AASHTO Bike Guide Webinar Series (Part 3)

Additional Advances in Bicycling Design

Jeremy Chrzan Toole Design

AASHTO Bike Guide Webinar Series

Part 1 6/26/25

Evolution of Bicycle Infrastructure and the AASHTO Bike Guide

Part 2 7/31/25

Design Principles of High-Comfort Bikeways

Part 3 9/11/25

Additional Advances in Bicycling Design

Follow-on deep dive sessions will be scheduled to address specific topics we identify from feedback following these episodes.

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Pedestrian and Bicycle Information Center

Advanced Topics and Operations

Webinar 3

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Owner | Multimodal Design Practice Lead
TOOLE DESIGN

July 31, 2025

2012 Guide compared to 2024 Guide

2012 Guide	2024 Guide	Notable Changes of 2024 compared to 2012
Chapter 1. Introduction	1. Introduction	REWRITE with new discussion of design range concept
Chapter 3. Bicycle Operation and Safety	2. Bicycle Operation & Safety	REWRITE of former Chapter 3
Chapter 2. Bicycle Planning	3. Bicycle Planning	REWRITE and NEW CONTENT added to former Chapter 2
	4. Facility Selection	NEW CHAPTER with a few items carried from Chapter 2
	5. Elements of Design	NEW CHAPTER with some content pulled from Chapters 4 and 5
Chapter 5. Design of Shared Use Paths	6. Shared Use Paths	REVISION of Chapter 5
	7. Separated Bike Lanes	NEW CHAPTER with new content
	8. Bicycle Boulevards	NEW CHAPTER with new content
Chapter 4. Design of On-Road Facilities	9. Bike Lanes & Shared Lanes	REVISION of Chapter 4
	10. Traffic Signals and Active Warning Devices	NEW CHAPTER with new content
	11. Roundabouts, Interchanges, and Alternative Intersections	NEW CHAPTER with new content
	12. Rural Area Bikeways	NEW CHAPTER with some content pulled from Chapter 4
	13. Structures	NEW CHAPTER with some content pulled from Chapter 5
	14. Wayfinding	NEW CHAPTER with some content pulled from Chapter 4
Chapter 7. Maintenance and Operations	15. Maintenance & Operations	REVISION of chapter 7
Chapter 6. Bicycle Parking Facilities	16. Parking, Bike Share, & End of Trip Facilities	REVISION of chapter 6

Chapter 9 – Shared Lanes and Bicycle Lanes

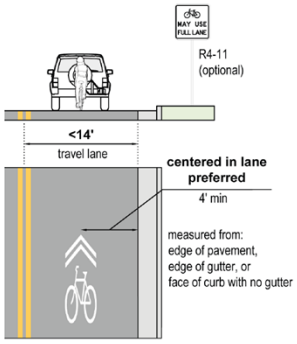
9.3.2. Limited Effectiveness of Wide Outside Lanes

Figure 9-1: Shared Lane Conditions (Rural Context, Suburban Context, Urban Context)

Rural Roadway

Suburban Arterial

Figure 9-3: Shared Lane Marking Lateral Placement in Travel Lanes < 14 Feet Without Parking



9.3.3. Sharrows with On-Street Parking

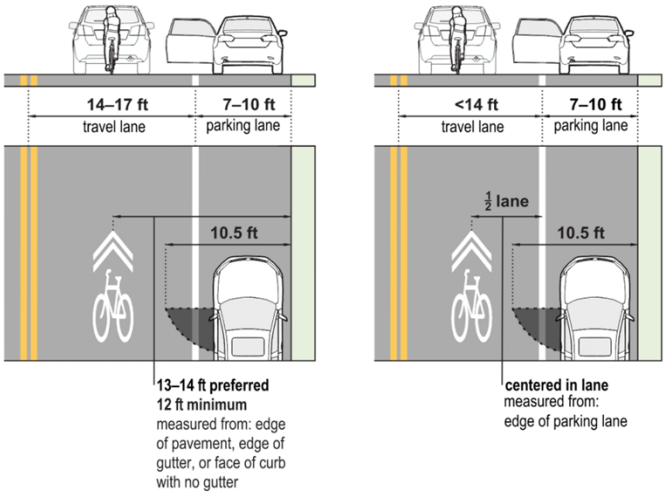


Figure 9-5: Shared Lane Marking Lateral Placement in Travel Lanes adjacent to a Parking Lane

9.4.1. Bicycle Lane Widths

Table 9-1: One-Way Standard Bicycle Lane Widths

One-Way Standard Bike Lane Widths				
Bike Lane Context	Practical Minimum (ft)	Recommended Lower Limit (ft)	Recommended Upper Limit (ft)	Practical Maximum (ft)
Adjacent to edge of Pavement	4[1]	5	7	8[3]
Adjacent to curb (exclusive of gutter)	5[1]	6	7	8[3]
Between through lanes and turn lanes[2]	5[1]	6	7	8[3]
Between buffers	4	5	7	8[3]
Adjacent to parking	5	6	7	8[3]
To allow occasional passing or side-by-side bicycling[4]	6.5	8[3]	10[3]	11[3]

Notes

[1]Shoulders should be provided in lieu of narrow bicycle lanes to avoid confusion below the practical minimum width.

[2]Buffers are desirable where bicycle lanes are located between through lanes and turn lanes, especially as motorist speeds exceed 30 mph.

[3]Buffered bike lanes or separated bike lanes should be considered in lieu of wider bicycle lanes to avoid confusion with a parking or travel lane.

[4]A minimum of 6.5 ft is necessary for occasional passing and 8 ft or more for comfortable side-by-side bicycling.

9.5. Buffered Bicycle Lanes

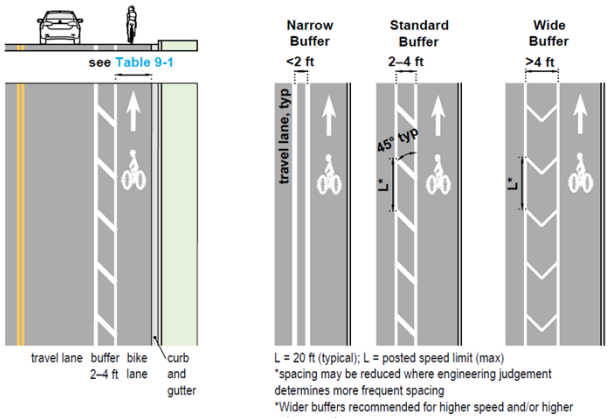


Figure 9-9: Buffer Design Options

9.6.4. Bicycle Lanes Adjacent to Parallel Parking and Loading

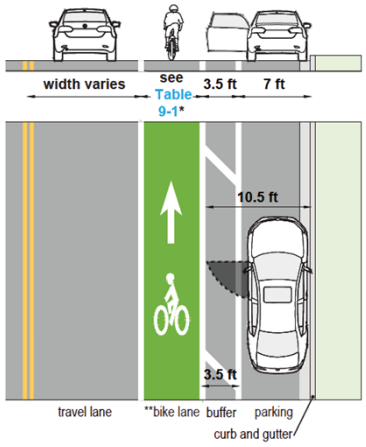


Figure 9-11: Bike Lane with a Door Zone Buffer adjacent to Parking

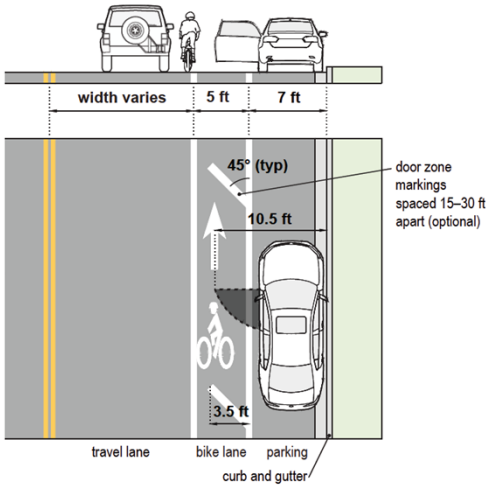


Figure 9-10: Constrained Bike Lane Adjacent to Parking Example

9.6.4.1 Minimum Width Bike Lane Considerations

9.8. Advisory Bike Lanes

Posted Speed:
- < 25 mph preferable
- < 35 mph max

ADT:
- < 3,000 preferable
- < 6,000 max

Need to consider sight distances

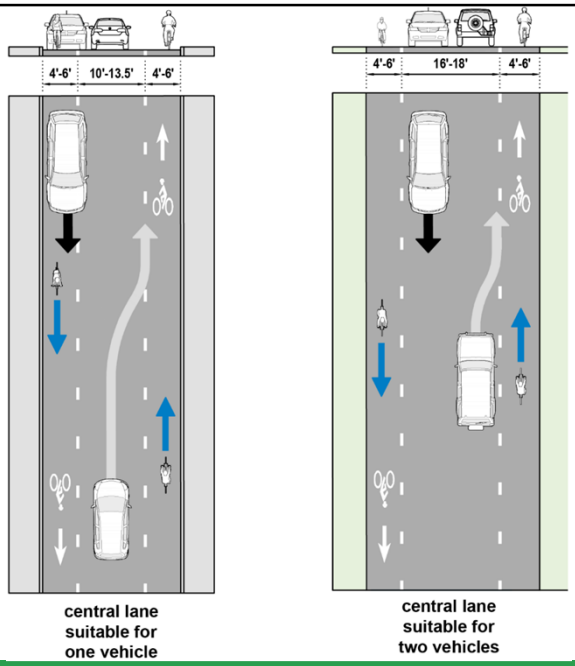
Figure 9-15: Example of an Advisory Bicycle Lane in Alexandria, VA

9.8. Advisory Bike Lanes

Two Variations:

- 10’-13.5’ travel lane
- 16’-18’ travel lane

CMF as “Edge Lane Roads”



9.11. Counterflow Bike Lanes

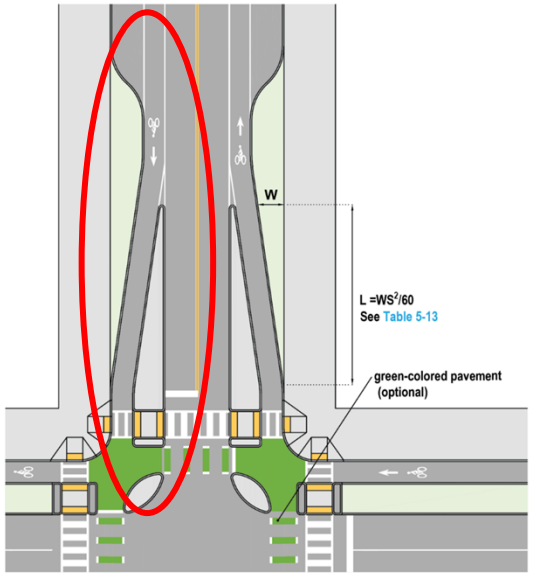
Recommended where:

- Provides substantial time savings to bicyclists in out-of-direction travel
- Provides direct access to high-use destinations
- Provides fewer conflicts compared to another route

9.12. Bike Lanes at Intersections/Driveways

Reminder:

- You can always transition a bike lane to a separated bike lane at intersections
- NCHRP 1125 recommends this above all other options for safety and comfort



9.12.3. Bike Lane with Right Turn Lane

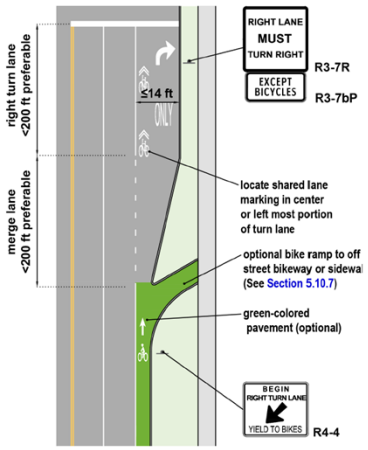


Figure 9-22: Example Right-Turn Only Lane with Shared Lane Markings

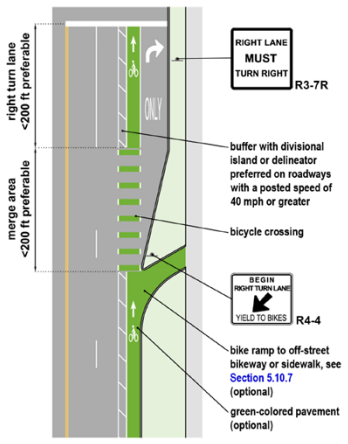


Figure 9-24: Example Bike Lanes on Streets >40 mph or Right-Turn Lanes >200 ft

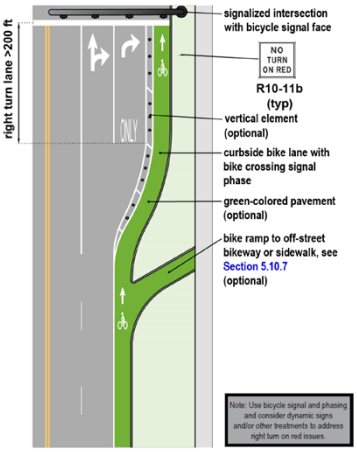


Figure 9-26: Example Bike Lane Approach to a Through-Right and a Right-Turn Only Lane

9.12.3. Bike Lane with Right Turn Lane

Keep right turn lane as short as possible

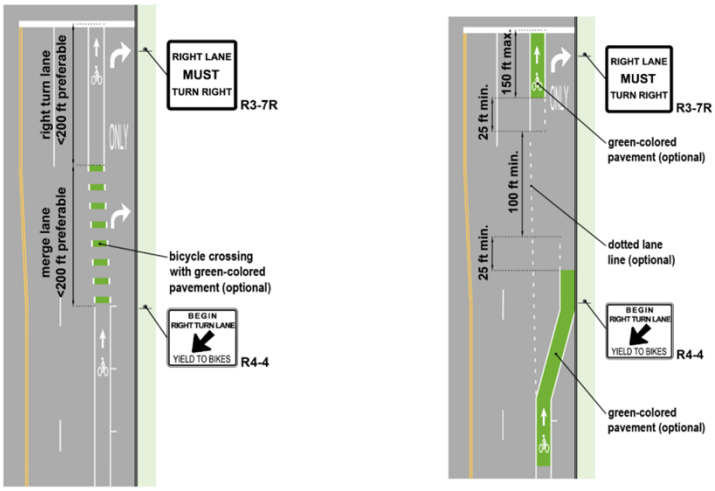
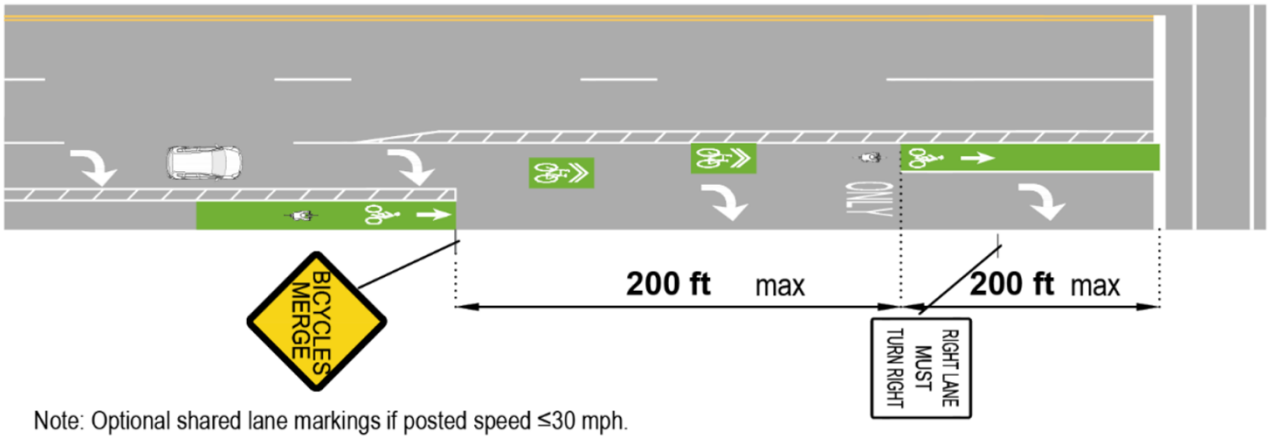


Figure 9-23: Example Bike Lanes on Streets

9.12.3. Bike Lane with Right Turn Lane Drop Scenario



Note: Optional shared lane markings if posted speed ≤30 mph.

Chapter 10 – Traffic Signals and Pedestrian Hybrid Beacons

10.1 Introduction
10.2 Design Guidance for Traffic Signal Control
10.3 Traffic Signal Phasing for Managing or Reducing Conflicts
10.4 Traffic Signal Timing for Bicyclists
10.5 Bicycle Signal Design Consideration
10.6 Detection for Bicycles
10.7 Design Guidance for Pedestrian Hybrid Beacons
10.8 Toucan Crossings with Traffic Signals

Signal Warrants

An engineering study can be used to justify a traffic signal

Anticipated volumes / suppressed demand can be considered for ped/bike volumes

Bikes can be counted as vehicles or pedestrians

10.2.3. Progression Speeds

- Reduce signal cycle lengths <30 seconds of delay
- Use bicyclist speeds for signal progression timing

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10.2.4. Traffic Signal Indication Options for Bicyclists

Bike signal head warrant:

- Leading or protected phasing
- Contra-flow movements
- Signal heads beyond cone of vision

Bike signal head application:

- Can only be used without conflicting vehicle turns
- Otherwise require RTE

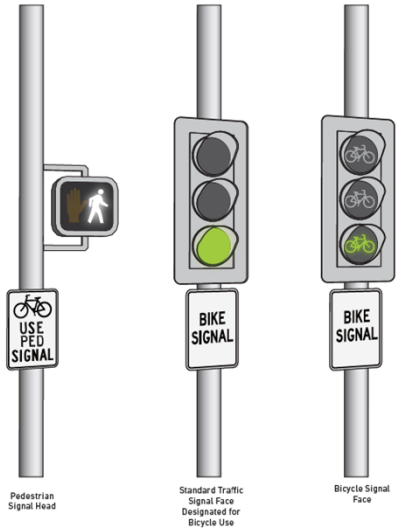

Figure 10-2: Examples of Signal Indication Options for Bicyclists

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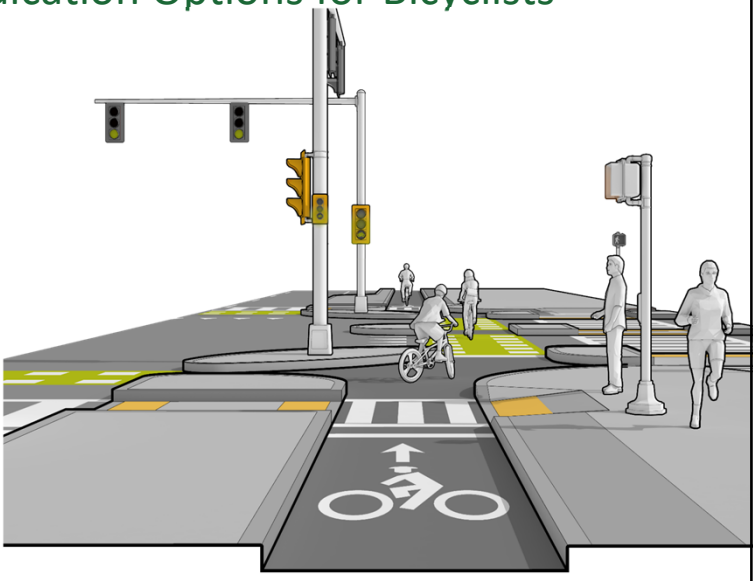
pedbikeinfo.org
@pedbikeinfo

10.2.4. Traffic Signal Indication Options for Bicyclists

- Size and layout of displays
- Number of displays
- Visibility
- Mounting height
- Considerations for placement with pedestrian signal equipment

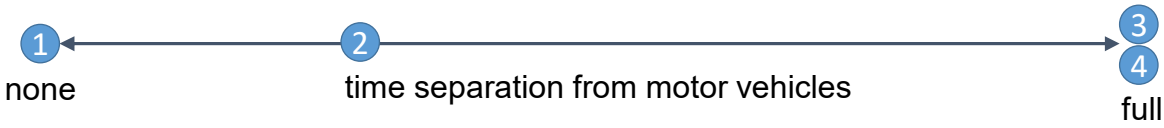


10.2.4. Traffic Signal Indication Options for Bicyclists

- Size and layout of displays
- Number of displays
- Visibility
- Mounting height
- Considerations for placement with pedestrian signal equipment

10.3. Signal Phasing for Bicyclists

1. Bike phase on with conflicting permissive vehicle turns
2. Leading bicycle interval with no conflicts, then bike phase on with conflicting permissive vehicle turns
3. Bike phase on with non-conflicting thru vehicle movement (no conflicts)
4. Protected bike phase: Bike phase on with no other vehicle movements



none — time separation from motor vehicles — full

10.3.5. Signal Phasing Schemes for Reducing Conflicts

Table 10-1: Recommended Hourly Turning Traffic Thresholds for Time-Separated Bicycle Movements

	Left Turn Crossing One Vehicle Lanes	Left Turn Crossing Two Vehicle Lanes
One-Way Bike Lane	≥ 100 ≥ 150*	≥ 50 ≥ 150*
Two-Way Bike Lane	≥ 50 ≥ 100*	ANY ≥ 100*

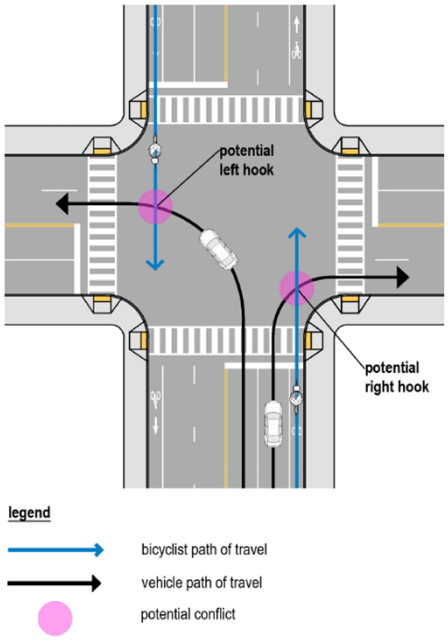


Figure 10-3: Left-Hook and Right-Hook Graphic

10.3.5. Signal Phasing Schemes for Reducing Conflicts (NCHRP 1125)

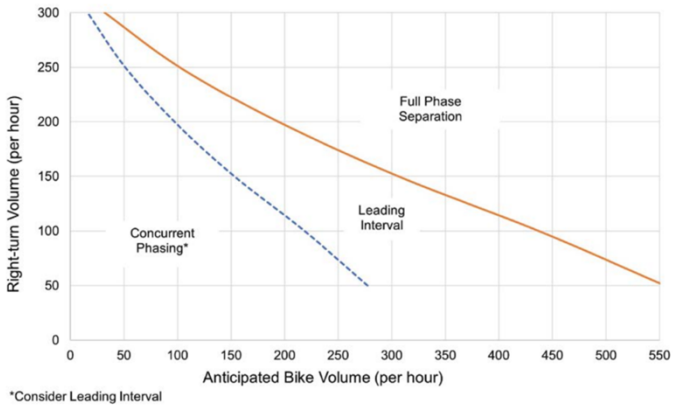


Figure 7. Protected corner signal phasing thresholds.

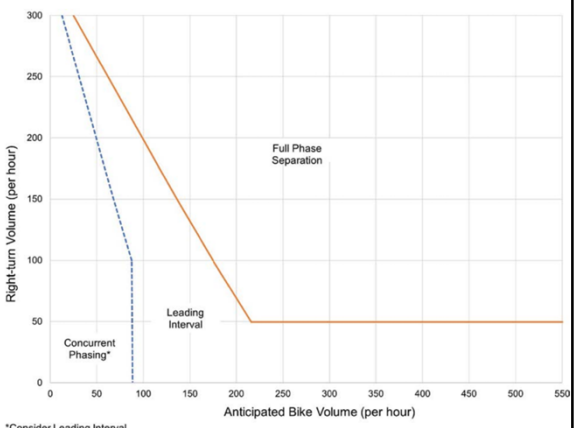


Figure 8. Separated bicycle lanes at intersection signal phasing thresholds.

10.4.1. Green Time, Change Interval and Clearance Intervals for Bicyclists

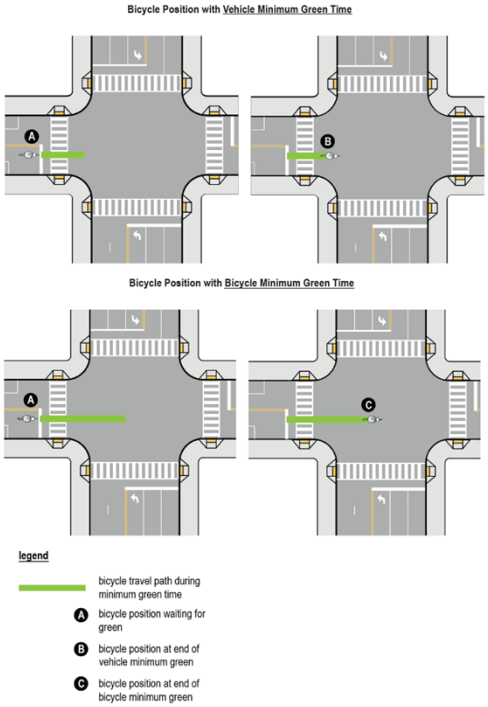
Vehicle Minimum Green

- vs -

Bicycle Minimum Green

Table 10-2: Bicycle Minimum Green Time Equation

Bicycle Minimum Green Time Equation		
$G_{min} = t + \frac{1.47v}{2a} + \frac{d+L}{1.47v}$		
Where:		
G_{min}	=	bicycle minimum green time (s)
v	=	attained bicycle crossing speed (assumed 8 mph)
t	=	perception reaction time (generally 1.5 s)
a	=	bicycle acceleration (assumed 2.5 ft/s²)
d	=	distance from stop bar to middle of the intersection (ft)
L	=	typical length of a bicycle (6 ft)



10.4.1. Red Clearance Interval

Time needed for bikes to clear the intersection

Table 10-5: Bicycle Red Clearance Equation

Bicycle Red Clearance		
$R_{bike} = \frac{D+L}{1.47u} + \left(t + \frac{1.47v}{2a}\right) - y$		
Where:		
D	=	width of intersection from stop bar to far side of travel lane
L	=	length of bike (6 ft)
u	=	speed of bicyclist (8 mph)
t	=	reaction time (1 sec)
a	=	bike deceleration (10 ft / s^2)
y	=	vehicle yellow time

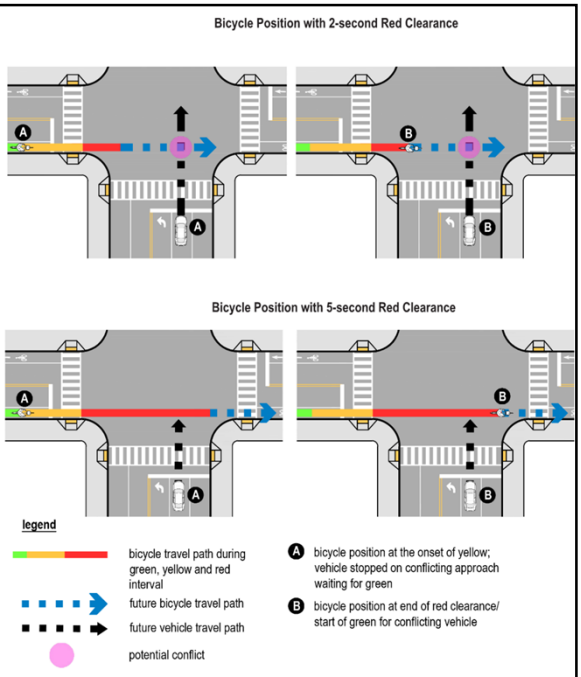


Figure 10-9: Bicycle Position During Red Clearance

10.6. Detection for Bicycles

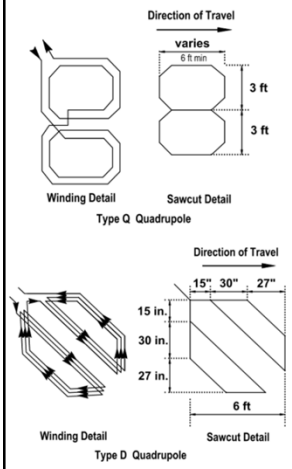


Figure 10-14: Examples of Inductive Loop Detection

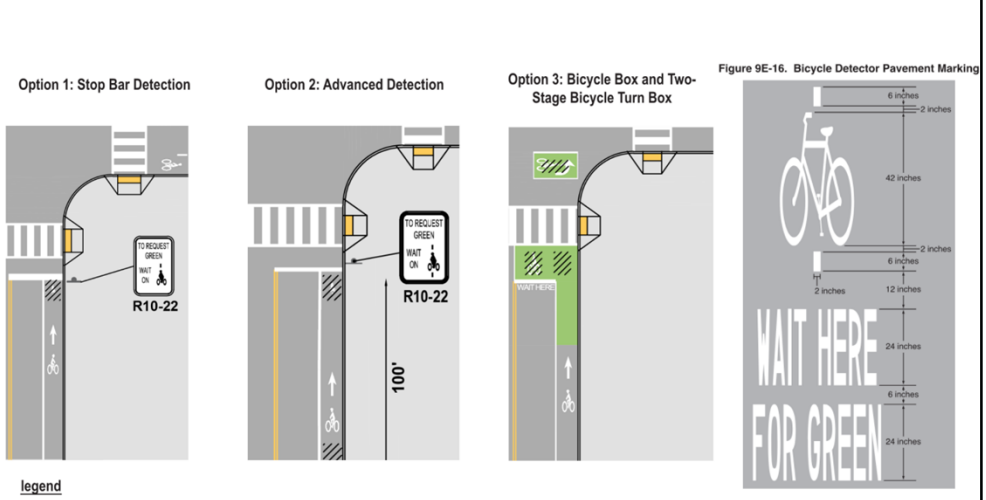


Figure 10-16: Example of Detection Zone Locations

Figure 9E-16. Bicycle Detector Pavement Marking

10.6. Detection for Bicycles

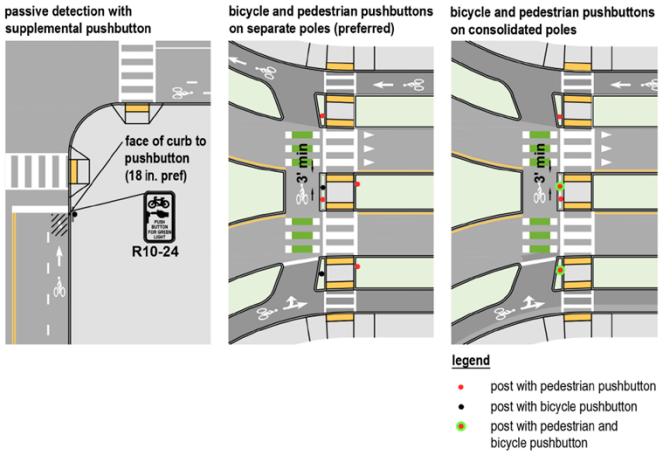


Figure 10-12: Pushbutton Locations

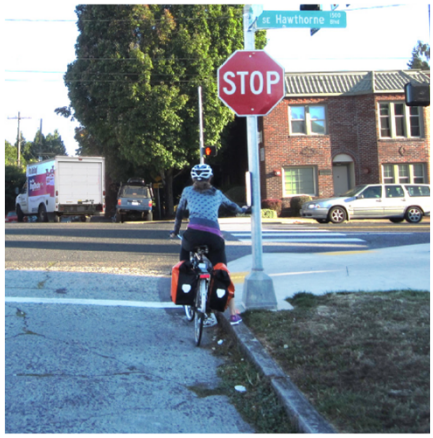


Figure 10-13: Example of Curbside Bicycle Pushbutton

Chapter 11: Bicycle Facility Design at Interchanges, Alternative Intersections, and Roundabouts

11.3. Exit and Entrance Ramps

- 75 to 90-degrees preferred
- 60-degrees still requires motorist to slow before executing merge or turn

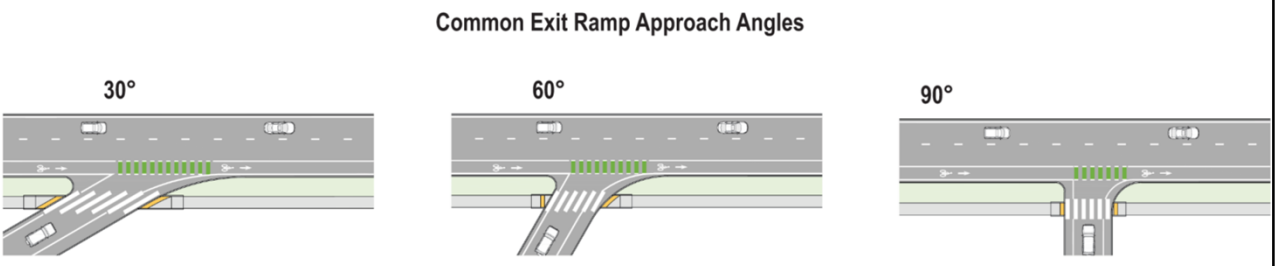


Figure 11-2: Examples of 30-, 60-, and 90-Degree Roadway Intersections

11.3. Exit and Entrance Ramps

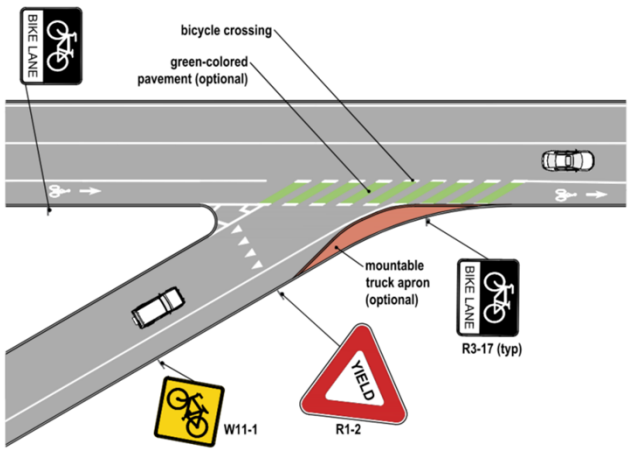


Figure 11-6: Bicycle Lane Carried across an Exit Ramp Throat

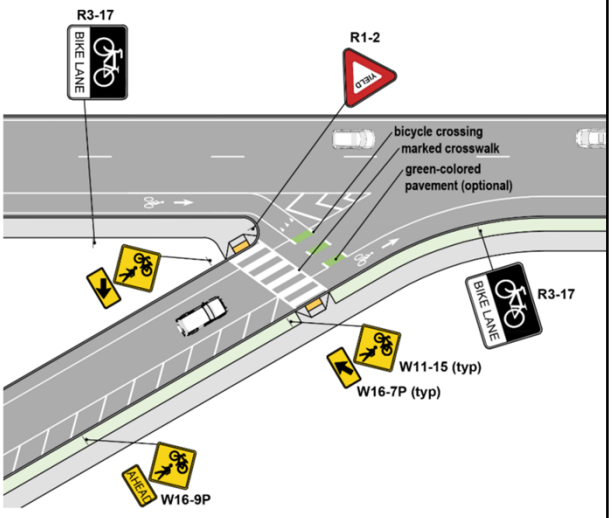


Figure 11-7: Bicycle Lane Shifted Perpendicular to Crossing of an Exit Ramp

11.3. Exit and Entrance Ramps

- On-road and off-road options
- Bike ramp to access to sidewalk
- Sidewalk becomes shared use path
- Perpendicular crossings

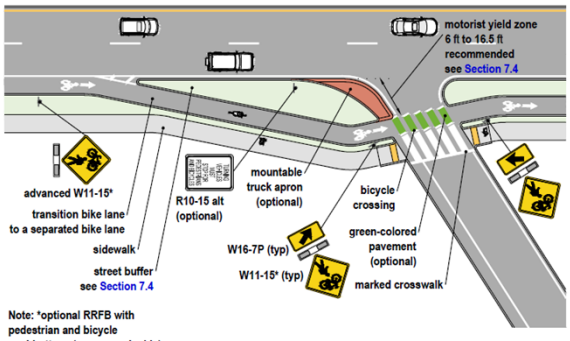


Figure 11-4: Entrance Ramp with Truck Apron and Separated Bike Lane

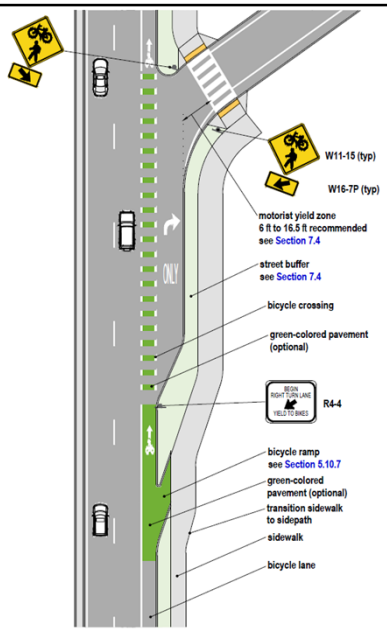


Figure 11-5: Entrance Ramp with Right-Turn Lane, Bike Lane, and Side Path

11.3.3. Merging and Weaving Areas

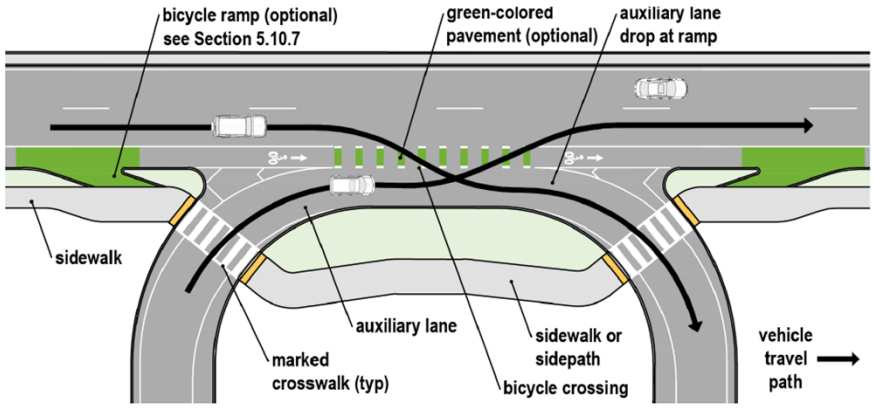


Figure 11-9: Bike Lane Positioned in High-Exposure Weaving Area

11.7. Conflicts between Bicyclists and Pedestrians in Shared Space

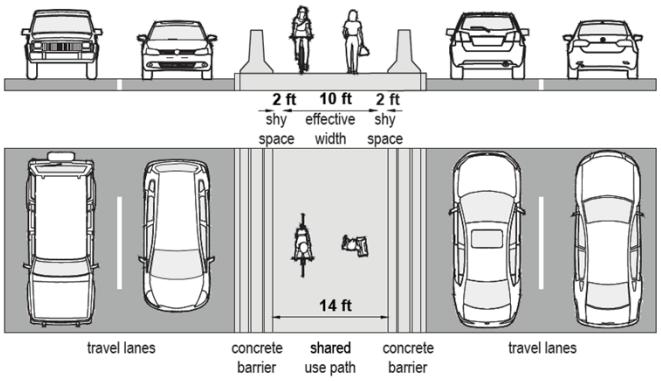


Figure 11-11: Constrained Median Shared Use Path (10 ft wide) with Concrete Barrier Buffers

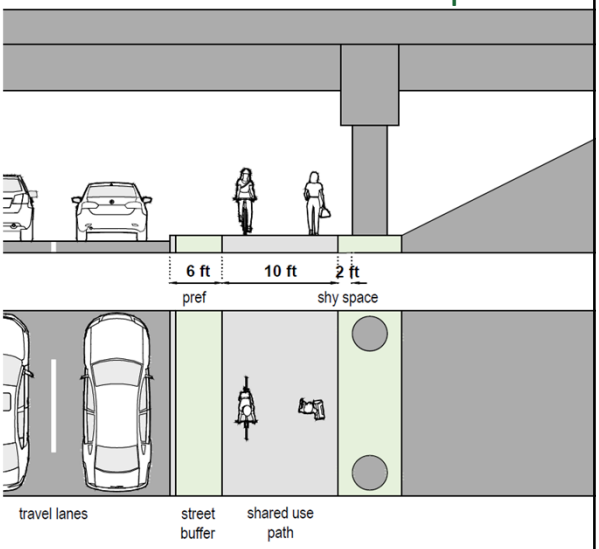


Figure 11-12: Side Path between Travel Lanes and Bridge Piers with Preferred Buffers

11.8. Channelized Right-Turn Lanes

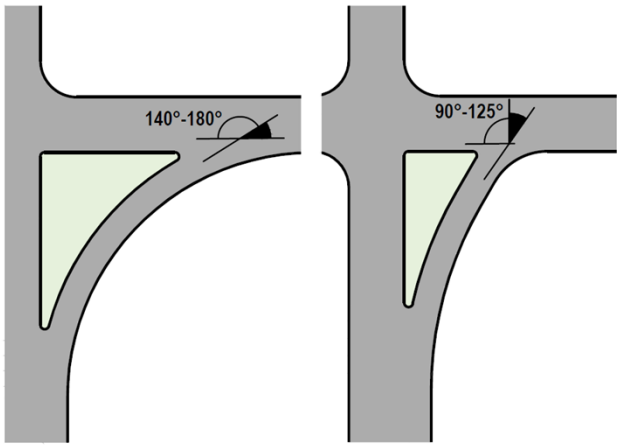


Figure 11-13: Channelized Right-Turn Lane Approach Angles

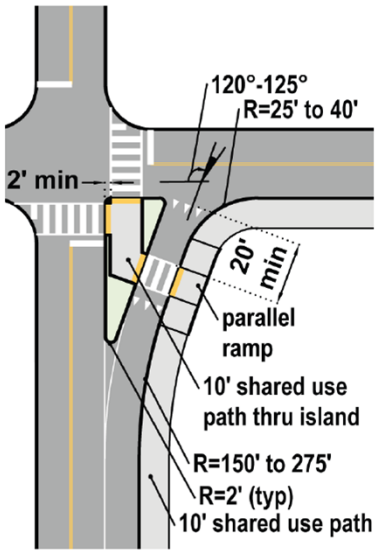


Figure 11-14: Channelized Right-Turn Refuge Island

11.10. Roundabouts

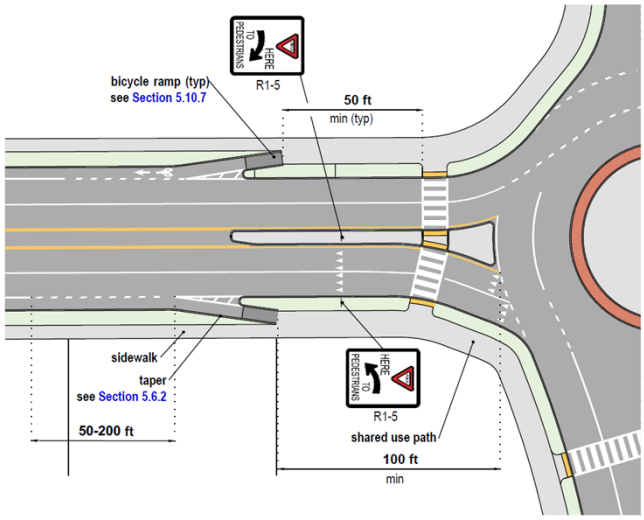


Figure 11-16: Typical Layout of Bike Lane Transitions to Shared Use Path at Multilane Roundabout with Bike Ramps

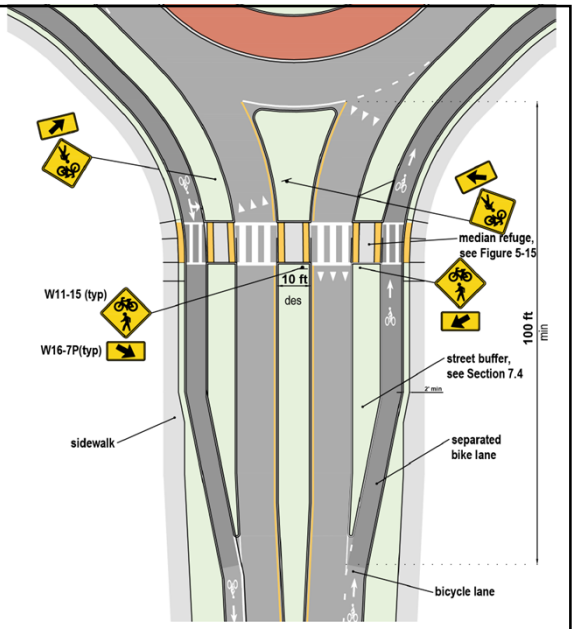


Figure 11-17: Typical Layout of Separated Bike Lanes at Roundabout

Chapter 12 – Rural Area Bikeways and Roadways

Section 12.3 - Design User Profiles

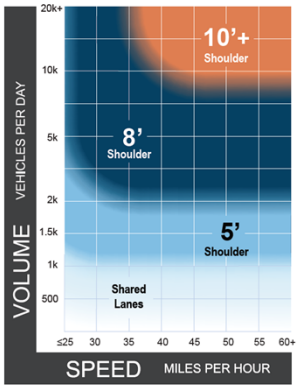
Design User:

Between Towns & Villages
- *Highly Confident*

In Towns & Villages
- *Interested but Concerned*

Figure 12-10: Sidepath along a Rural Road

Figure 4-2: Preferred Paved Shoulder Widths for Rural Roadways to Accommodate Highly Confident or Somewhat Confident Bicyclists



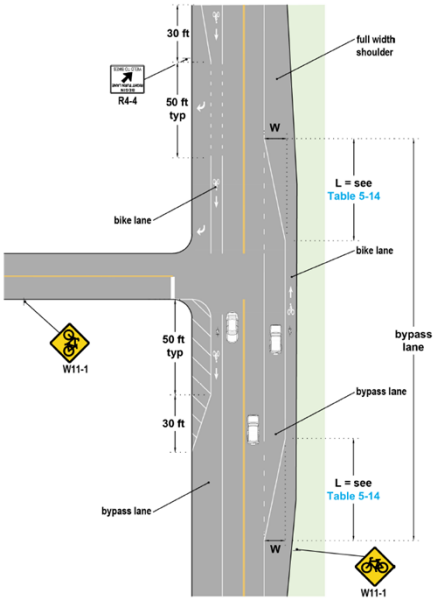


Figure 12-6: Bypass Lane with Paved Shoulder

12.4.3.2 Widths of Paved Shoulders

Table 12-1: Paved Shoulder Widths for Bicycling (see Chapter 12 References: FHWA, 2016b)

Paved Shoulder Widths Exclusive of Rumble Strips[i] for Bicycling				
Design Year Average Daily Traffic (ADT) and Posted Speed (MPH) Thresholds	Practical Minimum[ii]	Recommended Range		Practical Maximum
		Lower Limit[ii]	Upper Limit	
< 2,000; all speeds	2 ft	3 ft	5 ft[ii]	10 ft
2,000 - 6,000; all speeds	2 ft	4 ft	6 ft[ii]	10 ft
6,000 - 10,000; all speeds	4 ft	6 ft	8 ft[ii]	10 ft
> 10,000; ≤ 35 mph	5 ft	6 ft	8 ft[ii]	12 ft[iii]
> 10,000; > 40 mph[iv]	5 ft	6 ft	10 ft[iii]	12 ft[iii]

Notes
[i]See Section 12.5.1 for rumble strip design considerations.
[ii]Where roadside barriers, walls, or other vertical elements are present, they should be offset a minimum of 2 ft from the outer edge of the rideable shoulder to provide minimum shy distance to bicyclists (see Section 2.5.3.2.)
[iii]Where >10 percent of traffic consists of trucks.
[iv]Shared use paths are preferred.

Figure 12-3: Shoulder Widening on Uphill Section of Roadway to Accommodate Bicycling

12.5.1. Rumble Strip Placement and Design

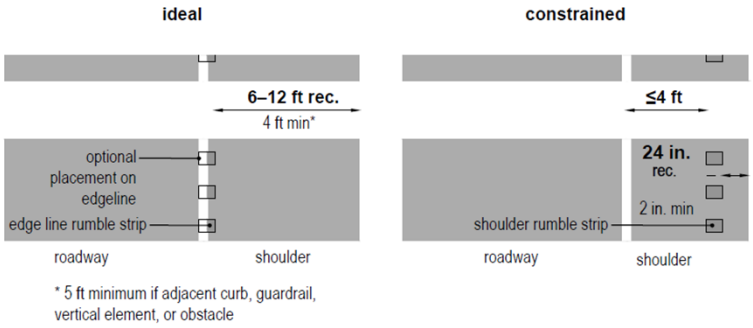
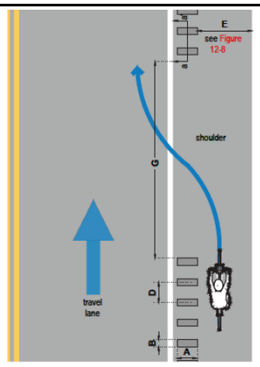


Figure 12-8: Rumble Strip Placement Options



Definitions	
Length (A)	Dimension of rumble strip measured lateral to the travel lane
Width (B)	Dimension of rumble strip measured parallel to the travel lane
Depth (C)	Vertical distance measured from top of pavement surface to bottom of a rumble strip pattern
Spacing (D)	Dimension between rumble strip patterns
Clear Path (E)	Distance from outside (for example, right) edge of rumble strip to outside edge of paved shoulder
Gap (G)	Distance measured parallel to roadway, between groups of rumble strip patterns

*Note: Figure not to scale.

Figure 12-9: Rumble Strip Minimum Gap Illustration

12.4.4. Advisory Shoulders (Experimental)

12.4.4. Advisory Shoulders (Experimental)

Similar to advisory bike lanes (see Section 9.8), advisory shoulders are an experimental design treatment for roads with lower traffic speeds and volumes where it is not feasible to provide standard bike lanes or shoulders for bicycle travel. When motor vehicles traveling in opposite directions meet, motorists may need to enter the advisory shoulder to create sufficient space to pass (see Figure 12-7). Experimental approval from FHWA is required to use this traffic control treatment. Where sidewalks are not present and it is desired for pedestrians to walk within the advisory shoulders, the advisory shoulder should be accessible to and usable by individuals with disabilities (see Section 1.6.3). See Section 1.6.1 for guidance on requests to experiment. See Section 9.8 and the FHWA Small Town and Rural Multimodal Networks Guide (see Chapter 12 References: FHWA, 2016b) for additional design guidance.

Note: The use of this treatment requires a Request to Experiment from FHWA. (See Section 1.6.1)

Figure 12-7: Example of Advisory Shoulders in Hanover, NH

Advisory shoulders may be considered in rural contexts on roads with the following characteristics:

- Low operating speeds
  - < 25 mph preferable
  - < 35 mph maximum
- Low to moderate motor vehicle volumes
  - < 3,000 vehicles/day preferable
  - < 6,000 vehicles/day maximum
- Infrequent heavy vehicles
- Adequate passing sight distance for motorists
- Regular bicycle traffic

If an advisory shoulder is being considered on a low-volume roadway with operating speeds above 35 mph, traffic calming treatments should be implemented to promote operating speeds at or below 35 mph.

Chapter 13 – Structures

13.1 Introduction
13.2 General Design Principles for Structures
13.3 Design Details for Bridges
13.4 Design Details for Underpasses
13.5 Options for Retrofitting Existing Structures
13.6 Connections to Nearby Facilities

13.2. General Design Principles for Structures

Figure 13-3: Examples of Structured Shared Use Path Crossings on the Washington and Old Dominion Trail over Fairfax County Parkway in Virginia (left), the Midtown Greenway in Minneapolis, MN (center), and the Palouse Trail Underpass of Washington State Route 270, Pullman, WA (right)

13.3. Design Details for Bridges

Figure 13-1: Bikeway along the Interstate 90 Bridge over Lake Washington, WA

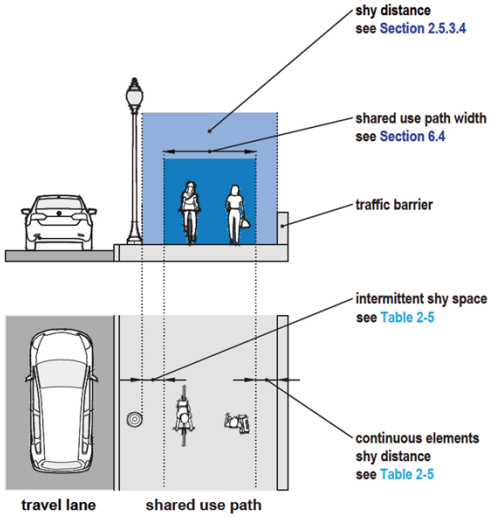


Figure 13-5: Horizontal Clearances for Shared Use Paths on Bridges Along Roads

Chapter 14 – Wayfinding Systems for Bicyclists

14.6. Bicycle Wayfinding Sign Assemblies

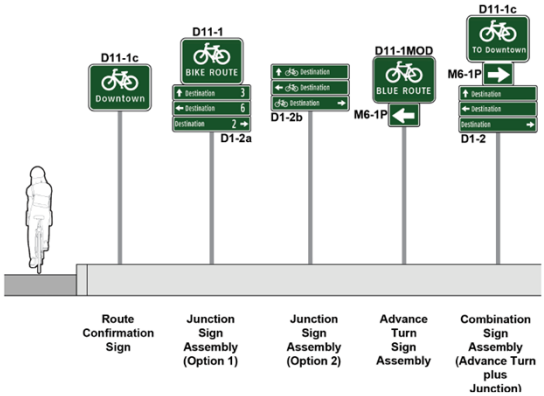


Figure 14-4: Examples of Confirmation, Decision, and Turn Sign Assemblies

Table 14-1: Mileage Rounding Guidelines

Mileage Rounding Guidelines	
Distance (mi)	Guideline
< 0.2	Do not include mileage; blocks are appropriate, if necessary
0.2 - 5.0	Round mileage to the nearest tenth of a mile
> 5.0	Round mileage to the nearest whole mile

Figure 14-7: Example of Community Wayfinding

Chapter 15 – Maintenance and Operations

15.1 Introduction
15.2 Maintenance Policy and Programs
15.3 Designing for Ease of Maintenance
15.4 Maintenance Activities
15.5 Temporary Traffic Control for Bicyclists (Maintenance of Traffic)

15.2. Maintenance Policy and Programs

Figure 15-1: Examples of Debris, Faded Markings, and Snow Clearing

Figure 15-4: Fog Sealing a Shared Use Path

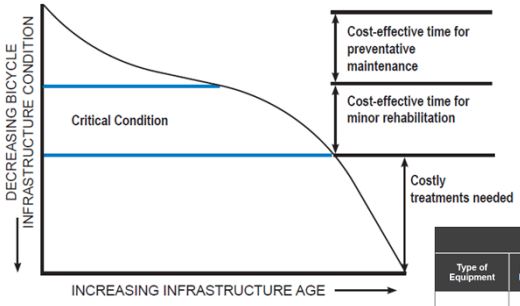


Figure 15-2: Bicycle Infrastructure Life Cycle

Table 15-1: Maintenance Equipment Types

Maintenance Equipment Types				
Type of Equipment	Corresponding Design Vehicle[a]	Width (ft)[b]	Height (ft)	Uses
3-Axle Single Unit Truck	SU-40	8	11-13	highway snow plowing, heavy construction, emergency vehicles
2-Axle Single Unit Truck	SU-30	8	11-13	ambulance, snow plowing, construction, routine maintenance
Pickup Truck	N/A	6-8	6-7	snow plowing, routine maintenance, law enforcement
Typical Skid-Steer Loader	N/A	5.5	6.5	snow plowing, routine maintenance, sweeping
Specialty Equipment	N/A	Varies by manufacturer		Varies

[a] For detailed information on vehicle geometry and turning radius, refer to Chapter 2 of AASHTO's *A Policy on Geometric Design of Highways and Streets* (See Chapter 15 References: AASHTO, 2018).
[b] Width of attachments such as sweeper brooms or snowplow blades may exceed the width of the vehicle.

Chapter 16 – Bicycle Parking, Bike Share Siting, and End of Trip Facilities

16.1 Introduction
16.2 Planning for Bicycle Parking
16.3 Short-Term Parking
16.4 Long-Term Parking
16.5 Rack Design
16.6 Short-Term and Long-Term Bicycle Parking Site Design
16.7 Bike Parking at Special Events
16.8 Bike Share Parking
16.9 Locker Rooms, Showers, and Repair Stations (End-of-Trip Facilities)

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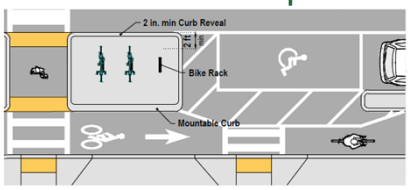
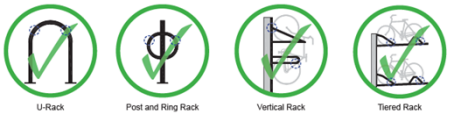
Figure 16-1: Directional Signage for Bicycle Parking

16.3. Short-Term Parking
16.3.4. Example Designs with Unique Considerations



Bike Parking on Raised Median Adjacent to Accessible Car Parking Space

Figure 16-2: On-Street Bicycle Corrals



Note:
◌ Locking point of a single bicycle on the rack

Figure 16-6: Examples of Recommended and Not Recommended Racks

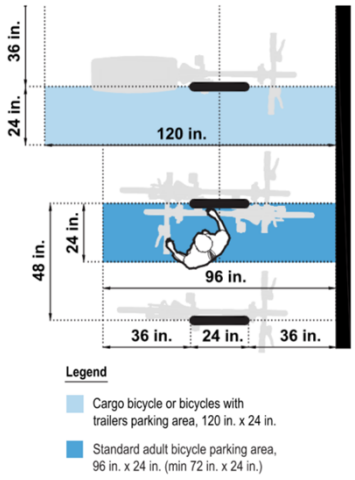
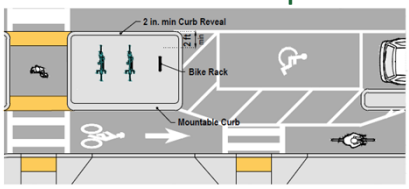


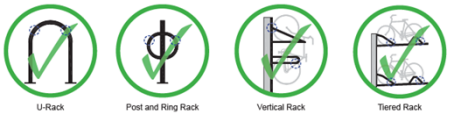
Figure 16-9: Bike Parking Footprint

16.3. Short-Term Parking
16.3.4. Example Designs with Unique Considerations



Bike Parking on Raised Median Adjacent to Accessible Car Parking Space

Figure 16-2: On-Street Bicycle Corrals



Note:
◌ Locking point of a single bicycle on the rack

Figure 16-6: Examples of Recommended and Not Recommended Racks

Table 16-1: Sample Short-Term Bicycle Parking Quantity Requirements

Short-Term Parking Quantities		
Types of Activity	Sample Bicycle Parking Quantities[a]	
	Most Contexts	Urbanized or High Bicycle Mode Share Areas
Multi-unit residential dwellings	0.05 spaces per bedroom	0.10 spaces per bedroom
Libraries and government buildings	One space per 10,000 square ft of floor area	One space per 8,000 square ft of floor area
Church, theatres, stadiums, parks, beaches	Spaces for 2 percent of maximum expected attendance	Spaces for 5 percent of maximum expected attendance
Schools (K-12)	One space per 20 students	1.5 spaces per 20 students
Colleges and universities	One space per 10 students of planned capacity	One space per 10 students of planned capacity
Rail or bus terminals and stations and airports	Spaces for 1.5 percent of a.m. peak passengers	Spaces for 2 percent of a.m. peak passengers
Retail- groceries	One space per 2,000 ft² of floor area	One space per 2,000 ft² of floor area
Retail- general	One space per 5,000 ft² of floor area	One space per 5,000 ft² of floor area
Office	One space per 20,000 ft² of floor area	One space per 20,000 ft² of floor area

[a] A minimum of two bike parking spots is recommended in all cases

Adapted from Anderson et al. (2010); see Chapter 16 References.

Thank you!
Questions?

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