

ACTIVE AND PUBLIC TRANSPORTATION FACILITY PLANNING BEST PRACTICES RECOMMENDATIONS



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ND Moves
active & public
transportation plan

NDDOT



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Preface

This element of the Active and Public Transportation Facility Planning Best Practices Recommendations contains the purpose, scope and use for the document as an outgrowth the ND Moves planning process. The overall ND Moves project contains its own Purpose, Scope and Use. Since it may in fact be used separate from the full ND Moves plan for a specific purpose, the scope and use was developed specifically for the Active and Public Transportation Facility Planning Best Practices Recommendations document.

PURPOSE

- Reference for best practices in active and public transportation facility planning in North Dakota.
- Provide expanded range of facility design guidance and tools related to active and public transportation facilities.
- Highlight key considerations when planning for active and public transportation infrastructure.
- Quick reference pages highlighting different types of active and public transportation facilities based on general context considerations.
- Support the transportation planning, scoping and design process to communicate and consider a broad range of options to support active and public transportation infrastructure.

SCOPE

The ND Moves plan is broad. The Active and Public Transportation Facility Planning Guide was developed as part of the ND Moves planning process and is intended to provide a range of best practices regarding the integration of facility design concepts to support both active and public transportation. This document is not a substitute for currently approved guidance regarding roadway design in North Dakota. The NDDOT Design Manual must be followed on all State Highways and Federal-Aid roadway projects and should be referenced for design considerations for active and public transportation.

USE

- This is not a design manual. For Federal and State Routes, the NDDOT design manual and applicable FHWA guide manuals adopted by the NDDOT design manual should be used for design.
- Supports the development of project concepts for consideration at the planning and scoping phase of a project.
- Supports the inherent design flexibility afforded by adopted NDDOT design manuals.
- Highlights resources that can be referenced for recommendations, considerations, and/or updates to North Dakota design manuals.
- After facility options are identified through this manual for use during the planning or scoping process, the ND Design Manual must be used to verify the feasibility of a facility and develop detailed designs.

Resources

Transit, bicycle and pedestrian facility planning guidance is a key part of ND Moves, North Dakota's statewide active and public transportation plan. This document is a quick reference to assist in planning for active and public transportation infrastructure. The guidance here is intended to serve as a starting point in the facility planning process. The following standards and guidelines were referenced in preparing this document. Consult the latest versions for any facility design considerations.

DESIGN MANUALS AND GUIDANCE ENDORSED BY NDDOT FOR DESIGN OF STATE HIGHWAYS AND FEDERAL-AID PROJECTS

NDDOT Design Manual (<https://www.dot.nd.gov/manuals/design/designmanual/designmanual.htm>)

NDDOT Traffic Operations Manual (<https://www.dot.nd.gov/divisions/programming/docs/trafficops.pdf>)

Manual on Uniform Traffic Control Devices (MUTCD) (<https://mutcd.fhwa.dot.gov/pdfs/2009r1r2/mutcd2009r1r2edition.pdf>)

AASHTO A Policy on Geometric Design of Highways & Streets (Greenbook) (can be purchased at <https://bookstore.transportation.org>.)

AASHTO Guide for the Development of Bicycle Facilities, (can be purchased at <https://bookstore.transportation.org>.)

AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities (can be purchased at <https://bookstore.transportation.org>.)

ADDITIONAL GUIDANCE, RESOURCES, AND RESEARCH

2015 FHWA Separated Bike Lane Planning and Design Guide (https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/separated_bikelane_pdg/separatedbikelane_pdg.pdf)

2012 NACTO Urban Bikeway Design Guide (<https://nacto.org/publication/urban-bikeway-design-guide/>)

2015 MASSDOT Separated Bike Lane Planning and Design Guide (<http://www.massdot.state.ma.us/highway/DoingBusinessWithUs/ManualsPublicationsForms/SeparatedBikeLanePlanningDesignGuide.aspx>)

2007 Mitigation Strategies for Design Exceptions (<https://safety.fhwa.dot.gov/geometric/pubs/mitigationstrategies/>)

2016 FHWA Small Town and Rural Multimodal Networks Guide (https://www.fhwa.dot.gov/environment/bicycle_pedestrian/publications/small_towns/fhwahep17024_lg.pdf)

2014 NCHRP 783: Evaluation of the 13 Controlling Criteria for Geometric Design (<http://www.trb.org/Publications/Blurbs/171358.aspx>)

FHWA Interim Approvals (https://mutcd.fhwa.dot.gov/res-interim_approvals.htm)

2011 (Draft) United States Access Board, Public Right-of-Way Accessibility Guidelines (<https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way>)

2005 Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations (<https://www.fhwa.dot.gov/publications/research/safety/04100/ref.cfm>)



Universal Design

Universal Design is the concept of meeting the needs of all potential users to the greatest extent possible while considering the physical, cognitive, emotional and social changes that people experience over the course of a lifetime.

PRINCIPLES

The Center for Universal Design at North Carolina State University developed the seven principles of Universal Design. The following are intentionally broad to guide a wide range of design disciplines including environments, products, and communication:

- 1. Equitable Use** - Useful to people with diverse abilities
- 2. Flexibility In Use**-The design accommodates a wide range of individual preferences and abilities
- 3. Simple and Intuitive Use**-Easy to understand regardless of language, abilities, knowledge, or concentration level
- 4. Perceptible Information**-The design communicates information effectively to the user regardless of the user's sensory abilities
- 5. Tolerance For Error**-The design minimizes hazards and the adverse consequences of accidental or unintended actions
- 6. Low Physical Effort**-The design can be used efficiently and comfortably and with a minimum of fatigue
- 7. Size and Space For Approach and Use**- Appropriate size and space is provided for approach and use of facility regardless of user's body size, posture, or mobility

LEGAL REQUIREMENTS

American with Disabilities Act (ADA)

Passed in 1990 and updated in 2010, states that "If a public entity has responsibility or **authority over streets, roads, or walkways**, its transition plan shall include **a schedule for providing curb ramps** or other sloped areas where pedestrian walks cross curbs, **giving priority to walkways serving entities covered by the Act**, including State and local government offices and facilities, transportation, places of public accommodation, and employers, followed by walkways serving other areas." ADA requirements apply to shared use paths as well as sidewalks.

PROWAG (Public Right-of-Way Access Guidelines)

- Federal standards proposed by the United States Access Board. While this resource is in draft status as of 2018, NDDOT applies PROWAG as a minimum in anticipation of formal adoption.



Universal Design (Cont.)

DESIGN CONSIDERATIONS

Vertical Clearances – ADA standards mandate that guardrails of other barriers be provided where the vertical clearance to an obstruction is less than 80 inches. The leading edge of such guardrail or barrier must be located not more than 27 inches above the sidewalk.

Curb Ramps – Perpendicular and parallel curb ramps are recommended over diagonal curb ramps.

Width of Accessible Route – PROWAG states minimum width of an accessible route must be 4 feet. If an accessible route has less than 5 feet clear width, then passing spaces at least 5 feet x 5 feet must be located at reasonable intervals not to exceed 200 feet (ADAAG). To remove need for passing areas NDDOT recommends 5 feet as the minimum width of sidewalks. A 6-foot sidewalk width is desired to allow two pedestrians to walk side by side and allow pedestrians with mobility aids to more easily pass each other.

Protruding Objects – ADA standards mandate that objects located between 27 inches and 80 inches from the ground not protrude more than 4 inches into the corridor. Objects longer than 4 inches should be placed no lower than 80 inches.

Sidewalk Surface – Avoid decorative pavement within the pedestrian zone to make it easier to discern for pedestrians with vision impairments. Avoid textured paving materials in the pedestrian through zone as they can cause pain to those in mobility devices with spinal injuries. According to ADA standards, sidewalk surfaces must be slip resistant. Apply a broom finish to concrete surfaces to increase skid resistance.

Grade – The grade of the walkway will generally follow the grade of the roadway and should ideally be no greater than 5% (ADAAG). Provide rest areas and periodic landings to lessen impact of steep grades.

Changes in Level – When possible, prevent changes in level through good design and active maintenance. If changes in level are unavoidable, follow the ADAAG requirements for changes in level.

Cross-Slopes – The maximum cross slope is 2%. Design for lower slopes to account for construction tolerances.

Driveways – Design the pedestrian portion of the driveway using the accessible route criteria: maximum cross-slope of 2%, flush changes in level and a minimum of 4 feet in width.

Gaps, Grates, and Openings – The maximum gap for grating and joints is 0.5 inches. For rail crossing flangeway gaps, there must be a maximum of 2.5 inch gap for non-freight rail and maximum of 3.0 inch gap for freight rail. The long dimension of the opening should be perpendicular or diagonal to the dominant direction of travel (ADAAG).

Doorway openings – If doors open onto pedestrian accessible routes, follow the Appendix D, Section 404 of 36 CFR Part 1191 (ADA) for requirements for clear space to provide accessible route to and around doorway openings.

FOR MORE INFORMATION

United States Access Board. Proposed Accessibility Guidelines for Pedestrian Facilities in the Public-Right-of-Way (PROWAG). 2011. (Chapter R3 and R4)

United States Access Board. ADA Accessibility Guidelines (ADAAG). 2002. (Section 4)
AASHTO. Guide for the Planning, Design, and Operation of Pedestrian Facilities. 2004.
NDDOT Design Manual (Section III-07.04)



Operating Needs of Bicyclists

Bikeway designers must have a clear understanding of how bicyclists operate and how their bicycle influences that operation. Bicyclists, by nature, are much more affected by poor facility design, construction and maintenance practices than motor vehicle drivers.

By understanding the unique characteristics and needs of bicyclists, a facility designer can provide quality facilities and minimize user risk.

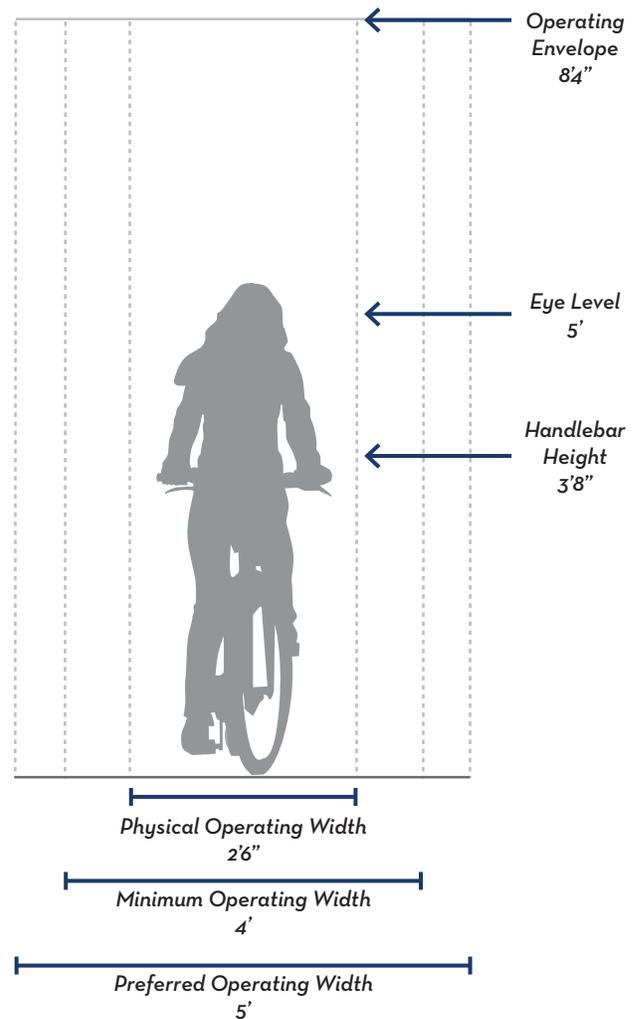
BICYCLE AS A DESIGN VEHICLE

Similar to motor vehicles, bicyclists and their bicycles exist in a variety of sizes and configurations. These variations occur in the types of vehicle (such as a conventional bicycle, a recumbent bicycle or a tricycle), and behavioral characteristics (such as the comfort level of the bicyclist). The design of a bikeway should consider reasonably expected bicycle types on the facility and utilize the appropriate dimensions.

The figure to the right illustrates the operating space and physical dimensions of a typical adult bicyclist, which are the basis for typical facility design. Bicyclists require clear space to operate within a facility. This is why the minimum operating width is greater than the physical dimensions of the bicyclist. Bicyclists prefer five feet or more operating width.

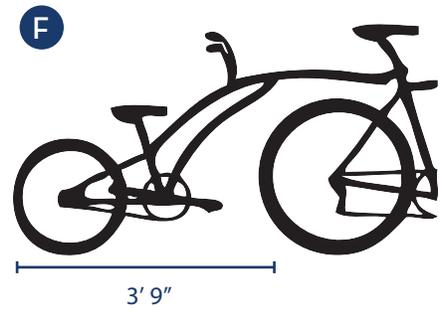
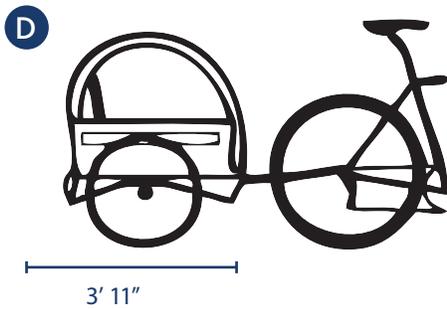
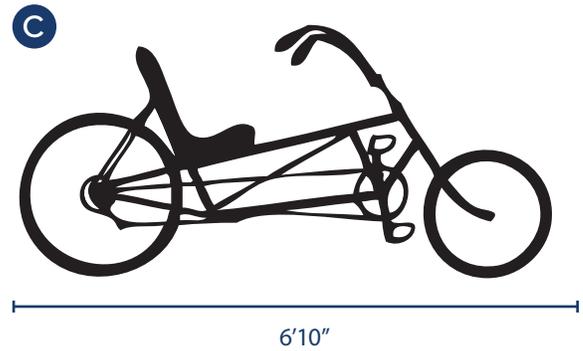
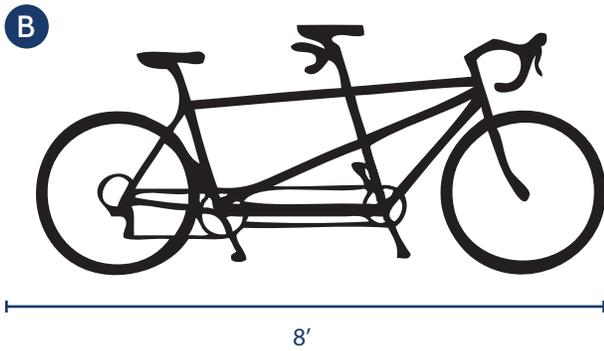
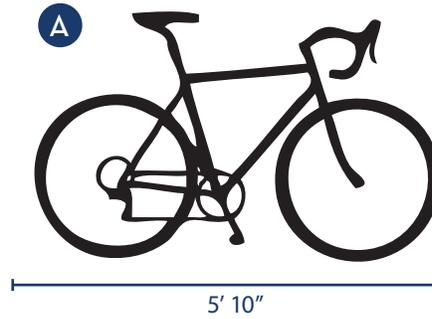
In addition to the design dimensions of a typical bicycle, there are many other commonly used pedal-driven cycles and accessories to consider when planning and designing bicycle facilities. The most common types include tandem bicycles, recumbent bicycles, and trailer accessories. The figure on the following page summarizes the typical dimensions for bicycle types.

Bicycle Rider - Typical Dimensions



Bicycle Design Vehicle - Typical Dimensions

- A: Adult Typical Bicycle
- B: Adult Tandem Bicycle
- C: Adult Recumbent Bicycle
- D: Child Trailer Length
- E: Child Trailer Width
- F: Trailer Bike Length



Source: AASHTO *Guide for the Development of Bicycle Facilities*, 4th Edition

Bicycle as Design Vehicle - Design Speed Expectations

BICYCLE TYPE	FEATURE	TYPICAL SPEED
Upright Adult Bicyclist	Paved level surfacing	8-12 mph*
	Crossing Intersections	10 mph
	Downhill	30 mph
	Uphill	5 -12 mph
Recumbent Bicyclist	Paved level surfacing	18 mph

* Typical speed for casual riders per AASHTO 2013.

FOR MORE INFORMATION
 2012 AASHTO *Guide for the Development of Bicycle Facilities*, 4th Edition



Bicycle User Type

The current AASHTO Guide to the Development of Bicycle Facilities encourages designers to identify their rider type based on the trip purpose (Recreational vs. Transportation) and on the level of comfort and skill of the rider (Causal vs. Experienced). A user-type framework for understanding a potential rider's willingness to bike is illustrated in the figure below. Developed by planners in Portland, OR* and supported by research**, this classification identifies four distinct types of bicyclists.

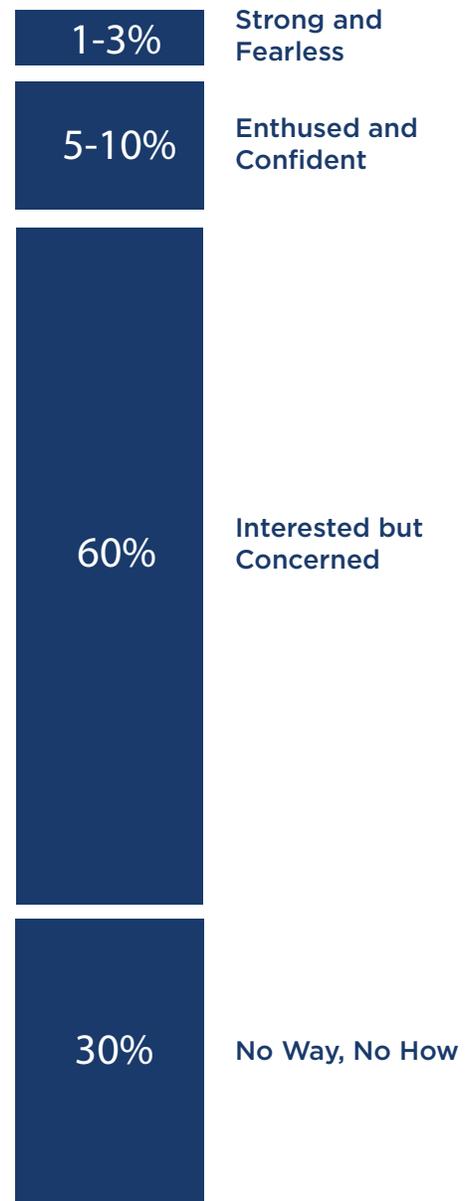
Strong and Fearless – This group is willing to ride a bicycle on any roadway regardless of traffic conditions. They are comfortable taking the lane and riding in a vehicular manner on major streets without designated bicycle facilities.

Enthusied and Confident - This group of bicyclists is willing to ride in most roadway situations but prefers to have a designated facility. They are comfortable riding on major streets with a bike lane.

Interested but Concerned – This group is more cautious and has some inclination towards bicycling, but is held back by concern over sharing the road with cars. They are not very comfortable on major streets, even with a striped bike lane, and prefer separated pathways or low traffic neighborhood streets.

No Way, No How – This group comprises residents who simply aren't interested at all in bicycling and may be physically unable or don't know how to ride a bicycle, and they are unlikely to adopt bicycling in any way.

Typical Distribution of Bicyclist Types



* Roger Geller, City of Portland Bureau of Transportation. Four Types of Cyclists. <http://www.portlandonline.com/transportation/index.cfm?&a=237507>. 2009.

** Dill, J., McNeil, N. Four Types of Cyclists? Testing a Typology to Better Understand Bicycling Behavior and Potential. 2012.

Operating Needs of Pedestrians

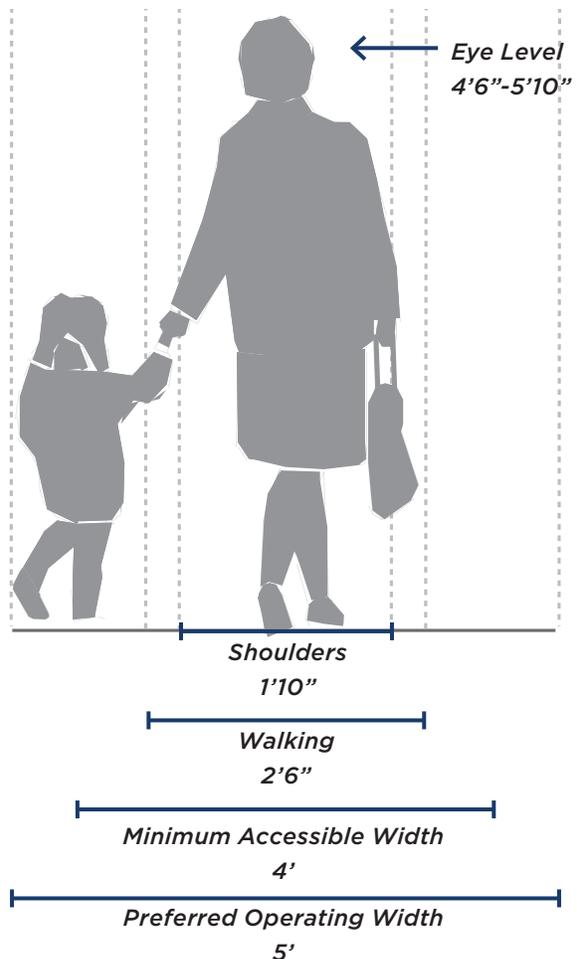
Pedestrians have a variety of characteristics and the pedestrian network should accommodate a variety of needs, abilities, and possible impairments. Age is one major factor that affects pedestrians' physical characteristics, walking speed, and environmental perception. Children have low eye height and walk at slower speeds than adults. They also perceive the environment differently at various stages of their cognitive development. Older adults walk more slowly and may require assistive devices for walking stability, sight, and hearing. The table below summarizes common pedestrian characteristics for various age groups.

The MUTCD recommends a normal walking speed of 3.5 feet per second when calculating the pedestrian clearance interval at traffic signals. The walking speed can drop to under 3 feet per second for areas with older populations and persons with mobility impairments. While the type and degree of mobility impairment varies greatly across the population, the transportation system should accommodate these users to the greatest reasonable extent.

PEDESTRIAN CHARACTERISTICS BY AGE

0-4	Learning to walk Requires constant adult supervision Developing peripheral vision and depth perception
5-8	Increasing independence, but still requires supervision Poor depth perception
9-13	Susceptible to "darting out" in roadways Insufficient judgment Sense of invulnerability
14-18	Improved awareness of traffic environment Insufficient judgment
19-40	Active, aware of traffic environment
41-65	Slowing of reflexes
65+	Difficulty crossing street Vision loss Difficulty hearing vehicles approaching from behind

Pedestrian - Typical Dimensions

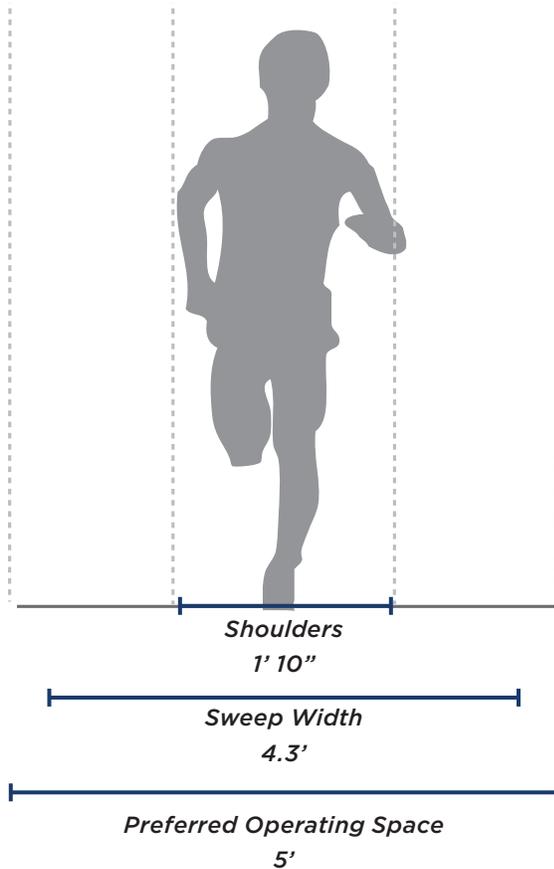


Source: AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities, Exhibit 2-1. 2004.*



OPERATING NEEDS OF RUNNERS

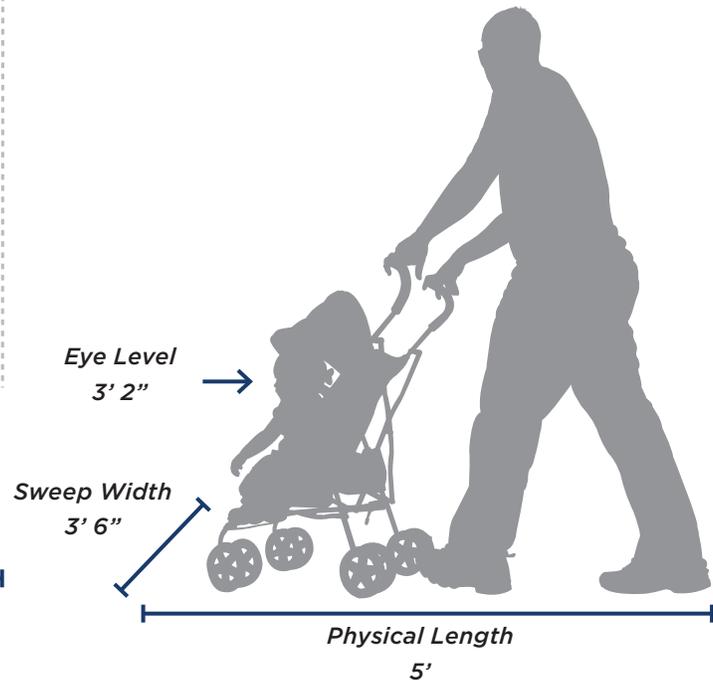
Running is an important recreation and fitness activity commonly performed on shared use paths. Many runners prefer softer surfaces (such as rubber, bare earth or crushed rock) to reduce impact. Runners can change their speed and direction frequently. If high volumes are expected, consider controlled interaction or separation of different types of users.



OPERATING NEEDS OF STROLLERS

Strollers are wheeled devices pushed by pedestrians to transport babies or small children. Stroller models vary greatly in their design and capacity. Some strollers are designed to accommodate a single child, others can carry 3 or more. Design needs of strollers depend on the wheel size, geometry and ability of the adult who is pushing the stroller.

Strollers commonly have small pivoting front wheels for easy maneuverability, but these wheels may limit their use on unpaved surfaces or rough pavement. Curb ramps are valuable to these users. Lateral overturning is one main safety concern for stroller users.



FOR MORE INFORMATION

2004 AASHTO *Guide for the Planning, Design, and Operation of Pedestrian Facilities (Chapter 2.2)*
2011 (Draft) United States Access Board, *Public Right-of-Way Accessibility Guidelines*

OPERATING NEEDS OF WHEELCHAIR USERS

As the American population ages, the number of people using mobility assistive devices (such as manual wheelchairs, powered wheelchairs) increases.

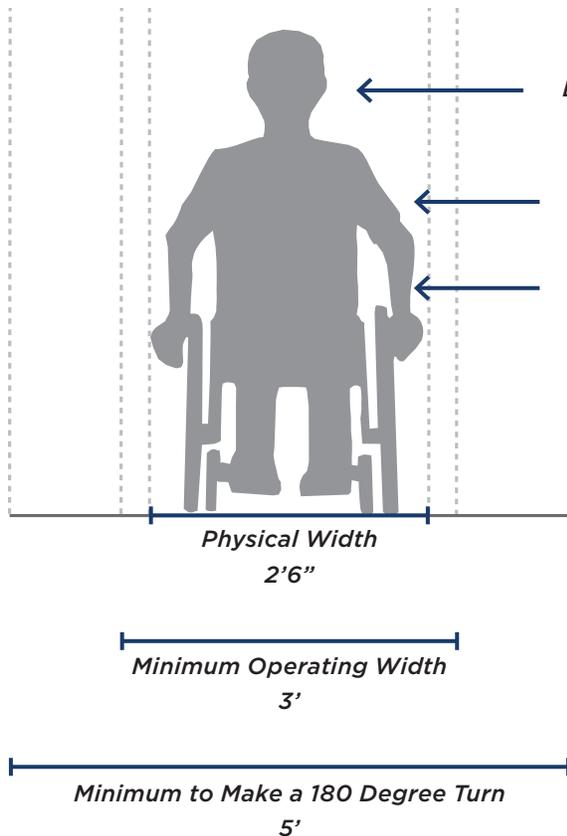
Manual wheelchairs are self-propelled devices. Users propel themselves using push rims attached to the rear wheels. Braking is done through resisting wheel movement with the hands or arm. Alternatively, a second individual can control the wheelchair using handles attached to the back of the chair.

Power wheelchairs use battery power to move the wheelchair. The size and weight of power wheelchairs limit their ability to negotiate obstacles without a ramp. Various control units are available that enable users to control the wheelchair movement, based on their ability (e.g., joystick control, breath controlled, etc).

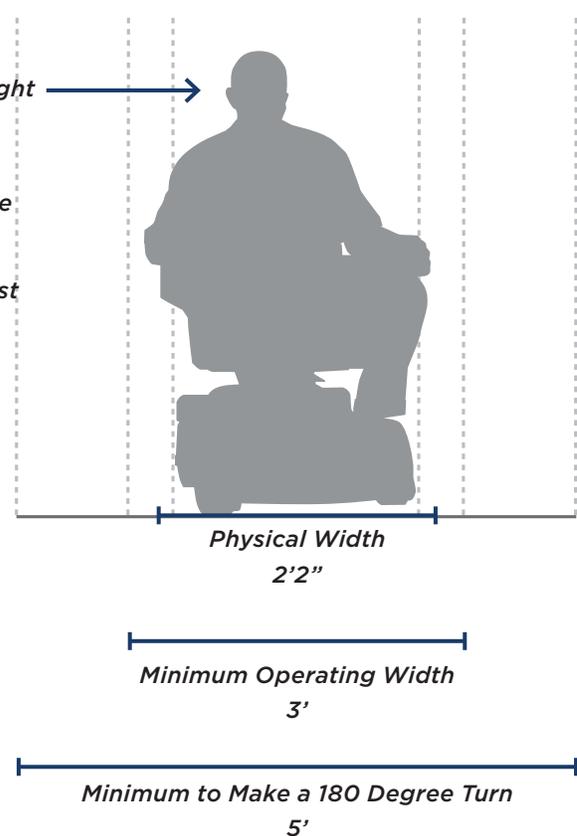
Maneuvering around a turn requires additional space for wheelchair devices. Providing adequate space for 180 degree turns at appropriate locations is an important element of accessible design.

EFFECT ON MOBILITY	DESIGN SOLUTION
Difficulty propelling over uneven or soft surfaces.	Firm, stable surfaces and structures, including ramps or beveled edges.
Cross-slopes cause wheelchairs to veer downhill.	Cross-slopes of less than two percent.
Require wider path of travel.	Sufficient width and maneuvering space.

Person Using Manual Wheelchair



Person Using Power Wheelchair





Operating Needs for Transit

Successful transit infrastructure design requires a collaborative design mentality that focuses on pedestrians and urban growth. No one single agency can implement transit infrastructure design. Instead, all agencies involved in the design of a roadway need to collaborate on the integration of transit infrastructure. While transit operators will utilize the infrastructure, city, county, and North Dakota Department of Transportation (NDDOT) agencies have jurisdiction over adjacent land and control other modal operations that will affect the success of the facilities. Designing transit infrastructure so that it is successful for riders, operators, and vehicles will produce effective street designs.

PEDESTRIAN ACCESS

Every transit rider is also be a pedestrian at some point in their trip, whether within the first or last mile. A transit facility, whether it is a stop, platform, or station, should be easily approachable by everyone on foot, wheelchair, and bicycle. Position safe, marked crossings at or immediately near an easily identified transit facility. Lighting for pedestrian connections to transit stops should be a key consideration for enhancing safety and security.

VEHICLE MOBILITY

The areas around bus stops and stations should provide adequate space for the bus to quickly pull up to the curb and allow all doors to be directly adjacent to the curb. Service times are negatively affected if the bus must slowly approach a boarding area and rider safety hazards are created by gaps between the bus door and curb.

OPERATOR CONVENIENCE

Bus operators must efficiently access and safely navigate through stops and stations. Designs that require an operator to significantly slow down affect service times and negatively affect the transit experience. Clear markers should indicate where the operator should stop every time at each stop or station. Design stations so waiting riders are easily visible and the operator does not accidentally pass by them.

Transit Service Types

Transit service varies greatly, and each service type requires different capital infrastructure. Service types are described in this section and followed by a discussion of capital infrastructure that may apply to one or more service type.

LOCAL FIXED ROUTE BUS

Fixed route bus service is provided on a repetitive, fixed schedule along a prescribed route where vehicles stop to pick up and drop off passengers along the route.

DEVIATED FIXED ROUTE BUS

Like local fixed route service, deviated fixed route bus service operates along a prescribed route on a set schedule. However, this type of service may deviate from the route alignment to pick up or drop off passengers who have requested the deviation.

COMMUTER FIXED ROUTE BUS

Commuter fixed route bus service operates on a fixed route with the primary purpose of connecting outlying areas with a central city. They are generally characterized by a coach bus, multiple stops in outlying areas, limited stops in the central city, and at least five miles of closed-door service.

BUS RAPID TRANSIT (BRT)

BRT service is a high-frequency local fixed route service that stops only at enhanced stations (i.e. stops less frequently than local fixed routes). Typically, a BRT system includes a portion of roadway that is dedicated to buses and uses transit signal priority or preemption at intersections to enhance efficiency along the route. BRT also usually involves off-board fare collection, level-platform boarding, and other design features to reduce delays caused by passengers boarding or leaving buses.

SCHOOL BUSSING

This service uses buses to carry school students and school personnel to and from their schools or school-related activities. These services can include public school buses, private school buses, and buses chartered from private companies to transport students and school personnel.

DIAL-A-RIDE

Dial-a-ride service is a form of on-demand transportation that typically operates in areas or at times when fixed-route service is not available. These systems can take the form of paratransit, taxis, or shuttle services.

Recommended Transit Infrastructure Based on Transit Service Type

The table below indicates the infrastructure that can be used for each type of transit service.

Stops are the most common type of infrastructure, given that they are the least expensive facility. Platforms are often used at higher demand service points, where local and commuter fixed route or BRT services operate. A station or depot involves a larger investment than stops or platforms and can serve as a multimodal hub serving various transportation types. Transit Signal Priority (TSP) is typically utilized for BRT services along arterial routes that may experience significant delay from traffic. Dial-a-ride service provides origin to destination service, so it is the only type of transit service that does not require transit-specific infrastructure in the right-of-way; however, sidewalks and level boarding areas on curbs, at intersections, and within parking lots or near entrances to destinations will make the service more productive and useful to riders.

Types of transit infrastructure are explored in more detail in the Transit Design Considerations Section.

	STOPS	PLATFORMS	STATION/ DEPOT	TRANSIT SIGNAL PRIORITY	PARK-AND- RIDE
LOCAL FIXED ROUTE BUS	X	X	X		
DEVIATED FIXED ROUTE BUS	X		X		
COMMUTER FIXED ROUTE BUS	X	X	X		X
BUS RAPID TRANSIT		X	X	X	X
SCHOOL BUSSING	X				
DIAL-A-RIDE					

Introduction to the Facility Selection Process

This section provides guidance on selecting an active transportation facility based on development context and roadway characteristics. The following section, “Active Transportation Facility Reference,” includes information and key considerations for each active transportation facility type referenced in the facility selection matrices.

OVERVIEW OF STEPS IN THE FACILITY SELECTION PROCESS

Step 1: Evaluation of Need

Determine whether a pedestrian or bicycle facility should be considered based on development context (urban, suburban/commercial, rural center, or rural) and roadway characteristics. If a facility should be considered, progress to step two.

Step 2: Facility Selection

Refer to the appropriate matrix based on the development context of the road. The matrix will indicate which facility types are preferred, potential, and not recommended based on the posted travel speed, average annual daily traffic, and roadway classification. Refer to the following section, “Active Transportation Facility Reference,” for further information about each facility type. Proceed to step three.

Step 3: Determine Number of Sides

Consider whether to install a facility on both sides or only one side of the street, taking into account number of travel lanes, average daily traffic volumes, land use/density/concentrations of destinations, local plans and policies, and whether the project provides a link in the existing or planned pedestrian or bicycle network.

BEYOND ENGINEERING

When new facility types are installed in a community, an effort should be made to educate community members about proper use of the facilities. This can be accomplished through door and bike hangers, signage at the site of the new facility, and online communications.



Step 1: Evaluation of Need

SHOULD A PEDESTRIAN AND / OR BICYCLE FACILITY BE CONSIDERED?

DEVELOPMENT CONTEXT		RECOMMENDATION
<p>URBAN</p> <p>Populations typically above 5,000. Character of private development: more density, mixed land uses, larger buildings, more hardscape, attached buildings, aligned frontages, masonry buildings, building signage; Characteristics of public space: shallow setbacks, streets and alleys, street grid, wide sidewalks, dedicated parking, raised curbs, curb bumpouts, street lighting, aligned street trees, likely adjacent to suburban/commercial; Civic characteristics: Plazas and squares, regional institutions.</p>		<p>Pedestrian and bicycle facilities should be considered. Reference Step 2 for facility selection guidance.</p>
<p>SUBURBAN / COMMERCIAL</p> <p>Populations typically above 5,000. Typically on edge of urban center. Character of private development: Less density, primarily residential, more greenspace, detached buildings, strip malls and parking lots, rotated frontages, wooden buildings, billboards; Characteristics of public space: deep setbacks, roads and lanes, larger turning radii, open swales, mixed tree clusters; Civic characteristics: parks and greens, local gathering places.</p>		<p>A pedestrian and/or bicycle facility should be considered. Reference Step 2 for facility selection guidance.</p>
<p>RURAL CENTER</p> <p>Populations typically below 5,000. Character of private development: more density, mixed land uses, more hardscape, attached buildings, aligned frontages, masonry buildings, building signage; Characteristics of public space: shallow setbacks, street grid, Main Street, on-street parking, raised curbs, street lighting, aligned street trees, likely adjacent to rural; Civic characteristics: Plazas and squares, parks and greens.</p>	<p>Are any of the following true?</p> <ul style="list-style-type: none"> • The road is within a neighborhood, serves as a Main Street, and/or connects to one or more trip generators. • The road is identified on the state or local pedestrian or bikeway network. • Road is an edge, extending beyond rural center into rural, and connects to one or more trip generators or compatible lane uses such as a school, park, transit route, or other destination. 	<p>If yes to any, a ped/bike facility should be considered. Reference Step 2 for facility selection guidance.</p> <p>If no to all, a pedestrian or bicycle facility is not a priority.</p>
<p>RURAL</p> <p>Low density, surface waterbodies, protected wetlands/habitat, transport corridors, agriculture, conservation easements, riparian corridors, livestock.</p>	<p>Are any of the following true?</p> <ul style="list-style-type: none"> • The road connects to one or more trip generators such as a school, park, transit route, or other destination. • The road is identified on the state or local bikeway network. 	<p>If yes to either, a ped/bike facility should be considered. Reference Step 2 for facility selection guidance.</p> <p>If no to both, a pedestrian or bicycle facility is not a priority.</p>

CONSIDERATIONS BEFORE BEGINNING STEP 2

The tables found on the following pages (Step 2) build on Step 1: Evaluation of Need. They present facility selection recommendations according to particular development contexts, locations, and roadway characteristics. In addition to taking preliminary steps toward project design, public engagement, and other aspects of implementation, the facility selection process gives public agency staff a chance to think about the context and land uses that are near a given project site. Furthermore, each project is a chance to work toward agency goals.

PROJECT GOALS AND ROADWAY PURPOSE

Before moving to the facility selection phase, also consider goals and the roadway's purpose. Consider the role that the road plays in a community and include local input within this process. Identifying a roadway's purpose early in the project helps streamline the project's later steps, including facility selection and design. Roadway purpose may vary from one location to the next. For example, some roads focus on mobility between built up areas. Others focus on placemaking near destinations that attract people within rural centers and downtowns. Establishing a clear roadway purpose aids planners and designers in developing goals that serve the vision of NDDOT and local agencies.

Revisiting the roadway purpose during the facility selection phase can confirm whether roadway design changes serve the desired purpose and the needs of people who use the roadway.

In addition to framing the project, goals serve as communication tools when interacting with members of the public, members of the development community, and other stakeholders. Goals can also be tied to funding criteria and priorities. Eventually, a virtuous cycle is created where outcome-based, measurable goals are tracked over time and expanded based on providing funding to projects that meet these goals.



Even after articulating clear goals, tradeoffs are often necessary regardless of the specific project. Understanding the site's context and the project's purpose will help NDDOT and local partners develop an approach for managing project tradeoffs. Goals for a specific roadway need to be considered compared to how the road is currently being used and competing desires for the road's use and purpose into the future. Tradeoffs occur based on limited roadway and curbside space, funding limitations, competing visions between agencies, and other factors. A variety of skills are needed when managing potential tradeoffs. Technical skills such as design flexibility and engineering judgement are needed alongside communication skills such as negotiation, active listening, and consensus building.

Tradeoffs

Tradeoffs can become pronounced when planning for on-street bicycling infrastructure because roadway widening is not typically an option during many street design projects. Instead, many projects focus on working within the existing pavement width. This can result in difficulty between adding bicycle lanes and maintaining on-street parking and lane capacity. Solutions to solving tensions that arise based on limited pavement width or right-of-way can be informed by the roadway's purpose and project goals. Depending on the context, on-street parking can benefit walkability by slowing car traffic and by providing a buffer between people walking and car traffic. On-street parking is also convenient for business patrons and employees. Weigh on-street parking and other infrastructure options according to potential benefits and limitations before finalizing street design concepts that may remove these features.

LAND USE AND TRANSPORTATION

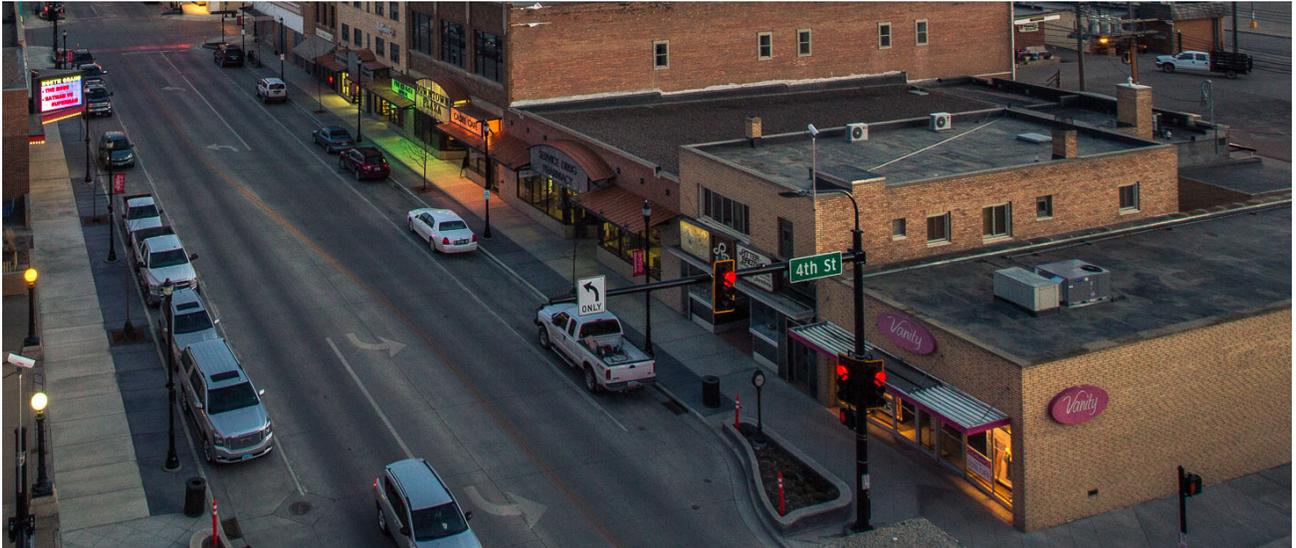
The facility selection process gives planners and engineers a chance for coordination between departments, agencies, and between the related disciplines of land use planning and transportation planning. Certain land use patterns make active and public transportation infrastructure more effective. This means they are more sensible investments from a funding perspective. On the other hand, transportation projects may include walking and bicycling elements while understanding that surrounding land uses would require changes to better support walking and bicycling.

Historically, there has been a mismatch between land use and transportation. For example, a downtown street may contain several businesses, gathering places, and other locations. However, the location may be served by a street that focuses on moving car and truck traffic. These locations may have minimal or no dedicated walking and bicycling facilities. Additionally, walkability is negatively impacted when the surrounding land use context features multiple surface parking lots and street facades with large setbacks located away from walking routes.

Continued collaboration between design professions, public agency staff, residents, business owners, and community advocates is necessary to work toward multimodal streets and surrounding land uses that support them. Pairing a thorough review of existing and proposed land use and development scenarios with bicycle and pedestrian facility selection is a best practice for evaluating potential impacts to the project site. This approach reiterates the need for collaboration across disciplines including coordination between planners, engineers, public health professionals, real estate developers, elected officials, and more.



Williston's Main Street was designed to move traffic into and through downtown. Speeding was prevalent along the wide four lane roadway. Although the street featured sidewalks, it did not attract heavy foot traffic.



Main Street in downtown Williston now features a visually narrow cross-section, curb extensions, increased density, street trees, sidewalks, and storefronts. (Image: willistondowntown.com).



SITE CONTEXT AND SUPPORTING ACTIVE TRANSPORTATION

Adjacent businesses, residences, and parks influence whether someone will feel comfortable walking or bicycling in that place. Certain types of streets and their surrounding context are better at supporting active transportation than others. The callout box to the right describes common qualities of places that support walking and bicycling. Elements of walkability are frequently referenced in terms of commercial areas. However, they also apply to residential and institutional (i.e., schools, government buildings) settings.

Elements of walkability are most commonly found within built up areas. Nonetheless, connections between built up areas are important to encourage active transportation. Sidewalks, sidepaths, and shared use paths enable these connections. The surrounding context influences whether people will feel comfortable using these connections to reach built up areas. Outside of built up areas, lighting, open sight lines and trimmed landscaping, legible signage, and well maintained facilities are important to complement safe intersections and pathways.

Elements of Walkability

- Good street connectivity
- Mixed land uses
- Street-facing windows and doors
- Human scale buildings, trees, and street furniture
- Street trees, especially those with adequate canopies for shade
- On-street parking or other buffers between people walking and moving traffic
- Interesting and visually complex buildings or landscaping
- Low traffic speeds and narrow streets
- Appropriately scaled lighting
- Proportionate building and tree canopy heights that invoke a sense of enclosure

USING FACILITY SELECTION TABLES

The tables included in Step 2: Facility Selection give guidance to help choose a facility based on a given roadway's classification, posted travel speed, and average annual daily traffic. The preceding sections discuss a need for planners, designers, and engineers to define a corridor's purpose at the start of a project, prior to working on facility selection. An understanding of the roadway's context and surrounding land uses is also needed before discussing potential infrastructure options for active transportation. The facility selection tables are separated according to development context to facilitate this process. Tables are divided according to urban, suburban/commercial, and rural/rural center development categories. Categories are further divided into locations within built up areas and outside these areas.

Step 2: Facility Selection

URBAN

Posted Travel Speed (mph)	Average Annual Daily Traffic	Yield Street / Bicycle Boulevard	Advisory Shoulder	Bike Lane	Buffer Separated Bike Lane	Barrier Separated Bike Lane	Sidewalk	Shared Use Trail / Sidepath
Local / Collector								
25 and below	< 500	Preferred	Preferred	Potential	Potential	Potential	Potential	Potential
	500-1500	Preferred	Preferred	Potential	Potential	Potential	Potential	Potential
	1500-3000	Potential	Potential	Potential	Potential	Potential	Potential	Potential
	3000-6000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	> 6000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
30	< 500	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	500-1500	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	1500-3000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	3000-6000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	> 6000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
35 and above	< 500	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	500-1500	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	1500-3000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	3000-6000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	> 6000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
Arterial								
30 and below	< 3000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	3000-10,000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	10,000-15,000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	15,000-20,000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	>20,000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
35 and above	< 3000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	3000-10,000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	10,000-15,000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	15,000-20,000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential
	>20,000	Not recommended	Not recommended	Potential	Potential	Potential	Potential	Potential

Legend

- Preferred
- Potential
- Not recommended



Step 2: Facility Selection (cont.)

SUBURBAN/COMMERCIAL

Posted Travel Speed (mph)	Average Annual Daily Traffic	Within built up area						Outside built up area			
		Yield Street / Bicycle Boulevard	Advisory Shoulder	Bike Lane	Buffer Separated Bike Lane	Barrier Separated Bike Lane	Sidewalk	Sidepath	Paved Shoulder	Bike Lane	Shared Use Trail / Sidepath*
Local / Collector											
25 and below	< 500	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	500-1500	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	1500-3000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	3000-6000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	> 6000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
30	< 500	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	500-1500	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	1500-3000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	3000-6000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	> 6000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
35 and above	< 500	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	500-1500	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	1500-3000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	3000-6000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	> 6000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Arterial											
30 and below	< 3000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	3000-10,000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	10,000-15,000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	15,000-20,000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	>20,000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
35 and above	< 3000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	3000-10,000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	10,000-15,000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	15,000-20,000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	>20,000	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green

*Outside of built up areas, a sidepath may be appropriate if pedestrian activity is expected.

Step 2: Facility Selection (cont.)

RURAL/RURAL CENTER

Posted Travel Speed (mph)	Average Annual Daily Traffic	Rural Center (or near destinations)					Rural (outside built up area)	
		Yield Street / Bicycle Boulevard	Advisory Shoulder	Bike Lanes*	Sidewalk	Sidepath	Paved Shoulder	Shared Use Path Sidepath
Local / Collector								
25 and below	< 500	Green	Green	Green	Green	Green	Green	Green
	500-1500	Green	Green	Green	Green	Green	Green	Green
	1500-3000	Green	Green	Green	Green	Green	Green	Green
	3000-6000	Green	Green	Green	Green	Green	Green	Green
	> 6000	Green	Green	Green	Green	Green	Green	Green
30	< 500	Green	Green	Green	Green	Green	Green	Green
	500-1500	Green	Green	Green	Green	Green	Green	Green
	1500-3000	Green	Green	Green	Green	Green	Green	Green
	3000-6000	Green	Green	Green	Green	Green	Green	Green
	> 6000	Green	Green	Green	Green	Green	Green	Green
35 and above	< 500	Green	Green	Green	Green	Green	Green	Green
	500-1500	Green	Green	Green	Green	Green	Green	Green
	1500-3000	Green	Green	Green	Green	Green	Green	Green
	3000-6000	Green	Green	Green	Green	Green	Green	Green
	> 6000	Green	Green	Green	Green	Green	Green	Green
Arterial								
30 and below	< 500	Green	Green	Green	Green	Green	Green	Green
	500-1500	Green	Green	Green	Green	Green	Green	Green
	1500-3000	Green	Green	Green	Green	Green	Green	Green
	3000-6000	Green	Green	Green	Green	Green	Green	Green
	> 6000	Green	Green	Green	Green	Green	Green	Green
35 and above	< 500	Green	Green	Green	Green	Green	Green	Green
	500-1500	Green	Green	Green	Green	Green	Green	Green
	1500-3000	Green	Green	Green	Green	Green	Green	Green
	3000-6000	Green	Green	Green	Green	Green	Green	Green
	> 6000	Green	Green	Green	Green	Green	Green	Green

*Conventional bike lanes, buffered separated bike lanes, or barrier separated bike lanes may be considered. On roadways with additional space and/or higher traffic speeds and volumes, separated bike lanes offer a higher level of comfort and are approachable for a wider range of potential users.

Step 3: Determine Number of Sides

Directional and on-street bicycle facilities should always be installed to allow for bicycle travel in both directions. When installed on a one-way street, on-street bicycle facilities should serve the direction of vehicle traffic.

Sidewalks on both sides of the street are recommended as the default approach to pedestrian facilities. However, in some cases, sidewalks and shared-use paths on one side of the street can effectively serve bicycle and pedestrian trips. The following considerations are intended to provide a general framework for evaluating whether off-street facilities such as sidewalks and shared use paths are needed on one or both sides of the street. Engineering judgement and an understanding of local needs, challenges, and connectivity should also be incorporated into evaluation, planning, and design.

CONSIDERATIONS:

Number of travel lanes

Streets with more than one travel lane in each direction are good candidates for sidewalk or shared use path on both sides of the street. Streets with more than one travel lane in each direction are typically more challenging for pedestrians to cross, have lower driver yielding rates, and an increased risk of hidden threat collisions. Providing facilities on both sides reduces the need for pedestrian to cross the street in order to access a separated facility.

Average daily traffic volumes

Streets with traffic volumes above 6,000 ADT are good candidates for sidewalk or shared use path on both sides of the street as higher vehicle volumes can make crossing the street more challenging to pedestrians. Providing facilities on both sides reduces the need for people to cross the street in order to access a separated facility.

Land use, density, and concentration of destinations

Pedestrian and bicycle demand typically increases with density. Streets in areas with medium to high density (existing or planned) are good candidates for sidewalk or shared use path on both sides of the street to accommodate higher levels of pedestrian and bicycle activity and demand. Roads that serve

vulnerable users such as low-income, children, or elderly populations are also good candidates for sidewalk or shared use path on both sides of the street.

In locations where destinations are concentrated on one side of the street, it may be adequate to construct sidewalk or shared use path on one side of the street. However, if a project is filling a pedestrian and/or bicycle gap on a roadway that has facilities on both sides, facilities should be constructed on both sides.

In low-density residential areas, sidewalk or shared use path on one side of the street may be adequate on local streets.

Do local plans or policies recommend facilities on one or both sides?

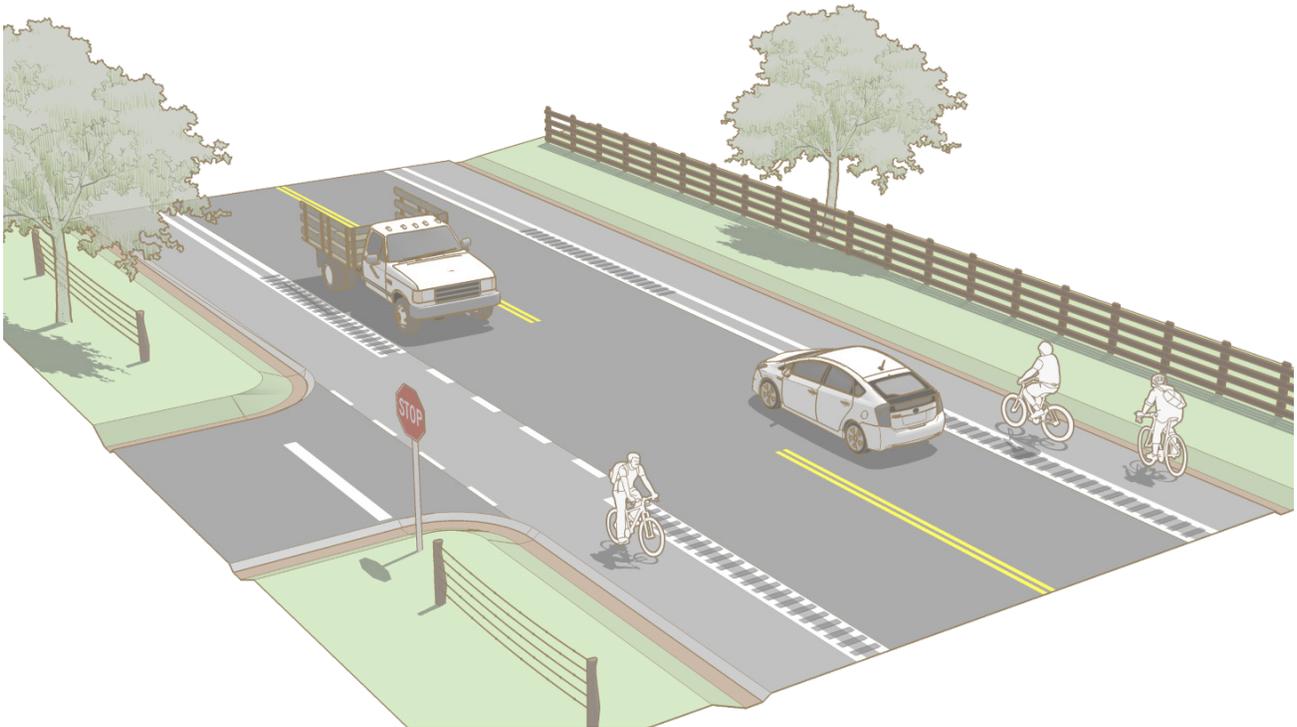
Note any local guidance or policies suggesting when facilities should be provided on one or both sides of the street.

Does the project provide a link in the existing or planned pedestrian or bicycle network?

Consider connections to existing and planned pedestrian and bicycle routes to maintain a consistent and well-connected network and reduce unnecessary street crossings. If the project is located along an existing or planned transit route, consider pedestrian access to/from dedicated transit stops.

Paved Shoulders

Paved shoulders on the edge of roadways can be enhanced to serve as a functional space for bicyclists and pedestrians to travel in the absence of other facilities with more separation. They are typically found in less-dense, or rural areas. According to AASHTO, shoulders intended for bicycle travel should be at least 4 feet in width, with a minimum 5 feet from the right edge of the rumble strip to any guardrail, curb, or other roadside barrier. These shoulders may often include signage alerting motorists to expect bicycle travel along the roadway. Shoulders may be implemented in excess of 4 feet under a variety of circumstances.



MARKINGS

On shoulders designed for bicycle and pedestrian accessibility, the edge should be clearly delineated and defined to discourage unnecessary encroachment by motor vehicles. Options beyond a normal white line include:

- A wide 8 in white line.
- A narrow buffer space—two normal 4 in solid white lines separated by an 18 in or greater space.
- A wide buffer space—two normal solid white lines, separated by a 4 ft or greater space and optional crosshatch markings.

Discontinue the edge line at intersections and major driveways. On a bicycle accessible shoulder, additional definition of the shoulder alignment may be desired. In these conditions, consider:

- A dotted white line to extend the edge line through intersections and major driveways.
- A second normal width dotted white line may be used to define the outside edge of the shoulder, defining both sides of the bicycle travel area.

USE OF RUMBLE STRIPS ON SHOULDERS

Rumble strips are a common safety treatment on many types of highways. For Tier 1 routes, bicyclists are expected to ride in the travel lane and are not expected to use any shoulder (if present). Where appropriate on Tier 2 and Tier 3 routes identified as bicycle routes, bicyclists may be expected to ride to the right of the rumble strip. The following recommended guidance follows from the AASHTO Bike Guide. A minimum of 4 feet clear shoulder should be provided to the right of the rumble strips. Rumble strips should not be installed on shoulders less than 6 feet wide when guardrail is placed at the edge of the shoulder. Place rumble strips to overlap with the roadway edgeline, also known as edgeline rumble strips or rumble strips.

Dimension, design, and placement of rumble strips:

- 12 inch spacing center-to-center
- 6-8 inches long, perpendicular to roadway
- 6 inch wide, measured parallel to roadway
- 3/8 inch deep
- Provide a bicycle gap pattern to allow access into and out of the shoulder area by bicyclists. The gap pattern consists of a 12 ft clear gap followed by rumbles, typical 40-60 ft

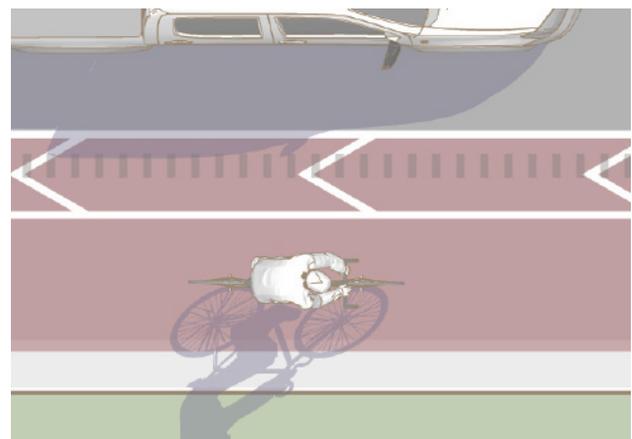
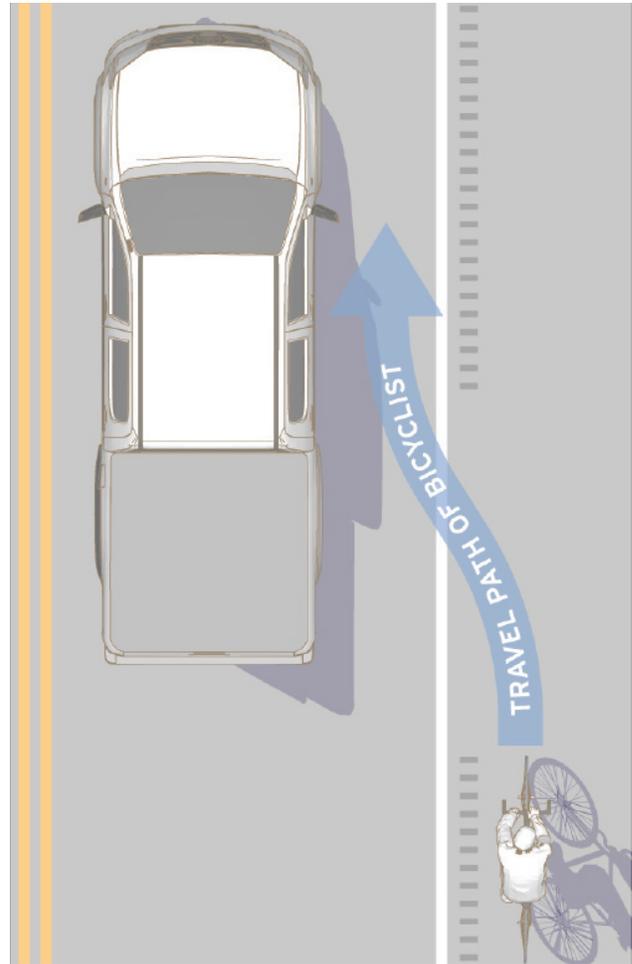
PAVEMENT CONTRAST AND COLOR

Contrasting or colored pavement materials may be used to differentiate the shoulder from the adjacent travel lanes.

Colored pavement in a paved shoulder is an aesthetic treatment to enhance awareness and is not intended to communicate a regulatory, warning, or guidance message to road users.

APPROPRIATE CONTEXT

- Land use: Outside built up areas in suburban/commercial and rural/rural center
- Street classification: local/collector and arterial
- Roadway conditions: All speeds and volumes



FOR MORE INFORMATION

2012 AASHTO Guide for the Development of Bicycle Facilities, 4th Edition (Chapter 4.5)
2016 FHWA Small Town and Rural Multimodal Networks Guide (Chapter 3-3)
2016 NCHRP Synthesis 490: Practice of Rumble Strips and Rumble Stripes

Shoulder Bikeways and the State Bike Network

As part of ND Moves, NDDOT has developed a planned State Bike Network. The State Bike Network is a 20-year vision to connect key transportation and recreation destinations across the state. It is primarily meant for long-distance bicycle trips, with the understanding that some network segments may be used for shorter connections between urban areas and destinations outside of built up areas, such as State Parks. As a result, the State Bike Network will primarily follow rural roadways, where shoulder bikeways are the most appropriate and cost-effective facility type.

The following sections describe the three tiers of the State Bike Network, infrastructure expectations for the network, and implementation guidance to build the network incrementally through investments in the State Highway System.

TIER DEFINITIONS

The purpose of this categorization is to ensure that NDDOT's limited resources are used most effectively to improve bicycling conditions where improvements are needed the most. Tier designations also indicate the level of infrastructure that is desired.

Tier 1 Routes - Primary State Bike Corridors

Definition

Tier 1 Corridors are low traffic volume paved roadways on the state highway system, or paved County Major Collectors (CMCs). Conditions on Tier 1 Corridors are already suitable for confident, recreational bicyclists. These roadways generally do not have bikeable shoulders; however, their low traffic volumes make these roadways comfortable for most confident bicyclists. Tier 1 Corridors provide low-traffic alternates to shoulder bikeways on higher-traffic roadways and follow scenic byways and backways where possible, Tier 1 corridors connect to several North Dakota State Parks and other more local or regional based destinations across North Dakota.

Infrastructure Expectation

There is no expectation of wide, bikeable shoulders on the Tier 1 network. However, as funding allows, safe, emergency pull off will be provided (e.g. shallow foreslopes; paved, unpaved, or grass shoulders, etc.). While there is no expectation of wide, bikeable shoulders, a Tier 1 designation does not preclude the development of shoulders for bicycle or other uses and benefits. Tier 1 routes have been established along roadways with traffic volumes that are generally below 750 ADT, with ADT of 1,000 considered acceptable in shorter segments of a Tier 1 route. Roadways with traffic volumes below 1,000 are typically suitable for confident bicyclists, even without the presence of a bikeable shoulder. Tier 1 Corridors are not on the Level 1 Freight Network.

NDDOT could use signage to improve awareness of bicycle traffic among vehicle drivers. NDDOT could also publish maps of Tier 1 routes to build awareness of these among bicyclists.

It is recommended that NDDOT monitor traffic volumes on these routes to understand if traffic volumes increase above 1,000 ADT. Tier 1 route designation may need to be modified if traffic volumes increase on a roadway.



Shoulder Bikeways and the State Bike Network (cont.)

Tier 2 Routes – Secondary State Bike Corridors

Definition

Tier 2 Corridors are low traffic volume roadways on the state highway system or County Major Collectors (CMCs). Tier 2 Corridors can be paved or unpaved roadways. Conditions on Tier 2 Corridors are generally suitable for confident, recreational bicyclists, though some bicyclists may prefer other routes in order to stay on paved surfaces. These roadways generally do not have bikeable shoulders. Tier 2 Corridors supplement the Tier 1 network by providing connections in areas where there are not roadways that meet Tier 1 criteria.

Infrastructure Expectation

There is no expectation of wide, bikeable shoulders on the Tier 2 network. Additionally, many of these routes will have steep foreslopes, no shoulders, and other features that may make exiting the driving lane difficult. Tier 2 routes have been established along roadways with traffic volumes that are generally below 1,500 ADT and are not on the Level 1 Freight Network. Tier 2 routes will generally be comfortable for confident recreational bicyclists due to low traffic volumes.

As with Tier 1 routes, NDDOT could use signage to improve awareness of bicycle traffic among vehicle drivers and publish bicycling maps of Tier 2 routes.

While Tier 2 Corridors are typically paved roadways, some gravel roadways are included in the system to make key connections where low-traffic alternate routes do not exist. Gravel Tier 2 Corridors are expected to remain gravel roadways and Tier 2 designation is not expected to drive the paving of a gravel roadway.

It is recommended that NDDOT monitor traffic volumes on these routes to understand if traffic volumes increase above 1,500 ADT. Tier 2 route designation may need to be modified if traffic volumes increase on a roadway. If traffic volumes increase, Tier 2 designation may need to shift to a different roadway, or the original roadway could shift to a Tier 3 designation.

Tier 3 Routes – Regional Bike Connector Corridors

Definition

Tier 3 Regional Bike Connector Corridors are located along roadways with greater than 1,500 ADT that provide critical intra-urban, statewide, and interstate connections. These routes are typically high-volume and/or high-speed state roadways where separation between cyclists and motorists is important for bicyclist safety and comfort. Tier 3 Corridors have been identified in locations where there is no suitable Tier 1 or Tier 2 connection to a key destination.

Infrastructure Expectation

The desired infrastructure for Tier 3 Corridors is a bikeable shoulder with a minimum width of 5 feet. The network has been designed to follow Interregional Corridors or State Corridors that in many cases already have bikeable shoulders. These routes may also be Level 1 Freight Corridors. These roadways are already a NDDOT priority for shoulder construction to support vehicle safety and provide other benefits. Bikeable shoulders should be provided to the greatest extent possible on these roadways.

US Bicycle Route System Alignment

Definition

US Bicycle Route System (USBRS) Alignments are identified to provide specific roadway segments following the USBRS National Corridor Plan. USBRS alignments can be any of the three tiers of the North Dakota State Bike Plan Network.

Infrastructure Expectation

The infrastructure expectation for US Bicycle Routes follows the North Dakota State Bike Plan network tier.

Shoulder Bikeways and the State Bike Network (cont.)

STATE BIKEWAY DESIGN RECOMMENDATIONS

Tier 1 and Tier 2 Bikeways and Constrained Corridors

The primary design recommendation for rural Tier 1 and 2 bikeways is signage. Tier 1 and 2 bikeways follow low traffic roadways that are generally suitable for confident bicyclists. As funding and topography allows, safe emergency pull off locations are recommended, using designs such as shallow foreslopes, or shoulders (paved, gravel, or grass).

The design options listed in the table below are appropriate for Tier 1 and 2 bikeways and roadways that are constrained or where shoulder widening is not planned or prioritized.

Design options for Tier 1 and 2 Bikeways and Constrained Corridors

DESIGN FACTOR	BEST PRACTICES AND GUIDANCE	WHEN INTERVENTION IS APPROPRIATE
<p>WARNING SIGNAGE - RURAL AREAS OPTION A</p> 	<p>On higher-speed rural roadways, best practices suggest using the MUTCD compliant W11-1 with a custom legend plaque reading “on Roadway.” This sign is appropriate on roadways with no shoulder, or where the shoulder clear width is less than 4 feet. Use engineering judgement to determine appropriate placement intervals.</p> <p>NOTE: The “Share the Road” (W11-1/W16-1P) assembly is not recommended for application on ND roadways. This sign’s usefulness has been challenged, based on arguments that it is ambiguous, imprecise, and frequently misinterpreted.*</p> <p><i>*Bike Delaware (2014) Why “Share the Road” is gone in Delaware. Available: http://www.bikede.org/2014/04/07/why-share-the-road-is-gone</i></p> <p><i>Pein W (2012a) The Share the Road Sign. Available: http://bicyclingmatters.files.wordpress.com/2008/04/the-share-the-road-sign3.pdf</i></p>	<p>Along Tier 1 and 2 routes. Along rural roadways where providing the target shoulder bikeway is not feasible or where they are not prioritized.</p>
<p>WARNING SIGNAGE - RURAL AREAS OPTION B</p> 	<p>An alternative option for rural roadway regulatory signage is MUTCD compliant W11 with custom plaque reading: “IN LANE”. Delaware DOT has adopted this sign assembly as the standard sign for rural bike route application. Use engineering judgement to determine appropriate placement. NDDOT would need to formally adopt the alternative “IN LANE” plaque.</p>	<p>Along Tier 1 and 2 routes. Along rural roadways where providing the target shoulder bikeway is not feasible or where they are not prioritized.</p>



Shoulder Bikeways and the State Bike Network (cont.)

DESIGN FACTOR	BEST PRACTICES AND GUIDANCE	WHEN INTERVENTION IS APPROPRIATE
<p>FLASHING BEACONS</p>  <p><i>Photo by Jonathan Maus for Bike Portland</i></p>	<p>On constrained roadways, such as bridges, tunnels or other short segments where a shoulder bikeway cannot be provided, a potential safety enhancement is the addition of flashing activated warning beacons. Warning beacons can be passively activated by bicyclists riding by a sensor or manually activated with a push button. The warning beacon displays a flashing pattern to alert motorists of the presence of bicyclists, and indicate the need to adjust their speed and passing behavior accordingly.*</p> <p>No guidance for this design intervention is currently available. Use engineering judgement when considering installation.</p> <p><i>*It should be noted that the effectiveness of this strategy has not been studied extensively.</i></p>	<p>This intervention is appropriate at specific “pinch-point” locations, such as a tunnel, bridge, narrow roadway section, or at locations where sight distance is limited, such as sharp turns, to provide a specific and clear signal to motorists to be aware of bicyclists through the pinch-point. It is not appropriate for long stretches of roadway.</p>
<p>UPHILL SHOULDER LANE</p>	<p>Uphill shoulder lanes can be considered in locations where there are sustained grades and limited places for uphill bicyclists to pull off the roadway. An uphill shoulder lane is a lane that can be used by bicyclists to climb the hill. Uphill shoulder lanes can be achieved through restriping the existing roadway cross-section or reconstructing the roadway on the uphill side of the road.</p> <p>Reference the recommended shoulder widths table on page 35 to determine the appropriate width of the uphill shoulder lane. Additional guidance for this type of facility is provided in the AASHTO Bike Guide (Chapter 4.5)</p>	<p>The speed difference between a bicyclist travelling uphill and a vehicle travelling uphill is much greater than the speed difference between a bicyclist travelling downhill and a vehicle travelling downhill. Due to this disparity in speeds, it may be advantageous to provide an uphill shoulder lane. This strategy is most appropriate on roadways with consistent grade increase, such as roadways through hilly areas.</p>

Shoulder Bikeways and the State Bike Network (cont.)

Tier 3

The primary design recommendation for rural Tier 3 bikeways is a shoulder bikeway. The intent of these facilities is to provide a comfortable bicycling experience for recreational bicyclists as speeds and volumes increase. In rural areas, paved shoulder bikeways act similarly to bike lanes in urban areas, providing a dedicated space for bicyclists to ride adjacent to motor vehicle traffic. Additional design features are discussed in the subsections below.

The following table presents minimum desired shoulder widths by traffic volume and truck percentage of traffic mix for Tier 3 bikeways, based on the AASHTO Guide for the Development of Bicycle Facilities, 4th Edition Chapter 4.7, Rural Bicycle Level of Traffic Stress Methodology adapted by the Colorado and Vermont Departments of Transportation, and guidance established in the Minnesota Department of Transportation Bikeway Design Manual. As truck volumes increase on a roadway, bicyclist comfort and safety are negatively impacted. Wider shoulders provide greater maneuvering room for bicyclists to avoid larger vehicles and associated wind blast. The minimum desired shoulder width was developed with the assumption that rumble strip placement may encroach into up to one foot of the shoulder, effectively reducing bicyclist operating space. See page 27 for further guidance on rumble strip placement on shoulder bikeways.

*Minimum Desired Shoulder Widths for Tier 3 Bikeways**

ADT	TRUCKS <10% OF TRAFFIC	TRUCKS >10% OF TRAFFIC
<2,000	5'	6'
2,000-10,000	6'	8'
>10,000	8'	10'

**Note: Shoulder dimensions assume that rumble strip placement may encroach up to one foot into the shoulder.*



Shoulder Bikeways and the State Bike Network (cont.)

Discussion on Shoulder Bikeway Width for Rural Roadways

AASHTO Chapter 4.5 specifies that for paved shoulders that accommodate bicyclists, the minimum width of the paved shoulder should be at least 4 feet. Wide shoulder bikeways are recommended to exceed this minimum design width for the following reasons:

- **Wide Shoulders Improve Safety:** A large portion of bicycle-vehicle crashes on rural roadways occur when a vehicle attempts to overtake a bicyclist on a roadway with no or little available paved shoulder width. As traffic volumes increase, overtaking conflicts increase as well. Wider shoulders also lessen the impact of wind-blast caused by passing vehicles, especially trucks passing at high rates of speed. The AASHTO Guide for the Development of Bicycle Facilities Chapter 4.5 states that shoulders wider than 4 feet are desirable if higher bicycle usage is expected or if motor vehicle speeds exceed 50 miles per hour; if use by heavy trucks, buses, or recreational vehicles is considerable; or if static obstructions exist at the right side of the roadway.
- **Wide Shoulders Improve Comfort:** The physical minimum operating width for a bicycle is 2.5 feet. 30 states, but not North Dakota, have passed laws that require motorists to provide bicyclists a minimum 3-foot berth when passing. This total minimum width (which assumes the bicyclist is riding at the edge of the road) equals 5.5 feet. Shoulders provided dedicated space for bicyclists, which improves comfort. Wide shoulders also give bicyclists maneuvering space to avoid road debris and other hazards.
- **Wide Shoulders have Maintenance Benefits:** Roadways deteriorate from the roadway edge first, and this deterioration minimizes the effective width of the shoulder for bicycling.
 - » As the shoulder deteriorates, the bicyclist may need to ride closer to the travel lane.
 - » As the effective width of the shoulder narrows, drivers may have to exit their lane to provide the 3-foot clear berth.
 - » Wider shoulders provide excess width that accounts for the fact that the shoulder edge may deteriorate, and that in the future, the effective width of the shoulder may be less than the design dimension.
- **Wide Shoulders Facilitate Passing:** 5.5' shoulders provide the minimum width necessary for a bicycle to operate within the shoulder and provide drivers with the minimum 3-foot clear passing berth within the existing travel lane. Passing a bicyclist riding in a shoulder is less stressful for both drivers and bicyclists.

Therefore, on high-speed, high-volume roadways, or routes where trucks represent greater than 10% of the traffic stream, a wide shoulder bikeway is the preferred design treatment. Shoulders provide benefits to other roadway users, beyond providing a dedicated space for bicyclists to ride.

Analysis Procedures Manual, Chapter 14 Multimodal Analysis. Oregon Department of Transportation (ODOT) December, 2012

Shoulder Bikeways and the State Bike Network (cont.)

IMPLEMENTATION GUIDANCE - STATE BIKE NETWORK

Intent

The following guidance is aimed at providing a linkage between the development of a North Dakota Statewide Bike Network and current design guideline and investment strategies utilized by NDDOT. The Statewide Bike Network is almost exclusively a rural facility implemented through the development of a what is termed a bikeable shoulder, as discussed on page 26. Implementation of a bikeable shoulder to support the Statewide Bike Network needs to be coordinated with existing design guidance and investment strategies employed by NDDOT.

Modifications to Current Investment Guidance to Support Statewide Network

Currently, NDDOT has approved the investment strategies listed below to maximize roadway life expectancy. These investment strategies have been developed in cooperation with FHWA and have been codified through the NDDOT Design Manual (Section I-06.02).

NDDOT Investment Strategies from NDDOT Design Manual (Section I-06.02)

INVESTMENT STRATEGY	DESCRIPTION
PREVENTATIVE MAINTENANCE	The intended purpose of this strategy is to protect the pavement structure, slow the rate of pavement deterioration, and/or correct deficiencies in the pavement surface only; structural deficiencies cannot be corrected with this application. The surface defects may be caused by the environment, and by daily wear and tear of traffic. This type of project may occur on the same roadway as frequently as supported by a cost effectiveness determination. An overlay is Preventive Maintenance when the maximum thickness is two inches (no allowance for rut filling).
MINOR REHABILITATION	This strategy aims to correct the structural integrity of the pavement without necessarily changing the existing geometrics. When an overlay is between two and three inches the project is Minor Rehabilitation.
STRUCTURAL IMPROVEMENT	A Structural Improvement restores the structural integrity of the pavement without necessarily changing the existing geometrics. In addition, the load carrying capacity should be increased to meet the HPCS guidelines. A Structural Improvement is either an HBP overlay more than three inches or a white top.
MAJOR REHABILITATION	Major Rehabilitation requires a large amount of work to bring the condition of the highway up to a level that will extend the service life. This strategy also provides the opportunity to perform operational improvements.
NEW/RECONSTRUCTION	There may be extensive changes to the existing route such as relocating on a new alignment, or completely removing the roadway down to the subgrade and rebuild from the bottom up. Everything from ADA requirements to signing must be addressed when performing a new reconstruction project.



Shoulder Bikeways and the State Bike Network (cont.)

Based on current NDDOT standards, each investment strategy establishes a minimum roadway width standard or guideline. The minimums are not meant to reduce the roadway width, but rather set a baseline to match existing roadway width following an improvement.

To support the development of the Statewide Bike Network, three Tiers of corridors have been developed, each with a unique infrastructure expectation to support safe bicycling standards. More discussion and description of the Tiered network is provided on page 28 and 29.

To meet the infrastructure expectations of Tier 3 bikeways, implementation will utilize a proposed deviation to the existing investment guidance for NDDOT roadways.

A recommended minimum roadway section has been developed for Tier 3 of the Statewide Bikeway Network (See table at right). Two roadway sections are recommended for Tier 3 based on ADT. Based on local conditions, AASHTO guidance, and precedent from other state plans and design manuals, 2,000 ADT is used as an initial threshold for variance between the two levels of infrastructure guidance on Tier 3 corridors. The threshold for Tier 3 corridors is 750 ADT.

Recommended shoulder widths based on minimum roadway widths in feet, assuming two 12-foot-wide travel lanes, are shown below.

Recommended Shoulder Widths Based on Roadway Widths (In Feet)

ROADWAY WIDTH	SHOULDER WIDTH
34	5
36	6
40	8

Tier 3 Roadway Sections*

ADT	TYPICAL SECTION (MINIMUM)	TOTAL ROADWAY WIDTH (MINIMUM)
<2,000	2-12' travel lanes, 2-5' shoulders	34 ft
>2,000	2-12' travel lanes, 2-6' shoulders	36 ft
Investment Trigger: Recommend these standards on investments > or = to Minor Rehabilitation		

*Note: Shoulder dimensions assume that rumble strip placement may encroach up to one foot into the shoulder.

Shoulder Bikeways and the State Bike Network (cont.)

The following table shows existing roadway minimum widths, as specified in Section I-06 of the NDDOT Design Manual. Recommended changes to roadway width minimums by corridor type and investment class are indicated in blue and yellow. This guidance would support development of the minimum infrastructure requirements for the recommended typical section and shoulder width on Tier 3 of the Statewide Bike Network

corridors in the State of North Dakota as projects are regularly programmed and constructed. It is recommended that consideration be given to active transportation improvements as stand alone projects, however it is recognized that this approach is currently inconsistent with NDDOT Design Guideline investment strategies. The following matrix represents an approach to incorporate the proposed tiered rural state bicycle network into current NDDOT Design Guideline work types.

Current Roadway Minimum Widths and Proposed Changes for Tier 3 Bikeways (In Feet)

Tier 3					
Interregional 4 - Lane	ADT				
INVESTMENT TYPE	<400	400-750	750-1500	1500-2000	>2000
NEW/RECONSTRUCTION	AASHTO STDS				
MAJOR REHABILITATION	36	36	36	36	36
STRUCTURAL IMPROVEMENT	32	32	32	32	32
MINOR REHABILITATION	32	32	32	32	32
PREVENTATIVE MAINTENANCE	31	31	31	31	31

Interregional 2 - Lane	ADT				
INVESTMENT TYPE	<400	400-750	750-1500	1500-2000	>2000
NEW/RECONSTRUCTION	32	36	36	36	40
MAJOR REHABILITATION	30	30	36	36	36
STRUCTURAL IMPROVEMENT	26	26	28	30	32
MINOR REHABILITATION	26	26	28	30	32
PREVENTATIVE MAINTENANCE	26	26	28	28	30

State Corridor*	ADT				
INVESTMENT TYPE	<400	400-750	750-1500	1500-2000	>2000
NEW/RECONSTRUCTION	32	36	36	36	40
MAJOR REHABILITATION	28	28	32	36	36
STRUCTURAL IMPROVEMENT	24	24	28	28	32
MINOR REHABILITATION	24	24	26	28	32
PREVENTATIVE MAINTENANCE	24	24	26	26	28

*Note: For District Corridors or Collectors that are Tier 3, apply the State Corridor guidance.

Key			
INCREASE TO 34' MINIMUM	INCREASE TO 36' MINIMUM	WHERE DEEMED FEASIBLE IN SCOPING PHASE	NO CHANGE



Yield Roadway

A yield roadway is designed to serve pedestrians, bicyclists, and motor vehicle traffic in the same slow-speed travel area. Yield roadways serve bidirectional motor vehicle traffic without lane markings in the roadway travel area. Yield roadways are designed with narrow roadway dimensions to prioritize local access and community quality of life.



DESIGN FEATURES

- The paved two-way travel lane should be narrow to encourage slow travel speeds and require courtesy yielding when vehicles traveling in opposite directions meet. Total traveled way width may vary from 12 ft to 20 ft.
- Traveled way width 15 ft or below functioning as a two-way single lane roadway should follow the guidance of AASHTO Low Volume Roads 2001.
- When width is 15 ft or narrower, provide pull-out areas every 200–300 ft to allow for infrequent meeting and passing events between motor vehicles. Pull-out areas may be established in the parking lane or roadside area.
- Access for emergency vehicles should be provided. There is no single fire code standard for local roads; however, a range of clear widths for parking and deploying fire department apparatus is between 16–20 ft. Designers should provide an opening of this width every 200–300 ft.

- At uncontrolled crossings of local streets, no special treatment is necessary. The additional space within the intersection area offers queuing opportunities when vehicles traveling in opposite directions meet.

APPROPRIATE CONTEXT

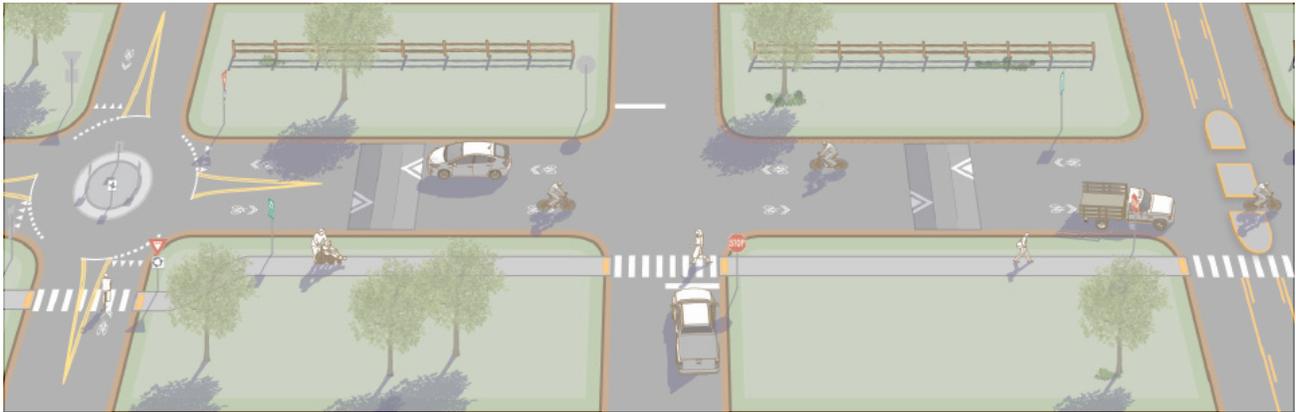
- Land use: urban, suburban/commercial and rural/rural center
- Street classification: local/collector
- Roadway conditions: AADT up to 3,000, speeds up to 25 mph

FOR MORE INFORMATION

2013 NACTO Urban Street Design Guide
2016 FHWA Small Town and Rural Design Guide
(Chapter 2-3)

Bicycle Boulevards/Calm Streets

Bicycle boulevards are low-volume, low-speed streets that are safe for bicyclists of all ages and abilities. Streets are modified to enhance user comfort by using treatments such as signage, pavement markings, traffic calming and/or traffic reduction, and intersection modifications. These treatments allow through movements of bicyclists while discouraging similar through-trips by non-local motorized traffic.



TYPICAL APPLICATION

- Parallel with and in close proximity to major thoroughfares (1/4 mile or less).
- Follow a desire line for bicycle travel that is ideally long and relatively continuous (2-5 miles).
- Avoid alignments with excessive zigzag or circuitous routing. The bikeway should have less than 10% out of direction travel compared to shortest path of primary corridor.

DESIGN FEATURES

- Signs and pavement markings are the minimum treatments necessary to designate a street as a bicycle boulevard.
- According to NACTO, bicycle boulevards should have a maximum posted speed of 25 mph. Use traffic calming to maintain an 85th percentile speed below 22 mph.
- Implement volume control treatments based on the context of the bicycle boulevard, using engineering judgment.
- Design intersection crossings to enhance safety and minimize delay for bicyclists.

APPROPRIATE CONTEXT

- Land use: urban, suburban/commercial and rural/rural center
- Street classification: local/collector
- Roadway conditions: AADT up to 3,000, speeds up to 25 mph

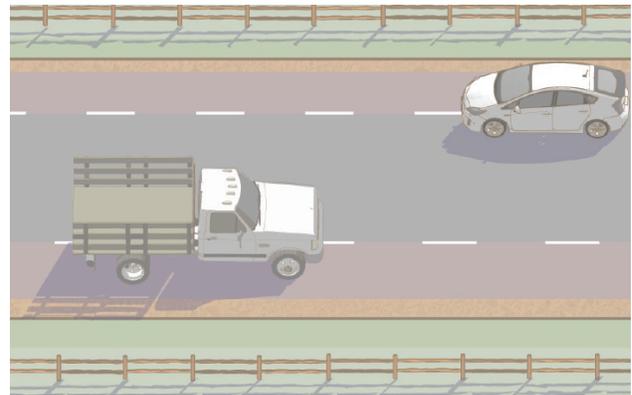
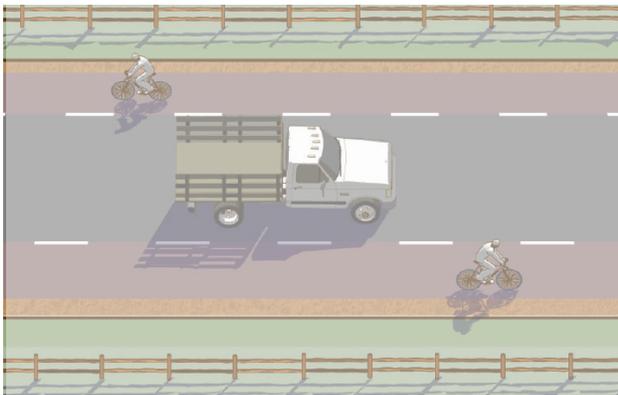
FOR MORE INFORMATION

2012 AASHTO Guide for the Development of Bicycle Facilities, 4th Edition (Chapter 4.10)
2012 NACTO Urban Bikeway Design Guide
2016 FHWA Small Town and Rural Design Guide (Chapter 2-9)



Advisory Shoulders

Advisory shoulders create usable shoulders for bicyclists on a roadway that is otherwise too narrow to accommodate one. The shoulder is delineated by pavement marking and optional pavement color. Motorists may only enter the shoulder when no bicyclists are present and must overtake these users with caution due to potential oncoming traffic.



NOTE

Advisory shoulders are a new treatment type in the United States and no performance data has yet been collected to compare to a substantial body of international experience. In order to install advisory shoulders, an approved Request to Experiment is required as detailed in Section 1A.10 of the MUTCD. FHWA is also accepting requests for experimentation with a similar treatment called “dashed bicycle lanes.”

APPROPRIATE CONTEXT

- Land use: Urban, suburban/commercial and rural/rural center
- Street classification: local/collector and arterial
- Roadway conditions: AADT limit 3,000-6000+; Speed limit 25-35mph+

ACCESSIBILITY

Advisory shoulders as described here are not intended for use by pedestrians. When advisory shoulders are intended for use by pedestrians, they must meet accessibility guidelines.

GEOMETRIC DESIGN

Advisory Shoulder

Unlike a conventional shoulder, an advisory shoulder is a part of the traveled way, and it is expected that vehicles will regularly encounter meeting or passing situations where driving in the advisory shoulder is necessary and safe.

The preferred width of the advisory shoulder space is 6 ft. Absolute minimum width is 4 ft when no curb and gutter is present.

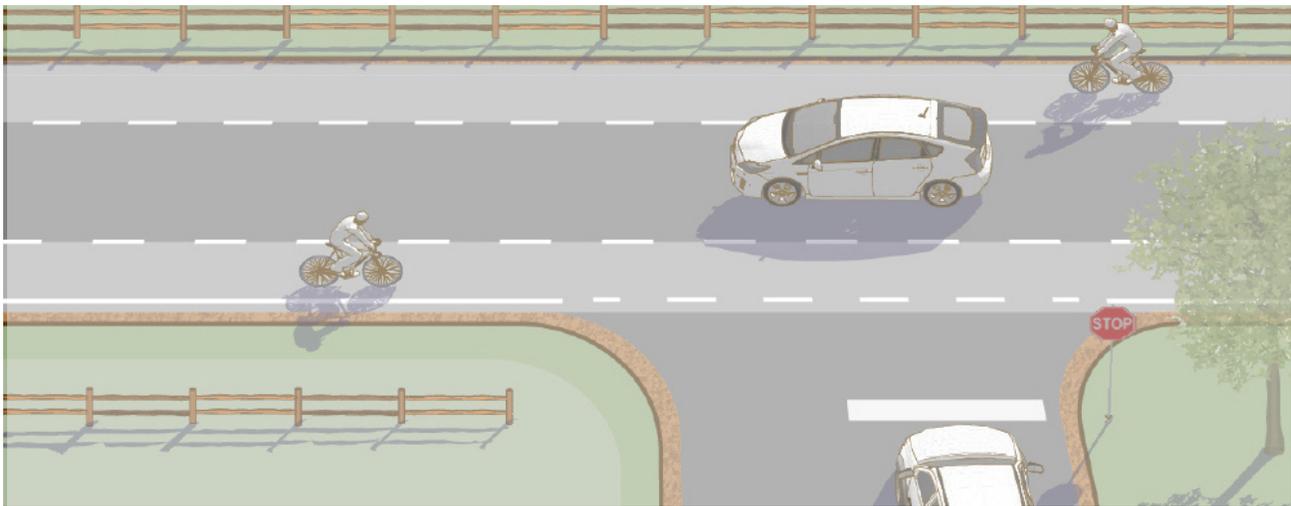
Consider using contrasting paving materials between the advisory shoulder and center travel lane to differentiate the advisory shoulder from the center two-way travel lane in order to minimize unnecessary encroachment and reduce regular straddling of the advisory shoulder striping.

Two-way Center Travel Lane

The two-way center travel lane is created from the remaining paved roadway space after the advisory shoulder has been accounted for.

Preferred two-way center travel lane width is 13.5-16 ft although may function with widths of 10-18 ft.

Advisory Shoulders (cont.)



MARKINGS

A broken lane line used to delineate the advisory shoulder should consist of 2 ft line segments and 6 ft gaps.

Where additional edge definition is desired, stripe a normal solid white edge line in addition to the broken advisory shoulder line.

In general, do not mark a center line on the roadway. Short sections may be marked with center line pavement markings to separate opposing traffic flows at specific locations, such as around curves, over hills, on approaches to at-grade crossings, and at bridges. At these locations, widen the paved roadway surface to provide space for paved bicycle-accessible shoulders and conventional width travel lanes.

SIGNS

Use signs to warn road users of the special characteristics of the street. Potential signs for use with advisory shoulders include:

Use an unmodified Two-Way Traffic warning sign (W6-3) to clarify two-way operation of the road.

Use a NO CENTER LINE warning sign (W8-12) to help clarify the unique striping pattern.

Use a NO PARKING ON PAVEMENT (R8-1) to discourage parking within the advisory shoulder.

INTERSECTIONS

Advisory shoulder designs work best on road segments without frequent stop or signal controlled intersections that require vehicles to stop within the roadway. The designer should strive to maintain the visual definition of the advisory shoulder through all driveways and street crossings, and provide a conventional shoulder at controlled intersections.

At minor street crossings, use a dotted line extension on both sides of the advisory shoulder to maintain delineation of the advisory shoulder space.

If contrasting pavement material is used, maintain the material through driveway crossings and minor intersections, as shown in the image above.

Where the road is controlled by a stop sign or traffic signal, discontinue the advisory shoulder 50 ft in advance of the intersection. At these locations, provide a bicycle accessible paved shoulder outside of the travel lanes or design for operation as a shared roadway.

FOR MORE INFORMATION

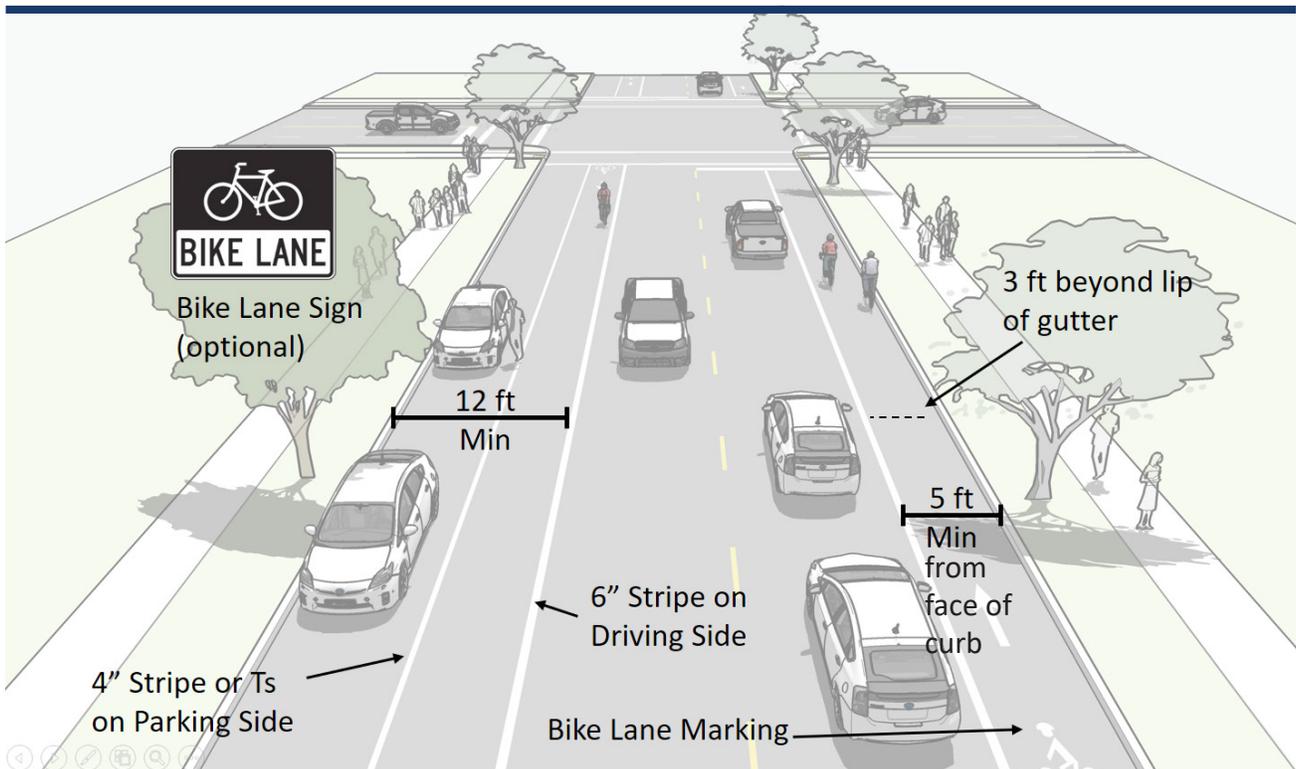
2016 FHWA Small Town and Rural Design Guide (Chapter 2-17)

2015 FHWA Bicycle Facilities and the Manual on Uniform Traffic Control Devices. https://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/mutcd/dashed_bike_lanes.cfm



Bike Lanes

Bike lanes designate an exclusive space for bicyclists through the use of pavement markings and signage. The bike lane is typically located on the right side of the street, between the adjacent travel lane and curb, and is used in the same direction as motor vehicle traffic.



TYPICAL APPLICATION

- Wider than minimum dimensions preferred whenever possible.
- Recommend greater protection as volumes warrant more than one travel lane in each direction

APPROPRIATE CONTEXT

- Land use: Urban, suburban/commercial and rural center
- Street classification: local/collector and arterial
- Roadway conditions: AADT limit 6,000-20,000+; Speed limit 30-35mph+

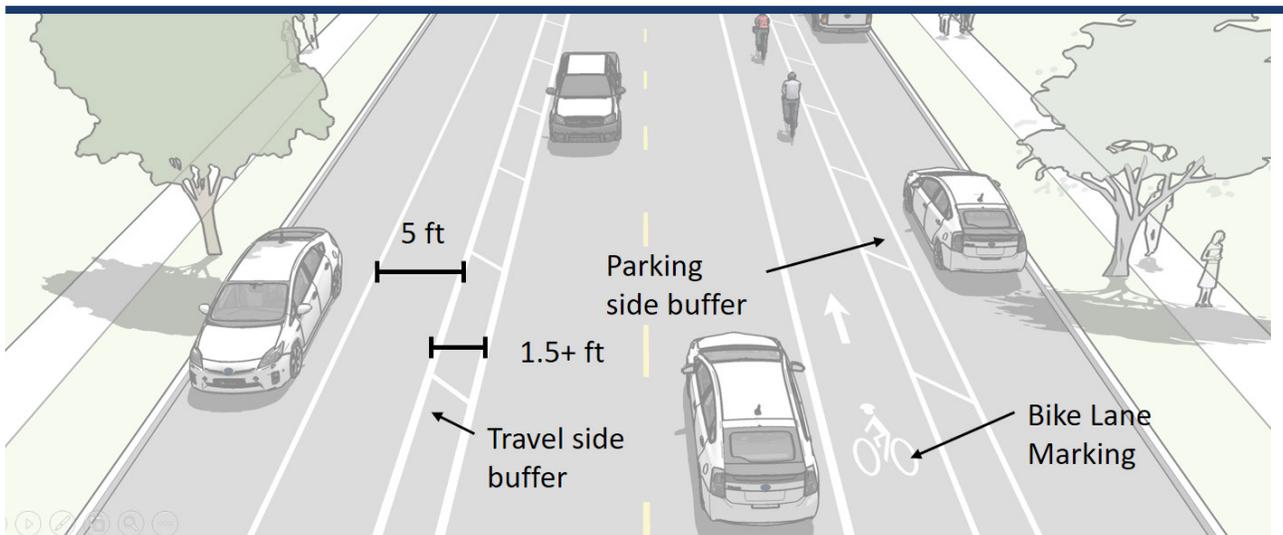
FOR MORE INFORMATION

2012 AASHTO Guide for the Development of Bicycle Facilities, 4th Edition (Chapter 4.6)
2012 NACTO Urban Bikeway Design Guide
NCHRP 766: Recommended Bicycle Lane Widths for Various Roadway Characteristics
2016 FHWA Small Town and Rural Design Guide (Chapter 3-11)

Buffered Bike Lanes

Buffered bike lanes are conventional bicycle lanes paired with a designated buffer space, separating the bicycle lane from the adjacent motor vehicle travel lane and/or parking lane. Buffered bike lanes follow general guidance for buffered preferential vehicle lanes as per MUTCD guidelines (section 3D-01).

Buffered bike lanes are designed to increase the space between the bike lane and the travel lane and/or parked cars. This treatment is appropriate for bike lanes on roadways with high motor vehicle traffic volumes and speed, adjacent to parking lanes, or a high volume of truck or oversized vehicle traffic.



TYPICAL APPLICATION

Applicable wherever a standard bike lane is being considered and special situations such as:

- Streets with high travel speeds, high volumes, and/or high % of large vehicle traffic,
- Streets with door zone risk, and
- Streets with extra lanes or width.
- Buffer may be placed on the side of the bike lane with greater conflict, or both sides if width allows.

APPROPRIATE CONTEXT

- Land use: Urban, within built up area in suburban/commercial and rural center
- Street classification: local/collector and arterial
- Roadway conditions: AADT limit 20,000+; Speed limit 30-35mph+

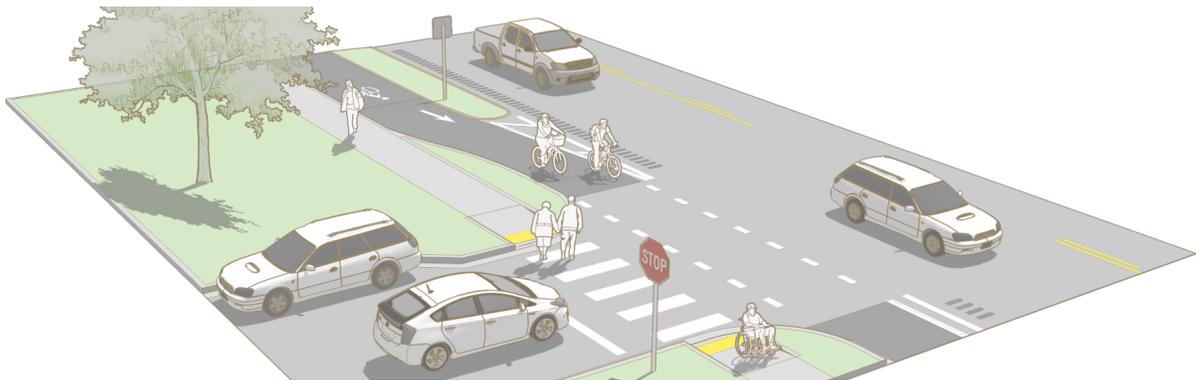
FOR MORE INFORMATION

2012 NACTO Urban Bikeway Design Guide
NCHRP 766: Recommended Bicycle Lane Widths for Various Roadway Characteristics
2016 FHWA Small Town and Rural Design Guide (Chapter 3-11)



Separated Bike Lanes

A separated bike lane (SBL) is an exclusive bike facility that combines the user experience of a separated path with the on-street infrastructure of a conventional bike lane. A SBL is physically separated from motor traffic and distinct from the sidewalk. SBLs have different forms but all share common elements—they provide space that is intended to be exclusively or primarily used by bicycles, and are separated from motor vehicle travel lanes, parking lanes, and sidewalks. In situations where on-street parking is allowed, these facilities are located to the curb-side of the parking (in contrast to bike lanes). SBLs are either raised or at street level and may use a variety of elements for physical protection from passing traffic.



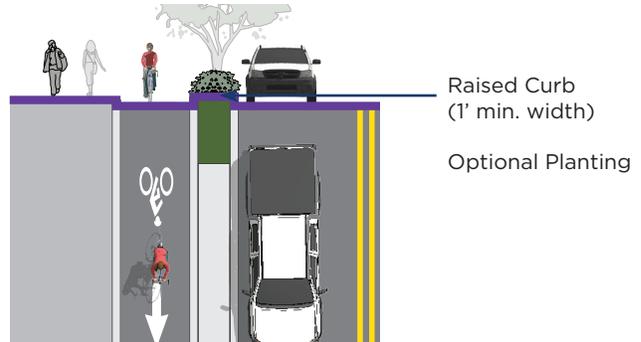
WIDTH CONSIDERATIONS

- 7 foot recommended minimum to allow passing.
- 5 foot minimum width in constrained locations.
- When placed adjacent to parking, provide a parking buffer that is a minimum of 3 feet wide to allow for passenger loading and to prevent door collisions.
- Curb design, and shy distance to obstructions will impact the effective width of the facility.
- Design so that bicyclists can pass each other without leaving the separated bike lane.
- Design as wide as needed to allow for available maintenance vehicles.

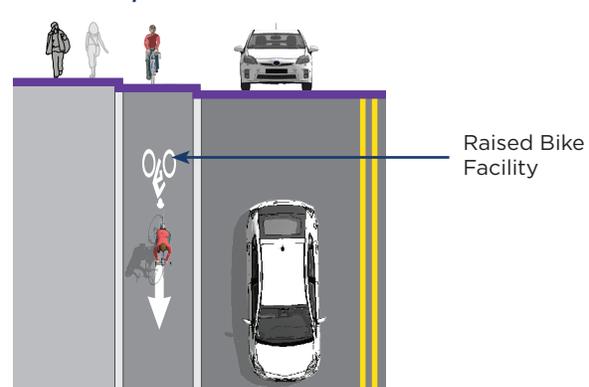
APPROPRIATE CONTEXT

- Land use: Urban, within built up area in suburban/commercial and rural center
- Street classification: local/collector and arterial
- Roadway conditions: All volumes and speeds

Median Separation

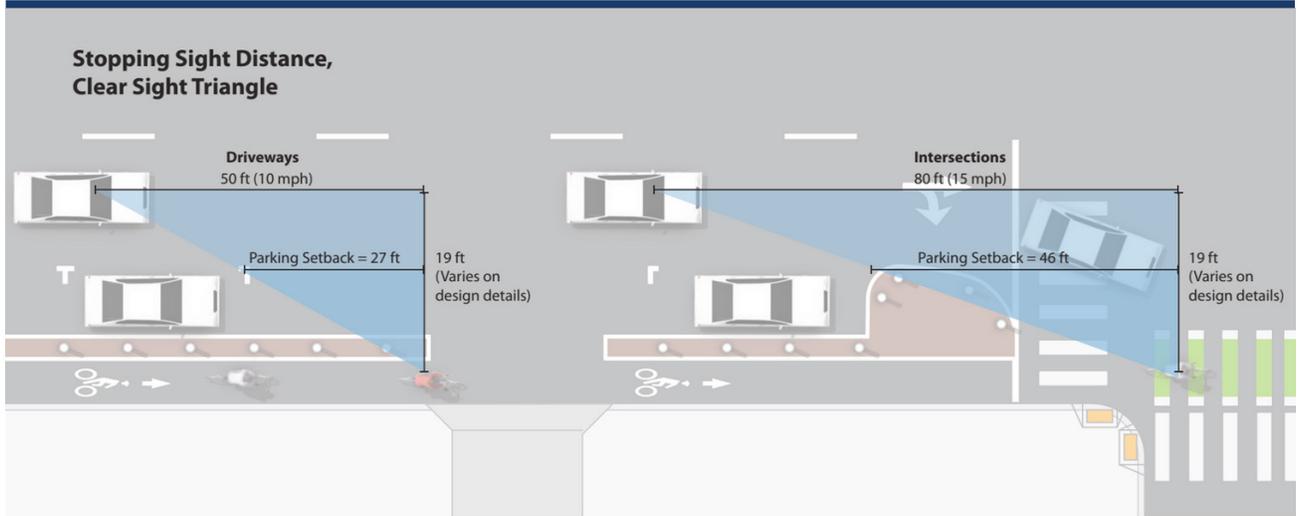


Grade Separation



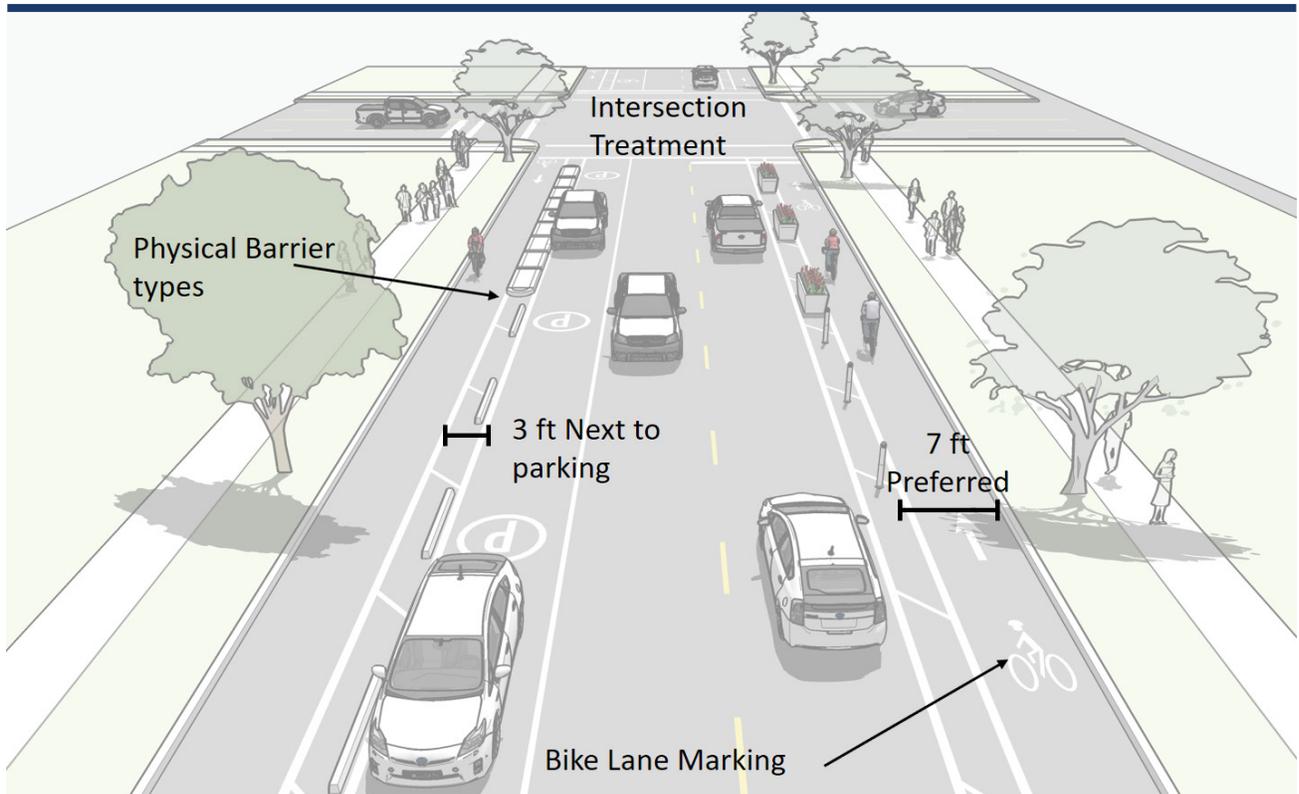
Separated Bike Lanes (Cont.)

BIKE LANE SETBACK TO PARKING OR OBSTRUCTIONS



Dimensions to be based on the design speed of the roadway, as reported in Table 9-21 Stopping Sight Distance for Turning Roadways in AASHTO's A Policy on Geometric Design of Highways and Streets.

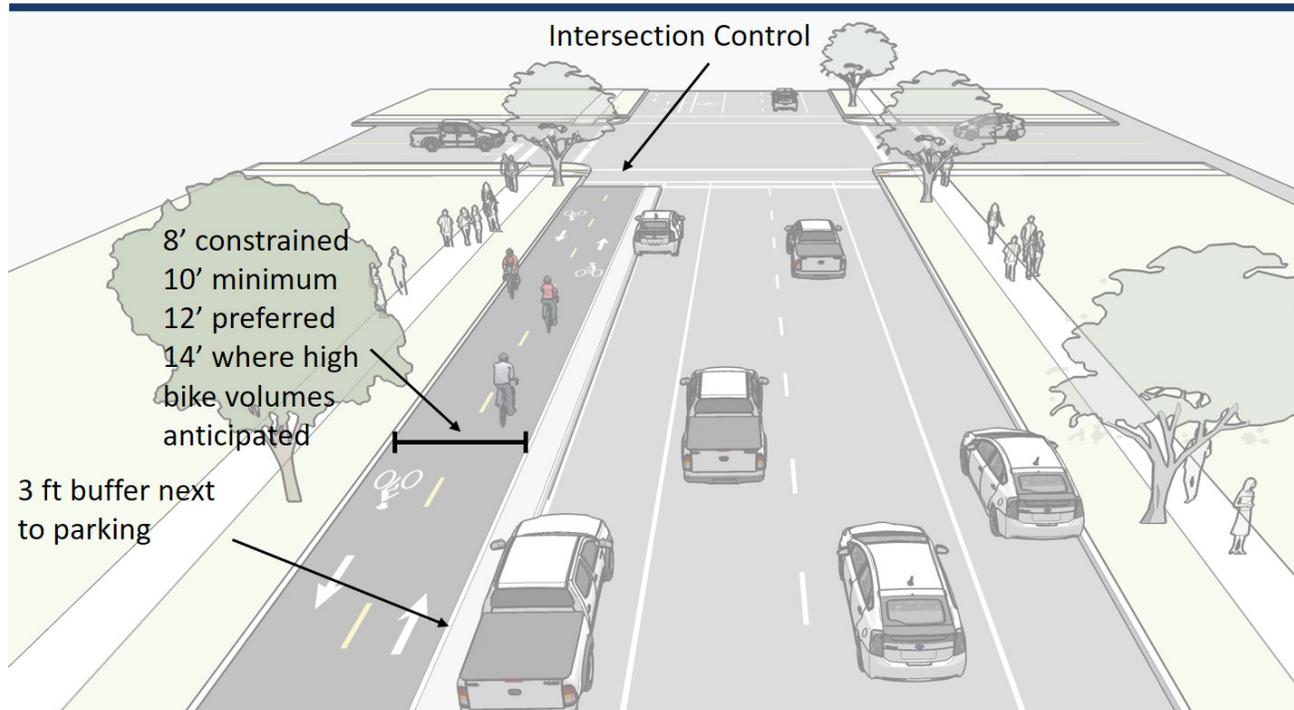
ONE-WAY BICYCLE OPERATION





Separated Bike Lanes (Cont.)

TWO WAY OPERATION



Considerations

Two-way separated bike lanes allow bicycle movement in both directions on one side of the road. Two-way separated bike lanes share some of the same design characteristics as one-way separated bike lanes, but require additional considerations at driveway and side-street crossings.

- Two-way separated bike lanes introduce more complex interactions and more challenging bikeway connections.
- Compared to one-way, two-way increases risk of injury by 50% at unsignalized intersections.
- Two-way separated bike lanes may require more complicated signalization and signal progression of contra-flow bicycle direction can be challenging.

Remedies for these issues are generally more expensive and complicated than on one-way facilities. Generally, one-way facilities function better than two-way facilities. Two-way facilities can function well if there are very few intersections and conflict points, such as along a large park or body of water.

Driveways & Conflict Points

Driveways are a critical problem for two way separated bike lanes. Design strategies for driveways include elimination and/or mitigation. Elimination of driveways can be accomplished using standard access management strategies.

Mitigation can be accomplished by improving sight lines, slowing vehicles by utilizing more abrupt driveway aprons, raising awareness of bicyclists, and setting them back.

FOR MORE INFORMATION

2015 FHWA Separated Bike Lane Planning and Design Guide

2015 MassDOT Separated Bike Lane Planning and Design Guide

2012 NACTO Urban Bikeway Design Guide

2016 FHWA Small Town and Rural Multimodal Networks Guide (Chapter 4-25)

Shared Use Paths

Shared use paths are physically separated from motorized vehicular traffic by either a physical barrier or clear space. They are often on their own alignments but may be located within the right-of-way of an adjacent roadway. Shared use paths accommodate pedestrians, so ADA access requirements must be met.

SURFACE TREATMENTS

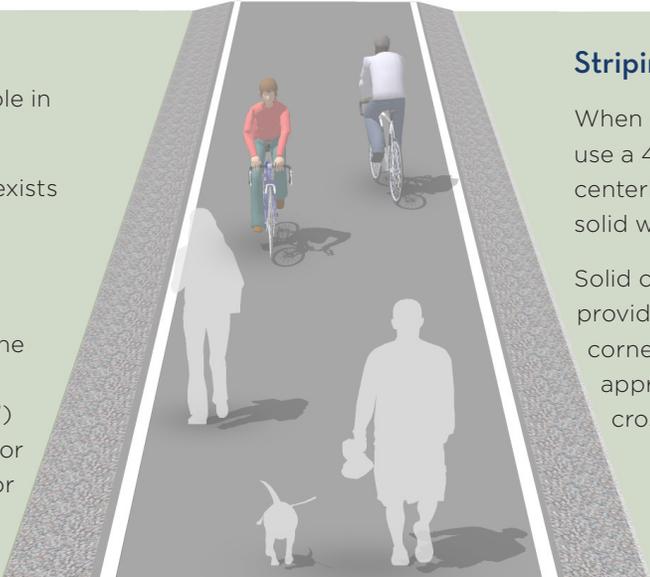
Shared use paths can be unpaved but these facilities may have greater problems with erosion, use by the physically disabled, use by alternative wheeled users (e.g. in-line skaters, skateboarders, etc), and snow removal. Unpaved paths may require more maintenance effort.

Paved paths are usually surfaced with either asphalt or concrete.

APPROPRIATE CONTEXT

- Land use: Urban, outside built up area in suburban and rural
- Street classification: local/collector and arterial
- Roadway conditions: All speeds and volumes

	Asphalt	Concrete
Pros	Smooth surface (no joints) Runners tend to prefer over concrete Cheaper up front cost (usually) Accelerated snow melting	Lower long-term lifecycle cost Less frequent maintenance required
Cons	More frequent maintenance required More prone to edge failure and root damage	Higher up front cost Runners tend to dislike this material Can have joint issues (saw cut preferred rather than trowel) Slower snow melting



Width:

- 10' minimum, 8' acceptable in constrained areas
- 12 - 14' where heavy use exists

Shoulder:

Provide 2 foot or greater shoulder on both sides of the path. An additional foot of lateral clearance (total of 3') is required by the MUTCD for the installation of signage or other furnishings.

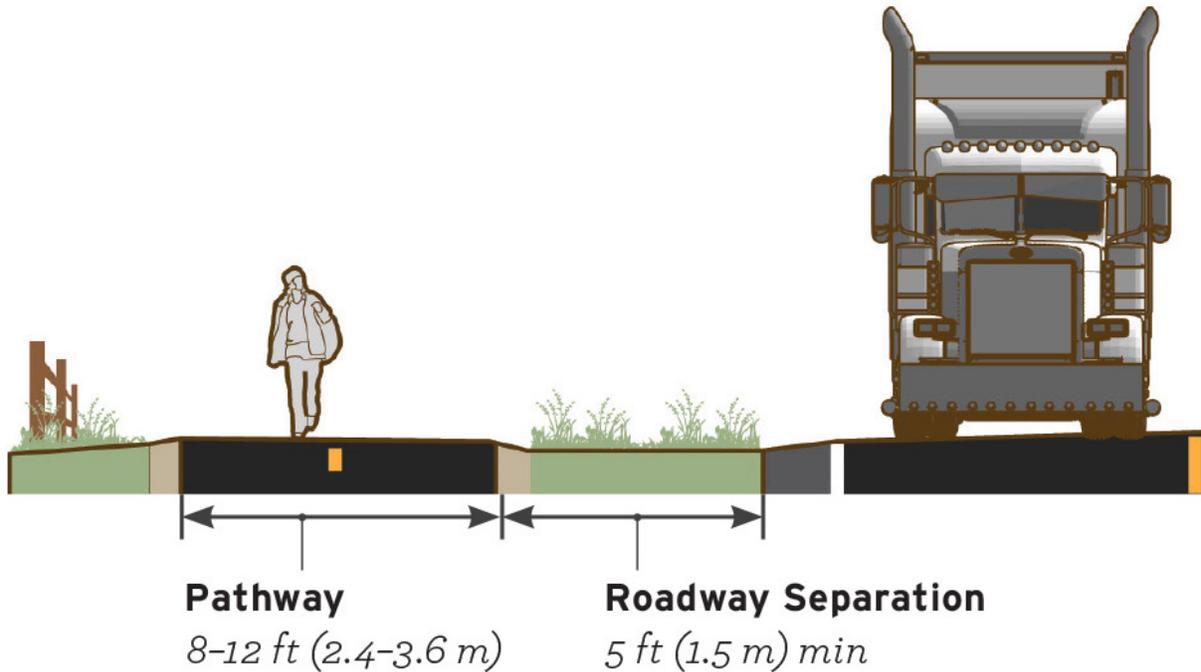
Striping:

When striping is required, use a 4 inch dashed yellow centerline stripe with 4 inch solid white edge lines.

Solid centerlines can be provided on tight or blind corners, and on the approaches to roadway crossings.

Sidepaths

The term sidepath refers to a shared use path located immediately adjacent and parallel to a roadway. Bicycle traffic may ride against the normal flow of motor vehicle traffic on these facilities. The sidepath design process should aim to mitigate wrong-way riding when bicyclists enter or leave the path.



APPROPRIATE CONTEXT

- Land use: Urban, suburban/commercial and rural/rural center
- Street classification: local/collector and arterial
- Roadway conditions: All speeds and volumes

WIDTH CONSIDERATIONS

Widths and design details of sidepath elements may vary in response to the desire for increased user comfort and functionality, the available right-of-way, and the need to preserve natural resources.

As user volumes or the mix of modes increases, additional path width is necessary to maintain comfort and functionality.

Minimum recommended pathway width is 10 ft. In low-volume situations and constrained conditions, the absolute minimum sidepath width is 8 ft. Provide a minimum of 2 ft clearance to signposts or vertical elements.

ROADWAY SEPARATION

Separation from the roadway should be informed by the speed and configuration of the adjacent roadway and by available right-of-way.

Preferred minimum separation width is 6.5 ft. Minimum separation distance is 5 ft.

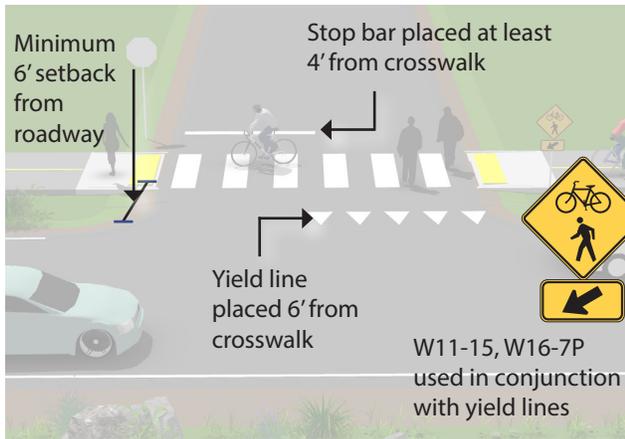
Separation narrower than 5 ft is not recommended, although may be accommodated with the use of a physical barrier between the sidepath and the roadway. The barrier and end treatments should be crashworthy which may introduce additional complexity if there are frequent driveways and intersections.

On high-speed roadways, a separation width of 16.5-20 ft is recommended for proper positioning at crossings and intersections.

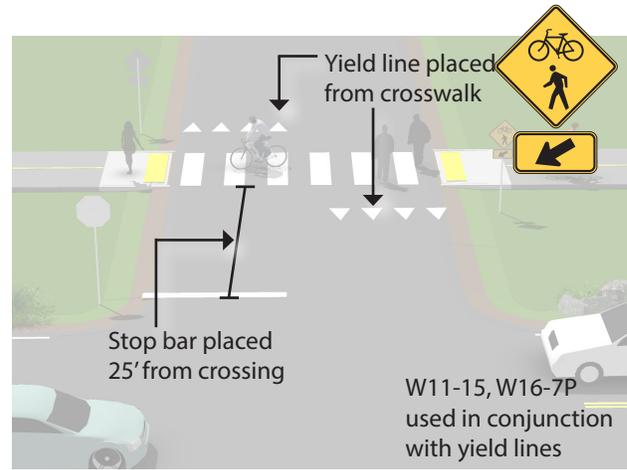
Sidepaths (Cont.)

DESIGN STRATEGIES FOR DRIVEWAYS

Adjacent Crossing - A separation of 6 feet emphasizes the visibility of riders at the approach to the crossing.



Setback Crossing - A set back of 25 feet separates the path crossing from merging/turning movements that may be competing for a driver's attention.



ADVANTAGES

Sidepaths are most advantageous when:

- Few driveways / side streets are encountered
- Sidepaths are available on both sides of the roadway
- Crossings are designed to be clear and visible to all users
- Adequate signage is used on the path
- Trail serves an important high-use link

CHALLENGES

Sidepath challenges include:

- Two-way travel on one side of the street
- Starting and ending points
- Driveway/Intersection safety
- Rules of the road are not always clear to drivers or bicyclists
- Should not be used as an alternative to bike lanes

FOR MORE INFORMATION

2012 AASHTO Guide for the Development of Bicycle Facilities, 4th Edition (Chapter 5)

PROWAG Guidelines: <http://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way>

2016 FHWA Small Town and Rural Multimodal Networks Guide (Chapter 4-3)



Sidewalks

Sidewalks are the most fundamental element of the walking network, as they provide an area for pedestrian travel separated from vehicle traffic. A variety of considerations are important in sidewalk design. Providing adequate and accessible facilities can lead to increased numbers of people walking, improved safety, and the creation of social space.

ZONES

The pedestrian area along a street may have multiple zones, including a parking lane/enhancement zone, edge zone, furnishing zone, pedestrian through zone, and frontage zone. The graphic below illustrates how these zones work in a main street setting.

APPROPRIATE CONTEXT

- Land use: urban, within built up areas in suburban/commercial and rural centers
- Street classification: local/collector, and arterial
- Roadway conditions: all speeds and volumes



PARKING LANE/ ENHANCEMENT ZONE	FURNISHING ZONE	PEDESTRIAN THROUGH ZONE	FRONTAGE ZONE
<p>The parking lane can act as a flexible space to further buffer the sidewalk from moving traffic. Curb extensions and bike corrals may occupy this space where appropriate.</p> <p>In the edge zone there may be a 6 inch wide curb.</p>	<p>The furnishing zone buffers pedestrians from the adjacent roadway, and is also the area where elements such as street trees, signal poles, signs, and other street furniture are properly located.</p>	<p>The through zone is the area intended for pedestrian travel. This zone should be entirely free of permanent and temporary objects.</p> <p>Wide through zones are needed in downtown areas or where pedestrian flows are high.</p>	<p>The Frontage Zone allows pedestrians a comfortable “shy” distance from the building fronts. It provides opportunities for window shopping, to place signs, planters, or chairs.</p> <p>Not applicable if adjacent to a landscaped space.</p>

Sidewalks (Cont.)

WIDTHS

The width and design of sidewalks will vary depending on street context, functional classification, and pedestrian demand. Below are preferred widths of each sidewalk zone according to general street type. Standardizing sidewalk guidelines for different areas of the city, dependent on the above listed factors, ensures a minimum level of quality for all sidewalks.



STREET CLASSIFICATION	PARKING LANE/ ENHANCEMENT ZONE	FURNISHING ZONE	PEDESTRIAN THROUGH ZONE	FRONTAGE ZONE
Local/Residential Streets	7 feet (if used)	2 - 5 feet	5 - 6 feet	1+ feet
Town/Main Street Areas	7 feet (if used)	4 - 6 feet	6 - 12 feet	2.5 - 10 feet
Suburban Arterials	7 feet (if used)	6+ feet	6+ feet	Varies
Urban Arterials	7 feet (if used)	4 - 6 feet	6 + feet	Varies

↑
Areas that have significant accumulations of snow during the winter may prefer a wider furnishing zone for snow storage.

↑
Six feet enables two pedestrians (including wheelchair users) to walk side-by-side, or to pass each other comfortably



Sidewalks (Cont.)

OBSTRUCTIONS

Obstructions to pedestrian travel in the sidewalk corridor typically include driveway ramps, curb ramps, sign posts, utility and signal poles, mailboxes, fire hydrants and street furniture.

Reducing the number of access points reduces the need for special provisions. Pursue this strategy first. Place obstructions between the sidewalk and the roadway to create a buffer for increased pedestrian comfort.

Dipping the entire sidewalk at the driveway approaches keeps the cross-slope at a constant grade, but allows faster vehicle turning. This is the least-preferred driveway option.

Placing the sidewalk behind the driveway eliminates the need for curb ramps and typically reduces the speed at which vehicles exit and enter the driveway

When sidewalks abut hedges, fences, or buildings, add an additional two feet of lateral clearance to provide appropriate shy distance.



Planter strips allow sidewalks to remain level, with the driveway grade change occurring within the planter strip.

When sidewalks abut angled on-street parking, use wheel stops to prevent vehicles from overhanging in the sidewalk.

DRIVEWAYS

Driveways are a common sidewalk obstruction, especially for wheelchair users. When constraints only allow curb-tight sidewalks, dipping the entire sidewalk at the driveway approaches keeps the cross-slope at a constant grade. However, this may be uncomfortable for pedestrians and could create drainage problems behind the sidewalk.

FOR MORE INFORMATION

NDDOT Design Manual (Section III-07.01)
PROWAG Guidelines: <http://www.access-board.gov/guidelines-and-standards/streets-sidewalks/public-rights-of-way>
2004 AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities (Chapter 3.2)
2013 NACTO Urban Street Design Guide
2016 FHWA Small Town and Rural Multimodal Networks Guide (Chapter 4-19)

Implementation Strategies

Bicycle and/or pedestrian facilities can be added through new build projects or major reconstructions. These opportunities may take several years to secure funding and carry out design and construction. Design new builds as multimodal corridors from the beginning of network and transportation planning and avoid the use of minimum dimensions for bicycle and pedestrian facilities. A shorter term method to implement bikeways and pedestrian facilities is to combine the addition of bicycle and pedestrian facilities in maintenance operations, resurfacing or rehabilitation to retrofit streets. There are three common methods of finding space for bicycle facilities on existing streets: lane removal/reconfiguration, lane narrowing, and parking removal.

CONTEXT CONSIDERATIONS

The implementation of bicycle and/or pedestrian facilities will need to consider the purpose of the subject roadway and the surrounding land uses, as well as, the connection to a larger multi-modal transportation network for determining the appropriateness of the facility. The existing and desired context of the location is critical in determining the purpose of the place, roadway, and associated characteristics within the right-of-way.

Often space within a right-of-way may be limited so the implementation of bicycle and/or pedestrian facilities should be balanced against other roadway and adjacent land use needs.

LANE REMOVAL/ RECONFIGURATION

The name “Road Diet” refers to the conversion of a four-lane undivided roadway with two through lanes in each direction to a 3-lane undivided roadway consisting of two through lanes on either side of a two-way left turn lane (TWLTL). Other lane reduction approaches are also referred to as road diets, e.g. 5-to-3 lane conversions but the 4-to-3 conversion is most common.

The 2012 FHWA Memorandum on Promoting the Implementation of Proven Safety Countermeasures lists road diets as one of the nine proven safety countermeasures.

According to the FHWA Road Diet Informational guide, benefits of the 4-to-3 lane conversion include:

- A 19 to 47 percent reduction in overall crashes
- A reduction in speed differential which reduces crash severity
- A reduction in various types of delay
- Right of way available for reallocation to pedestrian and bicycle facilities
- Risk reduction for pedestrians whether crossing at an intersection or mid-block
- An improvement of the livability or comfort level of the street

LANE NARROWING

Contrary to expectations, narrower lane widths do not reduce roadway capacity and can increase roadway safety.

Narrower Lanes do not Reduce Capacity

“The measured saturation flow rates are similar for lane widths between 10 feet and 12 feet. ... Thus, so long as all other geometric and traffic signalization conditions remain constant, there is no measurable decrease in urban street capacity when through lane widths are narrowed from 12 feet to 10 feet.” John Zegeer, P.E.,(2007).



Type of Roadway	Rural		Urban	
	US (feet)	Metric (meters)	US (feet)	Metric (meters)
Freeway	12	3.6	12	3.6
Ramps (1-lane)	12-30	3.6-9.2	12-30	3.6-9.2
Arterial	11-12	3.3-3.6	10-12	3.0-3.6
Collector	10-12	3.0-3.6	10-12	3.0-3.6
Local	9-12	2.7-3.6	9-12	2.7-3.6

Recommended Lane Widths from 2011 AASHTO Green Book

Several studies confirm that there is no documented reduction of capacity associated with narrowed lanes. Capacity is not degraded until lane widths are reduced to less than 10 feet. The 2010 Highway Capacity Manual has been revised to eliminate any saturation flow adjustments for lane widths between 10 and 13 feet wide.

Narrower Lanes do not Increase Crash Rates

Several studies indicate that 10-foot lanes cause no more crashes than 12-foot lanes in urban and suburban areas, and may cause fewer.

Potts, Ingrid B., Douglas W. Harwood, and Karen R. Richard. "Relationship of Lane Width to Safety on Urban and Suburban Arterials." 2007.

Hauer, E., F. M. Council, and Y. Mohammedshah. "Safety Models for Urban Four Lane Undivided Road Segments." 2004.

NCHRP Report 330: "Effective Utilization of Street Width on Urban Arterials." 1990.

REMOVE PARKING

If removal, reconfiguration or narrowing of existing lanes does not provide sufficient space for active transportation facilities, removal of on-street parking can be considered. Removal of parking is often a controversial proposal. On-street parking is valuable in retail districts. On-street parking positively impacts walkability by providing a buffer between the sidewalk and roadway travel lanes. With this in mind, parking removal should be considered in the larger context of adjacent land uses. Parking removal may be more successful in areas with little to no retail land uses and low use of existing on-street parking.

Some strategies to reduce the impact of parking removal are:

- If considering removal of one lane only, look for streets with less than 50% parking occupancy,
- Include immediate side streets in corridor parking occupancy analysis, and
- Consider side street reconfiguration to increase parking capacity and offset losses.

RESURFACING OPPORTUNITIES

Resurfacing of a street can provide an opportunity to easily and cost effectively add bicycle facilities. The FHWA has published guidance on the ways to take advantage of this process. Key lessons from FHWA Resurfacing Workbook include:

1. Provide adequate time
2. Multimodal approach – include key staff
3. Review relevant plans
4. Apply design flexibility

FOR MORE INFORMATION

2015 FHWA Incorporating On-Road Bicycle Networks into Resurfacing Projects
2014 FHWA Road Diet Informational Guide
2011 AASHTO A Policy on Geometric Design of Highways & Streets (Greenbook)
2013 NACTO Urban Street Design Guide

Crossing Treatment Toolkit

Intersections

Intersections are where the majority of bicycle-motor vehicle crashes occur. Proper design can reduce the risk faced by bicyclists at intersections.

DESIGN PRINCIPLES FOR INTERSECTIONS

Minimize Speed

Control through and turning speed of the majority of vehicles. Slower speeds at intersections reduce crash frequency and severity as well as increase yielding rates to bicyclists and pedestrians. See charts below.

Increase Awareness

Use signage and markings to make the presence of bicyclists expected and anticipated.

Increase Conspicuity

Use geometry to put bicyclists in a position where they are more visible through advance stop lines for cars and bend in or out geometry at side streets and driveways. Position motorists so that they cross the path of bicyclists at an angle as close to 90 degrees as possible.

Isolate Conflicts

Minimize the size and number of conflict points between turning vehicles and through moving bicyclists. Conflicts can also be isolated through signal phasing.

Clearly Assign Priority

Make it obvious which user has the legal right-of-way. Angled crossings and ambiguous designs can create confusion or a false sense of security.

Horizontal Curve Radius and Speed

V (mph)	E	F*	R (ft)
8	0	0.38	11
10	0	0.38	18
12	0	0.35	27
15	0	0.32	47

Values from AASHTO Green Book 2011, Table 3-7 and Equation 3-8

The formula for calculating turning speed is $R = V^2 / 15(0.01E + F)$ where:

R is the turning radius (effective)

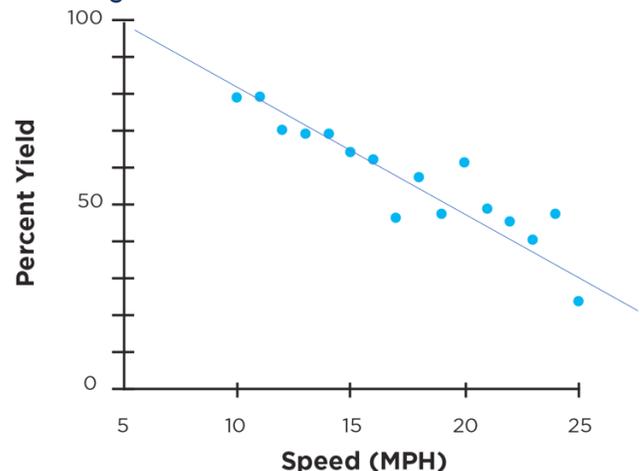
V is speed in miles per hour (mph)

E is super-elevation. This is assumed to be zero in urban conditions.

F is side friction factor

AASHTO. A Policy on Geometric Design of Highways and Streets. 2011. Table 3-7 and Equation 3-8

Driver Yielding Rates and Travel Speeds at Crossings



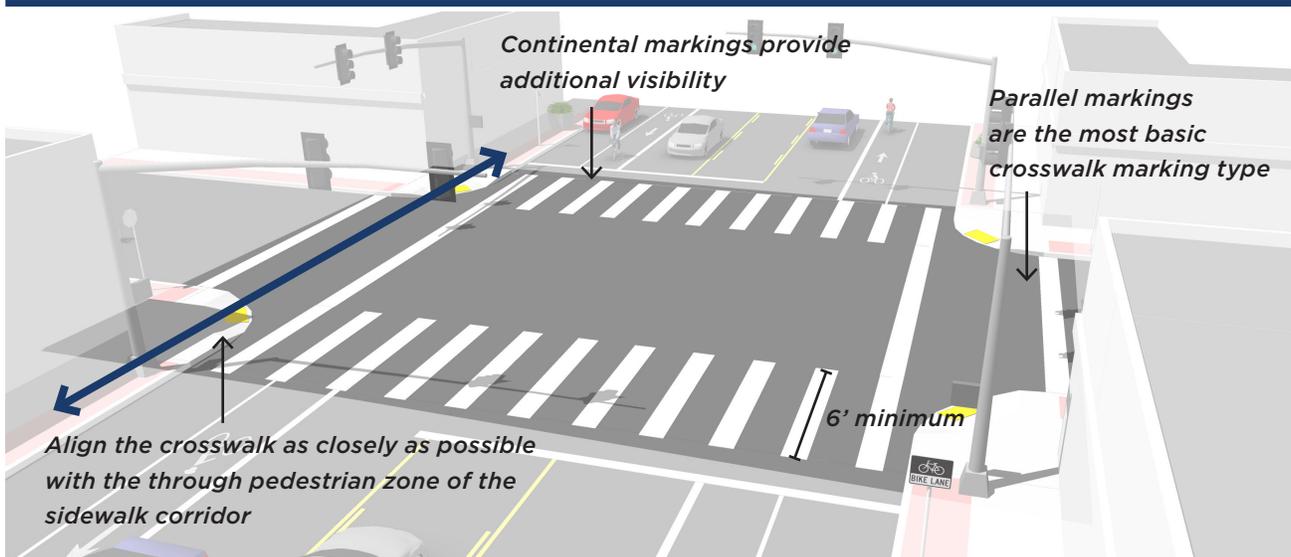
Geruschat, D.R., Driver Behavior in Yielding to Sighted and Blind Pedestrians at Roundabouts. 2005.



Crosswalks

A marked crosswalk signals to motorists that they must stop for pedestrians and encourages pedestrians to cross at designated locations. Installing crosswalks alone will not necessarily make crossings safer especially on multi-lane roadways.

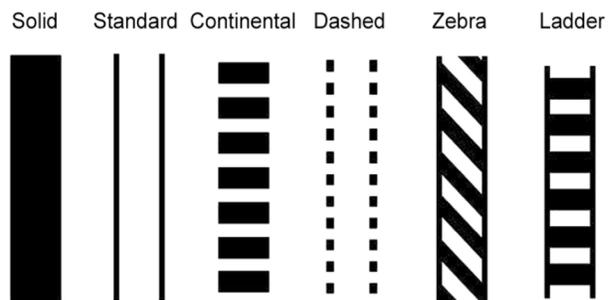
At mid-block locations, crosswalks can be marked where there is a demand for crossing and there are no nearby marked crosswalks.



GUIDANCE

At signalized intersections, mark all crosswalks. At un-signalized intersections, crosswalks may be marked under the following conditions:

- At a complex intersection, to orient pedestrians in finding their way across.
- At an offset intersection, to show pedestrians the shortest route across traffic with the least exposure to vehicular traffic and traffic conflicts.
- At an intersection with visibility constraints, to position pedestrians where they can best be seen by oncoming traffic.
- At an intersection within a school zone on a walking route.
- At intersections that serve pedestrian attractors or where pedestrian activity exists.

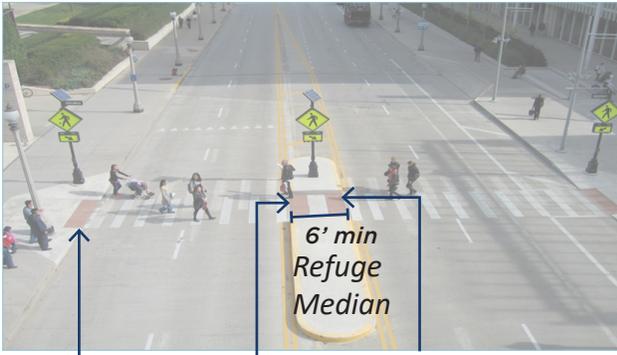


FOR MORE INFORMATION

2009 FHWA Manual on Uniform Traffic Control Devices
2004 AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities
2005 FHWA Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations
2010 FHWA Crosswalk Marking Field Visibility Study
2013 NACTO Urban Street Design Guide

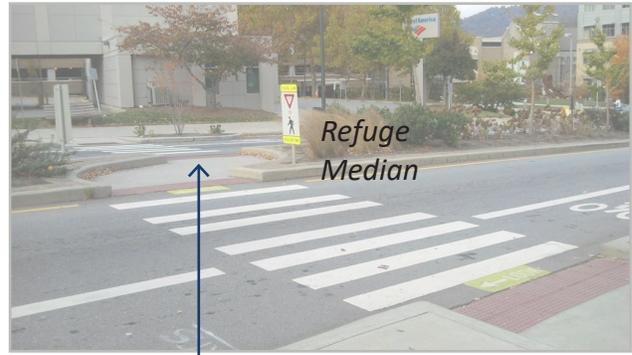
Refuge Medians

Median refuge islands provide added comfort when crossing roadways. Refuge islands simplify the pedestrians' decision-making process by splitting the crossing into two phases, and may communicate presence of crossing to motorists. Angle refuge islands to direct users to face oncoming traffic.



Include detectable warning surface at curbs and edge of each island to delineate the "safe" areas vs roadways

Seek as great as storage capacity as possible in design



The angled crosswalk "turns" pedestrians so they can more easily see oncoming traffic in the second half of the roadway.

TYPICAL APPLICATION

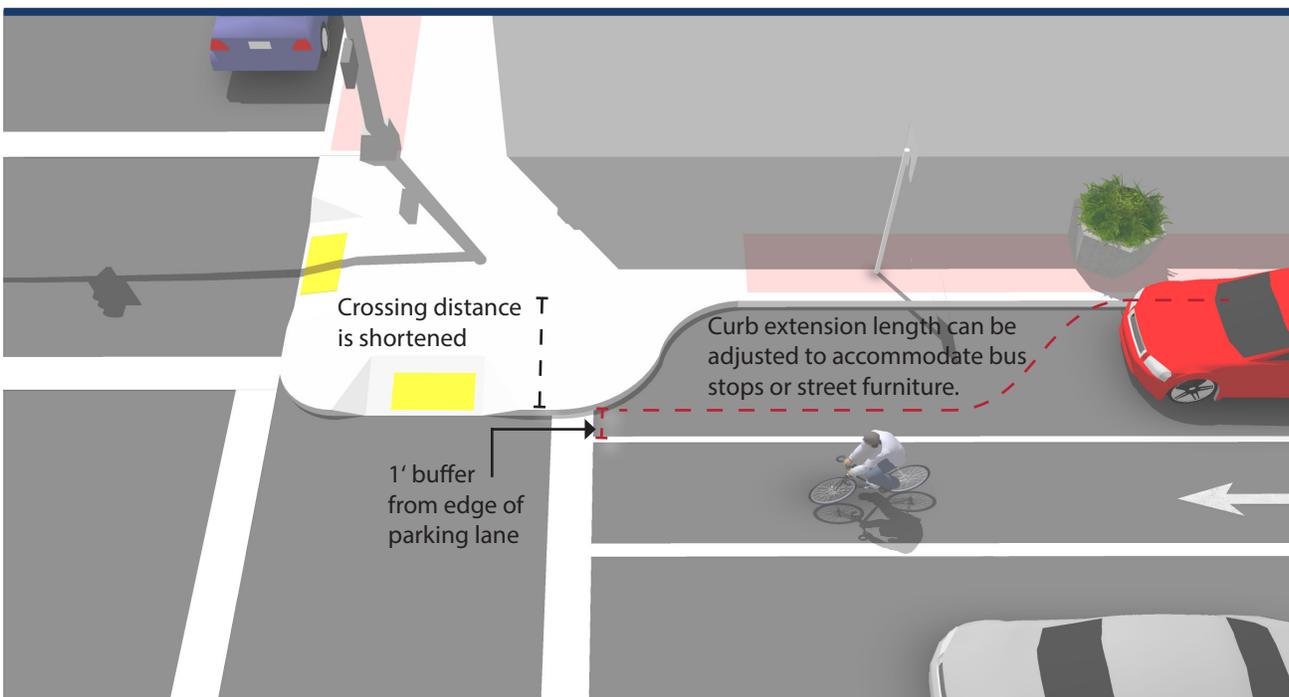
- On streets with a median or two-way left turn lane
- Can also be installed by narrowing lanes or shoulders at the crossing.
- Particularly important in areas where pedestrians access a transit stop or other clear origins/destinations are across from each other.

FOR MORE INFORMATION

2004 AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities
2004 AASHTO Policy on Geometric Design of Highways and Streets
2013 NACTO Urban Street Design Guide

Curb Extensions

Curb extensions minimize pedestrian exposure during crossing by shortening crossing distance and giving pedestrians a better chance to see and be seen before committing to crossing. They are appropriate for any crosswalk where it is desirable to shorten the crossing distance and there is a parking lane adjacent to the curb. Curb extensions also increase the available space for street furniture, benches, and low-level plantings. They may be implemented on downtown, neighborhood, suburban, and residential streets, large and small.



TYPICAL APPLICATION

- In most cases, the curb extensions should be designed to transition between the extended curb and the running curb in the shortest practicable distance.
- For purposes of efficient street sweeping, the minimum radius for the reverse curves of the transition is 10 ft. Balance the two radii so they are nearly equal.
- Terminate curb extensions one foot short of the parking lane to maximize bicyclist safety. Various measures to improve the visibility of the curb extension such as curb paint or other delineators may be used.

- If there is no parking lane, adding curb extensions may be a problem for bicycle travel and truck or bus turning movements.
- Curb extensions may be created from temporary materials such as bollards and pavement coloring. Follow FHWA guidance for use of color in colored crosswalks and islands.

FOR MORE INFORMATION

2004 AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities
2004 AASHTO Policy on Geometric Design of Highways and Streets
2013 NACTO Urban Street Design Guide

Mountable Truck Aprons

A mountable truck apron is a roadway design treatment that consists of a mountable (rollover) curb and colored or textured pavement to delineate the roadway and the apron. Often installed at signalized intersections, mountable aprons visually narrow an intersection to help calm traffic and reduce motor vehicle speeds. While freight, emergency, and other large vehicles are provided extra space to safely complete the turn, smaller vehicles (the majority of motorized road users) are discouraged from taking sweeping, high-speed turns.

Mountable truck aprons may be installed as retrofits to existing intersections or during full construction projects. The images below show examples mountable truck aprons installed as retrofits. In these conditions, the existing drainage profile was maintained, allowing street runoff to flow to the existing storm drains. The image on the right shows additional paint and striping to indicating where motorists should yield for pedestrians and avoid driving on the apron.



TYPICAL APPLICATION

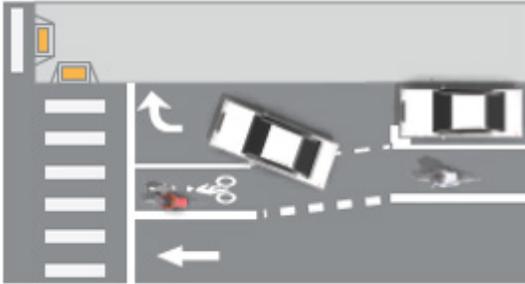
- Install 3-inch rolled curb to allow mounting by trucks and larger vehicles. Install 6-inch standard curb on which pedestrians wait.
- Install detectable warning on the curb ramp outside the truck apron where it transitions to street level.
- Recess the crosswalk striping for improved durability. Continue striping through the mountable curb area.
- To increase longevity and maintain contrast, use concrete (may be colored) in the mountable truck apron area.
- Use vertical delineators to separate pedestrian space from mountable truck apron and provide guidance to maintenance vehicles when snow accumulation hides curb.
- Incorporate gutter between mountable truck apron and standard curb to facilitate drainage.



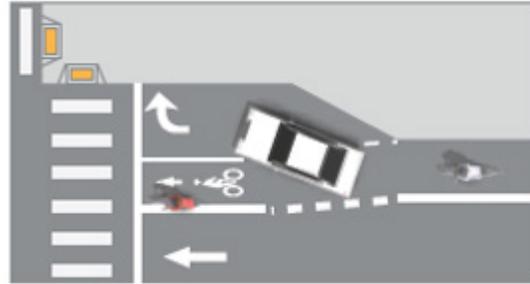
Right Turns and Bike Lanes

On-street bike facilities can create a threat when through-traveling bicyclists conflict with right-turning motorists.

WHEN AN AUXILIARY RIGHT TURN ONLY LANE IS ADDED



Parking Lane into Right Turn Only lane:
Through Bike lanes provide bicycle priority
within weaving area

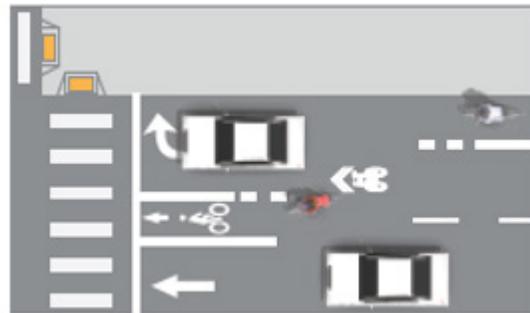


Right Turn Only lane through widening:
Through bike lanes provide bicycle priority
within weaving area

WHEN A THROUGH TRAVEL LANE DROPS INTO A RIGHT TURN ONLY LANE



Bicyclists are not provided priority in weaving area and must use caution to merge across motor vehicle traffic. Do not provide dotted line transition areas in these locations.



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.

Separated Bike Lanes

Separated bike lanes have additional options for interacting with right turn lanes. See NACTO Urban Bikeway Design Guide for guidance.



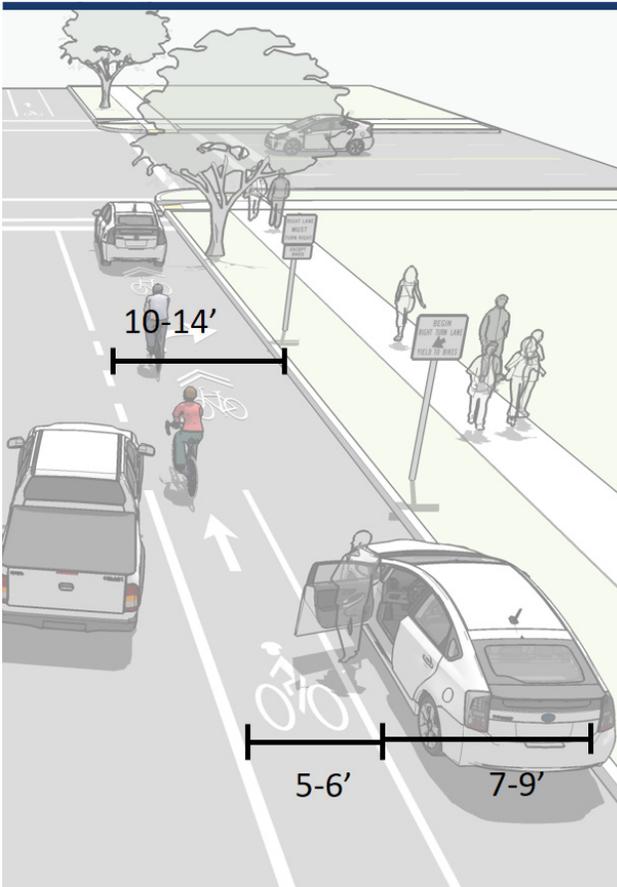
Exclusive bicycle signal phase used to separate conflicting movements

FOR MORE INFORMATION

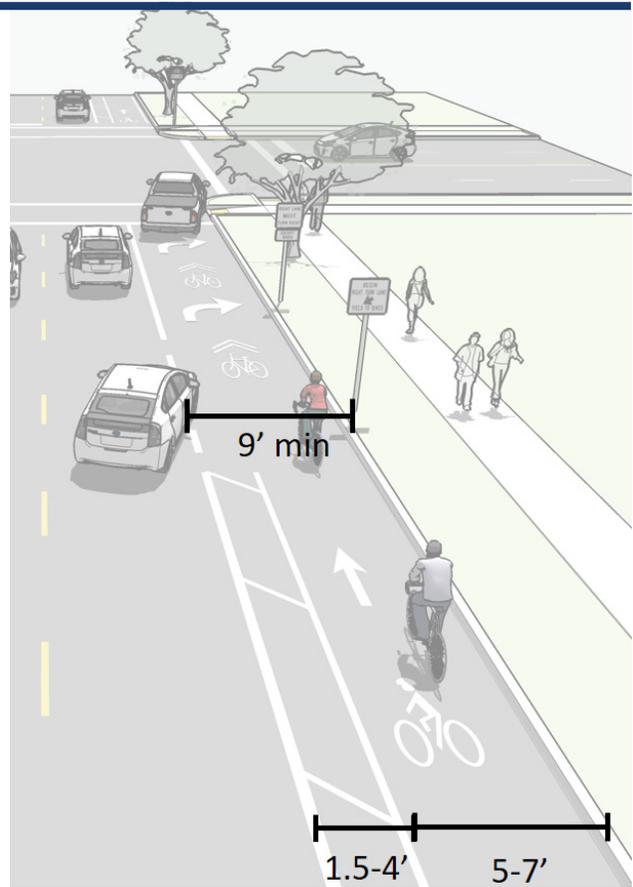
2012 NACTO Urban Bikeway Design Guide
2012 AASHTO Guide for the Development of Bicycle Facilities, 4th Edition (Chapter 4.8.1)

Shared Right Turn Lane

The shared right turn lane places shared lane markings within a right turn only lane. This treatment is recommended at intersections lacking sufficient space to accommodate both a standard through bike lane and right turn lane.



The combined width of the bike lane and parking lane create sufficient space for a right turn only lane



The combined width of the bike lane and buffer may be used to create a right turn only lane if 9 feet or greater

FOR MORE INFORMATION

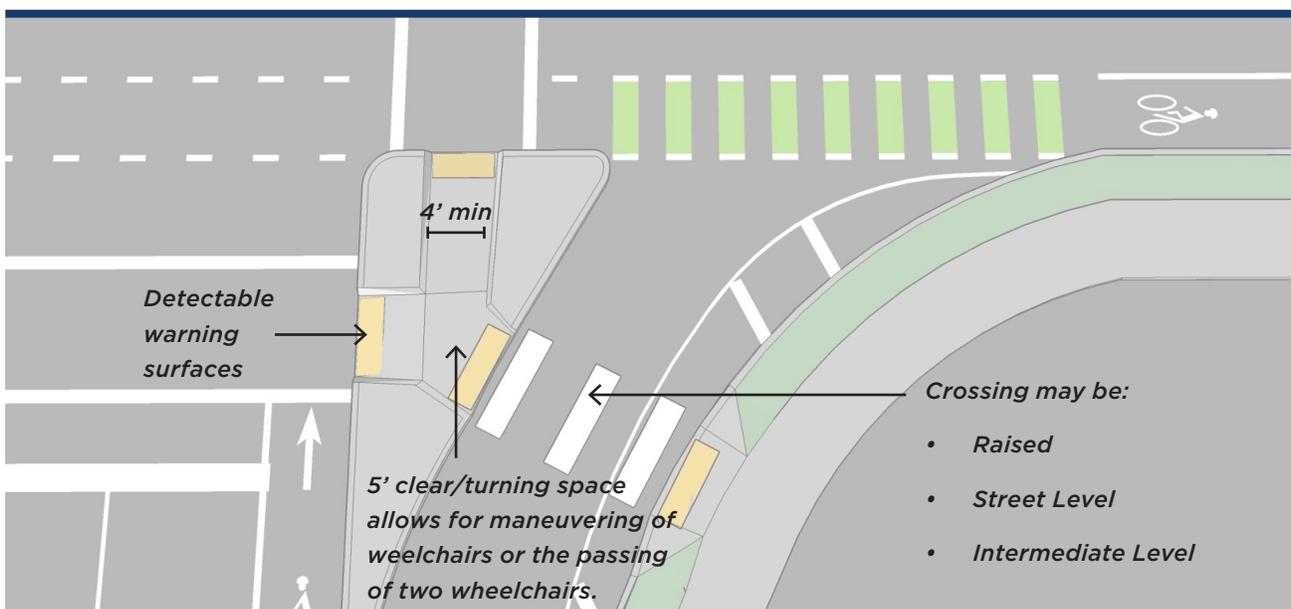
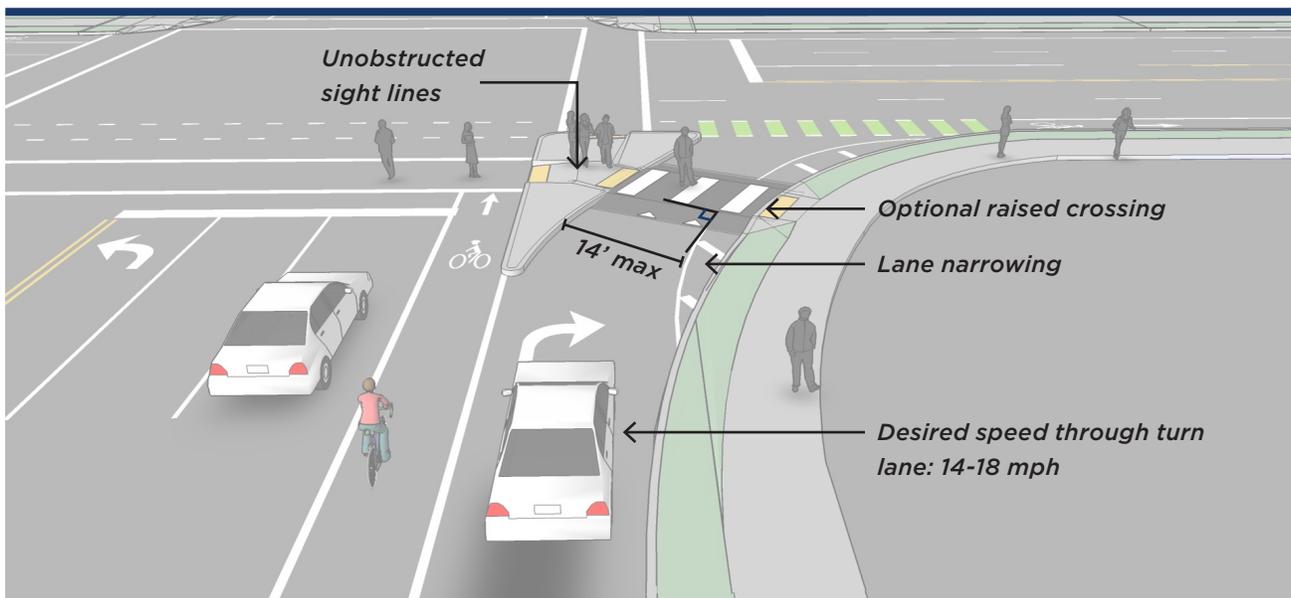
2012 AASHTO Guide for the Development of Bicycle Facilities, 4th Edition (Chapter 4.8.1)
2012 NACTO Urban Bikeway Design Guide



Channelized Right Turn Lanes

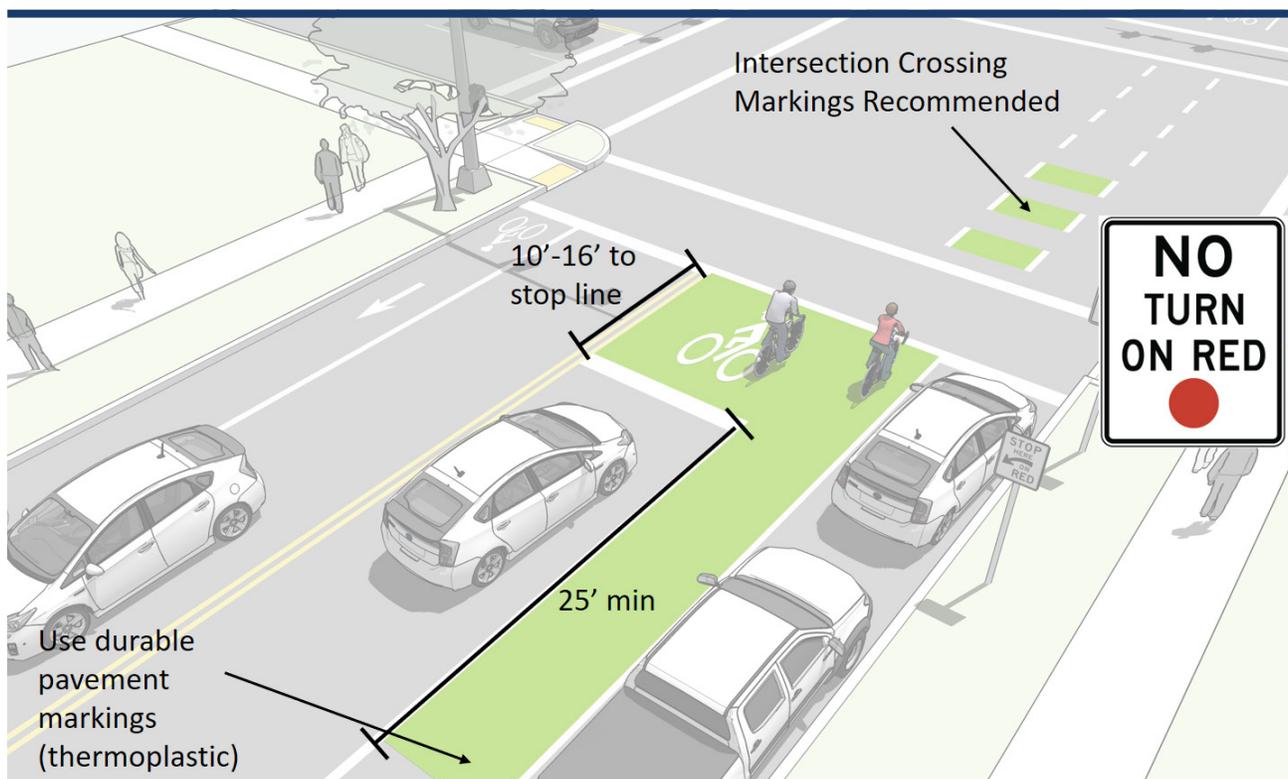
In some intersections of arterials streets, design vehicle requirements or intersection angles may result in wide turning radii at corners. Configuring the intersection as a channelized (or free-right) turn lane with a raised refuge island can improve conditions for pedestrians trying to cross the street.

To improve safety and comfort for pedestrians, measures to slow traffic at the pedestrian crossing are recommended such as provision of a raised crosswalk, signalized pedestrian walk phase, high visibility crosswalk, and/or pedestrian crossing signage. Corner aprons may be used where larger turn radius is required based on volume of large vehicles.



Bike Box

A bike box is a designated area located at the head of a traffic lane at a signalized intersection that provides bicyclists with a safe and visible space to get in front of queuing motorized traffic during the red signal phase. Motor vehicles must queue behind the white stop line at the rear of the bike box. Place bike boxes only at signalized intersections. Prohibit right turns on red for motor vehicles if the bike box is in front of the right turn only lane. Use bike boxes in locations that have a large volume of bicyclists. Bike boxes are best utilized in central areas where traffic is usually moving more slowly. Bike boxes may not be the best treatment for facilitating bicyclist left turns. See Two Stage Turn Queue Box. Carefully consider multi-lane bike boxes before implementation as the maneuvering time required to position is higher.



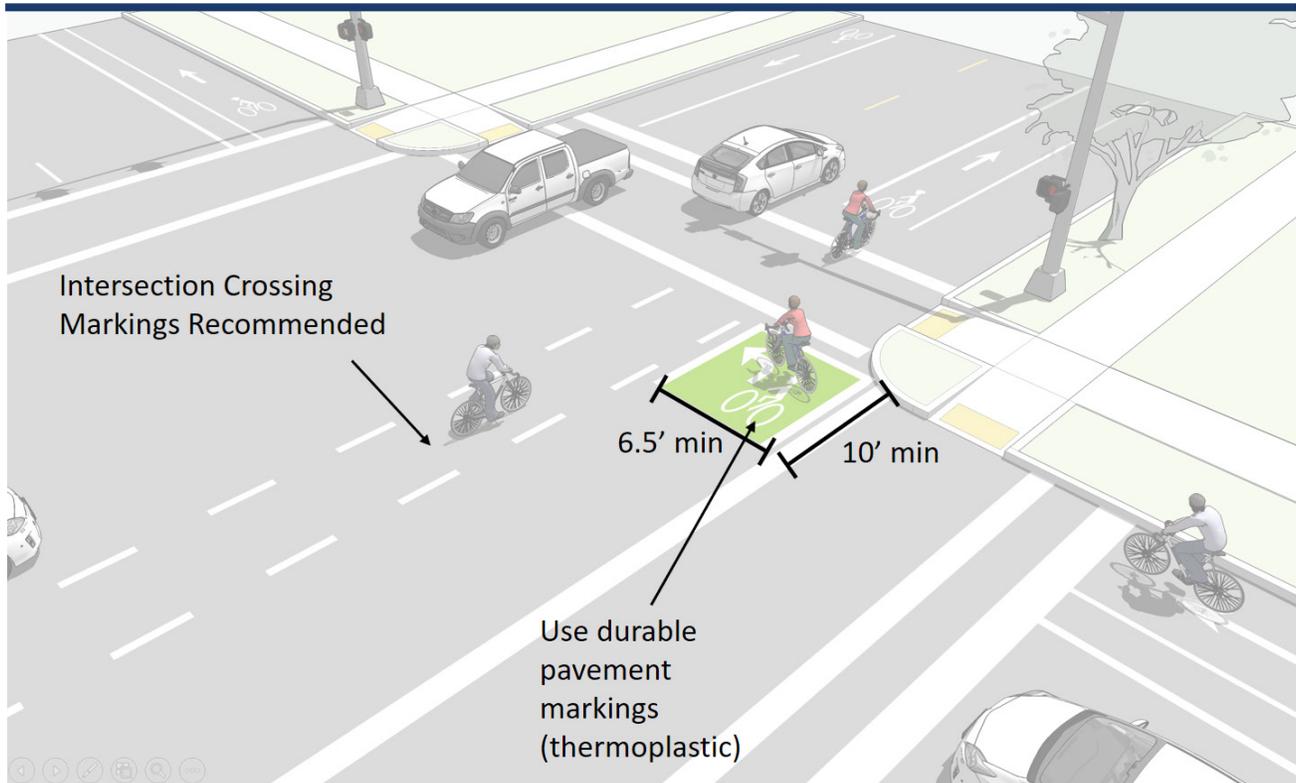
FOR MORE INFORMATION

2012 NACTO Urban Bikeway Design Guide
2017 FHWA Interim Approval for Optional Use of an Intersection Bicycle Box (IA-18)



Two Stage Turn Queue Box

Two-stage turn boxes offer bicyclists a safe way to make turns at multi-lane signalized intersections from a separated or conventional bike lane. On separated bikeways, bicyclists are often unable to merge into traffic to turn due to physical separation, making the provision of two-stage turn boxes critical.



TYPICAL APPLICATION

- Streets with high vehicle speeds and/or traffic volumes.
- At intersections with multi-lane roads with signalized intersections.
- At signalized intersections with a high number of bicyclists making a left turn from a right side facility
- On streets with separated bike lanes and intersecting bikeways
- Right turn on red from cross-street prohibited per FHWA IA-20.

DESIGN FEATURES

Place the two stage turn box in a protected area that does not conflict with vehicular or bicycle through lanes. Typically this is within the shadow of an on-street parking lane or separated bikeway buffer area. Place the turn box in front of the crosswalk to avoid conflict with pedestrians

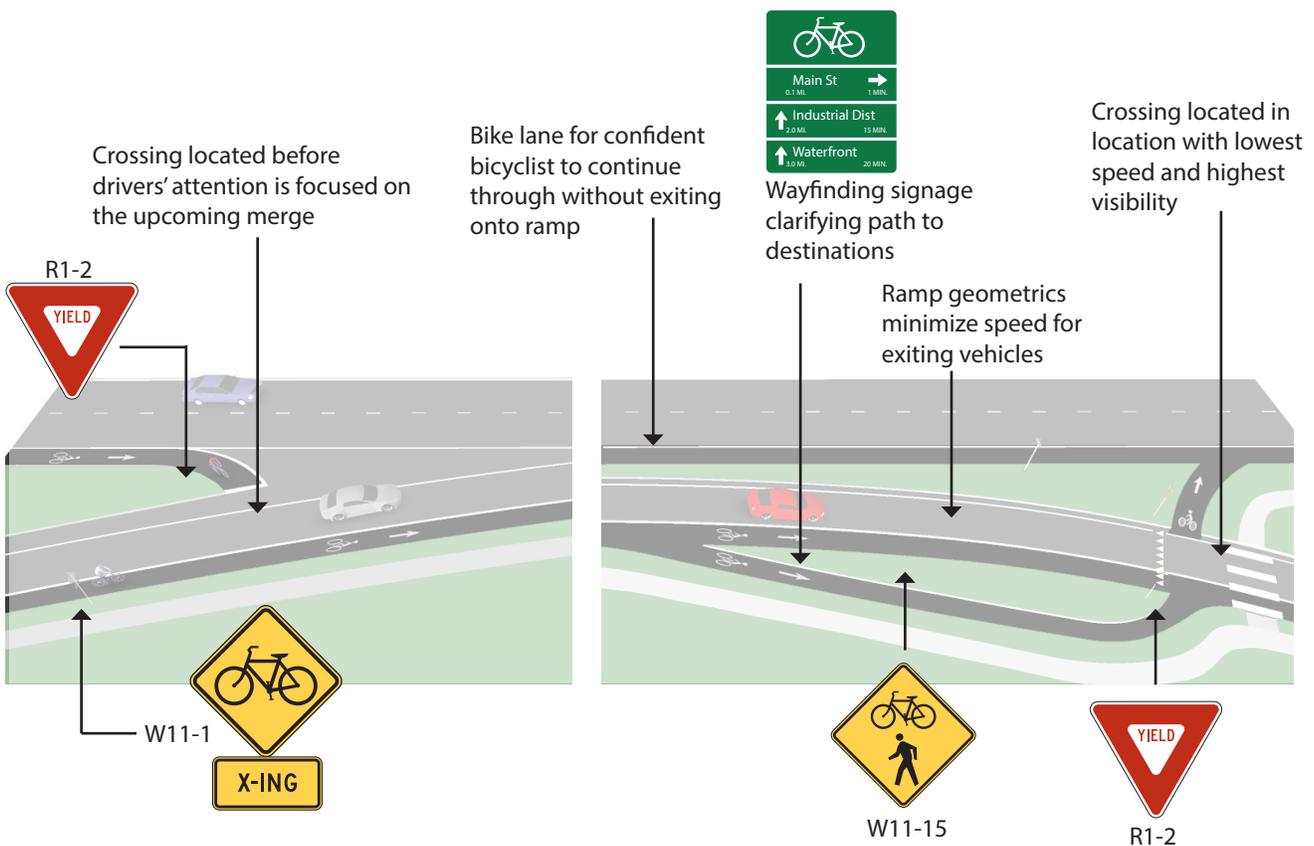
FOR MORE INFORMATION

2012 NACTO Urban Bikeway Design Guide
2017 FHWA Interim Approval for Optional Use of Two-Stage Bicycle Turn Boxes (IA-20)

Bike Lanes and Interchange Ramps

Some arterials may contain high speed freeway-style designs such as merge lanes and exit ramps, which can create difficulties for bicyclists. The entrance and exit lanes typically have intrinsic visibility problems because of low approach angles and feature high speed differentials between bicyclists and motor vehicles.

Strategies to improve safety focus on increasing sight distances, creating formal crossings, and minimizing crossing distances.



TYPICAL APPLICATION

Entrance Ramps:

Angle the bike lane to increase the approach angle with entering traffic. Position crossing before drivers' attention is focused on the upcoming merge.

Exit Ramps:

Use a jug handle turn to bring bicyclists to increase the approach angle with exiting traffic, and add yield striping and signage to the bicycle approach.

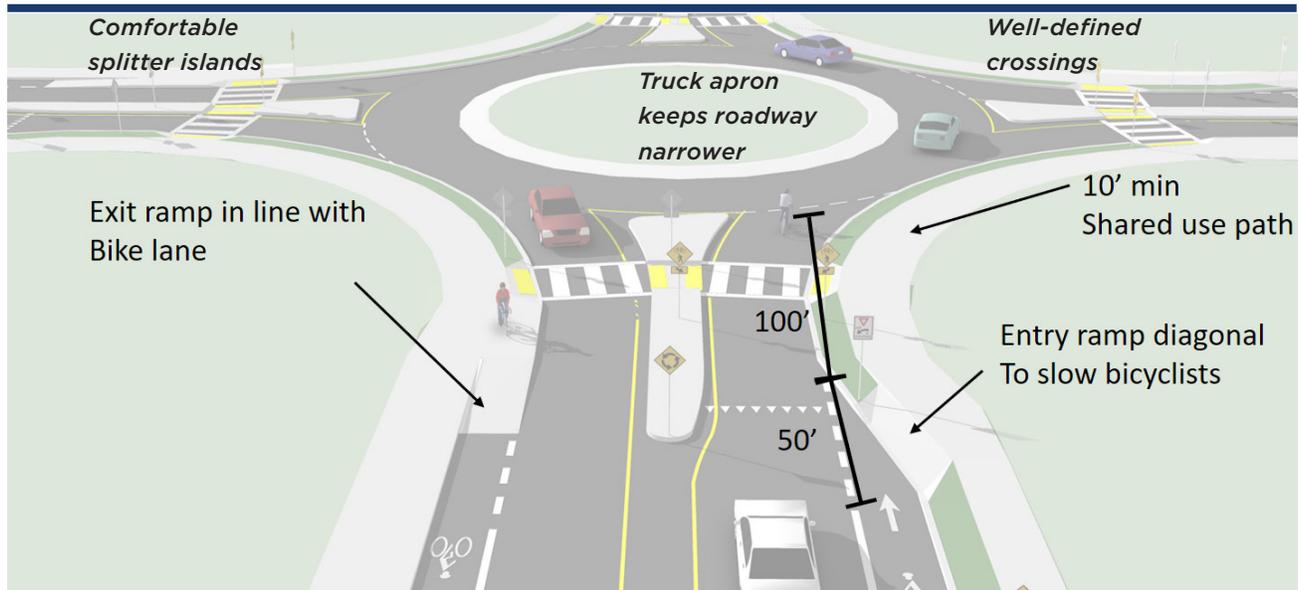
FOR MORE INFORMATION

2012 AASHTO Guide for the Development of Bicycle Facilities, 4th Edition (Chapter 4.12.10)



Roundabouts

At single lane roundabouts it is important to indicate to motorists, bicyclists and pedestrians the right-of-way rules using appropriately-designed signage, pavement markings, and geometric design elements.



TYPICAL APPLICATION

- 25 mph maximum circulating design speed.
- Design approaches/exits to lowest speeds possible.
- Encourage bicyclists navigating the roundabout like motor vehicles to “take the lane.”
- Maximize yielding rate of motorists to pedestrians and bicyclists at crosswalks.
- Provide separated facilities for bicyclists who prefer not to ride on the roadway.

Designing roundabouts that are safe and accessible to people with vision impairments requires significant future research. The following design guidance can lessen the impacts:

- Install setback, highly-visible crosswalks with detectable warning surfaces and guidance surfaces.

- Install single lane roundabouts with single entry lanes, rather than multi-lane roundabouts.
- Add accessible medians and splitter islands to reduce crossing distances and allow pedestrians to negotiate one direction of traffic at a time.

Traffic engineers are encouraged to work with people with vision impairments in their community to identify other design strategies and opportunities for compromises early on in the planning process.

MULTI-LANE ROUNDABOUTS

Multilane roundabouts involve higher vehicle speeds and a more complicated environment for all users.

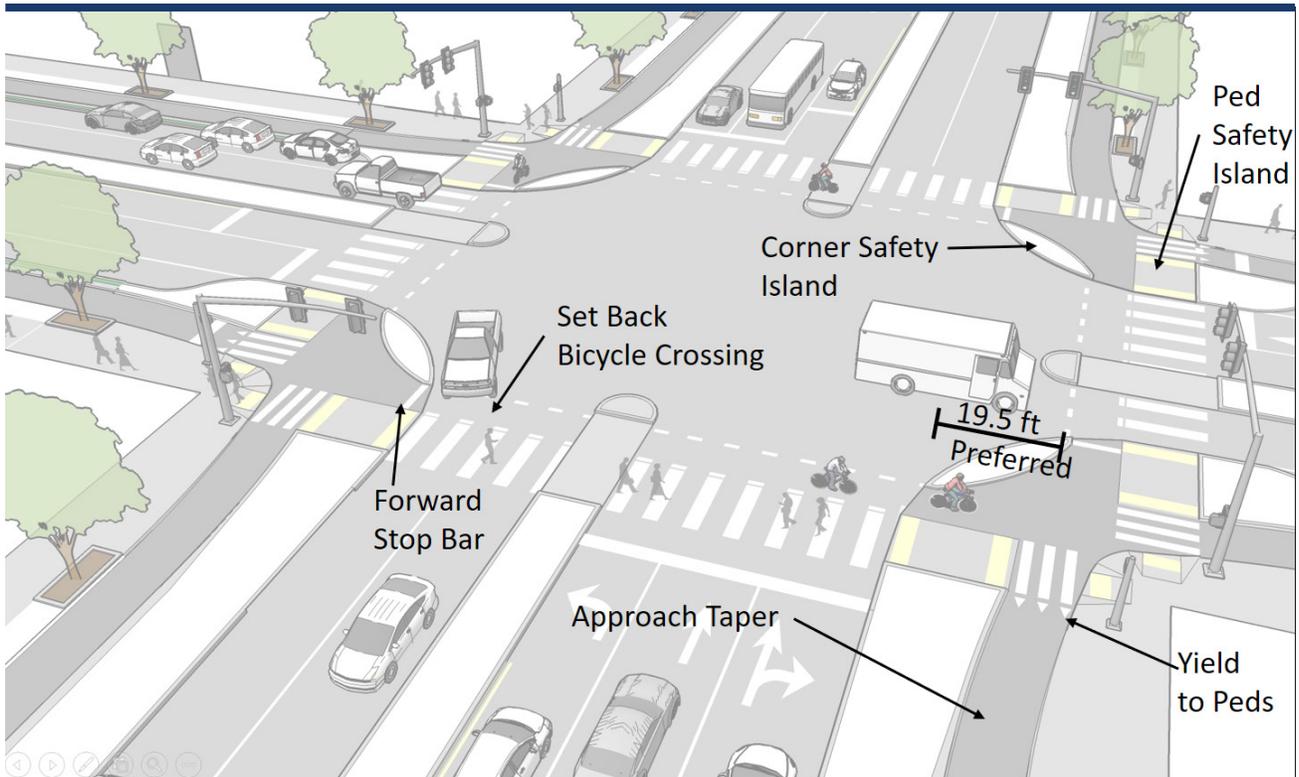
- Do not use shared lane facilities for bicyclists.
- Use bike ramps to connect with off-street facilities.
- Provide pedestrian activated signals to improve yielding at dual lane exits/entrances.

FOR MORE INFORMATION

2012 AASHTO Guide for the Development of Bicycle Facilities, 4th Edition (Chapter 4.12.11)
2010 NCHRP 672: Roundabouts An Informational Guide

Protected Intersections

A protected intersection, or “bend-out” uses a collection of intersection design elements to maximize user comfort within the intersection and promote a high rate of motorists yielding to people bicycling. The design maintains a physical separation within the intersection to define the turning paths of motor vehicles, slow vehicle turning speed, and offer a comfortable place for people bicycling to wait at a red signal.



TYPICAL APPLICATION

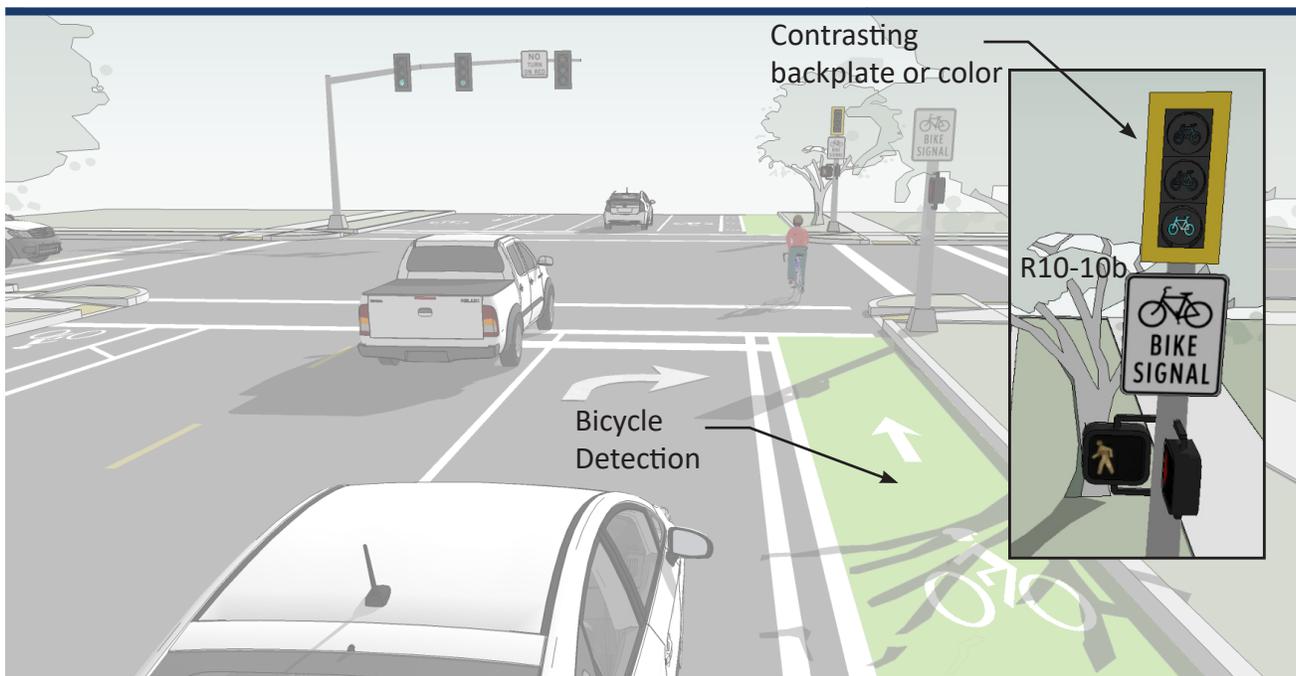
- Streets with separated bikeways protected by wide buffer or on-street parking.
- Where two separated bikeways intersect and two-stage left-turn movements can be provided for bicycle riders.
- Helps reduce conflicts between right-turning motorists and bicycle riders by reducing turning speeds and providing a forward stop bar for bicycles.
- Where it is desirable to create a curb extension at intersections to reduce pedestrian crossing distance.

FOR MORE INFORMATION
2015 MassDOT Separated Bike Lane Planning and Design Guide
2015 FHWA Separated Bike Lane Planning & Design Guide
2015 Lessons Learned: Evolution of the Protected Intersection at <https://altaplanning.com/resources/evolution-of-the-protected-intersection/>

Bicycle Signals

Bicycle signals are typically used to improve identified safety or operational problems involving bicycle facilities. Bicycle signal heads may be installed at signalized intersections to indicate bicycle signal phases and other bicycle-specific timing strategies. Bicycle signals can be actuated with bicycle sensitive loop detectors, video detection, or push buttons.

Bicycle signals are typically used to provide guidance for bicyclists at intersections where they may have different needs from other road users (e.g., bicycle-only movements).



TYPICAL APPLICATION

Bicycle signals are used:

- For contra-flow bicycle movements,
- Where high-volume turns will cross the bikeway, and
- Where concurrent phases are possible.
- Where a bicycle lane is established to the right of a right turn only lane (prohibited by MUTCD).

Bicycle signals are not used:

- Where conflicting turning traffic is minor.
- Where conflicting turning traffic can be prohibited.
- Where a protected phase can't be provided.

Current restrictions on bicycle signals include:

- No use of leading bicycle interval (LBI).
- No conflicts of any kind with vehicle movements.
- No bicycle scrambles.
- No use with hybrid beacons.
- Must have bike lane, no shared lane approaches.

FOR MORE INFORMATION

2012 NACTO Urban Bikeway Design Guide
2013 FHWA Interim Approval for Optional Use of a Bicycle Signal Face (IA-16)

Pedestrian Signals

Pedestrian signal indicators demonstrate to pedestrians when to cross at a signalized crosswalk. Equip all traffic signals with pedestrian signals except where a pedestrian crossing is prohibited or in rural areas with no pedestrian activity that are unlikely to see land use changes.

Countdown pedestrian signals are particularly valuable for pedestrians, as they indicate whether a pedestrian has time to cross the street before the signal phase ends. Use countdown signals at all signalized intersections.

SIGNALIZATION PRINCIPLES

Keep Cycles Short

Keep signal cycle length low to reduce wait time and promote pedestrian and vehicle compliance.

Prioritize

Prioritize pedestrians, transit, and bicycles. Signals set the tempo of the entire street. Transit signal priority is useful, as is bike-speed progression. But pedestrian safety and accessibility is the key priority.

Fewer Signal Phases

Minimize the number of phases. Like the cycle length, the number of phases will influence strongly the rate of compliance by pedestrians, bicyclists, and drivers.

Time to Intended Speed

Set progressions based on the speed desired. If set to the speed limit, any deviation from that limit will then encourage drivers to speed to catch up to the “green wave.”

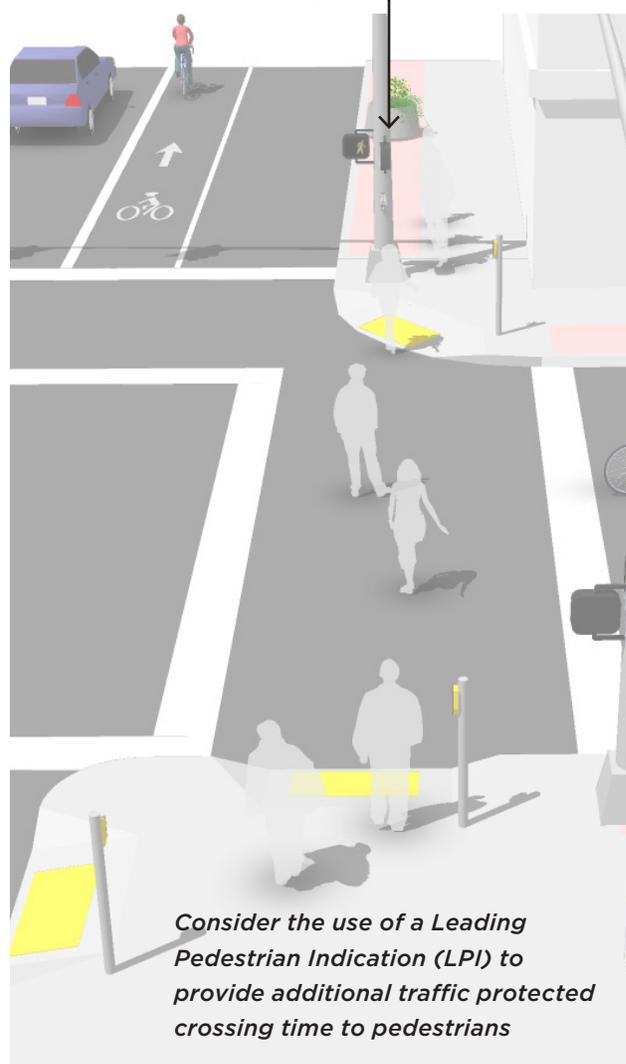
Adjust by Time of Day

Use time-of-day adjustments to subtly move capacity around based on different needs for the time of day to achieve the safest scenario.

Use Fixed Timing

Use pre-timed rather than actuated signals in an urban environment to create a predictable pedestrian intersection.

Audible pedestrian traffic signals provide crossing assistance to pedestrians with vision impairment at signalized intersections

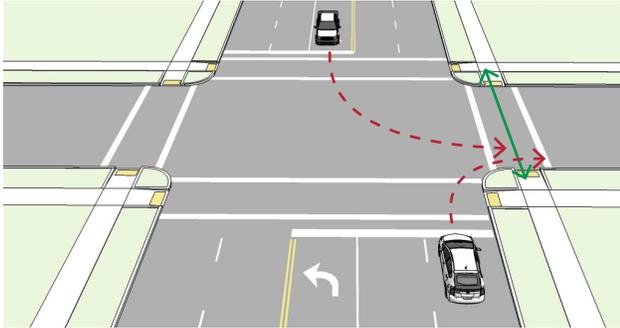


Consider the use of a Leading Pedestrian Indication (LPI) to provide additional traffic protected crossing time to pedestrians



Pedestrian Signals (Cont.)

MITIGATING PEDESTRIAN TURNING CONFLICTS



Two of the most common crash types involving pedestrians are left hooks and right hooks. The conflict occurs when vehicles have a green signal with a permissive left- or right-turn, and pedestrians have a WALK signal. Signal phasing can be improved with the following measures.

Leading Pedestrian Interval

Pedestrian WALK signal is displayed 2-4 seconds before the vehicular green indication to allow pedestrians time to establish a presence in the intersection before vehicles start turning (also referred to as Pedestrian Lead Time).

Lagging Lefts (if permissive)

Delay the ability of permissive lefts until mid-way through the phase so that pedestrians are out in the intersection and visible or are completing their crossing.

Split Phasing

Allow only one approach to proceed at a time, this reduces the number of turning conflicts possible during the pedestrian phase.

Exclusive Pedestrian Phasing

With an exclusive pedestrian phase, WALK signals are provided without green indications for any conflicting vehicle movements. Scramble pedestrian phasing is one type of exclusive phase during which pedestrians may walk in all directions, including diagonal. Exclusive pedestrian phasing and scramble pedestrian phasing should always include audible

information, because pedestrians with vision impairments cannot rely on the sound of vehicular traffic to identify the start of the WALK phase.

Reduced Corner Radii

The size of a curb's radius can have a significant impact on pedestrian comfort and safety. A smaller curb radius provides more pedestrian area at the corner, allows more flexibility in the placement of curb ramps, results in a shorter crossing distance and requires vehicles to slow more on the intersection approach. During the design phase, choose the smallest possible radius for the circumstances.

Advance stop bars

Advance stop bars increase pedestrian comfort and safety by stopping motor vehicles well in advance of marked crosswalks, allowing vehicle operators a better line of sight of pedestrians and giving inner lane motor vehicle traffic time to stop for pedestrians. 10 feet is desirable from the crosswalk.

Signs

Signs remind motorists of their duty to yield to pedestrians while turning left or right. MUTCD sign R10-15 (see right) is commonly used for this purpose. Blank out signs may be of use where pedestrian volumes are heavy, pedestrian volumes are intermittent, or crash history is documented.



MUTCD R10-15

FOR MORE INFORMATION

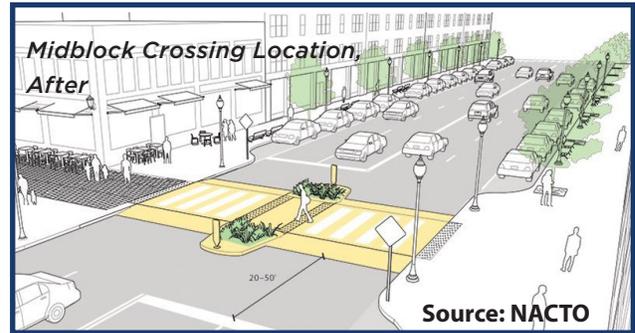
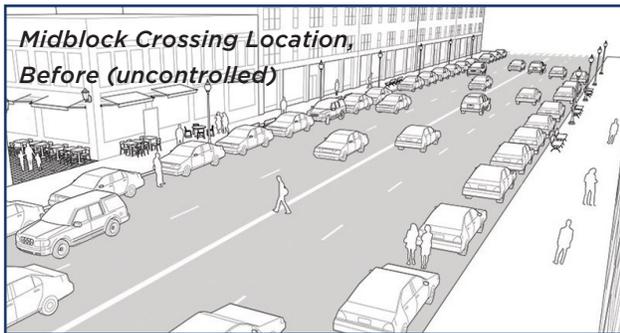
United States Access Board. Proposed Accessibility Guidelines for Pedestrian Facilities in the Public-Right-of-Way (PROWAG). 2011.

2004 AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities
2013 NACTO Urban Street Design Guide

Mid-Block Crossings

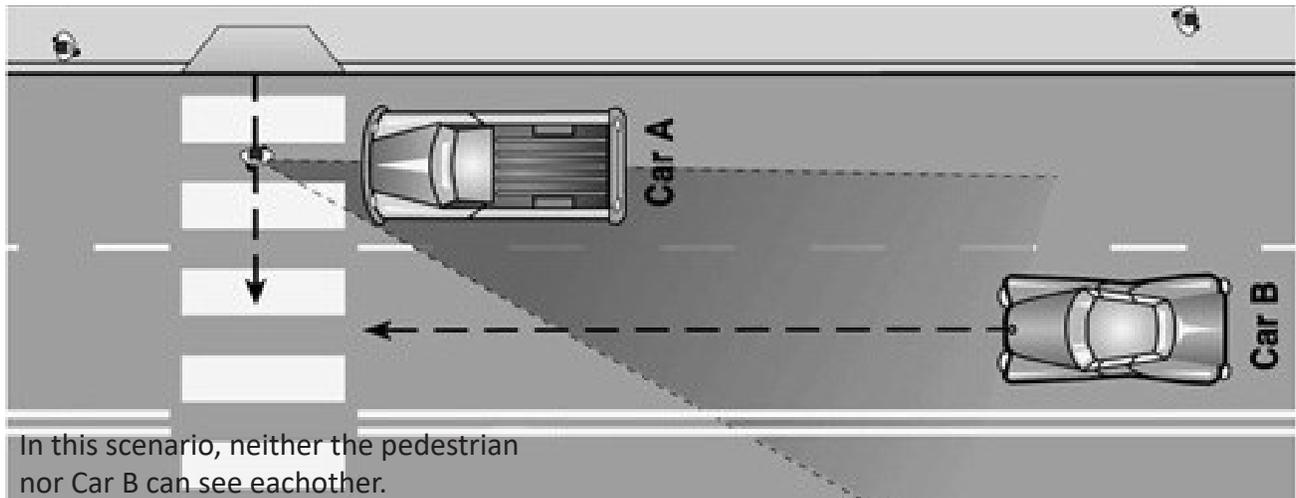
Mid-block crossings may be necessary where there are existing pedestrian desire lines or walking distance to the nearest signalized crossing is excessive. Depending on volumes and speeds, treatments at those crossings can range from a marked crosswalk to full signalization.

Alternatives which exist along this continuum vary in motorist compliance rate, cost, and delay. These alternatives include marked crosswalks, median refuge islands, active warning beacons, pedestrian hybrid beacons (PHB), and full signalization. The MUTCD dictates markings and signage used with each type, but engineering judgement should be used to determine the appropriate design solution.



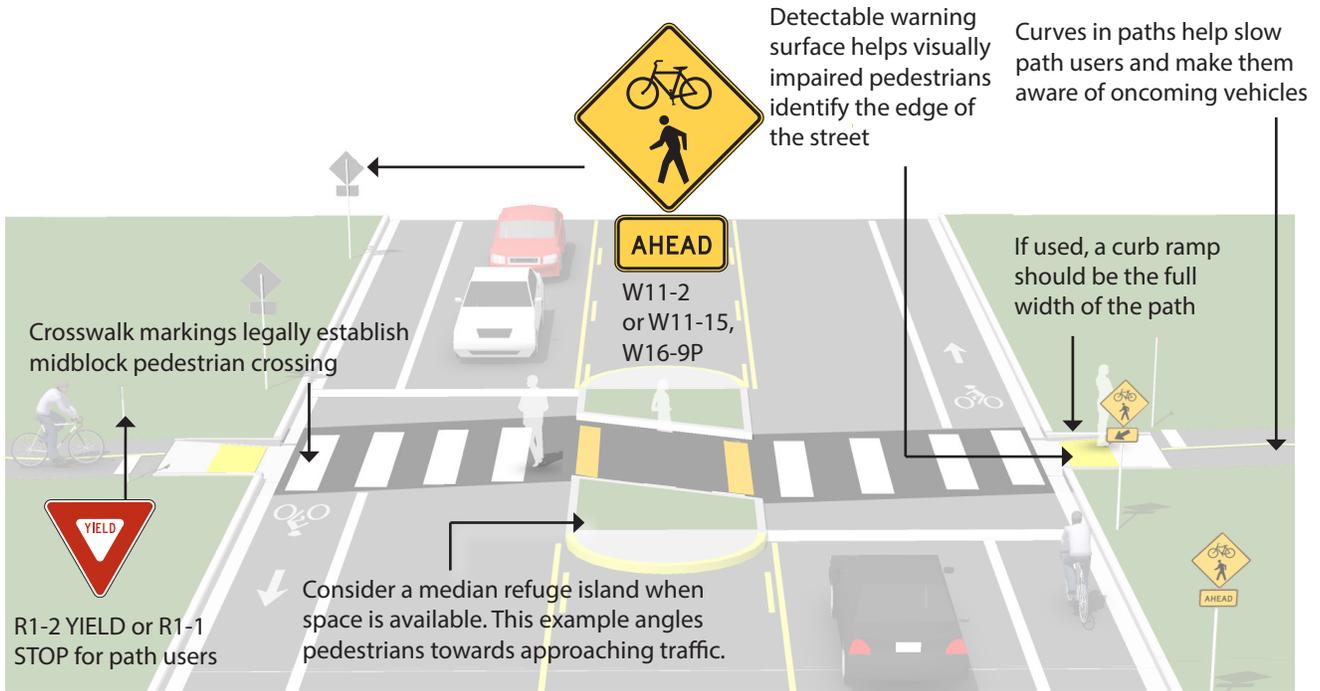
MULTIPLE THREAT

A “Multiple Threat” crash (also referred to as a double or dual-threat crash) occurs when one vehicle yields to a pedestrian or cyclist in a crosswalk, but the vehicle in the adjacent lane does not yield, striking the crossing person (see figure below). Advance yield lines increase likelihood of yielding to a pedestrian in a multiple threat scenario by 61% due to improved sight lines.





Mid-Block Crossings (Cont.)



CROSSWALK ONLY

Marked/un-signalized crossing typically consists of a marked crossing area, signage and other markings to slow or stop traffic. When space is available, using a median refuge island can improve user safety by providing pedestrians and bicyclists space to perform the safe crossing of one side of the street at a time.

Typical Application

- Maximum traffic volumes
 - ≤9,000-12,000 Average Daily Traffic (ADT) volume
 - Up to 15,000 ADT on two-lane roads, preferably with a median
 - Up to 12,000 ADT on four-lane roads with median
- Maximum travel speed: 35 MPH
- Minimum line of sight
 - 25 MPH zone: 155 feet
 - 35 MPH zone: 250 feet
 - 45 MPH zone: 360 feet

Considerations

- Where the speed limit exceeds 40 miles per hour, do not use marked crosswalks alone at unsignalized locations.
- Do not install crosswalks at locations that could present an increased risk to pedestrians, such as where there is poor sight distance, complex or confusing designs, a substantial volume of heavy trucks, or other dangers, without first providing adequate design features and/or traffic control devices.

Mid-Block Crossings (Cont.)



ACTIVE WARNING BEACONS

Active warning beacons are user actuated illuminated devices designed to increase motor vehicle yielding compliance at crossings of multi-lane or high volume roadways. Types of active warning beacons include conventional circular yellow flashing beacons, in-roadway warning lights, or pedestrian activated beacons. Warning beacons and flashing lights increase driver awareness of pedestrians at a crosswalk and increase yield compliance by 20-80%.

Typical Application

- Do not use warning beacons at crosswalks controlled by YIELD signs, STOP signs, or traffic signals.
- Use warning beacons that initiate operation based on pedestrian or bicyclist actuation and cease operation at a predetermined time after actuation or, with passive detection, after the pedestrian or bicyclist clears the crosswalk. Beacons should be unlit when not activated.
- Installations of active warning beacons on median islands improves driver yielding behavior.
- Activated flashing beacons have the most increased compliance of all the warning beacon enhancement options.

Considerations

- While RRFBs were proven to be highly effective, their properties can be replicated through the use of other devices.
- FHWA recommends the use of pedestrian activated beacons, with two circular-shaped yellow lights that flash in an alternating pattern, with a flash rate of 50-60 times per minute and an illuminated period of each flash a minimum of $\frac{1}{2}$ and maximum of $\frac{2}{3}$ of the total cycle.

FOR MORE INFORMATION

2012 NACTO Urban Bikeway Design Guide
2017 FHWA Interim Approval IA-21
FHWA Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations



Mid-Block Crossings (Cont.)



PEDESTRIAN HYBRID BEACON

A hybrid beacon, formerly known as a High-intensity Activated Crosswalk (HAWK), consists of a signal-head with two red lenses over a single yellow lens on the major street, and pedestrian and/or bicycle signal heads for the minor street. There are no signal indications for motor vehicles on the minor street approaches.

Hybrid beacons are used to improve non-motorized crossings of major streets in locations where side-street volumes do not support installation of a conventional traffic signal or where there are concerns that a conventional signal will encourage additional motor vehicle traffic on the minor street. Hybrid beacons may also be used at mid-block crossing locations.

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). If bicyclists are a major user of the crossing, minimize or eliminate the flashing “wig-wag” phase as bicyclists can enter the intersection at speed and drivers proceeding may not see them approaching.

Typical Application

- Hybrid beacons have volume based warrants in the MUTCD, but have frequently been installed without meeting warrants if roadway speed and volumes are excessive for comfortable user crossing.
- Where bike routes intersect major streets without existing signalized crossings.
- Where off-street bicycle or pedestrian facilities intersect major streets without existing signalized crossings.
- At mid-block crossings of major roadways with high bicycle or pedestrian volumes.

Considerations

- If installed within a signal system, signal engineers should evaluate the need for the hybrid signal to be coordinated with other signals.
- Prohibit parking and other sight obstructions for at least 100 feet in advance of and at least 20 feet beyond the marked crosswalk to provide adequate sight distance.

FOR MORE INFORMATION

2014 FHWA Pedestrian Hybrid Beacon Guide - Recommendations and Case Study
2012 NACTO Urban Bikeway Design Guide
2009 FHWA Manual on Uniform Traffic Control Devices (Chapter 4F)

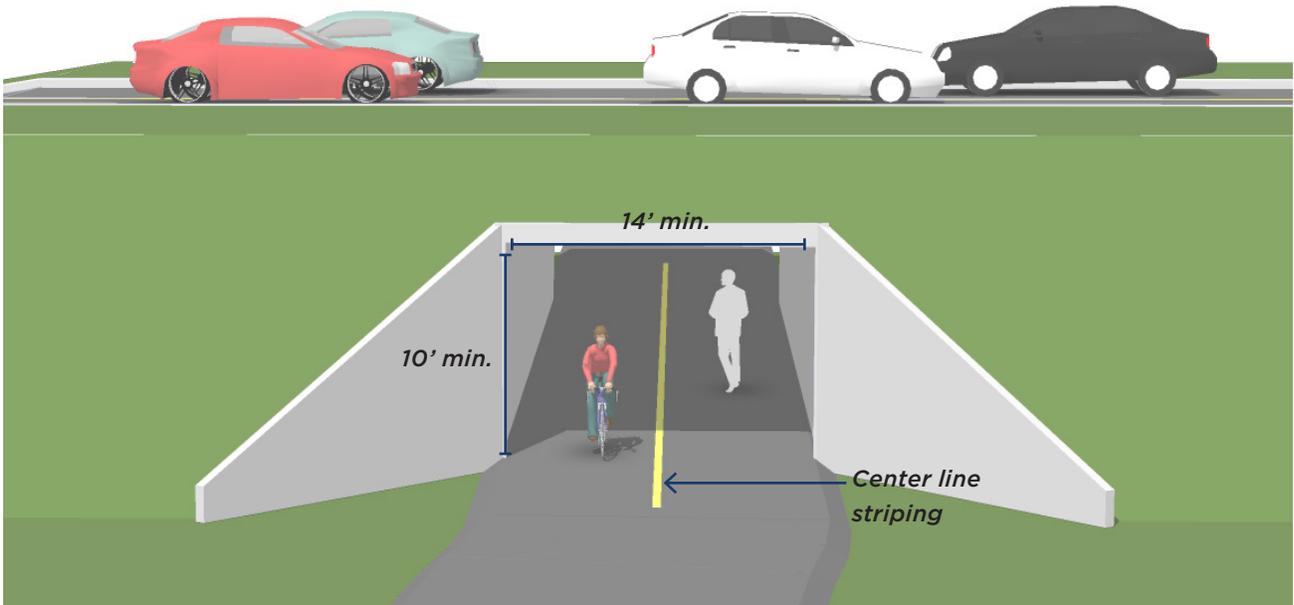
Grade-Separated Crossings

UNDERPASSES

Bicycle/pedestrian underpasses provide critical non-motorized system links by joining areas separated by barriers such as railroads and highway corridors.

There are no minimum roadway characteristics for considering grade separation. Depending on the type of facility or the desired user group grade separation may be considered in many types of projects.

Safety is a major concern with underpasses. Shared use path users may be temporarily out of sight from public view and may experience poor visibility themselves. To improve the perception of safety, design underpasses to be spacious and well-lit, with the entrance and exit visible throughout its entire length.



Typical Application

- 14 foot minimum width, greater widths preferred for lengths over 60 feet.
- 10 foot minimum height.
- The underpass should have a centerline stripe even if the rest of the path does not have one.
- Consider lighting during the design process for any underpass with high anticipated use or in culverts and tunnels.

Materials and Maintenance

- 14 foot width allows for maintenance vehicle access.
- Potential problems include conflicts with utilities, drainage, flood control and vandalism.



OVERPASSES

Bicycle/pedestrian overpasses provide critical non-motorized system links by joining areas separated by barriers such as waterways or major transportation corridors. In most cases, these structures are built in response to user demand for safe crossings where they previously did not exist.

While overpasses reduce conflicts between pedestrians/cyclists and drivers, they can be inconvenient and as a result, under-used. Overpasses require a minimum of 17 feet of vertical clearance to the roadway below versus a minimum elevation differential of around 12 feet for an underpass. This results in potentially greater elevation differences and much longer ramps for bicyclists and pedestrians to negotiate.

There are no minimum roadway characteristics for considering grade separation. Depending on the type of facility or the desired user group grade separation may be considered in many types of projects.



Accessibility

Overpasses for bicycles and pedestrians typically fall under the Americans with Disabilities Act (ADA), which strictly limits ramp slopes to 5% (1:20) with landings at 400 foot intervals, or 8.33% (1:12) with landings every 30 feet.

Overpasses pose potential concerns about visual impact and functional appeal, as well as space requirements necessary to meet ADA guidelines for slope.

Guidance

- 12 feet minimum width or the paved width of the approach path plus 2 feet, whichever is greater. If the overpass has any scenic vistas, provide additional width to allow for stopping. A separate 5 foot pedestrian area may be provided for facilities with high bicycle and pedestrian use.
- 10 foot headroom on overpass; clearance below will vary depending on feature being crossed.
 - Roadway: 17 feet
 - Freeway: 18.5 feet
 - Heavy Rail Line: 23 feet
- The overpass should have a centerline stripe even if the rest of the path does not have one.

Materials and Maintenance

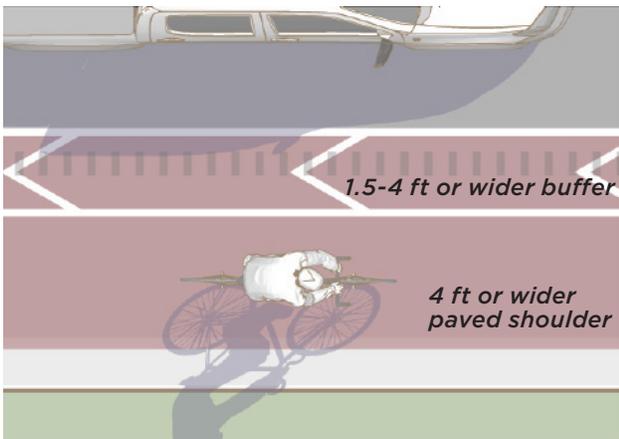
- Potential issues with vandalism.
- Overpasses can be more difficult to clear of snow than underpasses.

FOR MORE INFORMATION

2012 AASHTO Guide for the Development of Bicycle Facilities (Chapter 5.2.10)
2004 AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities

Heavy Truck Traffic

The presence of heavy truck traffic can make vulnerable road users feel unsafe and uncomfortable. Collisions with heavy trucks are much more likely to be fatal for pedestrians and bicyclists than collisions with passenger vehicles. Locate bicycle and pedestrian facilities on alternate routes, where practical. When an alternate route is not available, walking and bicycling facilities on routes with heavy truck traffic should be separated from truck traffic to the maximum extent possible.



BUFFERS

Large trucks create wind drafts, noise, and air pollution. Providing a separated trail with a vegetated buffer can shield bicyclists and pedestrians from these negative impacts.

When a physically separated trail is not practical, provide a wide shoulder with a buffer and bike-friendly rumble strips.

MAINTENANCE

Shoulders along truck routes may require more frequent sweeping, especially if trucks are hauling sand or gravel. Debris tends to collect along the edges of roadways, creating a hazard for bicyclists.

SIGNAGE

Place signage along truck routes to notify drivers of the presence of bicyclists and pedestrians. Bike Route Guide (D11-1c) signs are used to indicate to bicyclists that they are on a designated bikeway and make motorists aware of the bicycle route.

TRUCK SIDE GUARDS

Truck side guards and truck side skirts prevent bicyclists and pedestrians from becoming trapped beneath a truck in a collision. Truck side skirts also decrease air drag on the truck, improving fuel efficiency. Governments can require truck side guards on agency vehicles and contractors' vehicles, and develop programs to encourage use of side guards on trucks.

FOR MORE INFORMATION

US Department of Transportation Volpe Center: <https://www.volpe.dot.gov/our-work/truck-side-guards-resource-page>

Transit Design Considerations

Transit Best Practices

APPROPRIATE ADJACENT LAND USE

Surrounding land uses and site design have an impact on the success of transit service. Specifically, transit thrives in places with mixed land uses, higher residential densities, and compact site design.

Although transit service itself cannot change the adjacent land use or site design, it is important for capital infrastructure to reflect and react to the surrounding built environment in order to properly address the needs of riders.

For example, a bus stop that serves a far set-back apartment building does not have a shelter. On rainy days, riders have to choose between waiting in the rain for the bus or waiting inside the building and running to the stop when the bus becomes visible. The bus was not visible from blocks away and, as such, many riders missed the bus, because they were waiting inside. The addition of the capital infrastructure (e.g. a shelter or a “Bus Approaching” indicator at the stop) could have resolved this rider need.

SAFE, COMFORTABLE BOARDING AND ALIGHTING OPTIONS

It is essential that passengers feel safe and comfortable at transit stops, platforms, and stations. This includes adequate lighting and security cameras and designing stops, platforms, and stations such that no hiding places are possible.



RELIABLE AND COMPREHENSIVE SERVICE INFORMATION

Removing the unknown from transit service with service maps and timetables and/or real-time schedule information will increase passenger comfort while waiting for their next leg of the trip.

DESIGNS CONSISTENT WITH COMMUNITY CONTEXT

Capital improvements can vary greatly in application. While there are guidelines for sizes, finishes, and spacing of enhanced transit features, some deviation from the guided specification is encouraged such that the capital infrastructure fits within the context of a community.

For example, the Metro Transit bus shelters in the Twin Cities are branded with a uniform bus logo such that passengers know they are waiting at a designated bus stop (see figure at bottom left). However, at key stops on the system, more uniquely designed shelters are utilized. The bus stop shown in the figure at bottom right was designed as public art and is now a cornerstone of the intersection.

MULTIMODAL CONNECTIONS

Transit users are users of at least one other mode sometime in their trip. Ensuring that other modes have easy and convenient access to transit is an important element of transit infrastructure.



Image: BusinessWire.com

Transit-Supportive Roadway Design

Roadway design is important for the success of transit. The following design features are for consideration when transit is a priority.

TRAVEL LANE WIDTH

A balance is necessary with travel lane widths between easy on-street bus operations and minimizing street crossing distances for passengers once they have exited the bus. Transit functions best in general purpose travel lanes that are at least 11 feet wide.

In congested areas, buses may opt to travel on freeway shoulders to bypass traffic. In these scenarios, shoulder widths are recommended to be at least 10 feet wide and bus speeds are recommended to not exceed 35 miles per hour (FHWA).

SPEED LIMITS

Vehicle speeds greater than 30 miles per hour can make pedestrians and future passengers feel unsafe while waiting for transit. Streets with 30 miles per hour speed limits are excellent locations for transit facilities because they can:

- Accommodate medium to high volumes of traffic
- Achieve a balance of access and mobility for all modes
- Include a diverse set of walkable destinations
- Accommodate boarding and alighting in the travel lane from curb-extended stops or stations
 - » When transit stops exist on streets with speed limits over 30 miles per hour, it is recommended that transit stops be designed as off-street or pull-out stops, allowing the bus to exit general purpose traffic and act as a barrier between boarding/alighting passengers and fast moving traffic. Taper lengths for pull-out stops are largely dependent on the speed of general traffic.

- » When transit stops exist on streets with speed limits at or below 30 miles per hour, depending on traffic volumes, the bus can safely stop in the travel lane to allow passenger boarding or alighting.

TURNING RADII

Transit vehicles typically require an effective turning radius of approximately 20–30 feet, and the smallest turn radius that still accommodates all bus movements is optimal. A wide turn radius requires a bus to stop further from the intersection, which causes riders to walk farther and can reduce the availability of on street parking. Narrow turning radii reduces street crossing distance and may benefit operations by reducing the number of clear lanes needed to make a turning movement.

FOR MORE INFORMATION

Federal Highway Administration: Use of Freeway Shoulders for Travel — Guide for Planning, Evaluating, and Designing Part-Time Shoulder Use as a Traffic Management Strategy. <https://ops.fhwa.dot.gov/publications/fhwahop15023/ch1.htm>



Bus Stops

A basic bus stop may include a small bus shelter and a sign indicating a bus stop and potentially the route(s) serving the stop. Bus stops require sidewalk and curb space. Sidewalk space provides an area for riders to wait for the bus as well as board and exit the bus. The curb space allows the bus operator to safely maneuver the bus out of traffic and up to the edge of the sidewalk.



DESIGN DIMENSIONS

- Curb length: Varies depending on design speed of roadway and length of bus in operation. On 30 MPH roads, the minimum curb length needed to accommodate pull-out bus stops can be estimated as 2 times the length of the bus plus a 10' taper.
 - » For instance, 40-foot buses operating on 30 miles per hour roads need at least 90 feet clear curb space for the bus to pull into the boarding area, align doors with the curb, and pull out into general traffic
 - » For stops serving more than one bus at a time, add an extra bus length and 10 feet for each bus that will be at the stop at the same time
 - » Nearside stops need less pull-in length than farside stops because the bus can pull-in to the stop while navigating through the intersection
- Lane width: Transit functions best in travel lanes that are 11 feet or wider.

- Boarding area: The front of the bus shall be adjacent to a minimum of 5 feet wide by 8 feet deep unobstructed sidewalk space (ADA Std. 810.2.2).
- Distance to intersection: Bus stops that are located before an intersection (near-side stops) should be set back at least 15 feet so that they do not block the visibility of pedestrians (NACTO).
- Signage: Placing bus stop signs at the front of the stops indicates the approximate location where the front of the bus will be when stopped.

OTHER STREET DESIGN FEATURES TO CONSIDER

- On-street parking: If the speed limit is low enough, the platform may be shorter to allow for more parking
- Bicycle lanes: Maintain bicycle lanes in existing conditions when possible, dotting the bike lane across bus stops and/or turn outs

Bus Stops (Cont.)

BUS STOP LOCATION AND GEOMETRIC CONSIDERATIONS

When possible, locate bus stops at intersections to enable safe and easy pedestrian crossing movements. However, locating a stop near an intersection can produce pedestrian-vehicle conflicts and vehicle-vehicle conflicts. Additionally, bus operations and schedule are affected by the stop location within and geometry of the intersection. A summary of whether each consideration is a benefit or drawback to a bus stop location and geometric configuration is shown in the table below.

Geometric, Traffic, and Transit Operational Considerations for Bus Stop Placement

STOP LOCATION:	NEAR SIDE			FAR SIDE	
	In Pull-Out Stop	Within Right-Turn Lane	Within Through Travel Lane (Assumes Curb Bump-Out)	In Pull-Out Stop	Within Through Travel Lane (Assumes Curb Bump-Out)
Geometry of Stop					

GEOMETRIC CONSIDERATIONS

Intuitive Stop Location	Benefit	Drawback	Benefit	Neutral	Benefit
Efficient Use of Intersection Space	Neutral	Benefit	Neutral	Neutral	Neutral
Potential for On-Street Parking	Neutral	Neutral	Neutral	Drawback	Drawback

GENERAL TRAFFIC CONSIDERATIONS

Impact on General Traffic	Benefit	Drawback	Drawback	Benefit	Drawback
Vehicle-Pedestrian Conflict Prevention	Neutral	Benefit	Neutral	Neutral	Neutral

BUS DELAY OPERATIONAL CONSIDERATIONS

Prevent Delay from Re-entering Traffic	Drawback	Drawback	Benefit	Drawback	Benefit
Prevent Delay from Traffic Signal	Drawback	Drawback	Drawback	Benefit	Benefit
Prevents Rider Motion Sickness	Drawback	Drawback	Benefit	Drawback	Benefit



Platforms

A platform refers to a larger, defined transit waiting area at a stop. This could be at a bus stop or at a stop for other modes, such as trains, light rail transit (LRT), streetcar, or BRT. A bus stop typically does not include curb modifications while a platform may require some curb extensions to provide additional waiting space for transit riders. A platform may or may not include additional amenities outside of an open waiting space, and can also include the amenities detailed in the Station subsection as appropriate and space can accommodate.

Significant differences between a stop and platform include the addition of detectable warning strips as well as, potentially, raised curbs and bump-outs.

Detectable warning strips are two foot wide tactile plates that signify the edge of the platform to visually-impaired riders and provide additional footing for all riders during inclement weather.

Raised curbs are similar to standard curbs, but the height is increased to allow easier mobility in boarding and exiting the bus.

Bump-outs are extensions of the curb into the street. By extending the curb, the bus does not need to spend time navigating from the traffic lane to the platform, rather the bus stops briefly in the traffic lane while riders board and exit.



STREET DESIGN FEATURES

Platforms may require more curb space than a standard bus stop, especially if the platform uses curb bump-outs. Access points, alleys, and driveways may conflict with the space needed for a platform. If possible, closing the access points creates a greatly improved transit and pedestrian experience by removing possible vehicle-bus and vehicle-pedestrian collisions. If access points cannot be closed, the platform may be located elsewhere along the curb so that the access point is near the platform but not bisecting it.

- Curb Length: Same as stop with taper length
- Boarding area: Same as stop or wider
- Optional detectable warning strip: 2-foot deep tactile plates placed directly behind the curb. Can run along the entire length of platform or just length of one bus

- Possible raised curb: Curb height increased to nine inches
- Bump-outs: Taper bump-outs that extend into the street at 5:1 (five feet in length for every foot in depth). Platform length of one bus length is sufficient (plus one bus length + 10 feet for every additional bus stopped at the same time)

OTHER STREET DESIGN FEATURES TO CONSIDER

- On-street parking: Same as stop
- Bike parking: Provide ample bike parking to facilitate multi-modal connections to transit
- Bicycle lanes: Without bump-out, do not reroute bicycle lane. With bump-out, use floating transit stop (see figure above)
- Right-turn lanes: Same as stop
- Access points/nearby business curb cuts: Close curb cut or relocate platform

Stations

A station is an enhanced facility that requires more space than a traditional bus stop or platform. The necessary space depends on the type of transit served by the station. An LRT station, for example, accommodates several train cars and could be several hundred feet long, while a station that only serves buses may not require as much space.

AMENITIES

A station may also include many of the following characteristics:

- Shelter(s)
- Level-boarding platforms
- Off-board fare collection
- Unique name
- Passenger and route information
- Lighting, heating, and security technology
- Seating
- Bicycle parking (covered or uncovered)
- Real-time arrival information

The key difference between platforms and stations is pedestrian access to the infrastructure. The connotation of a platform is that it is adjacent to sidewalk or trail, whereas a station may be center-aligned and, therefore, require additional space to allow for pedestrian access into the station area.

Stations ideally provide separate spaces for pedestrians, amenities, and riders. The space nearest the curb shall have a detectable warning strip and provide a clear boarding area for riders to board and exit the bus (ADA Std. 705). The space behind the boarding area is recommended as a furnishing area dedicated to station amenities and a place for riders to wait for the bus. Active sidewalk is recommended behind the furnishing area. This space provides continual access to the furnishing and boarding areas along the entire station length.

DESIGN DIMENSIONS

- Curb length, boarding area, detectable warning strip: Same as platform



- Furnishing area: Furnishing areas shall be at least four feet deep (ADA Std. 305) and must be set back eight feet from the curb to allow clear bus boarding space along the entire platform (ADA Std. 810.2.2)
- Signage: Station signs and other markers are best placed approximately ten feet from the shelter. Front of bus aligns with station sign, not the shelter

OTHER STREET DESIGN FEATURES TO CONSIDER

Same considerations as platforms, plus:

- Ensure sidewalk space is located behind the furnishing area. Mixing the furnishings, pedestrians, and boarding area creates conflicts
- Remove right turn lanes for near-side bump out stations

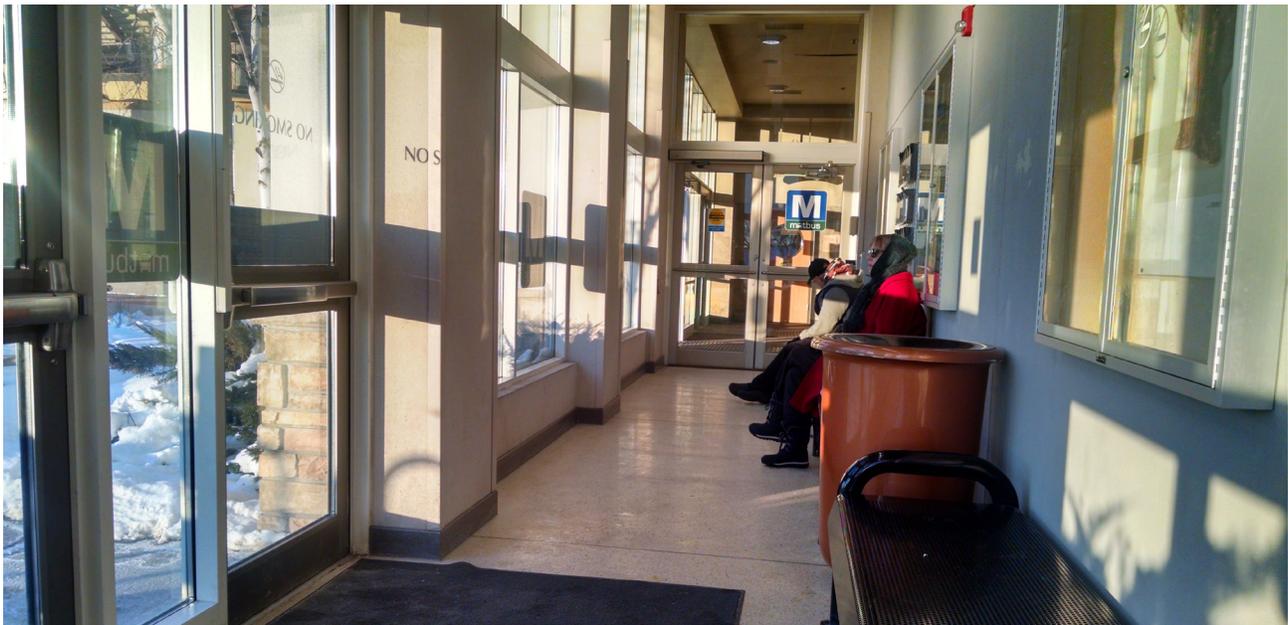
FLOATING STATIONS

Stations with bump-outs on streets with bicycle lanes may need to use a floating station design to avoid bicycle-bus and bicycle-vehicle collisions. In this case, the bicycle lane is routed behind the station so that bicyclists travel between the active sidewalk and bus station. Because this design creates pedestrian-cyclist conflicts, other pedestrian safety features are recommended in coordination with floating stations.



Depots

While a station typically only serves one or two local transit types like bus and light rail at one or two platforms, a depot is the compilation of several platforms and many times includes several modes. Depots can have buildings with public seating, restaurants, and bathrooms to accommodate passengers with long transfers. Depots are typically where intercity transit transfers occur.



DESIGN DIMENSIONS

- Platform length: Identify transit services to be accommodated in order to determine the platform length needed
- Include space for additional amenities
- Ensure to allow at least a six-foot-wide active sidewalk to pass through the depot
- Bus Lanes: Bus lanes operate best for passenger boarding and layovers in lanes that are 11 feet wide. An adjacent lane ensures that a stopped bus can easily be passed by another bus.

OTHER DESIGN FEATURES TO CONSIDER

- Nearby businesses
- Whether modes other than transit will use the space
- Parking demand
- Bike parking: in addition to short-term use outdoor racks, depots may provide long-term secure bike parking and/or covered bike parking

Transit Signal Priority (TSP)

Transit Signal Priority (TSP) is a general term for the technology that can be utilized at signalized intersections on a corridor or intersection level to prioritize traffic flow for transit. Implementation of TSP varies greatly, but the goal is to reduce dwell time at traffic signals for transit vehicles. This can be done by holding green lights longer or shortening red lights.

Although TSP does not need any physical space in public right-of-way outside of the signal infrastructure, it is beneficial to include the application of TSP in roadway design criteria. Urban corridors identified for improved transit service could be good candidates for TSP at signalized intersections.



DESIGN CONSIDERATIONS

- Volume of intersection compared to volume of transit passengers
- Presence of BRT or other enhanced transit service
- Right-turn movements
- Intersection spacing
- Intersection level-of-service
- Corridor delay



Park-and-Ride Facilities

Park-and-rides can be surface parking lots or multi-story parking ramps that are constructed to store the vehicles of transit passengers. Park-and-ride lots or ramps typically have transit service directly connected to the facility, enabling transit passengers to drive their personal vehicles to the park-and-ride, leave their car, and take transit for the next leg of their trip. Transit service at park-and-rides is most effective as a commuter fixed route bus service that takes passengers through congestion or to destinations where parking is significantly more expensive. Park-and-ride facilities operate best when they are uniquely designed according to the transit routing and the anticipated future demand of the transit service.



DESIGN DIMENSIONS

A typical parking stall is 10 feet wide by 20 feet long. To anticipate number of parking stalls needed, and thus the space required for the park-and-ride, the following piece of information is required:

- Peak daily ridership (current and future)
- Vehicle occupancy
- Percent access from bicycling and walking

DESIGN CONSIDERATIONS

- Access routes for non-automobile passengers
- Bike parking, including short-term use outdoor racks, covered bike parking, and long-term secure bike parking
- Real-time occupancy information

Winter Maintenance

Design Considerations

Designing and building facilities with winter and seasonal maintenance in mind provides high-quality, comfortable facilities for people walking, biking, and taking transit year-round.

BICYCLE AND PEDESTRIAN FACILITIES

Separated facilities like sidewalks, protected bike lanes, and trails require separate equipment to maintain, but are ultimately easier to maintain to a high standard.

Providing adequate buffer space for these facilities is key to year-round use as it provides space to store snow. Facilities placed back of curb or directly on the roadway are difficult to maintain and can become narrow or impassable in winter.

The table below shows example facility dimensions to allow for snow clearance. Preferred widths allow for plowed snow to fit within boulevard space. This maintains facility width after snow clearance.

Sidewalk	One-Way Protected Bike Lane	Sidepath/Two-Way Protected Bike Lane
		
<p>Preferred Sidewalk Width:</p> <p>Six to 12 feet in commercial areas. Four to eight feet along arterials and collectors. Six feet enables two pedestrians (including wheelchair users) to walk side-by-side or to pass each other comfortably.</p> <p>Preferred Buffer Width:</p> <p>Five feet or greater preferred. Three feet minimum recommended. Two feet allowable in constrained conditions.</p> <p>Equipment:</p> <p>ATV plow, ATV sweeper, snow blower</p>	<p>Preferred Bike Lane Width:</p> <p>Six feet (allows for bike lane narrowing due to snow events). Five feet may be used in constrained conditions.</p> <p>Preferred Buffer Width:</p> <p>Five feet or greater preferred. Three feet minimum recommended. Two feet allowable in constrained conditions.</p> <p>Equipment:</p> <p>ATV plow, ATV sweeper, pick-up mounted plow (if space allows within sidewalk grade bike lanes)</p>	<p>Preferred Pathway Width:</p> <p>Ten feet to 12 feet is preferred. Eight feet may be used in constrained conditions.</p> <p>Preferred Buffer Width:</p> <p>Five feet or greater preferred. Three feet minimum recommended. Two feet allowable in constrained conditions.</p> <p>Equipment:</p> <p>Pick-up mounted plow</p>



Design Considerations (cont.)



THERMOPLASTIC MARKINGS

Milling the area of pavement 3mm in depth where thermoplastic pavement markings are applied has shown to be effective in reducing damage as a result of snowplows in a recent study. While this method results in more expensive installation costs, if the bike lane is located on a street that receives heavy plowing, it may save in long-term maintenance costs (and help preserve safety conditions along the roadway).



TRANSIT STOPS

A stop, platform, or station benefits from a small area dedicated to emergency snow storage. Heavy snowfalls may not be adequately cleared immediately, but the transit facility shall be made fully operational soon after the weather event (28 CFR §35.133). Additionally, spacing amenities apart from each other on platforms and stations allows for a rotary power brush to clear snow between them.

Snow Removal Vehicles

Small snow removal vehicles are available from a number of different manufactures. Many small utility vehicles such as tractors, ATVs, bombardiers, and “skid steers” can be equipped with snow removal devices. Typically small vehicles are either equipped with snow plows, snow brushes (effective for removing light snow), or snow blowers (effective for relocating heavy snow). Many small snow removal vehicles can also be equipped with anti-icing applicators.

Lighter snow is best cleared by a rotary power brush. This may be attached to a small maintenance vehicle or a walk-behind model, whichever fits the space, budget, and maintenance agreements best. Rotary power brushes are superior to plows, because they do not cause as much damage to the sidewalk surfaces or detectable warning strips. They also help prevent snow from packing and freezing into solid ice.





Snow Removal Best Practices

Anti-icing pre-treatment, timely plowing, and clear communication between agencies and with the public are important to efficient and effective snow removal.



ANTI-ICING TREATMENTS

Apply anti-icing treatment to trails or separated bike lanes up to twenty-four hours before snow or freezing rain events to reduce the amount of snow clearing required during or after a snow event. Following the snow, the facility shall be cleared and additional anti-icing material should be added as necessary (28 CFR §35.133). This approach saves anti-icing material and time spent plowing.

The following are types of anti-icing materials used on roadways, trails, and bike lanes:

- Pre-wetted salt: Pre-wetted salt is roadway salt that is sprayed down with a brine solution either upon application or in storage prior to being loaded in trucks. Compared to dry salt, pre-wetting facilitates the dissolution of the salt, allowing for quicker reaction times, less material used, and improved application accuracy (dry salt tends to bounce off the travel path).
- Beet juice: Some roadway maintenance departments combine a beet juice solution with roadway salt and/or salt brine. Beet juice is an inexpensive additive to an anti-icing solution that improves the adherence of salt and sand to the roadway and also lowers the freezing temperature of the ice. The advantages of beet juice are that it is inexpensive, it adheres well to the roadway, and it is much more environmentally friendly than using plain road salt. A combination of beet juice and roadway salt and/or brine can reduce the number of anti-icing applications required and save costs.
- Calcium magnesium acetate: CMA is a low-corrosion, more environmentally friendly alternative to using salt on roadways and bike lanes. CMA is effective to the same temperatures as roadway salt. It is used in solid form or liquid form. CMA requires fewer applications than roadway salt.

Snow Removal Best Practices (cont.)

SNOW REMOVAL TIMING

Plow and/or treat walking and biking facilities within twenty-four hours of the end of a snowfall.

- Remove snow from walking and biking facilities after the adjacent street is plowed.
- Ensure that snow is removed from curb ramps and crosswalks after bike lanes are plowed. A maintenance worker will likely need to shovel these locations after the bike lane is cleared to reduce the likelihood of snow accumulating on curb ramps and crosswalks.

WINTER NETWORK PRIORITIZATION

Prioritization and scheduling is a key component of a successful winter network. For most jurisdictions, keeping all walking and biking facilities completely clear during or immediately after a heavy snow event is infeasible. It is best to clear primary facilities first, to provide the best access to the greatest number of people following a heavy storm event. Take destinations into account as well. If roadway clearing and anti-icing begin first thing in the morning, clear primary routes leading to schools and business districts first.

Also prioritize paths that are less heavily used but are the only means of making a key connection.

Isolated trails that serve recreational users may be reserved for use by cross country skiers and snowmobile and fatbike users.

ORDINANCES AND COMMUNICATION

It is important for state and local agencies to understand their maintenance responsibilities. Specify the standards for the maintenance of state roads by local authorities in a maintenance agreement.

To improve communication with the public around winter maintenance, agencies can:

- Create a service code for residents to report maintenance needs. Train staff to respond to service requests regarding walking and biking facilities. Afterwards, publicize residents' ability to request walking and biking facility maintenance.
- Communicate winter weather information through email, opt-in calls and text messages, mailers, and social media campaigns. Work with other departments to cross-promote winter-related messaging.
- Regularly meet with transportation advocates and members of the public to discuss winter maintenance practices and areas for improvements.
- Work with advocates, private-sector firms, and members of the public to create a crowd-sourced, interactive map to monitor snow clearance quality along walking and biking facilities.

Transit Agencies

Transit agencies may create maintenance agreements with municipalities regarding winter maintenance. Often a bus stop can be cleared at the same time as a sidewalk. However, platforms and stations may require additional clearing and equipment outside the scope of sidewalk cleaning alone.

Because platforms and stations typically have improved levels of transit service, upgraded winter maintenance is beneficial. The transit agency would then need to ensure the municipality has enough operational rotary power brushes and an available maintenance workforce schedule to keep the stations clean. If an agreement cannot be made, the transit agency would be responsible to keep the stations, platforms, and bus stops free of snow and ice.