CITY OF WICHITA

May 2014

STREET DESIGN GUIDANCE

Outlining street design considerations from existing City of Wichita and nationally-accepted guidance documents to aid in the development of the Wichita Street Design Guidance.

DISCOVERY REPORT

PEC Project #: 13676

PEC
PROFESSIONAL ENGINEERING CONSULTANTS, P.A.

TABLE OF CONTENTS

Prepared for:

City of Wichita
455 N Main
Wichita, KS 67203

Prepared by:

Professional Engineering Consultants, P.A.
303 South Topeka
Wichita, KS 67202

CHAPTER 1: INTRODUCTION

REPORT PURPOSE & OBJECTIVE

When designing a street, it is important to consider who will be using the street. Whether the users are between the curbs or outside of them, the design should be appropriate to the current and likely use. Also important is the consideration of context, the built and natural environment along and adjacent to the street.

This report is the first step in developing the City of Wichita's Street Design Guidance as well as determining desired changes to existing City guidance, standards, practices, and processes for street design. This report is an exploratory effort to gain insight into the City of Wichita design practice as well as inventory national street design practices. This report will be the basis for sound recommended changes to design guidance, standards, practices, and processes.

REPORT ORGANIZATION

Chapter 2 of this report summarize how the City of Wichita determines proper street designs. This includes a summary of existing guidance documents and standards on street design as well as practices and processes carried out by the City. Not only does this summary provide insight into the design process, it will also help determine the degree to which street designs help to achieve City goals. Any missing links between the designs and goals will aid in formulating the City's street design guidance.

Chapter 3 of this report also summarizes national best practices in street design. The national best practices will provide examples to aid in identifying desired changes to the street design process as well as what should be included in the City's street design guidance document.

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CHAPTER 2: CITY OF WICHITA DESIGN GUIDANCE & PROCESSES

This chapter summarizes the current City of Wichita street design processes, practices, guidance documents, and standards. Current City of Wichita street design guidance is found in many different documents. These documents were gathered and summarized in this chapter. Many of the summaries include graphics from the referenced documents to provide examples of design treatments.

The purpose of this chapter is to identify needed consistency between the current guidance and the new street design guidance being developed. Also, the summaries may spark the need or desire to update current guidance through discussions with staff about the contents of this chapter.

This chapter also summarizes the practices and processes carried out by the City of Wichita to determine needed and desired street designs and characteristics.

PRACTICES & PROCESSES

The City of Wichita determines proper designs internally and sometimes externally through contracts with consultants. The City is always heavily involved on the front end to determine much of the design characteristics, carrying out the design or oversight of consultant work, review, and approval.

Initial Design

The City currently uses engineering rationale to determine initial designs. These designs are based on needs determined by planning studies and street classifications, as well as pertinent information, such as traffic volumes and safety considerations.

Contract

When the City releases a street design RFP, the major design criteria are already determined, such as the number of lanes and bicycle accommodations. Consultants make recommendations and develop design alternatives for consideration during the concept phase. Determinations on specific design characteristics, such as the provision of right turn lanes, are made during the concept phase and included in the final design concept, which is ultimately approved by City Council before a project is approved for final design.

Review & Approval

Even if the City is not designing the street themselves, the City's engineering department is heavily involved throughout the design process in reviewing plans and individual elements. Other City departments review specifics related to their function (transit reviews transit design elements, parks reviews landscaping, etc.). Final approval of design and bid documents is made by the City Engineer.

GUIDANCE & STANDARDS

There are a multitude of existing City documents that guide street design. Other City documents include some elements of street design, but may not be considered design guidance. The following is a summary of these City documents.

Municipal Code

The City's Municipal Code generally identifies laws or rules to be followed, some of which relate to vehicles, bicyclists, and pedestrians. There are, however, there is a reference to design and materials to be used in the design and construction of streets, sidewalks, and paths. The Code states that sidewalks must be at least five feet wide, unless all sidewalks in a particular block are four feet wide or if approved by city council and/or the City Engineer (10.12.080). There are also requirements for the use of certain materials in the construction of facilities and references to the City's standard specifications. It is important to note that it is standard City practice to develop sidewalks that are at least six feet wide, when possible and appropriate.

Standard Specifications

The City's Standard Specifications do not specifically address the design of facilities. The focus is on providing specifics about construction, materials, and applications. There is one reference to design, which identifies that a minimum of ten feet of clear street width is required for a traffic lane in a work zone (107.9).

Subdivision Regulations

The City's Subdivision Regulations govern the development of undeveloped land. In relation to transportation, the purpose is to provide for efficient and orderly location of streets, reduction of vehicular

congestion, necessary on-site and off-site public improvements, and other facilities and improvements deemed appropriate.

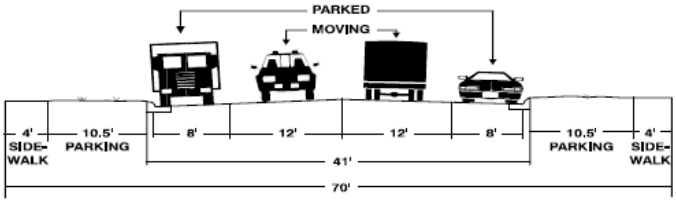
Article 7, Part 2 of the Subdivision Standards covers specific standards for streets. This provides general design guidance as well as general policy-level statements about the functional design of streets. The following are key points from Article 7 that may impact or influence design:

- ROW requirements for non-arterials to be based on the aggregate needs for functional components and must be in increments of two and even numbers only. The components include:
  - Moving or traffic lanes
    - 9'-12' depending on function
    - Paved streets other than arterials - measured from centerline to either the inside edge of a parking lane or the face of the curb (if no parking lanes)
  - Parking lanes
    - At least 8' wide
    - Up to 2' for curb or shoulder may be included as part of the parking lane
  - Curb or shoulder
    - Curbs require 2'
    - Shoulders (suburban or rural) not less than 3'
  - Border ares
    - Sometimes referred to as 'parking' in urban streets
    - 14.5' from back of curb to property line
    - Used for utilities, street lighting, traffic control devices, fire hydrants, sidewalks, landscaping, and transition area in grades
    - In suburban areas, variable width based on drainage needs

Street Classifications

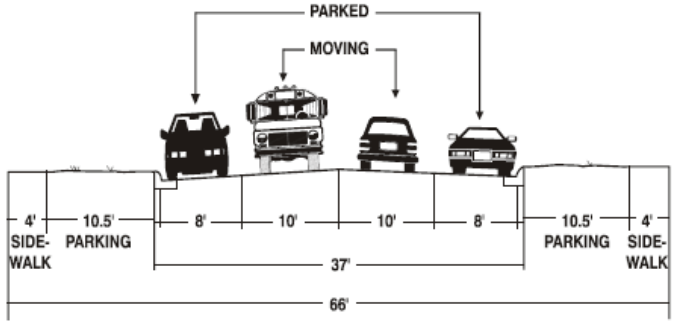
Urban business, office, commercial and industrial area:

- 2 moving lanes 12'
- 2 parking lanes 8'
- ROW 70'
- Roadway width 41'
- Without parking lanes, ROW is 58'

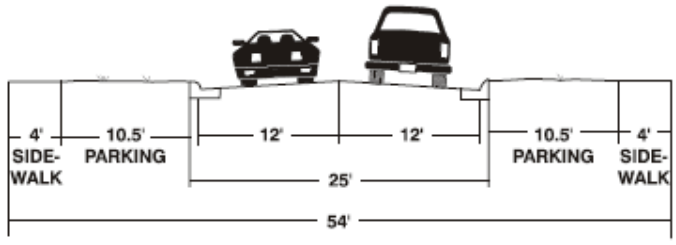


Urban collector streets:

- With parking or street serving garden apartments, multi-family high-rise, large-scale single-family, and other similar type dwelling units
  - 2 moving lanes 10'
  - 2 parking lanes 8'
  - ROW 66' (may be required to be greater for portion 150' back from intersection with an arterial)
  - Roadway width 37'



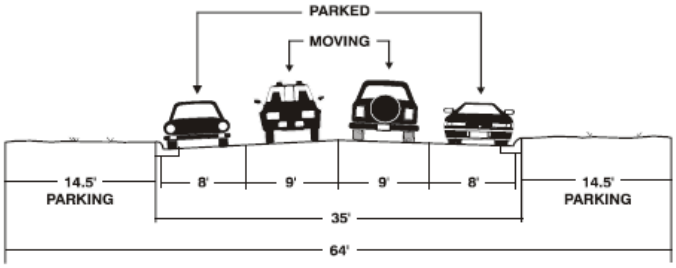
- Collector with no parking and w/o direct local access
  - 2 moving lanes 12'
  - ROW 54' (may be required to be greater for portion 150' back from intersection with an arterial)
  - Roadway width 25'



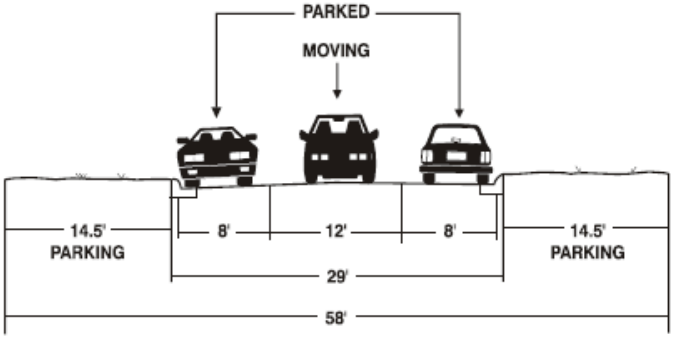
Urban local residential streets:

- Single and 2-family dwellings on continuous through streets more than 3 blocks in length

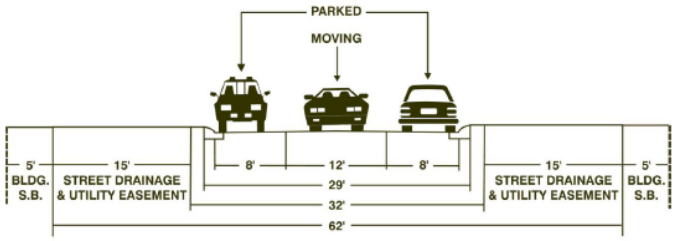
- 2 moving lanes 9′
- 2 parking lanes 8′
- ROW 64′
- Roadway width 35′



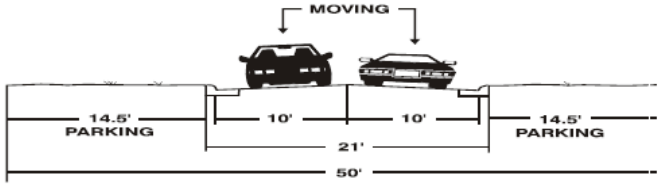
- Continuous through street more than 3 blocks long, where only one side contains a parking lane
  - ROW 58′
- Local Residential
  - 1 moving lane 12′
  - 2 parking lanes 8′
  - Street no more than 3 blocks long
  - Maximum of 24 single-family lots (12 each side) per block
  - Existing covenant providing for 4 off-street parking spaces per dwelling unit on each lot shall not be enforced by the OCI/Code Enforcement
  - ROW 58′
  - Roadway width 29′



- Narrow local residential
  - 1 moving lane 12′
  - 2 parking lanes 8′
  - Limited use in single-family and duplex cluster developments
  - Only for cul-de-sac or loop/circular street alignments
  - Not for through traffic or traffic not generated from fronting land uses
  - One narrow street shall not intersect another narrow street
  - Cul-de-sac streets - max 24 single-family lots
  - Loop/circular streets - max 48 single-family lots
  - 15′ street, drainage, and utility easement on each side
  - Minimum 5′ building setback from easement
  - ROW 32′
  - Roadway width 29′

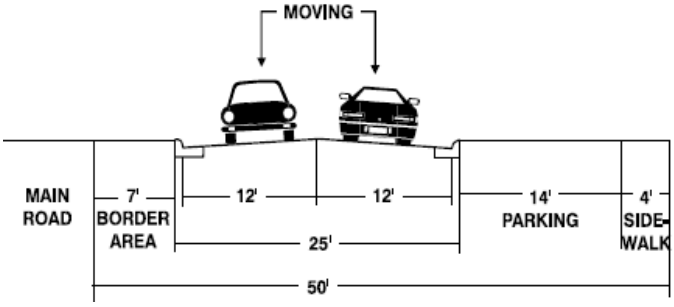


- Local Residential
  - 2 moving lanes 10′
  - No parking lanes
  - Street no more than 1 block long
  - Maximum of 24 single-family lots (12 on each side) per block
  - Cul-de-sacs no longer than 300 feet to center of turnaround radius
  - ROW 50′
  - Roadway width 21′



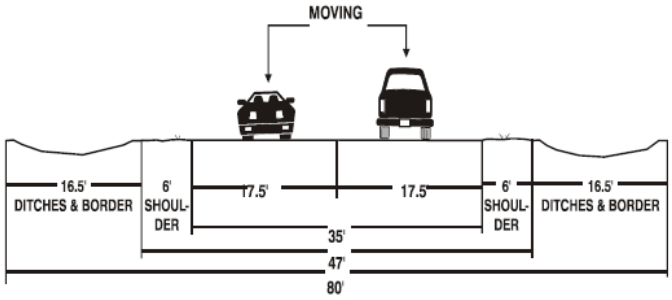
- Local - Frontage Road
  - 2 moving lanes
  - No parking lanes
  - 7′ border area between curb and main road ROW
  - ROW 50′

- Roadway width 25'



Suburban collector:

- 2 moving lanes 17.5'
- Shoulder, ditches, and border areas
- ROW 80'
- Roadway width 47' including shoulder



Suburban local residential:

- With access to existing street system on both ends
- 2 moving lanes 12.5'
- Shoulder, ditches, and border areas
- ROW 70'
- Roadway width 32' including shoulder

Other Provisions

- ROW of all section line roads and arterial not to be less than 120'
- ROW for arterial intersection approach to be 150' within 250' from the section line and taper to 120' at 350' from section line
- 25' by 25' corner clip at intersection
- Inside tangent at least 100' long between reverse curves on arterials and collectors whenever possible
- Minimum centerline curve radius of at least 350' for collectors
- Horizontal sight distance minimums:
  - Local streets - 200'
  - Collector streets - 300'
  - Arterial streets - 500'
- Minimum curb radii
  - Local/local residential - 20'
  - Local residential/collector - 30'
  - Local residential/arterial - 30'
  - Business, commercial, or industrial collector or arterial/business, commercial, or industrial collector or arterial - 50'

Article 8 of the Subdivision Regulations includes the following requirements in relation to design (sidewalks):

- When required, guaranteed from curb to curb of intersecting streets
- Constructed as near as possible to property lines as possible

Typical Standards for Major Approaches to High Traffic Generators

This document identifies and shows plan view layouts for connections from major shopping centers to city streets (2 options, two in/two out and one in/two out), major entrances to businesses and apartments to streets (2 options, with island and without), and the standard secondary approach (one option).

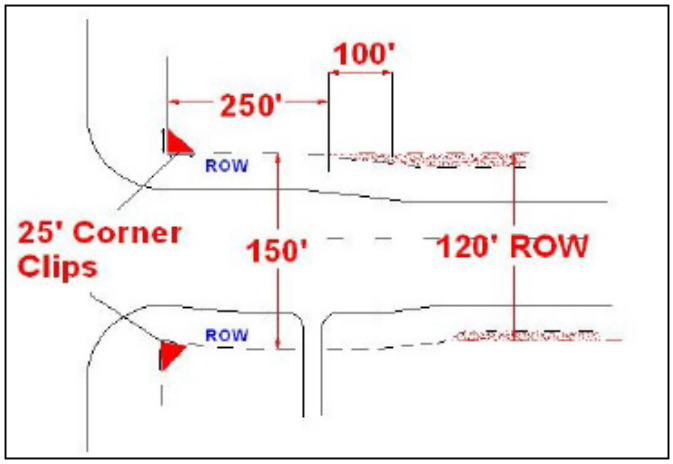
Access Management: Guidelines for Driveway Placement, Right-of-Way & Easement Requirements, and Traffic Impact Studies

The Access Management Guide provides guidance for decisions concerning driveway placement, right-of-way and cross-easement requirements, and traffic study needs for new development along major arterial streets. These guides apply to new subdivisions and site plans (limited extent to building permits and curb cut applications).

ROW Requirements

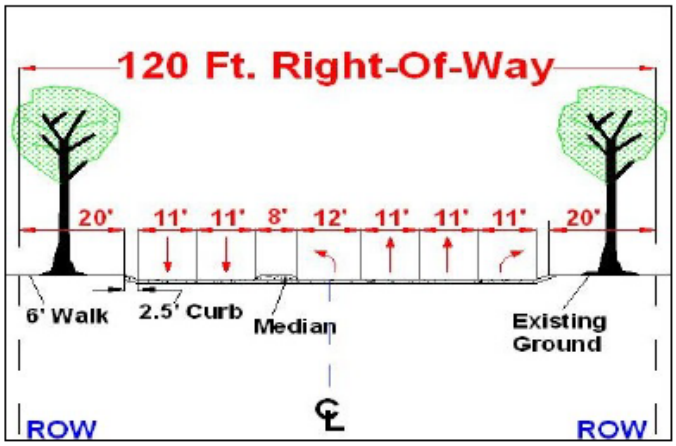
- Total ROW at approach is 150' for 250' from intersection
- 100' taper to the 120' ROW

- 25′ by 25′ corner clip to accommodate signals and walks



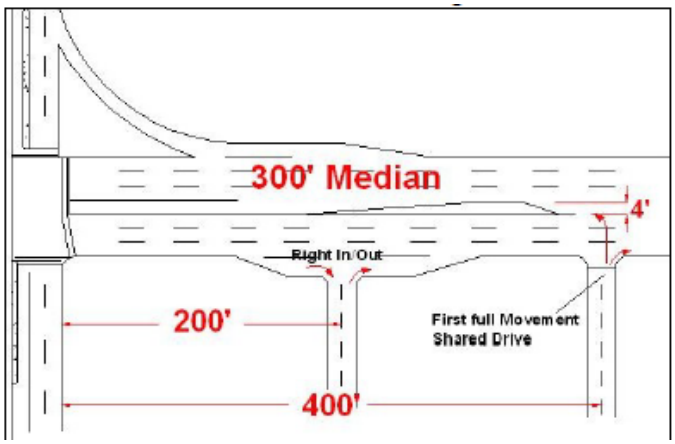
- Non-intersection ROW along major arterial is 120′

Typical configuration as shown below



Raised Center Medians at Major Approaches

- Include raised center medians at all major street approaches
- Designed to a minimum 300′ long and 4′ wide



Cross-Lot Access

- Encouraged between adjacent properties to minimize driveway accesses
- 30′ minimum width between properties
- Not really applicable

Deviation from Standards

Deviations are allowed where the character of the site, development, street, or area presents unusual conditions where application of the standards results in undue hardships or impracticalities.

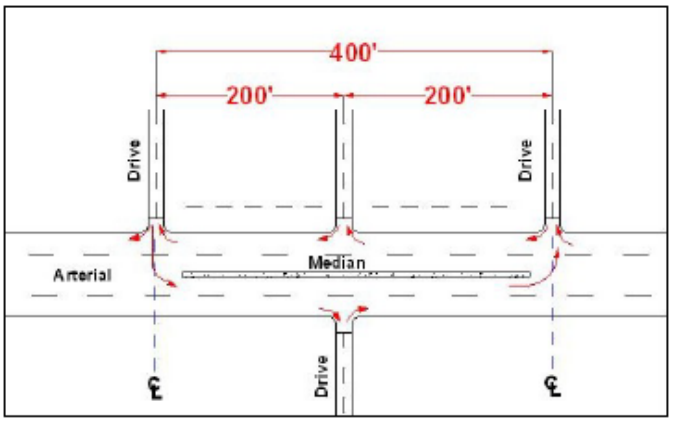
Driveway Setback on Arterial Intersections

- 200′ setback for the first right-in/out driveway from intersection
- 400′ setback for first full-turning movement driveway
- Distance measured from the point where the street ROWs intersect

Driveway Spacing on Major Arterials

Minimum driveway spacing:

- 400′ spacing between full-turning movement driveways on the same side of the street
- 200′ spacing for right-in/out driveways
- 200′ offset for drives not lined up on opposite sides of arterials and not having conflicting left turns
- 400′ offset for drives on opposite sides



Downtown Streetscape Design Guidelines

The Downtown Streetscape Design Guidelines help implement plans for downtown through a comprehensive design framework. To guide the street design, the framework uses a functional, contextual, and experiential input. It identifies six general street types and illustrates general cross-sections. It also provides a functional input matrix to aid in making individual determinations about street design. The framework focuses on providing context-sensitive street designs within downtown.

Bicycle Master Plan

The Wichita Bicycle Master Plan includes design guidance for facility types recommended by the Plan. Within Appendix G, the Plan offers considerations for different facility types and illustrates design options for specific accommodations. These designs are from the Manual on Uniform Traffic Control Devices (MUTCD) and the American Association of State Highway and Transportation Officials (AASHTO) guidance.

Pedestrian Master Plan

This plan is currently under development and may provide design guidance for pedestrian facilities.

Transit Vision Plan

This plan is under development and will guide future transit infrastructure. Although it is not anticipated to include design guidance, the location of future transit routing will provide locations for consideration of transit accommodations.

RELATED STANDARDS

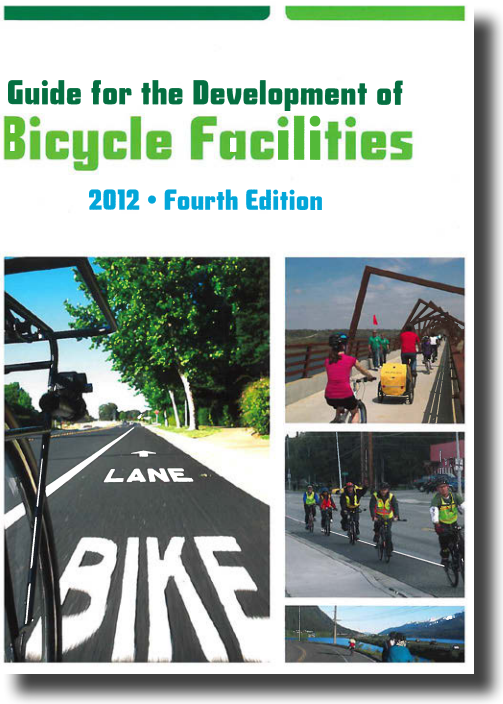
There are other agencies responsible for the design of roadways and other transportation facilities within the City of Wichita. For example, there are many highways through Wichita for which the Kansas Department of Transportation is responsible. The standards of other organizations responsible for facilities within the City of Wichita should be considered.

CHAPTER 3: NATIONAL GUIDANCE

This chapter identifies key national design guidance documents. The guidance documents will be used in coordination with City of Wichita guidance and processes to develop the street design guidelines currently being developed. This chapter provides references to illustrations in Appendix A showing different nationally accepted design treatments.

There are two main documents that establish national minimum standards for roadway design and and traffic control throughout the US. *A Policy on the Geometric Design of Highways and Streets (Green Book)* provides the primary configuration and design criteria for roadways. The *Manual on Uniform Traffic Control Devices (MUTCD)* defines acceptable traffic control standards for design features such as signage and pavement markings. Together, these two documents provide national consistency for designing streets to accommodate all users.

Building upon the MUTCD and Green Book, there are other guidance documents that focus on designs, controls, and applications for specific modes of travel.



For example, the *Guide for the Development of Bicycle Facilities* by the American Association of State Highway and Transportation Officials (AASHTO) provides specific guidance for accommodating bicycle travel. This guidance document (and others like it) should be used in conjunction with the Green Book and MUTCD.

NATIONAL GUIDANCE

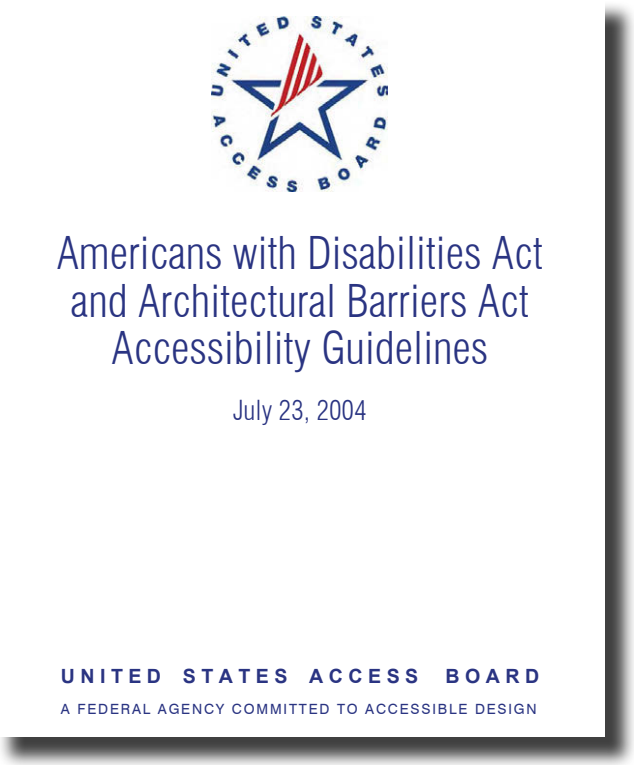
The National Association of City Transportation Officials (NACTO) has produced a guidance document for handling bicycle use along and crossing urban streets. Although there are many other guidance documents available, NACTO's *Urban Bikeway Design Guide* was selected as the source of graphic examples used in this document to illustrate most of the design treatments for bicycle facilities. This guide comprehensively illustrates the various design treatments within the context of the environment in which they would be used. The *Guide for the Development of Bicycle Facilities* by AASHTO also provides good reference in designing bicycle facilities.

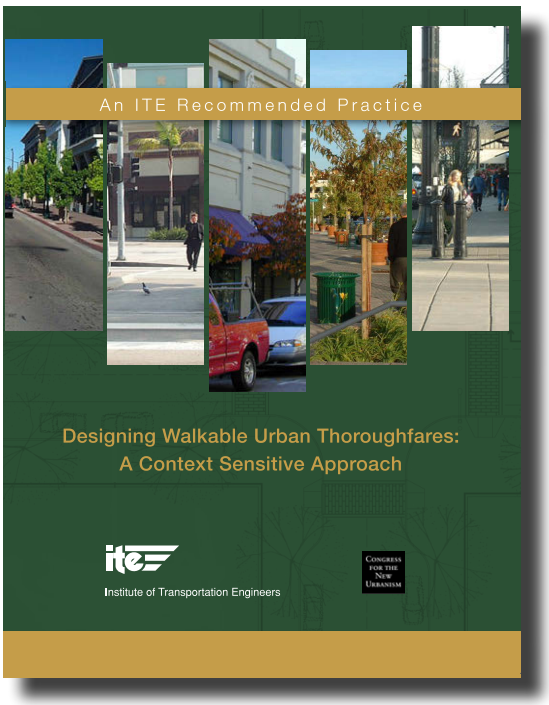
An influential guidance document for accommodating bicycles and pedestrians in street design is *Designing Walkable Urban Thoroughfares: A Context Sensitive Approach* produced by the Institute of Transportation

Engineers (ITE). Another document that will have major influence on design is the *Americans with Disabilities Act and Architectural Barriers Act Accessibility Guidelines* produced by the United States Access Board.

Illustrations of different designs from the aforementioned reference documents are included in Appendix A. These illustrations focus on bicycle facility accommodations due to their complex nature and comprehensive national guidance recently becoming available. The design of pedestrian and transit accommodations are included in some of the illustrations. The following list of design topics illustrated in Appendix A in the order shown:

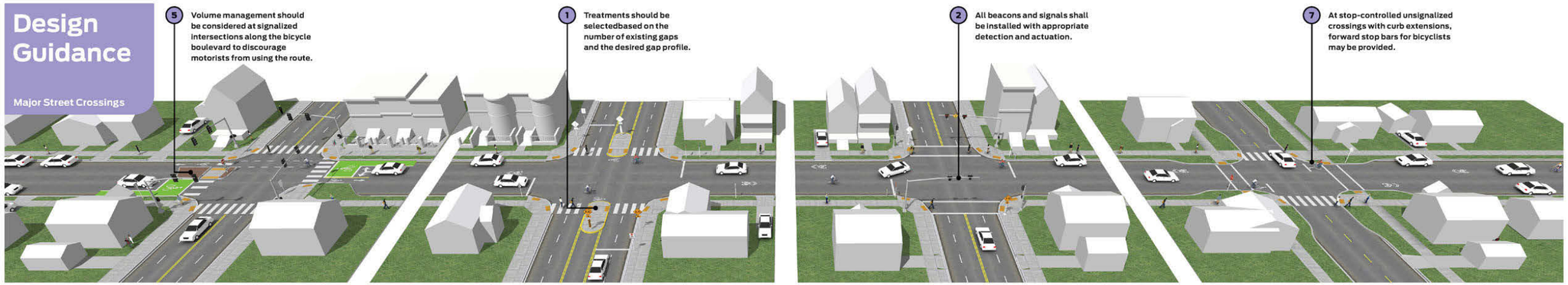
- Major Street Crossings
- Minor Street Crossings
- Signs and Pavement Markings
- Buffered Bike Lanes
- Conventional Bike Lanes
- Combined Bike Lane/Turn Lane
- Left Side Bike Lanes
- Through Bike Lanes
- Colored Bike Facilities
- Bike Boxes
- Shared Lane Markings
- Bicycle Signal Heads
- Bicycle Detection
- Hybrid Beacon for Bike Route Crossing
- Median Refuge Island
- Speed Management
- Volume Management
- Walkable Urban Thoroughfares
- Transit Facilities





APPENDIX A: DESIGN ILLUSTRATIONS

Exhibit A: Major Street Crossings



Required Features

1 Crossing devices shall be considered at any bicycle boulevard crossing of a roadway that is not stop controlled. Treatments should be selected based on the number of existing gaps and the desired gap profile.[163]

2 All beacons and signals shall be installed with appropriate detection and actuation, unless the bicycle boulevard crossing phase is set to recall each cycle.

Recommended Features

3 Supplemental signs and markings such as warning signs and crosswalk markings should be provided at bicycle boulevard crossings of major roads to improve crossing visibility.

4 At signalized intersections, longer minimum green times should be provided for bicyclists due to slower acceleration speeds. See detection and actuation for more information.

5 Volume management should be considered at signalized intersections along the bicycle boulevard to discourage motorists from using the route.

Optional Features

6 Geometric elements such as median refuge islands, curb extensions, neckdowns, and raised crosswalks may be provided to improve sight distance for bicyclists on the bicycle boulevard as well as for drivers on the cross street.

7 At stop-controlled unsignalized crossings with curb extensions, forward stop bars for bicyclists may be provided.

TUCSON, AZ (CREDIT: CITY OF TUCSON)

NACTO Urban Bikeway Design Guide

Table 6.2 Selected Characteristics of Walkable Thoroughfares

Characteristic	Walkable Thoroughfares	Vehicle-Oriented Thoroughfares
Target speed range	From Table 6.4.	25–35 mph.
Pedestrian separation from moving traffic	Curb parking and streetside furnishing zone.	Optional, typically separation achieved with planting strip.
Streetside width	Minimum 9 feet (residential) and 12 feet (commercial) to accommodate sidewalk, landscaping and street furniture.	Minimum 5 feet.
Block lengths	200–660 feet.	Up to one-quarter mile.
Protected pedestrian crossing frequency (pedestrian signals or high-visibility markings at unsignalized crossings)	200–600 feet.	As needed to accommodate pedestrian demands.
Pedestrian priority at signalized intersection	Pedestrian signals and pedestrian countdown heads, adequate crossing times, shorter cycle lengths and median refuges for very long crossings.	Vehicle priority; may have longer cycle lengths and require two cycles for slower pedestrians to cross wide streets with medians.
Pedestrian crossings	High-visibility crosswalks shortened by curb extensions where there is on-street parking.	Full street width.
Median width	6 feet minimum width at crosswalk, if used as pedestrian refuge, plus 10 feet for left-turn lane, if provided. 14 foot total width for left-turn lane if no refuge needed.	14–18 feet for single left-turn lane; 26–30 feet for double left-turn lane.
Vehicular access across sidewalks	24 feet or less, except if specific frequent design vehicle requires added width.	As needed.
Curb parking	Normal condition except at bus stops and pedestrian crossings.	None.
Curb return radius	10–30 feet; low-speed channelized right turns where other options are unworkable.	30–75 feet; high-volume turns channelized.

PORTLAND, OR

Crossing major streets without signalization requires an adequate number of acceptable gaps. Treatments that reduce the duration of the minimum acceptable gap can improve the number of crossing opportunities for bicyclists.

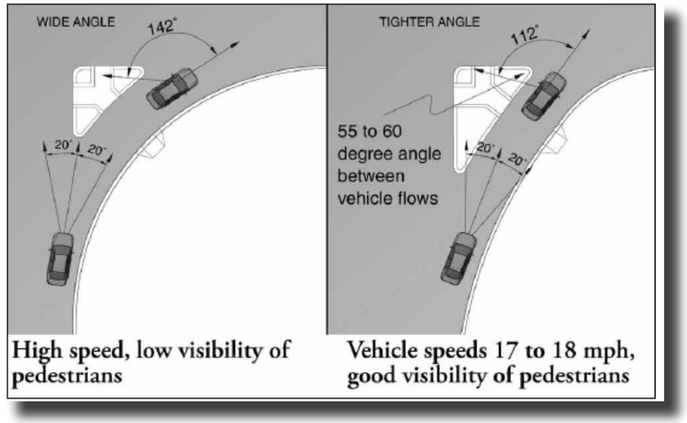
To calculate the minimum acceptable gap for a bicyclist to cross a major roadway the following equation is adapted from the ITE Manual of Traffic Engineering Studies (describing minimum acceptable gaps for pedestrians):

$$G = (W/S) + R$$

G = minimum acceptable gap, sec
W = crossing distance or width of roadway, ft
S = bicycling speed, ft/s (assumed to be 10 ft/sec for a bicyclist)
R = start-up time, s

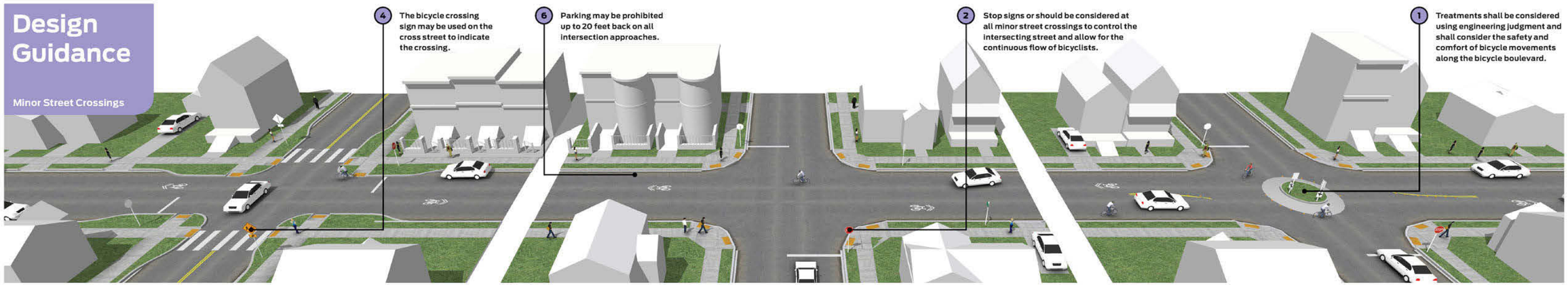
A **bicycle forward stop bar** can reduce the minimum acceptable gap by one second per side of the street.

A **median refuge area** can cut the acceptable gap needed to cross a major street by 50 percent.



ITE Designing Walkable Urban Thoroughfares

Exhibit B: Minor Street Crossings



Curb Extensions | Stop Sign for Cross Traffic | Neighborhood Traffic Circle

Required Features

1 There is no minimum required element to a minor street crossing since they can vary significantly depending on the geometry and the speed/volume of cross traffic. Treatments shall be considered using engineering judgment and shall consider the safety and comfort of bicycle movements along the bicycle boulevard.

Recommended Features

2 Stop signs or geometric design elements should be considered at all minor street crossings to control the intersecting street and allow for the continuous flow of bicyclists.[158]

3 Stop signs should control cross traffic only along the bicycle boulevard. If vehicle traffic increases along the bicycle boulevard, implement volume control measures. If vehicle speeds increase along the bicycle boulevard, implement speed control measures.

Optional Features

4 The bicycle crossing sign (MUTCD sign W11-1; may be supplemented with AHEAD plaque) may be used on the cross street to indicate the crossing.

5 The CROSS TRAFFIC DOES NOT STOP plaque (MUTCD sign W4-4P) may be used in combination with a STOP sign on the cross street to indicate the crossing.

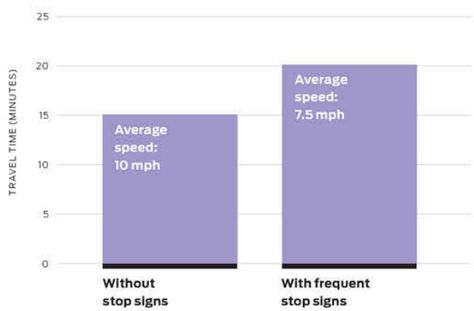
6 Parking may be prohibited up to 20 feet back on all intersection approaches to improve visibility.

7 A sign using the bicycle boulevard branding with an arrow may be used on the cross street to indicate the crossing.

BERKELEY, CA

NACTO Urban Bikeway Design Guide

BERKELEY, CA



Calculations assume a 2.5 mile trip distance. Delay calculation adapted from: City of Berkeley. (2000). Bicycle Boulevard Design Tools and Guidelines.

Exhibit C: Signs and Pavement Markings

Required Features

1 Bicycle wayfinding signage and pavement markings shall be included on bicycle boulevards. Pavement markings and identification/wayfinding signs provide a strong visual identity for the street and designate the corridor as a bicycle route.

2 Where the bicycle boulevard turns or jogs onto another street, signs and/or markings shall be provided to indicate how users can remain on the route.

3 Center line stripes (if present) shall be removed or not repainted, except for short sections on intersection approaches that have a stop line or traffic circle. Drivers have an easier time passing bicyclists on roads that do not have centerline stripes. If vehicles cannot easily pass each other using the full width of the street, it is likely that there is too much traffic for the street to be a successful bicycle boulevard.[128]

Recommended Features

4 Pavement markings should be large enough to be visible to all road users; 112 inches by 40 inches (the standard size of a shared lane marking) is the minimum recommended size.

5 Decision and turn signs should include destinations with arrows and distance and/or bicycling times. Bicycling time should assume a typical speed of 10 mph.

6 Advanced crossing warning signs such as MUTCD sign W11-1 (bicycle crossing; may be supplemented with AHEAD plaque) should be placed on intersecting streets with more than 5,000 vpd. A non-standard sign using the coloration and style of other bicycle boulevard signs may be used with an arrow showing bi-directional cross traffic.

7 On narrow local streets where it can be difficult for cars traveling in opposite directions to pass, pavement markings should be applied in closer intervals near the center of the travel lane.

Optional Features

8 Signs may differ from those outlined in the MUTCD to highlight or brand the bicycle boulevard network. If used, signs shall be consistent in content, design, and intent; colors reserved by the MUTCD Section 1A.12 for regulatory and warning road signs (red, yellow, orange, etc.) are not recommended. Green, blue and purple are commonly used.

9 Confirmation signs may include destinations and distance and/or bicycling times.

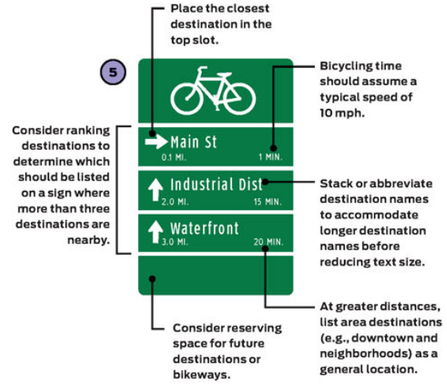
10 To minimize sign clutter, a bicycle symbol may be placed on a standard street name sign, along with distinctive coloration.[129]

11 Either shared lane markings or non-standard markings may be used along bicycle boulevards.

12 On particularly narrow streets (approximately 25 feet wide with parking), shared lane marking stencils may be placed either in the center of the lane facing each other, or with the bicycle marking in the center of the roadway and two sets of chevrons offset 1 foot in each direction or travel.

13 For wayfinding purposes, the orientation of the chevron marking at offset intersections may be adjusted to direct bicyclists along discontinuous routes. Alternately, an arrow may be used with the chevrons to indicate the direction of the turn.

14 On-street parking spaces may be delineated with paint or other materials to clearly indicate where a vehicle should be parked and to discourage motorists from parking their vehicles too far into the adjacent travel lane.[130]



NACTO Urban Bikeway Design Guide

Exhibit D: Buffered Bike Lanes

Design Guidance

Buffered Bike Lanes

Required Features

(1) Bicycle lane word and/or symbol and arrow markings (MUTCD Figure 9C-3) shall be used to define the bike lane and designate that portion of the street for preferential use by bicyclists.[9]

(2) The buffer shall be marked with 2 solid white lines, with diagonal hatching if 3 feet in width or wider. White lines on both edges of the buffer space indicate lanes where crossing is discouraged, though not prohibited. For clarity, consider dashing the buffer boundary where cars are expected to cross at driveways.[10]

(3) The buffer area shall have interior diagonal cross hatching or chevron markings if 3 feet in width or wider.[11]

Recommended Features

(4) If used, interior diagonal cross hatching should consist of 4 inch lines angled at 30 to 45 degrees and striped at intervals of 10 to 40 feet. Increased striping frequency may increase motorist compliance.[12]

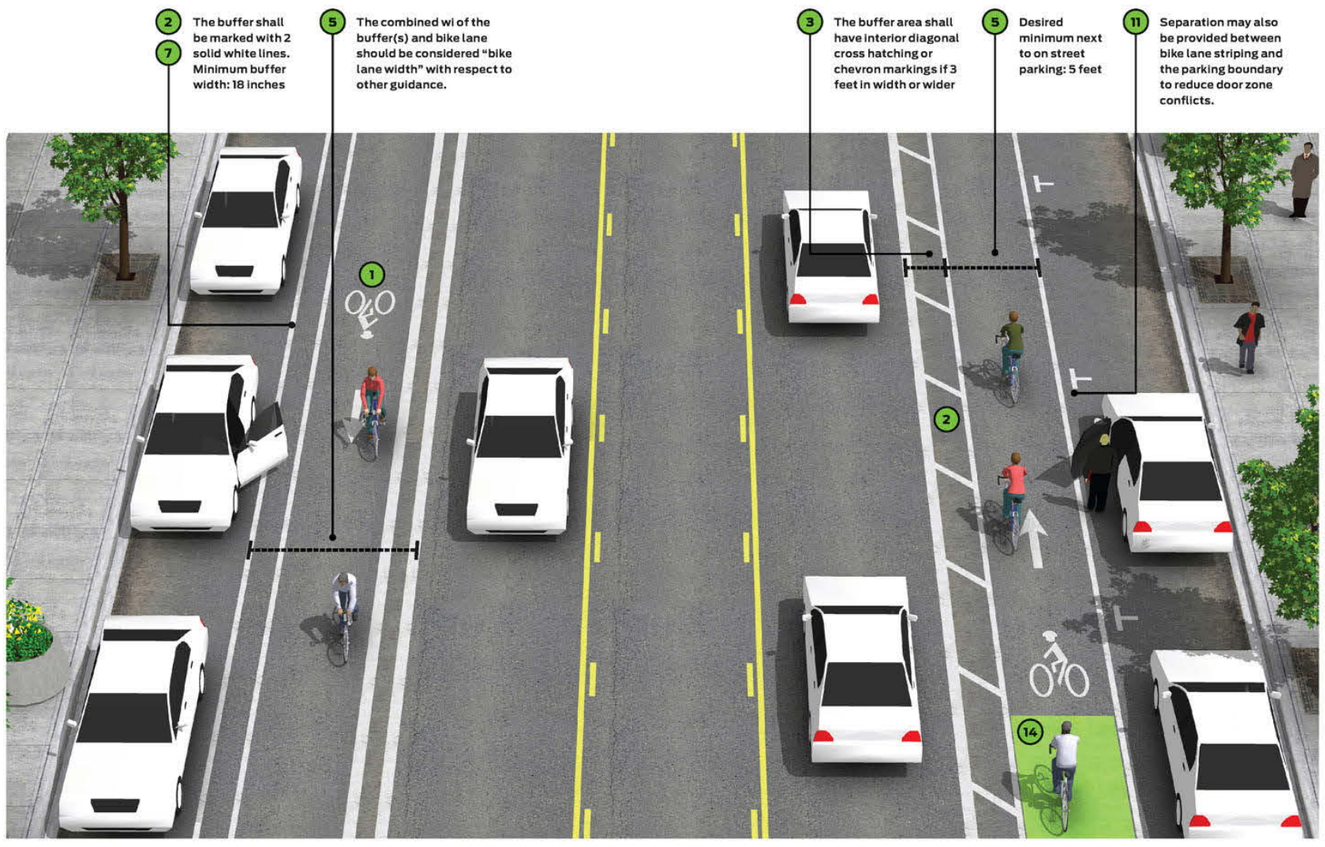
(5) The combined width of the buffer(s) and bike lane should be considered "bike lane width" with respect to guidance given in other documents that don't recognize the existence of buffers. Where buffers are used, bike lanes can be narrower because the shy distance function is assumed by the buffer. For example, a 3 foot buffer and 4 foot bike lane next to a curb can be considered a 7 foot bike lane. For travel side buffered lanes next to on street parking, a 5 foot minimum width is recommended to encourage bicyclists to ride outside of the door zone.

(6) Where bicyclist volumes are high, bicyclist speed differentials are significant, or where side-by-side riding is desired, the desired bicycle travel area width is 7 feet.

(7) Buffers should be at least 18 inches wide because it is impractical to mark a zone narrower than that.

(8) On intersection approaches with right turn only lanes, the bike lane should be transitioned to a through bike lane to the left of the right turn only lane, or a combined bike lane/turn lane should be used if available road space does not permit a dedicated bike lane.

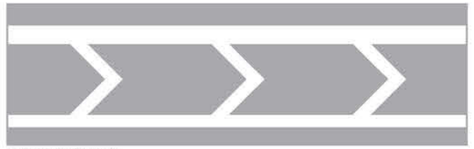
(9) On intersection approaches with no dedicated right turn only lane the buffer markings should transition to a conventional dashed line. Consider the use of a bike box at these locations.



Parking Side Buffer Configuration

Travel Side Buffer Configuration

MUTCD FIGURE 3B-24



MUTCD FIGURE 3B-24

MUTCD FIGURE 3D-2

Optional Features

(10) Like a conventional bike lane, a wide (6 to 8 inch) solid white line may be used to mark the edge adjacent to a motor vehicle travel lane. For a parking side buffer, parking T's or a solid line are acceptable to mark between a parking lane and the buffer.

(11) For travel lane buffer configurations, separation may also be provided between bike lane striping and the parking boundary to reduce door zone conflicts. This creates a type of parking-side buffer.

(12) On wide one-way streets with buffered bike lanes, consider adding a buffer to the opposite side parking lane if the roadway appears too wide. This will further narrow the motor vehicle lanes and encourage drivers to maintain lower speeds.

(13) The interior of the buffer area may use different paving materials to separate it from the bike lane. Textured surface materials may cause difficulties for bicyclists as surfaces may be rough. Increased maintenance requirements are likely.

(14) Color may be used at the beginning of each block to discourage motorists from entering the buffered lane. For other uses of color in buffered bike lanes see colored bike facilities.

NACTO Urban Bikeway Design Guide

APPENDIX A: DESIGN ILLUSTRATIONS

Exhibit E: Conventional Bike Lanes

Design Guidance

Conventional Bike Lanes

Required Features

(1) The desirable bike lane width adjacent to a curbface is 6 feet. The desirable ridable surface adjacent to a street edge or longitudinal joint is 4 feet, with a minimum width of 3 feet. In cities where illegal parking in bike lanes is an concern, 5 foot wide bike lanes may be preferred.[2]

(2) When placed adjacent to a parking lane, the desirable reach from the curb face to the edge of the bike lane (including the parking lane, bike lane, and optional buffer between them) is 14.5 feet; the absolute minimum reach is 12 feet. A bike lane next to a parking lane shall be at least 5 feet wide, unless there is a marked buffer between them. Wherever possible, minimize parking lane width in favor of increased bike lane width.[3]

(3) The desirable bike lane width adjacent to a guardrail or other physical barrier is 2 feet wider than otherwise in order to provide a minimum shy distance from the barrier.[4]

(4) Bicycle lane word and/or symbol and arrow markings (MUTCD Figure 9C-3) shall be used to define the bike lane and designate that portion of the street for preferential use by bicyclists.[5]

(5) Bike lane word, symbol, and/or arrow markings (MUTCD Figure 9C-3) shall be placed outside of the motor vehicle tread path at intersections, driveways, and merging areas in order to minimize wear from the motor vehicle path.

(6) A solid white lane line marking shall be used to separate motor vehicle travel lanes from the bike lane. Most jurisdictions use a 6 to 8 inch line.[6]

(7) A through bike lane shall not be positioned to the right of a right turn only lane or to the left of a left turn only lane (MUTCD 9C.04). A bike lane may be positioned to the right of a right turn only lane if split-phase signal timing is used. For additional information, see bicycle signal heads. For additional strategies for managing bikeways and right turn lanes, see through bike lanes in this guide.

Recommended Features

(8) Bike lanes should be made wider than minimum widths wherever possible to provide space for bicyclists to ride side-by-side and in comfort. If sufficient space exists to exceed desirable widths, see buffered bike lanes. Very wide bike lanes may encourage illegal parking or motor vehicle use of the bike lane.

(9) When placed adjacent to parking, a solid white line marking of 4 inch width should be used between the parking lane and the bike lane to minimize encroachment of parked cars into the bike lane.[7]

(10) Gutter seams, drainage inlets, and utility covers should be flush with the ground and oriented to prevent conflicts with bicycle tires.[8]

(11) If sufficient space exists, separation should be provided between bike lane striping and parking boundary markings to reduce door zone conflicts. Providing a wide parking lane may offer similar benefits. Refer to buffered bike lanes for additional strategies.

(12) If sufficient space exists and increased separation from motor vehicle travel is desired, a travel side buffer should be used. Refer to buffered bike lanes for additional details.

(13) Lane striping should be dashed through high traffic merging areas. See through bike lanes for more information.

(14) The desirable dimensions should be used unless other street elements (e.g., travel lanes, medians, median offsets) have been reduced to their minimum dimensions.

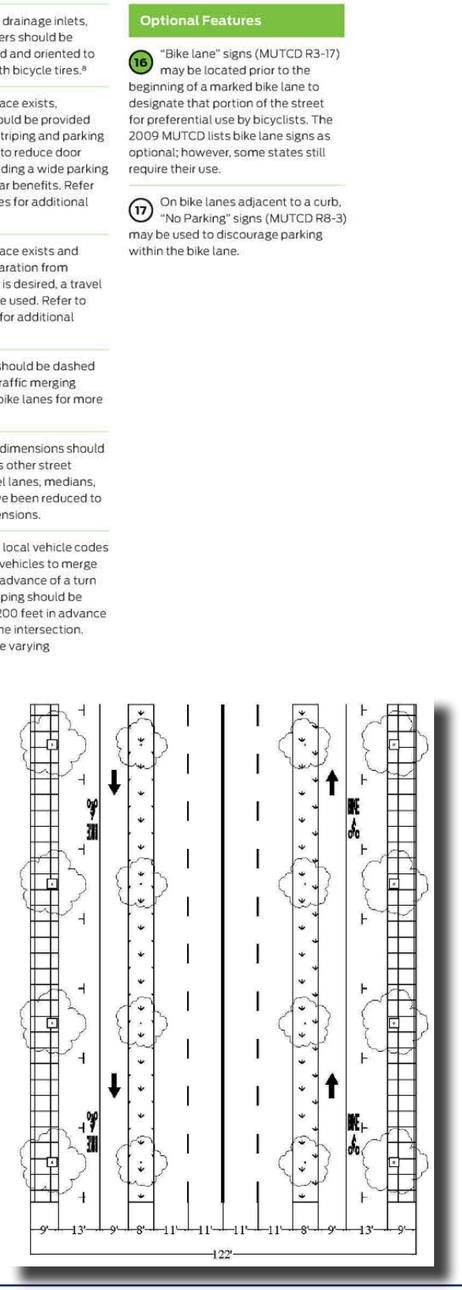
(15) In cities where local vehicle codes require motor vehicles to merge into the bike lane in advance of a turn movement, lane striping should be dashed from 50 to 200 feet in advance of intersections to the intersection. Different states have varying requirements.

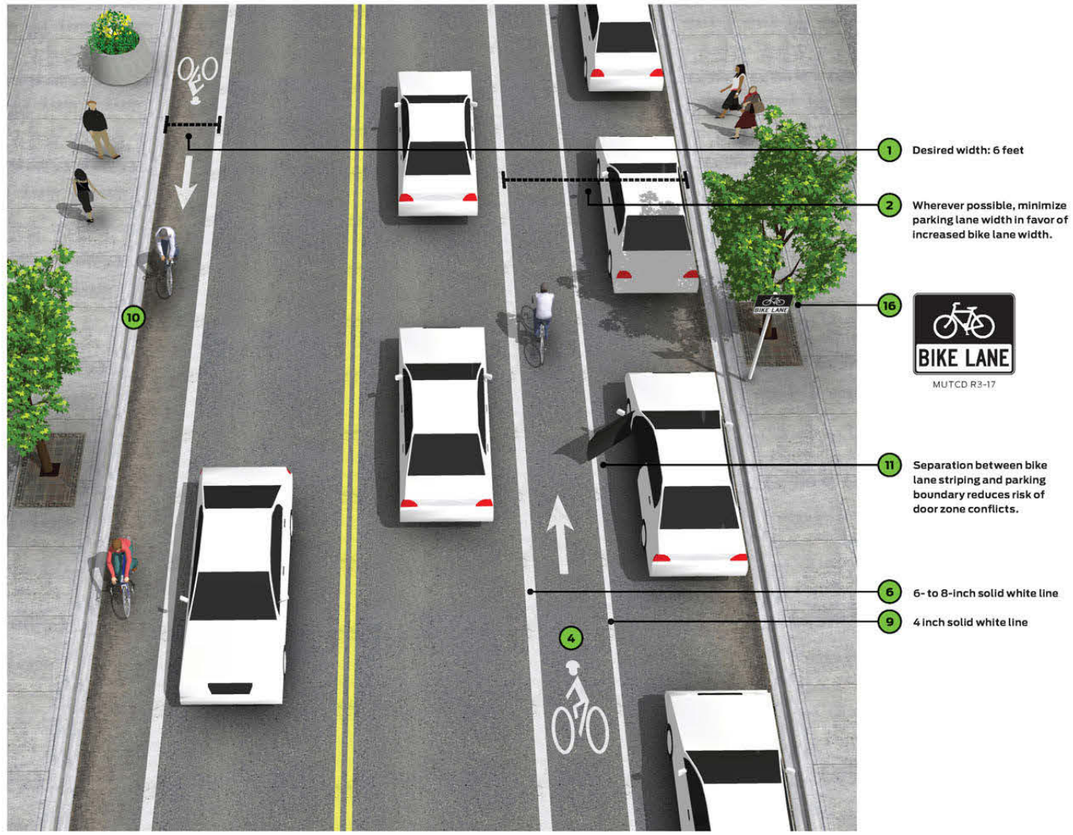
Optional Features

(16) "Bike lane" signs (MUTCD R3-17) may be located prior to the beginning of a marked bike lane to designate that portion of the street for preferential use by bicyclists. The 2009 MUTCD lists bike lane signs as optional; however, some states still require their use.

(17) On bike lanes adjacent to a curb, "No Parking" signs (MUTCD R8-3) may be used to discourage parking within the bike lane.

NACTO Urban Bikeway Design Guide





	Minimum Width	Recommended Width
Bicycle lane width—combined with on-street parking lane		
All thoroughfare types	13 feet	13 feet
Bicycle lane width—no on-street parking		
All thoroughfare types	5 feet[1]	6 feet

ITE Designing Walkable Urban Thoroughfares

Exhibit F: Combined Bike Lane/Turn Lane

Design Guidance

Combined Bike Lane/ Turn Lane

Guidance for conventional bicycle lanes and intersection crossing markings may also apply. When configured as a mixing zone for a cycle track, additional guidance for a cycle track intersection approach may also apply.

Required Features

(1) Some form of bicycle marking shall be used to clarify bicyclist positioning within the combined lane.

Recommended Features

(2) Within the combined lane, the bicycle area width should be 4 feet minimum.

(3) Width of combined lane should be 9 feet minimum, 13 feet maximum. A full bicycle through lane can be accommodated if the vehicle right turn only lane can be made 14 feet or wider.

(4) A dotted 4 inch line and bicycle lane marking should be used to bicyclist positioning within the combined lane without excluding cars from the suggested bicycle area.

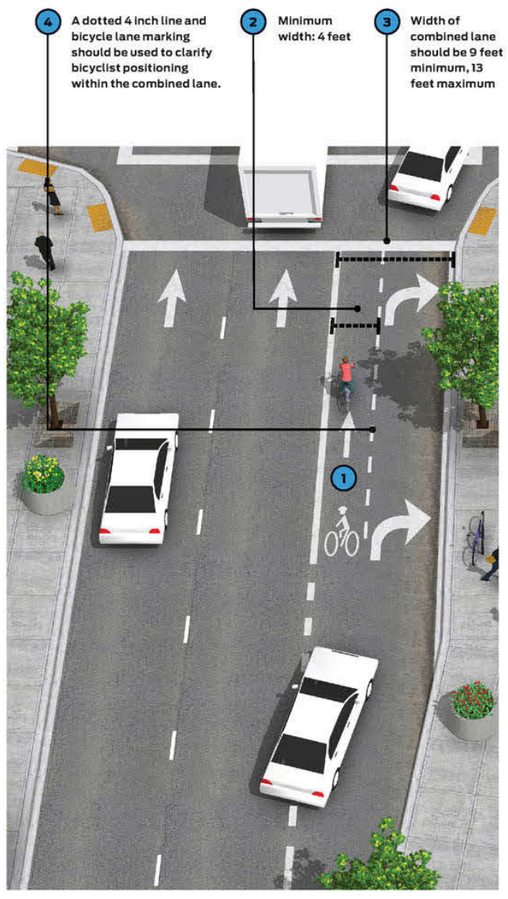
(5) If the right lane is signed for "Right Turn Only," or if a sign is otherwise needed to make it legal for through bicyclists to use a right turn lane, signage should be installed in advance alerting the start of the combined turn lane.

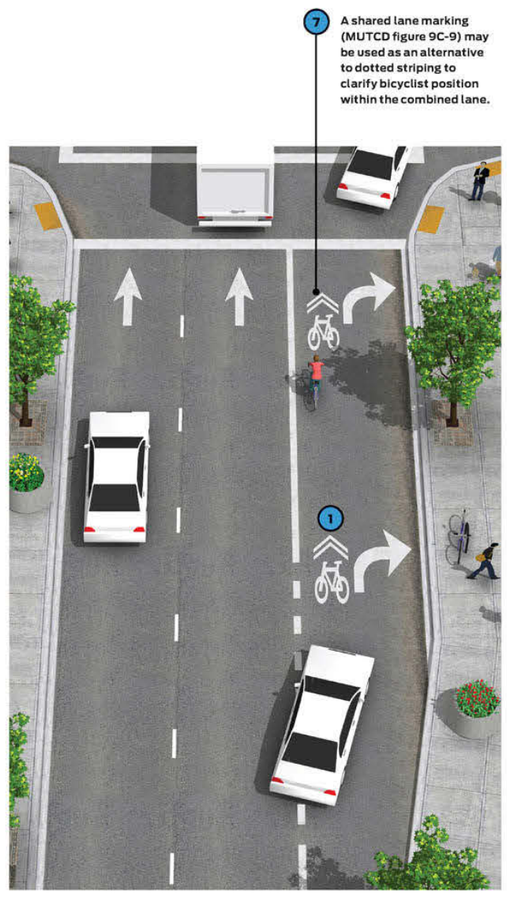
(6) If configured as a mixing zone on a cycle track corridor, the following features are recommended:

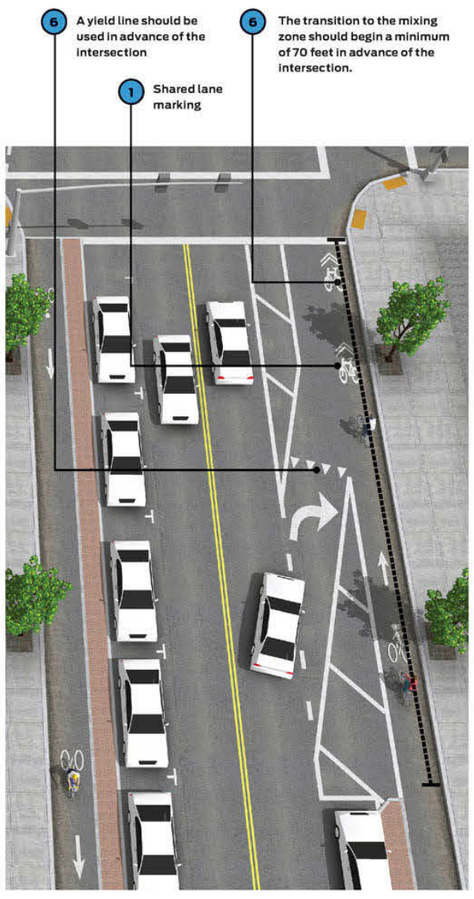
- A Turning Vehicles Yield to Bikes (modified R10-15) sign should be used in advance of the mixing zone.
- A yield line should be used in advance of the mixing zone.
- The transition to the mixing zone should begin a minimum of 70 feet in advance of the intersection. Mixing zones that are shorter in length and begin abruptly encourage slower vehicle speed.

Optional Features

(7) A shared lane marking (MUTCD figure 9C-9) may be used as an alternative to dotted striping to clarify bicyclist position within the combined lane.







NACTO Urban Bikeway Design Guide

Exhibit G: Left Side Bike Lanes

Design Guidance

Left-Side Bike Lanes

Required Features

1. Design guidance for conventional bike lanes applies to this treatment.

2. Left side bike lanes shall only be placed on the left side of one-way streets or two-way median divided streets.

Recommended Features

3. Signage should accompany left-side bicycle lanes to clarify proper use by bicyclists and may be effective in reducing wrong-way riding. Modified MUTCD R3 series sign shown.

4. Bicycle through lanes should be provided to the right of vehicle left turn pockets to reduce conflicts at intersections. This is important for through bicyclists as well as left turning bicyclists as left turning vehicles will cross paths with a left turning bicyclist. Additional guidance can be found in through bicycle lanes in this guide.

5. Where bicyclist demand is high and street space permits, a buffered bike lane configuration or wider than minimum dimensions should be used to allow bicyclists to pass one another without encroaching upon the adjacent travel lane.

6. Intersection treatments such as bike boxes and bike signals, should be considered to assist in the transition from left-side bike lanes to right-side bike lanes.

7. A "Yield to Bikes" sign should be post-mounted in advance of and in conjunction with a left turn lane to reinforce that bicyclists have the right-of-way going through the intersection.[15]

Optional Features

8. Colored pavement may be used along the facility to draw attention to the unique function of the lane, or within conflict areas for increased visibility of bicyclists.

BOSTON, MA

SAN FRANCISCO, CA

NACTO Urban Bikeway Design Guide

Exhibit H: Through Bike Lanes

Design Guidance

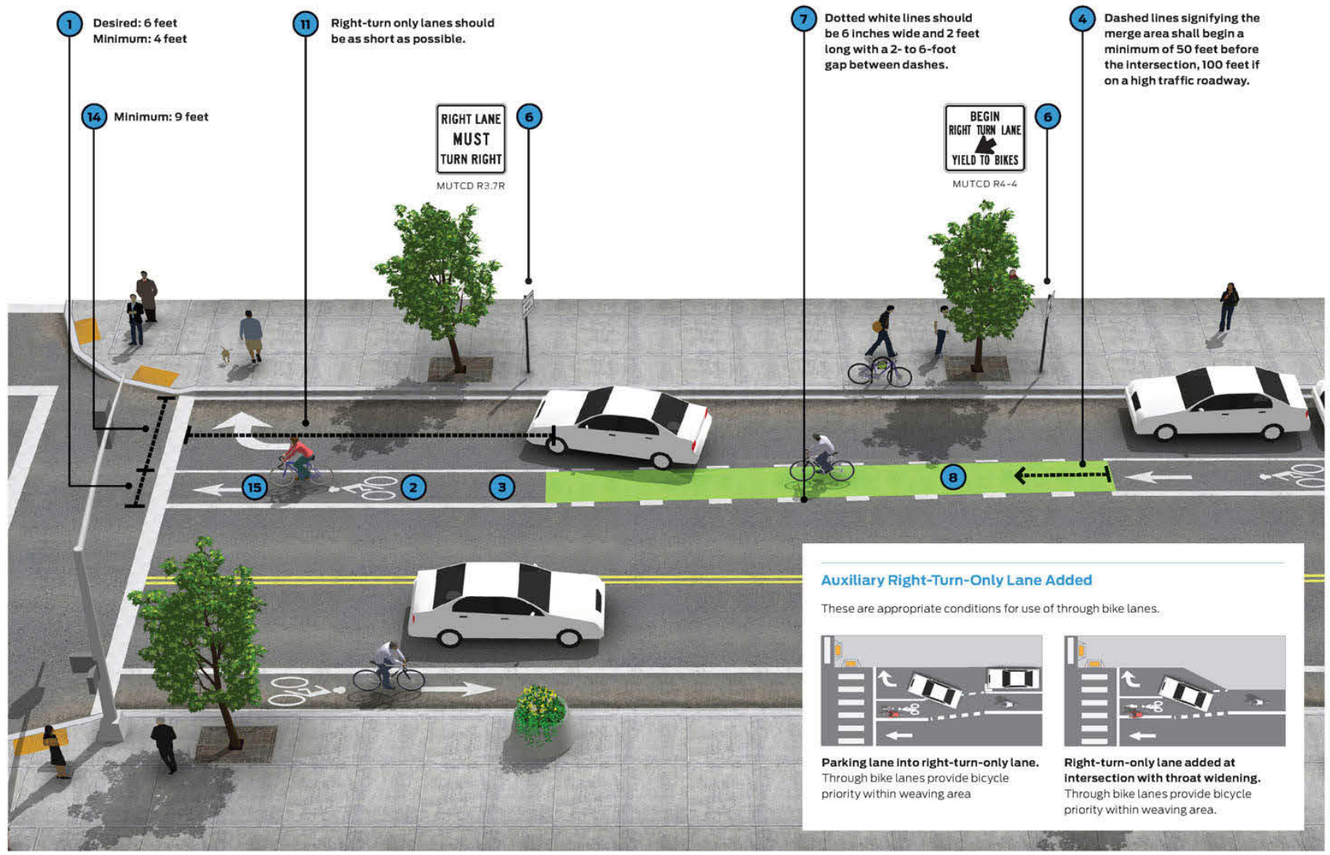
Through Bike Lanes

Required Features

1. The desired width of a dashed bike transition lane and through bike lane is 6 feet with a minimum width of 4 feet.
2. Bicycle lane word and/or symbol and arrow markings (MUTCD Figure 9C-3) shall be used to define the bike lane and designate that portion of the street for preferential use by bicyclists.
3. The through bike lane shall be placed to the left of the right-turn only lane.
4. Dotted lines signifying the merge area shall begin a minimum of 50 feet before the intersection (MUTCD). Dotted lines should begin 100 feet before the intersection if along a high speed/volume roadway.
5. Dotted lane line transition areas to through bike lanes shall not be used on streets with double right turn lanes. Double right turn lanes are extremely difficult for bicyclists to negotiate. Shared lane markings may be used in the center of the inside turn lane to designate the preferred path of through bicycle travel.

Recommended Features

6. Accompanying signage should include R3-7R "Right Lane Must Turn Right" and R4-4 "Begin Right Turn Yield to Bikes" (MUTCD).
7. Dotted white lines should be 6 inches wide and 2 feet long with a 2- to 6-foot gap between dashes (MUTCD).
8. Through bike lanes should be provided at any intersection approach where a right turn only auxiliary lane is created (also known as a right turn add lane). It is desirable for bicyclists to travel straight through the merging area to reinforce right-of-way.
9. Dotted lane line transition areas to through bike lanes should not be provided at any intersection approach where a through travel lane transitions into a right turn only lane (also known as a right turn drop or trap lane). In such instances consider utilizing an exclusive bicycle signal phase with the bike lane remaining to the right, or not delineating the merging area connecting to the through bicycle lane. Shared lane markings may be used to provide additional guidance.
10. At intersections with high right turning vehicle volumes, high bicyclist volumes, or along priority bicycle corridors, treatments beyond dotted white lines such as coloring and increased signing should be provided.
11. Right-turn only lanes should be as short as possible in order to limit the speed of cars in the right turn lane. Fast moving traffic on both sides can be uncomfortable for bicyclists.



Auxiliary Right-Turn-Only Lane Added

These are appropriate conditions for use of through bike lanes.

Parking lane into right-turn-only lane. Through bike lanes provide bicycle priority within weaving area

Right-turn-only lane added at intersection with throat widening. Through bike lanes provide bicycle priority within weaving area.

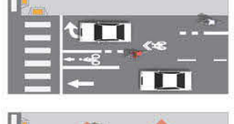
12. Terminating the bike lane in advance of the intersection is discouraged.
13. For intersections that lack the physical width to install a bicycle pocket, a combined bike/turn lane should be used.
14. Vehicle turn lane width should not be reduced to less than 9 feet.
15. Bicycle detection should be provided within the through bike lane.

Optional Features

16. On streets with a combined turn and through lane, shared lane markings may be used in the center of the lane.
17. A bike box may be used in lieu of a designated through bike lane.
18. Bicycle warning signs may be used in advance of the merge/transition area.

Through Travel Lane Transitions into Right-Turn-Only Lane

These are generally inappropriate conditions for use of through bike lanes. Consider alternate treatments.



Exclusive bicycle signal phase used to separate conflicting movements.

Bicycle lane dropped in advance of the intersection encourages bicyclists to merge across as gaps permit. Shared lane markings may be used to provide additional guidance.

Bicyclists are not provided priority in weaving area and must use caution to merge across potentially high-speed motor vehicle traffic. Dotted lane line transition areas to through bike lanes should not be provided at these locations.

NACTO Urban Bikeway Design Guide

Exhibit I: Colored Bike Facilities

Design Guidance

Colored Bike Facilities

Required Features

1. The color green shall be used to minimize confusion with other standard traffic control markings.[97]
2. Color shall be applied to the road surface to delineate space, increase visibility, and emphasize proper vehicle priority.[98]
3. Normal white bike lane lines shall be provided along the edges of the colored lane to provide consistency with other facilities and to enhance nighttime visibility.

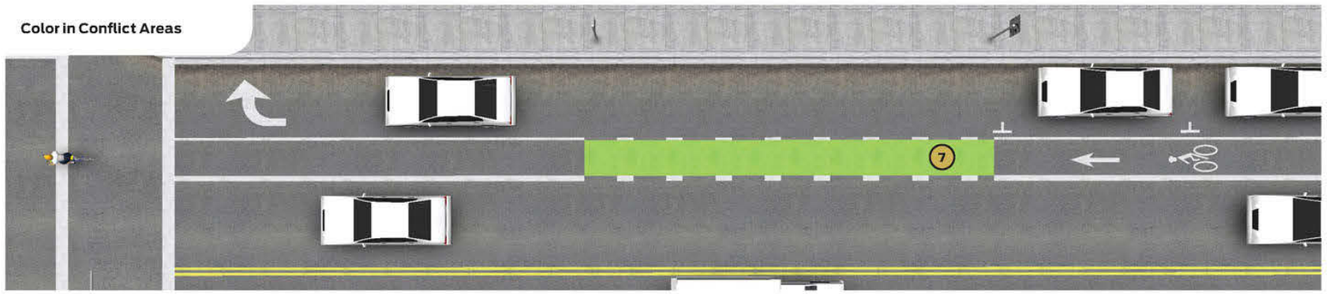
Recommended Features

4. The colored surface should be skid resistant and retro-reflective.
5. A "Yield to Bikes" sign should be used at intersections or driveway crossings to reinforce that bicyclists have the right-of-way at colored bike lane areas.[99]
6. The configuration of color should be consistently applied throughout the corridor.

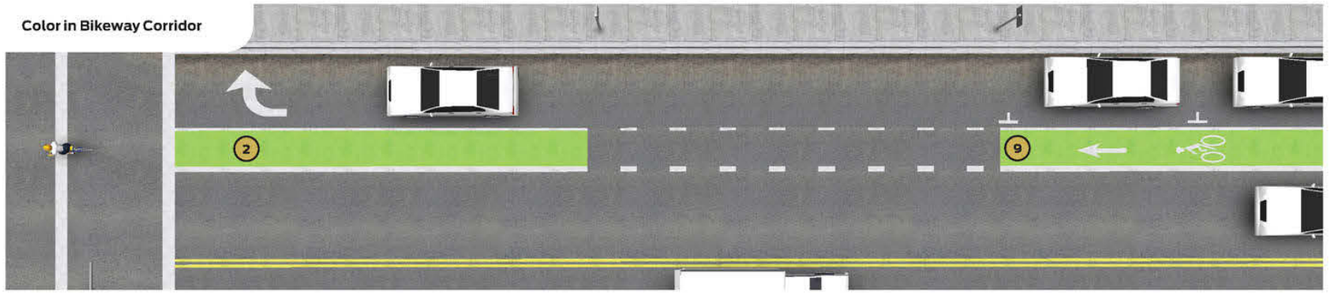
Optional Features

7. Color may be applied within conflict areas for increased visibility of bicyclists.
8. Color may be applied along a dashed pattern within a dashed bicycle lane to indicate merging areas. Dashed application of colored pavement mimics typical traffic striping layouts, where dashed markings indicate areas where merging maneuvers are permitted.[100]
9. Color may be applied along a corridor, with gaps in coloring to denote crossing areas. When used in this fashion, color can distinguish the bicycle facility along its entire length. This is particularly useful in high traffic situations or areas where traffic may encroach into the bike facility.[101]
10. Color may be used to supplement shared lane markings for added visibility.[102]

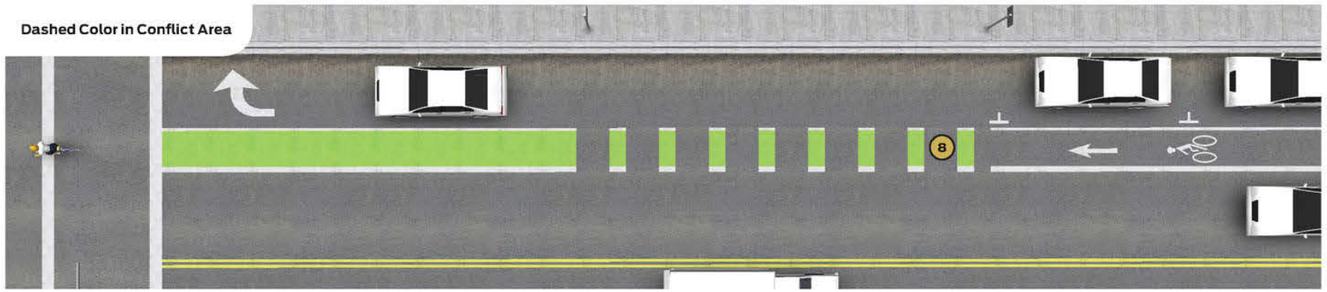
Color in Conflict Areas



Color in Bikeway Corridor



Dashed Color in Conflict Area



TUSCON, AZ

SAN FRANCISCO, CA (PHOTO: SFSTREETSBLOG)

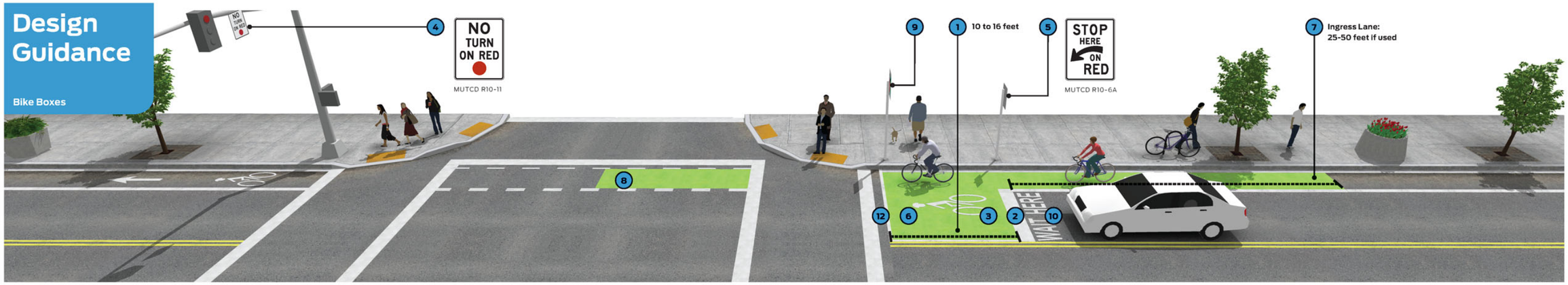
CHICAGO, IL

Best estimates for safety effects of one blue cycle crossing in a junction are a reduction of 10% in accidents and 19% in injuries.

Jensen, S. U. (2008). Safety effects of blue cycle crossings: A before–after study. Accident Analysis & Prevention, 40(2): 742-750.

NACTO Urban Bikeway Design Guide

Exhibit J: Bike Boxes



Required Features

1. A box formed by transverse lines shall be used to hold queuing bicyclists, typically 10 to 16 feet deep. Deeper boxes show less encroachment by motor vehicles.[51]

2. Stop lines shall be used to indicate the point behind which motor vehicles are required to stop in compliance with a traffic control signal. See MUTCD 3B.16.[52]

3. Pavement markings shall be used and centered between the crosswalk line and the stop line to designate the space as a bike box. The marking may be a Bike Symbol (MUTCD 9C-3A) or Helmeted Bicyclist Symbol (MUTCD 9C-3B.)

4. In cities that permit right turns on red signal indications, a "No Turn on Red" sign shall be installed overhead to prevent vehicles from entering the Bike Box.

Recommended Features

5. A "Stop Here on Red" sign should be post-mounted at the stop line to reinforce observance of the stop line. Additional signs may be used to clarify signal control. Among the legends that may be used for this purpose are "Bikes Stop Here on Red" or a supplemental "Except Bicycles" plaque in conjunction with R10-6 to indicate the bicyclist stop line.

6. Colored pavement should be used as a background color within the bike box to encourage compliance by motorists.[53]

7. An ingress lane should be used to define the bicycle space. Colored pavement may be used. When color is used, length shall be 25 to 50 feet to guarantee bicycle access to the box.[54]

8. An egress lane should be used to clearly define the potential area of conflict between motorists and bicyclists in the intersection when intersection is operating on a green signal indication. Refer to intersection crossing markings in this guide. Colored pavement or other markings may be used to define the potential area of conflict. An egress lane should not be used when there is no complimentary bicycle facility or lane on the far side of the intersection.[55]

9. A "Yield to Bikes" sign should be post-mounted in advance of and in conjunction with an egress lane to reinforce that bicyclists have the right-of-way going through the intersection.[56]

Optional Features

10. A "Wait Here" legend marking may be used to supplement the stop line and "Stop Here on Red" sign at a bike box.[57]

11. Stop lines may be placed up to 7 feet in advance of the bike box space to limit encroachment by motor vehicles.

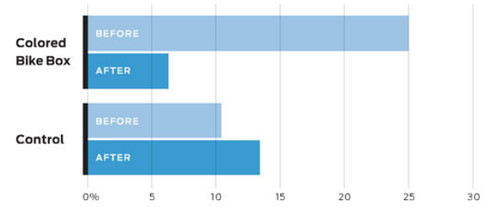
12. The box may be setback from the pedestrian crossing to minimize encroachment by cyclists into the pedestrian crossing.

13. Bike boxes may extend across multiple travel lanes to facilitate bicyclist left turn positioning. A two-stage turn queue box may be an alternative approach to facilitating left turns where there are multiple vehicle through lanes.[58]

14. Bike boxes may be combined with an exclusive bicycle signal phase or leading bicycle interval through the use of bicycle signal heads to allow clearance of the bicycle queue prior to the green indication for motorists.[59]

15. At areas with high volumes of right turning vehicles, an active display sign may be used to further alert drivers to the potential of conflict movements with bicyclists. This sign should use signal detection and actuation to activate only in the presence of bicyclists. At areas with high volumes of right turning vehicles, or low levels of motorist yielding compliance, an active display sign may be used to further alert drivers to the potential of conflict movements with bicyclists. This sign should use signal detection and actuation to activate only in the presence of bicyclists.

Proportion of Motor Vehicle Encroachment in Crosswalk



Adapted from: Dill, J., Monsere, C., McNeil, N. (2011). Evaluation of Bike Boxes at Signalized Intersections.

NACTO Urban Bikeway Design Guide

Exhibit K: Shared Lane Markings

Design Guidance

Shared Lane Markings

Required Features

1. The Shared Lane Marking in use within the United States is the bike-and-chevron "sharrow," illustrated in MUTCD figure 9C-9.

2. Shared Lane Markings shall not be used on shoulders, in designated bicycle lanes, or to designate bicycle detection at signalized intersections. (MUTCD 9C.07 03)

Recommended Features

3. Frequent, visible placement of markings is essential. The number of markings along a street should correspond to the difficulty bicyclists experience taking the proper travel path or position. SLMs used to bridge discontinuous bicycle facilities or along busier streets should be placed more frequently (50 to 100 feet) than along low traffic bicycle routes (up to 250 feet or more). SLMs used along low volume routes can be staggered by direction to provide markings closer together.[110]

4. Lateral placement is critical to encourage riders to avoid the "door zone," and to encourage safe passing behavior. MUTCD guidance recommends minimum placement when a parking lane is present at 11 feet from the curb face.[111]

5. On streets with posted 25 mph speeds or slower, preferred placement is in the center of the travel lane to minimize wear and encourage bicyclists to occupy the full travel lane.

6. On streets with posted 35 mph speeds or faster and motor vehicle volumes higher than 3,000 vpd shared lane markings are not a preferred treatment. On these streets other bikeway types are preferred.

7. If on-street vehicle parking is not present, SLMs should be placed far enough from the curb to direct bicyclists away from gutters, seams, and other obstacles. On streets with posted 25 mph speeds or slower, preferred placement is in the center of the travel lane to minimize wear and encourage bicyclists to occupy the full travel lane. MUTCD guidance recommends minimum placement with no parking at 4 feet from the curb face.[112]

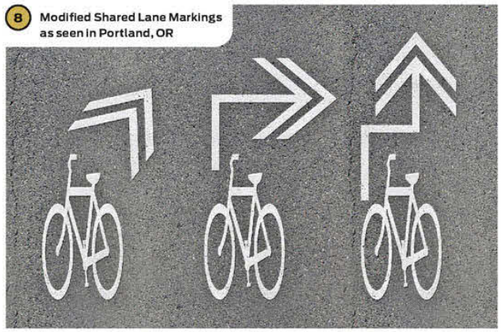
Optional Features

8. For wayfinding purposes the orientation of the chevron marking may be adjusted to direct bicyclists along discontinuous routes.

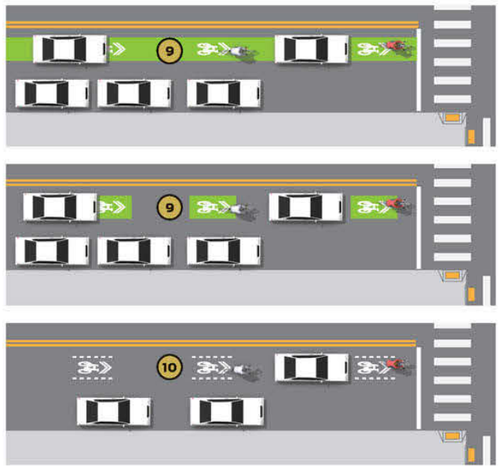
9. Color may be used to enhance the visibility of the shared lane marking and to further encourage desired lane positioning.[113]

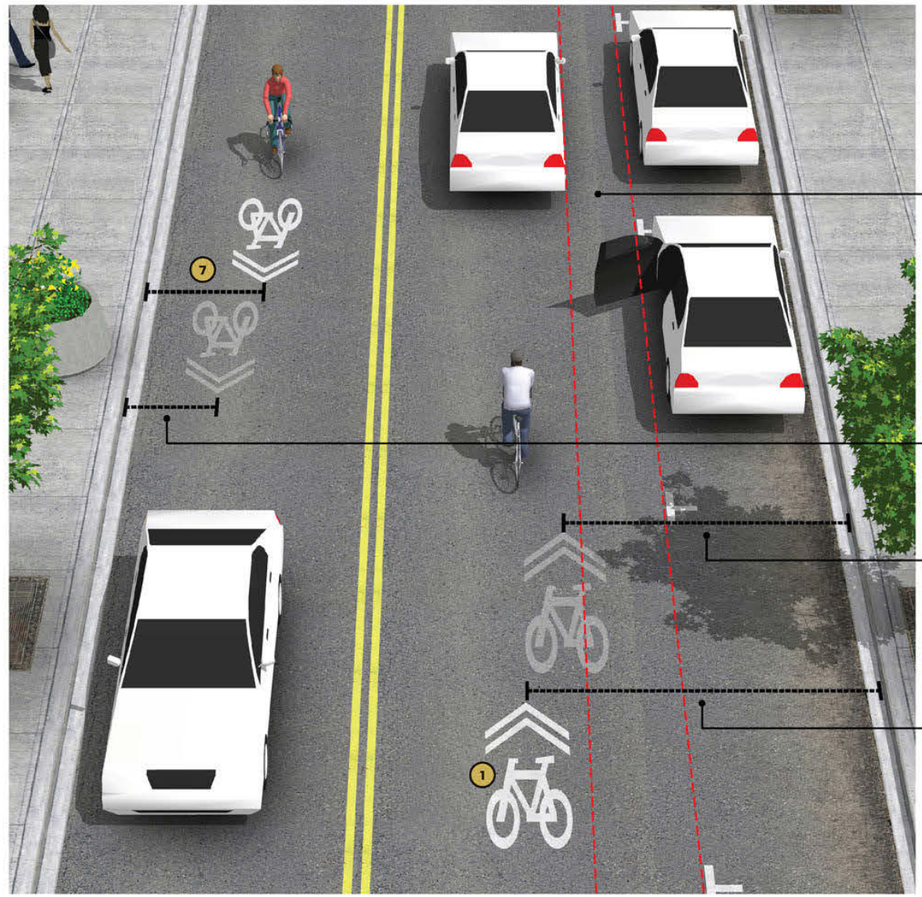
10. Dotted line markings may accompany the shared lane marking to further encourage desired lane positioning.[14]

8 **Modified Shared Lane Markings as seen in Portland, OR**



Optional Shared Lane Marking Applications





NACTO Urban Bikeway Design Guide

Exhibit L: Bicycle Signal Heads

Design Guidance

Bicycle Signal Heads

Required Features

(1) The bicycle signal head shall be placed in a location clearly visible to oncoming bicycles.

(2) If the bicycle phase is not set to recall each cycle, bicycle signals shall be installed with appropriate detection and actuation.

(3) An adequate clearance interval (i.e., the movement's combined time for the yellow and all-red phases) shall be provided to ensure that bicyclists entering the intersection during the green phase have sufficient time to safely clear the intersection before conflicting movements receive a green indication.[84]

(4) If the bicycle signal is used to separate through bicycle movements from right turning vehicles, then right turn on red shall be prohibited when the bicycle signal is active. This can be accomplished with the provision of a traffic signal with red, yellow, and green arrow displays. An active display to help emphasize this restriction is recommended.

(5) Bicycle signal heads are generally the preferred option over installing a sign instructing bicycles to use pedestrian signals. While instructing bicyclists to use pedestrian signals is a low-cost option, the length of the pedestrian clearance interval (typically timed at 3.5 feet per second) is usually inappropriate for bicyclists. The result is that approaching bicyclists have poor information about when it is safe and legal to enter the intersection.

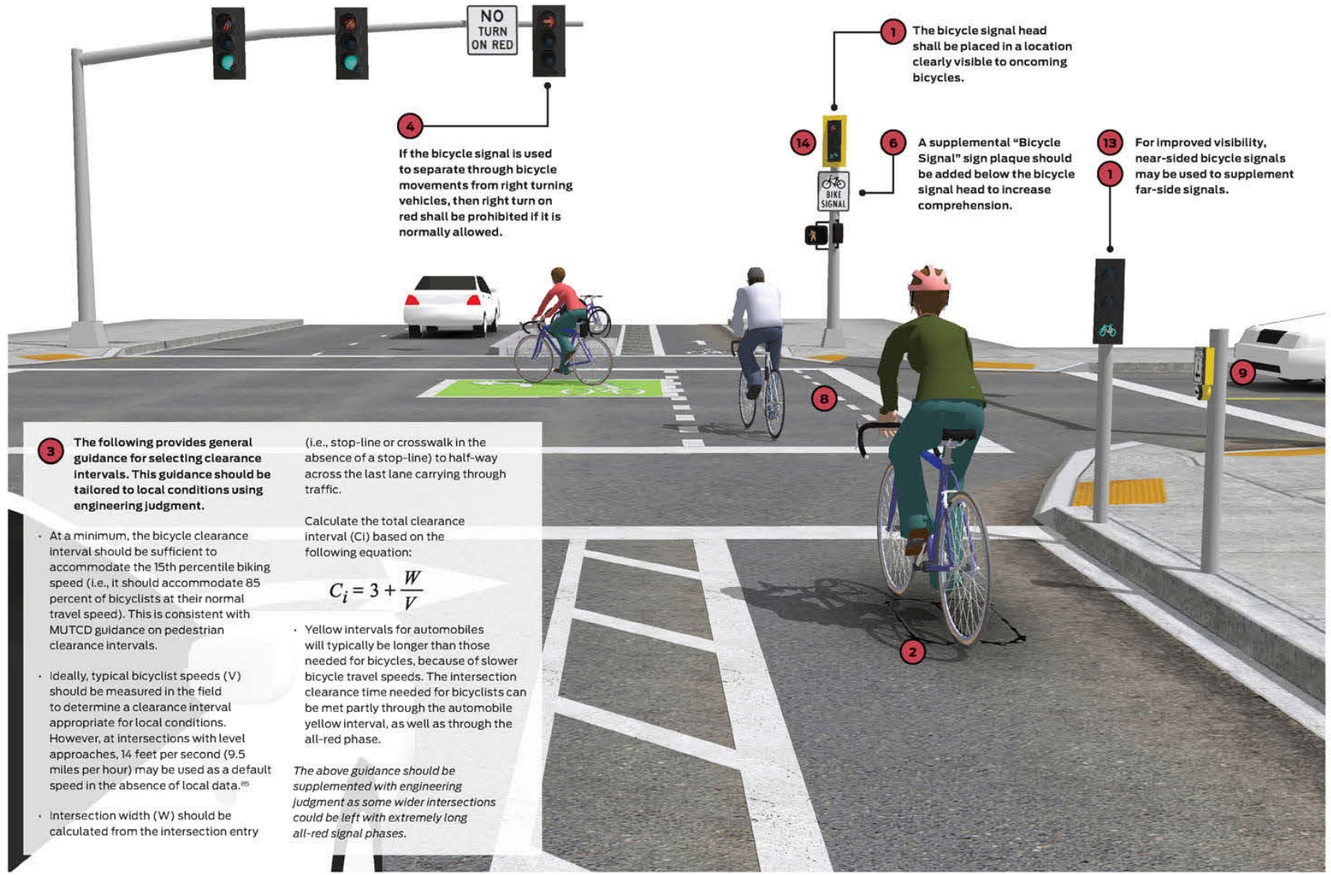
Recommended Features

(6) A supplemental "Bicycle Signal" sign plaque should be added below the bicycle signal head to increase comprehension.

(7) Signal timing with bicycle-only indications should consider activating the signal with each cycle prior to implementation with detection. This will increase awareness of the interval for motorists and bicyclists. In a close network of signals, the timing should consider how often a bicyclist will be stopped in the system to insure that undue delay is not a result of the bicycle-only signal.

(8) Intersection crossing markings should be used where the bicycle travel path through the intersection is unusual (e.g., diagonal crossing) or needed to separate conflicts.

(9) Passive actuation of bicycle signals through loops or another detection method is preferred to the use of push-buttons for actuation where practical. Passive actuation is more convenient for bicyclists. If push buttons are used, they should be mounted such that bicyclists do not have to dismount to actuate the signal.



(10) There are currently no national standards for determining the appropriate clearance intervals for bicycle signals. However, the primary factors in choosing an appropriate clearance interval are bicyclist travel speed and intersection width. At most signalized intersections, vehicular clearance intervals will likely function well for bicyclists. Exceptions requiring consideration include signals along cycle tracks or bicycle facilities that may be likely to serve significant levels of novice cyclists. See guidance for selecting clearance intervals at left.

(11) Bicyclists typically need longer minimum green times than motor vehicles due to slower acceleration speeds. This time is usually more critical for bicyclists on minor-road approaches, since crossing distance of major roads is typically greater than that of minor roads, and crossings from minor roads are often subject to short green intervals. Bicycle minimum green time is determined using the bicycle crossing time for standing bicycles.[86]

(12) Design and operation of bicycle signal heads should consider general MUTCD guidance on standards for traffic signals where applicable (e.g., positions of signal indications; visibility, aiming, and shielding of signal faces). Many of the MUTCD considerations for traffic signals will not apply to bicycle signals. Existing experience with bicycle signal installations in some cities has resulted in post mounted signals being utilized adjacent to the bikeway with a lower overall height. Some existing designs use shields and louvers to limit the driver's visibility of the bicycle signal to avoid potential confusion. Engineering judgment should be used to ensure that the positioning of bicycle signal heads is optimal for each installation. It is recommended that bicycle signal heads be separated from motor vehicle signal heads by at least two feet to increase comprehension.

Optional Features

(13) For improved visibility, near-sided bicycle signals may be used to supplement far-side signals. Smaller, half-sized signal heads with 4 inch lenses may be more appropriate in scale for near side installations.

(14) Visual variation in signal head housing for the bicycle signal when compared to adjacent traffic signals may increase contrast and awareness.

(15) If signal controlled bicycle turning movements are desired, consider pairing the bicycle signal head with a turn signal head to clarify protected, permissive, or restricted turning movements.

(16) Near-side bicycle signals may incorporate a "countdown to green" display to provide information about when a green bicycle indication will be provided. This treatment has proved popular in Europe, but there are currently no known installations in the United States.

NACTO Urban Bikeway Design Guide

Exhibit M: Bicycle Detection

Design Guidance

Bicycle Detection

Required Features

(1) The sensitivity of standard video, microwave and in-pavement loop detectors shall be adjusted to ensure that they detect bicyclists.

(2) Due to magnetic field symmetry, the center of inductive loops is the most sensitive location for detection for both diagonal slashed detectors and quadrupole loop detectors. Square and unmodified circle detectors are most sensitive at their edge.

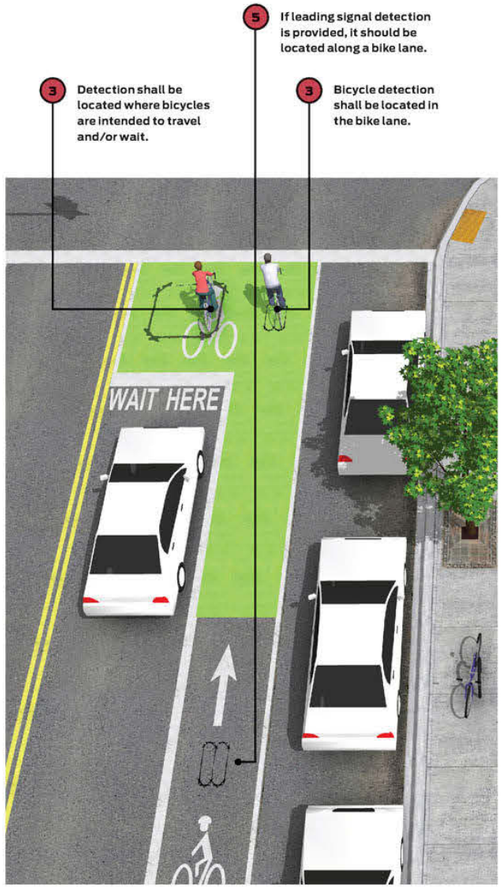
(3) If not provided within a dedicated bike lane, shoulder, or cycle track, bicycle signal detection shall be visible to bicyclists through signs and/or stencils so that bicyclists know that the intersection has detection and where to position their bicycle to activate the signal.

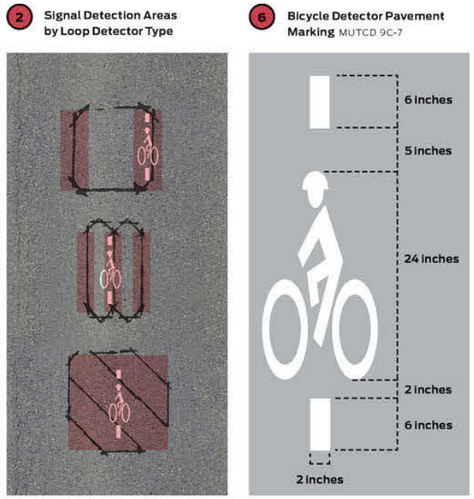
(4) If provided, push-button activation shall be located so bicyclists can activate the signal without dismounting. If used, push buttons should have a supplemental sign facing the bicyclist's approach to increase visibility.

(5) On streets with bike lanes or bikeable shoulders, bicycle detectors shall be located in the bike lane or shoulder. Detection shall be located where bicycles are intended to travel and/or wait. If leading signal detection is provided, it shall be located along a bike lane or in the outside travel lane. Detection at signals shall be placed where bicyclists wait, either in the center of a bike box or immediately behind the stop bar in the bike lane. Intersections without painted bicycle infrastructure shall provide detection in the center of the outside lane.

Recommended Features

(6) The MUTCD provides guidance on stencil markings and signage related to signal detection.





NACTO Urban Bikeway Design Guide

Exhibit N: Hybrid Beacon for Bike Route Crossings

Design Guidance

Hybrid Beacon for Bike Route Crossing of Major Street

Required Features

(1) The MUTCD provides warrants for the use of hybrid beacons based on motor vehicle speed, crossing length, motor vehicle volumes, and pedestrian volumes. These warrants do not explicitly consider bicyclists; however bicyclist crossing volumes may be added to pedestrian crossing volumes for the purposes of evaluating the warrant.[89]

(2) Engineering judgment and best practices should be used to ensure safe and appropriate signal timing for all phases. Appropriate yellow and red clearance intervals for bicycles should be calculated using the guidance provided for bike signals.

(3) The MUTCD provides standards related to the design and location of hybrid beacons (e.g., mounting location, height, etc.).

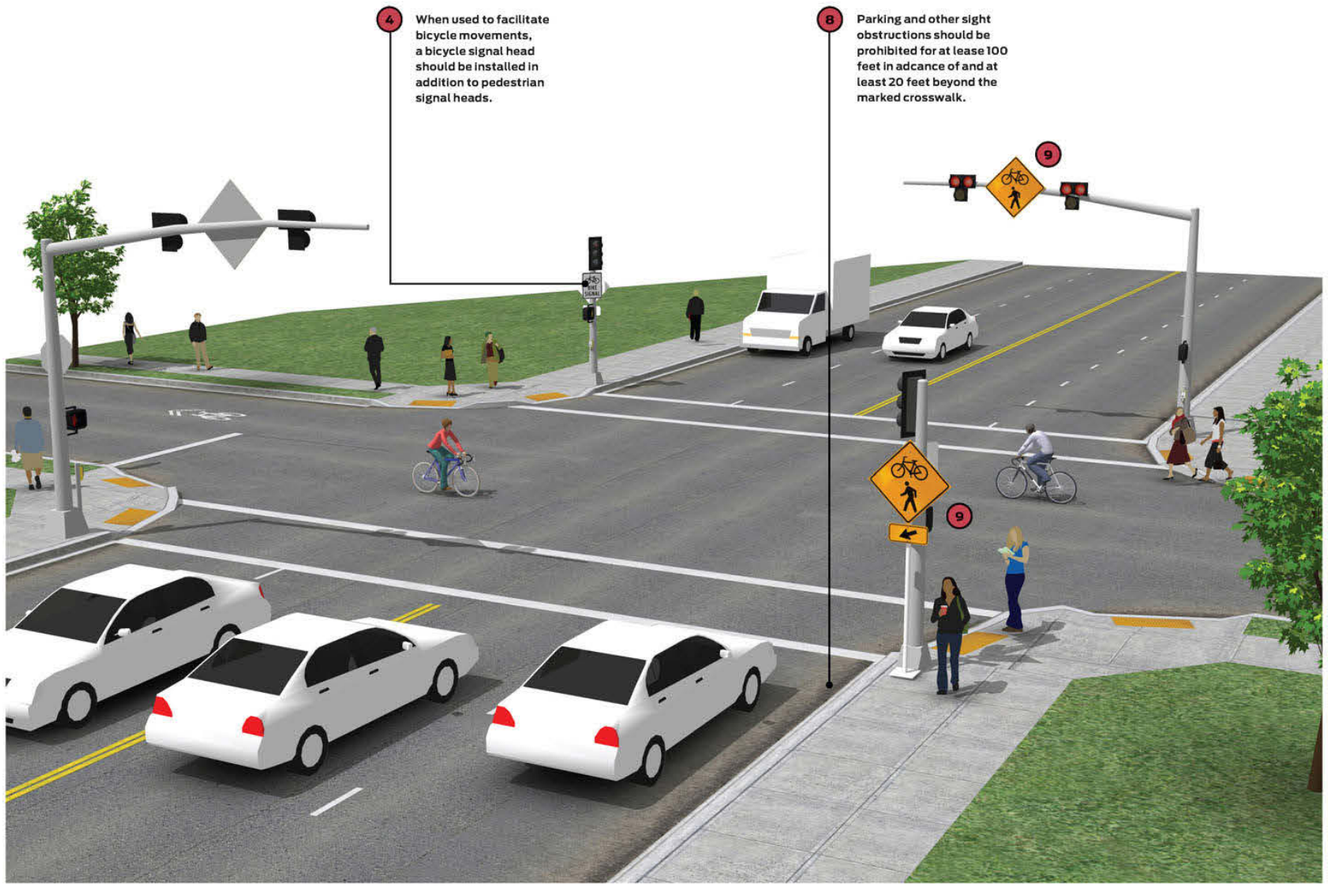
Recommended Features

(4) When hybrid beacons are installed to facilitate bicycle movements, a bicycle signal head should be installed in addition to pedestrian signal heads. This allows for safer and more efficient operations that effectively account for the different clearance requirements for pedestrians and bicycles. When used, a bicycle signal head should display a flashing red indication to bicyclists when the hybrid beacon is dark (i.e., the bicycle signal should not rest in dark). This allows bicyclists to treat the intersection as a "Stop" and proceed without the requirement of activating the hybrid signal.

(5) The 2009 MUTCD provides general guidance on establishing the length of flashing yellow and steady yellow phases; this guidance remains the same regardless of whether the hybrid beacon is used for a pedestrian crossing or bicycle crossing.

(6) The operations associated with the clearance intervals for the minor street approaches differ considerably when a hybrid beacon is used to facilitate bicycle crossings as opposed to pedestrian crossings. The MUTCD specifies that the corresponding phase on the major street for the pedestrian clearance interval is alternating flashing red, which allows vehicle to stop and proceed if there is no pedestrian. In particular, because of the speed at which bicyclists can enter the intersection and because many bicyclists will actually speed up when presented with a flashing "Don't Walk" indication, hybrid beacons should maintain the solid red indication for motorists throughout the full bicycle clearance interval (yellow plus all-red).

(7) The minimum length of the main street "rest in dark" interval should be set as short as possible to minimize bicyclist and pedestrian waiting time. Consider using a shorter minimum main street interval during off-peak periods than during peak periods.



(8) 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.[90]

(9) The installation should include suitable standard signs and pavement markings.[91]

(10) If installed within a signal system, signal engineers should evaluate the need for the hybrid beacon to be coordinated with other signals.

Operations

Hybrid beacon operations are significantly different from the operations of standard traffic control signals. The figure here on the reverse side illustrates the general sequence of phases for a hybrid beacon as applied for pedestrian crossings. The primary difference compared to a standard signal is that a hybrid beacon displays no indication (i.e., it is dark) when it is not actuated. Upon actuation (by a pedestrian or bicyclist on the minor street), the beacon begins flashing yellow, changes to steady yellow, then displays a solid red indication with both red lenses. During the solid red phase, drivers must stop and remain stopped, as with a standard traffic signal.

Prior to returning to no indication, the beacon displays an alternating flashing "wig-wag" red that allows drivers to stop and proceed when clear, as they would with a stop sign. To maximize safety when used for bicycle crossings, this phase should be very short and occur after the pedestrian signal head has changed to a solid "Don't Walk" indication as bicyclists can enter an intersection quickly.

The figure on the reverse side shows an example phasing diagram based on a Portland, Oregon, configuration, indicating how the solid red indication for drivers is maintained through bike clearance (phases 6 and 7).

Optional Features

(11) Due to the unique operational features of hybrid beacons, communities that are installing hybrid beacons for the first time may wish to coordinate installation with a public information campaign to educate roadway users on the operations and legal requirements associated with hybrid beacons.[92]

PORTLAND, OR

NACTO Urban Bikeway Design Guide

Exhibit O: Median Refuge Island

Design Guidance

Median Refuge Island

Required Features

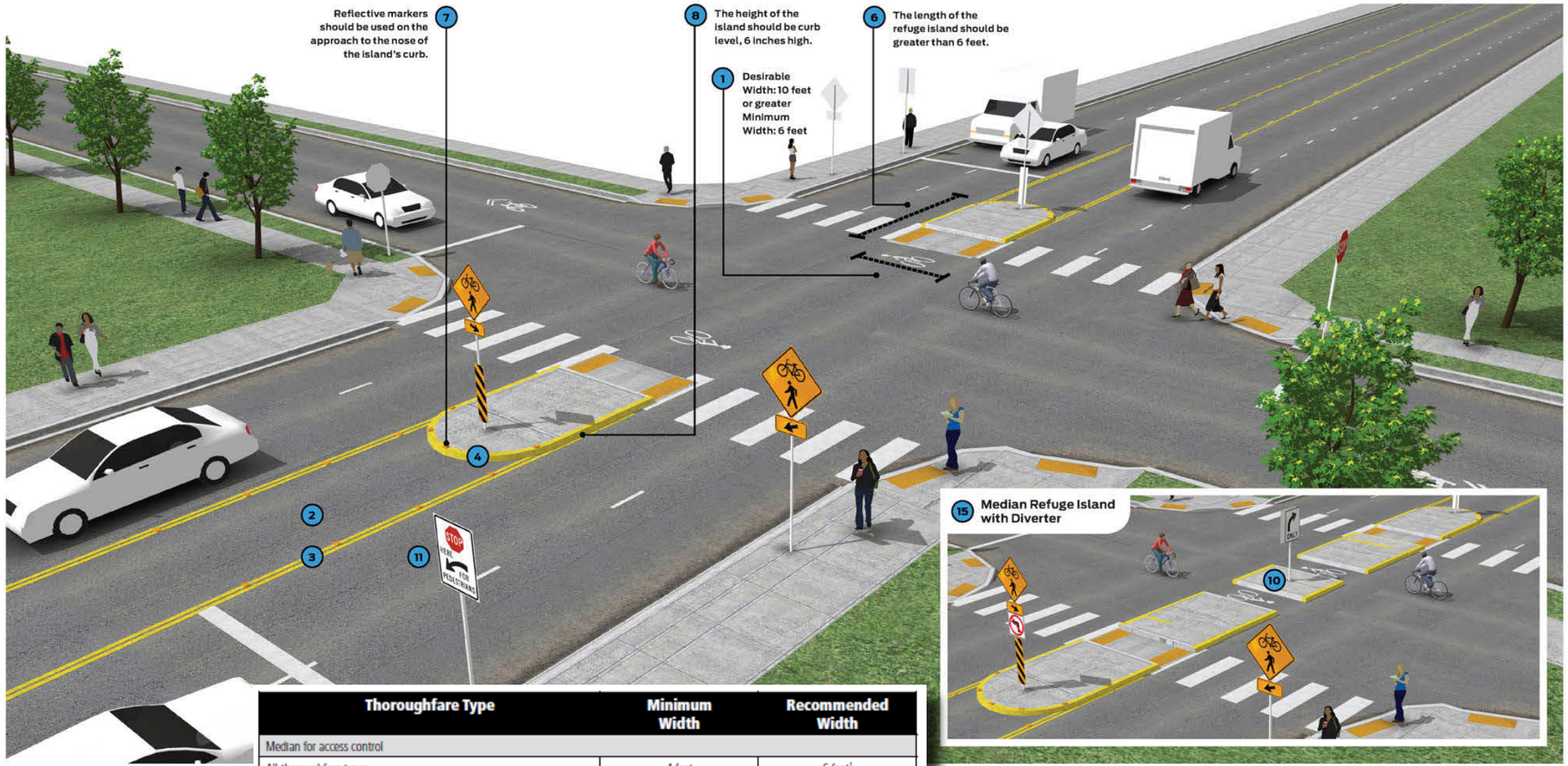
1. The desirable width of the median refuge is 10 feet or greater. The absolute minimum width is 6 feet.[73]
2. When applied on a two-way street, the median refuge shall be placed along the centerline of the roadway between the opposing directions of travel.
3. Pavement markings on the approach to the refuge island shall follow the guidance provided in Section 3I.02 of the MUTCD.[74]
4. The approach edge of the raised median shall be outlined in retroreflective white or yellow material.[75]
5. In areas with snow accumulation, reflective delineators shall be used to mark the island for increased visibility to snow plow crews.

Recommended Features

6. The length of the refuge island should be greater than 6 feet.[76]
7. Reflective markers should be used on the approach to the nose of the island's curb.[77]
8. The height of the island should be curb level, 6 inches high. When used as an exclusive bicycle facility it may be desirable to keep the refuge area at street level.[78]
9. An angled cut-through (45 degrees) should be provided to position bicyclists to face oncoming traffic. If the cut-through is to be shared with pedestrians, the 45-degree angle of the curb should transition back to being perpendicular to the street to provide proper directional cues for the blind.
10. The refuge area should be wide enough to accommodate two-way bicycle traffic.

Optional Features

11. "Advanced Stop" signs and markings for motorists may be included.[78]
12. Landscaping may be provided in the median, but it should not compromise visibility.[80]
13. Lighting may be installed for improving visibility of the facility at night.
14. At signalized intersections, push buttons or other detection methods may be provided to actuate the signal head.
15. The median refuge can be carried across the entire cross street approach to act as a diverter to prevent cut-through traffic on a bicycle route.

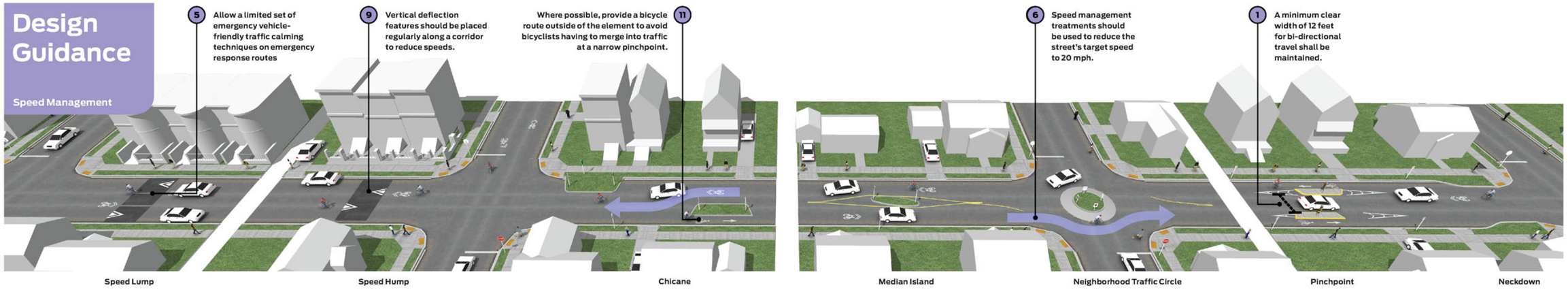


NACTO Urban Bikeway Design Guide

Thoroughfare Type	Minimum Width	Recommended Width
Median for access control		
All thoroughfare types	4 feet	6 feet[1]
Median for pedestrian refuge		
All thoroughfare types	6 feet	8 feet
Median for street trees and lighting		
All thoroughfare types	6 feet[2]	10 feet[3]
Median for single left-turn lane		
Collector avenues and streets	10 feet[4]	14 feet
Arterial boulevards and avenues	12 feet	16–18 feet
Median for dual left-turn lane		
Arterial boulevards and avenues	20 feet	22 feet
Median for transitway		
Dedicated rail or transit lanes	22 feet	22–24 feet
Added median width for platforms	10 feet for each side platform 30 feet for center platform	

ITE Designing Walkable Urban Thoroughfares

Exhibit P: Speed Management



Required Features

1 When using horizontal speed management treatments, a minimum clear width of 12 feet for travel shall be maintained.

2 Speed limits shall comply with local restrictions.

3 Speed zones (other than statutory speed limits) shall only be established on the basis of an engineering study that has been performed in accordance with traffic engineering practices (MUTCD 2B.13).

4 Speed limits shall be in multiples of 5 mph and signs shall be located at the points of change from one speed limit to another (MUTCD 2B.13).

Recommended Features

5 Emergency services should be in sync with transportation departments in recognizing that reducing speed and volume on local roadways, in addition to getting more people on foot and bike and out of cars, benefits their overall safety goals by reducing crash frequency and severity. The primary way of doing this is to develop an emergency response route classification map at the onset of the planning process, as discussed in route planning. Emergency vehicle response times should be considered where vertical deflection is used. Because emergency vehicles have a wider wheel base than passenger cars, speed lumps/cushions allow them to pass unimpeded while slowing most traffic.

Strategies include the following:

- Seek approval by emergency response officials for treatments on emergency response routes.
- Allow a limited set of emergency-vehicle-friendly traffic calming techniques on emergency response routes.[146]
- Estimate travel time impacts on emergency vehicle response time, and define goals to evaluate during a trial.[147]
- Implement speed management treatments on a trial basis, and work with emergency response officials to determine whether permanent features are appropriate.

6 Speed management treatments should be used to reduce the street's target speed to 20 mph.

7 After speed management measures are implemented, posted speed limits should be reduced to match 85th percentile speed (5 mph speed increments are recommended).

8 The impacts to traffic on adjacent streets should be monitored; while speed management treatments primarily affect motor vehicle speeds, they also reduce volumes, as drivers tend to avoid slower streets.[148]

9 Vertical deflection features should be placed regularly along a corridor to reduce speeds.[149]

10 Guidance for vertical traffic calming features:

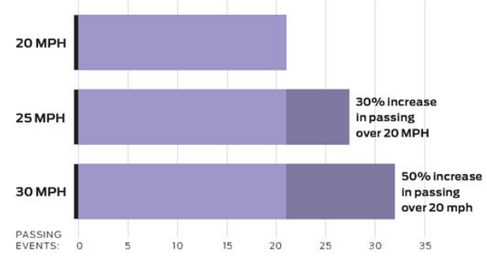
- Slopes should not exceed 1:10 or be less steep than 1:25.
- Side slopes on tapers should be no greater than 1:6 to reduce the risk of bicyclists losing their balance.
- The vertical lip should be no more than a quarter-inch high (Ewing, 2009).

11 Horizontal speed control measures should not infringe on bicycle space. Where possible, provide a bicycle route outside of the element to avoid bicyclists having to merge into traffic at a narrow pinchpoint. This technique can also improve drainage flow and reduce construction and maintenance costs.

Optional Features

12 Speed management may be implemented on a trial basis to gauge residents' support prior to finalizing the design. Temporary speed humps, tables, and lumps are available. Temporary traffic calming should be used with caution as they can diminish residents' opinions due to unappealing design and reduced functionality.

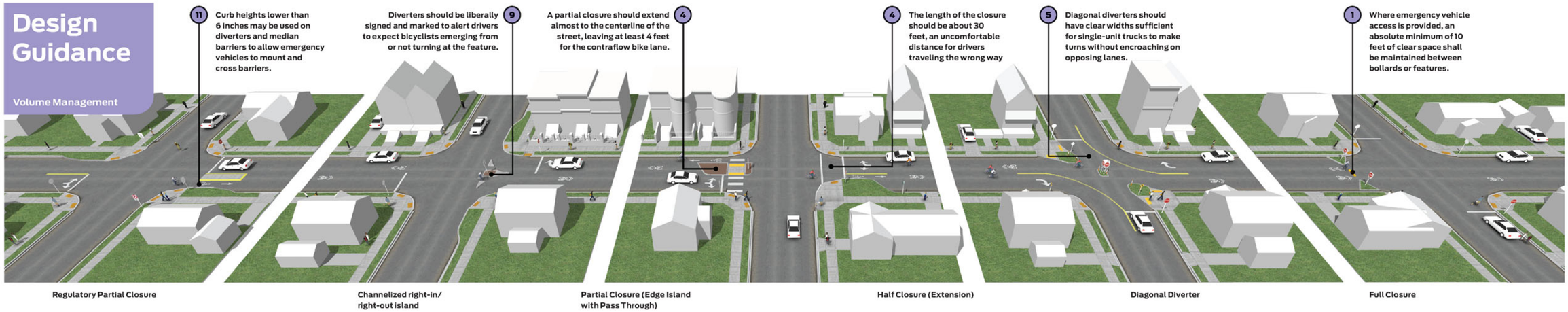
Depending on motor vehicle speeds, a bicyclist will be passed by a car going the same direction this many times during a 10 minute trip:



Values shown assume 3,000 VPD. Local street peak hour is 15 percent of ADT. 70 percent of peak hour traffic is in the peak direction. Cars are evenly spaced along the street: no platooning. Ten minute trip calculated during peak hour. Cars are travelling the posted speed limit (speed management techniques may be necessary). Note: Cars may pass bicyclists more or less frequently depending on how well these assumptions reflect reality.

NACTO Urban Bikeway Design Guide

Exhibit Q: Volume Management



Required Features

1. Where emergency vehicle access is provided, an absolute minimum of 10 feet of clear space shall be maintained between bollards or features. The presence of mountable curbs, flexible or collapsible objects, or restricted lanes may reduce space requirements.

2. Volume management treatments shall provide bicycle access, either through a 4-foot minimum contra-flow bike lane or a 5- to 6-foot opening between vertical curbs.

Recommended Features

3. Appropriate signs should be used to prohibit undesired automobile movements and access while permitting desired bicycle access.[154]

4. For a partial closure, the curb extension or edge island should extend almost to the centerline of the street, leaving at least 4 feet for the contraflow bike lane, and the adjacent travel lane may be narrowed through the closure. The length of the closure should be about 30 feet, an uncomfortable distance for drivers traveling the wrong way.

5. Diagonal diverters, median barriers, and forced-turn islands should have clear widths sufficient for single-unit trucks to make turns without encroaching on opposing lanes.

6. Volume control measures should not be used along primary emergency response routes. See route planning and speed management for a discussion of designating an emergency response network and minimizing impacts to emergency vehicles along bicycle boulevards.

7. Traffic volumes on other parallel non-arterial streets should be monitored to determine the impacts to volumes, which may require further mitigation. Neighbors and nearby businesses should be consulted to build support for volume management treatments prior to implementation.

8. Appropriate education for use of proposed treatments should be provided to neighbors and others who are likely to use the corridor.

9. Closures and diverters should be liberally signed and marked to alert drivers to expect bicyclists emerging from or not turning at the feature.

Optional Features

10. The partial closure curb extension or edge island may be tapered to deflect drivers to the right as they approach the feature.

11. Curb heights lower than 6 inches may be used on diverters and median barriers to allow emergency vehicles to mount and cross barriers.

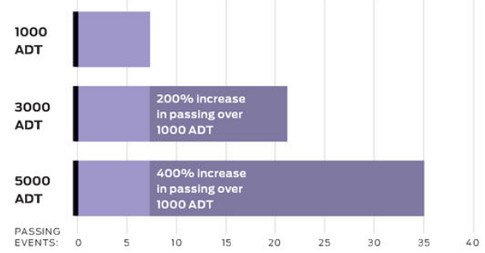
12. Bollards may be used for diagonal diverters, but 5 feet should be provided between them to accommodate one direction of bicycle travel.

13. Measures may be implemented on a trial basis to gauge resident support prior to finalizing the design. Temporary closures can be created with construction barrels or planters; however, an unappealing design aesthetic may diminish residents' opinions.

14. Channelizing devices may be used along a center line to preclude turns or along lane lines to preclude lane changing, as determined by engineering judgment.[155]

15. Consider defining a threshold of acceptable motor vehicle volume impacts to traffic on adjacent streets when using speed and volume management.[156]

Depending on motor vehicle volumes, a bicyclist will be passed by a car going the same direction this many times during a 10 minute trip:



Values shown assume 20 mph posted speed. Local street peak hour is 15 percent of ADT. 70 percent of peak hour traffic is in the peak direction. Cars are evenly spaced along the street: no platooning. 10 minute trip calculated during peak hour. Cars are travelling the posted speed limit (speed management techniques may be necessary). Note: Cars may pass bicyclists more or less frequently depending on how well these assumptions reflect reality.

NACTO Urban Bikeway Design Guide

Exhibit R: Walkable Thoroughfare Design

Thoroughfare Design Parameters for Walkable Mixed–Use Areas									
	General Urban (C–4)			Urban Center/Core (C–5/6)					
	Commercial			Residential			Commercial		
	Boulevard [1]	Avenue	Street	Boulevard [1]	Avenue	Street	Boulevard [1]	Avenue	Street
Context									
Building Orientation (entrance orientation)	front	front	front	front	front	front	front	front	front
Maximum Setback [2]	0 ft.	0 ft.	0 ft.	10 ft.	10 ft.	10 ft.	0 ft.	0 ft.	0 ft.
Off-Street Parking Access/Location	rear, side	rear, side	rear, side	rear	rear	rear, side	rear	rear	rear, side
Streetside									
Recommended Streetside Width [3]	19 ft.	16 ft.	16 ft.	21.5 ft.	19.5 ft.	16 ft.	21.5 ft.	19.5 ft.	16 ft.
Minimum sidewalk (throughway) width	8 ft.	6 ft.	6 ft.	10 ft.	9 ft.	6 ft.	10 ft.	9 ft.	6 ft.
Pedestrian Buffers (planting strip exclusive of travel way width) [3]	7 ft. tree well	6 ft. tree well	6 ft. tree well	7 ft. tree well	6 ft. tree well	6 ft. tree well	7 ft. tree well	6 ft. tree well	6 ft. tree well
Street Lighting	For all thoroughfares in all context zones, intersection safety lighting, basic street lighting, and pedestrian-scaled lighting is recommended. See Chapter 8 (Streetside Design Guidelines) and Chapter 10 (Intersection Design Guidelines).								
Traveled Way									
Target Speed (mph)	25–35	25–30 [4]	25	25–35	25–30	25	25–35	25–30 [4]	25
Number of Through Lanes [5]	4–6	2–4	2–4	4–6	2–4	2–4	4–6	2–4	2–4
Lane Width [6]	10–12 ft.	10–11 ft.	10–11 ft.	10–11 ft.	10–11 ft.	10–11 ft.	10–11 ft.	10–11 ft.	10–11 ft.
Parallel On-Street Parking Width [7]	8'	7–8 ft.	7–8 ft.	7 ft.	7 ft.	7 ft.	8 ft.	8 ft.	7–8 ft.
Min. Combined Parking/Bike Lane Width	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.
Horizontal Radius (per AASHTO) [8]	200–510 ft.	200–330 ft.	200 ft.	200–510 ft.	200–330 ft.	200 ft.	200–510 ft.	200–330 ft.	200 ft.
Vertical Alignment	Use AASHTO minimums as a target, but consider combinations of horizontal and vertical per AASHTO Green Book.								
Medians [9]	4–18 ft.	Optional 4–18 ft.	None	4–18 ft.	Optional 4–16 ft.	None	4–18 ft.	Optional 4–18 ft.	None
Bike Lanes (min./preferred width)	5 ft. / 6 ft.	5 ft. / 6 ft.	5 ft. / 6 ft.	5 ft. / 6 ft.	5 ft. / 6 ft.	5 ft. / 6 ft.	5 ft. / 6 ft.	5 ft. / 6 ft.	5 ft. / 6 ft.
Access Management [10]	High	Low–Moderate	Low–Moderate	Moderate	Low–Moderate	Low–Moderate	High	Low–Moderate	Low–Moderate
Typical Traffic Volume Range (ADT) [11]	15,000–50,000	1,500–30,000	1,000–15,000	15,000–30,000	1,500–20,000	500–5,000	15,000–40,000	1,500–30,000	1,000–15,000
Intersections									
Roundabout [12]	Consider urban single–lane roundabouts at intersections on avenues with less than 20,000 entering vehicles per day, and urban double–lane roundabouts at intersections on boulevards and avenues with less than 40,000 entering vehicles per day.								
Curb Return Radii/Curb Extensions and Other Design Elements	Refer to Chapter 10 (Intersection Design Guidelines)								

Thoroughfare Design Parameters for Walkable Mixed–Use Areas									
	Suburban (C–3)						General Urban (C–4)		
	Residential			Commercial			Residential		
	Boulevard [1]	Avenue	Street	Boulevard [1]	Avenue	Street	Boulevard [1]	Avenue	Street
Context									
Building Orientation (entrance orientation)	front, side	front, side	front, side	front, side	front, side	front, side	front	front	front
Maximum Setback [2]	20 ft.	20 ft.	20 ft.	5 ft.	5 ft.	5 ft.	15 ft.	15 ft.	15 ft.
Off-Street Parking Access/Location	rear, side	rear, side	rear, side	rear, side	rear, side	rear, side	rear	rear, side	rear, side
Streetside									
Recommended Streetside Width [3]	14.5–16.5 ft.	14.5 ft.	11.5 ft.	16 ft.	16 ft.	15 ft.	16.5-18.5 ft.	14.5 ft.	11.5 ft.
Minimum sidewalk (throughway) width	6 ft.	6 ft.	6 ft.	6 ft.	6 ft.	6 ft.	8 ft.	6 ft.	6 ft.
Pedestrian Buffers (planting strip exclusive of travel way width) [3]	8 ft. planting strip	6–8 ft. planting strip	5 ft. planting strip	7 ft. tree well	6 ft. tree well	6 ft. tree well	8 ft. planting strip	8 ft. planting strip	6 ft. planting strip
Street Lighting	For all thoroughfares in all context zones, intersection safety lighting, basic street lighting, and pedestrian-scaled lighting is recommended. See Chapter 8 (Streetside Design Guidelines) and Chapter 10 (Intersection Design Guidelines).								
Traveled Way									
Target Speed (mph)	25–35	25–30	25	25–35	25–35	25	25–35	25–30	25
Number of Through Lanes [5]	4–6	2–4	2	4–6	2–4	2	4–6	2–4	2
Lane Width [6]	10–11 ft.	10–11 ft.	10–11 ft.	10–12 ft.	10–11 ft.	10–11 ft.	10–11 ft.	10–11 ft.	10–11 ft.
Parallel On-Street Parking Width [7]	7 ft.	7 ft.	7 ft.	8 ft.	7-8 ft.	7-8 ft.	7 ft.	7 ft.	7 ft.
Min. Combined Parking/Bike Lane Width	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.	13 ft.
Horizontal Radius (per AASHTO) [8]	200–510 ft.	200–330 ft.	200 ft.	200–510 ft.	200–510 ft.	200 ft.	200–510 ft.	200–330 ft.	200 ft.
Vertical Alignment	Use AASHTO minimums as a target, but consider combinations of horizontal and vertical per AASHTO Green Book.								
Medians [9]	4–18 ft.	Optional 4–16 ft.	None	4–18 ft.	Optional 4–18 ft.	None	4–18 ft.	Optional 4–16 ft.	None
Bike Lanes (min./preferred width)	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./6 ft.	5 ft./ 6 ft.	5 ft. / 6 ft.
Access Management [10]	Moderate	Low	Low	High	Moderate	Low	Moderate	Low	Low
Typical Traffic Volume Range (ADT) [11]	20,000–35,000	1,500–25,000	500–5,000	20,000–50,000	1,500–35,000	1,000–10,000	10,000–35,000	1,500–20,000	500–5,000
Intersections									
Roundabout [12]	Consider urban single–lane roundabouts at intersections on avenues with less than 20,000 entering vehicles per day, and urban double–lane roundabouts at intersections on boulevards and avenues with less than 40,000 entering vehicles per day.								
Curb Return Radii/Curb Extensions and Other Design Elements	Refer to Chapter 10 (Intersection Design Guidelines)								

Sidewalk Zone [1]	C-6 and C-5			C-4 w/ Predominantly Commercial Ground Floor Use			C-4 w/ Predominantly Residential Frontage			C-3 w/ Predominantly Commercial Ground Floor Use			C-3 w/ Predominantly Residential Frontage		
Boulevard															
Edge	1.5 feet 2.5 feet at diagonal parking	21.5 foot (recommended)	12 foot (constrained)	1.5 feet 2.5 feet at diagonal parking	19 foot (recommended)	12 foot (constrained)	1.5 feet	17.5 foot (recommended)	9 foot (constrained)	1.5 feet 2.5 feet at diagonal parking	16 foot (recommended)	12 foot (constrained)	1.5 feet	15.5 foot (recommended)	9 foot (constrained)
Furnishings	7 feet (trees in tree wells)			7 feet (trees in tree wells)			8 feet (landscape strip w/ trees and grasses, or groundcovers)			7 feet (trees in tree wells)			8 feet (landscape strip w/ trees and grasses, or groundcovers)		
Throughway	10 feet			8 feet			8 feet			6 feet			6 feet		
Frontage	3 feet			2.5 feet			0 feet along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 feet along facades, tall walls and fences			1.5 feet			0 feet along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 feet along facades, tall walls and fences		
Avenue															
Edge	1.5 feet 2.5 feet at diagonal parking	19.5 foot (recommended)	12.0 foot (constrained)	1.5 feet 2.5 feet at diagonal parking	16 foot (recommended)	12 foot (constrained)	1.5 feet	15.5 foot (recommended)	9 foot (constrained)	1.5 feet 2.5 feet at diagonal parking	16 foot (recommended)	12 foot (constrained)	1.5 feet	15.5 foot (recommended)	9 foot (constrained)
Furnishings	6 feet (trees in tree wells)			6 feet (trees in tree wells)			8 feet (landscape strip w/ trees and grasses or groundcovers)			6 feet (trees in tree wells)			8 feet (landscape strip w/ trees and grasses or groundcovers)		
Throughway	9 feet			6 feet			6 feet			6 feet			6 feet		
Frontage	3 feet			2.5 feet			0 feet along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 feet along facades, tall walls and fences			2.5 feet			0 feet along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 feet along facades, tall walls and fences		
Street															
Edge	1.5 feet 2.5 feet at diagonal parking	16 foot (recommended)	12.0 foot (constrained)	1.5 feet 2.5 feet at diagonal parking	16 foot (recommended)	12 foot (constrained)	1.5 feet	13.5 foot (recommended)	9 foot (constrained)	1.5 feet 2.5 feet at diagonal parking	15 foot (recommended)	12 foot (constrained)	1.5 feet	12.5 foot (recommended)	9 foot (constrained)
Furnishings	6 feet (trees in tree wells)			6 feet (trees in tree wells)			6 feet (landscape strip w/ trees and grasses or groundcovers)			6 feet (trees in tree wells)			5 feet (landscape strip w/ trees and grasses or groundcovers)		
Throughway	6 feet			6 feet			6 feet			6 feet			6 feet		
Frontage	2.5 feet			2.5 feet			0 feet along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 feet along facades, tall walls and fences			1.5 feet			0 feet along lawn and groundcover 1 foot along low walls, fences and hedges 1.5 feet along facades, tall walls and fences		

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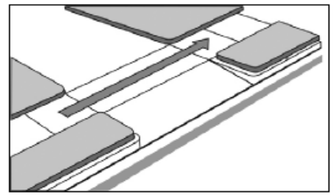

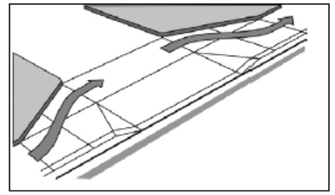

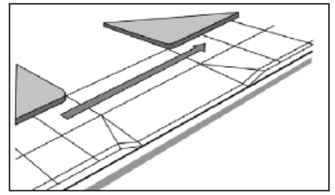

General
The decision to locate a midblock crosswalk will be based on numerous factors. Generally, however, consider providing a marked midblock crossing when protected intersection crossings are spaced greater than 400 feet or so that crosswalks are located no greater than 200 to 300 feet apart in high pedestrian volume locations, and meet the criteria below.
Midblock crossings may be considered when there is significant pedestrian demand to cross a street between intersections, such as connecting to major generators or transit stops.
Midblock crosswalks should be located at least 100 feet from the nearest side street or driveway so that drivers turning onto the major street have a chance to notice pedestrians and properly yield to pedestrians who are crossing the street.
Criteria
Streets with an average daily traffic volume (ADT) of 12,000 vehicles per day or less.
Multilane streets carrying less than 15,000 ADT if a raised pedestrian refuge median is provided.
Operating speeds less than 40 mph.
A minimum pedestrian crossing volume of 25 pedestrians per hour for at least four hours of a typical day.
Adequate sight distance is available for pedestrians and motorists.
Recommendations
Conform to PROWAG guidelines for the disabled and visually impaired.
Unsignalized midblock crosswalks should not be provided on streets where traffic volumes do not have gaps in the traffic stream long enough for a pedestrian to walk to the other side or to a median refuge. At locations with inadequate gaps that also meet MUTCD signalization warrants, consider a signalized midblock crossing.
Consider a signalized midblock crosswalk (including locator tone and audio pedestrian signal output as well as visual pedestrian countdown signal heads) where pedestrians must wait more than an average of 60 seconds for an appropriate gap in the traffic stream. When average wait times exceed 60 seconds, pedestrians tend to become impatient and cross during inadequate gaps in traffic. If this initial threshold is met, check pedestrian signal warrants in the MUTCD.
Provide overhead safety lighting on the approach sides of both ends of midblock crosswalks.
Provide wheelchair ramps or at-grade channels at midblock crosswalks with curbs and medians.
Provide raised median pedestrian refuge at midblock crossings where the total crossing width is greater than 60 feet, and on any unsignalized multi-lane thoroughfare crossing.
Use high-visibility (ladder-style) crosswalk markings to increase visibility longitudinally.
Provide advance stop or yield lines to reduce multiple-threat crashes.
Provide advance crosswalk warning signs for vehicle traffic.
Provide curb extensions at midblock crosswalks with illumination and signing to increase pedestrian and driver visibility.
"Z" crossing configurations should be used for midblock crossings with medians wherever possible (see **Figure 9.16**). Provide an at-grade channel in median at a 45-degree angle toward advancing traffic to encourage pedestrians to look for oncoming traffic.
Other Considerations
A strategy to calm traffic speeds in advance of and at a midblock crossing is to raise the pavement to meet the sidewalk elevation by use of gentle ramps (see **Figure 9.17**). Consider use of overhead flashing beacons.

Exhibit S: Transit Facilities

Thoroughfare Design Component	Factors to be Considered
Streetside (Chapter 8)	Streetside width at stops or stations
	Space for passenger requirements such as shelters, seating, waiting areas, trees, lighting and so forth.
	Accessibility requirements (lift pads)
Traveled Way (Chapter 9)	Available total right of way to accommodate running ways, stops and stations
	Lane width to accommodate transit vehicle in mixed-flow lanes
	Type of running way and separation (dedicated transitway, reversible/contraflow, HOV, median lanes, concurrent lanes)
	Median width to accommodate running ways and stations
	Pedestrian access to median stations
	Ability to accommodate on-street parking on transit streets
	Parking restrictions near stops and stations
	Bike/bus conflicts where buses stop in bike lane
	Pavement depth to accommodate buses; concrete pads at bus stops
	Additional width for transit facilities versus pedestrian crossing distance
	Roadway structural design for LRT
	Horizontal and vertical clearances for transit; maintenance requirements such as tree pruning
	Necessity for bus bays
	Transit operations on one-way streets, location of stops, turns
	Provision of an enforcement area on exclusive bus facilities (e.g., extended bus turnouts)
	Prohibition of turns across median running ways
	Overhead clearance for catenary power supply or trolley wires and space to mount poles
Intersections (Chapter 10)	Transit vehicle turning radius and curb return/extension design
	Queue jump lanes and special signal phasing
	Accommodating transit vehicles in roundabouts
	Near-side or far-side bus stops, BRT or rail stations and traffic operations
	Transit priority signal systems or special phasing for rapid and BRT
	Bus priority treatments; intersection design when contraflow bus lanes are used
	Special signal phasing and equipment for LRT
	Vehicle left-turn lanes adjacent to median stations
	Vehicle turn prohibitions in constrained rights of way or for operational efficiency
	Curb extension bus stop versus curbside stop
	Pavement grades through intersections and bus passenger comfort
	Movement restrictions and bus exemptions

Transit Facility or Design Element	Minimum Dimension
Lane width to accommodate standard urban bus, LRT vehicle, or streetcar	11 feet
Curbside bus stop length and no-parking zone (add 20 feet for articulated vehicles)	
Near-side bus stop	100 feet
Far-side bus stop	80 feet (Plus 5 feet from crosswalk or curb return)
Far-side bus stop after turn	90 feet (Plus 5 feet from crosswalk or curb return)
Midblock	120 feet
Bus bulb stop length (near side or far side)	40 feet
Distance between front of vehicle at near-side stop and crosswalk	10 feet
Single-side LRT/BRT platform width conforming to ADA guidelines	10 feet (8 feet plus 2 feet tactile strip)
Distance between LRT double track centerlines	12 feet
Maximum grade for LRT operation	6%
Height of platform	Low: 10 inches High: 36 inches
Width of two-track LRT channel	22 feet
Vertical clearance for LRT (top of rail to bottom of wire)	11.5 feet
Width of right of reserve for two tracks	19–33 feet
LRT/BRT station widths (including running way)	
Dual outside platforms	41 feet
Single center platform	55 feet
Single outside platform	31 feet

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Far Side Bus Stops	
Advantages	**Disadvantages**
• Minimizes conflict between buses and right turning vehicles traveling in the same direction • Minimizes sight distance problems on approaches to the intersection • Encourages pedestrians to cross behind the bus • Minimizes area needed for curbside bus zone • If placed just beyond a signalized intersection in a bus turnout, buses may more easily re-enter the traffic stream • If a turnout is provided, vehicle capacity through intersection is unaffected • Can better take advantage of traffic signal priority for buses	• If bus stops in travel lane, could result in traffic queued into intersection behind the bus (turnout will allow traffic to pass around the stopped bus) • If bus stops in travel lane, could result in rear-end accidents as motorists fail to anticipate stopped traffic • May cause passengers to access buses further from crosswalk • May interfere with right turn movement from cross street • May obscure sight distance for crossing vehicles • If signal priority not in use, bus may have to stop twice, once at signal and then at bus stop
Near Side Bus Stops	
Advantages	**Disadvantages**
• Minimizes interference when traffic is heavy on the far side of an intersection • Allows passengers to access buses close to crosswalk • Driver may use the width of the intersection to pull away from the curb • Allows passengers to board and alight when the bus is stopped for a red light • Provides the driver with the opportunity to look for oncoming traffic, including other buses with potential passengers	• Stopped bus interferes with right turns • May cause sight distance problem for approaching traffic, cross-street traffic and pedestrians • If located in a pullout or shoulder or at a signalized intersection, a traffic queue may make it difficult for buses to re-enter the traffic stream • Prohibits through traffic movement with green light, similar to far side stop without a bus turnout • May cause pedestrians to cross in front of the bus at intersections • Limits use of traffic signal priorities