint will line up with the proposed lane lines; and
  - Street cross-section widths can vary along the length of the conversion; therefore, instructions such as, "stripe a 4' wide bike lane," frequently do not produce the intended final cross-section. Consider which lanes should be held to a consistent width and where additional width of pavement should be absorbed to maintain the most consistent looking cross-section possible. For example:
    - 4 lanes to 3 lanes with bike lanes:
      - Small width variations may best be absorbed in the bike lane/shoulder, provided the bike lane maintains a minimum width, otherwise vary the width of the two-way left turn lane (TWLTL); and
      - Large variations of width should be absorbed in the TWLTL, so that the bike lane is not mistaken for a parking bay or travel lane.
    - 4 lanes to 2 lanes with bike lanes:
      - Measure from the center and define the travel lane width. Extra space may be absorbed in the bike lanes.
    - 4 lanes to 2 lanes with on-street parking on one side;
      - Absorb additional space in parking and bike lane adjacent to curb.

- Avoid paving over gutter pans to retrofit complete streets features, as any perceived benefit will likely be offset by future maintenance costs and difficulties, as well as impeded drainage.
- Take care (and follow up throughout process) that upgraded or added accessible ramps are placed in the correct location, especially where one ramp is being replaced with two, and ensure that the new ramps are oriented to the crosswalk. This is not always a “template”-type design item due to variable curb return radii, intersection configuration, angles, etc.
- In some cases, it may not be possible to maintain a constant typical section throughout the length of the project due to constraints related to right of way, topography, or physical features of the road. In these situations, some allowances should be discussed and considered as part of the planning process.

Project Examples

The following illustrates several examples of North Carolina projects that successfully applied complete streets strategies as part of maintenance projects. Additional examples of projects in various contexts are included in the Appendix.

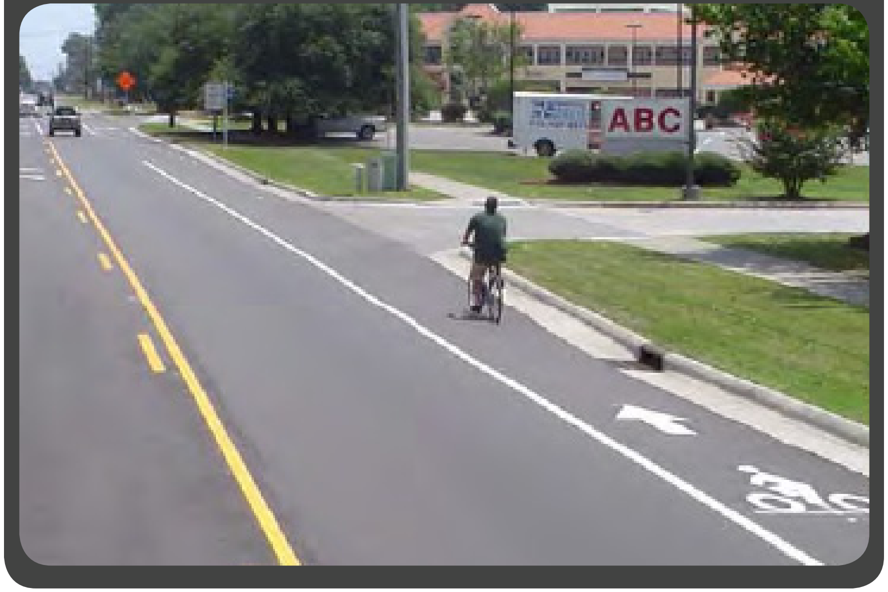
Bicycle Lanes and Road Diet

Project Location: Wrightsville Avenue, Wilmington

Project Type: Resurfacing

Description:

As part of a resurfacing project on Wrightsville Avenue between Military Cutoff Road and Eastwood Road, the pavement marking was revised to include bicycle lanes. In coordination with the local NCDOT Division office, the City of Wilmington provided a revised pavement marking plan for these improvements. This coordinated effort allowed the installation of bicycle lanes to be incorporated into the final design. Note that due to right-of-way and construction constraints, there are some areas along the project where bike lanes were not installed. In these areas, “Share the Road” signing was used.



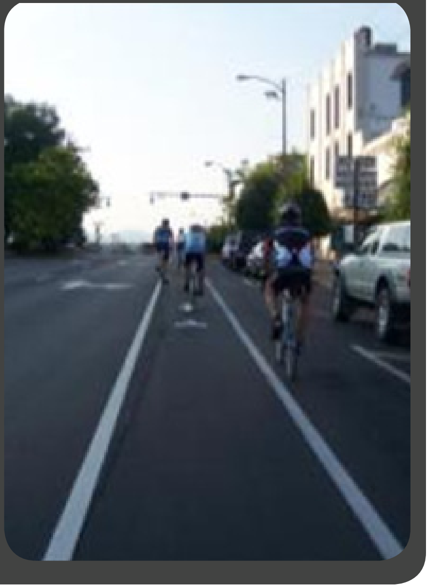
Street Conversion with New Bicycle Lanes

Project Location: Morganton

Project Type: Resurfacing and restriping

Description:

Series of three-lane one-way pairs (two through and exclusive right turn) were converted to two lanes (through, shared through-right) and a bike lane. Restriping was done as part of the resurfacing project and was accomplished within the existing curb and gutter.



Bicycle Lane

Project Location: Erwin Road, Durham

Project Type: Resurfacing

Description:

The City of Durham and NCDOT worked together to reduce the existing five-lane roadway section to three-lanes with bicycle lanes completed as part of a resurfacing project.

Reduce Lane Width to Add Bicycle Lanes

Project Location: Spring Forest Road, Raleigh
Project Type: Resurfacing

Description:

As part of a resurfacing project, lane widths were reduced to accommodate striped bicycle lanes. The existing five-lane section was maintained.

Spot Improvement

Project Location: Morganton

Project Type: Spot improvement

Description:

Island channelization was added at the intersection to provide pedestrian crossing and refuge area while reducing pedestrian exposure. A center median and pedestrian crosswalk were added.

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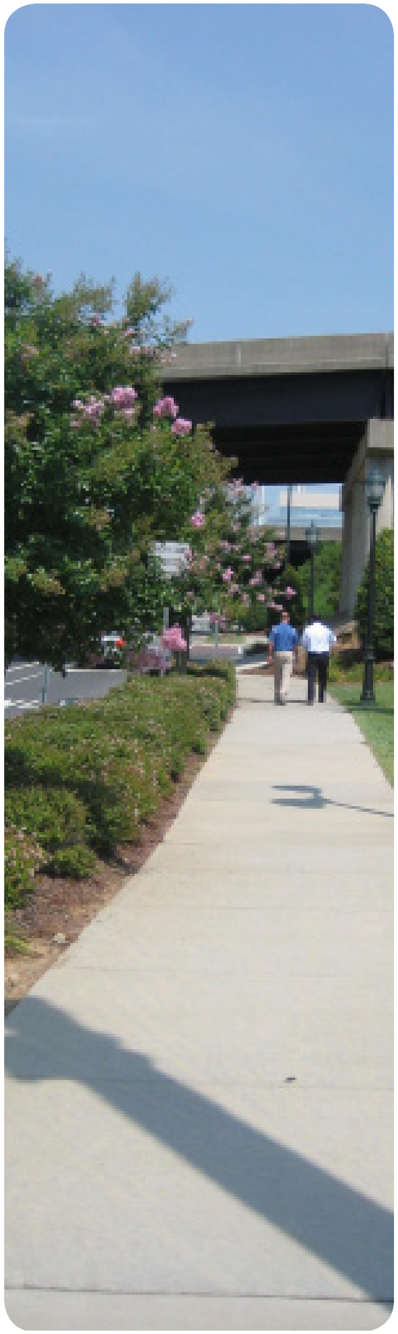
9: Street Elements: Design Considerations for Context-Based Solutions

When designing a street, the design input team designs for all users as well as the differing contexts that must be addressed. In doing so, there are various elements both street-side and within the street travel way (above and below grade) that should be considered in conjunction with the previous chapters related to the design of streets, structures and intersections. Some of these elements are related to safe mobility and accessibility with the complete street intent of expanding these concepts to all users. Other elements are focused on improving the quality of life, connectivity within and between communities and the integration of sustainable practices.

As described throughout this document, designing streets in the urban context will be different than in a rural context. The team should consider the context – area and street type – and competing demands within potentially limited right of way when addressing the broad range of elements included in this chapter.

This chapter includes principles and guidance on specific elements within a complete street. Street-side elements include: landscaping and street trees, stormwater facilities, slopes and retaining walls, curb and gutter, curb ramps, utilities, sight distance and accessibility. Street travel way elements include: drainage grates and utility covers, shoulder rumble strips, clear zone, and superelevation. The discussion of each element has been developed from the perspective of all users of the street, including motorists, pedestrians, bicyclists and transit users. Street side elements are equally important as the travel way elements in creating highly functional complete streets.



Street-Side Elements

The street-side is the part of a complete street that accommodates non-vehicular activity of the street and extends from the face of the buildings or edge of the development zone/private property zone to the face of the curb. It is the place where people walk, interact and access transit and buildings, and engage in activities along the street. The design of elements within the street-side is no less important for creating complete streets than those elements comprising the travel way. A broad range of technical engineering elements and design principles need to be considered in the design of the street-side including sidewalks, street trees, utilities and the needs of the pedestrians and transit users.

Landscaping and Street Trees

Landscaping and street trees are important elements of complete streets because they serve both aesthetic and functional purposes. Street trees and landscaping provide increased comfort, shade and aesthetics, making walking a viable transportation choice. Landscaping can aid in the comfort and safety of those who use or live adjacent to the street by providing a buffer between pedestrians and motor vehicles, and an element of traffic calming, which serves to enhance the pedestrian experience. Street trees add to the aesthetics of an area, adding texture and color to a normally dull asphalt or concrete surface and contributing positively to the environment by providing shade and reduced stormwater run-off. In developing the plan and design of a new street, or the potential retrofit or rehabilitation of an existing street, the design input team should consider the benefits of landscaping such as street trees, shrubs, lawns, decorative rock, and other materials in providing a pleasing setting for drivers, pedestrians, bicyclists, and abutting land owners. Ultimately the landscaping plan should consider the street trees and plantings as a system, not individual plantings. This adds to the sense of connectivity within the area and also adds to the perception of a continual buffer between motor vehicle and pedestrian activities.

Street trees and landscaping provide a level of comfort from the separation of vehicular traffic and pedestrian activity, and are appropriate along local/subdivision streets, main streets, avenues and some boulevards. Depending upon the context, street trees and other landscaping should be placed in either a planting strip or an amenity zone. A planting strip is an unpaved area between the sidewalk and the curb. Planting strips can increase pedestrian safety and comfort by serving as a buffer between vehicles and pedestrians. They can also absorb run off, enhancing storm water drainage and providing a natural way to water the plantings.

Similar to planting strips, an amenity zone is the area between the curb and sidewalk, but is hardscaped or inter-mixed with a planting strip. It is reserved for street furniture, utility poles, parking meters, signs, and street trees and landscaping. Appropriate planting techniques (tree grates, planters) and vegetation should be considered in the design of the amenity zone. Amenity zones are typically used in higher density or mixed-use areas with significant pedestrian activity, such as main streets.

The width of the planting strip and/or amenity zone should reflect and enhance the context. The recommended planting strip or amenity zone width for most street types is 6 to 8 feet, with 8 feet being the preferred width to provide for street trees. A wider planting strip of 10 to 12 feet is preferred for rural avenues if street trees are provided.

The considerations in the design of landscaping and street trees in the amenity zone or planting strip by the design input team should include:

- A tree canopy of large maturing street trees is desired on most street types. Medium maturing street trees are used when required by the context or constraints (for example underground utility lines, less planting space, high-speed streets).
- Ensure the street trees and plantings allow for visibility for drivers, pedestrians and bicyclists at driveways and intersections.
- Avoid placing street trees or landscaping rocks at driver or pedestrian decision points (for example island noses). Lower shrubs, landscaping or other vertical elements may be appropriate at some decision points.
- If full-time curbside parking is present, the landscaping should allow access to parked vehicles. Amenity zones may be designed to allow for hardscaped materials at parked vehicle access points or fencing around the tree bed to prevent stepping out into soft or grassy areas (although planting strips are allowed next to parking, depending on context).
- Off-set street trees to avoid locating them under utilities.
- Use medium maturing trees to avoid conflicts with utilities or other service wires. This avoids the potential of damage or “downing” during wind or ice events, and “tree topping” by the utility company which results in unattractive trees and can be detrimental to tree survival.
- Attempt to offset street trees and landscaping from underground utility lines, street lights, light standards, fire hydrants, water meters, or utility vaults to assure the growing root systems do not conflict with these utilities. Underground barriers known as “root barriers” should be considered to enclose roots when there is a potential for damage.

The complete streets planning and design process should recognize the benefits of street trees and landscaping as fully as the importance of other design requirements. Landscaping decisions should be a collaborative, incorporating the full design input team into the discussion, and should recognize that urban streets and their designs are different from rural roads.

Stormwater Facilities

As stated in Chapter 1, the NCDOT is committed to caring for the built and natural environment by promoting sustainable development practices. Toward that end, complete street projects should include sustainable drainage practices of which the goal is to preserve the existing hydrologic condition to the extent practicable and improve runoff characteristics and quality of the project site. Site drainage and stormwater management concepts need to be developed early during the project planning phase and remain consistent through design.

The NCDOT National Pollutant Discharge Elimination System (NPDES) permit requires the Department to have a post-construction stormwater program and policy to implement runoff treatment and control as well as retrofitting existing drainage systems in the areas where no stormwater management was provided. In the urban environment, stormwater management seeks to collect as much rain water as possible in the green zone of a complete street to store it, infiltrate it and/or use it as a resource. Stormwater management measures can be incorporated within other street features and traffic calming features such as vegetated/landscaped median and median islands, planting strips, urban street planters or tree boxes, curb extensions and bulb-outs.

Various types of treatment Best Management Practices (BMPs) for stormwater are continuing to be evaluated by NCDOT, including sand filters, bioretention, dry detention, filter strips, infiltration basins, wetlands, swales, catch basin inserts and Low Impact Development (LID) systems. The most economical and effective method for stormwater quality mitigation is to apply the BMPs at the greatest control of the pollutant. In most cases, for stormwater the point of greatest control is at the source of the pollutant, not at the end of the stormwater pipe. Stormwater treatment is often most cost-effective when integrated early in the planning and design process for the street.

Sustainable stormwater management practices should consider using green infrastructure as the preferred and priority treatment. It should also aim to capture water from a rain event as a resource and allow it to nourish street trees, roadside vegetation and soils. Sustainable street post-construction management practices include:

- Dry, Wet and Bio-Swales
- Infiltration trenches or devices
- Filtering (sand filters, organic filter, bioretention),
- Filter strips
- Porous pavement
- Stormwater Detention

The application and performance efficiency of these BMPs are documented in both the North Carolina Department of Transportation's "Stormwater Best Management Practices Toolbox" (NCDOT, March 2008) and North Carolina Department of Environment and Natural Resources (NCDENR)'s "Stormwater Best Management Practices Manual" (NCDENR, 2009).

Provision of Sidewalks: Slopes and Retaining Walls

In urban and suburban areas, the ability to provide sidewalks can be challenging when the terrain or limited right-of-way width restricts the lateral space available to build them. These locations are often where sidewalks are most needed, since walking on uneven terrain next to traffic is difficult at best. The design input team should consider the inclusion of slopes and retaining walls in the project as a means to provide the space for the sidewalks needed to accommodate all users. Providing retaining walls can make the difference between being able to construct a sidewalk or leaving a section of street "incomplete". Even with the advantage of providing retaining walls, there are design considerations to ensure that the sidewalk is functional for all users.

Designers should use the following general guidelines for projects that will incorporate retaining walls:

- For sidewalks constructed at the base of the retaining wall (between the wall and the street), be sure to include additional sidewalk width (space to remove the discomfort of having to walk immediately next to the wall or curb). The additional sidewalk width required might need to vary by the height of the wall, with higher walls requiring more space and very low walls requiring less. However, this distance should typically be at least one foot from the wall and, if the sidewalk must be back-of-curb due to space constraints, the design should include an additional foot on the street side. Generally, this means that a sidewalk next to a retaining wall should be at least 8 feet wide on avenues, boulevards, and parkways, not including the curb measurement.

- For sidewalks constructed near the top of retaining walls, provide the same additional sidewalk width as described above, and (depending on the height of the wall) include a handrail at the top of the retaining wall.

The determination of the material used in the retaining wall should fit within the context of the street, adding to the overall functionality of the pedestrian environment.

Curb and Gutter

Curb and gutter functions to intercept and convey water from the street to drainage structures. It can also allow for a narrower right-of-way and dress the edge of the traveled way – making it neat, uniform, and well-defined. Use of curb and gutter with a six inch or greater near-vertical face is effective in managing access by defining driveway locations. The six inch high curb is primarily a perceived barrier – it strongly discourages, but does not prevent, vehicles from leaving the traveled way. Curbs provide a clear demarcation between vehicle and pedestrian use areas, which in turn, provides a more pedestrian-friendly environment.

Curb and gutter is appropriate in urban areas and is neither common nor recommended on rural roadways with design or target speeds in excess of 45 mph. Most commonly, the width of the gutter pan is two feet, but some areas use a 1.5 feet gutter pan. This can affect the drainage characteristics of the street. To keep the water spread for a 1.5 feet gutter to the same width as that of a 2 feet gutter (with comparable cross-slope and longitudinal grade) would require that inlets be more closely spaced.

Curb Ramps

A curb ramp serves as the connection from the sidewalk to street level and allows a pedestrian or wheelchair user to move onto or off a sidewalk without difficulty. Curb ramps should be part of the initial construction of curbs, or whenever curbs are reconstructed including but not limited to, reconstruction for maintenance procedures/traffic operations, repair and/or utility changes. Curb ramps are also to be installed when streets with curb and gutter and sidewalk are resurfaced. Directional ramps are preferred over dual radial ramps.

The construction of curbs and ramps on each side of any street, where curbs and sidewalks are provided or planned and at other major points of pedestrian flow, shall meet the detailed design requirements for curb ramp standards, directional ramps, parallel ramps, shared landings and ramps in median and turn lane islands listed in Appendix D.

In general, the design input team should consider the following:

- Curb ramp placement and pedestrian crosswalk markings will vary, but must conform to traffic design standards and plans,
- Directional ramps are preferred over single radial ramps,
- A minimum of two curb ramps should typically be provided at each corner of an intersection,

- The walking surface should be stable, firm and a slip resistant surface, with detectable warning domes and appropriate landing dimensions and slopes,
- Curb ramps should be located and constructed relative to the crosswalk, and generally should align with the crossing. The ramps should allow for the crossing to occur in the safest, most visible portion of the corner.
- Place all pedestrian push button actuators and crossing signals as shown in the plans or as shown in the current edition of the MUTCD.

Utilities

When planning, designing and constructing sidewalks, planting strips, medians and other street features provided on complete streets, the design input team must allow for service access to underground and overhead utilities. Placement of utilities in the design of the street side should consider the following guidance:

- Longitudinal underground utility lines should be placed in a uniform alignment as close to the right of way line as practical, or within a planting strip or amenity zone.
- Consolidate utility poles and signage poles where possible. Remove redundant poles in retrofit situations.
- Whenever possible, utilities should be placed underground to preserve sidewalk capacity for pedestrians and allow for street trees and aesthetic treatments.
- When underground placement is not possible, consider alternative locations for utility poles including the back of the right of way or in the planting strip.

The land use context should always be considered in utility placement. In certain highly constrained locations it may be preferable to place utility poles in the planting strip rather than close to buildings. In no circumstance should poles be placed in the sidewalk and every attempt should be made to avoid or minimize conflicts with street trees. When placement of underground utilities is not practical, the following general considerations are applicable for establishing the location for above ground utilities:

- Utility poles and lines should be located as far as possible from the edge of the through lane, preferably near the right of way line.
- Longitudinal installations should be located on a uniform alignment, preferably near the right of way lines to preserve adequate space for planned street improvements. Longitudinal installations under the travelway are not desirable and should be avoided.
- To the extent feasible and practical, utility lines should cross the street perpendicular to the street alignment.
- The horizontal and vertical location of the utility lines within the street right of way limits should conform to the type of street and specific conditions for the street section involved. The location of the above ground utility facilities should be consistent with the clear zone guidance provided below, as well as the objective to minimize interference with street trees.

The following technical guidance should be considered by the design input team regarding the project's proposed right of way (ROW), Permanent Utility Easement (PUE), and utility pole placement along streets.

Main Streets, Avenues and Boulevards with Curb and Gutter:

Curb and Gutter Facilities: The proposed ROW should be set at a dimension that encompasses the green zone (planting strip) and sidewalk. For a curb and gutter facility posted at 25 mph, 35mph and 45 mph, the clear zone is defined as 8, 10 and 12 feet (see Figures 22 and 23), respectively. All new or relocated utility poles shall be placed at a clear zone offset or just outside the right of way and consequently beyond the clear zone values shown above. A PUE may be necessary beyond the proposed ROW to encompass the utility poles. A PUE is preferable along only one side of the street.

Figure 22: Recommended Green Zone and Sidewalk Zone for Streets with posted speeds of 25 and 35 mph (dimensions may vary based on context and available right of way and/or easements).

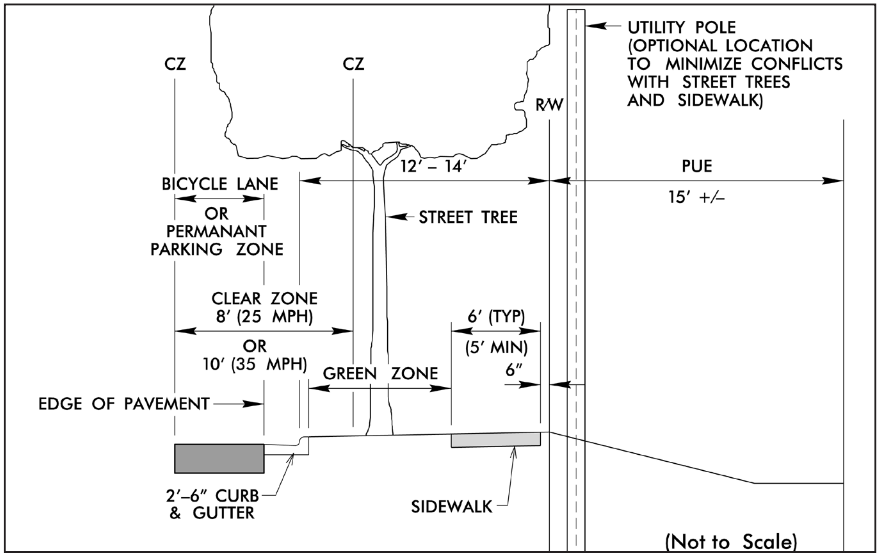
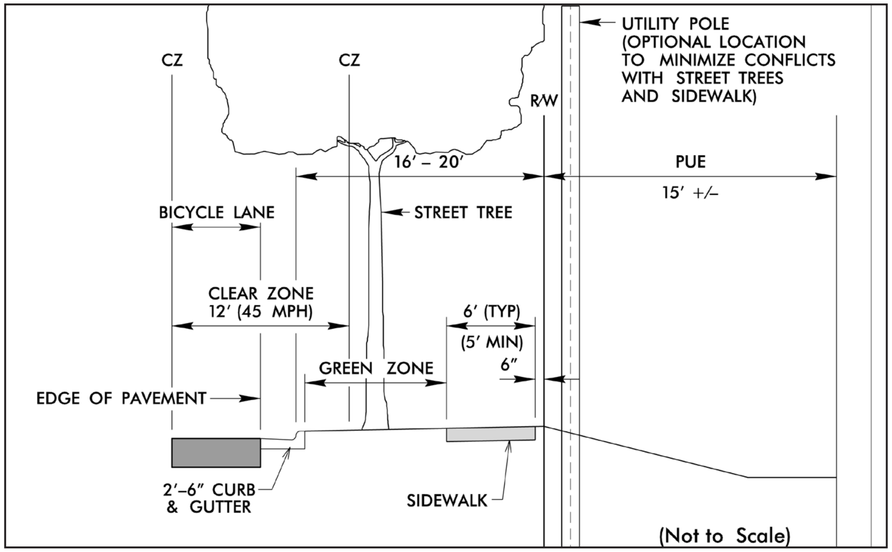


Figure 23: Recommended Green Zone and Sidewalk Zone for Streets with posted speeds of 45 mph (dimensions may vary based on context and available right of way and/or easements).



Parkways:

Shoulder Facilities with Limited or Full Control of Access (C/A): The proposed ROW with C/A should be set at a dimension that includes the project footprint and encompasses the clear zone as discussed later in this chapter and defined by the American Association of State Highway and Transportation Officials (AASHTO) Roadside Design Guide (current edition), (see Figure 24).

Parkways and Rural Roads:

Shoulder Facilities with No or Partial Control of Access (C/A): The proposed ROW should be set at a dimension that encompasses the project footprint and the clear zone as discussed later in this Chapter and defined by the AASHTO Roadside Design Guide. All new or relocated utility poles shall be placed outside the clear zone, but not necessarily beyond the ROW (see Figure 25). A PUE may be provided beyond the proposed ROW to encompass the utility poles and preferably along only one side of the street.

Site specific constraints such as insufficient ROW availability, prohibitive slopes and other factors may make implementation of the full clear zone infeasible. Furthermore, while complete streets such as main streets, avenues and boulevards should strive for utility poles located away from the street side, the application of clear zones for other objects is less consistent with the overall objectives for urban street designs. In such cases good engineering judgment should be used. Relocated and new utility poles should be placed as far as practical from the street to avoid conflicts with street trees and other street design elements that might be provided within the planting strip/amenity zone.

Figure 24: Recommended Utility Pole Placement for Full and Limited Control of Access Facilities with Shoulders.

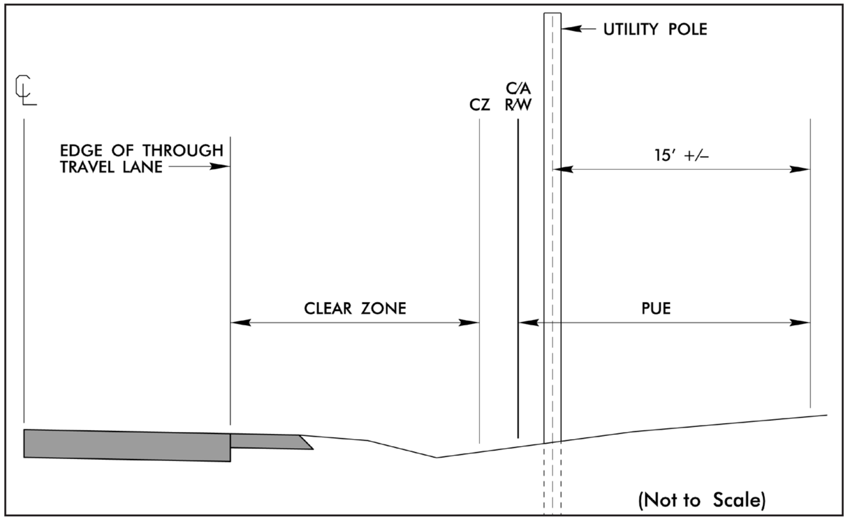
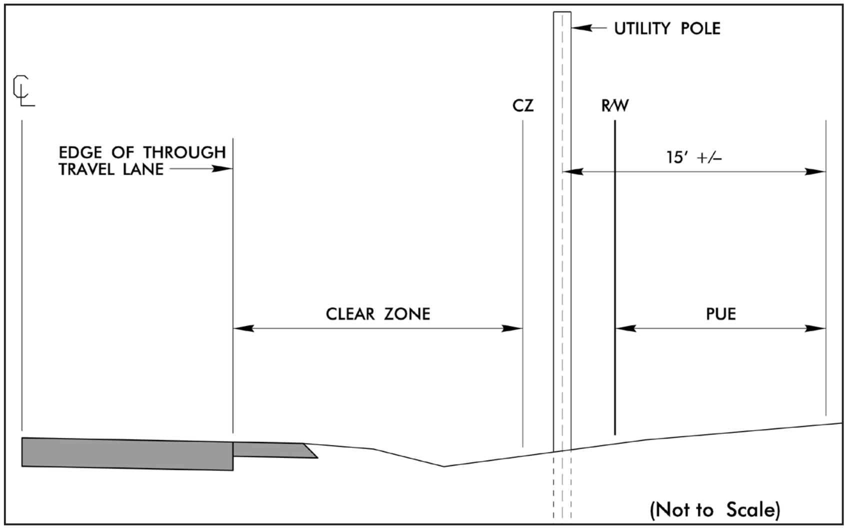
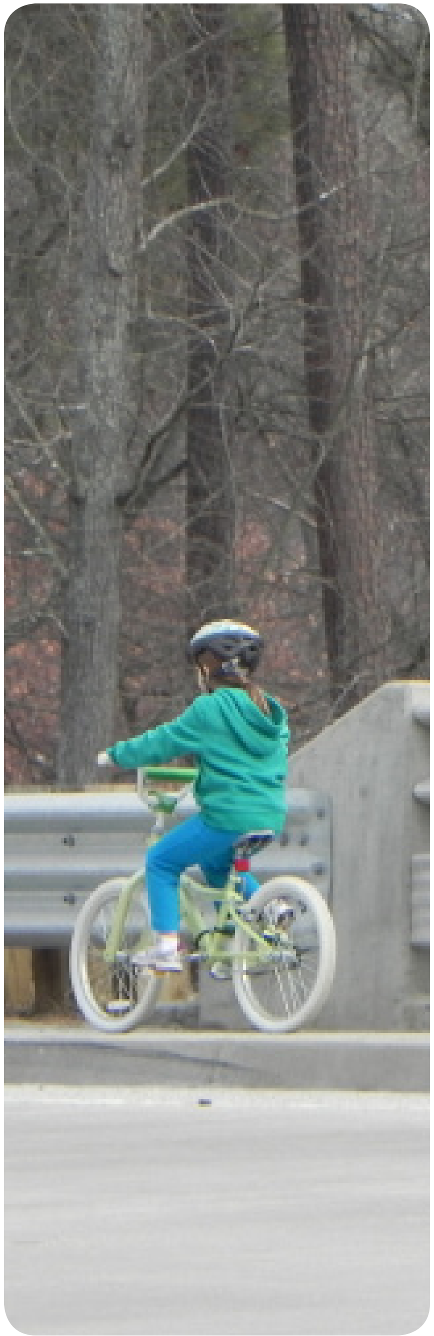


Figure 25: Recommended Utility Pole Placement for No or Partial Control of Access Facilities with Shoulders.





Sight Distance

Sight distance is the area that establishes a clear line of sight for a waiting vehicle, pedestrian or bicyclist to see oncoming traffic and make movements into, out of, or across a street or driveway connection. It is also for traffic to see entering vehicles or waiting vehicles, pedestrians and bicyclists.

For signalized intersections, sight distance should be developed based on AASHTO's A Policy on Geometric Design of Highways and Streets (Current Editon) "Case D – Intersections with Traffic Signal Control." "At signalized intersections, the first vehicle stopped on one approach should be visible to the driver of the first vehicle stopped on each of the other approaches. Left turning vehicles should have sufficient sight distance to select gaps in oncoming traffic and complete the left turns." Corner sight triangles are necessary for signal pole placement, guy wires, signal cabinets, unobstructed 5 to 6 foot wide sidewalks and wheelchair ramps with 4 foot by 4 foot landings when right of way lines are placed directly behind the planting strip and sidewalk. Corner sight triangles will not be symmetrical at skewed intersections.

For main streets and avenues with wider sidewalks and amenity zones, meeting the requirements of a strictly applied sight triangle may not be possible. "Likewise, the requirement for departure sight triangles along streets (when pulling out of streets or driveways), if applied strictly, may conflict with the desire to provide bus shelters, street furnishings, or enough street trees of significant size to create a canopy." (Charlotte, North Carolina, Urban Street Design Guidelines, p. 138). In cases where these design elements compete with departure sight distance, a more thorough evaluation of the sight distance may be appropriate. In order to achieve adequate departure sight distance, a minimum of 50% of an approaching vehicle must be visible to the entering vehicle at all times within the limits of the departure sight triangle. If this condition is met, the departure sight distance is considered adequate. Where trees are the subject of the evaluation, the caliper at full tree maturity should be considered. Typically, adequate sight distance is achieved with a tree spacing of 20 feet for small-maturing trees, 30 feet for medium-maturing trees, and 40 feet for large-maturing trees. Vertical and horizontal alignments can affect the results and should be considered when applying these spacing guidelines.

On streets such as boulevards and parkways, where higher speeds and land uses with deeper setbacks are found, a stricter application of sight distance will be applied. Providing "room for error" by motorists is necessary for maintaining safety along the higher speed street types and rural roads.

Accessibility

In planning and designing for complete streets, whether in a new street or a retrofit/rehabilitation project, each must be designed and implemented so that they are accessible and usable by individuals of all ages and abilities, to the maximum extent feasible. Integrating accessible features in new projects and planned alterations requires an understanding of both regulatory and usability concepts.

The Americans with Disabilities Act (ADA) of 1990 is a civil rights statute that prohibits discrimination against people with disabilities. The accessibility objective of a new or reconstructed project is to design and build a facility that is readily accessible and usable by people with disabilities.

Title II – ADA implementing regulation for title II. Title II – Public Entities (and public transportation) "prohibits disability discrimination by all public entities at the local (i.e. school district, municipal, city, county) and state level. Public entities must comply with Title II regulations by the U.S. Department of Justice. These regulations cover access to all programs and services offered by the entity. Access includes physical access described in the ADA Standards for Accessible Design and programmatic access that might be obstructed by discriminatory policies or procedures of the entity (ADA, 1990)."

"Title II also applies to public transportation provided by public entities through regulations by the U.S Department of Transportation. It includes the National Railroad Passenger Corporation, along with all other commuter authorities (ADA, 1990)."

As with any NCDOT project, complete streets projects must abide by these regulations and in fact seek to exceed the minimum in providing accessibility to all individuals of all ages and abilities. The design input team should address accessibility in their discussions, plans and designs, using current NCDOT guidance on accessibility.

Travel Way Considerations

The previous sections highlighted considerations with street-side elements. The following sections highlight considerations within the travel way of a street or roadway. These include drainage grates and covers, shoulder rumble strips, clear zone, and superelevation.

Drainage Grates and Utility Covers

Drainage grates and utility covers can be serious hazards to bicyclists. Drainage grates with openings running parallel to the curb can trap the front wheel of a bicycle causing loss of steering control, or allow narrow bicycle wheels to drop into the grate, resulting in damage to the wheel and frame and injury to the bicyclist. Care must be taken to ensure drainage grates are bicycle safe. Unsafe grates covers should be replaced with either Type E, F, or G, NCDOT standard grate covers as shown in the Appendix (or other bicycle-compatible drainage grate covers). When a street is designed, constructed or modified, all grates and covers should be bicycle safe.

Utility covers also create problems for bicyclists, and should typically not be located in the bicycle lane. Because they are particularly problematic (for bicyclists and motorists) if left projecting above the surface or

become sunken below the pavement surface, utility covers should be installed flush with the adjacent street surface and/or adjusted when streets are reconstructed or resurfaced.

Shoulder Rumble Strips

A shoulder rumble strip is a safety feature for motorists installed on a paved shoulder near the outside edge of the travel lane. It is made of a series of milled or raised elements intended to alert inattentive drivers (through vibration and sound) that their vehicles have left the travel lane. Rumble strips are placed as a countermeasure for driver error, rather than street deficiencies, and are typically used on high speed facilities in rural areas. They are less applicable on urban and suburban street types. Where they are used, rumble strips on shoulders should be designed to lessen impacts on other users (specifically bicyclists). Shoulder rumble strips with a narrow offset of 9 inches or less from the edge of the pavement marking (travel lane) have been shown to be the most effective, because the driver is alerted sooner and it provides a slightly larger recovery area after being alerted.

Characteristics of and concerns about rumble strips that limit their usefulness or application include low traffic speeds, noise for adjacent residences, limited pavement width, presence of curb and gutter, significant turning movements, and other conflicts for motorists, pedestrians and bicyclists.

Bicyclists are affected by rumble strips. As legal street and road users, bicyclists may be in the travel lane, but where paved shoulders are available and clear, bicyclists will often use them to avoid conflicts with faster moving vehicles in the travel lane. As described in Chapters 3 and 4, paved shoulders, if wide enough, can be an appropriate facility type for bicyclists on some higher speed roadways, such as parkways or rural roads. There are a number of measures that should be considered to accommodate bicyclists when installing rumble strips:

- Wide outside paved shoulders improve safety for all highway and road users. Where existing cross-section exists or is available, allow at least four feet beyond the rumble strips to the edge of the paved shoulder. Where guardrail, curb or other continuous obstructions exist, additional width (2 feet extra width) may be needed to provide adequate clearance for bicyclists.
- Bicycle gaps (recurring short gaps) should be designed in the continuous rumble strip pattern to allow for ease of movement of bicyclists from one side of the rumble to the other. A typical pattern is gaps of 10 to 12 feet between groups of the milled-in elements at 60 feet intervals.
- Decreased width of rumble strip and/or decreased offset width to the edge line (travel lane) may provide additional space usable to bicyclists.

Rumble strips have typically been used in rural areas where run-off-road crash problems exist, and their use on urban freeways and possibly urban parkways should be determined on the merit of the street cross-section and context. Rumble strips are generally not necessary on other complete street types. Installation will be considered on rural roads where posted speed limits and/or statutory speeds are at 55 miles per hour and above. Installation will be considered along specific rural roads where significant numbers of run-off-road-crashes that include any form of motorist inattention has been identified.

Clear Zone

For traditional roadway design, the clear zone design concept is an attempt to furnish a “forgiving” roadside for motorists by reducing the effects of striking a fixed object located within a certain distance from the roadway. The particular width of the clear zone – measured from the edge of the through travel lane – is based on statistical analysis of the results of vehicle tests. The recommended widths are typically influenced by vehicle speed, traffic volume, and street alignment, but context and area does play a role in the application of clear zone.

In urban areas (towns as well as cities), on arterials and other non-controlled access facilities, right-of-way is often extremely limited, safety and comfort for all users is the objective, and, in many cases, it is not practical or appropriate to establish a clear zone that eliminates all fixed objects. Therefore, the application of the clear zone concept is of lower priority for urban/suburban main streets, avenues and some boulevards than on other higher speed facilities.

On local/subdivision streets, main streets, avenues and appropriate boulevards, urban environments are characterized by sidewalks beginning at the face of the curb or by sidewalks positioned behind planting strips with street trees, enclosed drainage, numerous fixed objects (signs, utility poles, luminaire (lighting) supports, fire hydrants, sidewalk furniture, etc.) and frequent traffic stops. These environments typically have lower operating speeds and, in many instances, on-street parking is provided. A lateral offset to vertical obstructions (signs, utility poles, luminaire (lighting) supports, fire hydrants, etc., including breakaway devices) is provided in lieu of keeping the clear zone free of all fixed objects.

Where the clear zone values cannot be achieved or are not applicable due to the context and expected speeds (e.g. main streets and avenues), the street should provide sufficient lateral offset to roadside fixed objects. Historically a lateral distance value, referred to as an operational offset, of 1.5 ft. has been considered a minimum lateral distance for placing the edge of objects from the curb face for urban streets. This minimum lateral offset, though sometimes misinterpreted as such, was never intended to represent an acceptable safety design criterion. In a constrained urban environment, there is still a need to position rigid objects as far away from the active travel way as possible.

For curb and gutter facilities posted at 25 mph, 35 mph and 45 mph, NCDOT has defined its urban clear zone as 8-ft., 10-ft. and 12-ft., respectively. This distance is measured from the edge of the through travel lane. In extremely constrained environments, deviations from the urban clear zone dimensions will be discussed by NCDOT and the local agency on a case-by-case basis.

Generally, the principles and guidelines for the AASHTO Roadside Design Guide discuss roadside safety considerations for rural highways, interstates, and freeways where speeds are generally higher, approaching or exceeding 50 mph, and vehicles are operating under free-flow conditions. In rural environments, where speeds are higher and there are fewer constraints, a clear zone appropriate for the traffic volumes, design speed and facility type should be provided in accordance the current edition of the AASHTO Roadside Design Guide. These values are also appropriate for freeways, urban parkways and rural roads. Typical clear zones for freeways and rural roads for speeds of 35 mph, 45 mph, and 55 mph are 14-ft., 20-ft. and 30-ft., respectively.

Decisions regarding the design of forgiving street sides must be made on an individual basis, while considering the value of the street to the community, the benefits of street trees to the environment, anticipated vehicle speeds, the effects of visual friction on reducing speeds, and crash history. Regardless of the decision made about the project’s specific street-side design, the decision should be made using a collaborative process.

Superelevation

Superelevation is the cross slope of a street between the two edges of pavement. Cross slope helps rainwater to drain off the road. In curves, the outside edge of pavement is raised to increase driving comfort through the curve. Superelevation has its place in roadway design – especially on high speed facilities and interchanges with large size trucks. Superelevation can be beneficial for traffic operations, because it generally allows for higher speeds. However, and particularly when related to complete street objectives, various factors often combine to make the use unnecessary in low-speed urban areas. These factors include wide pavement areas, the desire to maintain low speed streets, break-over angles at side streets, reduced visibility of crosswalks, lane alignments, impacts to adjacent property and the higher frequency of intersecting streets and driveways. A full discussion of the application of superelevation to low-speed streets is presented in the current edition of AASHTO's A Policy on Geometric Design of Highways and Streets. Table 3 provides general recommendations for superelevation on various street types.

In keeping with NCDOT's streets objectives, horizontal curves on low-speed urban streets can be designed without superelevation. The minimum radii and corresponding superelevation rates for urban streets and rural roads are shown in Table 3, with flexibility based on discussion with the project input team.

The purpose of this chapter was to identify and describe the intent for various design elements for complete streets, organized by street-side elements and elements within the travel way. The key with each of these elements is to maintain flexibility in the design, and to specifically emphasize that streets in urban, suburban, and town environments will be designed differently than higher speed roadways in rural contexts.

Table 3: Minimum Superelevation and Curve Radii

Context (Street Type)	Design Speed (mph)	Superelevation (e)	Minimum Radii (feet)	Superelevation and Friction Distribution*
Urban and Suburban				
	20	-2% (NC)	107	Method 2
	25	-2% (NC)	198	Method 2
	30	-2% (NC)	333	Method 2
	35	-2% (NC)	510	Method 2
	40	-2% (NC)	762	Method 2
	45	-2% (NC)	1039	Method 2
(Parkway)	>45	+4%	N/A	Method 1
Rural				
(Road)	35	+4%	371	Method 1
(Road)	40	+4%	533	Method 1
(Road)	45	+4%	711	Method 1
(Boulevard)	50	+4%	926	Method 1
(Parkway)	50	+6%	833	Method 1
(Parkway)	60	+6%	1330	Method 1

*Source: AASHTO

NOTES: Method 1 – Superelevation and Friction Distribution uses superelevation and side friction to establish driver comfort through a curve. This allows curves to be sharper and contain more camber/cross slope to establish driver comfort at respective speeds.

Method 2 – Superelevation and Friction Distribution uses side friction alone to establish driver comfort through a curve. Because this method is completely dependent on available side friction, its use is generally limited to low-speed streets. This method is particularly advantageous on low-speed urban streets where, because of various constraints, superelevation frequently cannot be provided.

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Key Definitions

AASHTO: American Association of State Highway and Transportation Officials

Access Management: Access management is a set of techniques that state and local governments can use to control direct access to streets.

Americans with Disabilities Act (ADA): This act prohibits discrimination against people with disabilities. Transportation facilities that support accessibility for people with disabilities include curb ramps, detectable warning pads and level landings, among other features.

Area Type: Categories used in these guidelines to describe a variety of areas or geographies. The nine different types include three urban area types (Central Business District, Urban Center, and Urban Residential), three suburban area types (Suburban Center, Suburban Residential and Suburban Core) and three rural area types (Rural Village, Rural Developed and Countryside).

Complete Streets: Complete streets are streets designed to be safe and comfortable for all users, including pedestrian, bicyclists, transit riders, motorists and individuals of all ages and capabilities. These streets generally include sidewalks, appropriate bicycle facilities, transit stops, right-sized street widths, context-based traffic speeds, and are well-integrated with surrounding land uses.

Comprehensive Transportation Plan (CTP): A transportation system plan to meet the future needs of a planning area for a minimum twenty (20) year period. This include a mutually adopted (by MPO's, RPO's, and NCDOT) multi-modal set of maps that serve that show the long range vision for serving present and anticipated future travel demand for all users. This plan includes all potential project types.

Growth Area: An area where growth is likely to occur and that is categorized as, or transitioning to, urban and/or suburban. It also may include a town or community and areas around or near parks, lakes and schools.

Level of Service (LOS): A measure used to describe the effectiveness of transportation infrastructure for motor vehicles; traditionally used to describe traffic flow.

Long Range Transportation Plan (LRTP): A federally mandated, long-term planning document detailing the transportation improvements and polices to be implemented in an MPO's planning area. It is developed by MPO's and represented municipalities, in partnership with NCDOT, and includes projects that are scheduled for funding over the next twenty (20) years.

Metropolitan Planning Organization (MPO): A regional policy body, required in urbanized populations over 50,000, that is responsible for carrying out the metropolitan planning requirements for federal highway and transit legislation in cooperation with the state and other transportation providers. The MPO develops transportation plans and programs for the metropolitan area.

NACTO: National Association of City Transportation Officials.

NEPA: National Environmental Policy Act of 1969, as amended. NEPA requires all federal agencies to consider environmental factors through a systematic interdisciplinary approach before committing to a course of action. The NEPA process is an overall framework for the environmental evaluation of federal actions, including transportation projects.

North Carolina Complete Streets Policy: Adopted in July 2009; represents North Carolina's approach to interdependent, multi-modal transportation networks that safely accommodate access and travel for all users. The policy states that "working in partnership with local government agencies, interest groups, and the public, NCDOT will plan, fund, design, construct and manage complete street networks that sustain mobility while safely accommodating walking, biking, and riding transit."

North Carolina Transportation Plan: A 30-year document that defines the mission and goals of the Department and sets out key objectives and strategies to achieve them. These elements guide decision making, including investment decisions.

Quality of Service (QOS): A qualitative assessment of the level to which a street provides for all modes of travel, with a particular focus on bicyclists, pedestrians and transit users. Quality of Service is based on the physical and operational designs of the street and emphasizes that these affect the functionality of the street for all users, particularly non-motorists.

Rural Planning Organization (RPO): A regional planning body of local elected officials or their designees and a representative of local transportation systems formed by a memorandum of understanding with NCDOT to work cooperatively with the Department to plan rural transportation systems and to advise the Department on rural transportation policy.

State Transportation Improvement Program (STIP): The State Transportation Improvement Plan represents a 7 year subset of the Project List included in NCDOT's Program and Resource Plan. NCDOT reviews the draft STIP annually and updates the STIP every two years.

Target Speed: Target speed refers to the preferred travel speed on the street.

Traffic Calming: One or a combination of mainly physical measures installed within the street right of way to control traffic speeds and improve the safety and livability of local streets. Traffic calming measures are intended to reduce the negative effect of motor vehicle use, alter driver behavior and improve conditions for non-motorized street users.

Traffic volume: Traffic volume refers to the amount of of motor vehicles that travel on a street.

RESEARCH & DEVELOPMENT

North Carolina Pedestrian Crossing Guidance

Bastian J. Schroeder, PhD, PE
Sarah Worth O'Brien
Daniel J. Findley, PhD, PE
Institute for Transportation Research and Education (ITRE)
North Carolina State University

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Bastian J. Schroeder, Ph.D, P.E.
Sarah Worth O'Brien
Daniel J. Findley, Ph.D, P.E.

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7. Author(s)
Bastian Schroeder, Ph.D., P.E. (Bastian_Schroeder@ncsu.edu)
Sarah Worth O'Brien (skworth@ncsu.edu)
Daniel J. Findley, Ph.D., P.E. (Daniel_Findley@ncsu.edu)

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North Carolina State University
Centennial Campus Box 8601
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This research report is geared at providing guidance to NCDOT for when to consider marking crosswalks at uncontrolled approaches for pedestrians, installing pedestrian signal heads at existing signalized intersections, or providing supplemental treatments at a crossing location.

The primary deliverable of the project, the crosswalk assessment flowchart, is intended to be a self-contained, wall-mounted poster that fully describes most aspects of the evaluation and decision-making process. This report is intended to supplement that flowchart, providing background for the flowchart with references to research and underlying data used to develop the guidance.

The guidelines principally consist of four parts: Step 1) Document Existing Characteristics / Signalized Crossing Assessment, Step 2) Unsignalized Crossing or Midblock Crossing Assessment, Step 3) Additional / Alternative Treatments Assessment, and Step 4) Pedestrian Hybrid Beacon (PHB) Assessment.

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DISCLAIMER

The contents of this report reflect the views of the authors and not necessarily the views of the Institute for Transportation Research and Education or North Carolina State University. The authors are responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the North Carolina Department of Transportation or the Federal Highway Administration at the time of publication. This report does not constitute a standard, specification, or regulation.

Some of the guidance provided in this document is based on the 2009 version of the MUTCD. Future editions of the MUTCD may supersede recommendations or actions conveyed herein and should be consulted before making or implementing decisions.

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Scott Cole, P.E., P.L.S. - Chair
Joel C. Cranford
D.D. (Bucky) Galloway, P.E.
Steven J. Hamilton, P.E., CPM
W.L. (Lee) Jernigan, P.E.
Ernest Morrison, P.E.
Kumar Trivedi, P.E.
Terry M. Hopkins, P.E.
Dale Stokes
Anthony D. Wyatt, P.E., PTOE
Robert J. Ziemba, P.E.

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EXECUTIVE SUMMARY

The North Carolina Department of Transportation (NCDOT) is frequently faced with the decision of whether or not to provide a marked crosswalk at uncontrolled approaches for pedestrians, and of whether or not to install pedestrian signal heads at existing signalized intersections. Further, the question often arises of what supplemental treatments, in addition to crosswalk markings, may be appropriate or needed at un-signalized intersections or uncontrolled midblock crossing locations.

Oftentimes, specific guidance for provision of these pedestrian facilities is lacking. While the 2009 Manual of Uniform Traffic Control Devices (MUTCD) and existing NCDOT policies cover a variety of applications, there are still significant gaps in the available guidance. In an era of increasing emphasis on complete streets to ensure pedestrian needs are appropriately balanced with other transportation modes, and a focus on assuring an accessible transportation system to all road users, clear guidance is important.

The task of determining which crossing locations warrant the installation of pedestrian facilities is complex but can be approached in a systematic manner to provide benefits to users of the transportation network. This research was particularly focused on guidelines for NCDOT to evaluate the feasibility of including crosswalks and/or pedestrian signalization at signalized intersections and marked crosswalks on the approaches of uncontrolled intersections. Consistent and appropriate guidance can support decision making for whether or not the installation of pedestrian facilities at a particular crossing location provides a safe crossing for pedestrians and is the optimal use of improvement funds. The guidance allows for, and emphasizes the importance of, engineering judgment and some design flexibility while providing the necessary decision support for NCDOT staff in the crosswalk assessment process.

The primary deliverable of the project, the crosswalk assessment flowchart tool, is intended to be a self-contained, wall-mounted poster that fully describes most aspects of the evaluation and decision-making process. This report is intended to supplement that flowchart, providing background for the flowchart, and references to research and underlying data used to develop the guidance.

The guidelines principally consist of four parts: Step 1) Document Existing Characteristics / Signalized Crossing Assessment, Step 2) Unsignalized Crossing or Midblock Crossing Assessment, Step 3) Additional / Alternative Treatments Assessment, and Step 4) Pedestrian Hybrid Beacon (PHB) Assessment. Key inputs in the sequential crosswalk assessment flowchart are pedestrian and vehicular volumes, roadway cross-section and design attributes, and vehicular speed, as well as various other considerations. The potential outcomes of the assessment process include recommendations for marking crosswalks, installing supplemental treatments, warranting signal or pedestrian hybrid beacon installation, as well as cases where no action is required. Throughout the process, all guidance for marking crosswalks and treatment installations are subject to the availability of funds to install and maintain the treatment.

The development of the guidelines was accomplished through the following tasks including a review of literature; survey of NCDOT, municipal, and state practices; compilation of literature and survey findings; and refinement of the process through collaboration with NCDOT. These research findings will guide future installations of pedestrian treatments with a consistent, repeatable process that will provide a safety benefit for users of the transportation network in North Carolina. While this report focuses towards NCDOT practices, it may serve as guidance for municipalities in North Carolina and perhaps outside the state as well.

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Pedestrian Crossing Guidance

0 INTRODUCTION

This guidebook is intended as supplemental information to a pedestrian crosswalk assessment flowchart tool developed for the North Carolina Department of Transportation (NCDOT), which lays out a series of steps to evaluate the need for treatments to assist pedestrians at potential crossing locations. That product will henceforth be referred to as "the Flowchart" in this document. The Flowchart was designed as a self-contained document; however, some users of the Flowchart may prefer additional detail to the notations provided. Therefore, this guidebook offers the same process that is laid out in the Flowchart, while offering additional resources and references to support the process. The Flowchart itself may be accessed on NCDOT's website (www.ncdot.gov) and is designed to be printed as a 36 in. by 85 in. poster.

0.1 EVALUATE CROSSINGS BY APPROACH

The pedestrian crossing treatment evaluative process is designed to be applied at the approach level (i.e., each approach to the crossing should be considered individually) for each leg of an intersection or for mid-block crossing locations. While the guidance may also be applied to crossings of shared use paths, trails, or other locations where bicyclists may share the facility with pedestrians, it is important to note that the research supporting the guidance and Flowchart are based on pedestrian-only usage.

Crossing needs and considerations for bicyclists may differ: they are able to travel at speeds greater than pedestrians; space requirements on crossing islands or medians for any queuing or storage of bicyclists may be larger; lateral clearance needs may be wider to allow for the maneuverability of slower moving bicyclists who are more likely to weave to maintain balance; and sight distances for bicyclists approaching an intersection differ from pedestrians, due to differences in speed and stopping distance. Additional guidance on design considerations for shared use path crossings can be found in the *Guide for the Development of Bicycle Facilities*. (AASHTO, 2012)

0.2 GENERAL PRINCIPLES AND CONSIDERATIONS

There are several general principles and considerations for the use of this guide.

- Engineering judgement is always encouraged when considering the appropriateness of a desired crossing location, as well as what traffic control device(s), if any, may be suitable to assist pedestrians with crossing. While thresholds for factors are provided, particular consideration or additional study may be necessary for sites near threshold values, or where special circumstances or special populations are present.

- Field investigations are strongly recommended to confirm site characteristics and input data, and to observe pedestrian and driver behaviors. In some cases, field visits may be required to collect data needed to move through the crossing treatment evaluation process.
- Only one scenario results in an endpoint where the action indicated is required (See Section 1.3.2). Following the Flowchart and guidance through to an endpoint will typically result in one of the following recommended actions to consider:
    - Pedestrian signal heads at an existing signalized intersection,
    - Marked crosswalk at a previously uncontrolled intersection or midblock location,
    - Geometric improvements to the pedestrian crossing,
    - Supplemental warning signs, markings, actuated beacons or Rectangular Rapid Flashing Beacons,
    - Pedestrian Hybrid Beacon,
    - Traffic signal to assist pedestrians at a previously uncontrolled location, or
    - No action required.
- Decisions that lead to the consideration of or need for a treatment should only be implemented if financial resources are available to install and maintain the treatment. Local participation is encouraged to support the installation of treatments identified as appropriate.

Figure 1 Following the Flowchart and guidance through to an endpoint will result in one of six potential recommended outcomes.

0.3 INAPPROPRIATE USE OF GUIDANCE

The pedestrian crossing treatment evaluative process is not intended to be used to prioritize sidewalk improvements or to evaluate the connectivity of a pedestrian network. National Cooperative Highway Research Program Report 803 *Pedestrian and Bicycle Transportation along Existing Roads – ActiveTrans Priority Tool Guidebook* provides a methodology and tool to assist agencies in evaluating and prioritizing the need to provide or improve facilities for active travelers, (Lagerwey, Hintze, Elliott, Toole, & Schneider, 2015)

Crossing locations within school zones or along school walking routes are a specialized type of crossing that may require additional considerations. Therefore, school-related crossing evaluations are outside the scope of this crossing treatment evaluative process.

Crossing locations called to the Department's attention through a written request for reasonable access under the Americans with Disabilities Act (ADA) should not be evaluated using this guide or Flowchart.[1] ADA requests follow a different process established through the "Standard Practice for Pedestrian Reasonable Access requests from Pedestrians with Qualifying Disabilities under the Americans with Disabilities Act." (NCDOT, 2009)

0.4 WHEN TO USE THE GUIDANCE

The pedestrian crossing treatment evaluation process may be prompted through a variety of mechanisms. Most commonly, it is expected that the Department will initiate an evaluation of a crossing location at the request of a municipality or citizen. Pedestrian crash hot spot locations identified through crash analyses may also trigger an investigation for alternative or additional crossing treatments using the Flowchart as a means to mitigate possible crash factors. As local agencies develop pedestrian or greenway plans, it may be beneficial to review crossing locations identified and prioritized through the planning process to better evaluate infrastructure needs and develop useful cost estimates.

While it is more likely that this evaluation process will be performed in response to a particular request or prioritized location, it could also be utilized as a proactive means to systematically review existing crossing locations as part of a basic needs assessment and inventory. It is possible to envelop the Flowchart as a component within established operations and maintenance assessment workflows currently implemented in the Department.

0.5 OVERVIEW OF PROCESS STEPS

There are four main steps to move through when evaluating a pedestrian crossing. These steps are intended to be performed in sequential order:

Step 1: Document Existing Characteristics / Signalized Crossing Assessment

Step 2: Unsignalized Crossing or Midblock Crossing Assessment

---

[1] ADA compliance for equivalent facilitation only applies to locations with existing pedestrian facilities. Crosswalks constitute distinct elements of the right-of-way intended to facilitate pedestrian traffic, and as such, they must comply with ADA regulations when installed or resurfaced. Resurfacing of a crosswalk requires the provision of curb ramps at that crosswalk. (DOJ/DOT, 2013)

Step 3: Additional / Alternative Treatments Assessment

Step 4: Pedestrian Hybrid Beacon (PHB) Assessment

While some requests may be for a specific treatment at a crossing location, following the steps in the Flowchart sequentially ensures that the crossing location is reviewed comprehensively. For example, a municipality may request a PHB at a particular location. Rather than jumping to Step 4 to evaluate the location for a PHB, it is prudent for the evaluator to remove all preconceived notions of the solutions or outcomes that may result, and, instead, he/she should objectively apply the Flowchart guidance beginning with the first step. This ensures that all relevant factors and road characteristics are considered when determining a potential course of action.

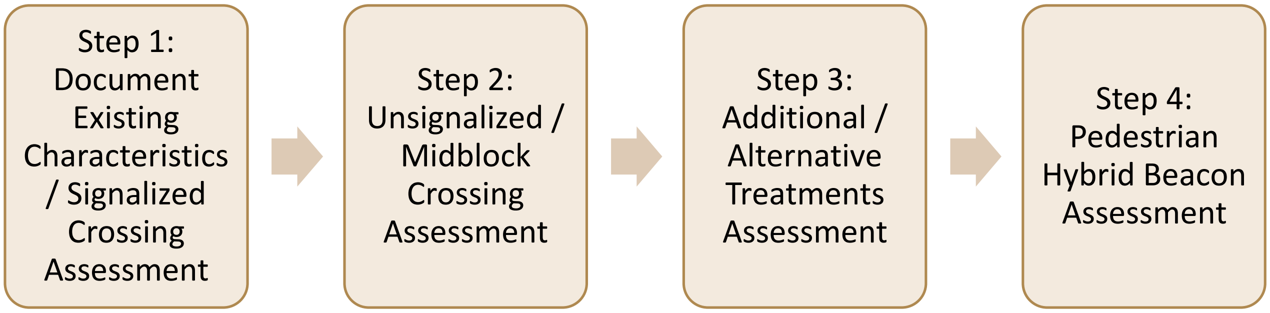

Figure 2 Overview of Pedestrian Crossing Treatment Evaluation Process

1 STEP 1: DOCUMENT EXISTING CHARACTERISTICS / SIGNALIZED CROSSING ASSESSMENT

There are six (6) potential checks to complete as part of Step 1. The first three checks will be performed for all crossing locations under evaluation, while the fourth and fifth check applies only to locations at existing signals, and the sixth check applies only to unsignalized locations:

1) Gather relevant data
2) Check for presence of ADA compliant path
3) Check crossing type
4) Check for the application of 2009 MUTCD 4E.03 conditions
5) Check pedestrian volume
6) Check for the presence of an adjacent crossing opportunity

After moving through the Step 1 Flowchart element, an evaluator will end at one of four (4) potential outcomes:

- No Action Required
- Install Pedestrian Signal Heads (Required)
- Consider Installing Pedestrian Signal Heads
- Move to Step 2

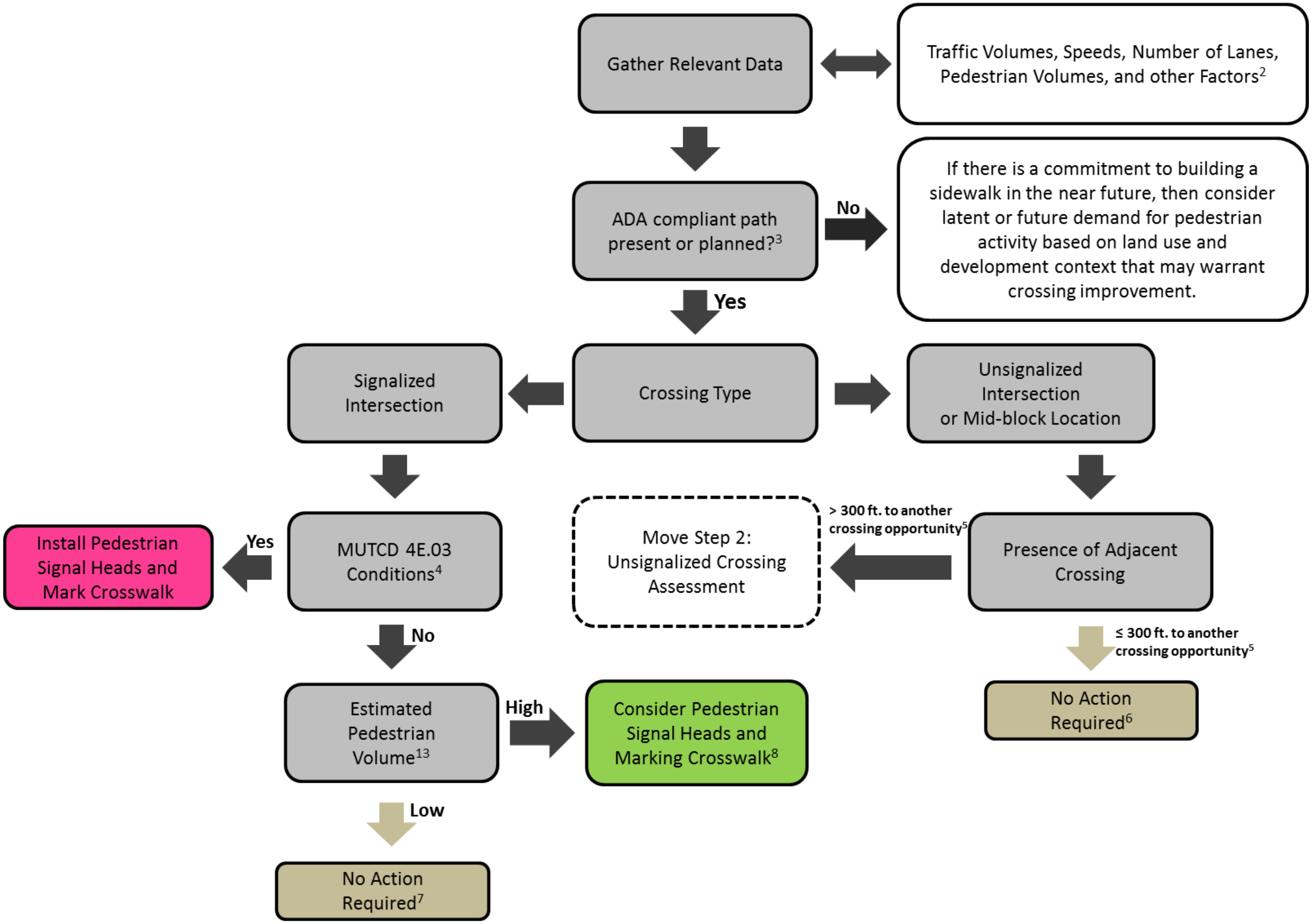

Figure 3 Flowchart Element for Step 1: Document Existing Characteristics / Signalized Crossing Assessment

1.1 GATHER RELEVANT DATA

Based on current research, the Flowchart utilizes six primary factors as data inputs the evaluator should gather as part of Step 1. These key variables of interest may be needed at more than one junction within the Flowchart:

- Distance to Adjacent Crossing
- Vehicle Traffic Volume
- Speed Limit and/or Operating Speed
- Pedestrian Volume
- Number of Lanes and/or Crossing Distance
- Total Pedestrian Delay

Additional factors may be considered when installing or improving a pedestrian crossing as they can enhance an understanding of the local context of the pedestrian facility in question. Some of these factors may need to be gathered as part of Step 1, or the evaluator may find the additional data is needed after working through the Flowchart to conduct an engineering study or to better apply engineering judgement prior to determining a treatment outcome. While specific thresholds or measures are not given for the factors below, gathering these additional data upfront when possible will enable the evaluator to more holistically assess the potential need for a crossing or crossing improvement, or may influence whether a combination of treatments is best suited at a particular location. These additional factors include:

- Site distance restrictions and obstructions,
- Driver yielding rates,
- Pedestrian compliance,
- Observed crossing behaviors and travel paths,
- Crash history,
- Heavy truck traffic,
- Lighting considerations,
- Proximity to or location of transit stops,
- Presence of special pedestrian populations (e.g. children and/or the elderly),
- Future traffic and or pedestrian volumes (5 to 10 years out), and
- Future nearby land use changes, growth, or development patterns (5 to 10 years out).

1.2 CHECK FOR PRESENCE OF EXISTING OR PLANNED ADA COMPLIANT PATH

Evaluators must check for sidewalk or other existing pedestrian facilities that comprise the portion of an accessible route as defined by the US Access Board.[2] When these facilities are present, the check is satisfied and the evaluator may move on to the next check.

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[2] "*Accessible Route* – A continuous unobstructed path connecting all accessible elements and… may include parking access aisles, curb ramps, crosswalks at vehicular ways, walks, ramps, and lifts." (US Access Board, 2002) The path is considered ADA compliant when the prepared surface is intended for pedestrian use and it meets current regulations.

Figure 4 Sidewalk, ramps, and detectable warnings at this corner serve as an ADA compliant path.

If pedestrian facilities are not present, the evaluator should consult with the local agency to determine if there are plans to build them in the near future.[3] For locations where agencies demonstrate a firm commitment to provide a sidewalk and secure the funds to do so within the next five (5) years, the evaluator can proceed with the crossing assessment, as this check is satisfied.

If facilities are not present and there are no plans to install them, the check is not satisfied and the evaluator halts progress through the Flowchart. However, this does not mean that the original request for crossing assistance is without merit. Evaluators should consider pedestrian activity at the potential crossing location and within 150 feet of either side of the location. If there is sufficient pedestrian activity or indications of latent or future demand based on land use and development context, the Department may consider initiating a separate project development process with the local agency outside the scope of the Flowchart process to discern the feasibility of constructing an ADA compliant path, and then reevaluate the crosswalk configuration at that time.

1.3 CHECK CROSSING TYPE

Simply put, the evaluator indicates whether the crossing location is at a signalized or unsignalized location. This decision point in the Flowchart determines the type of crossing assessment to apply. For signalized intersections, evaluators will complete Step 1. Unsignalized or midblock locations will be further assessed through Steps 2, 3, and 4 of the Flowchart.

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[3] This guidance is aligned with a memorandum on alternate curb ramp designs, which states, "during the preliminary engineering design, if an entity expresses a firm comment to provide sidewalks in the near future of completing a project, curb ramps can be shown on the pavement marking plans provided by the Signing and Delineation Unit." (Lacy, 2011)

1.3.1 Unsignalized Intersection or Mid-block Crossing Type

For locations that are unsignalized, evaluators must first consider the proximity of the potential crossing to adjacent existing crossings.

- If the potential crossing is less than or equal to 300 feet to another unsignalized crossing opportunity, or less than 400 feet to a signalized intersection, then No Action is required.[4] The evaluator should confirm that the existing nearby crossing location can sufficiently meet pedestrian needs. If observed pedestrian activity reveals that they do not use the existing crossing location, further investigation may be needed to assess the existing crossing opportunity. In some cases, the existing adjacent crossing may need to be improved and/or enhanced with landscaping or other positive guidance to encourage and direct pedestrians to cross at the existing location. Engineering judgement should be used for unique circumstances where closely spaced crosswalks may be needed due to pedestrian activity.

Figure 5 Midblock crossing of a shared use path.

- If the potential crossing is greater than 300 feet to another unsignalized crossing opportunity, or greater than 400 feet to a signalized intersection[5], then the evaluator moves to Step 2 in the Flowchart for further assessment.

1.3.2 Signalized Intersection Type

If the crossing type is at a signalized location, then the crossing is evaluated for the need for pedestrian signal heads. Where the crosswalk is not currently marked, if the decision is made to install pedestrian signal heads, the crosswalk should also be marked.[6]

Two checks are performed as part of the Signalized Crossing Assessment. The crossing is first checked to determine if pedestrian signal heads are required, per 2009 MUTCD 4E.03. If not, then the estimated

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[4] From section 4D.01.06 of the MUTCD, "Midblock crosswalks shall not be signalized if they are located within 300 feet from the nearest traffic control signal, unless the proposed traffic control signal will not restrict the progressive movement of traffic." Additional guidance is given that midblock crossings should not be signalized if located within 100 feet from STOP or YIELD controlled side streets or driveways. (Federal Highway Administration, 2009)

[5] The NCDOT clarified that "mid-block crosswalks should not be located within 300 feet of a non-signalized intersection and 400 feet of a signalized intersection, as to not interfere with the functionality of the intersection." (NCDOT, 2008) This standard practice guidance is irrespective of whether the mid-block crossing will be signalized.

[6] Use engineering judgment based on location context to determine what type of pattern is most appropriate. High-visibility markings may be appropriate for school crosswalks or where pedestrians or marked crosswalks may not be expected by drivers. (National Committee on Uniform Traffic Control Devices, 2011)

pedestrian volume is checked. It is also recommended to consider pedestrian signal head installations where:

- The estimated pedestrian volume is above a specified "low volume" threshold discussed below,
- To be consistent with adjacent intersections (e.g. in a downtown area), or
- Where they may otherwise enhance pedestrian safety.

1.3.2.1 Check for 2009 MUTCD 4E.03 Conditions

At a signalized crossing location, the evaluator must review the crossing to determine if it meets any of the conditions listed in 4E.03 of the MUTCD:

> *01 Pedestrian signal heads shall be used in conjunction with vehicular traffic control signals under any of the following conditions:*
>
> *A. If a traffic control signal is justified by an engineering study and meets either Warrant 4, Pedestrian Volume or Warrant 5, School Crossing (see Chapter 4C);*
>
> *B. If an exclusive signal phase is provided or made available for pedestrian movements in one or more directions, with all conflicting vehicular movements being stopped;*
>
> *C. At an established school crossing at any signalized location; or*
>
> *D. Where engineering judgment determines that multi-phase signal indications (as with split-phase timing) would tend to confuse or cause conflicts with pedestrians using a crosswalk guided only by vehicular signal indications.* (Federal Highway Administration, 2009)

If the crossing meets any of items A through D, then the standard **requires** that pedestrian signal heads be installed. Installed pedestrian signal heads should conform to MUTCD's guidance on signal timing to provide sufficient pedestrian clearance times for crossing. See Section 4E.06 of the 2009 MUTCD for further details.

Figure 6 Protective-permissive left turn signals may be confusing to pedestrians attempting to rely on the vehicular traffic signals to know when it is their turn to cross, and therefore engineering judgement must determine whether Section 1.3.2.1 D of the 2009 MUTCD applies.

1.3.2.2 Check Estimated Pedestrian Volume

In most cases, existing pedestrian volume data will be sparse. Therefore, two primary options are available to gather such data: 1) conduct an observational study or 2) estimate volume using proxy measures.

If the evaluator elects to conduct a study, the following is recommended to gather pedestrian counts:

- Seven continuous days of counts are preferred, when possible. Where resources are not available to collect a week's worth of data, a minimum of one weekend and one weekday should be collected. The days of the week selected should target when the highest pedestrian activity is expected.[7]

- Restricting data collection to during daylight hours only is acceptable unless the land use context around the site suggests that nighttime pedestrian activity should be expected.
- Counts at the potential crossing location under study should include pedestrians that cross within 150 feet of either side of the crossing.
- Coordinate effort with the Division of Bicycle and Pedestrian Transportation for feedback on additional or unique site-specific considerations prior to conducting the study, and to obtain guidance on data collection protocols for pedestrian studies.

When observational data does not exist and will not be collected, proxy measures can be estimated based on land use context and are sufficient to estimate pedestrian volume at a crossing. Crossings that are near pedestrian trip generators or destinations, or those that may connect complementary land uses should be considered for enhancement. Where proxy measures are used, they should be well documented in the evaluator's assessment.

Because existing pedestrian volume data is limited, the evaluator must use engineering judgement to choose the appropriate low volume threshold from the following considerations:

- The crossing area has less than 25 pedestrians per pedestrian peak hour OR less than 100 pedestrians per day.
- At mid-block locations only: crossing area has less than 25 pedestrians per pedestrian peak hour for at least four hours. (NCDOT, 2008)
- The crossing area is not near high pedestrian trip generators.
- The crossing area does not connect complementary land uses.

Lower volume thresholds may be considered for crossings with a significant presence of a special population, such as children or the elderly. Where the estimated pedestrian volume is considered low, no action is required.

---

[7] Bicycle and pedestrian volumes are lower and more variable due to weather (e.g., temperature and precipitation) and other factors than motor vehicle traffic. Therefore, it is more difficult to calculate AADT from shorter durations than seven days. (Nordback, Marshall, Janson, & Stolz, 2013) The *Traffic Monitoring Guide* suggests a 7 day duration, noting that "depending on several other factors…the preferred duration of automatic counts could be as long as 14 days." If manual observers are used to collect the counts due to resource limitations, a 12-hour count is preferred. (Federal Highway Administration, 2013)

Figure 7 While pedestrian signal heads may not be required at a typical urban signalized intersection, pedestrian signal heads and marked crosswalks may make sense to provide consistency in application throughout a downtown system.

Regardless of whether pedestrian signal heads are required or recommended for consideration, the evaluator may also review the signalized crossing for geometric or other improvements that could enhance pedestrian safety, accessibility, and comfort. For example, treatments such as curb extensions or median islands, where appropriate, can shorten crossing distances or allow for two-stage crossings while improving signal timing and intersection capacity. Necessary upgrades to curb ramp placement and design (i.e. slope, cross-slope, level landing, detectable warnings, etc.) required for ADA compliance should be documented. Where vehicles are observed consistently encroaching on the crosswalk at a signalized location, the evaluator may consider other aspects, such as stop bar placement, or the need for NO RIGHT TURN ON RED signage.

2 STEP 2: UNSIGNALIZED / MID-BLOCK CROSSING ASSESSMENT

There are four (4) potential checks to complete as part of Step 2:

1) Check the number of lanes
2) Check posted or operating speed
3) Check vehicular traffic volume
4) Check pedestrian volume

After moving through the Step 2 Flowchart element, an evaluator will end at one of three (3) potential outcomes:

- No Action Required
- Consider Marking Crosswalk
- Move to Step 3

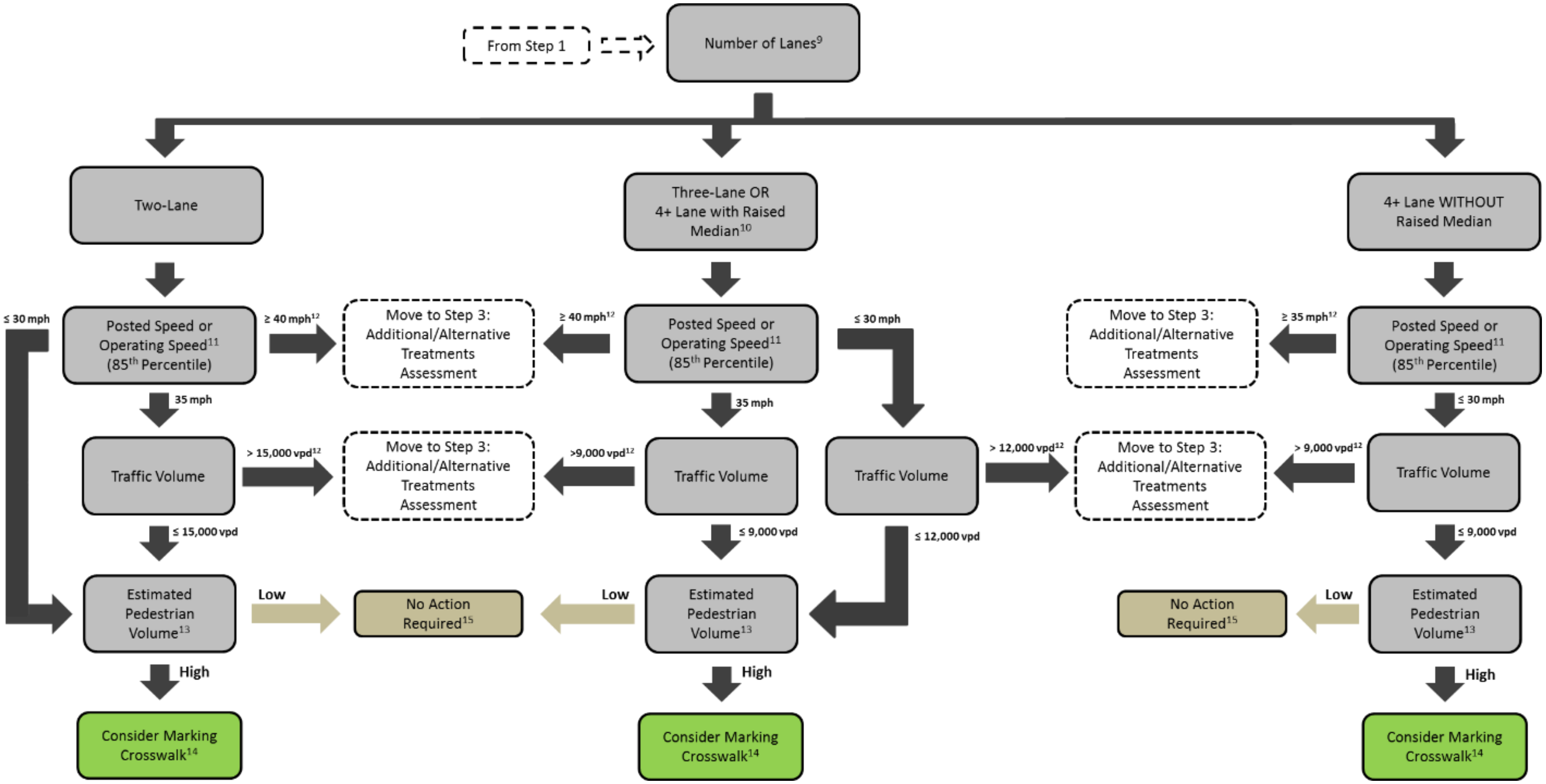

Figure 8 Flowchart Element for Step 2: Unsignalized or Midblock Crossing Assessment

2.1 CHECK NUMBER OF LANES

The number of lanes is a metric that serves as a proxy for crossing distance. Longer crossing distances are more challenging for pedestrians to cross safely without assistance. When counting the number of lanes at a potential crossing location, in general, they should be counted from one edge of right-of-way to the other, to encompass the full crossing. Multiple lanes in one direction may also increase the potential for a multiple-threat crash, where a near-lane vehicle who yields to a crossing pedestrian may block the view of an approaching far-lane vehicle.

The evaluator may also consider each stage of a two-stage pedestrian crossing as a discrete crossing when counting the number of lanes, provided there is sufficient storage and refuge space in the median to clearly separate the two crossing directions.

Raised medians that function as a pedestrian refuge or crossing island affect how an evaluator categorizes the number of lanes metric. These medians must be at least 6 feet wide to function as a refuge area for pedestrians, as shown in Figure 9. As an indication of median length, basic island design from the 2011 AASTHO Green Book indicates that urban curbed corner islands should be no less than 50 ft^2 and those at rural intersections should be a minimum of 75 ft^2. (AASHTO, 2011) Multi-lane undivided roads or roads with painted medians are considered as having no raised median. Two-way center turn lanes are also not considered medians and should be counted as a lane.

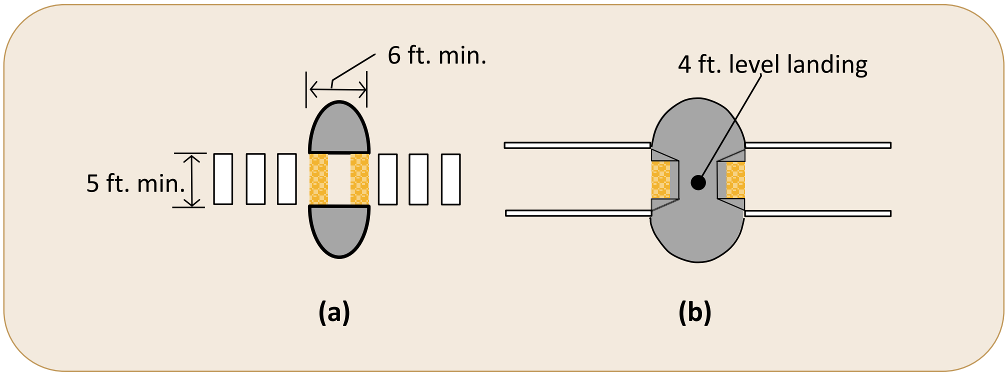

Figure 9 Raised medians must be at least 6 feet wide to serve as a pedestrian refuge island (part a). Crossing islands that include ramps must be wide enough to include a 4-foot square level landing as well as the ramp depths necessary to comply with ADA slope requirements (part b).

The Flowchart does not consider on-street parking, bike lanes, or other features that may increase the overall crossing distance. Therefore, the evaluator may use engineering judgement to adjust the number of lanes to better reflect existing street characteristics that may result in longer crossing distances.

After determining the number of lanes, the evaluator assigns the crossing to one of three options:

- 2-lane crossing,
- 3-lane crossing or 4- or more lane crossing with a raised median, or
- 4- or more lane without a raised median,

and continues to assess the next factor on the Flowchart, posted or operating speed.

2.2 CHECK POSTED SPEED OR OPERATING SPEED

For many crossings, the posted speed limit can be used as an approximation of operating conditions. Where there is a concern that the 85th percentile operating speeds may be near or exceed speed thresholds indicated on the Flowchart (which are based on posted speeds), a speed study should be conducted to determine the 85th percentile speed. If both posted and operating speed data are available, the evaluator should conservatively use whichever speed is higher.

The thresholds below reflect recommendations based on the research findings of a 2005 FHWA study on *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations*. (Zegeer, 2005) The researchers compared five years of crash data from 2,000 crossings across 30 U.S. cities where marked and unmarked crosswalk sites with otherwise similar characteristics were paired for comparison. The majority of these sites (93%) had speed limits between 25 to 35 mph, so the lack of variation in speed limits across sites made it difficult to find a direct relationship between speed and the frequency of pedestrian crashes. However, the study confirmed the relationship between speed and crash severity, where speed limits of 35 mph or greater correlated to more fatal or type A (serious or incapacitating) pedestrian injuries. Given the increase in crash severity, and given that it is not standard practice in the United States to mark a crosswalk at uncontrolled locations where speed limits are 40 mph or greater, Zegeer *et al.* do not recommend marking crosswalks alone under this condition (Zegeer, 2005). Additionally, pedestrians may have more difficulty judging available gaps as vehicle speeds increase.

Regardless of the number of lanes, for crossings where vehicle speed is greater than or equal to 40 mph, the evaluator automatically moves to Step 3 to consider additional treatments. Marking the crosswalk alone under this condition is not suitable, as it may increase the risk of a pedestrian crash. (Zegeer, 2005) Likewise, for locations with four or more lanes without a raised median where the vehicle speed is greater than or equal to 35 mph, the Flowchart directs the evaluator to automatically move to Step 3.

2.2.1 On Two-Lane Roads

For two-lane roads, the posted speed or 85th percentile operating speed is evaluated against three thresholds. A two-lane road typically refers to two-way traffic with one lane in each direction. However, for four-lane divided facilities, each side of the crossing may be evaluated as a two-lane road, if the crossing is completed in two distinct stages (interrupted by a median refuge).

- Where speed is less than or equal to 30 mph, the speed check is satisfied, and the evaluator moves to check pedestrian volume.
- Where speed is 35 mph, the speed check is satisfied, and the evaluator moves to check traffic volume.
- Where speed is greater than or equal to 40 mph, the speed check fails, and the evaluator moves to Step 3.

Figure 10 At an unsignalized intersection, if the posted or operating speed of a two-lane road is greater than or equal to 40 mph, marking a crosswalk alone is not recommended as it may increase the risk of a pedestrian crash.

2.2.2 On Three-Lane Roads or Four-or-More-Lane Roads with a Raised Median

For three-lane roads, or roads with four or more lanes with a raised median, the posted speed or 85th percentile operating speed is evaluated against only two thresholds.

- Where speed is less than or equal to 35 mph, the speed check is satisfied and the evaluator moves to check traffic volume.
- Where speed is greater than or equal to 40 mph, the speed check fails, and the evaluator moves to Step 3.

2.2.3 On Four-or-More-Lane Roads without a Raised Median

For roads with four or more lanes that do not have a raised median, the posted speed or 85th percentile operating speed is evaluated against two thresholds.

- Where speed is less than or equal to 30 mph, the speed check is satisfied, and the evaluator moves to check traffic volume.
- Where speed is greater than or equal to 35 mph, the speed check fails, and the evaluator moves to Step 3.

2.3 CHECK VEHICLE VOLUME

Gap opportunities are a function of vehicle volume. While multilane facilities may be associated with higher vehicle volumes, they may not be inherently more difficult to cross. The same number of vehicles per day on a two-lane road compared to a multilane road could allow pedestrians more gap opportunities on the multilane facility, thereby making it effectively easier to cross. Therefore, only checking the number of lanes of a crossing is an insufficient proxy for measuring vehicle volumes and understanding gap opportunities. Zegeer *et al.* found that traffic volume is one of the primary factors associated with pedestrian crashes. (2005) It is noted though that multilane facilities may pose a risk of multiple threat situations as discussed above, which should be included as an additional safety consideration in the overall assessment.

The traffic volume thresholds below are supported by the 2005 study by Zegeer. At potential crossing locations where the traffic volume is close to a given threshold, engineering judgement should be used with consideration of additional factors, such as crash history, presence of special pedestrian populations like the elderly, heavy truck volumes, etc. to decide which branch of the Flowchart to follow.

Regardless of the number of lanes or speed, for crossings where traffic volume is greater than or equal to 15,000 vpd, the evaluator automatically moves to Step 3 to consider additional treatments. Marking the crosswalk alone under this condition is not suitable, as it may increase the risk of a pedestrian crash. (Zegeer, 2005)

2.3.1 On Two-Lane Roads, 35 mph

For two-lane roads with a speed of 35 mph, the traffic volumes are evaluated based on a threshold volume of 15,000 vehicles per day (vpd).

- Where traffic volume is less than or equal to 15,000 vpd, the traffic volume is satisfied, and the evaluator moves to check pedestrian volume.
- Where traffic volume is greater than 15,000 vpd, the traffic volume check fails, and the evaluator moves to Step 3.

2.3.2 On Three-Lane Roads or Four-or-More-Lane Roads with a Raised Median, 30 mph or Less

For three-lane roads, or roads with four or more lanes with a raised median and a speed for 30 mph or less, the traffic volumes are evaluated based on a threshold volume of 12,000 vpd.

- Where traffic volume is less than 12,000 vpd, the traffic volume check is satisfied and the evaluator moves to check pedestrian volume.
- Where traffic volume is greater than or equal to 12,000 vpd, the traffic volume check fails, and the evaluator moves to Step 3.

2.3.3 On Three-Lane Roads or Four-or-More-Lane Roads with a Raised Median, 35 mph

For three-lane roads, or roads with four or more lanes with a raised median and a speed for 35 mph, the traffic volumes are evaluated based on a threshold volume of 9,000 vpd.

- Where traffic volume is less than or equal to 9,000 vpd, the traffic volume check is satisfied and the evaluator moves to check pedestrian volume.
- Where traffic volume is greater than 9,000 vpd, the traffic volume check fails, and the evaluator moves to Step 3.

2.3.4 On Four-or-More-Lane Roads without a Raised Median, 30 mph or Less

For roads with four or more lanes without a raised median and a speed for 30 mph or less, the traffic volumes are evaluated based on a threshold volume of 9,000 vpd.

- Where traffic volume is less than or equal to 9,000 vpd, the traffic volume check is satisfied, and the evaluator moves to check pedestrian volume.
- Where traffic volume is greater than 9,000 vpd, the traffic volume check fails, and the evaluator moves to Step 3.


Figure 11 On roads with 4 or more lanes without a raised median, if the posted or operating speed is 35 mph or more, marking a crosswalk alone is not recommended. Even if vehicle speeds are 30 mph or less, if the traffic volume is greater than 9,000 vpd, marking a crosswalk alone may increase the risk of a pedestrian crash. Instead, additional/alternative treatments should be considered.

2.4 CHECK PEDESTRIAN VOLUME

See Section 1.3.2.2 above for more on how to conduct this check to determine whether the estimated pedestrian volume at a potential crossing is low.

- Where pedestrian volume is Low, no action is required. The gap availability, based on number of lanes, speed, and traffic volume, should allow for sufficient crossing opportunities.
- Where pedestrian volume is not Low, the evaluator may consider marking a crosswalk.[8]

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[8] Use engineering judgment based on location context to determine if the crosswalk should be marked and what type of pattern is most appropriate. Mid-block crosswalks should be marked using a high-visibility pattern. (NCDOT, 2008) High-visibility markings may also be appropriate for school crosswalks or where pedestrians or marked crosswalks may not be expected by drivers. (National Committee on Uniform Traffic Control Devices, 2011)

3 STEP 3: ADDITIONAL / ALTERNATIVE TREATMENTS ASSESSMENT

There are four (4) potential checks to complete as part of Step 3:

1) Check posted or operating speed
2) Check pedestrian volume
3) Check MUTCD signal warrants
4) Check pedestrian delay

After moving through the Step 3 Flowchart element, an evaluator will end at one of five (5) potential outcomes:

- Consider Geometric Improvements
- Consider Installing a Traffic Signal
- Consider Marking Crosswalk
- Consider Supplemental Treatments
- Move to Step 4

Factors and thresholds within Step 3 are predicated on research findings and guidance conveyed in *NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings.* (Fitzpatrick, et al., NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings, 2006) This report includes "Appendix A. Guidelines for Pedestrian Crossing Treatments" which comprises a process and worksheet tools to determine general recommendations for crossing treatment types to consider at an unsignalized location. The inputs used in Fitzpatrick's guidance are reflected in the checks within Step 3 of NCDOT's Flowchart.

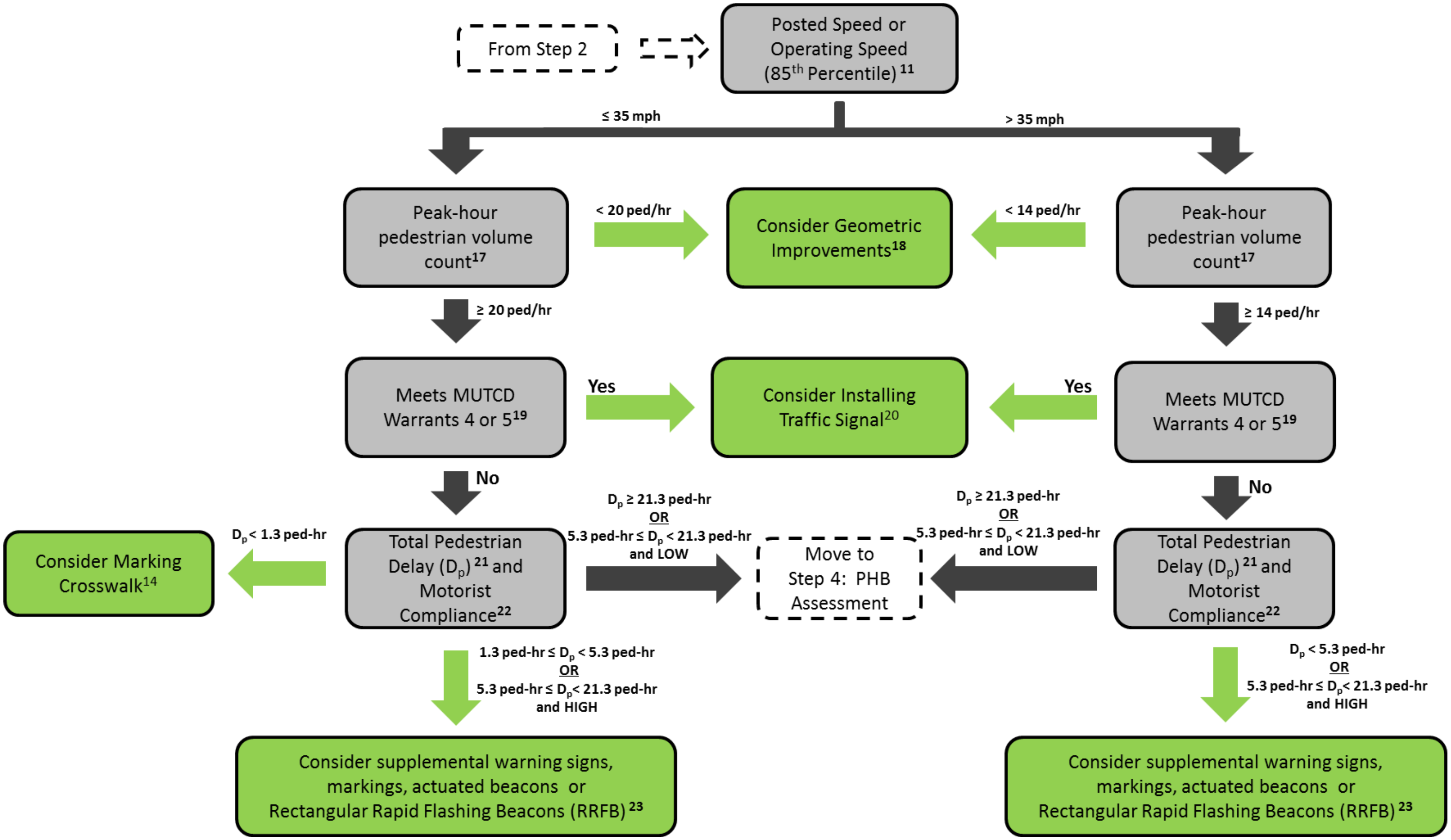

Figure 12 Flowchart Element for Step 3: Additional / Alternative Treatments Assessment

3.1 CHECK SPEED

For many crossings, the posted speed limit can be used as an approximation of operating conditions. Where there is a concern or evidence that the 85th percentile operating speeds may be near or exceed 35 mph, a speed study can be conducted to determine the 85th percentile speed. If both posted and operating speed data are available, the evaluator should conservatively use whichever speed is higher.

When comparing motorist yielding compliance at a variety of crossing treatments on roads with posted speed limits ranging from 25 to 40 mph, Fitzpatrick *et al.* found a critical speed of 35 mph – the best compliance of non-red indicating devices was observed at treatments on roads with posted speeds less than 35 mph. (2006) Therefore, the path to proceed through Step 3 depends on whether the crossing location is on a roadway with a posted speed limit above 35 mph or at 35 mph or below.

3.2 CHECK PEAK-HOUR PEDESTRIAN VOLUME

Step 3 requires *observed* pedestrian volume data, rather than *estimated* volume based on proxy information. Count thresholds include pedestrians crossing the roadway within 150 ft. of the crossing location being assessed. At an intersection, pedestrians are counted crossing in both directions and across both legs of the roadway assessed, as shown in Figure 13. Note that this check is for the pedestrian peak-hour volume, which may not necessarily be the same peak-hour as the vehicles. For example, near a school, the pedestrian peak-hour may align with school dismissal, whereas the vehicle peak-hour may be up to three hours later. If the pedestrian peak hour time is not known, an initial pedestrian count study should be conducted using the general guidelines recommended in section 1.3.2.2 above.

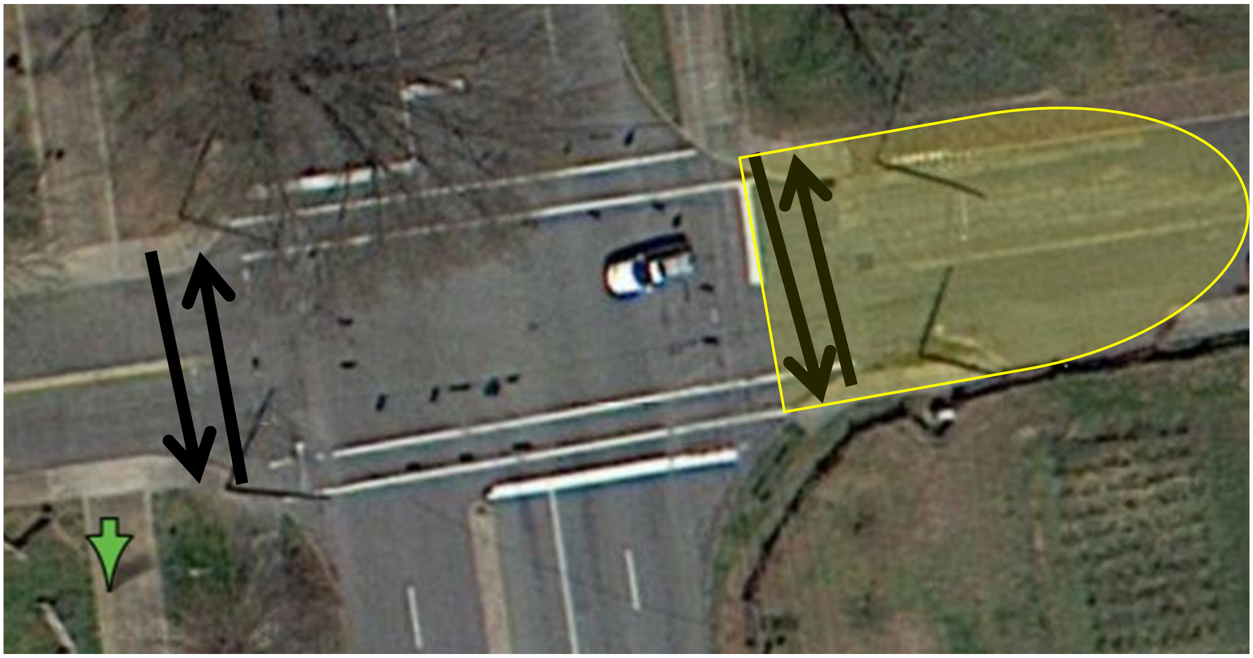

Figure 13 In this example, the crossing being evaluated is the west leg. Pedestrians are counted crossing northbound and southbound on the east and west legs (shown by black arrows) and up to 150 feet away from the intersection (shown by yellow highlighted area).

3.2.1 On Road with Speed 35 mph or Less

On roads with a posted speed or 85th percentile operating speed of 35 mph or less, a pedestrian volume threshold of 20 pedestrians per pedestrian peak hour applies.

- Where the peak-hour pedestrian volume is less than 20 pedestrians per hour, consider geometric improvements.
- Where the peak-hour pedestrian volume is greater than or equal to 20 pedestrians per hour, check MUTCD signal warrants.

3.2.2 On Road with Speed Greater than 35 mph

On roads with a posted speed or 85th percentile operating speed greater than 35 mph, a pedestrian volume threshold of 14 pedestrians per pedestrian peak hour applies.

- Where the peak-hour pedestrian volume is less than 14 pedestrians per hour, consider geometric improvements.
- Where the peak-hour pedestrian volume is greater than or equal to 14 pedestrians per hour, check MUTCD signal warrants.

When considering geometric improvements, further engineering study is needed to determine what, if any modifications should be implemented. These improvements may include the installation of median refuge islands, curb extensions, or traffic calming devices. Improvements may also include other modifications that minimize the crossing distance, straighten crossings to be as perpendicular as feasible to the traffic being crossed, and enhance visibility of and by the pedestrian by removing obstacles to lines of sight. See the common resources list in Appendix A for more on the countermeasures studied for *NCHRP Report 562* and a link to PEDSAFE for other countermeasure options.

3.3 CHECK MUTCD WARRANTS 4 OR 5

A traffic signal may be warranted based on pedestrian volume. The evaluator must conduct an engineering study per the MUTCD to determine if a traffic signal may be justified based on minimum conditions.[9] While other relevant traffic signal warrants may simultaneously be analyzed through the study, of particular relevance to the pedestrian crossing evaluation process is whether Warrant 4 - Pedestrian Volume or Warrant 5 - School Crossing, is satisfied. The following is paraphrased from the 2009 MUTCD. The full language of the MUTCD for Warrants 4 and 5, including the referenced charts, are provided in Appendix B.

Per Section 4C.05, the Pedestrian Volume signal warrant is met and a traffic signal must be considered if:

- For each of any 4 hours of an average day, there are at least 107 pedestrians per hour crossing a street with at least 1,100 vehicles per hour; or
- For any 1 hour of an average day, there are at least 133 pedestrians per hour crossing a street with at least 1,450 vehicles per hour.

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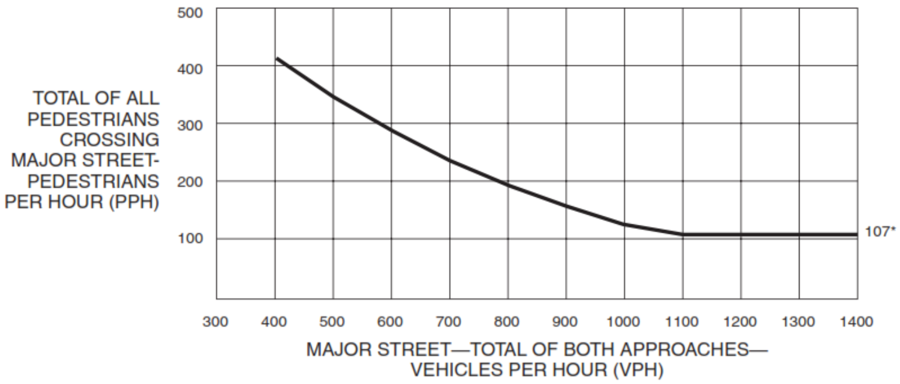
[9] 2009 MUTCD 4C.01 indicates the “satisfaction of a traffic signal warrant shall not in itself require the installation of a traffic control signal.” (Federal Highway Administration, 2009)

If the posted or 85th percentile operating speeds are greater than 35 mph or if the crossing location is in a “built-up area of an isolated community having a population of less than 10,000” then the pedestrian volume thresholds are lowered to:

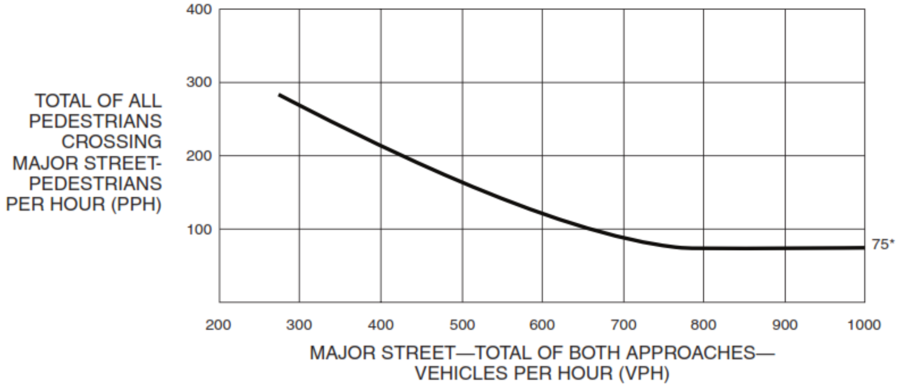
- At least 75 pedestrians per hour where for any 4 hours crossing at least 750 vehicles per hour; or
- At least 93 pedestrians per hour for any 1 hour crossing at least 1,050 vehicles per hour.

Figure 4C-5. Warrant 4, Pedestrian Four-Hour Volume



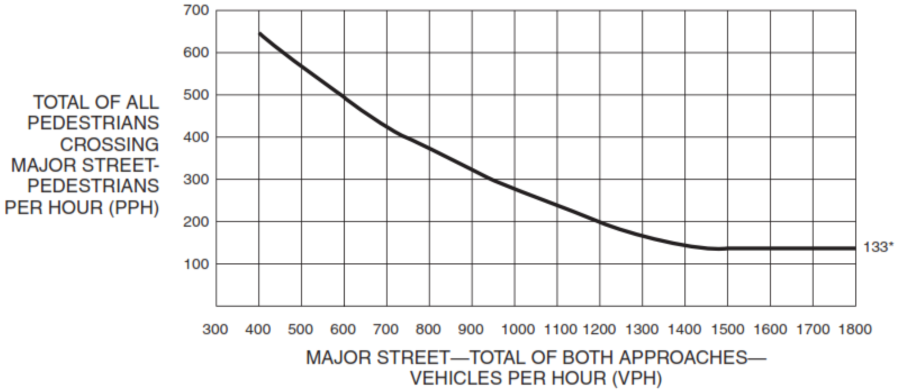
*Note: 107 pph applies as the lower threshold volume.

Figure 4C-6. Warrant 4, Pedestrian Four-Hour Volume (70% Factor)



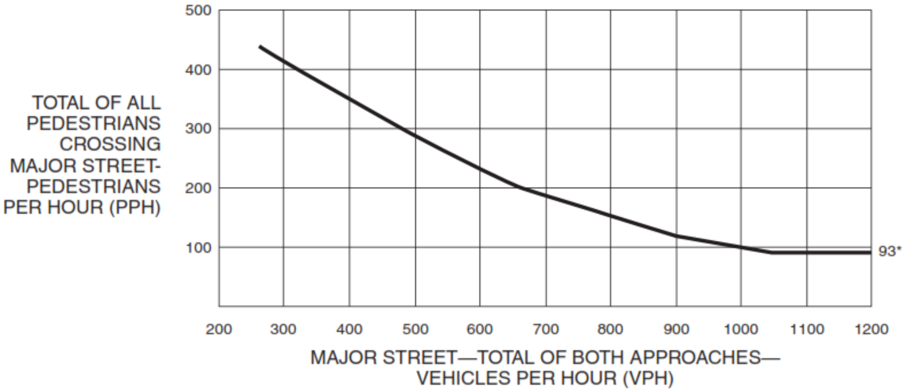
*Note: 75 pph applies as the lower threshold volume.

Figure 4C-7. Warrant 4, Pedestrian Peak Hour



*Note: 133 pph applies as the lower threshold volume.

Figure 4C-8. Warrant 4, Pedestrian Peak Hour (70% Factor)



*Note: 93 pph applies as the lower threshold volume.

Figure 14 Traffic Signal Warrant 4, Pedestrian Volume figures from the 2009 MUTCD. When pedestrian and vehicle volumes at a potential crossing location are plotted, points that fall above the curve in the appropriate graph indicate that a traffic signal is warranted.

Meeting Warrant 4 is a function of both pedestrian and vehicle volumes at the crossing. Therefore, as vehicle volumes decrease, the threshold for the pedestrian volume needed to meet the warrant rises. See the figures in Figure 14 above for more details – plotted points that fall above the curve in the appropriate figure from the 2009 MUTCD (4C-5, -6, -7, or -8) indicate the Warrant is met.

Warrant 5 applies when a particular subset of pedestrians at a crossing is schoolchildren, and the crossing is established as a school crossing. The warrant is a function of gap frequency and schoolchildren volume. It is met if at least 20 schoolchildren are crossing at the peak crossing hour and the number of gaps is less than the number of minutes during the period when they are crossing.

Figure 15 Depending on pedestrian and traffic volumes, a traffic signal may be warranted. If Warrant 4 or 5 of the MUTCD are met, and the traffic signal is installed, then pedestrian signal heads are also required. Photo credit: Caroline Culler, Wikimedia Commons

Neither Warrant applies if the crossing location is less than 300 feet of another signalized or STOP controlled intersection unless the proposed signal will not restrict progressive movement of traffic. (4C.05.04 and 4C.06.04)

- If Warrants 4 or 5 are met, consider installing a traffic signal. There is no requirement to install the signal, per 4C.01 - engineering judgment and other operational considerations should be factored in when making this decision. (Federal Highway Administration, 2009) Other treatment options, like the pedestrian hybrid beacon, may be able to be used instead of a signal to mitigate impacts on vehicular delay. If the decision is made to install the traffic signal, the installation of pedestrian signal heads is also required. See Section 1.3.2.1 above. Financial resources must be available to install and maintain the signals.
- If Warrants 4 or 5 are not met, then check pedestrian delay.

3.4 CHECK PEDESTRIAN DELAY

In general, pedestrian delay increases as vehicle volume increases, as adequate gap opportunities become less frequent. Pedestrians may be willing to accept increased delay at some crossings where gap opportunities are controlled by an upstream signal; however, at locations where the next opportunity for a gap is uncertain or random, pedestrians may engage in more risky crossing behaviors as pedestrian delay increases.

Total pedestrian delay is calculated by multiplying the average delay per pedestrian by the number of pedestrians in the peak-hour. Average pedestrian delay is calculated using Equation 18-21 of the 2000 *Highway Capacity Manual*. The 2000 HCM was the most recent version of the HCM at the time the

Fitzpatrick et al (2006) study was conducted. Newer versions of the HCM feature slightly revised pedestrian analysis methods, but the crosswalk research was calibrated based on the 2000 HCM. Average pedestrian delay is a function of crossing distance, walking speed, pedestrian start-up and end clearance time, and traffic volume and flow rate. The peak-hour pedestrian volume gathered in Section 3.2 above is used for the number of pedestrians. For example, if the *HCM* delay is estimated as 40 seconds per pedestrian, and the peak-hour volume observed is 90 pedestrians, then:

$$Total\ Delay = 40\ \frac{sec}{ped} \times 90\ \frac{ped}{hr} \times \frac{1\ hr}{3600\ sec} = 1\ ped\text{-}hr$$

The Total Pedestrian Delay thresholds and treatment considerations below are based on the research conducted to inform the “Guidelines for Pedestrian Crossing Treatments” described in Appendix A of *NCHRP Report 562*. (Fitzpatrick, et al., NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings, 2006) The worksheets, inputs, and variables from *Report 562* used to calculate total pedestrian delay are also included in Appendix C of this guidebook.

3.4.1 On Road with Speed 35 mph or Less

On roads with a posted speed or 85th percentile operating speed of 35 mph or less, three potential conditions are distinguished, based on pedestrian delay and motorist compliance.

- Where the total pedestrian delay is less than 1.3 pedestrian-hours, consider marking a crosswalk.[10]
- Where motorist compliance is LOW[11]:
    - And the total pedestrian delay is greater than or equal to 1.3 pedestrian-hours but less than 5.3 pedestrian-hours, consider supplemental warning signs, markings, actuated beacons or Rectangular Rapid Flashing Beacons (RRFB).
    - And the total pedestrian delay is greater than or equal to 5.3 pedestrian-hours but less than 21.3 pedestrian-hours, move to Step 4.
- Where motorist compliance is HIGH:
    - And the total pedestrian delay is greater than or equal to 5.3 pedestrian-hours but less than 21.3 pedestrian-hours, consider supplemental warning signs, markings, actuated beacons or Rectangular Rapid Flashing Beacons (RRFB).
    - And the total pedestrian delay is greater than 21.3 pedestrian-hours, move to Step 4.

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[10] Use engineering judgment based on location context to determine if the crosswalk should be marked and what type of pattern is most appropriate. Mid-block crosswalks should be marked using a high-visibility pattern. (NCDOT, 2008) High-visibility markings may also be appropriate for school crosswalks or where pedestrians or marked crosswalks may not be expected by drivers. (National Committee on Uniform Traffic Control Devices, 2011)

[11] Motorist compliance is considered “HIGH” if, within the general vicinity of the crossing location, driver culture is such that motorists tend to yield to a pedestrian attempting to cross at an uncontrolled location. If motorists rarely stop for a crossing pedestrian, then compliance is considered “LOW”. (Fitzpatrick, et al., NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings, 2006)

3.4.2 On Road with Speed Greater than 35 mph

On roads with a posted speed or 85th percentile operating speed greater than 35 mph, two potential conditions are distinguished, based on pedestrian delay and motorist compliance.

- Where motorist compliance is LOW:
  - And the total pedestrian delay is less than 5.3 pedestrian-hours, consider supplemental warning signs, markings, actuated beacons or Rectangular Rapid Flashing Beacons (RRFB).
  - And the total pedestrian delay is greater than or equal to 5.3 pedestrian-hours but less than 21.3 pedestrian-hours, move to Step 4.
- Where motorist compliance is HIGH:
  - And the total pedestrian delay is greater than or equal to 5.3 pedestrian-hours but less than 21.3 pedestrian-hours, consider supplemental warning signs, markings, actuated beacons or Rectangular Rapid Flashing Beacons (RRFB).
  - And the total pedestrian delay is greater than 21.3 pedestrian-hours, move to Step 4.

Supplemental signs, markings, and beacons include devices that enhance the visibility of the crossing beyond the standard marked crosswalk and pedestrian crossing signs. These devices may include advanced yield lines and signage, in-street Yield-to-Pedestrian signs, overhead signage, or pedestrian-actuated beacons such as the RRFB, among others. Additional study is needed to determine what, if any enhanced or active traffic control devices should be implemented. See the Common Resources List in Appendix A for more on these or other options.

3.4.3 Quick Reference Charts to Estimate Total Pedestrian Delay

While the evaluator may choose to employ the worksheets provided in *NCHRP Report 562* to calculate Total Pedestrian Delay, a series of charts are provided in Appendix C to quickly estimate this factor. These charts are organized by posted speed limit, crossing distance, and community population thresholds, and are a function of peak-hour pedestrian volumes and peak-hour traffic volumes. The evaluator selects the appropriate chart and then plots the peak-hour pedestrian and traffic volumes at the potential crossing location. Three curves are given on each chart, which reflect the 1.3, 5.3, and 21.3 pedestrian-hour thresholds of Total Pedestrian Delay. Depending on where a point is plotted, Total Pedestrian Delay may be Low, Medium-Low, Medium-High, or High:

- Plotted points that fall below the 1.3 ped-hr line are considered Low;
- Plotted points that fall between the 1.3 ped-hr and 5.3 ped-hr lines are considered Medium-Low;
- Plotted points that fall between the 5.3 ped-hr and 21.3 ped-hr lines are considered Medium-High;
- Plotted points that fall above the 21.3 ped-hour line are considered High.

Table 1 is used to then identify the appropriate treatment category based on the speed limit, motorist compliance and type of Total Pedestrian Delay.

Table 1 Total Pedestrian Delay – Treatment Selection Guidance

Speed	**Motorist Compliance**	**Total Pedestrian Delay Type**			
		Low (< 1.3 ped-hrs)	**Medium-Low (≥ 1.3 to < 5.3 ped-hrs)**	**Medium-High (≥ 5.3 to < 21.3 ped-hrs)**	**High (≥ 21.3 ped-hrs)**
≤ 35 mph	Low	Consider Marking Crosswalk	Consider Supplemental Treatments	Move to Step 4	Move to Step 4
	High	Consider Marking Crosswalk	Consider Supplemental Treatments	Consider Supplemental Treatments	Move to Step 4
> 35 mph	Low	Consider Supplemental Treatments	Consider Supplemental Treatments	Move to Step 4	Move to Step 4
	High	Consider Supplemental Treatments	Consider Supplemental Treatments	Consider Supplemental Treatments	Move to Step 4

Figure 16 illustrates a plotted point in the Medium-High category. In this example, because the Total Pedestrian Delay is Medium High, the speed is less than 35 mph, and motorist compliance is low, Table 1 indicates that the evaluator move to Step 4 to continue to assess the crossing location for a Pedestrian Hybrid Beacon.

Example Scenario

- Crossing location: road in an urban area.
- Speed limit or 85th percentile operating speed: 35 mph or less.
- Crossing distance: 36 ft.
- Peak-hour vehicle volume: 2,000.
- Peak-hour pedestrian volume: 20.
- Motorist Compliance: Low

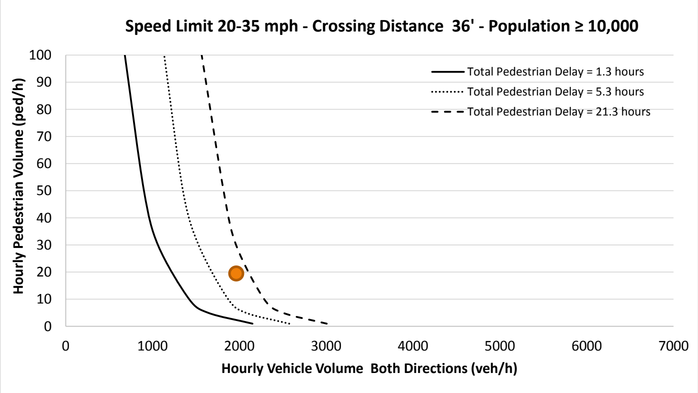

Figure 16 Example scenario using the "Speed Limit 20-35 mph – Crossing Distance 36' – Population ≥ 10,000" chart from Appendix C.to determine Total Pedestrian Delay type. Example shows a Medium-High delay between 5.3 and 21.3 ped-hrs.

4 STEP 4: PEDESTRIAN HYBRID BEACON ASSESSMENT

There are four (4) checks to complete as part of Step 4:

1) Check posted or operating speed
2) Check crosswalk length
3) Check pedestrian volume
4) Check vehicle volume

After moving through the Step 4 Flowchart element, the evaluator will determine whether to consider installing a Pedestrian Hybrid Beacon (PHB).

Factors and thresholds within Step 4 are from the 2009 MUTCD in Section 4F.01.06 and 4F.01.07, which is predicated on research findings and guidance conveyed in *NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings.* (Fitzpatrick, et al., NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings, 2006) Step 4 of the Flowchart is essentially a continuation of Step 3. While Step 3 follows the guidelines in *Report 562* to reach treatment category endpoints of “Crosswalk” or “Active or Enhanced”, the “Red” treatment category of *Report 562* is assessed through Step 4.

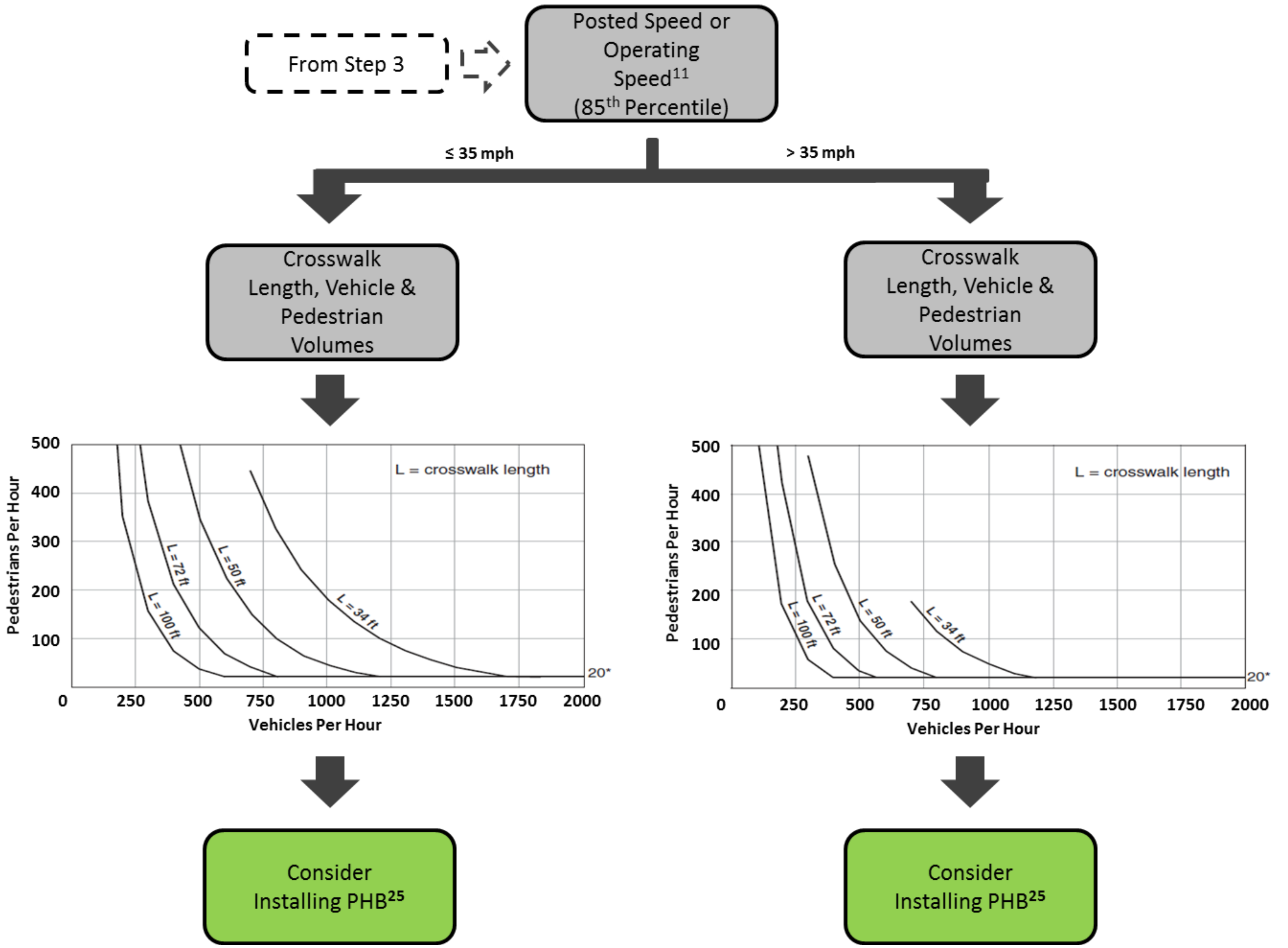

Figure 17 Flowchart Element for Step 4: Pedestrian Hybrid Beacon (PHB) Assessment

4.1 CHECK SPEED

See Section 3.1 above – the posted or operating speed used in Step 3 is carried through to Step 4.

4.2 CHECK CROSSWALK LENGTH, VEHICLE & PEDESTRIAN VOLUMES

Crosswalk length represents the distance a pedestrian would need to cross before reaching either a raised median refuge island or the far curb or edge of pavement. On-street parking, bike lanes, or other features that may increase the overall crossing distance should be included in the crosswalk length measurement.

When determining the number of vehicles per peak-hour, the evaluator must first consider whether vehicle volume should represent one or both approaches. Per Section 4F.07 of the 2009 MUTCD, the total of both approaches should be used. This assumes that a pedestrian should be able to cross from one curb to the far curb. Where a raised median is sufficiently designed to serve as a pedestrian refuge island (see Section 2.1 for minimum island design dimensions), the crossing task may effectively function as a two-stage crossing. In this case, each approach can be separately assessed, using the peak-hour vehicle volume for an approach and the corresponding crosswalk length to the island.

See Section 3.2 above for determining pedestrian volume.

Once vehicle and pedestrian volumes are known, the evaluator plots the point on the appropriate graph based on the posted or operating speed. Figure 4F-1 from the 2009 MUTCD (shown in Figure 18) is used where the roadway is 35 mph or less while Figure 4F-2 (shown in Figure 19) is used if the speed is greater than 35mph.

4.2.1 On Road with Speed Less Than or Equal to 35 mph

On roads with a posted speed or 85th percentile operating speed of 35 mph or less, two potential conditions are distinguished, based on the crosswalk length curve.

- A PHB is recommended for consideration where the plotted point falls above the curve for the appropriate crosswalk length line on the graph in Figure 18.
- If the plotted point falls below the applicable curve, consider supplemental warning signs, markings, actuated beacons or RRFBs.

4.2.2 On Road with Speed Greater than 35 mph

On roads with a posted speed or 85th percentile operating speed of greater than 35, two potential conditions are distinguished, based on the crosswalk length curve.

- A PHB is recommended for consideration where the plotted point falls above the curve for the appropriate crosswalk length line on the graph Figure 19.
- If the plotted point falls below the applicable curve, consider supplemental warning signs, markings, actuated beacons or RRFBs.

The evaluator interpolates values between curves if the measured crosswalk length is not represented by one of the four graphed. Consideration for installation of a PHB assumes that a traffic signal was not warranted, or, if warranted, that the installation of a traffic signal was rejected after conducting an engineering study.

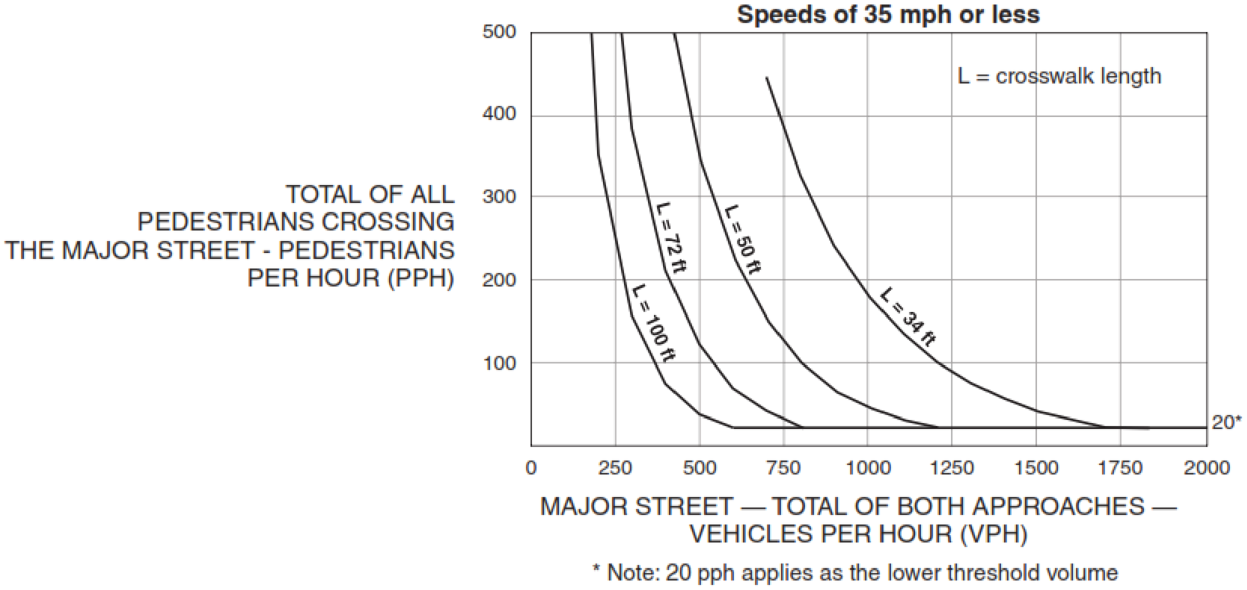

Figure 18 From the 2009 MUTCD, PHB application should be considered to assist pedestrians crossing roads less than or equal to 35 mph when the plotted point falls above the curve for a given crosswalk length.

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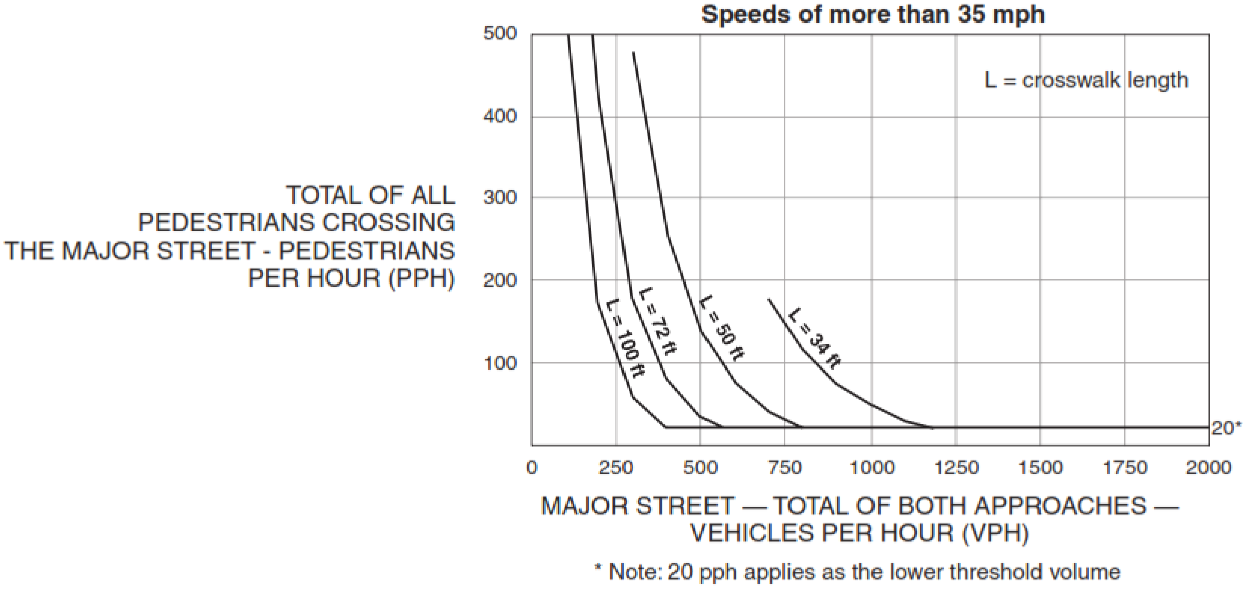

Figure 19 From the 2009 MUTCD, PHB application should be considered to assist pedestrians crossing roads greater than 35 mph when the plotted point falls above the curve for a given crosswalk length.

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Appendix A. COMMON RESOURCES LIST

Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations – Final Report and Recommended Guidelines (2005)

http://www.fhwa.dot.gov/publications/research/safety/04100/04100.pdf

Step 2: Unsignalized or Midblock Crossing Assessment is largely founded upon FHWA's *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations.* This study determined a relationship between an increased risk of pedestrian crashes and marked crosswalks on roads with certain cross-sections, vehicle volumes, and speeds.

Zegeer et al.'s report recommends where marked crosswalks may be considered and where marking them alone may increase the risk of a pedestrian crash. The recommendations laid out in Table 11 in the report served as the basis for the Flowchart paths laid out in Step 2.

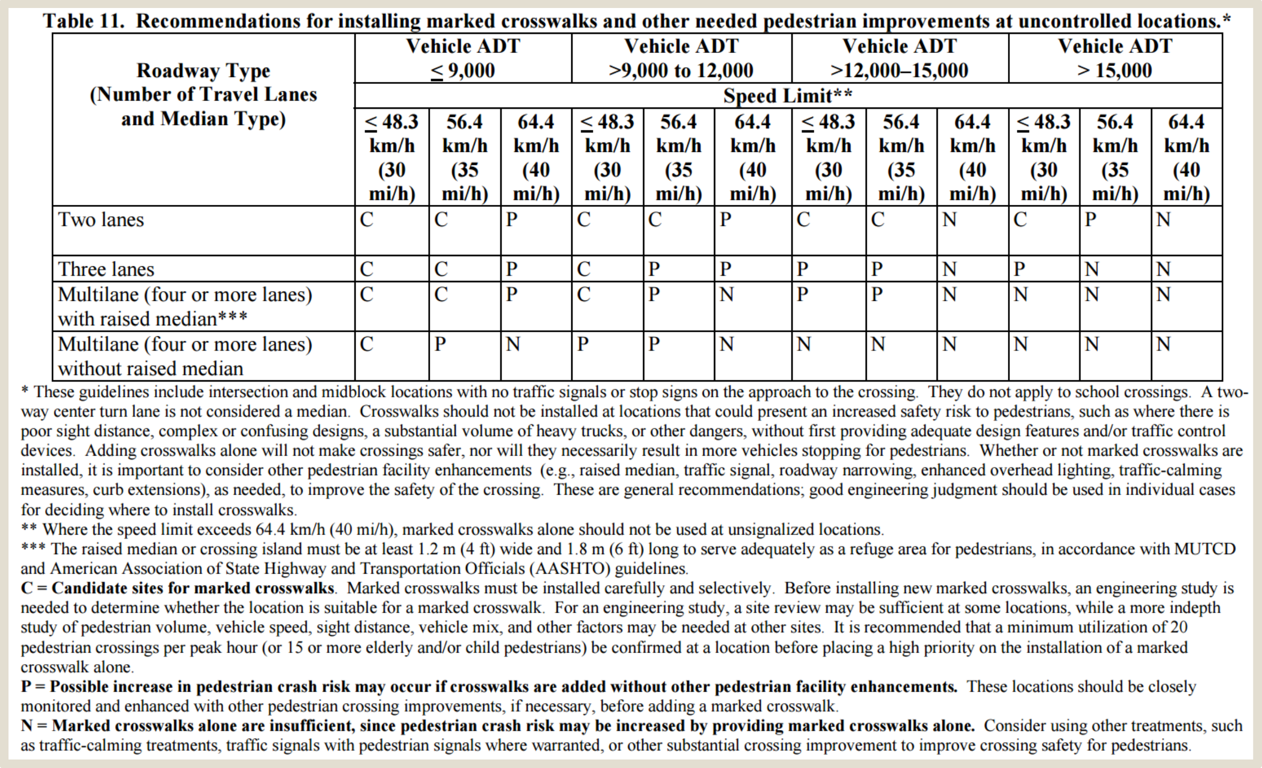


Table 11. Recommendations for installing marked crosswalks and other needed pedestrian improvements at uncontrolled locations.*

Roadway Type (Number of Travel Lanes and Median Type)	Vehicle ADT ≤ 9,000			Vehicle ADT >9,000 to 12,000			Vehicle ADT >12,000–15,000			Vehicle ADT > 15,000		
	Speed Limit**											
	≤ 48.3 km/h (30 mi/h)	56.4 km/h (35 mi/h)	64.4 km/h (40 mi/h)	≤ 48.3 km/h (30 mi/h)	56.4 km/h (35 mi/h)	64.4 km/h (40 mi/h)	≤ 48.3 km/h (30 mi/h)	56.4 km/h (35 mi/h)	64.4 km/h (40 mi/h)	≤ 48.3 km/h (30 mi/h)	56.4 km/h (35 mi/h)	64.4 km/h (40 mi/h)
Two lanes	C	C	P	C	C	P	C	C	N	C	P	N
Three lanes	C	C	P	C	P	P	P	P	N	P	N	N
Multilane (four or more lanes) with raised median***	C	C	P	C	P	N	P	P	N	N	N	N
Multilane (four or more lanes) without raised median	C	P	N	P	P	N	N	N	N	N	N	N

* These guidelines include intersection and midblock locations with no traffic signals or stop signs on the approach to the crossing. They do not apply to school crossings. A two-way center turn lane is not considered a median. Crosswalks should not be installed at locations that could present an increased safety risk to pedestrians, such as where there is poor sight distance, complex or confusing designs, a substantial volume of heavy trucks, or other dangers, without first providing adequate design features and/or traffic control devices. Adding crosswalks alone will not make crossings safer, nor will they necessarily result in more vehicles stopping for pedestrians. Whether or not marked crosswalks are installed, it is important to consider other pedestrian facility enhancements (e.g., raised median, traffic signal, roadway narrowing, enhanced overhead lighting, traffic-calming measures, curb extensions), as needed, to improve the safety of the crossing. These are general recommendations; good engineering judgment should be used in individual cases for deciding where to install crosswalks.

** Where the speed limit exceeds 64.4 km/h (40 mi/h), marked crosswalks alone should not be used at unsignalized locations.

*** The raised median or crossing island must be at least 1.2 m (4 ft) wide and 1.8 m (6 ft) long to serve adequately as a refuge area for pedestrians, in accordance with MUTCD and American Association of State Highway and Transportation Officials (AASHTO) guidelines.

C = Candidate sites for marked crosswalks. Marked crosswalks must be installed carefully and selectively. Before installing new marked crosswalks, an engineering study is needed to determine whether the location is suitable for a marked crosswalk. For an engineering study, a site review may be sufficient at some locations, while a more indepth study of pedestrian volume, vehicle speed, sight distance, vehicle mix, and other factors may be needed at other sites. It is recommended that a minimum utilization of 20 pedestrian crossings per peak hour (or 15 or more elderly and/or child pedestrians) be confirmed at a location before placing a high priority on the installation of a marked crosswalk alone.

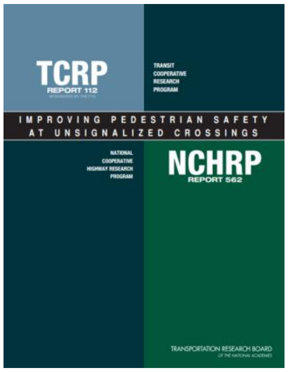
P = Possible increase in pedestrian crash risk may occur if crosswalks are added without other pedestrian facility enhancements. These locations should be closely monitored and enhanced with other pedestrian crossing improvements, if necessary, before adding a marked crosswalk.

N = Marked crosswalks alone are insufficient, since pedestrian crash risk may be increased by providing marked crosswalks alone. Consider using other treatments, such as traffic-calming treatments, traffic signals with pedestrian signals where warranted, or other substantial crossing improvement to improve crossing safety for pedestrians.

Figure 20 Copy of Table 11 from Zegeer's report.

NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Crossings

http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_562.pdf



Steps 3 and 4 of the Flowchart are based on research findings and recommendations from NCHRP 562: *Improving Pedestrian Safety at Unsignalized Crossings.* Fitzpatrick's research team studied pedestrian behavior and motorist compliance in 42 study sites across seven states. This report is the source for the updated 2009 MUTCD pedestrian signal warrant and PHB application guidance. The researchers also made recommendations to reduce the pedestrian walking speed to 3.5 seconds when calculating signal timing, which is also reflected in the 2009 MUTCD, based on their study.

Figure 21 shows that treatments indicating a red signal or beacon, which are circled in red, are most effective at getting drivers to yield for pedestrians, given the clear regulatory message they convey. Treatments that enhance a marked crosswalk, circled in blue, vary in their effectiveness to encourage motorist yielding. Overhead flashing beacons, circled in yellow, also range in their effectiveness; however drivers appear more likely to yield when pedestrians actuate the flashing beacon (OfPb) using a pushbutton rather than where it is passively activated through some sensor technology.

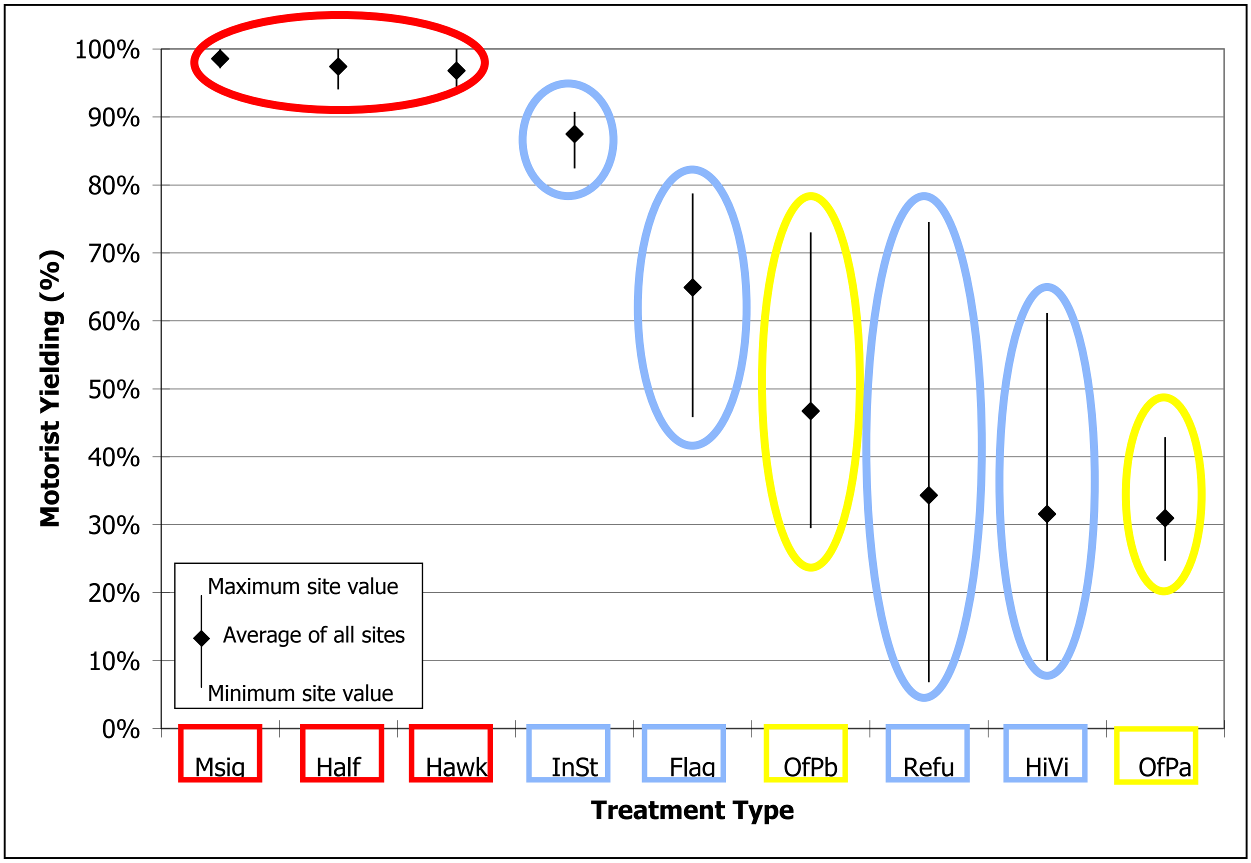


Figure 21 From Figure 24 in NCHRP Report 562 showing the average motorist yielding compliance percentages for each treatment. Abbreviations: Msig=midblock signal; Half=half signal; Hawk=HAWK signal beacon (PHB); InSt=in-street crossing signs; Flag=pedestrian crossing flags; OfPb=overhead flashing beacon (pushbutton activation); Refu=median refuge island; HiVi=high-visibility signs and markings; OfPa=overhead flashing beacons (passive activation)

In general, each treatment's effectiveness is influenced by the characteristics of the roadway (such as speed, number of lanes, and traffic volume) and the land use context (commercial versus residential area) in which it is implemented. For example, median refuge islands are much more likely to influence motorist yielding on a two-lane or low-speed road than a 4-lane or high-speed road.

A quick-reference visual of each treatment studied in NCHRP 562 are provided below. Additional information for each can be obtained through PEDSAFE.

Midblock Traffic Signal Tucson, AZ – image from FHWA	 Mike Cynecki
Half Signal Portland, OR – image from FHWA	

Pedestrian Hybrid Beacon Charlotte, NC – Beatties Ford Rd.	
In-Street Yield to Pedestrian Signage Raleigh, NC	

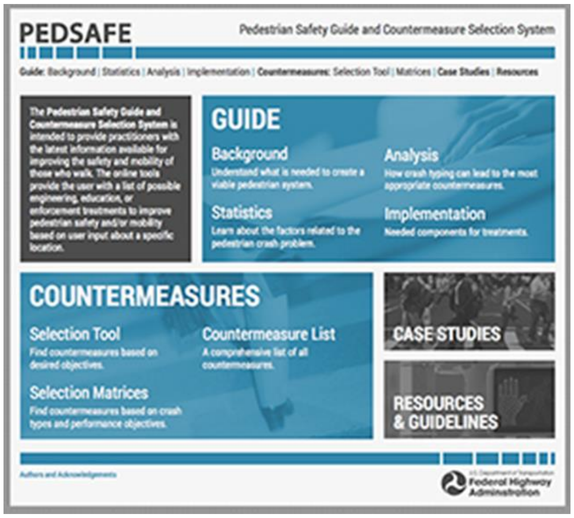
Pedestrian Crossing Flags Davidson, NC – Image from Brenda Barger/Davidsonnews.net	
Overhead Flashing Beacon San Antonio, TX – image from USTA Today	

Median Refuge Island Asheville, NC – image from www.pedbikeimages.org / Lyubov Zuyeva	
High-Visibility Markings Cary, NC – Park Village Dr.	

PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System
http://www.pedbikesafe.org/PEDSAFE/

This online guide includes a matrix of pedestrian treatments and a selection tool to help evaluators form a 'short list' of candidate countermeasures for a given issue. Options can also be selected based on the crash type to be mitigated or the performance objective targeted. It includes basic descriptions, considerations, safety effectiveness, cost estimates, and case study examples for the following treatments related to pedestrian crossings:

- Marked Crosswalks and Enhancements
- Crossing Islands
- Raised Medians
- Curb Extensions
- Modify Skewed Intersections
- Pedestrian Signals
- Pedestrian Hybrid Beacon
- Rectangular Rapid Flash Beacon
- Signing



The **Pedestrian Safety Guide and Countermeasure Selection System** is intended to provide practitioners with the latest information available for improving the safety and mobility of those who walk. The online tools provide the user with a list of possible engineering, education, or enforcement treatments to improve pedestrian safety and/or mobility based on user input about a specific location.

GUIDE

Background
Understand what is needed to create a viable pedestrian system.

Analysis
How crash typing can lead to the most appropriate countermeasures.

Statistics
Learn about the factors related to the pedestrian crash problem.

Implementation
Needed components for treatments.

COUNTERMEASURES

Selection Tool
Find countermeasures based on desired objectives.

Countermeasure List
A comprehensive list of all countermeasures.

Selection Matrices
Find countermeasures based on crash types and performance objectives.

MUTCD: Manual on Uniform Traffic Control Devices
http://mutcd.fhwa.dot.gov/htm/2009r1r2/html_index.htm

Pertinent Chapters and Sections in the 2009 version related to pedestrian crossing devices:

- Section 2C.50 Non-Vehicular Warning Signs
- Section 3B.18 Crosswalk Markings
- Section 4C.05 Warrant 4, Pedestrian Volume
- Section 4C.06 Warrant 5, School Crossing
- Chapter 4E. Pedestrian Control Features
- Chapter 4F. Pedestrian Hybrid Beacons
- Chapter 4N. In-Roadway Lights

See excerpts of 2009 MUTCD included in Appendix B.

NCDOT Policies:

- Standard Practice for Crosswalks – Mid-Block (Unsignalized) Signing (Feb. 2, 2008)
  https://connect.ncdot.gov/resources/safety/Teppl/TEPPL%20All%20Documents%20Library/C-36_pr.pdf

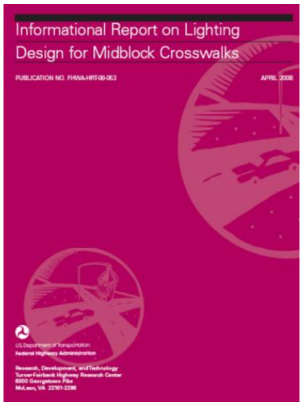
- Alternate Curb Ramp Designs Memorandum (Oct. 20, 2011)
  https://connect.ncdot.gov/resources/safety/Teppl/TEPPL%20All%20Documents%20Library/C53%20%E2%80%93%20Memo%20111020.pdf

- Interim Approval for Optional Use of Rectangular Rapid Flashing Beacons (RRFBs) https://connect.ncdot.gov/resources/safety/Teppl/TEPPL%20All%20Documents%20Library/ApprovalLetter.PDF

Pedestrian Hybrid Beacon Guide – Recommendations and Case Study
http://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa14014/

Informational Report on Lighting Design for Midblock Crosswalks (2008)
http://www.fhwa.dot.gov/publications/research/safety/08053/08053.pdf

This brief document includes information on lighting parameters and design criteria that should be considered when installing fixed roadway lighting for midblock crosswalks. It includes guidance for lighting placement and lumens levels, as well as minor guidance for lighting at intersections.


Informational Report on Lighting Design for Midblock Crosswalks

PUBLICATION NO. FHWA-HRT-08-053
APRIL 2008

U.S. Department of Transportation
Federal Highway Administration

Research, Development, and Technology
Turner-Fairbank Highway Research Center
6300 Georgetown Pike
McLean, VA 22101-2296

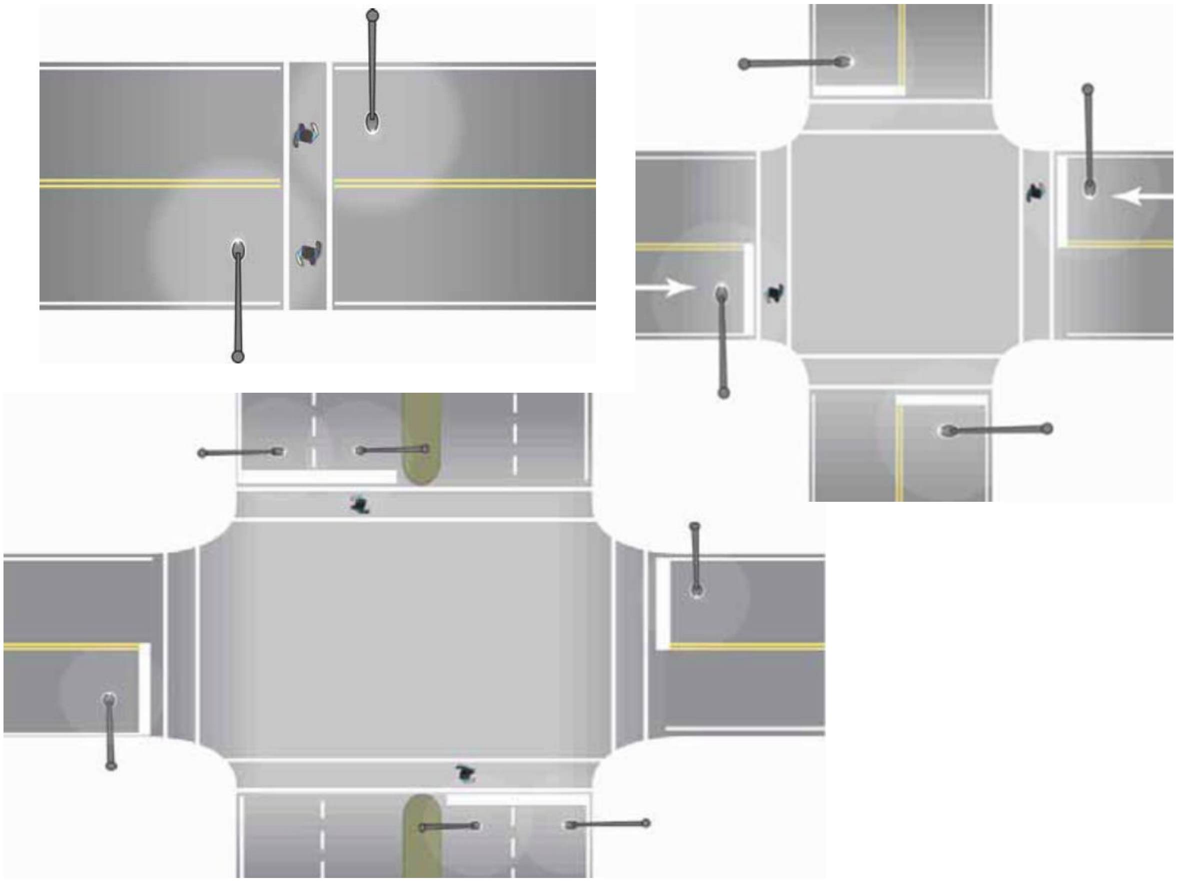
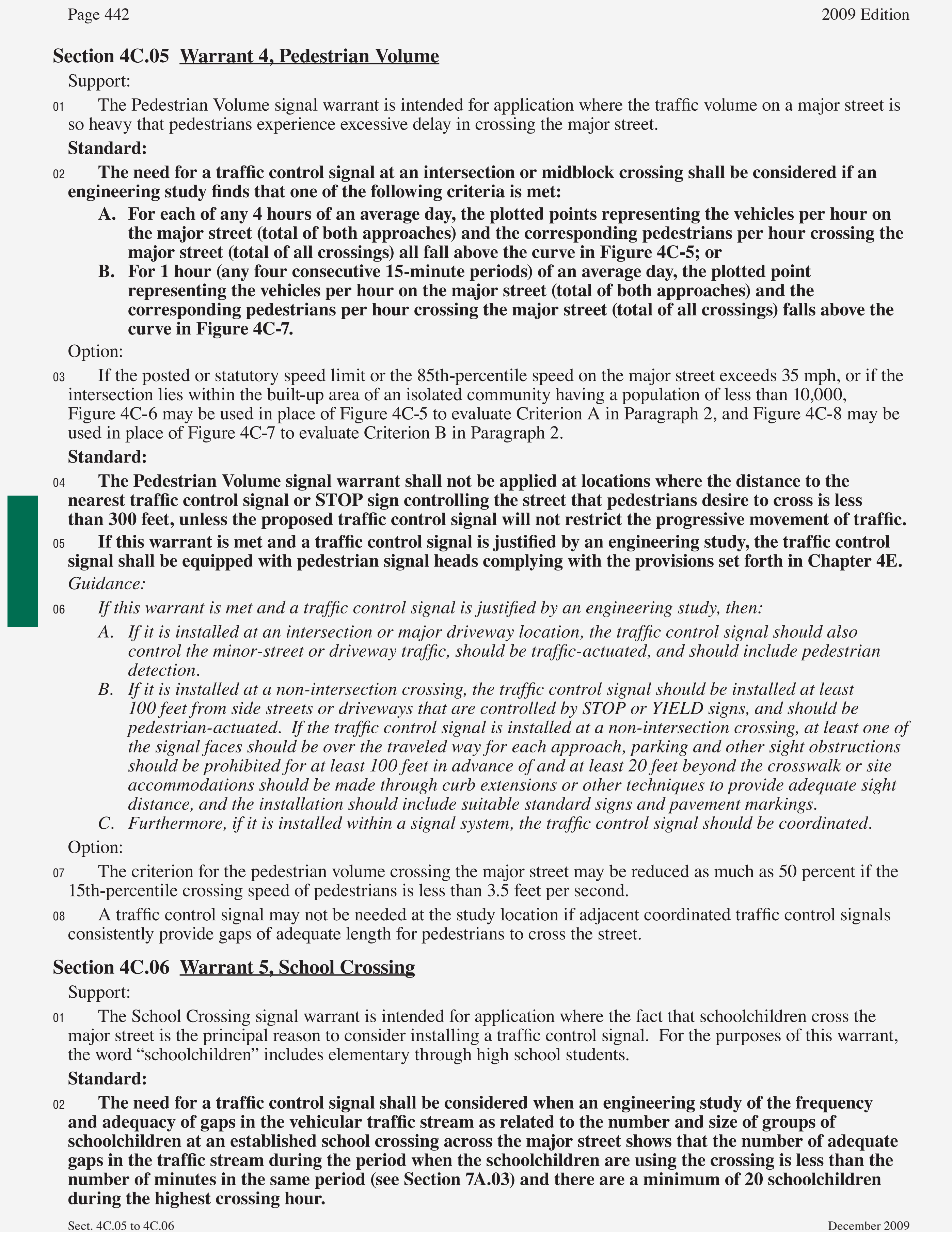


Figure 22 New lighting layout designs to illuminate pedestrians in crosswalks. In general, lighting should be placed downstream of the crosswalk to silhouette the pedestrian at a recommended lighting level of 20 lux at five feet above the pavement. From Figures 12 (midblock), 14 (intersection), and 15 (wide intersection) of Informational Report. (2008)

Appendix B. EXCERPTS FROM THE 2009 MUTCD

The following pages include excerpts from the MUTCD of the following sections or full chapters:

- Section 4C.05 Warrant 4, Pedestrian Volume
- Section 4C.06 Warrant 5, School Crossing
- Chapter 4E. Pedestrian Control Features
- Chapter 4F. Pedestrian Hybrid Beacons



Section 4C.05 Warrant 4, Pedestrian Volume

Support:

01 The Pedestrian Volume signal warrant is intended for application where the traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street.

Standard:

02 **The need for a traffic control signal at an intersection or midblock crossing shall be considered if an engineering study finds that one of the following criteria is met:**

A. For each of any 4 hours of an average day, the plotted points representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street (total of all crossings) all fall above the curve in Figure 4C-5; or

B. For 1 hour (any four consecutive 15-minute periods) of an average day, the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding pedestrians per hour crossing the major street (total of all crossings) falls above the curve in Figure 4C-7.

Option:

03 If the posted or statutory speed limit or the 85th-percentile speed on the major street exceeds 35 mph, or if the intersection lies within the built-up area of an isolated community having a population of less than 10,000, Figure 4C-6 may be used in place of Figure 4C-5 to evaluate Criterion A in Paragraph 2, and Figure 4C-8 may be used in place of Figure 4C-7 to evaluate Criterion B in Paragraph 2.

Standard:

04 **The Pedestrian Volume signal warrant shall not be applied at locations where the distance to the nearest traffic control signal or STOP sign controlling the street that pedestrians desire to cross is less than 300 feet, unless the proposed traffic control signal will not restrict the progressive movement of traffic.**

05 **If this warrant is met and a traffic control signal is justified by an engineering study, the traffic control signal shall be equipped with pedestrian signal heads complying with the provisions set forth in Chapter 4E.**

Guidance:

06 *If this warrant is met and a traffic control signal is justified by an engineering study, then:*

A. If it is installed at an intersection or major driveway location, the traffic control signal should also control the minor-street or driveway traffic, should be traffic-actuated, and should include pedestrian detection.

B. If it is installed at a non-intersection crossing, the traffic control signal should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs, and should be pedestrian-actuated. If the traffic control signal is installed at a non-intersection crossing, at least one of the signal faces should be over the traveled way for each approach, parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the crosswalk or site accommodations should be made through curb extensions or other techniques to provide adequate sight distance, and the installation should include suitable standard signs and pavement markings.

C. Furthermore, if it is installed within a signal system, the traffic control signal should be coordinated.

Option:

07 The criterion for the pedestrian volume crossing the major street may be reduced as much as 50 percent if the 15th-percentile crossing speed of pedestrians is less than 3.5 feet per second.

08 A traffic control signal may not be needed at the study location if adjacent coordinated traffic control signals consistently provide gaps of adequate length for pedestrians to cross the street.

Section 4C.06 Warrant 5, School Crossing

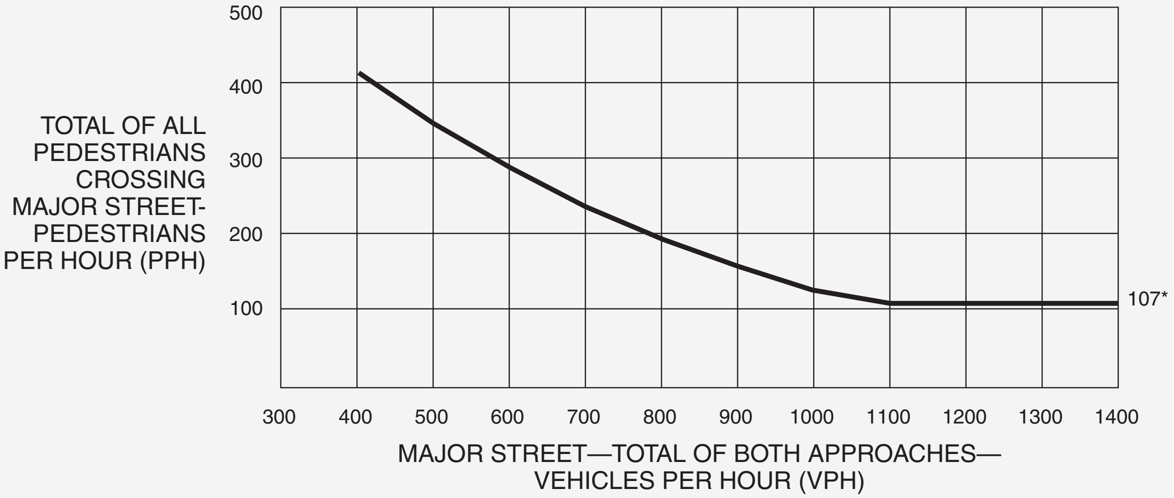
Support:

01 The School Crossing signal warrant is intended for application where the fact that schoolchildren cross the major street is the principal reason to consider installing a traffic control signal. For the purposes of this warrant, the word "schoolchildren" includes elementary through high school students.

Standard:

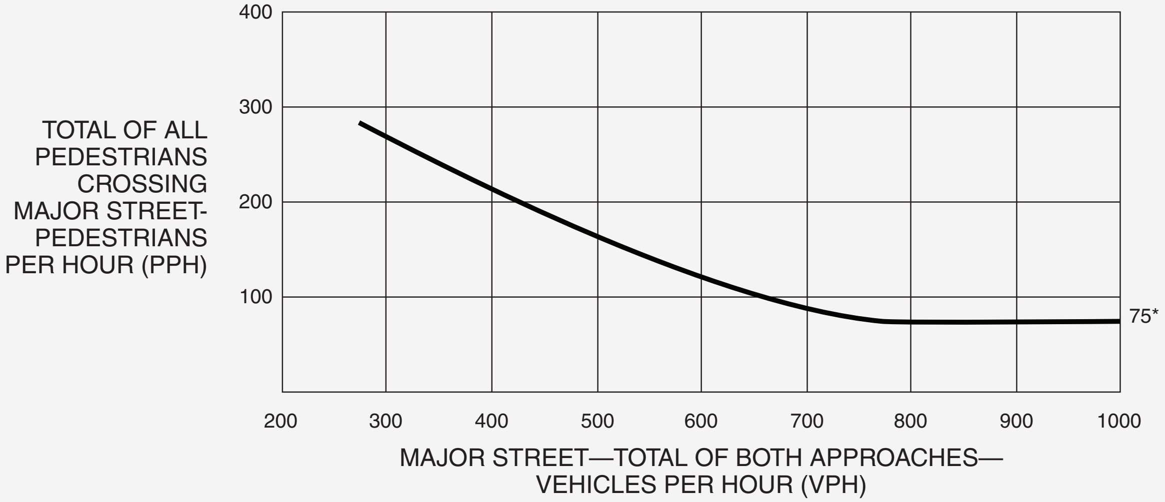
02 **The need for a traffic control signal shall be considered when an engineering study of the frequency and adequacy of gaps in the vehicular traffic stream as related to the number and size of groups of schoolchildren at an established school crossing across the major street shows that the number of adequate gaps in the traffic stream during the period when the schoolchildren are using the crossing is less than the number of minutes in the same period (see Section 7A.03) and there are a minimum of 20 schoolchildren during the highest crossing hour.**

Figure 4C-5. Warrant 4, Pedestrian Four-Hour Volume



*Note: 107 pph applies as the lower threshold volume.

Figure 4C-6. Warrant 4, Pedestrian Four-Hour Volume (70% Factor)



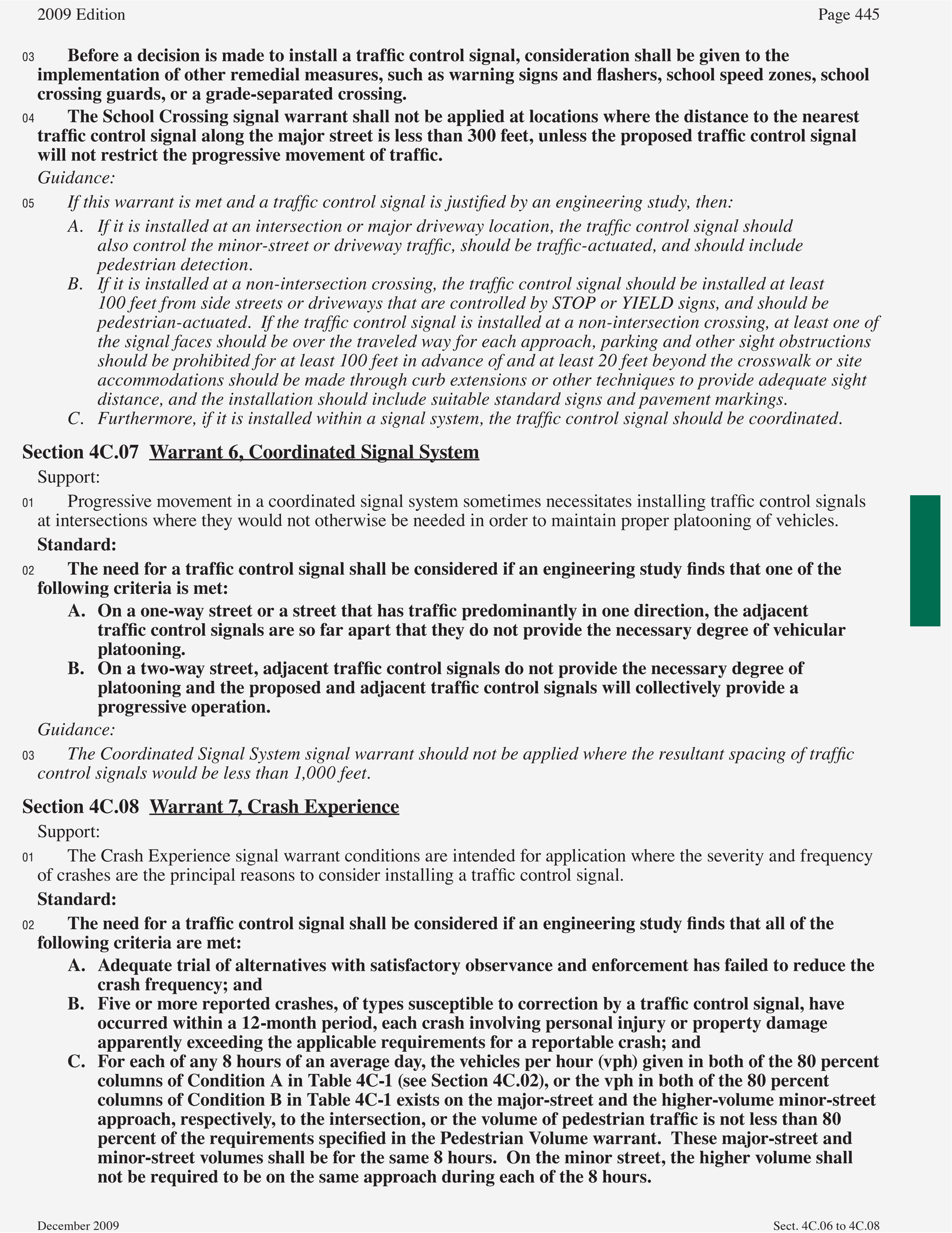
*Note: 75 pph applies as the lower threshold volume.

Figure 4C-7. Warrant 4, Pedestrian Peak Hour

*Note: 133 pph applies as the lower threshold volume.

Figure 4C-8. Warrant 4, Pedestrian Peak Hour (70% Factor)

*Note: 93 pph applies as the lower threshold volume.



03 **Before a decision is made to install a traffic control signal, consideration shall be given to the implementation of other remedial measures, such as warning signs and flashers, school speed zones, school crossing guards, or a grade-separated crossing.**

04 **The School Crossing signal warrant shall not be applied at locations where the distance to the nearest traffic control signal along the major street is less than 300 feet, unless the proposed traffic control signal will not restrict the progressive movement of traffic.**

Guidance:

05 *If this warrant is met and a traffic control signal is justified by an engineering study, then:*

- *A. If it is installed at an intersection or major driveway location, the traffic control signal should also control the minor-street or driveway traffic, should be traffic-actuated, and should include pedestrian detection.*
- *B. If it is installed at a non-intersection crossing, the traffic control signal should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs, and should be pedestrian-actuated. If the traffic control signal is installed at a non-intersection crossing, at least one of the signal faces should be over the traveled way for each approach, parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the crosswalk or site accommodations should be made through curb extensions or other techniques to provide adequate sight distance, and the installation should include suitable standard signs and pavement markings.*
- *C. Furthermore, if it is installed within a signal system, the traffic control signal should be coordinated.*

Section 4C.07 Warrant 6, Coordinated Signal System

Support:

01 Progressive movement in a coordinated signal system sometimes necessitates installing traffic control signals at intersections where they would not otherwise be needed in order to maintain proper platooning of vehicles.

Standard:

02 **The need for a traffic control signal shall be considered if an engineering study finds that one of the following criteria is met:**

- **A. On a one-way street or a street that has traffic predominantly in one direction, the adjacent traffic control signals are so far apart that they do not provide the necessary degree of vehicular platooning.**
- **B. On a two-way street, adjacent traffic control signals do not provide the necessary degree of platooning and the proposed and adjacent traffic control signals will collectively provide a progressive operation.**

Guidance:

03 *The Coordinated Signal System signal warrant should not be applied where the resultant spacing of traffic control signals would be less than 1,000 feet.*

Section 4C.08 Warrant 7, Crash Experience

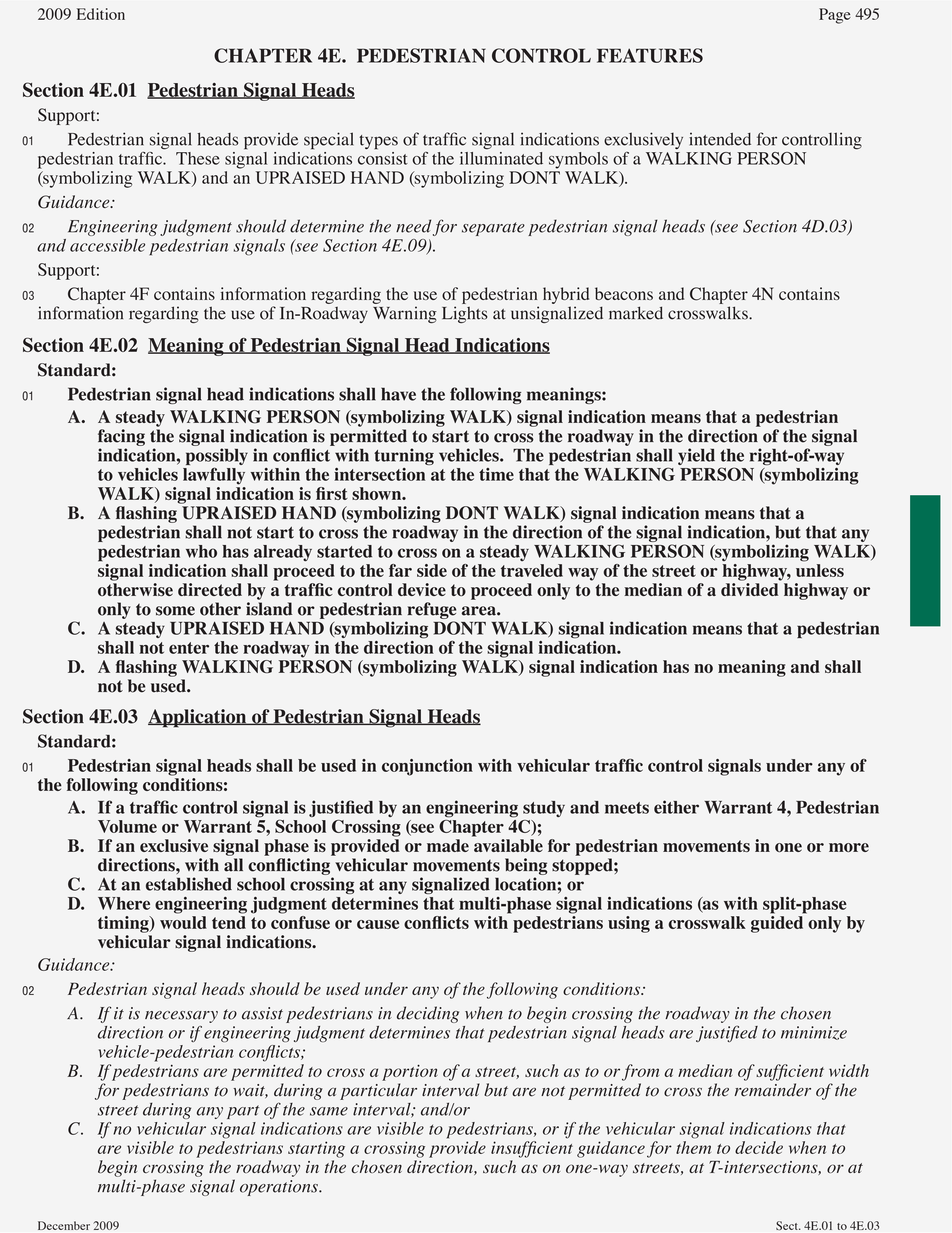
Support:

01 The Crash Experience signal warrant conditions are intended for application where the severity and frequency of crashes are the principal reasons to consider installing a traffic control signal.

Standard:

02 **The need for a traffic control signal shall be considered if an engineering study finds that all of the following criteria are met:**

- **A. Adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the crash frequency; and**
- **B. Five or more reported crashes, of types susceptible to correction by a traffic control signal, have occurred within a 12-month period, each crash involving personal injury or property damage apparently exceeding the applicable requirements for a reportable crash; and**
- **C. For each of any 8 hours of an average day, the vehicles per hour (vph) given in both of the 80 percent columns of Condition A in Table 4C-1 (see Section 4C.02), or the vph in both of the 80 percent columns of Condition B in Table 4C-1 exists on the major-street and the higher-volume minor-street approach, respectively, to the intersection, or the volume of pedestrian traffic is not less than 80 percent of the requirements specified in the Pedestrian Volume warrant. These major-street and minor-street volumes shall be for the same 8 hours. On the minor street, the higher volume shall not be required to be on the same approach during each of the 8 hours.**



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CHAPTER 4E. PEDESTRIAN CONTROL FEATURES

Section 4E.01 Pedestrian Signal Heads

Support:

01 Pedestrian signal heads provide special types of traffic signal indications exclusively intended for controlling pedestrian traffic. These signal indications consist of the illuminated symbols of a WALKING PERSON (symbolizing WALK) and an UPRAISED HAND (symbolizing DONT WALK).

Guidance:

02 *Engineering judgment should determine the need for separate pedestrian signal heads (see Section 4D.03) and accessible pedestrian signals (see Section 4E.09).*

Support:

03 Chapter 4F contains information regarding the use of pedestrian hybrid beacons and Chapter 4N contains information regarding the use of In-Roadway Warning Lights at unsignalized marked crosswalks.

Section 4E.02 Meaning of Pedestrian Signal Head Indications

Standard:

01 **Pedestrian signal head indications shall have the following meanings:**

- **A. A steady WALKING PERSON (symbolizing WALK) signal indication means that a pedestrian facing the signal indication is permitted to start to cross the roadway in the direction of the signal indication, possibly in conflict with turning vehicles. The pedestrian shall yield the right-of-way to vehicles lawfully within the intersection at the time that the WALKING PERSON (symbolizing WALK) signal indication is first shown.**
- **B. A flashing UPRAISED HAND (symbolizing DONT WALK) signal indication means that a pedestrian shall not start to cross the roadway in the direction of the signal indication, but that any pedestrian who has already started to cross on a steady WALKING PERSON (symbolizing WALK) signal indication shall proceed to the far side of the traveled way of the street or highway, unless otherwise directed by a traffic control device to proceed only to the median of a divided highway or only to some other island or pedestrian refuge area.**
- **C. A steady UPRAISED HAND (symbolizing DONT WALK) signal indication means that a pedestrian shall not enter the roadway in the direction of the signal indication.**
- **D. A flashing WALKING PERSON (symbolizing WALK) signal indication has no meaning and shall not be used.**

Section 4E.03 Application of Pedestrian Signal Heads

Standard:

01 **Pedestrian signal heads shall be used in conjunction with vehicular traffic control signals under any of the following conditions:**

- **A. If a traffic control signal is justified by an engineering study and meets either Warrant 4, Pedestrian Volume or Warrant 5, School Crossing (see Chapter 4C);**
- **B. If an exclusive signal phase is provided or made available for pedestrian movements in one or more directions, with all conflicting vehicular movements being stopped;**
- **C. At an established school crossing at any signalized location; or**
- **D. Where engineering judgment determines that multi-phase signal indications (as with split-phase timing) would tend to confuse or cause conflicts with pedestrians using a crosswalk guided only by vehicular signal indications.**

Guidance:

02 *Pedestrian signal heads should be used under any of the following conditions:*

- *A. If it is necessary to assist pedestrians in deciding when to begin crossing the roadway in the chosen direction or if engineering judgment determines that pedestrian signal heads are justified to minimize vehicle-pedestrian conflicts;*
- *B. If pedestrians are permitted to cross a portion of a street, such as to or from a median of sufficient width for pedestrians to wait, during a particular interval but are not permitted to cross the remainder of the street during any part of the same interval; and/or*
- *C. If no vehicular signal indications are visible to pedestrians, or if the vehicular signal indications that are visible to pedestrians starting a crossing provide insufficient guidance for them to decide when to begin crossing the roadway in the chosen direction, such as on one-way streets, at T-intersections, or at multi-phase signal operations.*

December 2009 Sect. 4E.01 to 4E.03

Option:

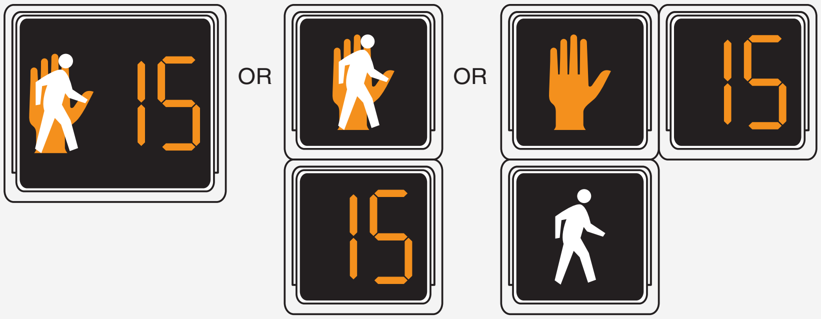
03 Pedestrian signal heads may be used under other conditions based on engineering judgment.

Section 4E.04 Size, Design, and Illumination of Pedestrian Signal Head Indications

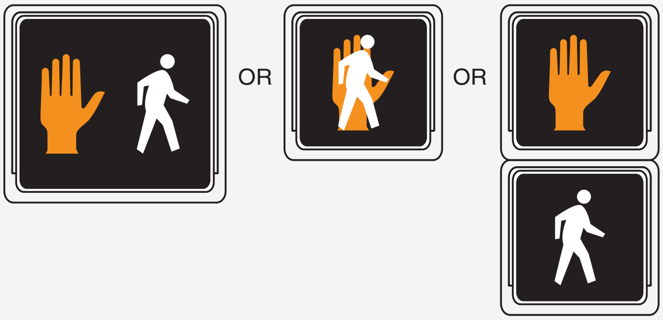
Standard:

Figure 4E-1. Typical Pedestrian Signal Indications

A - With countdown display



B - Without countdown display



01 All new pedestrian signal head indications shall be displayed within a rectangular background and shall consist of symbolized messages (see Figure 4E-1), except that existing pedestrian signal head indications with lettered or outline style symbol messages shall be permitted to be retained for the remainder of their useful service life. The symbol designs that are set forth in the "Standard Highway Signs and Markings" book (see Section 1A.11) shall be used. Each pedestrian signal head indication shall be independently displayed and emit a single color.

02 If a two-section pedestrian signal head is used, the UPRAISED HAND (symbolizing DONT WALK) signal section shall be mounted directly above the WALKING PERSON (symbolizing WALK) signal section. If a one-section pedestrian signal head is used, the symbols shall be either overlaid upon each other or arranged side-by-side with the UPRAISED HAND symbol to the left of the WALKING PERSON symbol, and a light source that can display each symbol independently shall be used.

03 The WALKING PERSON (symbolizing WALK) signal indication shall be white, conforming to the publication entitled "Pedestrian Traffic Control Signal Indications" (see Section 1A.11), with all except the symbol obscured by an opaque material.

04 The UPRAISED HAND (symbolizing DONT WALK) signal indication shall be Portland orange, conforming to the publication entitled "Pedestrian Traffic Control Signal Indications" (see Section 1A.11), with all except the symbol obscured by an opaque material.

05 When not illuminated, the WALKING PERSON (symbolizing WALK) and UPRAISED HAND (symbolizing DONT WALK) symbols shall not be readily visible to pedestrians at the far end of the crosswalk that the pedestrian signal head indications control.

06 For pedestrian signal head indications, the symbols shall be at least 6 inches high.

07 The light source of a flashing UPRAISED HAND (symbolizing DONT WALK) signal indication shall be flashed continuously at a rate of not less than 50 or more than 60 times per minute. The displayed period of each flash shall be a minimum of 1/2 and a maximum of 2/3 of the total flash cycle.

Guidance:

08 Pedestrian signal head indications should be conspicuous and recognizable to pedestrians at all distances from the beginning of the controlled crosswalk to a point 10 feet from the end of the controlled crosswalk during both day and night.

09 For crosswalks where the pedestrian enters the crosswalk more than 100 feet from the pedestrian signal head indications, the symbols should be at least 9 inches high.

10 If the pedestrian signal indication is so bright that it causes excessive glare in nighttime conditions, some form of automatic dimming should be used to reduce the brilliance of the signal indication.

Option:

11 An animated eyes symbol may be added to a pedestrian signal head in order to prompt pedestrians to look for vehicles in the intersection during the time that the WALKING PERSON (symbolizing WALK) signal indication is displayed.

Standard:

12 **If used, the animated eyes symbol shall consist of an outline of a pair of white steadily-illuminated eyes with white eyeballs that scan from side to side at a rate of approximately once per second. The animated eyes symbol shall be at least 12 inches wide with each eye having a width of at least 5 inches and a height of at least 2.5 inches. The animated eyes symbol shall be illuminated at the start of the walk interval and shall terminate at the end of the walk interval.**

Section 4E.05 Location and Height of Pedestrian Signal Heads

Standard:

01 **Pedestrian signal heads shall be mounted with the bottom of the signal housing including brackets not less than 7 feet or more than 10 feet above sidewalk level, and shall be positioned and adjusted to provide maximum visibility at the beginning of the controlled crosswalk.**

02 **If pedestrian signal heads are mounted on the same support as vehicular signal heads, there shall be a physical separation between them.**

Section 4E.06 Pedestrian Intervals and Signal Phases

Standard:

01 **At intersections equipped with pedestrian signal heads, the pedestrian signal indications shall be displayed except when the vehicular traffic control signal is being operated in the flashing mode. At those times, the pedestrian signal indications shall not be displayed.**

02 **When the pedestrian signal heads associated with a crosswalk are displaying either a steady WALKING PERSON (symbolizing WALK) or a flashing UPRAISED HAND (symbolizing DONT WALK) signal indication, a steady or a flashing red signal indication shall be shown to any conflicting vehicular movement that is approaching the intersection or midblock location perpendicular or nearly perpendicular to the crosswalk.**

03 **When pedestrian signal heads are used, a WALKING PERSON (symbolizing WALK) signal indication shall be displayed only when pedestrians are permitted to leave the curb or shoulder.**

04 **A pedestrian change interval consisting of a flashing UPRAISED HAND (symbolizing DONT WALK) signal indication shall begin immediately following the WALKING PERSON (symbolizing WALK) signal indication. Following the pedestrian change interval, a buffer interval consisting of a steady UPRAISED HAND (symbolizing DONT WALK) signal indication shall be displayed for at least 3 seconds prior to the release of any conflicting vehicular movement. The sum of the time of the pedestrian change interval and the buffer interval shall not be less than the calculated pedestrian clearance time (see Paragraphs 7 through 16). The buffer interval shall not begin later than the beginning of the red clearance interval, if used.**

Option:

05 During the yellow change interval, the UPRAISED HAND (symbolizing DON'T WALK) signal indication may be displayed as either a flashing indication, a steady indication, or a flashing indication for an initial portion of the yellow change interval and a steady indication for the remainder of the interval.

Support:

06 Figure 4E-2 illustrates the pedestrian intervals and their possible relationships with associated vehicular signal phase intervals.

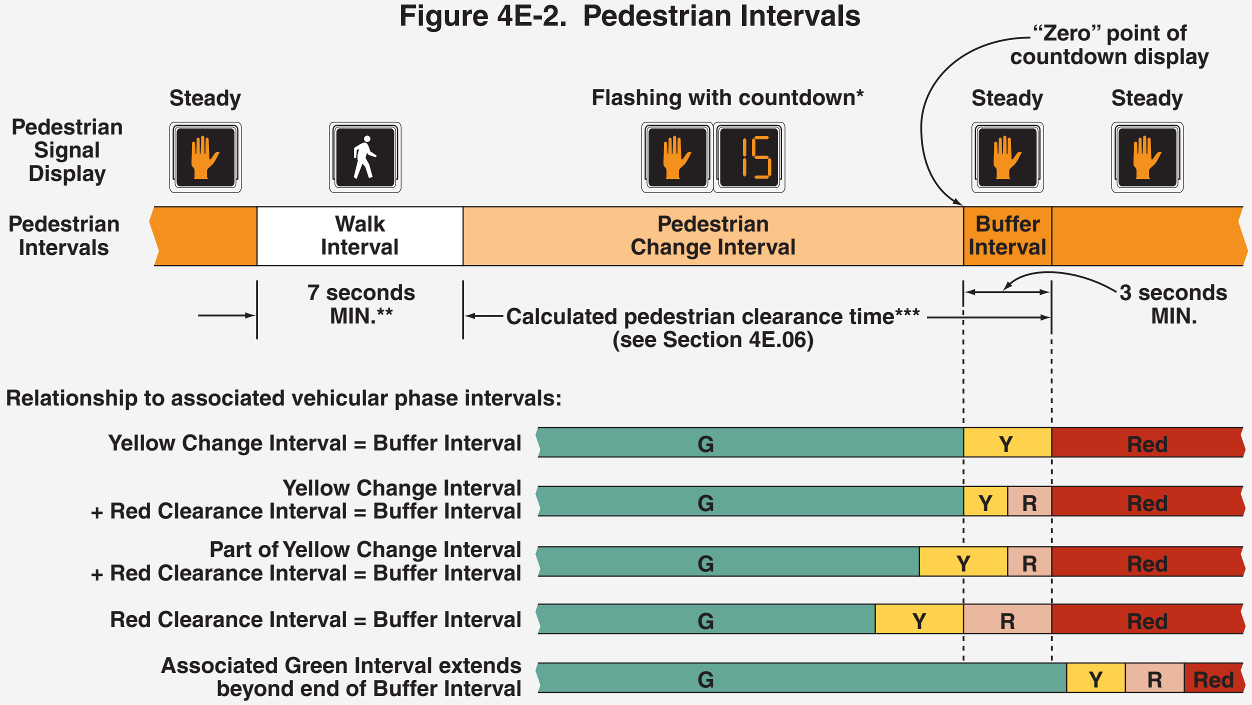
Guidance:

07 *Except as provided in Paragraph 8, the pedestrian clearance time should be sufficient to allow a pedestrian crossing in the crosswalk who left the curb or shoulder at the end of the WALKING PERSON (symbolizing WALK) signal indication to travel at a walking speed of 3.5 feet per second to at least the far side of the traveled way or to a median of sufficient width for pedestrians to wait.*

Option:

08 A walking speed of up to 4 feet per second may be used to evaluate the sufficiency of the pedestrian clearance time at locations where an extended pushbutton press function has been installed to provide slower pedestrians an opportunity to request and receive a longer pedestrian clearance time. Passive pedestrian detection may also be used to automatically adjust the pedestrian clearance time based on the pedestrian's actual walking speed or actual clearance of the crosswalk.

Figure 4E-2. Pedestrian Intervals



Legend

G = Green Interval
Y = Yellow Change Interval (of at least 3 seconds)
R = Red Clearance Interval
Red = Red because conflicting traffic has been released

* The countdown display is optional for Pedestrian Change Intervals of 7 seconds or less.

** The Walk Interval may be reduced under some conditions (see Section 4E.06).

*** The Buffer Interval, which shall always be provided and displayed, may be used to help satisfy the calculated pedestrian clearance time, or may begin after the calculated pedestrian clearance time has ended.

---

09 The additional time provided by an extended pushbutton press to satisfy pedestrian clearance time needs may be added to either the walk interval or the pedestrian change interval.

Guidance:

10 *Where pedestrians who walk slower than 3.5 feet per second, or pedestrians who use wheelchairs, routinely use the crosswalk, a walking speed of less than 3.5 feet per second should be considered in determining the pedestrian clearance time.*

11 *Except as provided in Paragraph 12, the walk interval should be at least 7 seconds in length so that pedestrians will have adequate opportunity to leave the curb or shoulder before the pedestrian clearance time begins.*

Option:

12 If pedestrian volumes and characteristics do not require a 7-second walk interval, walk intervals as short as 4 seconds may be used.

Support:

13 The walk interval is intended for pedestrians to start their crossing. The pedestrian clearance time is intended to allow pedestrians who started crossing during the walk interval to complete their crossing. Longer walk intervals are often used when the duration of the vehicular green phase associated with the pedestrian crossing is long enough to allow it.

Guidance:

14 *The total of the walk interval and pedestrian clearance time should be sufficient to allow a pedestrian crossing in the crosswalk who left the pedestrian detector (or, if no pedestrian detector is present, a location 6 feet from the face of the curb or from the edge of the pavement) at the beginning of the WALKING PERSON (symbolizing WALK) signal indication to travel at a walking speed of 3 feet per second to the far side of the traveled way being crossed or to the median if a two-stage pedestrian crossing sequence is used. Any additional time that is required to satisfy the conditions of this paragraph should be added to the walk interval.*

Option:

15 On a street with a median of sufficient width for pedestrians to wait, a pedestrian clearance time that allows the pedestrian to cross only from the curb or shoulder to the median may be provided.

Standard:

16 **Where the pedestrian clearance time is sufficient only for crossing from the curb or shoulder to a median of sufficient width for pedestrians to wait, median-mounted pedestrian signals (with pedestrian detectors if actuated operation is used) shall be provided (see Sections 4E.08 and 4E.09) and signing such as the R10-3d sign (see Section 2B.52) shall be provided to notify pedestrians to cross only to the median to await the next WALKING PERSON (symbolizing WALK) signal indication.**

Guidance:

17 *Where median-mounted pedestrian signals and detectors are provided, the use of accessible pedestrian signals (see Sections 4E.09 through 4E.13) should be considered.*

Option:

18 During the transition into preemption, the walk interval and the pedestrian change interval may be shortened or omitted as described in Section 4D.27.

19 At intersections with high pedestrian volumes and high conflicting turning vehicle volumes, a brief leading pedestrian interval, during which an advance WALKING PERSON (symbolizing WALK) indication is displayed for the crosswalk while red indications continue to be displayed to parallel through and/or turning traffic, may be used to reduce conflicts between pedestrians and turning vehicles.

Guidance:

20 *If a leading pedestrian interval is used, the use of accessible pedestrian signals (see Sections 4E.09 through 4E.13) should be considered.*

Support:

21 If a leading pedestrian interval is used without accessible features, pedestrians who are visually impaired can be expected to begin crossing at the onset of the vehicular movement when drivers are not expecting them to begin crossing.

Guidance:

22 *If a leading pedestrian interval is used, it should be at least 3 seconds in duration and should be timed to allow pedestrians to cross at least one lane of traffic or, in the case of a large corner radius, to travel far enough for pedestrians to establish their position ahead of the turning traffic before the turning traffic is released.*

23 *If a leading pedestrian interval is used, consideration should be given to prohibiting turns across the crosswalk during the leading pedestrian interval.*

Support:

24 At intersections with pedestrian volumes that are so high that drivers have difficulty finding an opportunity to turn across the crosswalk, the duration of the green interval for a parallel concurrent vehicular movement is sometimes intentionally set to extend beyond the pedestrian clearance time to provide turning drivers additional green time to make their turns while the pedestrian signal head is displaying a steady UPRAISED HAND (symbolizing DONT WALK) signal indication after pedestrians have had time to complete their crossings.

Section 4E.07 Countdown Pedestrian Signals

Standard:

01 **All pedestrian signal heads used at crosswalks where the pedestrian change interval is more than 7 seconds shall include a pedestrian change interval countdown display in order to inform pedestrians of the number of seconds remaining in the pedestrian change interval.**

Option:

02 Pedestrian signal heads used at crosswalks where the pedestrian change interval is 7 seconds or less may include a pedestrian change interval countdown display in order to inform pedestrians of the number of seconds remaining in the pedestrian change interval.

Standard:

03 **Where countdown pedestrian signals are used, the countdown shall always be displayed simultaneously with the flashing UPRAISED HAND (symbolizing DONT WALK) signal indication displayed for that crosswalk.**

04 **Countdown pedestrian signals shall consist of Portland orange numbers that are at least 6 inches in height on a black opaque background. The countdown pedestrian signal shall be located immediately adjacent to the associated UPRAISED HAND (symbolizing DONT WALK) pedestrian signal head indication (see Figure 4E-1).**

05 **The display of the number of remaining seconds shall begin only at the beginning of the pedestrian change interval (flashing UPRAISED HAND). After the countdown displays zero, the display shall remain dark until the beginning of the next countdown.**

06 **The countdown pedestrian signal shall display the number of seconds remaining until the termination of the pedestrian change interval (flashing UPRAISED HAND). Countdown displays shall not be used during the walk interval or during the red clearance interval of a concurrent vehicular phase.**

Guidance:

07 *If used with a pedestrian signal head that does not have a concurrent vehicular phase, the pedestrian change interval (flashing UPRAISED HAND) should be set to be approximately 4 seconds less than the required pedestrian clearance time (see Section 4E.06) and an additional clearance interval (during which a steady UPRAISED HAND is displayed) should be provided prior to the start of the conflicting vehicular phase.*

08 *For crosswalks where the pedestrian enters the crosswalk more than 100 feet from the countdown pedestrian signal display, the numbers should be at least 9 inches in height.*

09 *Because some technology includes the countdown pedestrian signal logic in a separate timing device that is independent of the timing in the traffic signal controller, care should be exercised by the engineer when timing changes are made to pedestrian change intervals.*

10 *If the pedestrian change interval is interrupted or shortened as a part of a transition into a preemption sequence (see Section 4E.06), the countdown pedestrian signal display should be discontinued and go dark immediately upon activation of the preemption transition.*

Section 4E.08 Pedestrian Detectors

Option:

01 Pedestrian detectors may be pushbuttons or passive detection devices.

Support:

02 Passive detection devices register the presence of a pedestrian in a position indicative of a desire to cross, without requiring the pedestrian to push a button. Some passive detection devices are capable of tracking the progress of a pedestrian as the pedestrian crosses the roadway for the purpose of extending or shortening the duration of certain pedestrian timing intervals.

03 The provisions in this Section place pedestrian pushbuttons within easy reach of pedestrians who are intending to cross each crosswalk and make it obvious which pushbutton is associated with each crosswalk. These provisions also position pushbutton poles in optimal locations for installation of accessible pedestrian signals (see Sections 4E.09 through 4E.13). Information regarding reach ranges can be found in the "Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)" (see Section 1A.11).

Guidance:

04 *If pedestrian pushbuttons are used, they should be capable of easy activation and conveniently located near each end of the crosswalks. Except as provided in Paragraphs 5 and 6, pedestrian pushbuttons should be located to meet all of the following criteria (see Figure 4E-3):*

- *A. Unobstructed and adjacent to a level all-weather surface to provide access from a wheelchair;*
- *B. Where there is an all-weather surface, a wheelchair accessible route from the pushbutton to the ramp;*
- *C. Between the edge of the crosswalk line (extended) farthest from the center of the intersection and the side of a curb ramp (if present), but not greater than 5 feet from said crosswalk line;*
- *D. Between 1.5 and 6 feet from the edge of the curb, shoulder, or pavement;*
- *E. With the face of the pushbutton parallel to the crosswalk to be used; and*
- *F. At a mounting height of approximately 3.5 feet, but no more than 4 feet, above the sidewalk.*

05 *Where there are physical constraints that make it impractical to place the pedestrian pushbutton adjacent to a level all-weather surface, the surface should be as level as feasible.*

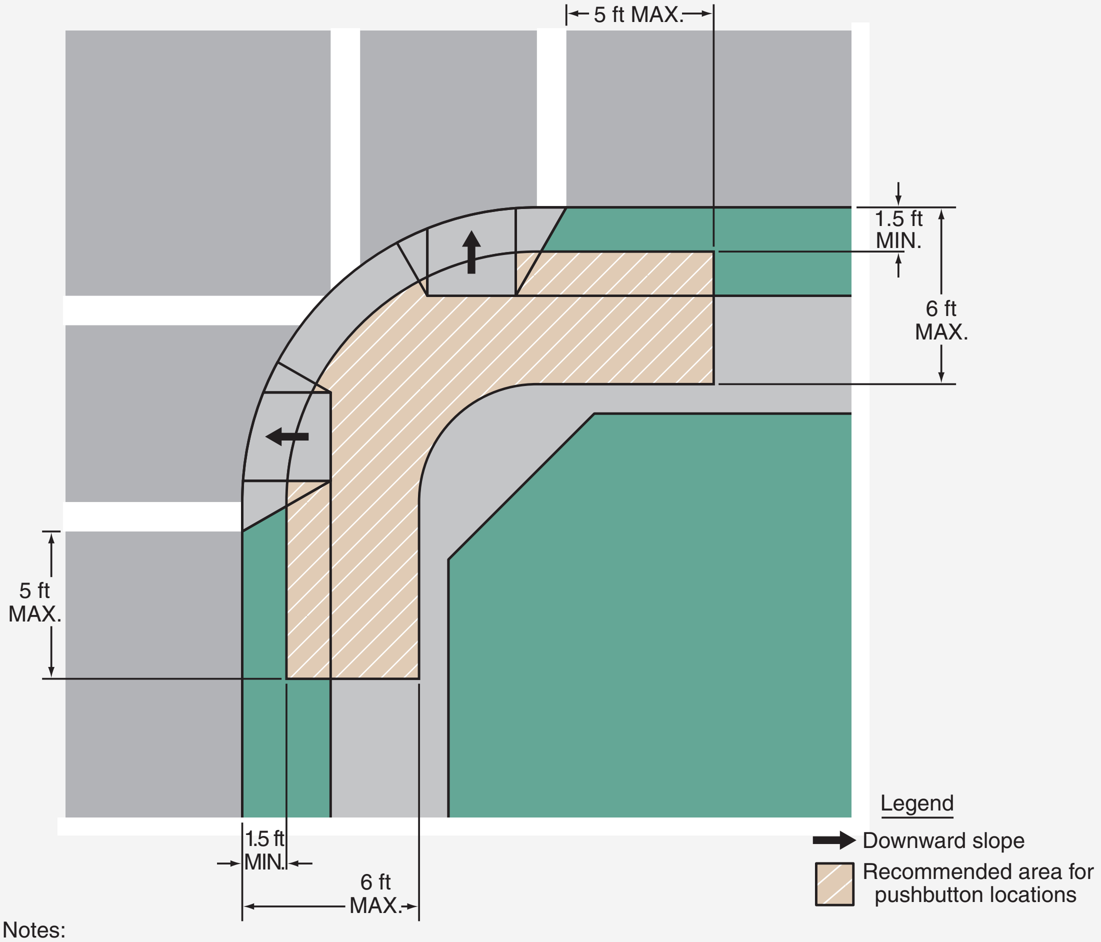
06 *Where there are physical constraints that make it impractical to place the pedestrian pushbutton between 1.5 and 6 feet from the edge of the curb, shoulder, or pavement, it should not be farther than 10 feet from the edge of curb, shoulder, or pavement.*

07 *Except as provided in Paragraph 8, where two pedestrian pushbuttons are provided on the same corner of a signalized location, the pushbuttons should be separated by a distance of at least 10 feet.*

Option:

08 Where there are physical constraints on a particular corner that make it impractical to provide the 10-foot separation between the two pedestrian pushbuttons, the pushbuttons may be placed closer together or on the same pole.

Figure 4E-3. Pushbutton Location Area



Notes:

1. Where there are constraints that make it impractical to place the pedestrian pushbutton between 1.5 feet and 6 feet from the edge of the curb, shoulder, or pavement, it should not be further than 10 feet from the edge of curb, shoulder, or pavement.
2. Two pedestrian pushbuttons on a corner should be separated by 10 feet.
3. This figure is not drawn to scale.
4. Figure 4E-4 shows typical pushbutton locations.

Support:

09 Figure 4E-4 shows typical pedestrian pushbutton locations for a variety of situations.

Standard:

10 **Signs (see Section 2B.52) shall be mounted adjacent to or integral with pedestrian pushbuttons, explaining their purpose and use.**

Option:

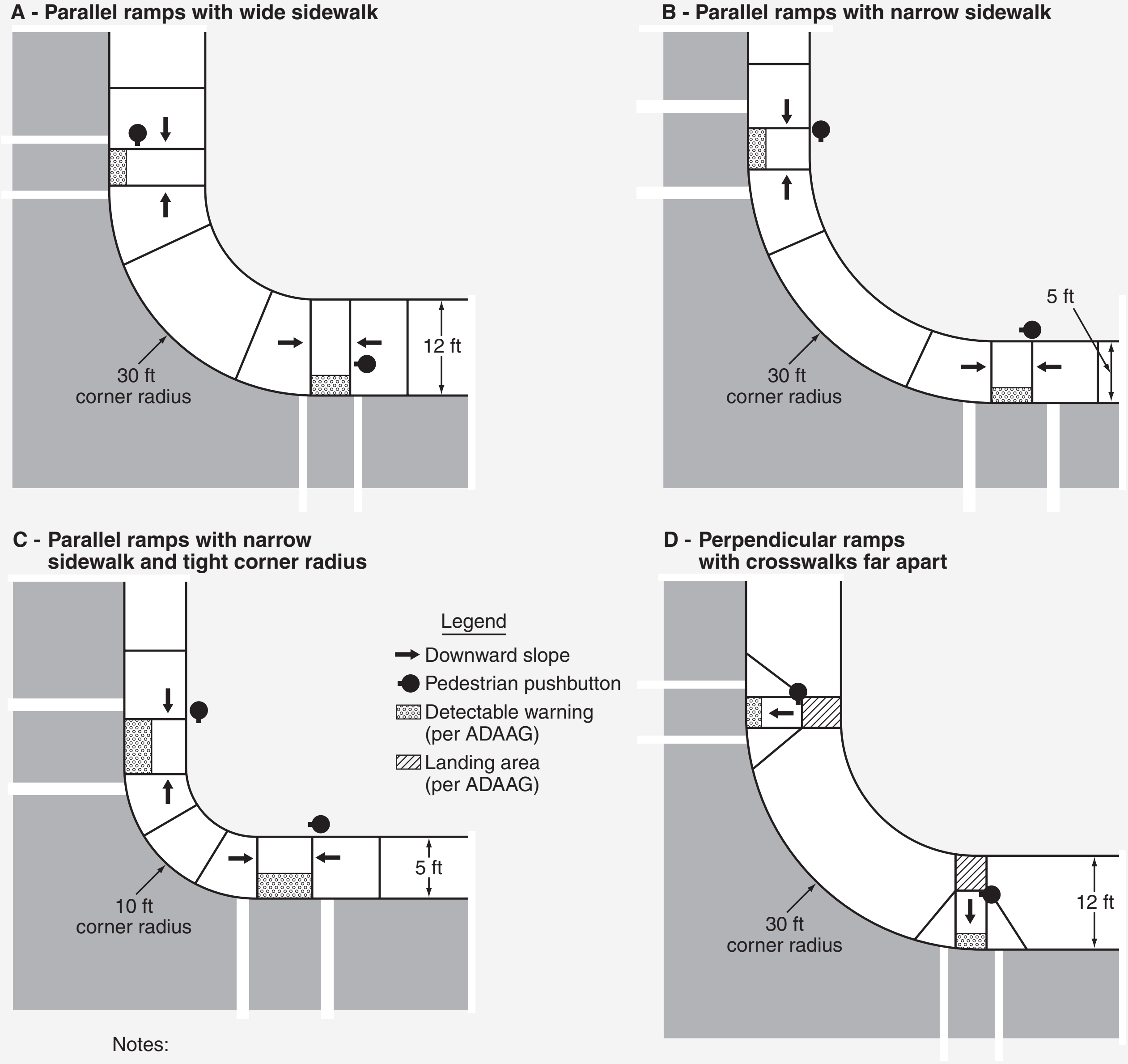
11 At certain locations, a supplemental sign in a more visible location may be used to call attention to the pedestrian pushbutton.

Standard:

12 **The positioning of pedestrian pushbuttons and the legends on the pedestrian pushbutton signs shall clearly indicate which crosswalk signal is actuated by each pedestrian pushbutton.**

13 **If the pedestrian clearance time is sufficient only to cross from the curb or shoulder to a median of sufficient width for pedestrians to wait and the signals are pedestrian actuated, an additional pedestrian detector shall be provided in the median.**

Figure 4E-4. Typical Pushbutton Locations (Sheet 1 of 2)



A - Parallel ramps with wide sidewalk

B - Parallel ramps with narrow sidewalk

C - Parallel ramps with narrow sidewalk and tight corner radius

D - Perpendicular ramps with crosswalks far apart

Notes:

1. This figure is not drawn to scale.
2. These drawings are intended to describe the typical locations for pedestrian pushbutton installations. They are not intended to be a guide for the design of curb cut ramps.
3. Figure 4E-3 shows the recommended area for pushbutton locations.

Guidance:

14 *The use of additional pedestrian detectors on islands or medians where a pedestrian might become stranded should be considered.*

15 *If used, special purpose pushbuttons (to be operated only by authorized persons) should include a housing capable of being locked to prevent access by the general public and do not need an instructional sign.*

Standard:

16 **If used, a pilot light or other means of indication installed with a pedestrian pushbutton shall not be illuminated until actuation. Once it is actuated, the pilot light shall remain illuminated until the pedestrian's green or WALKING PERSON (symbolizing WALK) signal indication is displayed.**

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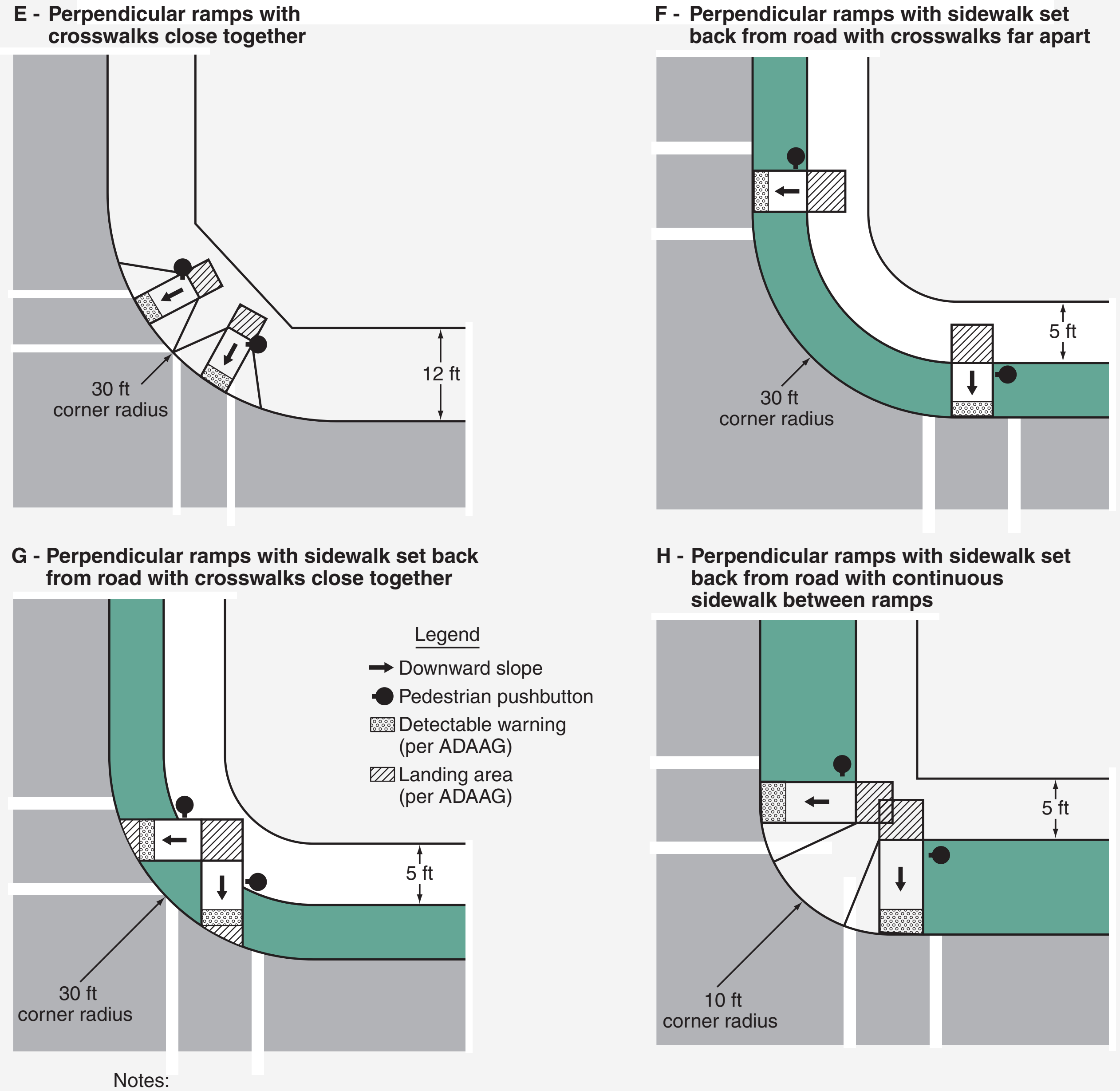
Figure 4E-4. Typical Pushbutton Locations (Sheet 2 of 2)



Notes:

1. This figure is not drawn to scale.
2. Tese drawings are intended to describe the typical locations for pedestrian pushbutton installations. They are not intended to be a guide for the design of curb cut ramps.
3. Figure 4E-3 shows the recommended area for pushbutton locations.

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17 **If a pilot light is used at an accessible pedestrian signal location (see Sections 4E.09 through 4E.13), each actuation shall be accompanied by the speech message "wait."**

Option:

18 At signalized locations with a demonstrated need and subject to equipment capabilities, pedestrians with special needs may be provided with additional crossing time by means of an extended pushbutton press.

Standard:

19 **If additional crossing time is provided by means of an extended pushbutton press, a PUSH BUTTON FOR 2 SECONDS FOR EXTRA CROSSING TIME (R10-32P) plaque (see Figure 2B-26) shall be mounted adjacent to or integral with the pedestrian pushbutton.**

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Section 4E.09 Accessible Pedestrian Signals and Detectors – General

Support:

01 Accessible pedestrian signals and detectors provide information in non-visual formats (such as audible tones, speech messages, and/or vibrating surfaces).

02 The primary technique that pedestrians who have visual disabilities use to cross streets at signalized locations is to initiate their crossing when they hear the traffic in front of them stop and the traffic alongside them begin to move, which often corresponds to the onset of the green interval. The existing environment is often not sufficient to provide the information that pedestrians who have visual disabilities need to cross a roadway at a signalized location.

Guidance:

03 *If a particular signalized location presents difficulties for pedestrians who have visual disabilities to cross the roadway, an engineering study should be conducted that considers the needs of pedestrians in general, as well as the information needs of pedestrians with visual disabilities. The engineering study should consider the following factors:*

- *A. Potential demand for accessible pedestrian signals;*
- *B. A request for accessible pedestrian signals;*
- *C. Traffic volumes during times when pedestrians might be present, including periods of low traffic volumes or high turn-on-red volumes;*
- *D. The complexity of traffic signal phasing (such as split phases, protected turn phases, leading pedestrian intervals, and exclusive pedestrian phases); and*
- *E. The complexity of intersection geometry.*

Support:

04 The factors that make crossing at a signalized location difficult for pedestrians who have visual disabilities include: increasingly quiet cars, right turn on red (which masks the beginning of the through phase), continuous right-turn movements, complex signal operations, traffic circles, and wide streets. Furthermore, low traffic volumes might make it difficult for pedestrians who have visual disabilities to discern signal phase changes.

05 Local organizations, providing support services to pedestrians who have visual and/or hearing disabilities, can often act as important advisors to the traffic engineer when consideration is being given to the installation of devices to assist such pedestrians. Additionally, orientation and mobility specialists or similar staff also might be able to provide a wide range of advice. The U.S. Access Board (www.access-board.gov) provides technical assistance for making pedestrian signal information available to persons with visual disabilities (see Page i for the address for the U.S. Access Board).

Standard:

06 **When used, accessible pedestrian signals shall be used in combination with pedestrian signal timing. The information provided by an accessible pedestrian signal shall clearly indicate which pedestrian crossing is served by each device.**

07 **Under stop-and-go operation, accessible pedestrian signals shall not be limited in operation by the time of day or day of week.**

Option:

08 Accessible pedestrian signal detectors may be pushbuttons or passive detection devices.

09 At locations with pretimed traffic control signals or non-actuated approaches, pedestrian pushbuttons may be used to activate the accessible pedestrian signals.

Support:

10 Accessible pedestrian signals are typically integrated into the pedestrian detector (pushbutton), so the audible tones and/or messages come from the pushbutton housing. They have a pushbutton locator tone and tactile arrow, and can include audible beaconing and other special features.

Option:

11 The name of the street to be crossed may also be provided in accessible format, such as Braille or raised print. Tactile maps of crosswalks may also be provided.

Support:

12 Specifications regarding the use of Braille or raised print for traffic control devices can be found in the “Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG)” (see Section 1A.11).

Standard:

13 **At accessible pedestrian signal locations where pedestrian pushbuttons are used, each pushbutton shall activate both the walk interval and the accessible pedestrian signals.**

Section 4E.10 Accessible Pedestrian Signals and Detectors – Location

Support:

01 Accessible pedestrian signals that are located as close as possible to pedestrians waiting to cross the street provide the clearest and least ambiguous indication of which pedestrian crossing is served by a device.

Guidance:

02 *Pushbuttons for accessible pedestrian signals should be located in accordance with the provisions of Section 4E.08 and should be located as close as possible to the crosswalk line furthest from the center of the intersection and as close as possible to the curb ramp.*

Standard:

03 **If two accessible pedestrian pushbuttons are placed less than 10 feet apart or on the same pole, each accessible pedestrian pushbutton shall be provided with the following features (see Sections 4E.11 through 4E.13):**

A. A pushbutton locator tone,
B. A tactile arrow,
C. A speech walk message for the WALKING PERSON (symbolizing WALK) indication, and
D. A speech pushbutton information message.

04 **If the pedestrian clearance time is sufficient only to cross from the curb or shoulder to a median of sufficient width for pedestrians to wait and accessible pedestrian detectors are used, an additional accessible pedestrian detector shall be provided in the median.**

Section 4E.11 Accessible Pedestrian Signals and Detectors – Walk Indications

Support:

01 Technology that provides different sounds for each non-concurrent signal phase has frequently been found to provide ambiguous information. Research indicates that a rapid tick tone for each crossing coming from accessible pedestrian signal devices on separated poles located close to each crosswalk provides unambiguous information to pedestrians who are blind or visually impaired. Vibrotactile indications provide information to pedestrians who are blind and deaf and are also used by pedestrians who are blind or who have low vision to confirm the walk signal in noisy situations.

Standard:

02 **Accessible pedestrian signals shall have both audible and vibrotactile walk indications.**

03 **Vibrotactile walk indications shall be provided by a tactile arrow on the pushbutton (see Section 4E.12) that vibrates during the walk interval.**

04 **Accessible pedestrian signals shall have an audible walk indication during the walk interval only. The audible walk indication shall be audible from the beginning of the associated crosswalk.**

05 **The accessible walk indication shall have the same duration as the pedestrian walk signal except when the pedestrian signal rests in walk.**

Guidance:

06 *If the pedestrian signal rests in walk, the accessible walk indication should be limited to the first 7 seconds of the walk interval. The accessible walk indication should be recalled by a button press during the walk interval provided that the crossing time remaining is greater than the pedestrian change interval.*

Standard:

07 **Where two accessible pedestrian signals are separated by a distance of at least 10 feet, the audible walk indication shall be a percussive tone. Where two accessible pedestrian signals on one corner are not separated by a distance of at least 10 feet, the audible walk indication shall be a speech walk message.**

08 **Audible tone walk indications shall repeat at eight to ten ticks per second. Audible tones used as walk indications shall consist of multiple frequencies with a dominant component at 880 Hz.**

Guidance:

09 *The volume of audible walk indications and pushbutton locator tones (see Section 4E.12) should be set to be a maximum of 5 dBA louder than ambient sound, except when audible beaconing is provided in response to an extended pushbutton press.*

Standard:

10 **Automatic volume adjustment in response to ambient traffic sound level shall be provided up to a maximum volume of 100 dBA.**

Guidance:

11 *The sound level of audible walk indications and pushbutton locator tones should be adjusted to be low enough to avoid misleading pedestrians who have visual disabilities when the following conditions exist:*

A. *Where there is an island that allows unsignalized right turns across a crosswalk between the island and the sidewalk.*
B. *Where multi-leg approaches or complex signal phasing require more than two pedestrian phases, such that it might be unclear which crosswalk is served by each audible tone.*
C. *At intersections where a diagonal pedestrian crossing is allowed, or where one street receives a WALKING PERSON (symbolizing WALK) signal indication simultaneously with another street.*

Option:

12 An alert tone, which is a very brief burst of high-frequency sound at the beginning of the audible walk indication that rapidly decays to the frequency of the walk tone, may be used to alert pedestrians to the beginning of the walk interval.

Support:

13 An alert tone can be particularly useful if the walk tone is not easily audible in some traffic conditions.

14 Speech walk messages communicate to pedestrians which street has the walk interval. Speech messages might be either directly audible or transmitted, requiring a personal receiver to hear the message. To be a useful system, the words and their meaning need to be correctly understood by all users in the context of the street environment where they are used. Because of this, tones are the preferred means of providing audible walk indications except where two accessible pedestrian signals on one corner are not separated by a distance of at least 10 feet.

15 If speech walk messages are used, pedestrians have to know the names of the streets that they are crossing in order for the speech walk messages to be unambiguous. In getting directions to travel to a new location, pedestrians with visual disabilities do not always get the name of each street to be crossed. Therefore, it is desirable to give users of accessible pedestrian signals the name of the street controlled by the pushbutton. This can be done by means of a speech pushbutton information message (see Section 4D.13) during the flashing or steady UPRAISED HAND intervals, or by raised print and Braille labels on the pushbutton housing.

16 By combining the information from the pushbutton message or Braille label, the tactile arrow aligned in the direction of travel on the relevant crosswalk, and the speech walk message, pedestrians with visual disabilities are able to correctly respond to speech walk messages even if there are two pushbuttons on the same pole.

Standard:

17 **If speech walk messages are used to communicate the walk interval, they shall provide a clear message that the walk interval is in effect, as well as to which crossing it applies. Speech walk messages shall be used only at intersections where it is technically infeasible to install two accessible pedestrian signals at one corner separated by a distance of at least 10 feet.**

18 **Speech walk messages that are used at intersections having pedestrian phasing that is concurrent with vehicular phasing shall be patterned after the model: "Broadway. Walk sign is on to cross Broadway."**

19 **Speech walk messages that are used at intersections having exclusive pedestrian phasing shall be patterned after the model: "Walk sign is on for all crossings."**

20 **Speech walk messages shall not contain any additional information, except they shall include designations such as "Street" or "Avenue" where this information is necessary to avoid ambiguity at a particular location.**

Guidance:

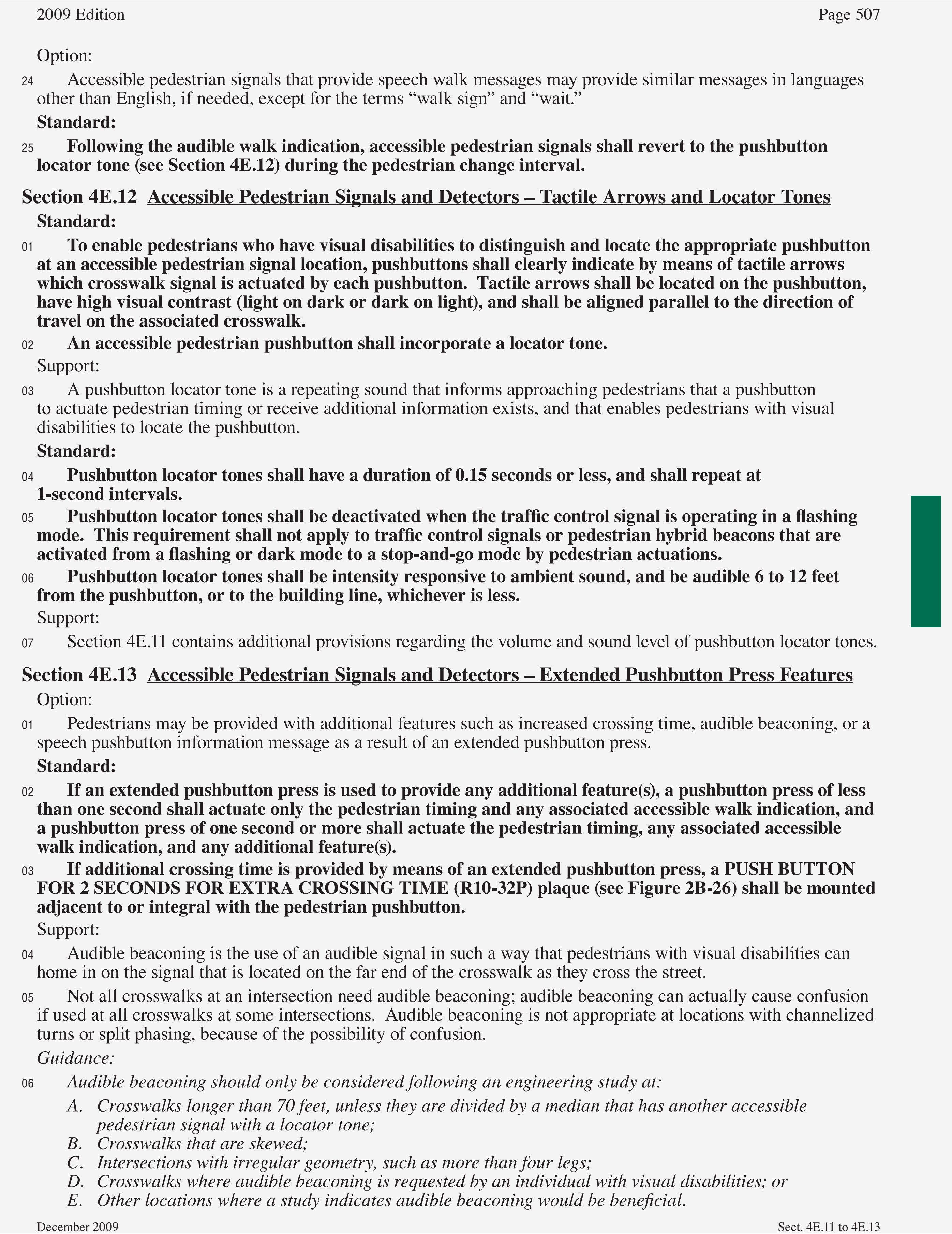
21 *Speech walk messages should not state or imply a command to the pedestrian, such as "Cross Broadway now." Speech walk messages should not tell pedestrians that it is "safe to cross," because it is always the pedestrian's responsibility to check actual traffic conditions.*

Standard:

22 **A speech walk message is not required at times when the walk interval is not timing, but, if provided:**

A. It shall begin with the term "wait."
B. It need not be repeated for the entire time that the walk interval is not timing.

23 **If a pilot light (see Section 4E.08) is used at an accessible pedestrian signal location, each actuation shall be accompanied by the speech message "wait."**



Option:

24 Accessible pedestrian signals that provide speech walk messages may provide similar messages in languages other than English, if needed, except for the terms "walk sign" and "wait."

Standard:

25 **Following the audible walk indication, accessible pedestrian signals shall revert to the pushbutton locator tone (see Section 4E.12) during the pedestrian change interval.**

Section 4E.12 Accessible Pedestrian Signals and Detectors – Tactile Arrows and Locator Tones

Standard:

01 **To enable pedestrians who have visual disabilities to distinguish and locate the appropriate pushbutton at an accessible pedestrian signal location, pushbuttons shall clearly indicate by means of tactile arrows which crosswalk signal is actuated by each pushbutton. Tactile arrows shall be located on the pushbutton, have high visual contrast (light on dark or dark on light), and shall be aligned parallel to the direction of travel on the associated crosswalk.**

02 **An accessible pedestrian pushbutton shall incorporate a locator tone.**

Support:

03 A pushbutton locator tone is a repeating sound that informs approaching pedestrians that a pushbutton to actuate pedestrian timing or receive additional information exists, and that enables pedestrians with visual disabilities to locate the pushbutton.

Standard:

04 **Pushbutton locator tones shall have a duration of 0.15 seconds or less, and shall repeat at 1-second intervals.**

05 **Pushbutton locator tones shall be deactivated when the traffic control signal is operating in a flashing mode. This requirement shall not apply to traffic control signals or pedestrian hybrid beacons that are activated from a flashing or dark mode to a stop-and-go mode by pedestrian actuations.**

06 **Pushbutton locator tones shall be intensity responsive to ambient sound, and be audible 6 to 12 feet from the pushbutton, or to the building line, whichever is less.**

Support:

07 Section 4E.11 contains additional provisions regarding the volume and sound level of pushbutton locator tones.

Section 4E.13 Accessible Pedestrian Signals and Detectors – Extended Pushbutton Press Features

Option:

01 Pedestrians may be provided with additional features such as increased crossing time, audible beaconing, or a speech pushbutton information message as a result of an extended pushbutton press.

Standard:

02 **If an extended pushbutton press is used to provide any additional feature(s), a pushbutton press of less than one second shall actuate only the pedestrian timing and any associated accessible walk indication, and a pushbutton press of one second or more shall actuate the pedestrian timing, any associated accessible walk indication, and any additional feature(s).**

03 **If additional crossing time is provided by means of an extended pushbutton press, a PUSH BUTTON FOR 2 SECONDS FOR EXTRA CROSSING TIME (R10-32P) plaque (see Figure 2B-26) shall be mounted adjacent to or integral with the pedestrian pushbutton.**

Support:

04 Audible beaconing is the use of an audible signal in such a way that pedestrians with visual disabilities can home in on the signal that is located on the far end of the crosswalk as they cross the street.

05 Not all crosswalks at an intersection need audible beaconing; audible beaconing can actually cause confusion if used at all crosswalks at some intersections. Audible beaconing is not appropriate at locations with channelized turns or split phasing, because of the possibility of confusion.

Guidance:

06 *Audible beaconing should only be considered following an engineering study at:*

- *A. Crosswalks longer than 70 feet, unless they are divided by a median that has another accessible pedestrian signal with a locator tone;*
- *B. Crosswalks that are skewed;*
- *C. Intersections with irregular geometry, such as more than four legs;*
- *D. Crosswalks where audible beaconing is requested by an individual with visual disabilities; or*
- *E. Other locations where a study indicates audible beaconing would be beneficial.*

Option:

07 Audible beaconing may be provided in several ways, any of which are initiated by an extended pushbutton press.

Standard:

08 **If audible beaconing is used, the volume of the pushbutton locator tone during the pedestrian change interval of the called pedestrian phase shall be increased and operated in one of the following ways:**

- **A. The louder audible walk indication and louder locator tone comes from the far end of the crosswalk, as pedestrians cross the street,**
- **B. The louder locator tone comes from both ends of the crosswalk, or**
- **C. The louder locator tone comes from an additional speaker that is aimed at the center of the crosswalk and that is mounted on a pedestrian signal head.**

Option:

09 Speech pushbutton information messages may provide intersection identification, as well as information about unusual intersection signalization and geometry, such as notification regarding exclusive pedestrian phasing, leading pedestrian intervals, split phasing, diagonal crosswalks, and medians or islands.

Standard:

10 **If speech pushbutton information messages are made available by actuating the accessible pedestrian signal detector, they shall only be actuated when the walk interval is not timing. They shall begin with the term "Wait," followed by intersection identification information modeled after: "Wait to cross Broadway at Grand." If information on intersection signalization or geometry is also given, it shall follow the intersection identification information.**

Guidance:

11 *Speech pushbutton information messages should not be used to provide landmark information or to inform pedestrians with visual disabilities about detours or temporary traffic control situations.*

Support:

12 Additional information on the structure and wording of speech pushbutton information messages is included in ITE's "Electronic Toolbox for Making Intersections More Accessible for Pedestrians Who Are Blind or Visually Impaired," which is available at ITE's website (see Page i).

CHAPTER 4F. PEDESTRIAN HYBRID BEACONS

Section 4F.01 Application of Pedestrian Hybrid Beacons

Support:

01 A pedestrian hybrid beacon is a special type of hybrid beacon used to warn and control traffic at an unsignalized location to assist pedestrians in crossing a street or highway at a marked crosswalk.

Option:

02 A pedestrian hybrid beacon may be considered for installation to facilitate pedestrian crossings at a location that does not meet traffic signal warrants (see Chapter 4C), or at a location that meets traffic signal warrants under Sections 4C.05 and/or 4C.06 but a decision is made to not install a traffic control signal.

Standard:

03 **If used, pedestrian hybrid beacons shall be used in conjunction with signs and pavement markings to warn and control traffic at locations where pedestrians enter or cross a street or highway. A pedestrian hybrid beacon shall only be installed at a marked crosswalk.**

Guidance:

04 *If one of the signal warrants of Chapter 4C is met and a traffic control signal is justified by an engineering study, and if a decision is made to install a traffic control signal, it should be installed based upon the provisions of Chapters 4D and 4E.*

05 *If a traffic control signal is not justified under the signal warrants of Chapter 4C and if gaps in traffic are not adequate to permit pedestrians to cross, or if the speed for vehicles approaching on the major street is too high to permit pedestrians to cross, or if pedestrian delay is excessive, the need for a pedestrian hybrid beacon should be considered on the basis of an engineering study that considers major-street volumes, speeds, widths, and gaps in conjunction with pedestrian volumes, walking speeds, and delay.*

06 *For a major street where the posted or statutory speed limit or the 85th-percentile speed is 35 mph or less, the need for a pedestrian hybrid beacon should be considered if the engineering study finds that the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding total of all pedestrians crossing the major street for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4F-1 for the length of the crosswalk.*

07 *For a major street where the posted or statutory speed limit or the 85th-percentile speed exceeds 35 mph, the need for a pedestrian hybrid beacon should be considered if the engineering study finds that the plotted point representing the vehicles per hour on the major street (total of both approaches) and the corresponding total of all pedestrians crossing the major street for 1 hour (any four consecutive 15-minute periods) of an average day falls above the applicable curve in Figure 4F-2 for the length of the crosswalk.*

08 *For crosswalks that have lengths other than the four that are specifically shown in Figures 4F-1 and 4F-2, the values should be interpolated between the curves.*

Section 4F.02 Design of Pedestrian Hybrid Beacons

Standard:

01 **Except as otherwise provided in this Section, a pedestrian hybrid beacon shall meet the provisions of Chapters 4D and 4E.**

02 **A pedestrian hybrid beacon face shall consist of three signal sections, with a CIRCULAR YELLOW signal indication centered below two horizontally aligned CIRCULAR RED signal indications (see Figure 4F-3).**

03 **When an engineering study finds that installation of a pedestrian hybrid beacon is justified, then:**

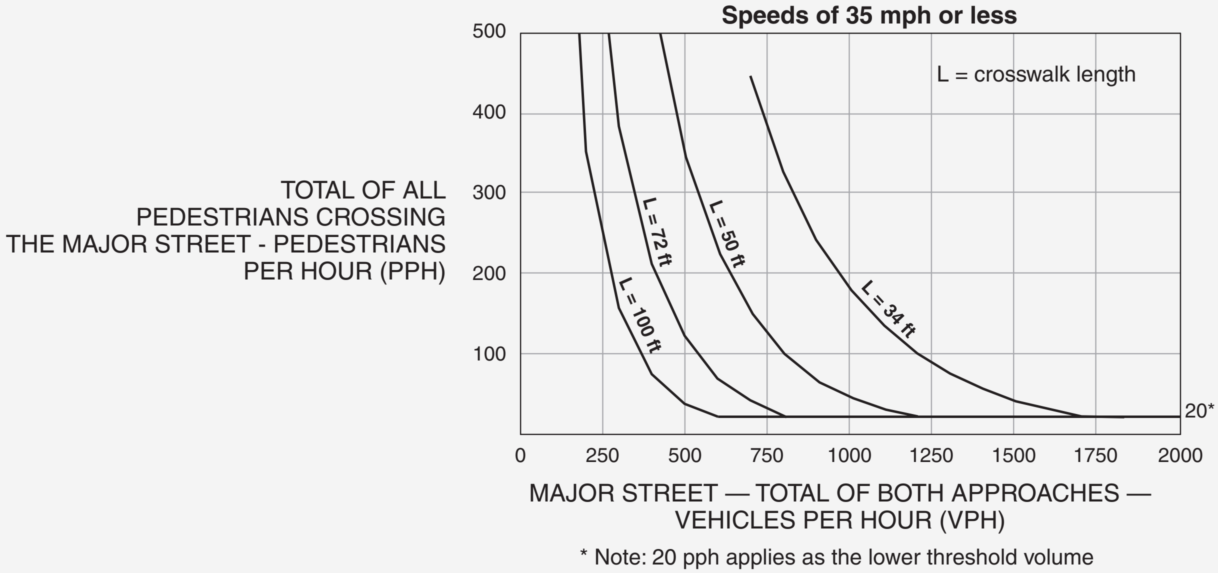
- **A. At least two pedestrian hybrid beacon faces shall be installed for each approach of the major street,**
- **B. A stop line shall be installed for each approach to the crosswalk,**
- **C. A pedestrian signal head conforming to the provisions set forth in Chapter 4E shall be installed at each end of the marked crosswalk, and**
- **D. The pedestrian hybrid beacon shall be pedestrian actuated.**

Guidance:

04 *When an engineering study finds that installation of a pedestrian hybrid beacon is justified, then:*

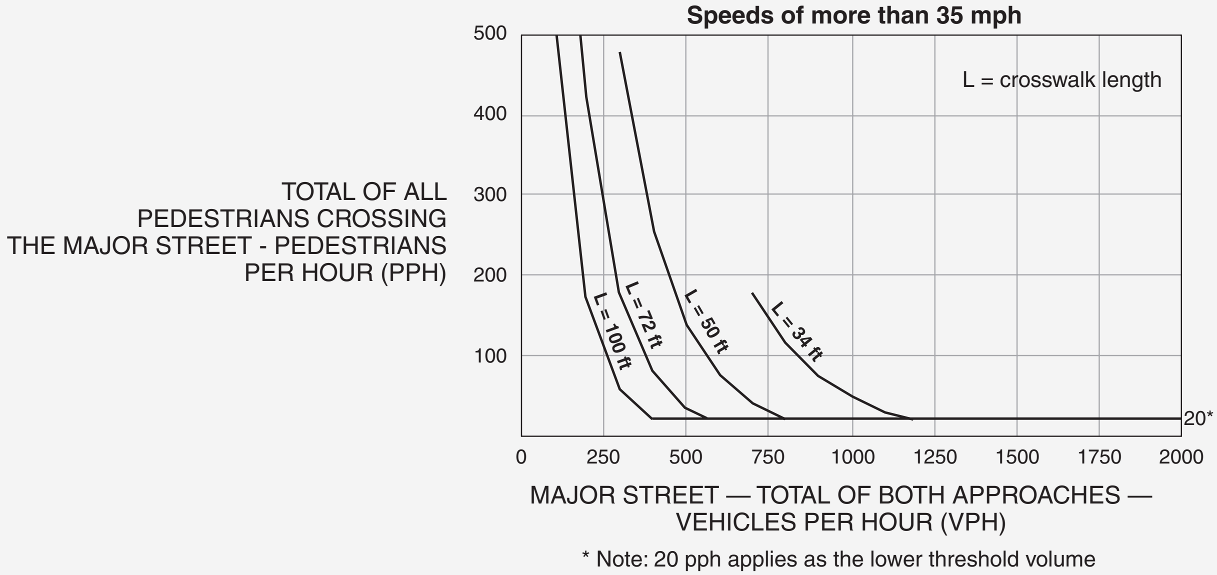
- *A. The pedestrian hybrid beacon should be installed at least 100 feet from side streets or driveways that are controlled by STOP or YIELD signs,*

Figure 4F-1. Guidelines for the Installation of Pedestrian Hybrid Beacons on Low-Speed Roadways



* Note: 20 pph applies as the lower threshold volume

Figure 4F-2. Guidelines for the Installation of Pedestrian Hybrid Beacons on High-Speed Roadways



* Note: 20 pph applies as the lower threshold volume

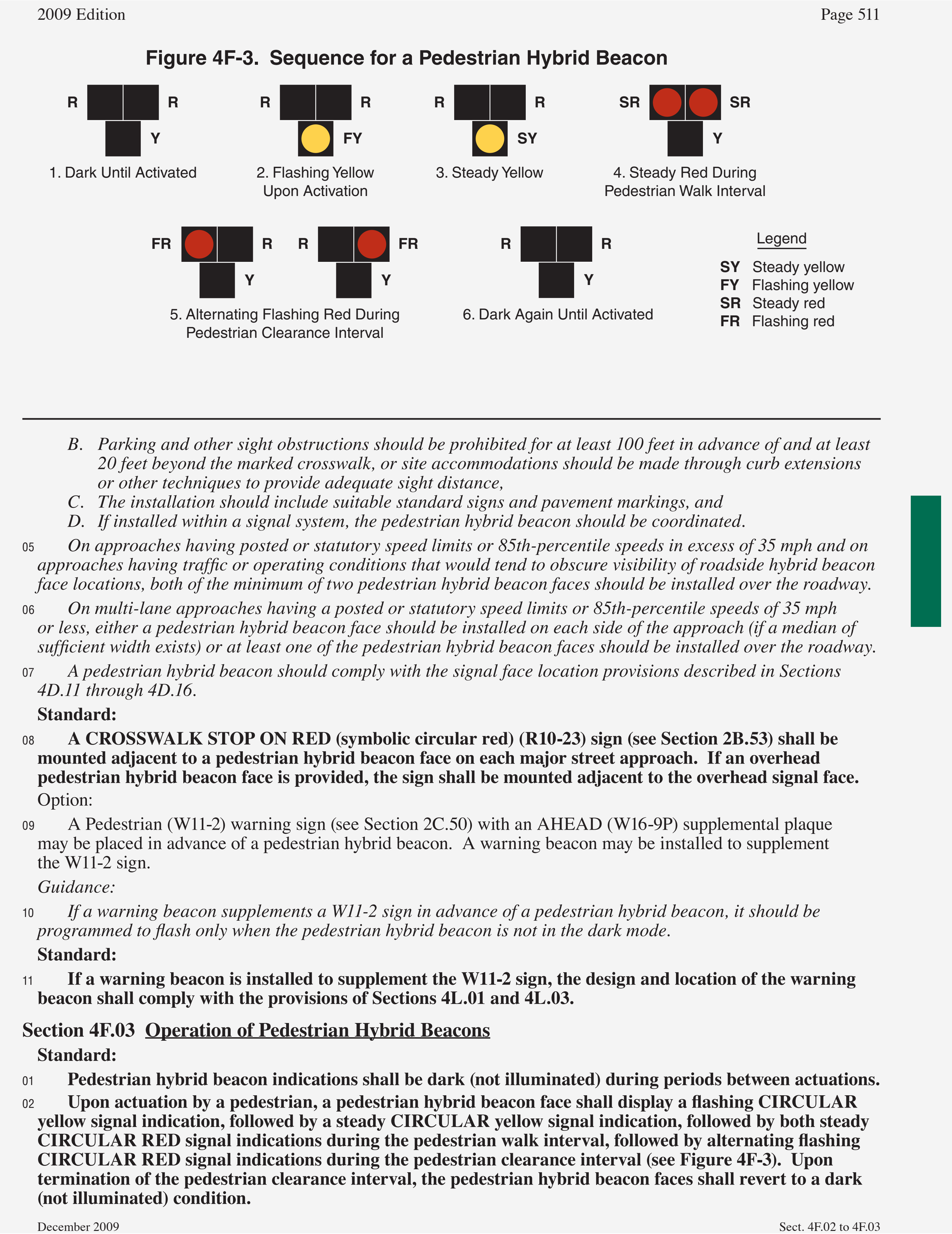


Figure 4F-3. Sequence for a Pedestrian Hybrid Beacon

1. Dark Until Activated

2. Flashing Yellow Upon Activation

3. Steady Yellow

4. Steady Red During Pedestrian Walk Interval

5. Alternating Flashing Red During Pedestrian Clearance Interval

6. Dark Again Until Activated

Legend

SY	Steady yellow
FY	Flashing yellow
SR	Steady red
FR	Flashing red

B. Parking and other sight obstructions should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the marked crosswalk, or site accommodations should be made through curb extensions or other techniques to provide adequate sight distance,

C. The installation should include suitable standard signs and pavement markings, and

D. If installed within a signal system, the pedestrian hybrid beacon should be coordinated.

05 *On approaches having posted or statutory speed limits or 85th-percentile speeds in excess of 35 mph and on approaches having traffic or operating conditions that would tend to obscure visibility of roadside hybrid beacon face locations, both of the minimum of two pedestrian hybrid beacon faces should be installed over the roadway.*

06 *On multi-lane approaches having a posted or statutory speed limits or 85th-percentile speeds of 35 mph or less, either a pedestrian hybrid beacon face should be installed on each side of the approach (if a median of sufficient width exists) or at least one of the pedestrian hybrid beacon faces should be installed over the roadway.*

07 *A pedestrian hybrid beacon should comply with the signal face location provisions described in Sections 4D.11 through 4D.16.*

Standard:

08 **A CROSSWALK STOP ON RED (symbolic circular red) (R10-23) sign (see Section 2B.53) shall be mounted adjacent to a pedestrian hybrid beacon face on each major street approach. If an overhead pedestrian hybrid beacon face is provided, the sign shall be mounted adjacent to the overhead signal face.**

Option:

09 A Pedestrian (W11-2) warning sign (see Section 2C.50) with an AHEAD (W16-9P) supplemental plaque may be placed in advance of a pedestrian hybrid beacon. A warning beacon may be installed to supplement the W11-2 sign.

Guidance:

10 *If a warning beacon supplements a W11-2 sign in advance of a pedestrian hybrid beacon, it should be programmed to flash only when the pedestrian hybrid beacon is not in the dark mode.*

Standard:

11 **If a warning beacon is installed to supplement the W11-2 sign, the design and location of the warning beacon shall comply with the provisions of Sections 4L.01 and 4L.03.**

Section 4F.03 Operation of Pedestrian Hybrid Beacons

Standard:

01 **Pedestrian hybrid beacon indications shall be dark (not illuminated) during periods between actuations.**

02 **Upon actuation by a pedestrian, a pedestrian hybrid beacon face shall display a flashing CIRCULAR yellow signal indication, followed by a steady CIRCULAR yellow signal indication, followed by both steady CIRCULAR RED signal indications during the pedestrian walk interval, followed by alternating flashing CIRCULAR RED signal indications during the pedestrian clearance interval (see Figure 4F-3). Upon termination of the pedestrian clearance interval, the pedestrian hybrid beacon faces shall revert to a dark (not illuminated) condition.**

03 **Except as provided in Paragraph 4, the pedestrian signal heads shall continue to display a steady UPRAISED HAND (symbolizing DONT WALK) signal indication when the pedestrian hybrid beacon faces are either dark or displaying flashing or steady CIRCULAR yellow signal indications. The pedestrian signal heads shall display a WALKING PERSON (symbolizing WALK) signal indication when the pedestrian hybrid beacon faces are displaying steady CIRCULAR RED signal indications. The pedestrian signal heads shall display a flashing UPRAISED HAND (symbolizing DONT WALK) signal indication when the pedestrian hybrid beacon faces are displaying alternating flashing CIRCULAR RED signal indications. Upon termination of the pedestrian clearance interval, the pedestrian signal heads shall revert to a steady UPRAISED HAND (symbolizing DONT WALK) signal indication.**

Option:

04 Where the pedestrian hybrid beacon is installed adjacent to a roundabout to facilitate crossings by pedestrians with visual disabilities and an engineering study determines that pedestrians without visual disabilities can be allowed to cross the roadway without actuating the pedestrian hybrid beacon, the pedestrian signal heads may be dark (not illuminated) when the pedestrian hybrid beacon faces are dark.

Guidance:

05 *The duration of the flashing yellow interval should be determined by engineering judgment.*

Standard:

06 **The duration of the steady yellow change interval shall be determined using engineering practices.**

Guidance:

07 *The steady yellow interval should have a minimum duration of 3 seconds and a maximum duration of 6 seconds (see Section 4D.26). The longer intervals should be reserved for use on approaches with higher speeds.*

Appendix C. TOTAL PEDESTRIAN DELAY CHARTS

This appendix provides a series of 15 quick-reference charts to assist evaluators in quickly estimating Total Pedestrian Delay. These charts were prepared by utilizing two worksheets from *NCHRP Report 562* to calculate Total Pedestrian Delay curves. The worksheets and list of variables and inputs that go into them also are provided at the end of this appendix for situations in which an evaluator needs to calculate Total Pedestrian Delay rather than rely on one of the quick-reference charts.

The quick-reference charts were developed using default assumptions and inputs for variables in the worksheets. Charts are provided for two speed categories (less than or equal to 35 mph, or greater than 35 mph) and for locations where the area population is less than 10,000. Within each of these three scenarios, one chart is provided for five different crossing distance assumptions: 12 ft., 24 ft., 36 ft., 48 ft., or 60 ft. Default values of 3.5 ft/sec for pedestrian walking speed and 3 sec for the pedestrian start-up and end clearance times were used.

Pedestrian Delay Charts

Use appropriate graph to estimated pedestrian delay based on the following inputs:

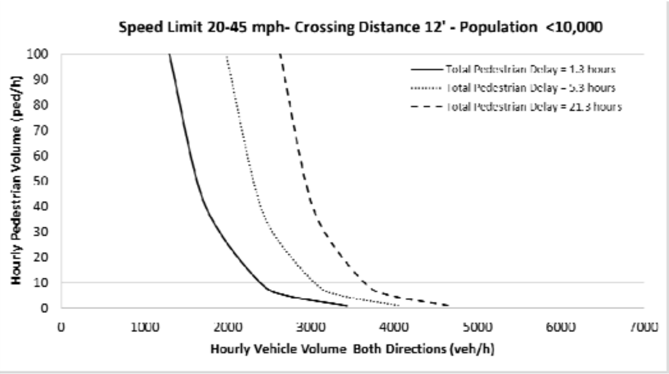
- Crossing Distance – distance pedestrian would cross to reach a median refuge island or the edge of pavement on far side,
- Speed – posted or 85th percentile operating speed of major road
- Pedestrian Volume – number of pedestrians crossing the major road in a peak hour, including crossings within 150 feet of the location
- Vehicle Volume – number of vehicles, including bicycles, on both approaches of the major road in a peak hour. If median refuge island present, treat volume for each approach separately

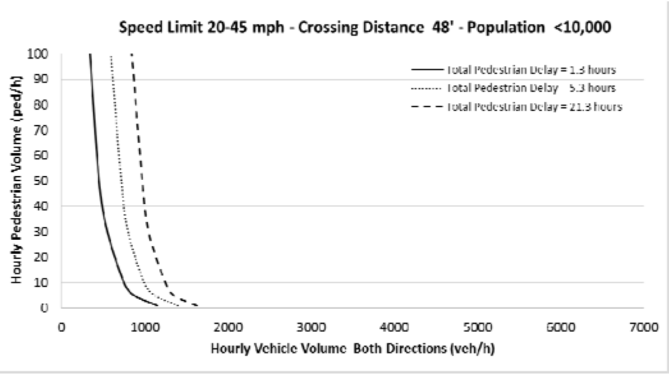
Based on where the point falls on the graph used, use table below to identify a treatment type or next step.

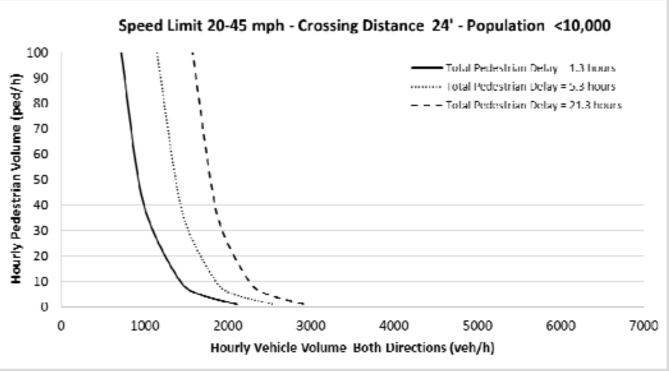
Treatment Selection Guidance

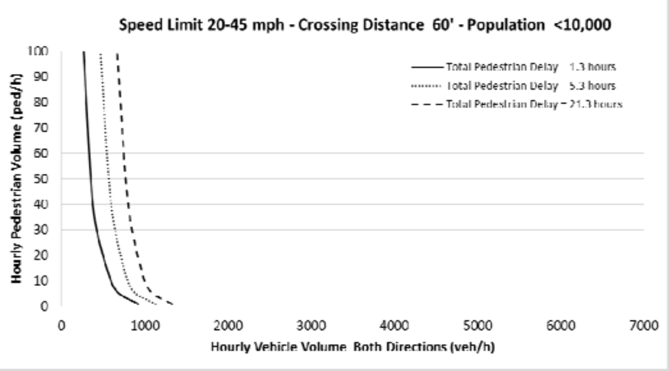
Speed Limit	Motorist Compliance	Pedestrian Delay			
		Low (< 1.3 ped-hr)	Medium-Low (≥ 1.3 ped-hr to < 5.3 ped-hr)	Medium-High (≥ 5.3 ped-hr to < 21.3 ped-hr)	High (≥ 21.3 ped-hr)
≤ 35 MPH	Low	Consider Marking Crosswalk	Consider Supplemental Treatments	Move to Step 4: PHB Assessment	Move to Step 4: PHB Assessment
	High	Consider Marking Crosswalk	Consider Supplemental Treatments	Consider Supplemental Treatments	Move to Step 4: PHB Assessment
> 35 MPH	Low	Consider Supplemental Treatments	Consider Supplemental Treatments	Move to Step 4: PHB Assessment	Move to Step 4: PHB Assessment
	High	Consider Supplemental Treatments	Consider Supplemental Treatments	Consider Supplemental Treatments	Move to Step 4: PHB Assessment

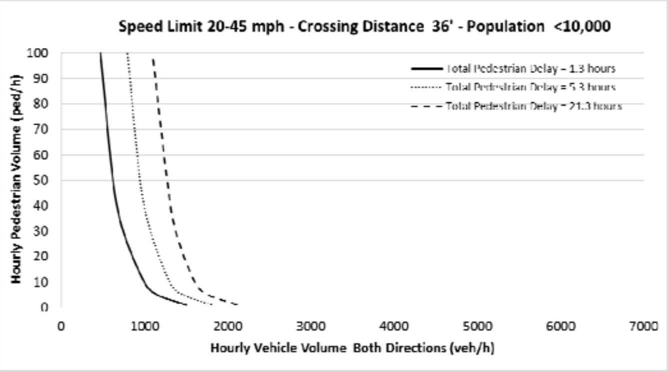
Last Updated April 14, 2015

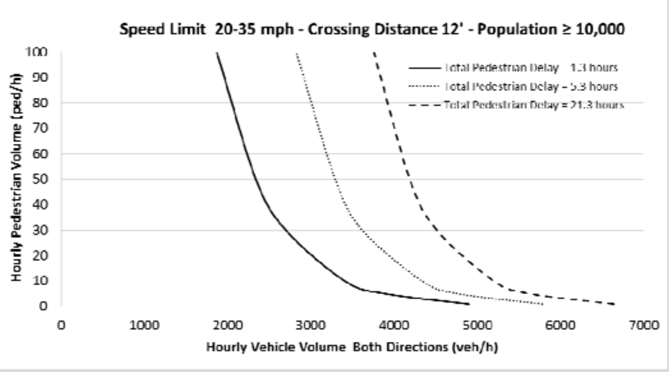


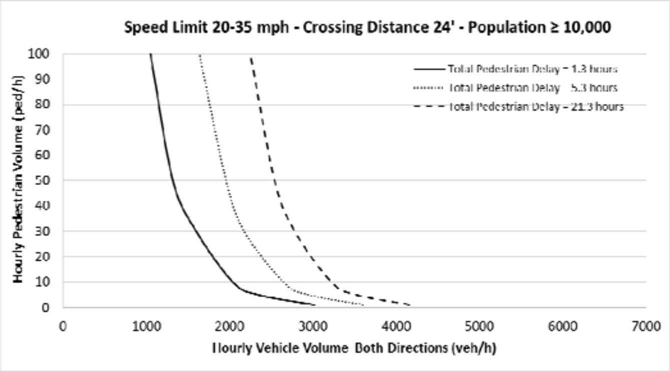




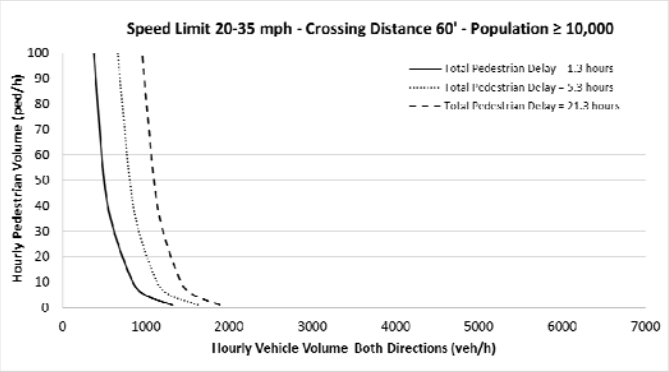




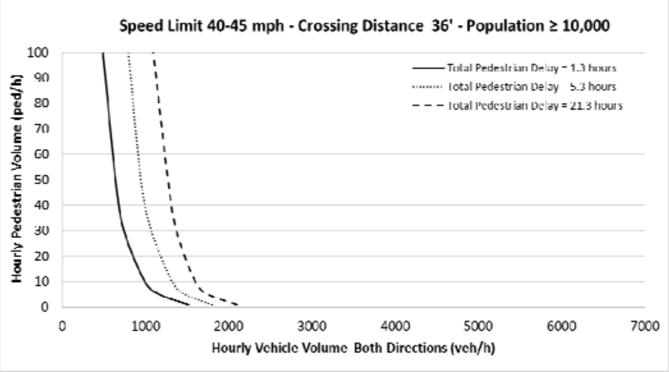




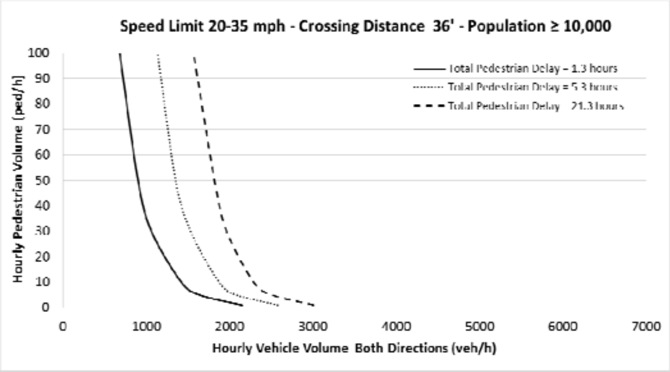
Speed Limit 20-35 mph - Crossing Distance 24' - Population ≥ 10,000



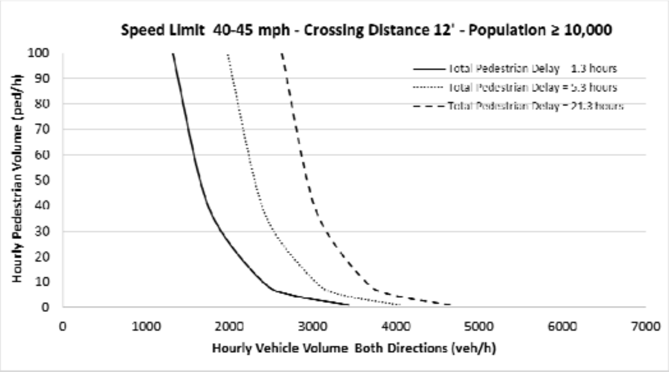
Speed Limit 20-35 mph - Crossing Distance 60' - Population ≥ 10,000



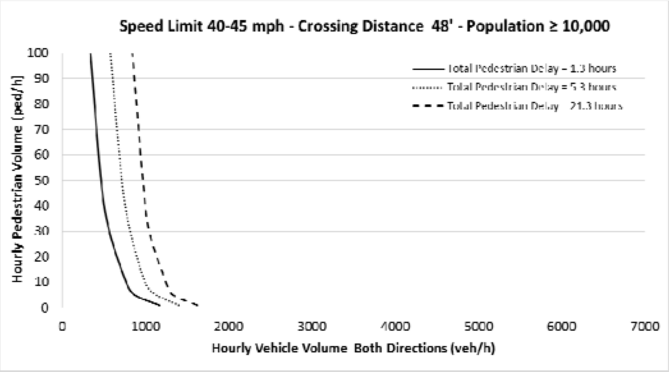
Speed Limit 40-45 mph - Crossing Distance 36' - Population ≥ 10,000



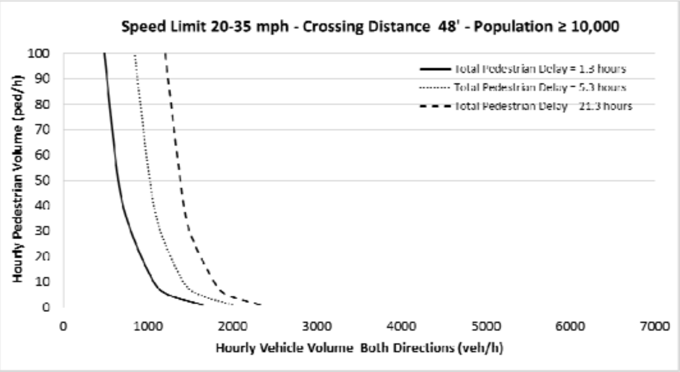
Speed Limit 20-35 mph - Crossing Distance 36' - Population ≥ 10,000



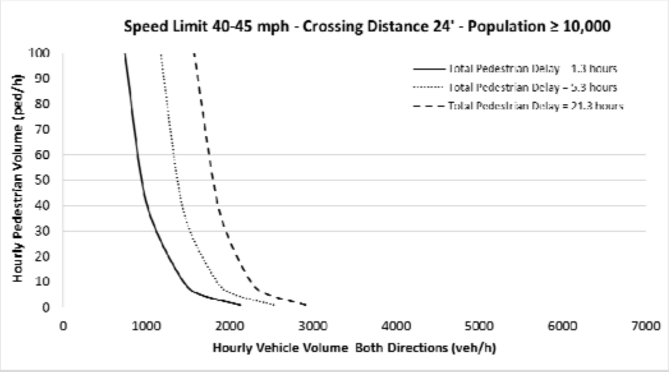
Speed Limit 40-45 mph - Crossing Distance 12' - Population ≥ 10,000



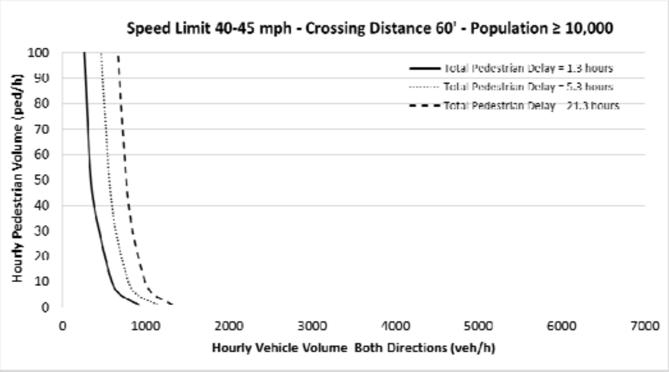
Speed Limit 40-45 mph - Crossing Distance 48' - Population ≥ 10,000



Speed Limit 20-35 mph - Crossing Distance 48' - Population ≥ 10,000

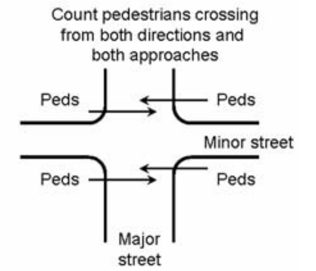


Speed Limit 40-45 mph - Crossing Distance 24' - Population ≥ 10,000



Speed Limit 40-45 mph - Crossing Distance 60' - Population ≥ 10,000

Table A-1. Input Variables for Guidelines for Pedestrian Crossing Treatment.

INPUT VARIABLES	TERM	DISCUSSION
ROAD CHARACTERISTICS		
Speed on the major street (mph)	S_{maj}	Use the major road posted or statutory speed limit for the facilities or, if available, the 85th percentile speed to determine which worksheet is applicable. Worksheet 1 is used when the speed is 35 mph (55 km/h) or less, while Worksheet 2 is used when the speed exceeds 35 mph (55 km/h).
Pedestrian **crossing distance** (ft)	L	Pedestrian crossing distance represents the distance that a pedestrian would need to cross before reaching either the far curb or a median refuge island. The distance would be between the near and far curbs if a painted or raised median refuge island is not present, or to the median refuge island if the island is present. Note if a parking stall is present, its width should be included in the crossing distance measurement. Crossing distance rather than number of lanes was selected for the procedure so that the extra time needed by a pedestrian to cross bike lanes, two-way left-turn lanes, wide lanes, etc. could be considered.
COUNTS		
Peak-hour **pedestrian volume** crossing major roadway (ped/h)	V_p	Pedestrian volume is the number of pedestrians crossing the major roadway in a peak hour. The count includes all pedestrian crossings of the major roadway at the location. 
Major road peak hour **vehicle volume** (veh/h)	$V_{maj\text{-}s}$ $V_{maj\text{-}d}$	Vehicle volume represents the number of vehicles and bicycles on both approaches of the major road during a peak hour. If a painted or raised median refuge island is present of sufficient size to store pedestrians (minimum of 6 ft [1.8 m] wide), then consider the volume on each approach individually. In the signal warrant calculations, use the volume on both approaches ($V_{maj\text{-}s}$). For the delay calculations, the volume ($V_{maj\text{-}d}$) would reflect either both approaches if a refuge island is not present or each approach individually if a refuge island is present.
LOCAL PARAMETERS		
Motorist **compliance** for region (high or low)	Comp	Compliance reflects the typical behavior of motorists for the site. If motorists tend to stop for a pedestrian attempting to cross at an uncontrolled location, then compliance is "high." If motorists rarely stop for a crossing pedestrian, then compliance is "low."
Pedestrian **walking speed** (ft/s)	S_p	Walking speed represents the speed of the crossing pedestrians. Recent research has suggested walking speeds of 3.5 ft/s (1.1 m/s) for the general population and 3.0 ft/s (0.9 m/s) for the older population. If calculating for a site, determine the 15th percentile value of those using the crossing.
Pedestrian **start-up** time and end clearance time (s)	t_s	Start-up time is used in the calculation of the critical gap. A value of 3 s is suggested in the *Highway Capacity Manual*.

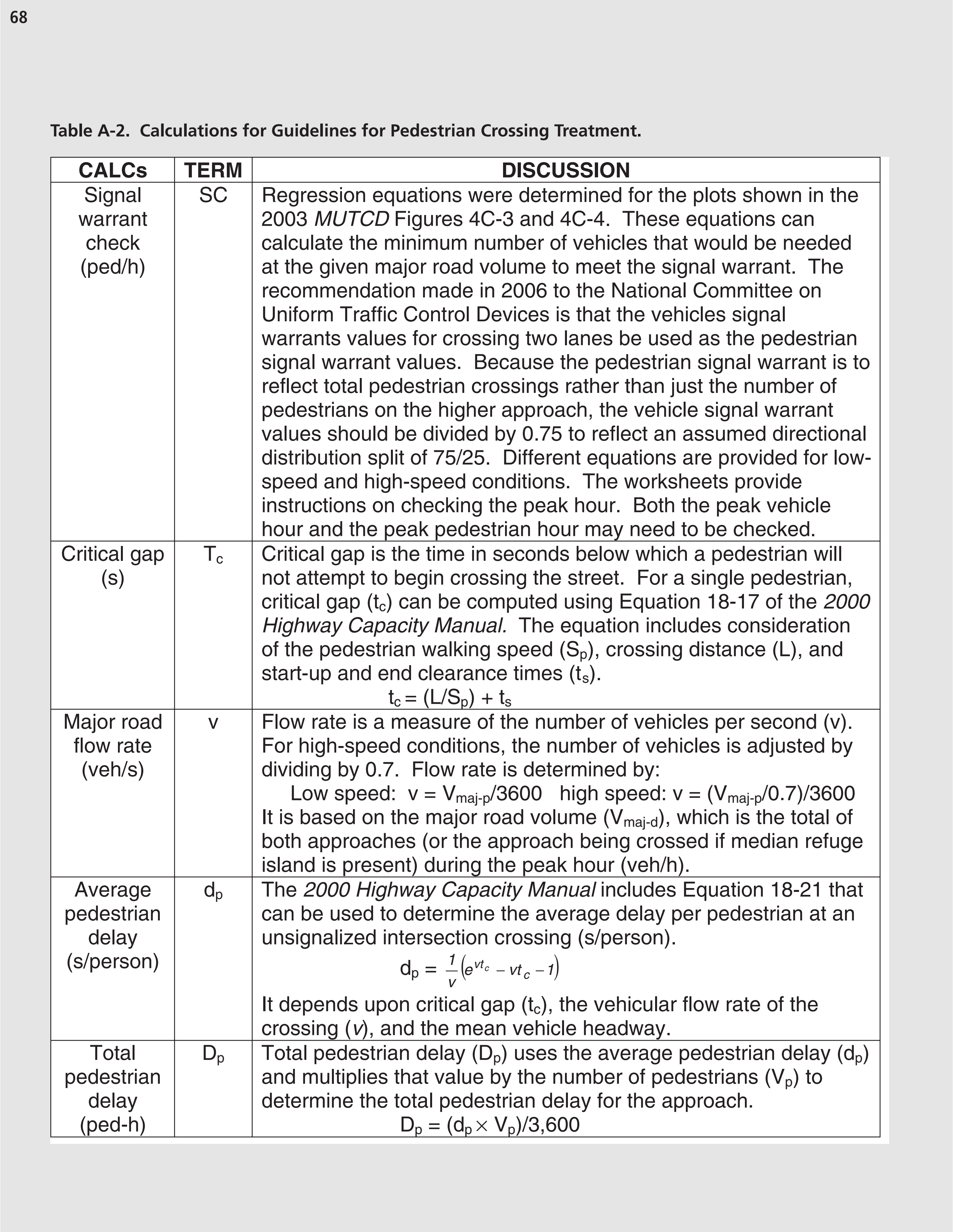
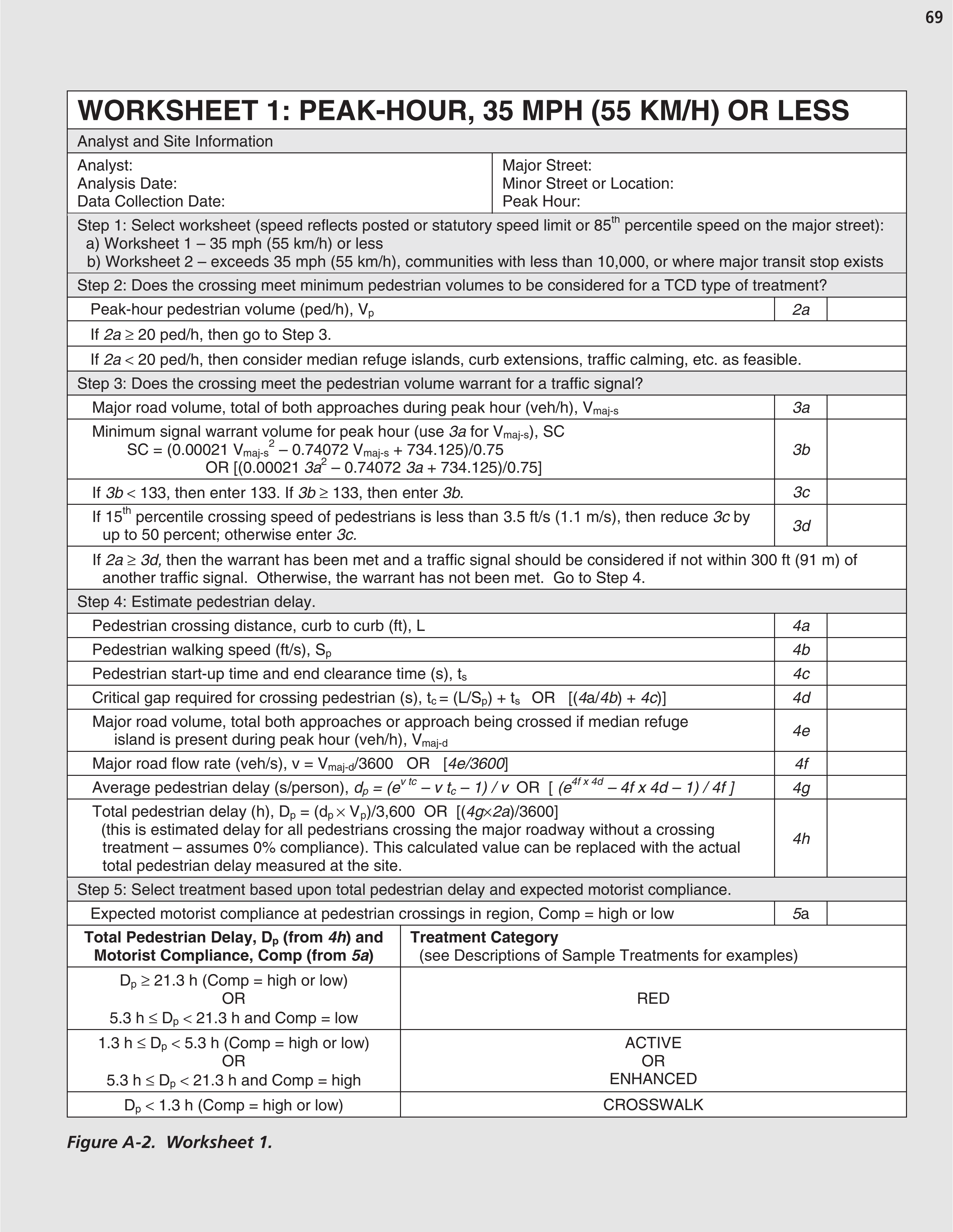


Table A-2. Calculations for Guidelines for Pedestrian Crossing Treatment.

CALCs	TERM	DISCUSSION
Signal warrant check (ped/h)	SC	Regression equations were determined for the plots shown in the 2003 *MUTCD* Figures 4C-3 and 4C-4. These equations can calculate the minimum number of vehicles that would be needed at the given major road volume to meet the signal warrant. The recommendation made in 2006 to the National Committee on Uniform Traffic Control Devices is that the vehicles signal warrants values for crossing two lanes be used as the pedestrian signal warrant values. Because the pedestrian signal warrant is to reflect total pedestrian crossings rather than just the number of pedestrians on the higher approach, the vehicle signal warrant values should be divided by 0.75 to reflect an assumed directional distribution split of 75/25. Different equations are provided for low-speed and high-speed conditions. The worksheets provide instructions on checking the peak hour. Both the peak vehicle hour and the peak pedestrian hour may need to be checked.
Critical gap (s)	T_c	Critical gap is the time in seconds below which a pedestrian will not attempt to begin crossing the street. For a single pedestrian, critical gap (t_c) can be computed using Equation 18-17 of the *2000 Highway Capacity Manual.* The equation includes consideration of the pedestrian walking speed (S_p), crossing distance (L), and start-up and end clearance times (t_s). $t_c = (L/S_p) + t_s$
Major road flow rate (veh/s)	v	Flow rate is a measure of the number of vehicles per second (v). For high-speed conditions, the number of vehicles is adjusted by dividing by 0.7. Flow rate is determined by: Low speed: $v = V_{maj\text{-}p}/3600$ high speed: $v = (V_{maj\text{-}p}/0.7)/3600$ It is based on the major road volume ($V_{maj\text{-}d}$), which is the total of both approaches (or the approach being crossed if median refuge island is present) during the peak hour (veh/h).
Average pedestrian delay (s/person)	d_p	The *2000 Highway Capacity Manual* includes Equation 18-21 that can be used to determine the average delay per pedestrian at an unsignalized intersection crossing (s/person). $d_p = \frac{1}{v}\left(e^{vt_c} - vt_c - 1\right)$ It depends upon critical gap (t_c), the vehicular flow rate of the crossing (*v*), and the mean vehicle headway.
Total pedestrian delay (ped-h)	D_p	Total pedestrian delay (D_p) uses the average pedestrian delay (d_p) and multiplies that value by the number of pedestrians (V_p) to determine the total pedestrian delay for the approach. $D_p = (d_p \times V_p)/3{,}600$



WORKSHEET 1: PEAK-HOUR, 35 MPH (55 KM/H) OR LESS

Analyst and Site Information

Analyst: Analysis Date: Data Collection Date:	Major Street: Minor Street or Location: Peak Hour:

Step 1: Select worksheet (speed reflects posted or statutory speed limit or 85th percentile speed on the major street):

a) Worksheet 1 – 35 mph (55 km/h) or less

b) Worksheet 2 – exceeds 35 mph (55 km/h), communities with less than 10,000, or where major transit stop exists

Step 2: Does the crossing meet minimum pedestrian volumes to be considered for a TCD type of treatment?		
Peak-hour pedestrian volume (ped/h), V_p	*2a*	
If *2a* ≥ 20 ped/h, then go to Step 3.		
If *2a* < 20 ped/h, then consider median refuge islands, curb extensions, traffic calming, etc. as feasible.		
Step 3: Does the crossing meet the pedestrian volume warrant for a traffic signal?		
Major road volume, total of both approaches during peak hour (veh/h), $V_{maj\text{-}s}$	*3a*	
Minimum signal warrant volume for peak hour (use *3a* for $V_{maj\text{-}s}$), SC SC = (0.00021 $V_{maj\text{-}s}^2$ – 0.74072 $V_{maj\text{-}s}$ + 734.125)/0.75 OR [(0.00021 $3a^2$ – 0.74072 *3a* + 734.125)/0.75]	*3b*	
If *3b* < 133, then enter 133. If *3b* ≥ 133, then enter *3b*.	*3c*	
If 15th percentile crossing speed of pedestrians is less than 3.5 ft/s (1.1 m/s), then reduce *3c* by up to 50 percent; otherwise enter *3c.*	*3d*	
If *2a* ≥ *3d,* then the warrant has been met and a traffic signal should be considered if not within 300 ft (91 m) of another traffic signal. Otherwise, the warrant has not been met. Go to Step 4.		
Step 4: Estimate pedestrian delay.		
Pedestrian crossing distance, curb to curb (ft), L	*4a*	
Pedestrian walking speed (ft/s), S_p	*4b*	
Pedestrian start-up time and end clearance time (s), t_s	*4c*	
Critical gap required for crossing pedestrian (s), $t_c = (L/S_p) + t_s$ OR [(*4a*/*4b*) + *4c*)]	*4d*	
Major road volume, total both approaches or approach being crossed if median refuge island is present during peak hour (veh/h), $V_{maj\text{-}d}$	*4e*	
Major road flow rate (veh/s), $v = V_{maj\text{-}d}/3600$ OR [*4e/3600*]	*4f*	
Average pedestrian delay (s/person), $d_p = (e^{v\,t_c} - v\,t_c - 1) / v$ OR $[\,(e^{4f \times 4d} - 4f \times 4d - 1) / 4f\,]$	*4g*	
Total pedestrian delay (h), $D_p = (d_p \times V_p)/3{,}600$ OR [(*4g*×*2a*)/3600] (this is estimated delay for all pedestrians crossing the major roadway without a crossing treatment – assumes 0% compliance). This calculated value can be replaced with the actual total pedestrian delay measured at the site.	*4h*	
Step 5: Select treatment based upon total pedestrian delay and expected motorist compliance.		
Expected motorist compliance at pedestrian crossings in region, Comp = high or low	*5*a	

Total Pedestrian Delay, D_p (from *4h*) and Motorist Compliance, Comp (from *5a*)	**Treatment Category** (see Descriptions of Sample Treatments for examples)
$D_p \geq 21.3$ h (Comp = high or low) OR 5.3 h ≤ D_p < 21.3 h and Comp = low	RED
1.3 h ≤ D_p < 5.3 h (Comp = high or low) OR 5.3 h ≤ D_p < 21.3 h and Comp = high	ACTIVE OR ENHANCED
D_p < 1.3 h (Comp = high or low)	CROSSWALK

Figure A-2. Worksheet 1.

WORKSHEET 2: PEAK-HOUR, EXCEEDS 35 MPH (55 KM/H)

Analyst and Site Information		
Analyst: Analysis Date: Data Collection Date:	Major Street: Minor Street or Location: Peak Hour:	
Step 1: Select worksheet (speed reflects posted or statutory speed limit or 85th percentile speed on the major street): a) Worksheet 1 – 35 mph (55 km/h) or less b) Worksheet 2 – exceeds 35 mph (55 km/h), communities with less than 10,000, or where major transit stop exists		
Step 2: Does the crossing meet minimum pedestrian volumes to be considered for a TCD type of treatment?		
Peak-hour pedestrian volume (ped/h), V_p	*2a*	
If *2a* ≥ 14 ped/h, then go to Step 3.		
If *2a* < 14 ped/h, then consider median refuge islands, curb extensions, traffic calming, etc. as feasible.		
Step 3: Does the crossing meet the pedestrian volume warrant for a traffic signal?		
Major road volume, total of both approaches during peak hour (veh/h), $V_{maj\text{-}s}$	*3a*	
Minimum signal warrant volume for peak hour (use 3*a* for $V_{maj\text{-}s}$), SC $SC = (0.00035\ V_{maj\text{-}s}^2 - 0.80083\ V_{maj\text{-}s} + 529.197)/0.75$ OR $[(0.00035\ 3a^2 - 0.80083\ 3a + 529.197)/0.75]$	*3b*	
If *3b* < 93, then enter 93. If *3b* ≥ 93, then enter *3b*.	*3c*	
If 15th percentile crossing speed of pedestrians is less than 3.5 ft/s (1.1 m/s), then reduce *3c* by up to 50 percent; otherwise enter *3c.*	3*d*	
If *2a* ≥ *3d,* then the warrant has been met and a traffic signal should be considered if not within 300 ft (91 m) of another traffic signal. Otherwise, the warrant has not been met. Go to Step 4.		
Step 4: Estimate pedestrian delay.		
Pedestrian crossing distance, curb to curb (ft), L	*4a*	
Pedestrian walking speed (ft/s), S_p	*4b*	
Pedestrian start-up time and end clearance time (s), t_s	*4c*	
Critical gap required for crossing pedestrian (s), $t_c = (L/S_p) + t_s$ OR $[(4a/4b) + 4c)]$	*4d*	
Major road volume, total both approaches or approach being crossed if median refuge island is present during peak hour (veh/h), $V_{maj\text{-}d}$	*4e*	
Major road flow rate (veh/s), $v = (V_{maj\text{-}d}/0.7)/3600$ OR $[(4e/0.7)/3600]$	*4f*	
Average pedestrian delay (s/person), $d_p = (e^{v\,tc} - v\,t_c - 1)/v$ OR $[(e^{4f \times 4d} - 4f \times 4d - 1)/4f]$	*4g*	
Total pedestrian delay (h), $D_p = (d_p \times V_p)/3{,}600$ OR $[(4g \times 2a)/3600]$ (this is estimated delay for all pedestrians crossing the major roadway without a crossing treatment – assumes 0% compliance). This calculated value can be replaced with the actual total pedestrian delay measured at the site.	*4h*	
Step 5: Select treatment based upon total pedestrian delay and expected motorist compliance.		
Expected motorist compliance at pedestrian crossings in region, Comp = high or low	*5*a	

Total Pedestrian Delay, D_p (from *4h*) and Motorist Compliance, Comp (from *5a*)	**Treatment Category** (see Descriptions of Sample Treatments for examples)
$D_p \geq 21.3$ h (Comp = high or low) OR $5.3 \text{ h} \leq D_p < 21.3$ h and Comp = low	RED
$D_p < 5.3$ h (Comp = high or low) OR $5.3 \text{ h} \leq D_p < 21.3$ h and Comp = high	ACTIVE OR ENHANCED

Figure A-3. Worksheet 2.

Appendix D. LITERATURE REVIEW AND STATE OF THE PRACTICE

Guidance for the application of pedestrian signal heads is principally provided in section 4E.03 of the 2009 Manual of Uniform Traffic Control Devices (MUTCD) (2009). The premise of the MUTCD guidance is to consider the use of pedestrian signal heads at locations where pedestrian volumes warrant them, where special populations may be present (i.e. a school crossing), or where vehicular signal indications provide insufficient guidance for pedestrians to safely decide when to cross, such as where signal phasing may confuse or cause conflicts with pedestrians or where they may have limited visibility of the signals. The MUTCD also provides general guidance and support about crosswalk markings. However, the MUTCD does not describe conditions under which a crosswalk must be marked, nor does it provide conditions under which the installation of a traffic signal or pedestrian hybrid beacon is required.

In research, Fitzpatrick et al. (Fitzpatrick, et al., TCRP Report 112/NCHRP Report 562: Improving Pedestrian Safety at Unsignalized Intersections, 2006) performed a comprehensive review of pedestrian and vehicle interaction at unsignalized intersections, which included a thorough review of various pedestrian crossing treatments. That research is also the basis of the revised pedestrian volume traffic signal warrant (Warrant 4) in the 2009 MUTCD.

Even before the discussion of specific crossing treatments, the decision of whether or not to mark a crosswalk is an important consideration. In research performed by Zegeer et al. (Zegeer, et al., Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations, 2005) the authors quantified the safety performance of marked and unmarked crosswalks at uncontrolled locations, and they concluded that striping of crosswalks alone may in some cases actually have a negative impact on pedestrian safety. The research resulted in a table of guidelines for marking uncontrolled crosswalk locations as a function of crossing widths and vehicular traffic demands, which is reflected in the revised crosswalk marking guidance (section 3B.18.09) in the 2009 MUTCD.

In an effort to overcome some of the limitations of the MUTCD, several states and municipalities have developed their own guidance for the provision of pedestrian signals and other crossing treatments. Examples of this practice include the Pedestrian Guide or Signal Guidelines for states like Minnesota (2005), Alabama (Alabama Department of Transportation, 2007), California (California Department of Transportation, 2012), and Georgia (Georgia Department of Transportation, 2011), as well as municipal guidance including special pedestrian warrants for the City of Boulder, Colorado (City of Boulder Department of Transportation, 2011), or the Pedestrian Safety Guidelines for Sacramento, CA (Sacramento Transportation & Air Quality Collaborative, 2005). Even so, according to the Uncontrolled Crossings Task Force who conducted a survey of current practices in 2013, two-thirds of the jurisdictions who responded do not have written policies or guidelines other than the MUTCD for applying marked crosswalks. The majority of the agency respondents indicated the need for improved guidance for the installation of pedestrian crossing treatments, specifically on when to install a crosswalk and what treatment to apply. (Uncontrolled Crossings Task Force, 2014)

In general, the NCDOT relies on the MUTCD for guidance on crossing treatments and does not have additional written policies or guidelines. The NCDOT issued a policy of standard practice criteria and recommendations in February 2008 for marking and signing mid-block crosswalks specifically. The policy calls for an engineering study to be conducted to determine that a mid-block crosswalk would improve operation and pedestrian safety in lieu of other traffic control measures, but it does not identify factors or locations where mid-block crosswalks should be considered. It does, however, provide guidance on where they should not be installed with considerations for speed, proximity to adjacent crossing locations, visibility, and traffic volume for both pedestrians and vehicles; and how they may be enhanced through the installation of refuge islands, in-street signage, high visibility markings and other treatments. (North Carolina Department of Transportation, 2008)

The2009 MUTCD currently allows for many different styles of crosswalk markings including high visibility markings with longitudinal lines parallel to traffic flow. Little guidance is given on when to use a particular style of marking, which allows for agency flexibility; however, the National Committee on Uniform Traffic Control Devices (NCUTCD) issued a recommendation in 2011 to modify the MUTCD to clarify specification details when using high visibility markings. (Markings Technical Committee of the NCUTCD, 2011) This recommendation incorporates findings from research done by Fitzpatrick et al. on the daytime and nighttime visibility of different marking styles. (Fitzpatrick K. , Chrysler, Iragavarapu, & Park, November 2010) While the research determined high visibility markings were more easily detected further upstream compared with continental markings, no research was found that investigated whether yielding rates are impacted by different crosswalk marking styles.

In the consideration of pedestrian performance at signalized and unsignalized crossings, methodologies in the Highway Capacity Manual (Transportation Research Board, 2010) may be used to predict pedestrian delay at signalized intersections, with additional detail for unsignalized intersection theory given in Troutbeck and Brilon (Troutbeck & Brilon, 2002). Another valuable source for pedestrian treatments and countermeasures is PEDSAFE (Federal Highway Administration, 2013), which contains a variety of case studies on pedestrian treatment applications and describes 11 countermeasures specific to crossing locations. Guidance on pedestrian accommodations and performance at modern roundabouts is available in Rodegerdts et al. (Rodegerdts & et al., 2007), and while roundabouts are not the central piece of this research, lessons learned from the report can be applied to other unsignalized applications.

A key consideration in pedestrian accommodations is the special needs and civil rights of pedestrians with disabilities. To that effect, the US Access Board (US Access Board, 2006) has issued draft Guidelines for Accessible Public Rights of Way (PROWAG), which includes specific requirements for public rights of way that are expected to be adopted by the U.S. Department of Justice in the near future. The PROWAG references several countermeasures specific for pedestrians, many of which have been evaluated in recent work for the Federal Highway Administration (Fitzpatrick K. , Chrysler, Houten, Hunter, & Turner, 2011) (Fitzpatrick & Park, 2010). Additionally, a technical assistance memo jointly issued by the Department of Justice and the Department of Transportation to clarify curb ramp requirements states that “crosswalks constitute distinct elements of the right-of-way intended for pedestrian traffic.” (Department of Justice/Department of Transportation, July 8, 2013)

The review of the literature speaks to the complexity of the decision-making process for selecting pedestrian treatments, and specifically for the provision of pedestrian signals and marked crosswalks at intersections and midblock locations. This complexity clearly speaks to the need for this research, which will result in clear guidelines for application in North Carolina.

D.1 STATE OF THE PRACTICE

The researchers surveyed multiple agencies throughout North Carolina including the state highway divisions and the larger municipalities across the state. These agencies discussed the current practice and/or guidelines being followed for when to implement a crosswalk or other pedestrian crossing treatment in their division or municipality. Agencies outside of North Carolina were also contacted.

D.2 NORTH CAROLINA HIGHWAY DIVISIONS

All 14 of the North Carolina highway divisions were contacted about the current practices in their division regarding marking crosswalks and implementing additional pedestrian facilities. In most cases the division traffic engineer spoke on behalf of the division. All were initially asked some basic questions about how many requests are received each year for a pedestrian facility and how these requests are brought to the attention of the division traffic engineer. On average, each division receives around 10 to 15 requests from citizens or municipalities.

After a request is received, a site visit is conducted. Three main considerations are noted at the site: presence of an existing sidewalk network, pedestrian volumes, and site geometry:

- Most divisions said that if a sidewalk network was present, including curb ramps, then the crosswalk marking would most likely be approved. However, if the sidewalk network was not present, or if present but no curb ramps, then the crosswalk marking would either be denied or the division would propose a joint project with the municipality. If the municipality agreed to construct the sidewalks and/or construct the curb ramps, then the division would agree to mark the crosswalk.
- Pedestrian volume was recorded to justify a pedestrian signal or other pedestrian crossing treatment based on the MUTCD warrants. However, at the time they were interviewed, some divisions felt that the MUTCD warrants were too high and developed their own threshold of 20-30 pedestrian crossings per hour. Additionally, at locations where requests are simply to mark a crosswalk, the site was observed for pedestrian activity, and no specific counts were taken.
- Other site characteristics were considered, including width of the roadway, speed limit (85th percentile), site distance, proximity to a school or greenway, and if the location was for a crosswalk at an intersection or midblock. Marking crosswalks at intersections were more straightforward to approve than at midblock locations. Other considerations that were mentioned included crash history, vehicle volumes, constructability and cost.

The MUTCD was most often cited by NCDOT division staff for pedestrian warrants, but half of the divisions also mentioned Traffic Engineering Policies, Practices, and Legal Authority (TEPPL) Topic C-36 (North Carolina Department of Transportation, 2008) as the source used when considering mid-block crosswalks. Additionally, Division 3 has developed their own guidance for marking crosswalks in beach communities (NCDOT Division 3, December 21, 2010). This guideline considers beach access points, number of residential units, crash history, pedestrian population (i.e. handicapped or senior citizens) and the local adopted pedestrian plan.

High visibility crosswalks were mentioned by most of the divisions, though the use of high visibility crosswalks was varied. Some thought that high visibility crosswalks should only be place at midblock locations or at locations were pedestrians were unlikely to be, while others thought that high visibility should be applied to all crosswalks.

The divisions were asked to discuss what other crossing treatments beyond marked crosswalks are considered and the decision process(es) through which they are implemented. Pedestrian signals were mentioned as an additional treatment with most divisions using the MUTCD warrants as justification while others considered lower pedestrian volumes than the MUTCD. One division noted that it was unclear when to install a pedestrian signal based on the new complete street guidelines. Four divisions have used pedestrian hybrid beacons (PHB) and three have used rectangular rapid-flash beacons (RRFB) to enhance specific crossing locations.

Overall, the divisions seemed pleased that additional guidance through this research would soon be developed to aid in the decision-making process. Some requested more specific guidance for when to implement PHBs and RRFBs. Others mentioned that they preferred the guidelines be flexible so as not to rule out engineering judgment.

D.3 LARGE NORTH CAROLINA MUNICIPALITIES

Nine major municipalities within North Carolina gave information about how marked crosswalks are implemented within their cities, including: Asheville, Cary, Charlotte, Durham, Fayetteville, Greensboro, Raleigh, Wilmington, and Winston-Salem. Either a city transportation engineer or the city traffic engineer represented the city during the interview. The amount of requests that are received by each of these cities varies greatly, with some cities only receiving a few, while others receive hundreds a year.

Each of the cities conducts a site visit upon receiving a request for a pedestrian treatment. The major considerations that are noted while on site include the pedestrian volume and site characteristics. In most cases, the site is observed for pedestrian activity - counts are conducted when a pedestrian signal is being considered or for midblock locations. Site characteristics include nearby pedestrian generators (i.e. schools, proximity to city trails), crossing distances or number of lanes, landscape, grading, roadway alignment, street lighting, and presence of a refuge island and if the location will be a midblock or an intersection crosswalk. Another consideration mentioned by half the cities is the presence of an existing sidewalk and curb ramps. In most cases the city will try to install or update curb ramps, if needed, but this effort may be limited by available funds. Some cities are being proactive and are working to fill in gaps in the existing sidewalk network and mark crosswalks to extend the network. Furthermore, some cities are also being proactive with new construction projects by setting the stop bar and loop detectors back in anticipation of marking the crosswalk location when future need arises.

The cities referenced the MUTCD for signal warrants but also considered a multitude of other resources published from ITE, FHWA, and AASHTO, as well as the NCDOT Complete Street Planning and Design Guidelines. Some cities (Cary, Charlotte, Raleigh, and Wilmington) have developed their own set of guidelines for when to mark a crosswalk, specifically at unsignalized locations.

Similar to the additional pedestrian treatments mentioned by the highway divisions, a popular treatment for municipalities is the high visibility crosswalk. The application of these markings included crossings at or near: greenways, schools, midblock locations, high pedestrian crossing locations, and busy streets. More than half of the cities discussed providing midblock crossing locations as an additional pedestrian treatment, implemented at greenways and locations with high volumes of pedestrians. Three cities have installed PHBs and three have installed RRFBs. Additional treatments mentioned included refuge islands, pedestrian warning signs, stamped crosswalks, striping an edge line to create a multi-use lane, flexible delineator posts, and camera detection of bicyclists and/or pedestrians at trail crossings.

At the end of the interview, the city representatives were asked for any additional comments they would like to add, and a great amount of feedback was collected.

- One city would like to use the In-Street Pedestrian Crossing sign (R1-6) in more locations but felt that they were restricted on the acceptable locations.
- Current NCDOT practices suggest that the state treats policy much of the “should” and “may” guidance in the MUTCD as “shall”, while municipalities tend to make use of the flexibility written in the MUTCD.
- One city suggested that a crossing difficulty index be included with the crosswalk guidance. The index would add weight or emphasis to special needs populations and specific origins-destinations. One example would be that a difficult crossing with a low volume of pedestrians would have a similar weight or emphasis as an easy crossing with a high volume of pedestrians.
- Another city solicits requests each year from the citizens and staff on locations that need improvement. This city works to fill in the gaps of the sidewalk network and construct as many crosswalks as allowed by the annual budget.
- In other areas, developers may be asked to provide pedestrian treatments if a new development is predicted to generate pedestrian volumes.

Overall the cities seemed to approve a majority of the crosswalk requests, within the limits of a specific budget. Many are trying to be proactive with pedestrian facilities and are working to promote walking. Additionally, the cities are eager to see the completed guidance, particularly information on PHBs and RRFBs.

D.4 OTHER STATES

To date, two agencies outside of North Carolina have been contacted about their current crosswalk guidelines; Minnesota DOT (MnDOT) and the city of Boulder, CO.

D.4.1 Minnesota Department of Transportation

A pedestrian and bicycle safety engineer for MnDOT discussed the current state crosswalk guidance being implemented. The *Guidance for Installation of Pedestrian Crosswalks in Minnesota* was first released in 2005 and is currently undergoing an update. The existing guidance includes a report and a flowchart, which is loosely based on the 2002 FHWA executive summary and recommended guidelines of the *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations* (Zegeer, Stewart, Huang, & Lagerwey, Safety Effects of Marked Vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines, 2002). The Minnesota guidance has received mixed reviews; the pedestrian and bicycling community feels that it is too restrictive with too strong of wording, while city engineers tend to mark crosswalks more often than the guide would suggest, and the state engineers are content with the current guide. The new guideline being developed will implement changes based on the various feedback and criticisms MnDOT has received since the original guideline was released. These include the following:

- Addition of a table similar to the one in the 2002 FHWA study (Zegeer, Stewart, Huang, & Lagerwey, Safety Effects of Marked Vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines, 2002)
- Work to include more of the guidance from the 2002 FHWA study (Zegeer, Stewart, Huang, & Lagerwey, Safety Effects of Marked Vs. Unmarked Crosswalks at Uncontrolled Locations: Executive Summary and Recommended Guidelines, 2002)
- Information on when to consider additional crossing treatments, like how the city of Boulder does for RRFBs
- Incorporate some of the information currently found only in the report into the flow chart as well
- Add information on additional countermeasures to improve safety, such as, curb extensions at crosswalk locations, intersection and street lighting, and address the multiple-threat scenario by, for example, using overhead RRFBs

MnDOT found that the report section of the original guide was being overlooked and that most engineers using the guide would view only the flow chart. Furthermore, the state often fields complaints from citizens about lack of consistency in its application across the state. The original guide was meant to standardize practice, but since the guideline is not mandated, inconsistencies remain.

One additional point that was made is that the state is currently conducting research into automated pedestrian and bicycle counts which will aid in the state being more proactive with pedestrian treatments and crossing facilities in the future.

D.4.2 City of Boulder, Colorado

A transportation operations engineer from the city of Boulder, CO was contacted to discuss the current crosswalk guideline being implemented by the city. The *Pedestrian Crossing Treatment Installation Guidelines* was created in 1996 and has since undergone three revisions, with the latest update in 2011.

The first version was found to be insufficient and relied heavily on engineering judgment. The current revision had the following updates:

- Added guidance on new crossing treatments including RRFBs
- Examined how to improve compliance
- Provided research sources to back up data

The current guide is typically used for low volume roads and to determine minimum pedestrian volume thresholds. Additionally, the latest version has received positive response from the bicycling and pedestrian community.

The current guideline contains a flow chart with thresholds originating from the 2005 FHWA study (Zegeer, et al., Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations, 2005) and have been verified by city engineers. The city also examined the effect of pedestrian volume on vehicle compliance, and found that 15-20 crossings per hour resulted in good compliance.

One of the new crossing treatments that was included in the guideline is the RRFB; on which the city has done extensive research from their own installations and from gathering information from other parts of the country. The first RRFB was installed 15 years ago. Since then, 20 different locations have been evaluated, with several of the locations eventually replaced with a traffic signal. Outside of the state, the city has gathered information from Oregon where RRFBs are installed in rural locations with high speeds.

Besides RRFBs, the city has also implemented PHBs but has found these devices to not be very successful. Compliance did not improve with the installation of a PHB and produced similar results as a traffic signal. When deciding whether to install a PHB or a signal, the city prefers to install a traffic signal.

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