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Augusta Regional Transportation Study

Appendix E: Bicycle and Pedestrian Facility Design Guidelines

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Introduction

This technical handbook is intended to assist the Augusta Regional Transportation Study in the selection and design of pedestrian and bicycle facilities. The following chapters pull together best practices by facility type from public agencies and municipalities nationwide. Within the design chapters, treatments are covered within a single sheet tabular format relaying important design information and discussion, example photos, schematics (if applicable), and existing summary guidance from current or upcoming draft standards. Existing standards are referenced throughout and should be the first source of information when seeking to implement any of the treatments featured here.

Guiding Principles

The following are guiding principles for these bicycle and pedestrian design guidelines:

- **The walking and bicycling environment should be safe.** All bicycling and walking routes should be physically safe and perceived as safe by all users. Safe means minimal conflicts with external factors, such as noise, vehicular traffic and protruding architectural elements. Safe also means routes are clear and well marked with appropriate pavement markings and directional signage.

- **The pedestrian and bicycle network should be accessible.** Sidewalks, Shared-use paths, bike routes and crosswalks should permit the mobility of residents of all ages and abilities. The pedestrian and bicycle network should employ principles of universal design. Bicyclists have a range of skill levels, and facilities should be designed with a goal of providing for inexperienced/recreational bicyclists (especially children and seniors) to the greatest extent possible.

- **Pedestrian and bicycle network improvements should be economical.** Bicycle improvements should achieve the maximum benefit for their cost, including initial cost and maintenance cost, as well as a reduced reliance on more expensive modes of transportation. Where possible, improvements in the right-of-way should stimulate, reinforce and connect with adjacent private improvements.

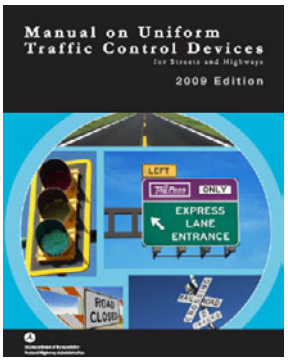
- **The pedestrian and bicycle network should connect to places people want to go.** The pedestrian and bicycle network should provide continuous direct routes and convenient connections between destinations such as homes, schools, shopping areas, public services, recreational opportunities and transit. A complete network of on-street bicycling facilities should connect seamlessly to existing and proposed multi-use trails to complete recreational and commuting routes.

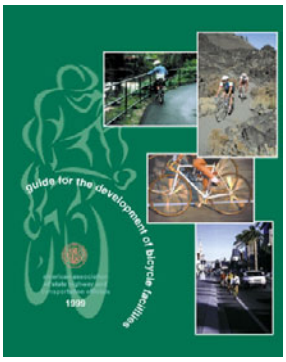
- **The walking and bicycling environment should be clear and easy to use. Sidewalks** Shared-use paths and crossings should allow all people to easily find a direct route to a destination with minimal delays, regardless of whether these persons have mobility, sensory, or cognitive disability impairments. All roads are legal for the use of bicyclists (except those roads designated as limited access facilities, which prohibit bicyclists). This means that most streets are bicycle facilities and should be designed, marked and maintained accordingly.

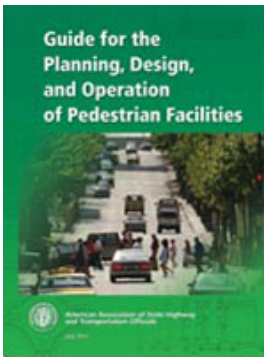
- **The walking and bicycling environment should be attractive enhance community livability.** Good design should integrate with and support the development of complementary uses and should encourage preservation and construction of art, landscaping and other items that add value to communities. These components might include open spaces such as plazas, courtyards and squares, and amenities like street furniture, banners, art, plantings and special paving. These along with historical elements and cultural references, should promote a sense of place. Public activities should be encouraged and the municipal code should permit commercial activities such as dining, vending and advertising when they do not interfere with safety and accessibility.

- **Design guidelines are flexible and should be applied using professional judgment.** This document references specific national guidelines for bicycle and pedestrian facility design, as well as a number of design treatments not specifically covered under current guidelines. Statutory and regulatory guidance may change. For this reason, the guidance and recommendations in this document function to complement other resources considered during a design process, and in all cases sound engineering judgment should be used.

National Standards







The Federal Highway Administration's **Manual of Uniform Traffic Control Devices** (MUTCD) defines the standards used by road managers nationwide to install and maintain traffic control devices on all public streets, highways, bikeways, and private roads open to public traffic. The MUTCD is the primary source for guidance on lane striping requirements, signal warrants, and recommended signage and pavement markings.

To further clarify the MUTCD, the FHWA created a table of contemporary bicycle facilities that lists various bicycle-related signs, markings, signals, and other treatments and identifies their official status (e.g., can be implemented, currently experimental). See **Bicycle Facilities and the Manual on Uniform Traffic Control Devices.**[1]

Bikeway treatments not explicitly covered by the MUTCD are often subject to experiments, interpretations and official rulings by the FHWA. The **MUTCD Official Rulings** is a resource that allows website visitors to obtain information these supplementary materials. Copies of various documents (such as incoming request letters, response letters from the FHWA, progress reports, and final reports) are available on this website.[2]

American Association of State Highway and Transportation Officials (AASHTO) **Guide for the Development of Bicycle Facilities** last updated in 1999 provides detailed guidance on dimensions, use, and layout of specific facilities.

The standards and guidelines presented by AASHTO provide basic information about the design of bicycle and pedestrian facilities, such as minimum sidewalk widths, bicycle lane dimensions, more detailed striping requirements and recommended signage and pavement markings. An update to this guide is in progress, and is likely to provide revised guidance on standard facilities and new information on more contemporary bikeway designs.

Offering similar guidance for pedestrian design, the 2004 AASHTO **Guide for the Planning, Design and Operation of Pedestrian Facilities** provides comprehensive guidance on planning and designing for people on foot.

The National Association of City Transportation Officials' (NACTO) 2011 **Urban Bikeway Design Guide**[3] is the newest publication of nationally recognized bikeway design standards, and offers guidance on the current state of the practice designs. The NACTO Urban Bikeway Design Guide is based on current practices in the best cycling cities in the world. The intent of the guide is to offer substantive guidance for cities seeking to improve bicycle transportation in places where competing demands for the use of the right of way present unique challenges. All of the NACTO Urban Bikeway Design Guide treatments are in use internationally and in many cities around the US.

Some of these treatments are not directly referenced in the current versions of the AASHTO Guide to Bikeway Facilities or the Manual on Uniform Traffic Control Devices (MUTCD), although many of the elements of these treatments are found within these documents. In all cases, engineering judgment is recommended to ensure that the application makes sense for the context of each treatment, given the many complexities of urban streets.

1 *Bicycle Facilities and the Manual on Uniform Traffic Control Devices. (2011). FHWA. http://www.fhwa.dot.gov/environment/bikeped/mutcd_bike.htm*

2 *MUTCD Official Rulings. FHWA. http://mutcd.fhwa.dot.gov/orsearch.asp*

3 *http://nacto.org/cities-for-cycling/design-guide/*

Local Standards

The South Carolina Department of Transportation (SCDOT) offers additional local guidance regarding the design of non-motorized transportation facilities. This guidance can be found in SCDOT Engineering Directive Memorandums (EDM) covering specific topics. The EDMs most relevant to the content in this guide are listed below and attached to this document:

SCDOT EDM 22: Considerations for Bicycle Facilities and **SCDOT EDM 53: Installation of Rumble Strips** provide guidance on the design of shared roadways and the application of rumble strips on SCDOT's state highway system. In addition, typical sections for both the design of bicycle facilities on new projects and restriping of existing five-lane sections to accommodate bicycle facilities are included. Other design considerations for bicycle accommodations are also discussed.

The Georgia Department of Transportation (GDOT) also offers guidance on the design of non-motorized transportation facilties.

Georgia Department of Transportation's Design Policy Manual is the primary source for highway design standards to be used in roadway construction plans for Federal-Aid projects and State-Aid projects. Chapter 9 focuses on the specifics of bicycle and pedestrian accommodations.

Additional References

In addition to the previously described national standards, the basic bicycle and pedestrian design principals outlined in this chapter are derived from the documents listed below. Many of these documents are available online and provide a wealth of public information and resources.

Additional U.S. Federal Guidelines

- American Association of State Highway and Transportation Officials. (2001). *AASHTO Policy on Geometric Design of Streets and Highways*. Washington, DC. www.transportation.org
- United States Access Board. (2007). *Public Rights-of-Way Accessibility Guidelines (PROWAG)*. Washington, D.C. http://www.access-board.gov/PROWAC/alterations/guide.htm

Best Practice Documents

- Association of Pedestrian and Bicycle Professionals (APBP). (2010). *Bicycle Parking Design Guidelines, 2nd Edition.*
- City of Portland Bureau of Transportation. (2010). *Portland Bicycle Master Plan for 2030.* http://www.portlandonline.com/transportation/index.cfm?c=44597
- Federal Highway Administration. (2005). *BIKESAFE: Bicycle Countermeasure Selection System.* http://www.bicyclinginfo.org/bikesafe/index.cfm
- Federal Highway Administration. (2005). *PEDSAFE: Pedestrian Safety Guide and Countermeasure Selection System.* http://www.walkinginfo.org/pedsafe/
- Federal Highway Administration. (2005). *Report HRT-04-100, Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations.* http://www.tfhrc.gov/safety/pubs/04100/
- Federal Highway Administration. (2001). *Designing Sidewalks and Trails for Access.* http://www.fhwa.dot.gov/environment/sidewalk2/contents.htm
- Oregon Department of Transportation. (1995). *Oregon Bicycle and Pedestrian Plan.* http://www.oregon.gov/ODOT/HWY/BIKEPED/planproc.shtml
- Rosales, Jennifer. (2006). *Road Diet Handbook: Setting Trends for Livable Streets.*

Glossary

The following list is comprised of common terms, acronyms and concepts used in bicycle transportation planning, design and operation.

AASHTO – American Association of State Highway and Transportation Officials

Accessible route – in the ADA, a continuous route on private property that is accessible to persons with disabilities. There must be at least one accessible route linking the public sidewalk to each accessible building.

Actuated signal – a signal where the length of the phases for different traffic movements is adjusted for demand by a signal controller using information from detectors.

ADA – Americans with Disabilities Act of 1990; broad legislation mandating provision of access to employment, services, and the built environment to those with disabilities.

At-grade crossing – A junction where bicycle path or sidewalk users cross a roadway over the same surface as motor vehicle traffic, as opposed to a grade-separated crossing where users cross over or under the roadway using a bridge or tunnel.

Audible pedestrian signals – pedestrian signal indicators that provide an audible signal to assist visually impaired pedestrians in crossing the street.

BAFUL - Bicycles Allowed Full Use of Lane

Bicycle boulevard - See neighborhood greenway. Streets designed to give bicyclists priority by limiting or prohibiting motor vehicle through traffic by using barriers or other design elements, in order to enhance bicycle safety and enjoyment.

Bicycle facilities - A general term used to describe all types of bicycle-related infrastructure including linear bikeways and other provisions to accommodate or encourage bicycling, including bike racks and lockers, bikeways, and showers at employment destinations.

Bike lane - A striped lane for one-way bike travel on a street or highway.

Bicycle level of service (BLOS) – Indication of bicyclist comfort level for specific roadway geometries and traffic conditions. Roadways with a better (lower) score are more attractive (and usually safer) for bicyclists.

Bike path – A paved pathway separated from motorized vehicular traffic by an open space or barrier and either within the highway right-of-way or within an independent alignment. Bike paths may be used by pedestrians, bicyclists, skaters, wheelchair users, runners, and other non-motorized users.

Bike route - A shared roadway specifically identified for use by bicyclists, providing a superior route based on traffic volumes and speeds, street width, directness, and/or cross-street priority; designated by signs only.

Bikeway – A generic term for any road, street, path or way that in some manner is specifically designed for bicycle travel, regardless of whether such facilities are designated for the exclusive use of bicycles or are to be shared with other transportation modes.

Bollard – Post used to restrict motor vehicle use of bicycle paths.

Clearance interval – the length of time that the DON'T WALK indication is flashing on a pedestrian signal indication. **Clearance, lateral** – Width required for safe passage of bicycle path users as measured on a horizontal plane.

Clearance, vertical – Height required for safe passage of bicycle path users as measured on a vertical plane.

Crosswalk – any portion of a roadway at an intersection or elsewhere that is distinctly indicated for pedestrian crossing. Where there are no pavement markings, there is a crosswalk at each leg of every intersection, defined by law as the prolongation or connection of the lateral lines of the sidewalks.

Curb extension – an area where the sidewalk and curb are extended into the parking lane, usually in order to shorten pedestrian crossing distance. Also called "bulb-out" or "curb bulb."

Curb ramp – a combined ramp and landing to accomplish a change of level at a curb in order to provide access to pedestrians using wheelchairs.

Directional signs – Signs typically placed at road and bicycle path junctions (decision points) to guide bicycle path users toward a destination or experience.

Geometry - The vertical and horizontal characteristics of a transportation facility, typically defined in terms of gradient, degrees,

and super elevation.

Grade separation - Vertical separation of travelways through use of a bridge or tunnel so that traffic conflicts are minimized.

Grade-separated crossing – A bridge or tunnel allowing bicycle path users to cross a major roadway without conflict.

HCM - Highway Capacity Manual

HDM – Highway Design Manual

Level of service (LOS) - Term for the measurement of how well traffic "flows" on a roadway system or how well an intersection functions.

Loop detector - A device placed under the pavement at intersections to detect a vehicle or bicycle and subsequently trigger a signal to turn green.

Medians – Area in the center of the roadway that separates directional traffic; may provide a striped crossing and halfway point for pedestrians (also can be effective traffic calming design). Medians may be level with the surrounding roadway or "raised" using curb and gutter. Medians may include landscaping, concrete, paint/striping or any combination thereof.

Multi-use path – A trail that permits more than one type of user, such as a trail designated for use by both pedestrians and bicyclists.

MUTCD – Federal Manual of Uniform Traffic Control Devices

Neighborhood Greenways – Streets designed to give bicyclists priority by limiting or prohibiting motor vehicle through traffic by using barriers or other design elements, in order to enhance bicycle safety and enjoyment. See bicycle boulevard.

Paved shoulder – The edge of the roadway beyond the outer stripe edge that provides a place for bicyclists; functions as this only when it is wide enough (4-5 feet), free of debris, and does not contain rumble strips or other obstructions.

Pavement marking – An assortment of markings on the surface of the pavement that provide directions to motorists and other road users as to the proper use of the road (the "Manual on Uniform Traffic Control Devices" determines these standard markings).

Pedestrian – a person afoot; a person operating a pushcart; a person riding on, or pulling a coaster wagon, sled, scooter, tricycle, bicycle with wheels less than 14 inches in diameter, or a similar conveyance, or on roller skates, skateboard, wheel-chair or a baby in a carriage.

Pedestrian signal indication – the lighted WALK/DON'T WALK (or walking man/hand) signal that indicates the pedestrian phase.

Refuge islands – Corner raised triangles or medians, used by pedestrians and bicyclists at intersections or mid-block crossings for assistance with crossing wide streets, especially where motor vehicle right turn lanes exist.

Right-of-way (ROW) - The right of one vehicle, bicycle or pedestrian to proceed in a lawful manner in preference to another vehicle, bicycle, or pedestrian. Also the strip of property in which a transportation facility or other facility is built.

Shared lane marking (SLM) or **Sharrow** – Shared Lane Pavement Marking

Shared roadway - A roadway where bicyclists and motor vehicles share the same space with no striped bike lane. Any roadway where bicycles are not prohibited by law (i.e. interstate highways or freeways) is a shared roadway.

Sidewalk – an improved facility intended to provide for pedestrian movement; usually, but not always, located in the public right-of-way adjacent to a roadway. Typically constructed of concrete.

Sight distance - The distance a person can see along an unobstructed line of sight.

Traffic calming - Changes in street alignment, installation of barrier, and other physical measures to reduce traffic speeds and/or cut-through traffic volume in the interest of street safety, livability, and other public purposes.

Traffic control devices - Signs, signals or other fixtures, whether permanent or temporary, placed on or adjacent to a travelway by authority of a public body having jurisdiction to regulate, warn, or guide traffic.

Traffic volume - The number of vehicles that pass a specific point in a specific amount of time (hour, day, year).

Wide curb lane – A 14 foot (or greater) wide outside lane adjacent to the curb of a roadway that provides space for bicyclists to ride next to (to the right of) motor vehicles. Also referred to as a "wide outside lane". If adjacent to parking, 22 foot wide pavement may also be considered a wide curb lane.

Design Needs of Bicyclists

The purpose of this section is to provide the facility designer with an 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. Bicyclists lack the protection from the elements and roadway hazards provided by an automobile's structure and safety features. By understanding the unique characteristics and needs of bicyclists, a facility designer can provide the highest quality facilities and minimize risk to their users.

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.

Figure 2-1 illustrates the operating space and physical dimensions of a typical adult bicyclist, which are the basis for typical facility design. The bicyclist requires 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, although four feet is minimally acceptable.

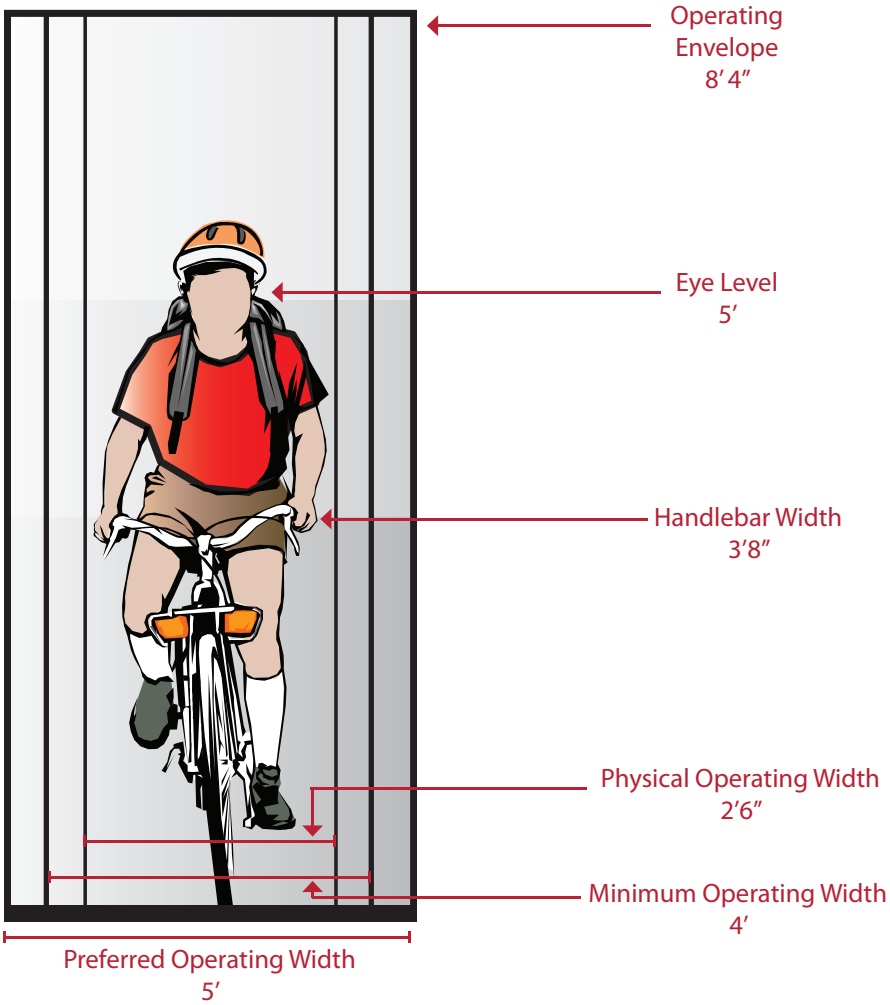


Figure 2-1 Standard Bicycle Rider Dimensions

Source: AASHTO Guide for the Development of Bicycle Facilities, 3rd Edition

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. Figure 2-2 and Table 2-1 summarize the typical dimensions for bicycle types.

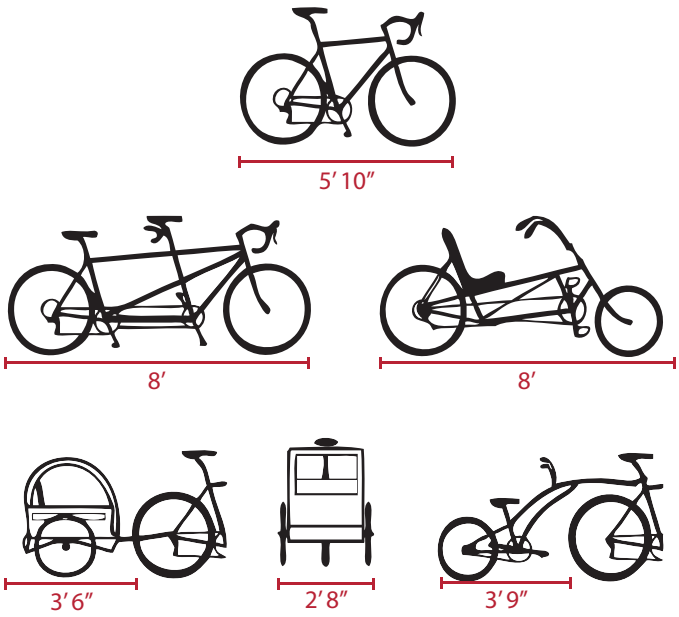


Figure 2-2 Bicycle as Design Vehicle - Typical Dimensions

Source: AASHTO Guide for the Development of Bicycle Facilities, 3rd Edition *AASHTO does not provide typical dimensions for tricycles.

Table 2-1 Bicycle as Design Vehicle - Typical Dimensions

Bicycle Type	Feature	Typical Dimensions
Upright Adult Bicyclist	Physical width	2 ft 6 in
	Operating width (Minimum)	4 ft
	Operating width (Preferred)	5 ft
	Physical length	5 ft 10 in
	Physical height of handlebars	3 ft 8 in
	Operating height	8 ft 4 in
	Eye height	5 ft
	Vertical clearance to obstructions (tunnel height, lighting, etc)	10 ft
	Approximate center of gravity	2 ft 9 in - 3 ft 4 in
Recumbent Bicyclist	Physical length	8 ft
	Eye height	3 ft 10 in
Tandem Bicyclist	Physical length	8 ft
Bicyclist with child trailer	Physical length	10 ft
	Physical width	2 ft 6 in

Design Speed Expectations

The expected speed that different types of bicyclists can maintain under various conditions also influences the design of facilities such as shared use paths. Table 2-2 provides typical bicyclist speeds for a variety of conditions.

The skill level of the bicyclist also provides dramatic variance in expected speeds and behavior. There are several systems of classification currently used within the bicycle planning and engineering professions. These classifications can be helpful in understanding the characteristics and infrastructure preferences of different bicyclists.

It should be noted that these classifications may change in type or proportion over time as infrastructure and culture evolve. Often times an instructional course can change a less confident bicyclist into one that can comfortably and safely share the roadway with vehicular traffic. Bicycle infrastructure should be planned and designed to accommodate as many user types as possible with the consideration of separate or parallel facilities to provide a comfortable experience for the greatest number of bicyclists.

Table 2-2 Bicycle as Design Vehicle - Design Speed Expectations

Bicycle Type	Feature	Typical Speed
Upright Adult Bicyclist	Paved level surfacing	15 mph
	Crossing Intersections	10 mph
	Downhill	30 mph
	Uphill	5 -12 mph
Recumbent Bicyclist	Paved level surfacing	18 mph

*Tandem bicycles and bicyclists with trailers have typical speeds equal to or less than upright adult bicyclists.

Types of Bicyclists

It is important to consider bicyclists of all skill levels when creating a non-motorized plan or project. Bicyclist skill level greatly influences expected speeds and behavior, both in separated bikeways and on shared roadways. Bicycle infrastructure should accommodate as many user types as possible, with decisions for separate or parallel facilities based on providing a comfortable experience for the greatest number of bicyclists.

The bicycle planning and engineering professions currently use several systems to classify the population, which can assist in understanding the characteristics and infrastructure preferences of different bicyclists. The most conventional framework classifies the "design cyclist" as *Advanced*, *Basic*, or *Child*[1]. A more detailed understanding of the US population as a whole is illustrated in Figure 2-3. Developed by planners in the City of Portland, OR[2] and supported by data collected nationally since 2005, this classification provides the following alternative categories to address 'varying attitudes' towards bicycling in the US:

- **Strong and Fearless** (Very low percentage of population) – Characterized by bicyclists that will typically ride anywhere regardless of roadway conditions or weather. These bicyclists can ride faster than other user types, prefer direct routes and will typically choose roadway connections -- even if shared with vehicles -- over separate bicycle facilities such as greenways.

- **Enthused and Confident** (5-10% of population) -This user group encompasses 'intermediate' bicyclists who are fairly comfortable riding on all types of bicycle facilities but usually choose low traffic streets or greenways when available. These bicyclists may deviate from a more direct route in favor of a preferred facility type. This group includes all kinds of bicyclists such as commuters, recreationalists, racers and utilitarian bicyclists.

- **Interested but Concerned** (approximately 60% of population) – This user type comprises the bulk of the cycling population and represents bicyclists who typically only ride a bicycle on low traffic streets or greenways under favorable weather conditions. These bicyclists perceive significant barriers to their increased use of cycling, specifically traffic and other safety issues. These bicyclists may become "Enthused & Confident" with encouragement, education and experience.

- **No Way, No How** (approximately 30% of population) – Persons in this category are not bicyclists, and perceive severe safety issues with riding in traffic. Some people in this group may eventually become more regular cyclists with time and education. A significant portion of these people will not ride a bicycle under any circumstances.

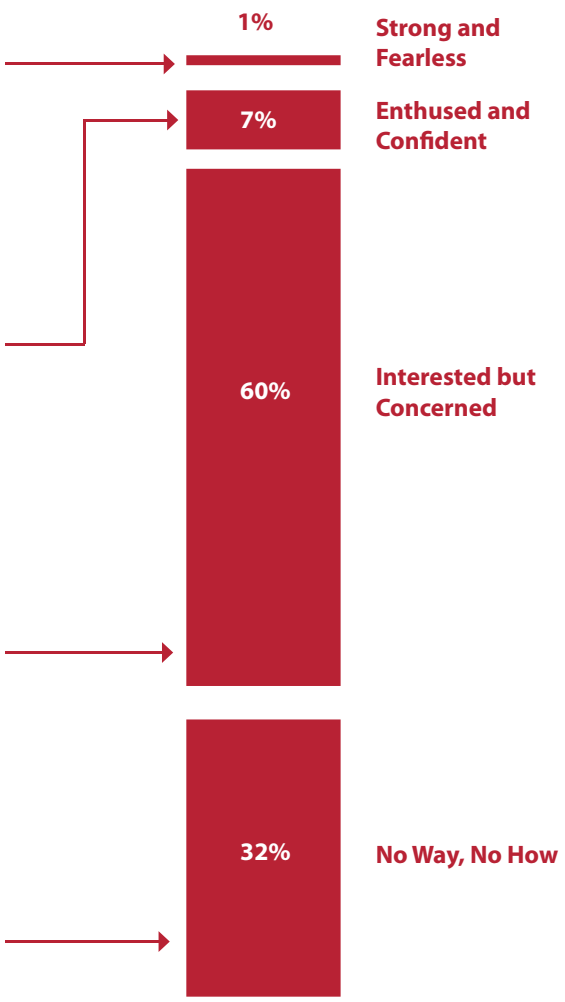


Figure 2-3 Typical distribution of bicyclist types

1 *Selecting Roadway Design Treatments to Accommodate Bicycles. (1994). Publication No. FHWA-RD-92-073*

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

Planned Bikeway Facilities

These design guidlines describe a wide range of bicycle facilties, including some that are not specifically called for in the Augusta Regional Transportation Study. The facilities listed below are included in the Study and are the foundation of the bicycle network. Follow the references below for full guidance on each treatment.

Bike routes without any specific bicycle facilities are **shared roadways** (page 31) where bicyclists and cars operate within the same travel lane, either side by side or in single file depending on roadway configuration. This facility provides continuity with other bicycle facilities (usually bike lanes), or designates preferred routes through high-demand corridors.

Shared lane markings may be used to enhance bike routes by providing clear direction to motorists and bicylists about riding postition and route.

Paved shoulders, **striped bike lanes** and **buffered bike lanes** are all types of **separated bikeways** (page 43). Separated Bikeways use signage and striping to delineate the right-of-way assigned to bicyclists and motorists. Bike lanes encourage predictable movements by both bicyclists and motorists.

Greenways (page 79) are facilities separated from roadways for use by bicyclists and pedestrians. These corridors offer excellent transportation and recreation opportunities for bicyclists of all ages and skills. Greenways are frequently located in railroad or utility corridors.

Multi-use paths along roadways (page 86) offer separation from parallel motor vehicle traffic. These facilties are most appropriate along roads with infrequent intersections or driveways.

Design Needs of Pedestrians

Types of Pedestrians

Similar to bicyclists, pedestrians have a variety of characteristics and the transportation 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 walk. 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. Table 3-1 summarizes common pedestrian characteristics for various age groups.

The MUTCD recommends a normal walking speed of three and a half feet per second when calculating the pedestrian clearance interval at traffic signals. The walking speed can drop to three 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.

Table 3-1 Pedestrian Characteristics by Age

Age	Characteristics
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 "dart out" intersection dash
	Poor judgment
	Sense of invulnerability
14-18	Improved awareness of traffic environment
	Poor judgment
19-40	Active, fully aware of traffic environment
41-65	Slowing of reflexes
65+	Difficulty crossing street
	Vision loss
	Difficulty hearing vehicles approaching from behind

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

Table 3 2 summarizes common physical and cognitive impairments, how they affect personal mobility, and recommendations for improved pedestrian-friendly design.

Table 3-2 Disabled Pedestrian Design Considerations

Impairment	Effect on Mobility	Design Solution
Wheelchair and Scooter Users	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 to less than two percent.
	Require wider path of travel.	Sufficient width and maneuvering space
Walking Aid Users	Difficulty negotiating steep grades and cross slopes; decreased stability.	Smooth, non-slipperly travel surface.
	Slower walking speed and reduced endurance; reduced ability to react.	Longer pedestrian signal cycles, shorter crossing distances, median refuges, and street furniture.
Hearing Impairment	Less able to detect oncoming hazards at locations with limited sight lines (e.g. driveways, angled intersections, right-turn slip lanes) and complex intersections.	Longer pedestrian signal cycles, clear sight distances, highly visible pedestrian signals and markings.
Vision Impairment	Limited perception of path ahead and obstacles	Accessible text (larger print and raised text), accessible pedestrian signals (APS), guide strips and detectable warning surfaces, safety barriers, and lighting.
	Reliance on memory	
	Reliance on non-visual indicators (e.g. sound and texture)	
Cognitive Impairment	Varies greatly. Can affect ability to perceive, recognize, understand, interpret, and respond to information.	Signs with pictures, universal symbols, and colors, rather than text.

Sidewalks

Sidewalks are the most fundamental element of the walking network, as they provide an area for pedestrian travel that is separated from vehicle traffic. Sidewalks are typically constructed out of concrete and are separated from the roadway by a curb or gutter and sometimes a landscaped planting strip area. Sidewalks are a common application in both urban and suburban environments.

Attributes of well-designed sidewalks include the following:

Accessibility: A network of sidewalks should be accessible to all users.

Adequate width: Two people should be able to walk side-by-side and pass a third comfortably. Different walking speeds should be possible. In areas of intense pedestrian use, sidewalks should accommodate the high volume of walkers.

Safety: Design features of the sidewalk should allow pedestrians to have a sense of security and predictability. Sidewalk users should not feel they are at risk due to the presence of adjacent traffic.

Continuity: Walking routes should be obvious and should not require pedestrians to travel out of their way unnecessarily.

Landscaping: Plantings and street trees should contribute to the overall psychological and visual comfort of sidewalk users, and be designed in a manner that contributes to the safety of people.

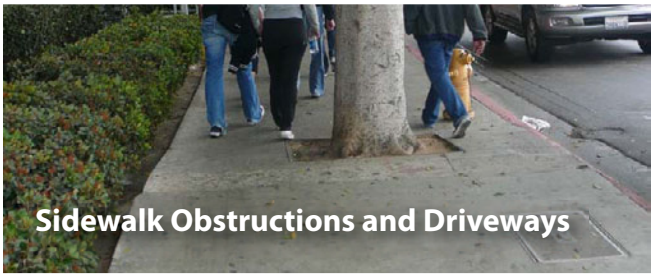
Drainage: Sidewalks should be well graded to minimize standing water.

Social space: There should be places for standing, visiting, and sitting. The sidewalk area should be a place where adults and children can safely participate in public life.

Quality of place: Sidewalks should contribute to the character of neighborhoods and business districts.

Zones in the Sidewalk Corridor

Sidewalk Widths


Sidewalk Obstructions and Driveways

Pedestrian Access in Construction Areas

This Section Includes:

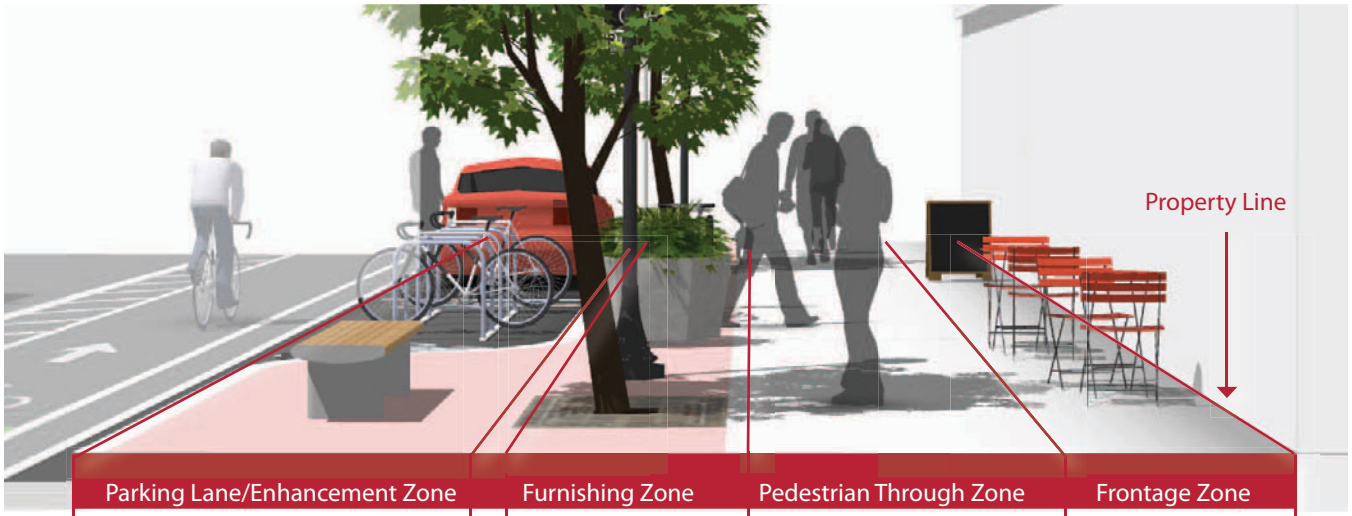
- Zones in the Sidewalk Corridor
- Sidewalk Widths
- Sidewalk Obstructions and Driveway Ramps
- Pedestrian Access in Construction Areas

Sidewalks

Zones in the Sidewalk Corridor

Description

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.



Parking Lane/Enhancement Zone

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.

In the edge zone there should be a 6 inch wide curb.

Edge Zone

Furnishing Zone

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.

Pedestrian Through Zone

The through zone is the area intended for pedestrian travel. This zone should be entirely free of permanent and temporary objects.

Wide through zones are needed in downtown areas or where pedestrian flows are high.

Frontage Zone

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.

Not applicable if adjacent to a landscaped space.

Discussion

Sidewalks should be more than areas to travel; they should provide places for people to interact. There should be places for standing, visiting, and sitting. Sidewalks should contribute to the character of neighborhoods and business districts, strengthen their identity, and be an area where adults and children can safely participate in public life.

Additional References and Guidelines

United States Access Board. (2002). Accessibility Guidelines for Buildings and Facilities.
United States Access Board. (2007). Public Rights-of-Way Accessibility Guidelines (PROWAG).
AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.

Materials and Maintenance

Sidewalks are typically constructed out of concrete and are separated from the roadway by a curb or gutter and sometimes a landscaped boulevard. Colored, patterned, or stamped concrete can add distinctive visual appeal.

Sidewalks

Sidewalk Widths

Description

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	Total
Local Streets	Varies	2 - 6 feet	5 - 6 feet	N/A	6.5 - 10 feet
Commercial Areas	Varies	4 - 6 feet	6 - 12 feet	2 - 10 feet	12 - 28 feet
Arterials and Collectors	Varies	2 - 6 feet	5 - 8 feet	2 - 5 feet	9 -19 feet

GDOT recommends a 6-ft wide buffer space between the back of curb and the sidewalk.

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

Discussion

It is important to provide adequate width along a sidewalk corridor. Two people should be able to walk side-by-side and pass a third comfortably. In areas of high demand sidewalks should contain adequate width to accommodate the high volumes and different walking speeds of pedestrians. The Americans with Disabilities Act requires a 4 foot clear width in the pedestrian zone plus 5 foot passing areas every 200 feet. GDOT recommends the minimum width of sidewalk be 5-ft of clear unobstructed space.

Additional References and Guidelines

United States Access Board. (2007). Public Rights-of-Way Accessibility Guidelines (PROWAG).
AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.
GDOT. (2011). Design Policy Manual. Ch. 9

Materials and Maintenance

Sidewalks are typically constructed out of concrete and are separated from the roadway by a curb or gutter and sometimes a landscaped boulevard. Surfaces must be firm, stable, and slip resistant. Colored, patterned, or stamped concrete can add distinctive visual appeal.

Sidewalks

Sidewalk Obstructions and Driveway Ramps

Guidance

Reducing the number of accesses reduces the need for special provisions. This strategy should be pursued first.

Obstructions should be placed between the sidewalk and the roadway to create a buffer for increased pedestrian comfort.

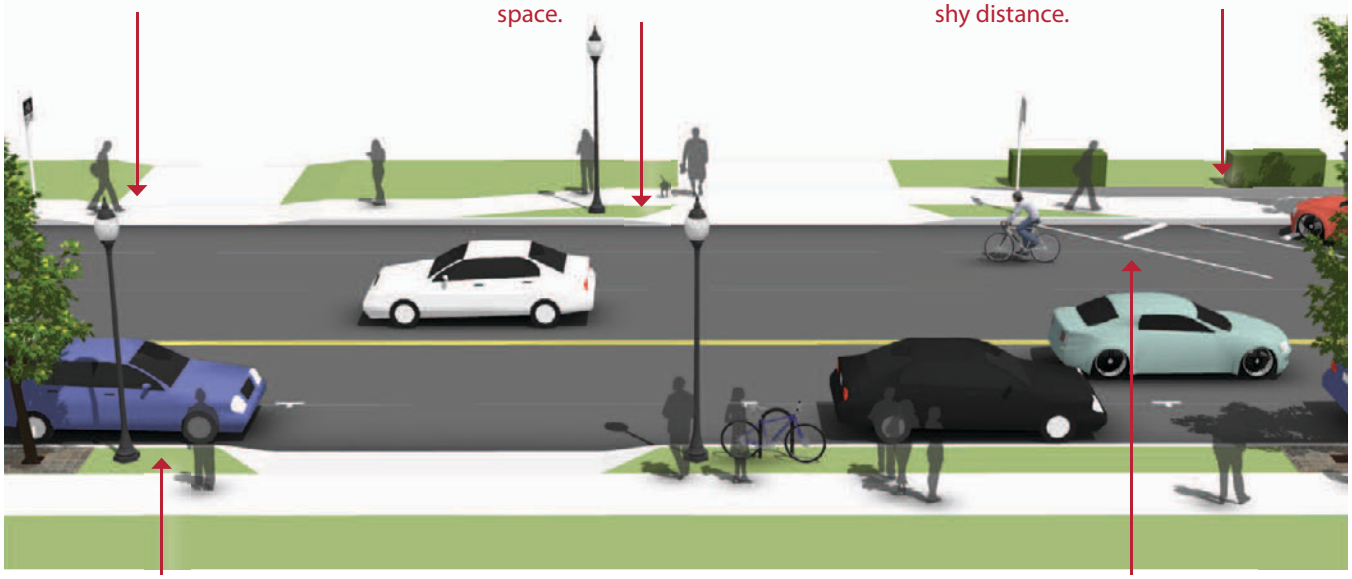
Description

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.

Dipping the entire sidewalk at the driveway approaches keeps the cross-slope at a constant grade. (The least preferred driveway option)

Where constraints preclude a planter strip, wrapping the sidewalk around the driveway provides adequate driveway ramp space.

When sidewalks abut hedges, fences, or buildings, an additional two feet of lateral clearance should be added 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, wheel stops should be used to prevent vehicles from overhanging in the sidewalk.

Discussion

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.

Additional References and Guidelines

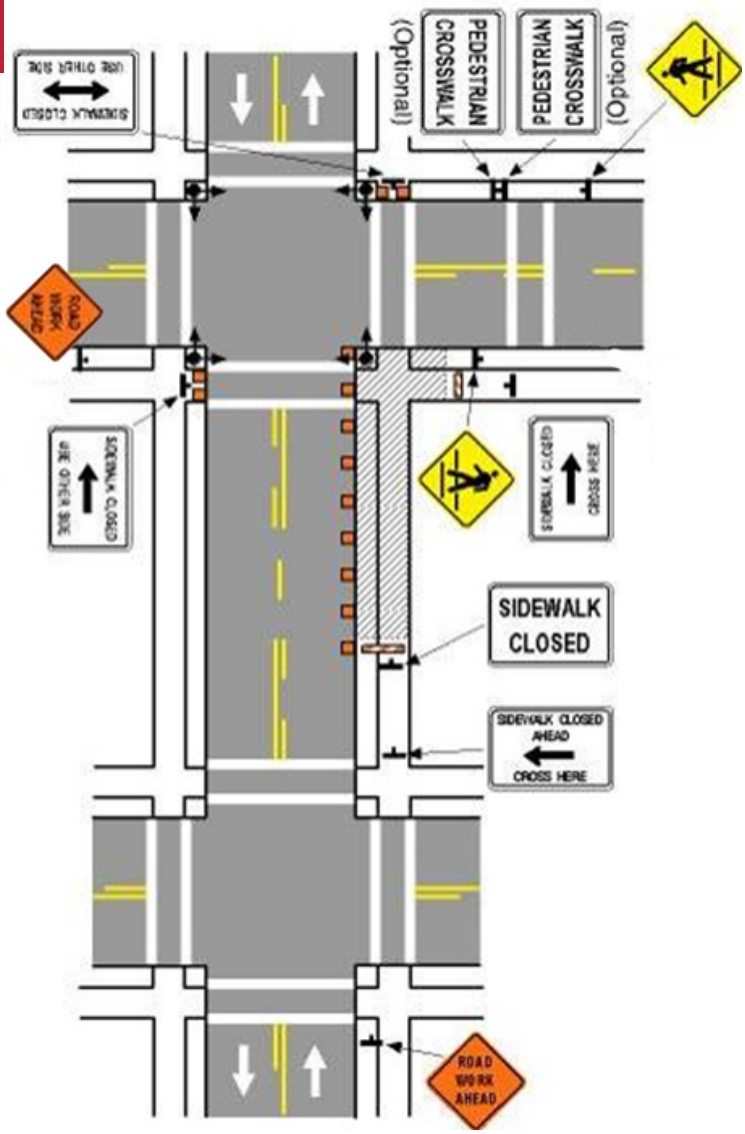
United States Access Board. (2002). Accessibility Guidelines for Buildings and Facilities.
United States Access Board. (2007). Public Rights-of-Way Accessibility Guidelines (PROWAG).
AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.

Materials and Maintenance

Sidewalks are typically constructed out of concrete and are separated from the roadway by a curb or gutter and sometimes a landscaped boulevard. Surfaces must be firm, stable, and slip resistant.

Construction and Repair Zones

Pedestrian Access Through Construction Areas



Description

Measures should be taken to provide for the continuity of a pedestrian's trip through a construction closure. Only in rare cases should pedestrians be detoured to another street when travel lanes remain open.

Guidance

- Pedestrians should be provided with a safe, accessible, convenient path that replicates as nearly as practical the most desirable characteristics of the existing sidewalks or a footpaths. The alternate circulation path shall be parallel the disrupted pedestrian access route, be located on the same side of the street, and accommodate the disabled.
- The alternate route should have a width of 5 feet minimum, and an additional foot of width for each vertical element along the route.
- In rare cases where access is not available on the same side of the street, the alternate pedestrian route may be located on the opposite side of the street as long as the distance of the disrupted pedestrian route does not exceed 300 feet.
- Signage related to construction activities shall be placed in a location that does not obstruct the path of bicycles or pedestrians, including bicycle lanes, wide curb lanes, or sidewalks.

Discussion

The removal of a pedestrian access route, curb ramp, or pedestrian street crossing, even for a short time, may severely limit or totally preclude pedestrians, especially those with a disability, from navigating in the public right-of-way. It might also preclude access to buildings, facilities, or sites on adjacent properties.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices.
AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.

Materials and Maintenance

The alternate route should include sidewalks and pedestrian access routes, curb ramps, pedestrian crossings, lighting, and all other elements included in these standards.

Pedestrians at Intersections

Attributes of pedestrian-friendly intersection design include:

Clear Space: Corners should be clear of obstructions. They should also have enough room for curb ramps, for transit stops where appropriate, and for street conversations where pedestrians might congregate.

Visibility: It is critical that pedestrians on the corner have a good view of vehicle travel lanes and that motorists in the travel lanes can easily see waiting pedestrians.

Legibility: Symbols, markings, and signs used at corners should clearly indicate what actions the pedestrian should take.

Accessibility: All corner features, such as curb ramps, landings, call buttons, signs, symbols, markings, and textures, should meet accessibility standards and follow universal design principles.

Separation from Traffic: Corner design and construction should be effective in discouraging turning vehicles from driving over the pedestrian area. Crossing distances should be minimized.

Lighting: Adequate lighting is an important aspect of visibility, legibility, and accessibility.

These attributes will vary with context but should be considered in all design processes. For example, suburban and rural intersections may have limited or no signing. However, legibility regarding appropriate pedestrian movements should still be taken into account during design.

See **Crossing Beacons and Signals** for a discussion of signalization in support of pedestrians.

This Section Includes:

- Marked Crosswalks
- Raised Crosswalks
- Reducing Crossing Distance
  - Median Refuge Islands
  - Curb Extensions
  - Minimizing Curb Radii
- Minimizing Conflict with Automobiles
  - Advance Stop Bars
  - Parking Control
- ADA Compliant Curb Ramps

Marked Crosswalks

Raised Crosswalks

Median Refuge Islands

Curb Extensions

Minimizing Conflict with Automobiles

ADA Compliant Curb Ramps

Marked Crosswalks

Guidance

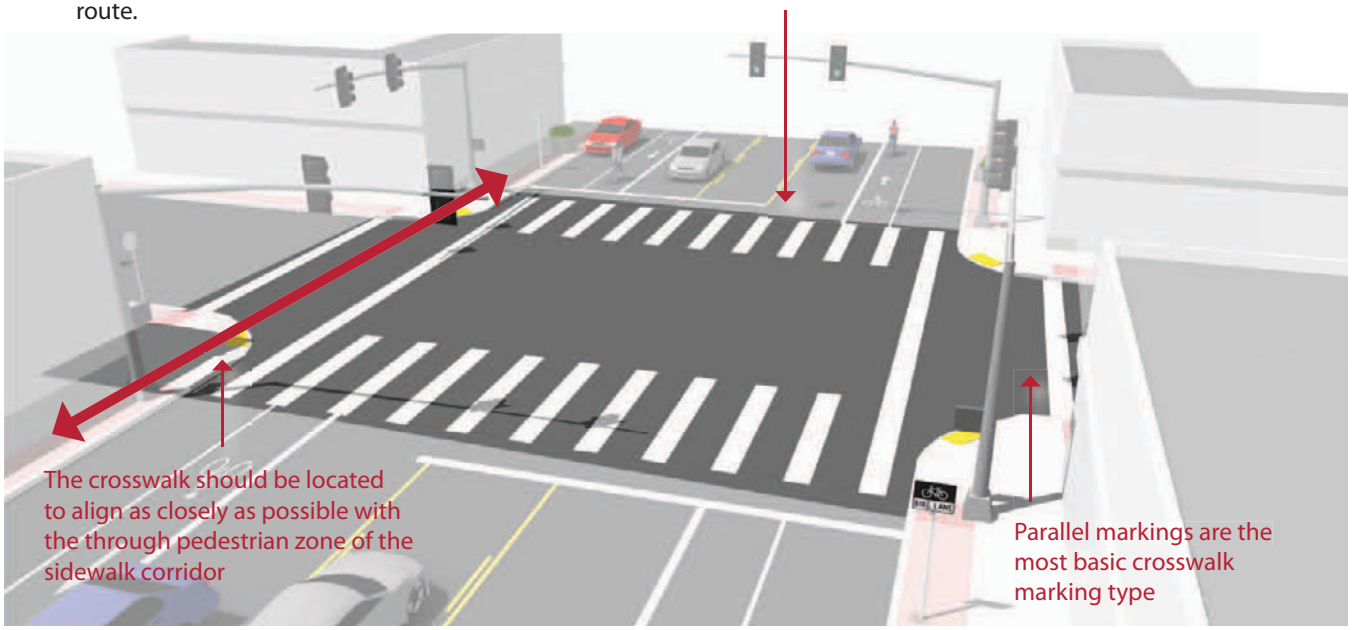
At signalized intersections, all crosswalks should be marked. At un-signalized intersections, crosswalks may be marked under the following conditions:

- 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.

Description

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.



Discussion

Continental crosswalk markings should be used at crossings with high pedestrian use or where vulnerable pedestrians are expected, including: School crossings, across arterial streets for pedestrian-only signals, at mid-block crosswalks, at intersections where there is expected high pedestrian use and the crossing is not controlled by signals or stop signs.

See **Crossing Beacons and Signals** for a discussion of enhancing pedestrian crossings.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices. (3B.18)
AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.
FHWA. (2005). Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations.
FHWA. (2010). Crosswalk Marking Field Visibility Study.

Materials and Maintenance

Because the effectiveness of marked crossings depends entirely on their visibility, maintaining marked crossings should be a high priority. Thermoplastic markings offer increased durability than conventional paint.

Marked Crosswalks

Raised Crosswalks

Guidance

- Use detectable warnings at the curb edges to alert vision-impaired pedestrians that they are entering the roadway.
- Approaches to the raised crosswalk may be designed to be similar to speed humps.
- Raised crosswalks can also be used as a traffic calming treatment.

Description

A raised crosswalk or intersection can eliminate grade changes from the pedestrian path and give pedestrians greater prominence as they cross the street. Raised crosswalks should be used only in very limited cases where a special emphasis on pedestrians is desired; review on case-by-case basis.

Discussion

Like a speed hump, raised crosswalks have a traffic slowing effect which may be unsuitable on emergency response routes.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices. (3B.18)
AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.
USDOJ. (2010). ADA Standards for Accessible Design.

Materials and Maintenance

Because the effectiveness of marked crossings depends entirely on their visibility, maintaining marked crossings should be a high priority.

Reducing Crossing Distance

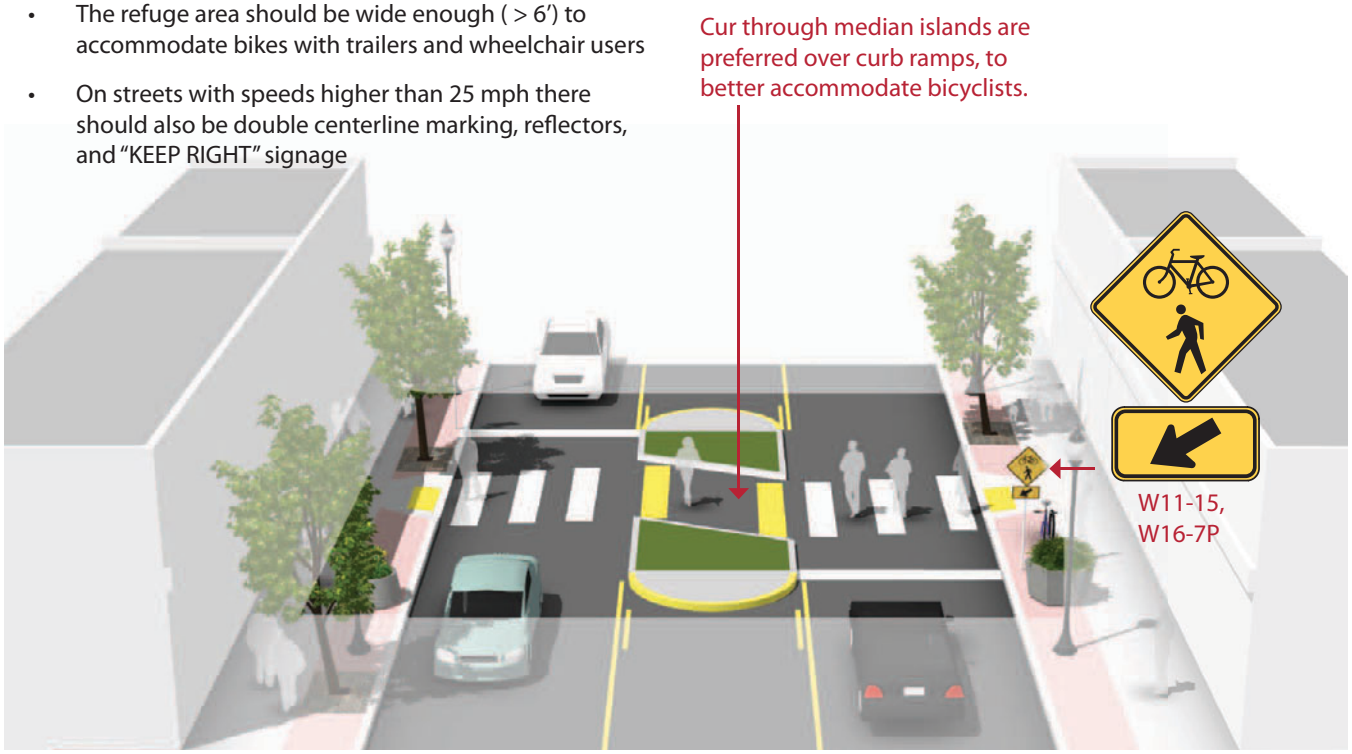
Median Refuge Islands

Guidance

- Can be applied on any roadway with more than two lanes of traffic.
- Appropriate at signalized or unsignalized crosswalks
- The refuge island must be accessible, preferably with an at-grade passage through the island rather than ramps and landings.
- The island should be at least 6' wide between travel lanes and at least 20' long
- The refuge area should be wide enough (> 6') to accommodate bikes with trailers and wheelchair users
- On streets with speeds higher than 25 mph there should also be double centerline marking, reflectors, and "KEEP RIGHT" signage

Description

Median refuge islands are located at the mid-point of a marked crossing and help improve pedestrian safety by allowing pedestrians to cross one direction of traffic at a time. Refuge islands minimize pedestrian exposure by shortening crossing distance and increasing the number of available gaps for crossing.



Discussion

If a refuge island is landscaped, the landscaping should not compromise the visibility of pedestrians crossing in the crosswalk. Shrubs and ground plantings should be no higher than 1 ft 6 in.

On multi-lane roadways, consider configuration with **active warning beacons** for improved yielding compliance.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices.
AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Refuge islands may collect road debris and may require somewhat frequent maintenance. Refuge islands should be visible to snow plow crews and should be kept free of snow berms that block access.

Reducing Crossing Distance

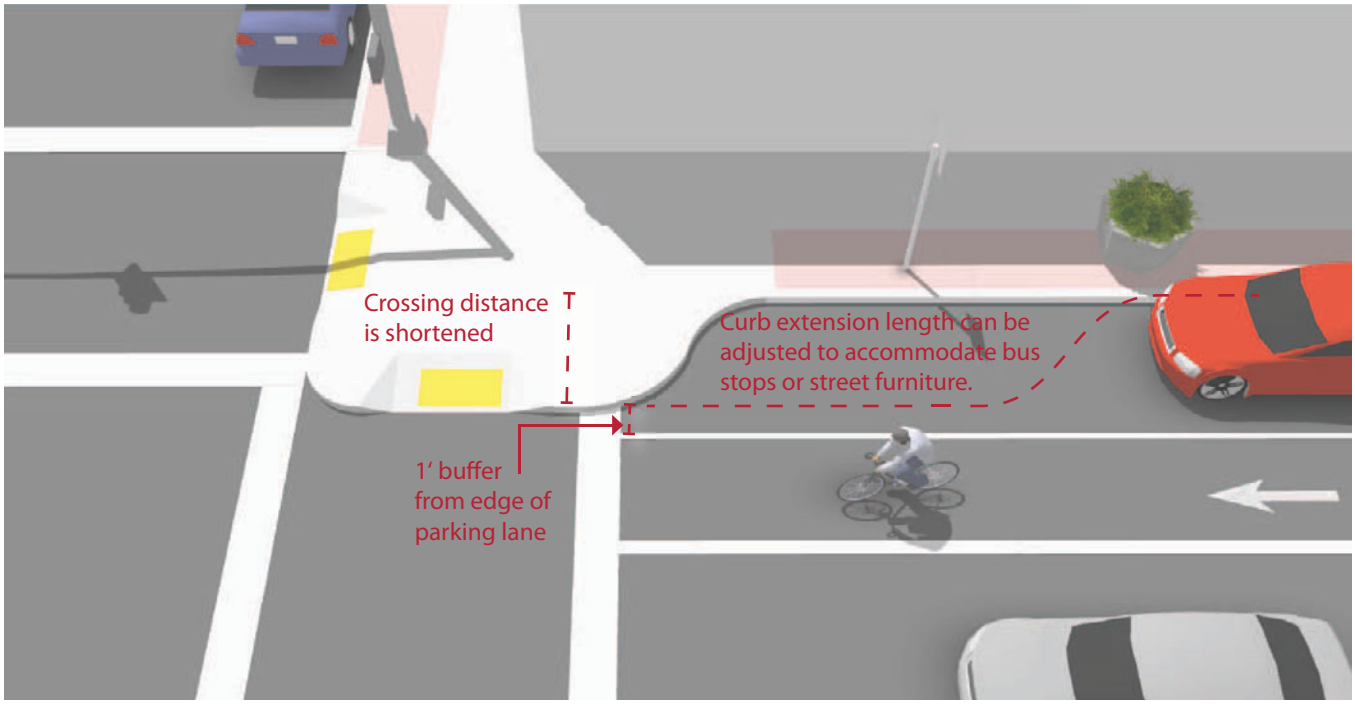
Curb Extensions

Guidance

- 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 and the two radii should be balanced to be nearly equal
- Curb extensions should terminate one foot short of the parking lane to maximize bicyclist safety.

Description

Curb extensions minimize pedestrian exposure during crossing by shortening crossing distance and give 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.



Discussion

If there is no parking lane, adding curb extensions may be a problem for bicycle travel and truck or bus turning movements.

If a refuge island is landscaped, the landscaping should not compromise the visibility of pedestrians crossing in the crosswalk. Shrubs and ground plantings should be no higher than 1 ft 6 in.

Additional References and Guidelines

AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.
AASHTO. (2004). A Policy on Geometric Design of Highways and Streets.

Materials and Maintenance

Planted curb extensions may be designed as a bioswale, a vegetated system for stormwater management.

Reducing Crossing Distance

Minimizing Curb Radii

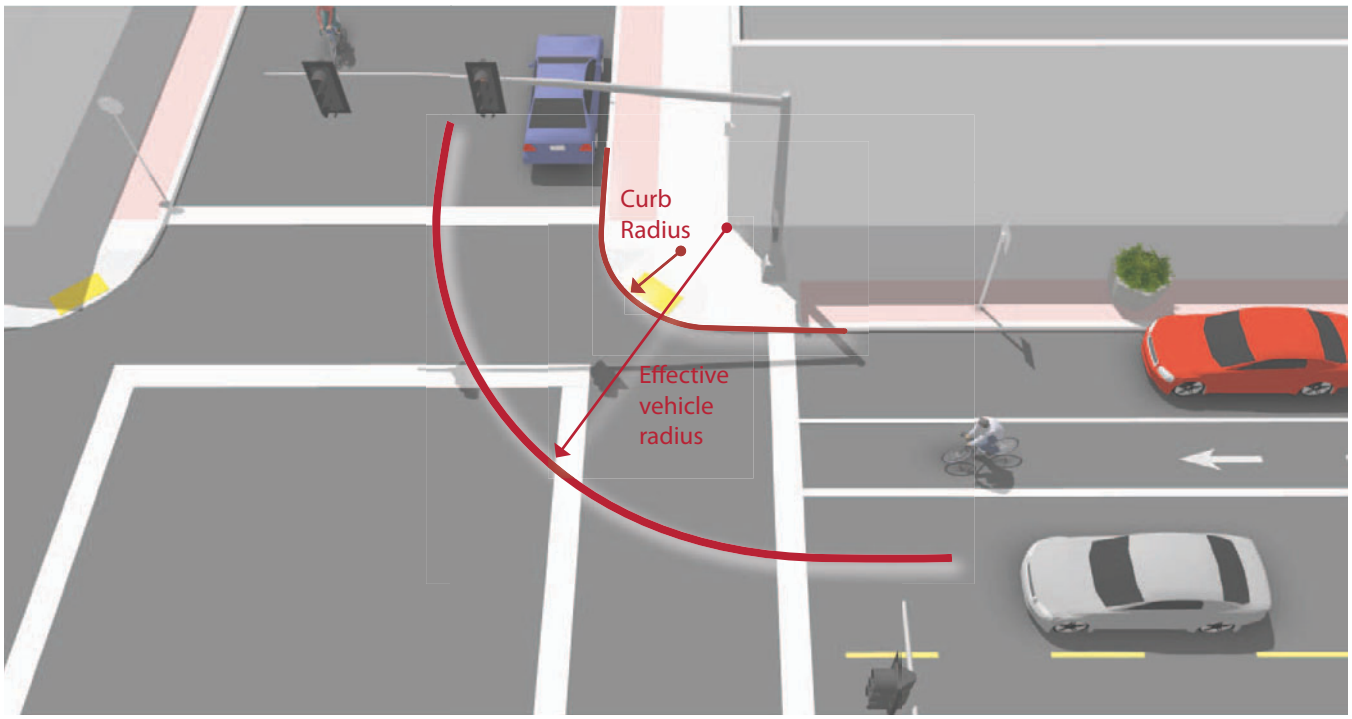
Guidance

The radius may be as small as 3 ft where there are no turning movements, or 5 ft where there are turning movements and there is adequate street width and a larger effective curb radius created by parking or bike lanes.

Description

The size of a curb's radius can have a significant impact on pedestrian comfort and safety. A smaller the 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, the chosen radius should be the smallest possible for the circumstances.

A small curb radius is also beneficial for street sweeping operations.



Discussion

Several factors govern the choice of curb radius in any given location. These include the desired pedestrian area of the corner, traffic turning movements, the turning radius of the design vehicle, the geometry of the intersection, the street classifications, and whether there is parking or a bike lane (or both) between the travel lane and the curb.

Additional References and Guidelines

AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.
AASHTO. (2004). A Policy on Geometric Design of Highways and Streets.

Materials and Maintenance

A small curb radius is also beneficial for street sweeping operations.

Minimizing Conflict with Automobiles

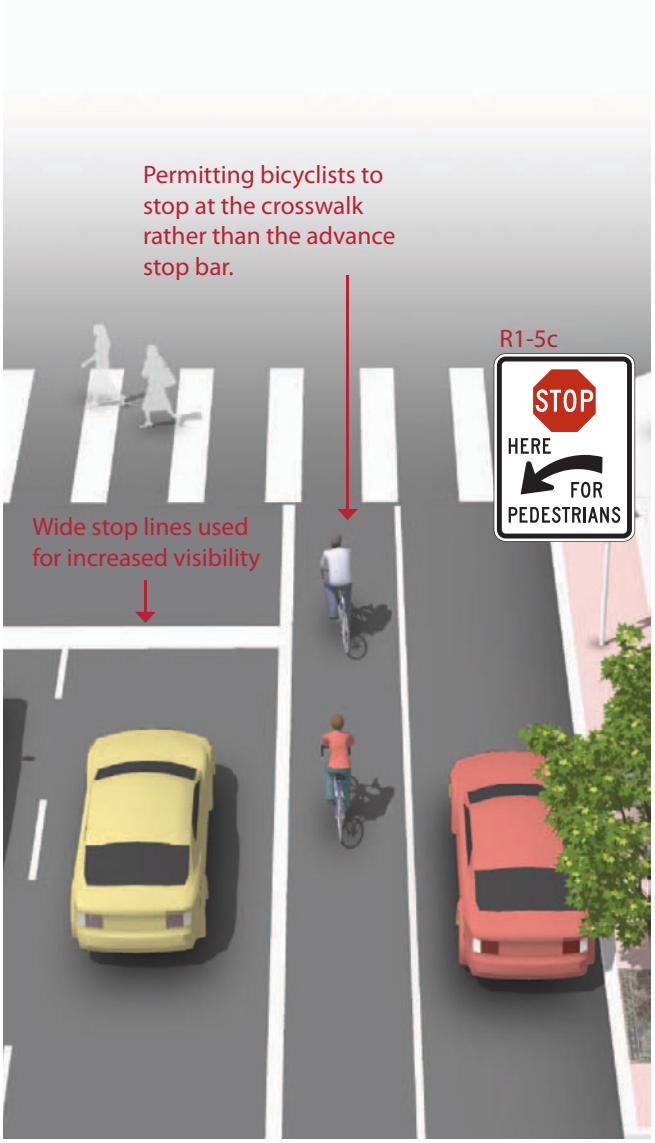
Advance Stop Bar

Description

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.

Guidance

- On streets with at least two travel lanes in each direction.
- Prior to a marked crosswalk
- In one or both directions of motor vehicle travel
- Recommended 30 feet in advance of the crosswalk
- A "Stop Here for Pedestrians" sign should accompany the advance stop bar



Discussion

If a bicycle lane is present, mark the advance stop bar to permit bicyclists to stop at the crosswalk ahead of the stop bar.

If the State law requires drivers to YIELD to pedestrians in crosswalks, a Yield Line marking must be used rather than a stop line in these cases.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices.

Materials and Maintenance

Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

Minimizing Conflict with Automobiles

Parking Control

Guidance

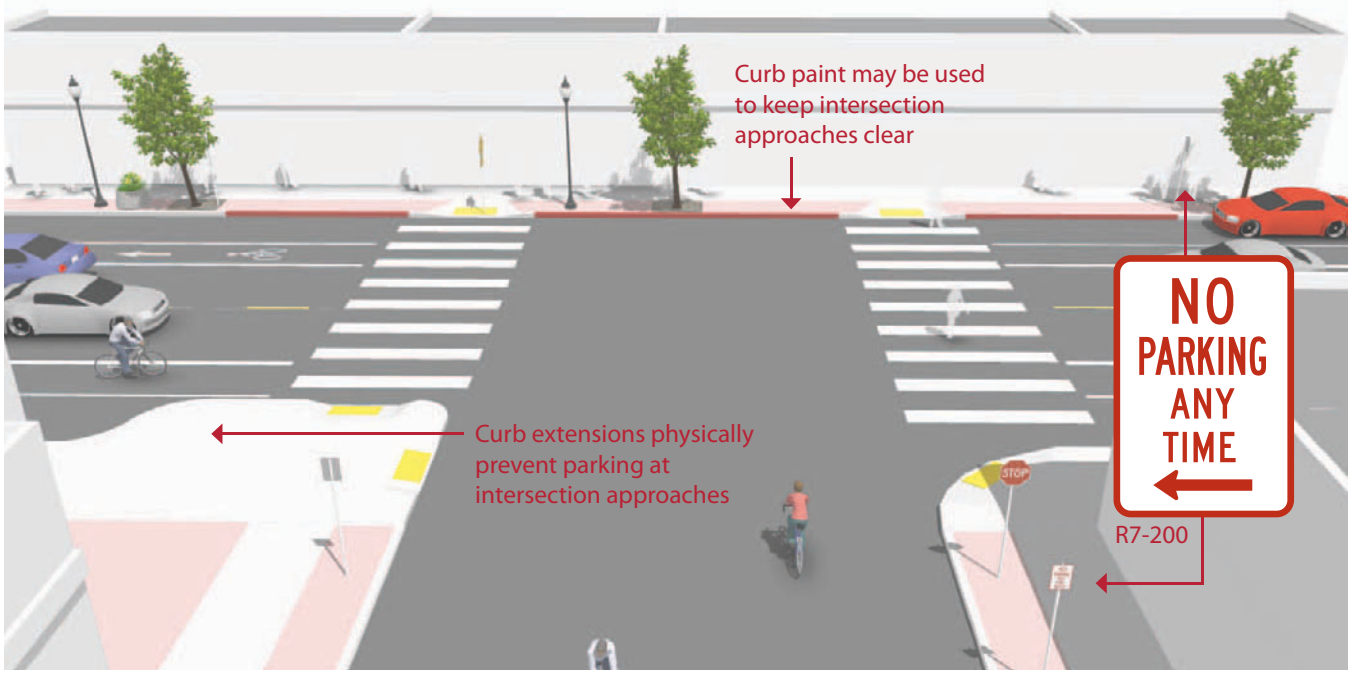
Curb extensions, 'No Parking' signage, or curb paint can be used to keep the approach to intersections clear of parked vehicles.

At "T" and offset intersections, where the boundaries of the intersection may not be obvious, this prohibition should be made clear with signage.

Parking shall not be allowed within any type of intersection adjacent to schools, school crosswalks, and parks. This includes "T" and offset intersections.

Description

Parking control involves restricting or reducing on-street parking near intersections with high pedestrian activity. Locating parking away from the intersection improves motorist's visibility on the approach to the intersection and crosswalk. Improved sight lines at intersections reduces conflicts between motorists and pedestrians.



Discussion

In areas where there is high parking demand parking compact vehicles may be allowed within "T" or offset intersections and on either side of the crosswalk. At these locations, signs will be placed to prohibit parking within the designated crosswalk areas, and additional enforcement should be provided, particularly when the treatment is new.

Additional References and Guidelines

AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.
AASHTO. (2004). A Policy on Geometric Design of Highways and Streets.

Materials and Maintenance

Signage and striping require routine maintenance.

ADA Compliant Curb Ramps

ADA Compliant Curb Ramps

Guidance

- The landing at the top of a ramp shall be at least 4 feet long and at least the same width as the ramp itself.
- The ramp shall slope no more than 1:50 (2.0%) in any direction.
- If the ramp runs directly into a crosswalk, the landing at the bottom will be in the roadway.
- If the ramp lands on a dropped landing within the sidewalk or corner area where someone in a wheelchair may have to change direction, the landing must be a minimum of 5′-0″ long and at least as wide as the ramp, although a width of 5′-0″ is preferred.

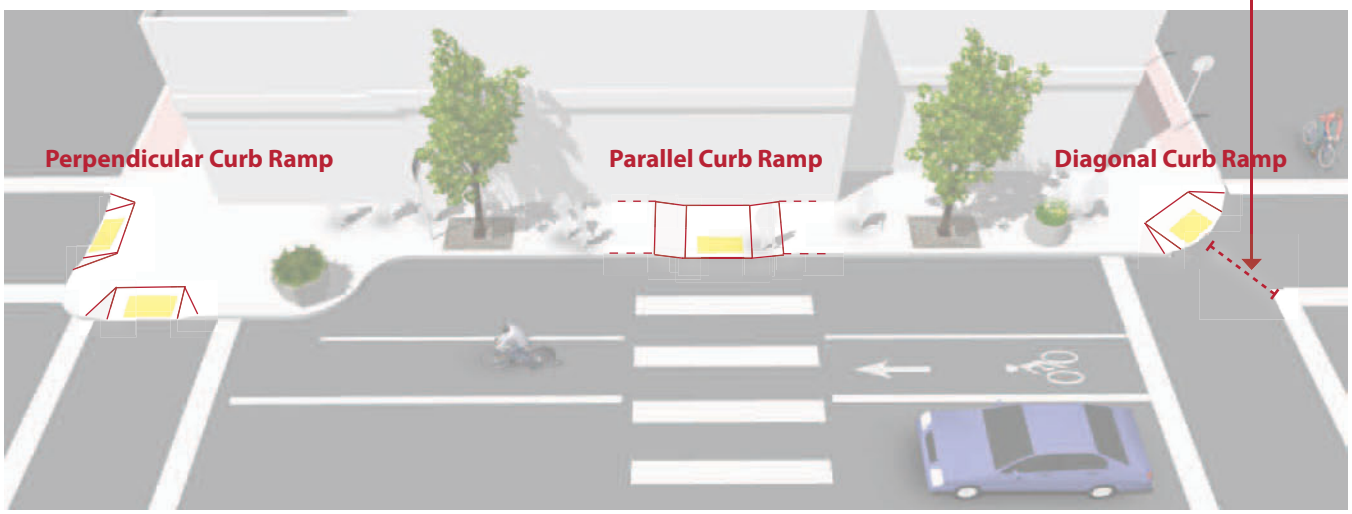
Description

Curb ramps are the design elements that allow all users to make the transition from the street to the sidewalk. There are a number of factors to be considered in the design and placement of curb ramps at corners. Properly designed curb ramps ensure that the sidewalk is accessible from the roadway. A sidewalk without a curb ramp can be useless to someone in a wheelchair, forcing them back to a driveway and out into the street for access.

Although diagonal curb ramps might save money, they create potential safety and mobility problems for pedestrians,including reduced maneuverability and increased interaction with turning vehicles,particularly in areas with high traffic volumes. Diagonal curb ramp configurations are the least preferred of all options.

Curb ramps shall be located so that they do not project into vehicular traffic lanes, parking spaces, or parking access aisles. Three configurations are illustrated below.

Diagonal ramps shall include a clear space of at least 48″ within the crosswalk for user maneuverability



Crosswalk spacing not to scale. For illustration purposes only.

Discussion

The edge of an ADA compliant curb ramp will be marked with a tactile warning device (also known as truncated domes) to alert people with visual impairments to changes in the pedestrian environment. Contrast between the raised tactile device and the surrounding infrastructure is important so that the change is readily evident. These devices are most effective when adjacent to smooth pavement so the difference is easily detected. The devices must provide color contrast so partially sighted people can see them.

Additional References and Guidelines

United States Access Board. (2002). Accessibility Guidelines for Buildings and Facilities.
United States Access Board. (2007). Public Rights-of-Way Accessibility Guidelines (PROWAG).
USDOJ. (2010). ADA Standards for Accessible Design.

Materials and Maintenance

It is critical that the interface between a curb ramp and the street be maintained adequately. Asphalt street sections can develop potholes in the at the foot of the ramp, which can catch the front wheels of a wheelchair.

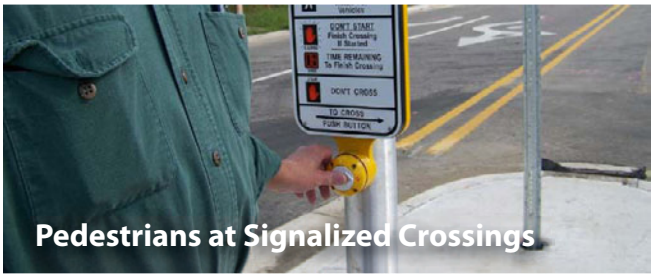
Crossing Beacons and Signals

Crossing beacons and signals facilitate crossings of roadways for pedestrians and bicyclists. Beacons make crossing intersections safer by clarifying when to enter an intersection and by alerting motorists to the presence of pedestrians in the crosswalk.

Flashing amber warning beacons can be utilized at un-signalized intersection crossings. Push buttons, signage, and pavement markings may be used to highlight these facilities for pedestrians, bicyclists and motorists.

Determining which type of signal or beacon to use for a particular intersection depends on a variety of factors. These include speed limits, Average Daily Traffic (ADT), and the anticipated levels of pedestrian and bicycle crossing traffic.

An intersection with crossing beacons may reduce stress and delays for a crossing users, and discourage illegal and unsafe crossing maneuvers.



Pedestrians at Signalized Crossings

Bicycle Detection and Actuation

Active Warning Beacons

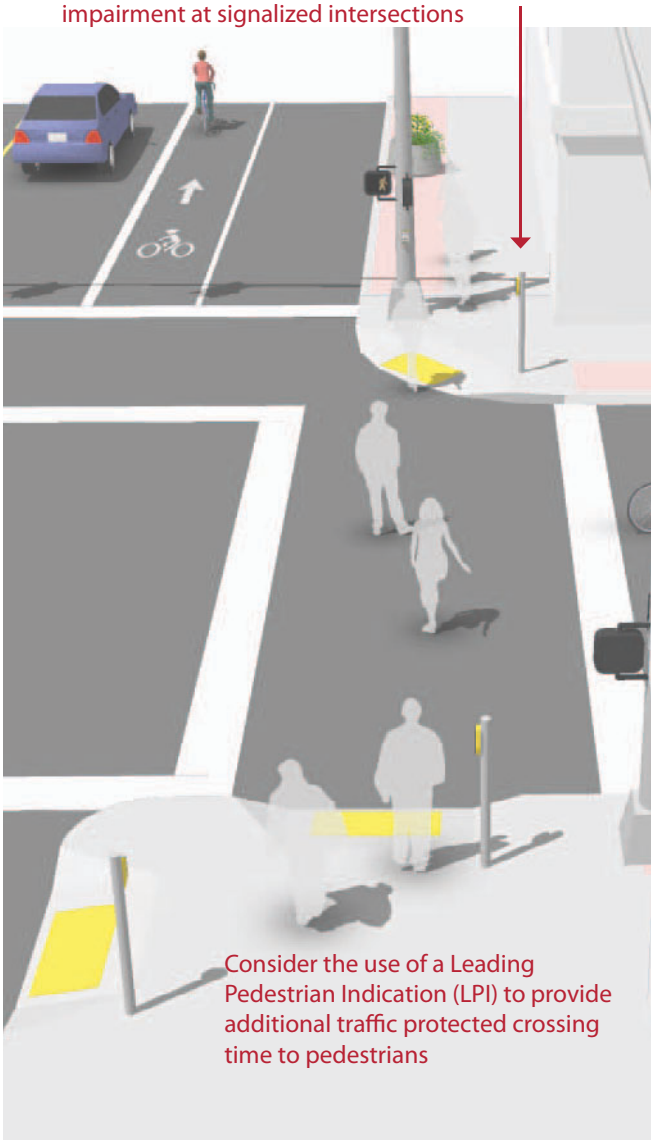
Hybrid Beacons

This Section Includes:

- Accommodating Pedestrians at Signalized Crossings
- Bicycle Detection and Actuation
- Active Warning Beacons
- Hybrid Beacon for Mid-Block Crossing

Crossing Beacons and Signals

Accommodating Pedestrians at Signalized Crossings



Description

Pedestrian Signal Head

Pedestrian signal indicators demonstrate to pedestrians when to cross at a signalized crosswalk. All traffic signals should be equipped with pedestrian signal indications except where pedestrian crossing is prohibited by signage.

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. Countdown signals should be used at all signalized intersections.

Signal Timing

Providing adequate pedestrian crossing time is a critical element of the walking environment at signalized intersections. The MUTCD recommends traffic signal timing to assume a pedestrian walking speed of 4' per second, meaning that the length of a signal phase with parallel pedestrian movements should provide sufficient time for a pedestrian to safely cross the adjacent street.

At crossings where older pedestrians or pedestrians with disabilities are expected, crossing speeds as low as 3' per second may be assumed. Special pedestrian phases can be used to provide greater visibility or more crossing time for pedestrians at certain intersections.

In busy pedestrian areas such as downtowns, the pedestrian signal indication should be built into each signal phase, eliminating the requirement for a pedestrian to actuate the signal by pushing a button.

Discussion

When push buttons are used, they should be located so that someone in a wheelchair can reach the button from a level area of the sidewalk without deviating significantly from the natural line of travel into the crosswalk, and marked (for example, with arrows) so that it is clear which signal is affected.

In areas with very heavy pedestrian traffic, consider an all-pedestrian signal phase to give pedestrians free passage in the intersection when all motor vehicle traffic movements are stopped.

Additional References and Guidelines

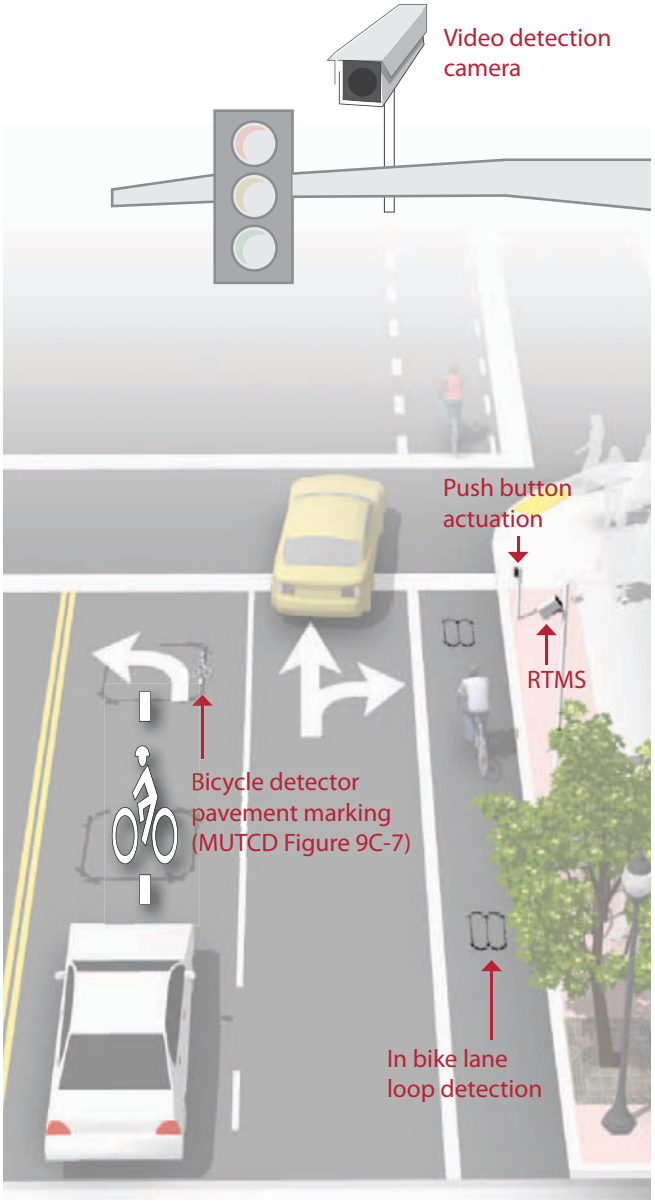
United States Access Board. (2007). Public Rights-of-Way Accessibility Guidelines (PROWAG).
AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.

Materials and Maintenance

Depending on power supply, maintenance can be minimal. If solar power is used, RRFBs should run for years without issue.

Crossing Beacons and Signals

Bicycle Detection and Actuation



Description

Push Button Actuation

User-activated button mounted on a pole facing the street.

Loop Detectors

Bicycle-activated loop detectors are installed within the roadway to allow the presence of a bicycle to trigger a change in the traffic signal. This allows the bicyclist to stay within the lane of travel without having to maneuver to the side of the road to trigger a push button.

Loops that are sensitive enough to detect bicycles should be supplemented with pavement markings to instruct bicyclists how to trip them, as well as signage.

Video Detection Cameras

Video detection cameras can also be used to determine when a vehicle is waiting for a signal. These systems use digital image processing to detect a change in the image at a location. Video detection can be calibrated for bikes, bike lanes, and bike pockets. Video camera system costs range from $20,000 to $25,000 per intersection.

Remote Traffic Microwave Sensor Detection (RTMS)

RTMS is a system which uses frequency modulated continuous wave radio signals to detect objects in the roadway. This method marks the detected object with a time code to determine its distance from the sensor. The RTMS system is unaffected by temperature and lighting, which can affect standard video detection.

Discussion

Proper bicycle detection should meet two primary criteria: 1) accurately detects bicyclists and 2) provides clear guidance to bicyclists on how to actuate detection (e.g., what button to push, where to stand).

Bicycle loops and other detection mechanisms can also provide bicyclists with an extended green time before the light turns yellow so that bicyclists of all abilities can reach the far side of the intersection.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Signal detection and actuation for bicyclists should be maintained with other traffic signal detection and roadway pavement markings.

Crossing Beacons and Signals

Active Warning Beacons

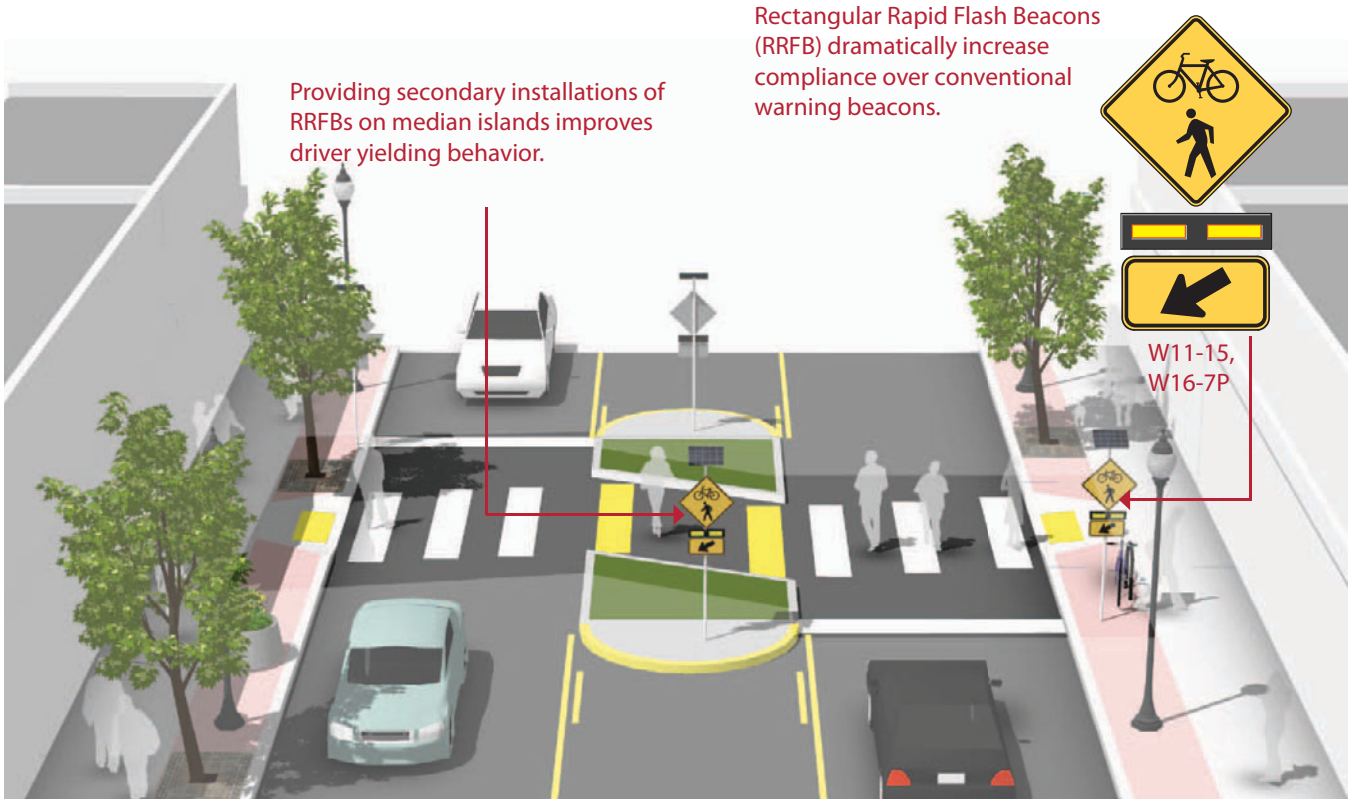
Guidance

- Warning beacons shall not be used at crosswalks controlled by YIELD signs, STOP signs, or traffic signals.
- Warning beacons shall initiate operation based on pedestrian or bicyclist actuation and shall cease operation at a predetermined time after actuation or, with passive detection, after the pedestrian or bicyclist clears the crosswalk.

Description

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 Rectangular Rapid Flash Beacons (RRFB).



Discussion

Rectangular rapid flash beacons have the most increased compliance of all the warning beacon enhancement options.

A study of the effectiveness of going from a no-beacon arrangement to a two-beacon RRFB installation increased yielding from 18 percent to 81 percent. A four-beacon arrangement raised compliance to 88 percent. Additional studies over long term installations show little to no decrease in yielding behavior over time.

Additional References and Guidelines

NACTO. (2011). Urban Bikeway Design Guide.
FHWA. (2009). Manual of Uniform Traffic Control Devices.
FHWA. (2008). MUTCD - Interim Approval for Optional Use of Rectangular Rapid Flashing Beacons (IA-11)

Materials and Maintenance

Depending on power supply, maintenance can be minimal. If solar power is used, RRFBs should run for years without issue.

Crossing Beacons and Signals

Hybrid Beacon for Mid-Block Crossing

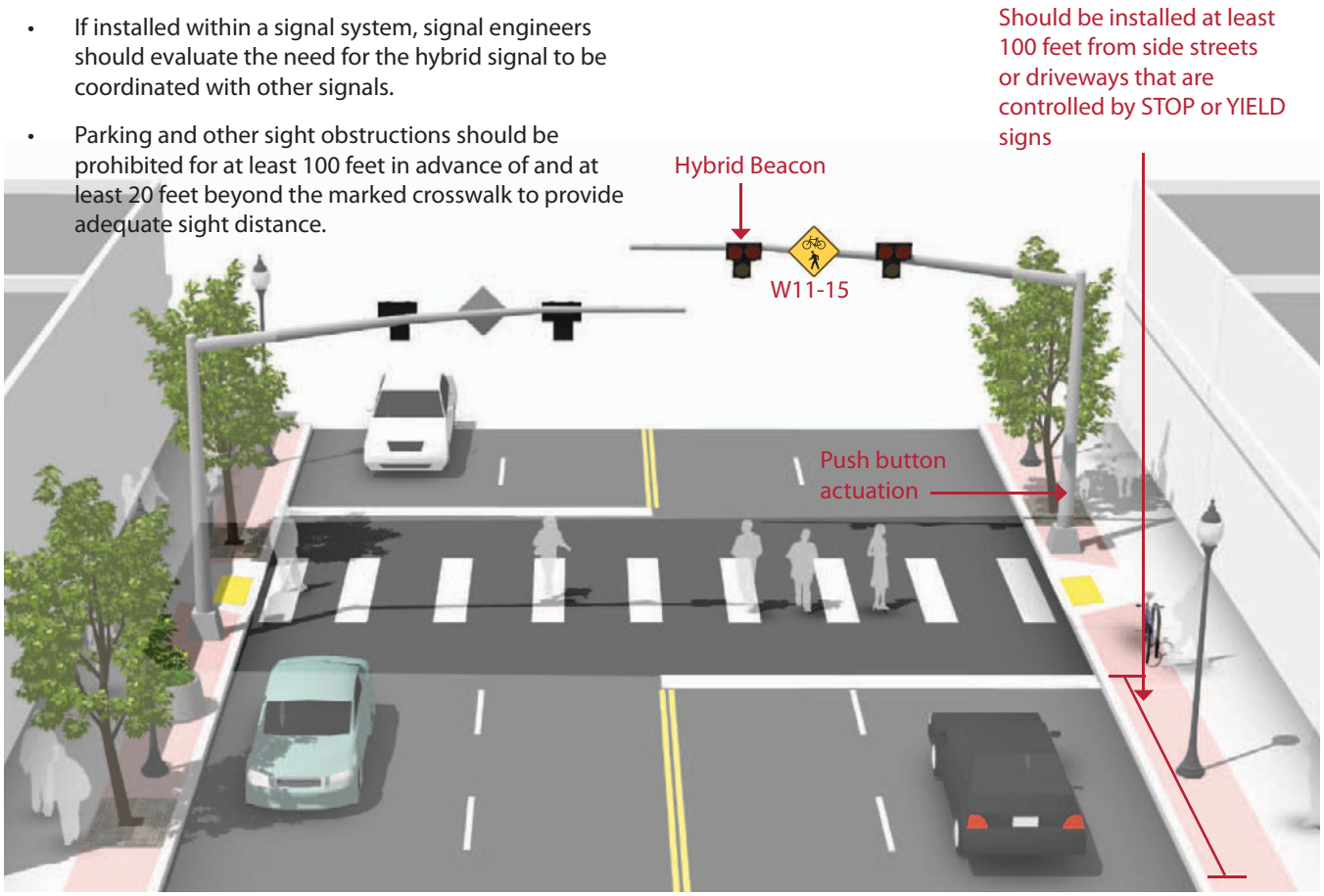
Guidance

Hybrid beacons may be installed without meeting traffic signal control warrants if roadway speed and volumes are excessive for comfortable pedestrian crossings.

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

Description

Hybrid beacons are used to improve non-motorized crossings of major streets. A hybrid beacon consists of a signal-head with two red lenses over a single yellow lens on the major street, and a pedestrian signal head for the crosswalk



Discussion

Hybrid beacon signals are normally activated by push buttons, but may also be triggered by infrared, microwave or video detectors. The maximum delay for activation of the signal should be two minutes, with minimum crossing times determined by the width of the street.

Each crossing, regardless of traffic speed or volume, requires additional review by a registered engineer to identify sight lines, potential impacts on traffic progression, timing with adjacent signals, capacity, and safety.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices.
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Hybrid beacons are subject to the same maintenance needs and requirements as standard traffic signals. Signing and striping need to be maintained to help users understand any unfamiliar traffic control.

Shared Roadways

On shared roadways, bicyclists and motor vehicles use the same roadway space. These facilities are typically used on roads with low speeds and traffic volumes, however they can be used on higher volume roads with wide outside lanes or shoulders. A motor vehicle driver will usually have to cross over into the adjacent travel lane to pass a bicyclist, unless a wide outside lane or shoulder is provided.

Shared roadways employ a large variety of treatments from simple signage and shared lane markings to more complex treatments including directional signage, traffic diverters, chicanes, chokers, and /or other traffic calming devices to reduce vehicle speeds or volumes.

Bicycle boulevards

Bicycle boulevards are a special class of shared roadways designed for a broad spectrum of bicyclists. They are low-volume local streets where motorists and bicyclists share the same travel lane. Treatments for bicycle boulevards are selected as necessary to create appropriate automobile volumes and speeds, and to provide safe crossing opportunities of busy streets.

Bike Routes

Shared Lane Markings

Bicycle Boulevards

This section includes:

- Bike Routes
- Shared Lane Markings
- Bicycle Boulevards

Bike Routes

Guidance

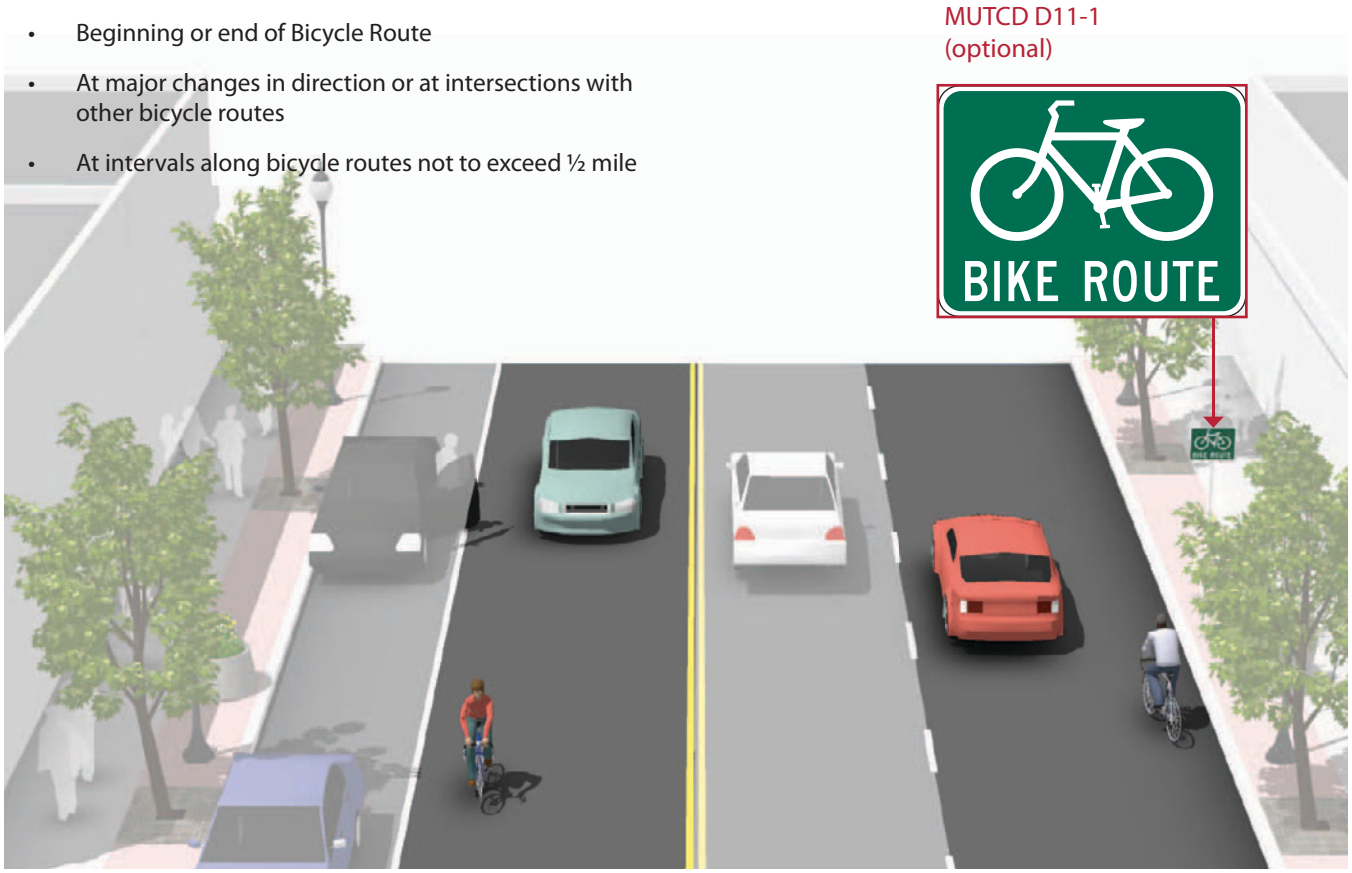
Lane width varies depending on roadway configuration.

Bicycle Route signage (D11-1) should be applied at intervals frequent enough to keep bicyclists informed of changes in route direction and to remind motorists of the presence of bicyclists. Commonly, this includes placement at:

- Beginning or end of Bicycle Route
- At major changes in direction or at intersections with other bicycle routes
- At intervals along bicycle routes not to exceed ½ mile

Description

Bike routes are regular streets shared with motor vehicles. They are typically used on roads with low speeds and traffic volumes, however can be used on higher volume roads with wide outside lanes or shoulders. A motor vehicle driver will usually have to cross over into the adjacent travel lane to pass a bicyclist, unless a wide outside lane or shoulder is provided.



Discussion

Bike routes serve either to provide continuity with other bicycle facilities (usually bike lanes) or to designate preferred routes through high-demand corridors.

This configuration differs from a **bicyle boulevard** due to a lack of traffic calming, wayfinding, pavement markings and other enhancements designed to provide a higher level of comfort for a broad spectrum of users.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.

Materials and Maintenance

Maintenance needs for bicycle wayfinding signs are similar to other signs, and will need periodic replacement due to wear.

Shared Lane Marking

Guidance

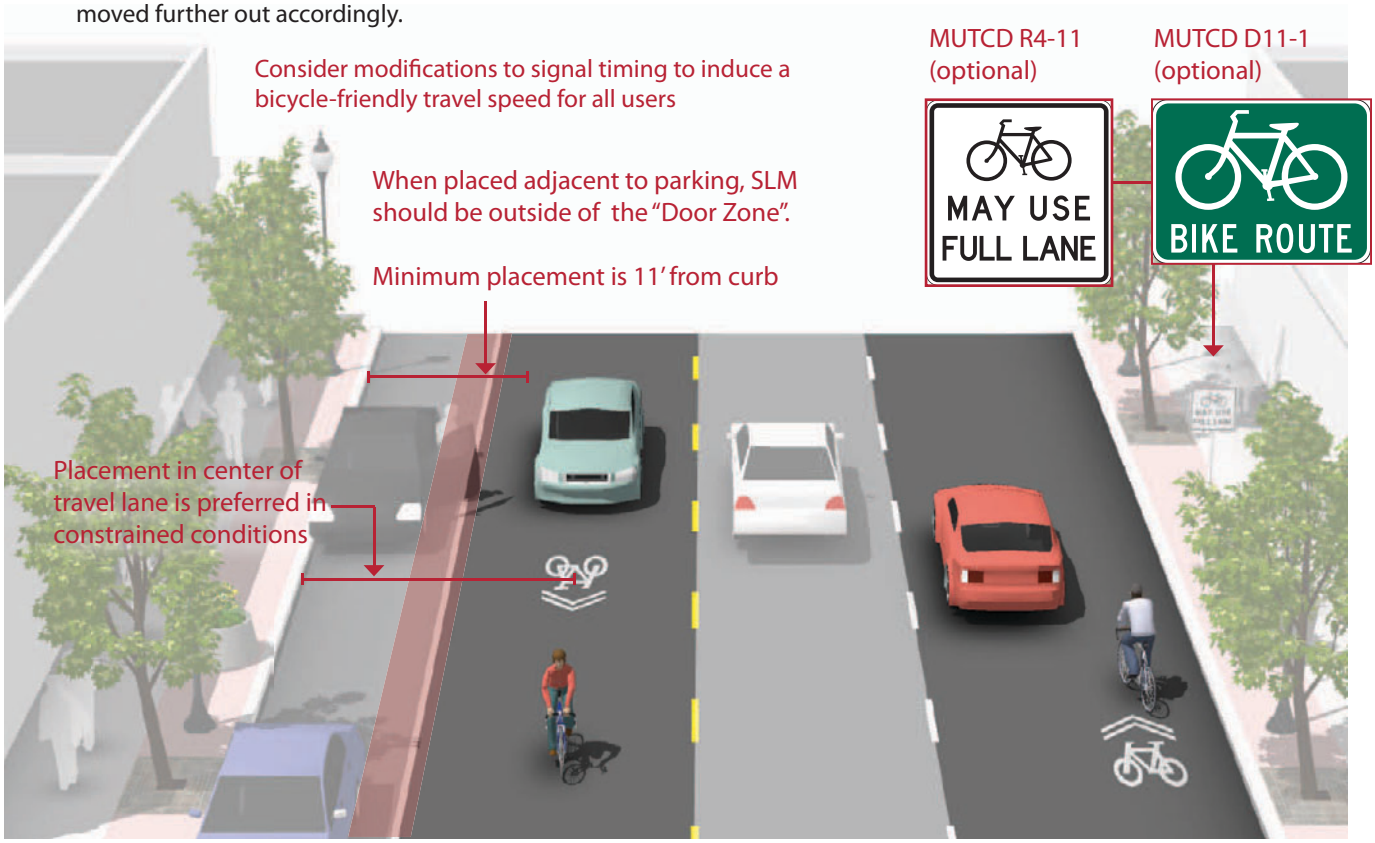
- In constrained conditions, preferred placement is in the center of the travel lane to minimize wear and promote single file travel.
- Minimum placement of SLM marking centerline is 11 feet from edge of curb where on-street parking is present, 4 feet from edge of curb with no parking. If parking lane is wider than 7.5 feet, the SLM should be moved further out accordingly.

Description

Shared lane markings (SLM) are used on shared roadways to encourage bicycle travel and proper positioning within the lane.

In constrained conditions, the SLMs are placed to discourage unsafe passing by motor vehicles. On a wide outside lane, the SLMs can be used to promote bicycle travel next to (to the right of) motor vehicles.

In all conditions, SLMs should be placed outside of the door zone of parked cars.



Discussion

Bike lanes should be considered on roadways with outside travel lanes wider than 15 feet, or where other lane narrowing or removal strategies may provide adequate road space. Shared Lane Markings shall not be used on shoulders, in designated **bicycle lanes**, or to designate **bicycle detection** at signalized intersections. (MUTCD 9C.07 03)

This configuration differs from a **bicycle boulevard** due to a lack of traffic calming, wayfinding, and other enhancements designed to provide a higher level of comfort for a broad spectrum of users.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Placing the SLM markings between vehicle tire tracks will increase the life of the markings and minimize the long-term cost of the treatment.

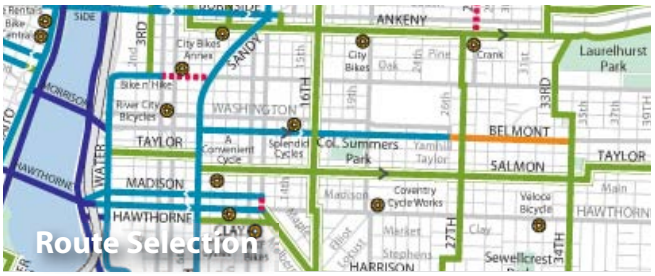
Bicycle Boulevards

Bicycle Boulevards are a special class of shared roadway designed to accommodate a broad spectrum of bicyclists.

Also known as neighborhood greenways, bicycle boulevards are low-volume, low-speed streets that have been optimized for bicycle travel 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.

Jurisdictions throughout the country use a wide variety of strategies to determine where specific treatments are applied. While no federal guidelines exist, several best practices have emerged for the development of bicycle boulevards. At a minimum, bicycle boulevards should include distinctive pavement markings and wayfinding signs. They can also use combinations of traffic calming, traffic diversion, and intersection treatments to improve the bicycling environment. The appropriate level of treatment to apply is dependent on roadway conditions, particularly motor vehicle speeds and volumes.

Traffic conditions on bicycle boulevards should be monitored to provide guidance on when and where treatments should be implemented. When motor vehicle speeds and volumes or bicyclist delay exceed the preferred limits, additional treatments should be considered for the bicycle boulevard.



Route Selection

Basic Treatments

Traffic Calming

Traffic Diversion

Intersection Treatments

This section includes:

- Route Selection
- Basic Treatments
- Traffic Calming
- Traffic Diversion
- Intersection Treatments

Bicycle Boulevards

Route Selection

Guidance

- Streets are signed at 25 mph or less to improve the bicycling environment and decrease risk and severity of crashes.
- Traffic volumes are limited to 3,000 vehicles per day (ideally less than 1,500) to minimize passing events and potential conflicts with motor vehicles.
- Use of streets that parallel major streets can discourage non-local motor vehicle traffic without significantly impacting motorists.
- Use of streets where a relatively continuous route for bicyclists exists and/or where treatments can provide wayfinding and improve crossing opportunities at offset intersections.
- Use of streets where bicyclists have right-of-way at intersections or where right-of-way is possible to assign to bicyclists.

Description

Bicycle boulevards should be developed on streets that improve connectivity to key destinations and provide a direct route for bicyclists. Local streets with existing traffic calming, traffic diversions, or signalized crossings of major streets are good candidates, as they tend to be existing bicycle routes and have low motor vehicle speeds and volumes. Other streets where residents have expressed a desire for traffic calming are also good options.

Bicycle boulevards parallel to commercial streets improve access for 'interested but concerned' bicyclists and complement bike lanes on major roadways.

In Portland, OR, the bicycle network includes a high density of neighborhood greenways parallel to streets with bike lanes.

- MULTI-USE PATH Closed to motor vehicles
- MULTI-USE PATH (unpaved)
- BIKE BOULEVARDS / NEIGHBORHOOD GREEN STREETS pavement markings & directional signs to guide cyclists
- SHARED ROADWAY on lower traffic street
- BIKE LANE or wide shoulder, usually on higher traffic streets
- SHARED ROADWAY WITH WIDER OUTSIDE LANE on moderate and higher traffic street

Discussion

Bicycle boulevards should form a continuous network of streets or off-street facilities that accommodate bicyclists who are less willing to ride on streets with motorized traffic. Most bicycle boulevards are located on residential streets, though they can also be on commercial or industrial streets. Due to the presence of trucks and commercial vehicles, as well as the need to maintain good traffic flow and retain motor vehicle parking, bicycle boulevards on commercial or industrial streets can tolerate higher automobile speeds and volumes than would be desired on neighborhood streets. Vertical traffic calming can minimize impacts to large vehicles and parking.

Additional References and Guidelines

Alta Planning + Design and IBPI. (2009). Bicycle Boulevard Planning and Design Handbook.
City of Berkeley. (2000). Bicycle Boulevard Design Tools and Guidelines.
City of Emeryville. (2011). Bicycle Boulevard Treatments.

Materials and Maintenance

Repaving, street sweeping and other maintenance should occur with higher frequency than on other local streets.

Bicycle Boulevards

Basic Treatments

Description

Signs and pavement markings are the minimum treatments necessary to designate a street as a bicycle boulevard. Together, they visibly designate a roadway to both bicyclists and motorists. Signs, and in some cases pavement markings, provide wayfinding to help bicyclists remain on the designated route.

Guidance

Pavement Markings

Place symbols every 250-800 feet along a linear corridor, as well as after every intersection.

On narrow streets where a motor vehicle cannot pass a bicyclist within one lane of traffic, place stencils in the center of the travel lane.

See **marked shared roadway** guidance for additional information on the use of shared lane markings.

A bicycle symbol can be placed on a standard road sign, along with distinctive coloration.

Signs

See **bikeway signing** for guidance on developing bicycle wayfinding signage. Some cities have developed unique logos or colors for wayfinding signs that help brand their bicycle boulevards.

Be consistent in content, design, and intent; colors reserved by the Manual on Uniform Traffic Devices (MUTCD) for regulatory and warning road signs are not recommended.

Signs can include information about intersecting bikeways and distance/time information to key destinations.

Discussion

Wayfinding signs displaying destinations, distances, and "riding time" can dispel common misperceptions about time and distance while increasing users' comfort and accessibility to the bicycle boulevard network. Bicycle boulevards frequently include offset intersections or 'jog' onto another street. Signs and pavement markings can help bicyclists remain on the route. In addition, fewer businesses or services are located along local streets, and signs inform bicyclists of the direction to key destinations, including commercial districts, transit hubs, schools and universities, and other bikeways.

Additional References and Guidelines

City of Milwaukie. (2009). Milwaukie Bicycle Wayfinding Signage Plan
City of Oakland (2009). Design Guidelines for Bicycle Wayfinding Signage
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Pavement markings should be repainted and signs replaced as needed. Wayfinding signs should be regularly updated with new major destination and bicycle facilities.

Vertical Traffic Calming

Description

Motor vehicle speeds affect the frequency at which automobiles pass bicyclists as well as the severity of crashes that can occur. Maintaining motor vehicle speeds closer to those of bicyclists' greatly improves bicyclists' comfort on a street. Slower vehicular speeds also improve motorists' ability to see and react to bicyclists and minimize conflicts at driveways and other turning locations.

Vertical speed control measures are composed of slight rises in the pavement, on which motorists and bicyclists must reduce speed to cross.

Guidance

- Bicycle boulevards should have a maximum posted speed of 25 mph. Use traffic calming to maintain an 85th percentile speed below 22 mph.
- Speed humps are raised areas usually placed in a series across both travel lanes. A 14' long hump reduces impacts to emergency vehicles. Speed humps can be challenging for bicyclists, gaps can be provided in the center or by the curb for bicyclists and to improve drainage. Speed humps can also be offset to accommodate emergency vehicles.
- Speed lumps or cushions have gaps to accommodate the wheel tracks of emergency vehicles.
- Speed tables are longer than speed humps and flat-topped. Raised crosswalks are speed tables that are marked and signed for a pedestrian crossing.
- For all vertical traffic calming, slopes should not exceed 1:10 or be less steep than 1:25. Tapers should be no greater than 1:6 to reduce the risk of bicyclists losing their balance. The vertical lip should be no more than a 1/4" high.

Speed Hump

Offset Speed Hump

Temporary Speed Cushion

Raised Crosswalk

Discussion

Emergency vehicle response times should be considered where vertical deflection is used. Because emergency vehicles have a wider wheel base than passenger cars, speed lumps/cushions allow them to pass unimpeded while slowing most other traffic. Alternatively, speed tables are recommended because they cannot be straddled by a truck, decreasing the risk of bottoming out.

Traffic calming can also deter motorists from driving on a street. Monitor vehicle volumes on adjacent streets to determine whether traffic calming results in inappropriate volumes. Traffic calming can be implemented on a trial basis.

Additional References and Guidelines

Alta Planning + Design and IBPI. (2009). Bicycle Boulevard Planning and Design Handbook.
BikeSafe. (No Date). Bicycle countermeasure selection system.
Ewing, Reid. (1999). Traffic Calming: State of the Practice.
Ewing, Reid and Brown, Steven. (2009). U.S. Traffic Calming Manual.

Materials and Maintenance

Traffic calming should be designed to minimize impacts to snowplows. Vegetation should be regularly trimmed to maintain visibility and attractiveness.

Horizontal Traffic Calming

Description

Horizontal speed control measures are obstacles on the side of the travel lane, which cause motorists to slow down to either navigate the travel feature or because the roadway narrows.

Horizontal speed control measures may reduce the design speed of a street, and they can be used in conjunction with reduced speed limits to reinforce the expectation that motorists lower their speeds.

Guidance

- Maintain a minimum clear width of 20 feet or 28 feet with parking on both sides, with a constricted length of at least 20 feet in the direction of travel.
- Chicanes are a series of raised or delineated curb extensions, edge islands, or parking bays on alternating sides of a street forming an "S"-shaped curb, which reduce vehicle speeds by requiring motorists to shift laterally through narrowed travel lanes.
- Pinchponts are curb extensions placed on both sides of the street, narrowing the travel lane and encouraging all road users to slow down. When placed at intersections, pinchpoints are known as chokers or neckdowns, and reduce curb radii and further reducing motor vehicle speeds.
- Traffic circles are raised or delineated islands placed at intersections that reduce vehicle speeds by narrowing turning radii and the travel lane. Traffic circles can also include a paved apron to accommodate the turning radii of larger vehicles like fire trucks or school buses.

Temporary Curb Extension

Chicane

Choker or Neckdown

Pinchpoint with Bicycle Access

Discussion

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

Traffic calming can also deter motorists from driving on a street. Monitor vehicle volumes on adjacent streets to determine whether traffic calming results in inappropriate volumes. Traffic calming can be implemented on a trial basis.

Additional References and Guidelines

Alta Planning + Design and IBPI. (2009). Bicycle Boulevard Planning and Design Handbook.
BikeSafe. (No Date). Bicycle countermeasure selection system.
Ewing, Reid. (1999). Traffic Calming: State of the Practice.
Ewing, Reid and Brown, Steven. (2009). U.S. Traffic Calming Manual.

Materials and Maintenance

Traffic calming should be designed to minimize impacts to snowplows. Vegetation should be regularly trimmed to maintain visibility and attractiveness.

Traffic Diversion

Description

Motor vehicle traffic volumes also affect the operation of a bicycle boulevard. Higher vehicle volumes reduce bicyclists' comfort and can result in more potential conflicts.

Implement volume control treatments based on the context of the bicycle boulevard, using engineering judgment. Target motor vehicle volumes range from 1,000 to 3,000 vehicles per day, above which the route should be striped as a **bike lane** or considered a **signed shared roadway**.

Guidance

- Traffic diversion treatments reduce motor vehicle volumes by completely or partially restricting through traffic on a bicycle boulevard.
- Partial closures allow full bicycle passage while restricting vehicle access to one way traffic at that point.
- Diagonal diverters require all motor vehicle traffic to turn.
- Median diverters (see **major intersections**) restrict through motor vehicle movements while providing a refuge for bicyclists to cross in two stages.
- Street closures create a "T" that blocks motor vehicles from continuing on a bicycle boulevard, while bicycle travel can continue unimpeded. Full closures can accomodarte emergency vehicles with the use of mountable curbs (maximum of six inches high).

Partial Closure

Diagonal Diverter

Median Diverter

Full Closure

Discussion

Bicycle boulevards on streets with volumes higher than 3,000 vehicles per day are not recommended, although a segment of a bicycle boulevard may accommodate more traffic for a short distance if necessary to complete the corridor. Providing additional separation with a **bike lane**, **cycle track** or other treatment is recommended where traffic calming or diversion cannot reduce volumes below this threshold.

Additional References and Guidelines

Alta Planning + Design and IBPI. (2009). Bicycle Boulevard Planning and Design Handbook.
Ewing, Reid. (1999). Traffic Calming: State of the Practice.
Ewing, Reid and Brown, Steven. (2009). U.S. Traffic Calming Manual.
Oregon Department of Transportation. (1998). Right-In Right-Out Channelization.

Materials and Maintenance

Depending on the diverter type, these treatments can be challenging to keep clear of snow and debris. Vegetation should be regularly trimmed to maintain visibility and attractiveness.

Minor Intersection Treatments

Description

Treatments at minor roadway intersections are designed to improve the visibility of a bicycle boulevard, raise awareness of motorists on the cross-street that they are likely to encounter bicyclists, and enhance safety for all road users.

Guidance

- On the bicycle boulevard, the majority of intersections with minor roadways should stop-control cross traffic to minimize bicyclist delay. This will maximize through-bicycle connectivity and preserve bicyclist momentum.
- Traffic circles are a type of **horizontal traffic calming** that can be used at minor street intersections. Traffic circles reduce conflict potential and severity while providing traffic calming to the corridor.
- If a stop sign is present on the bicycle boulevard, a second stop bar for bicyclists can be placed closer to the centerline of the cross street than the motorists' stop bar to increase the visibility of bicyclists waiting to cross the street.
- Curb extensions can be used to move bicyclists closer to the centerline to improve visibility and encourage motorists to let them cross.

Stop Signs on Cross-Street

Traffic Circles

Bicycle Forward Stop Bar

Curb Extension

Discussion

Stop signs increase bicycling time and energy expenditure, frequently leading to non-compliance by bicyclists and motorists, and/or use of other less desirable routes. Bicycle boulevards should have fewer stops or delays than other local streets; a typical bicycle trip of 30 minutes can increase to 40 minutes if there is a STOP sign at every block (*Berkeley Bicycle Boulevard Design Tools and Guidelines*). If several stop signs are turned along a corridor, speeds should be monitored and traffic-calming treatments used to reduce excessive vehicle speeds on the bicycle boulevard.

Additional References and Guidelines

City of Berkeley. (2000). Bicycle Boulevard Design Tools and Guidelines.
City of London Transport for London. Advanced stop lines (ASLS) background and research studies.
Transportation Research Board. (2006). Improving Pedestrian Safety at Unsignalized Crossings. NCHRP Report # 562.

Materials and Maintenance

Vegetation in traffic circles and curb extensions should be regularly trimmed to maintain visibility and attractiveness. Repaint bicycle stop bars as needed.

Major Intersection Treatments

Description

The quality of treatments at major street crossings can significantly affect a bicyclist's choice to use a bicycle boulevard, as opposed to another road that provides a crossing treatment.

Guidance

- **Bike boxes** increase bicyclist visibility to motorists and reduce the danger of right "hooks" by providing a space for bicyclists to wait at signalized intersections.
- Median islands provided at uncontrolled intersections of bicycle boulevards and major streets allow bicyclists to cross one direction of traffic at a time as gaps in traffic occur.
- **Hybrid Beacons**, **active warning beacons** and **bicycle signals** can facilitate bicyclists crossing a busy street on which cross-traffic does not stop.
- Select treatments based on engineering judgment; see National Cooperative Highway Research Program (NCHRP) Report # 562 *Improving Pedestrian Safety at Unsignalized Crossings* (2006) for guidance on appropriate use of crossing treatments. Treatments are designed to improve visibility and encourage motorists to stop for pedestrians; with engineering judgement many of the same treatments are appropriate for use along bicycle boulevards.

Bike Box

Median Island

Hybrid Beacon (HAWK)

Rectangular Rapid Flash Beacon (RRFB)

Discussion

Bicycle boulevard retrofits to local streets are typically located on streets without existing signalized accommodation at crossings of collector and arterial roadways. Without treatments for bicyclists, these intersections can become major barriers along the bicycle boulevard and compromise safety.

Additional References and Guidelines

Transportation Research Board. (2006). *Improving Pedestrian Safety at Unsignalized Crossings.* NCHRP Report # 562.
Federal Highway Administration. (2004). *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations.* FHWA-RD-04-100

Materials and Maintenance

Maintain signs, markings, and other treatments and replace as needed. Monitor intersections for bicyclist delay to determine if additional treatments are warranted.

Offset Intersection Treatments

Description

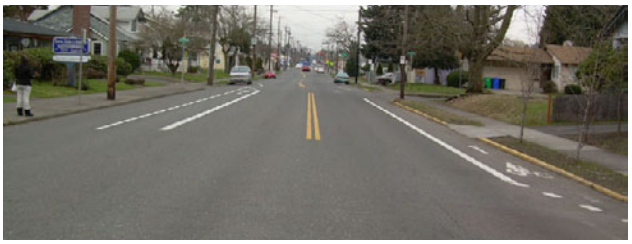
Offset intersections can be challenging for bicyclists who are required to briefly travel along the busier cross street in order to continue along the bicycle boulevard.

Guidance

- Appropriate treatments depend on volume of traffic including turning volumes, the speed limit or 85th percentile speed of the main street and the type of bicyclist using the crossing.
- **Contraflow bike lanes** allow bicyclists to travel against the flow of traffic on a one-way street and can improve bicycle boulevard connectivity.
- Bicycle left-turn lanes can be painted where a bicycle boulevard is offset to the right on a street that has sufficient traffic gaps. Bicyclists cross one direction of traffic and wait in a protected space for a gap in the other direction. The bike turn pockets should be at least 4 feet wide, with a total of 11 feet for both turn pockets and center striping.
- Short **bike lanes** on the cross street assist with accessing a bicycle boulevard that jogs to the left. Crossing treatments should be provided on both sides to minimize wrong-way riding.
- A **cycle track** can be provided on one side of a busy street. Bicyclists enter the cycle track from the bicycle boulevard to reach the connecting segment of the bicycle boulevard. This maneuver may be signalized on one side.

Contraflow Bike Lane

Left Turn Bike Lanes



Short Bike Lanes on the Cross Street

Cycle Track Connection

Discussion

Because bicycle boulevards are located on local streets, the route is often discontinuous. Wayfinding and pavement markings assist bicyclists with remaining on the route.

Additional References and Guidelines

Hendrix, Michael. (2007). *Responding to the Challenges of Bicycle Crossings at Offset Intersections.* Third Urban Street Symposium.

Materials and Maintenance

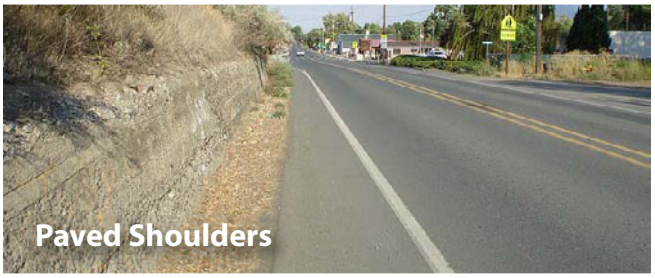
Paint can wear more quickly in high traffic areas or in winter climates. Facilities should be cleared of snow through routine snow removal operations.

Separated Bikeways

Designated exclusively for bicycle travel, separated bikeways are segregated from vehicle travel lanes by striping, and can include pavement stencils and other treatments. Separated bikeways are most appropriate on arterial and collector streets where higher traffic volumes and speeds warrant greater separation.

Separated bikeways can increase safety and promote proper riding by:

- Defining road space for bicyclists and motorists, reducing the possibility that motorists will stray into the bicyclists' path.
- Discouraging bicyclists from riding on the sidewalk.
- Reducing the incidence of wrong way riding.
- Reminding motorists that bicyclists have a right to the road.



This section includes:

Paved Shoulders

Conventional Bike Lanes

- Bike Lane With No On-Street Parking
- Bike Lane Next to Parallel Parking
- Bike Lane Next to Diagonal Parking

Additional Bike Lane Configurations

- Buffered Bike Lanes

Separated Bikeways

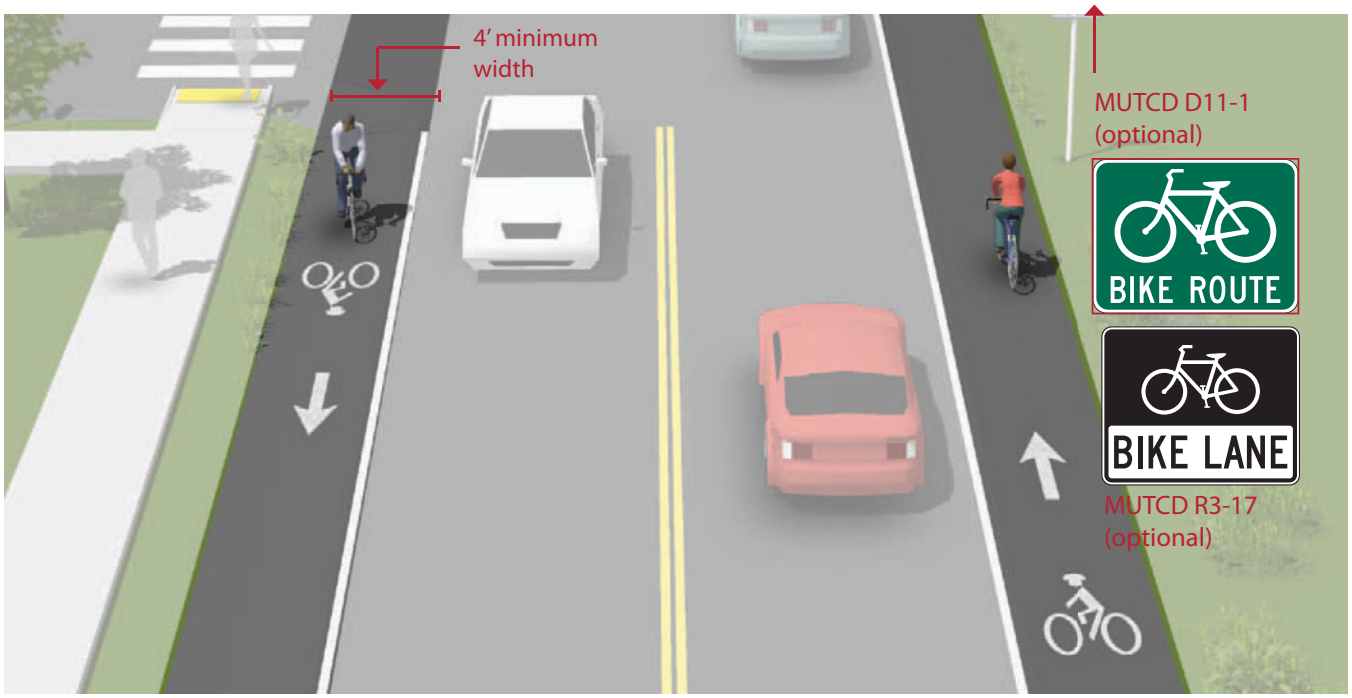
Paved Shoulders

Guidance

- On rural sections (shoulder) with ADT greater than 500, bike lanes/paved shoulders should be a minimum of 4 feet wide in each direction to accommodate bicycle travel.
- Where motor vehicle speeds exceed 50 mph or the percentage of trucks, buses, and recreational vehicles is greater than 5 percent consider providing a 6 foot minimum width.
- If it is not possible to meet minimum bicycle lane dimensions, a reduced width paved shoulder can still improve conditions for bicyclists.

Description

Typically found in less-dense areas, paved shoulders are paved roadways with striped shoulders (4'+) wide enough for bicycle travel. Paved shoulders often, but not always, include signage alerting motorists to expect bicycle travel along the roadway. Paved shoulders should be considered a temporary treatment, with full bike lanes planned for construction when the roadway is widened or completed with curb and gutter. This type of treatment is not typical in urban areas and should only be used where constraints exist.



Discussion

A wide outside lane may be sufficient accommodation for bicyclists on streets with insufficient width for bike lanes but which do have space available to provide a wider (14'-16') outside travel lane. Consider configuring as a **marked shared roadway** in these locations.

Where feasible, **roadway widening** should be performed with pavement resurfacing jobs, but not exceeding desirable bike lane widths.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.

Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates. Shoulder bikeways should be cleared of snow through routine snow removal operations.

Bike Lane with No On-Street Parking

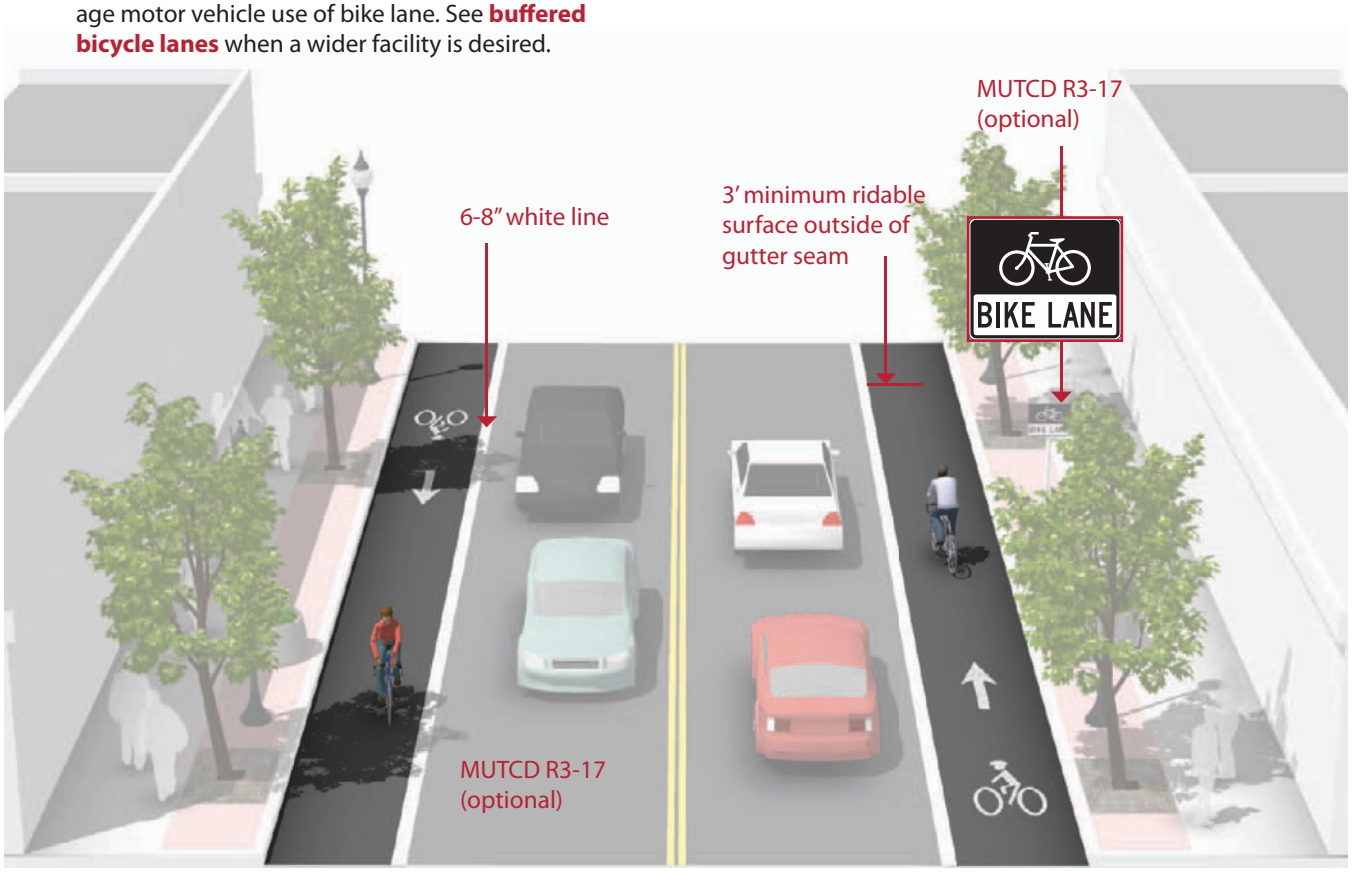
Guidance

- 4 foot minimum width. The gutter pan is not to be included in the width of the bike lane.
- 7 foot maximum width for use adjacent to arterials with high travel speeds. Greater widths may encourage motor vehicle use of bike lane. See **buffered bicycle lanes** when a wider facility is desired.

Description

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.

A bike lane width of 7 feet makes it possible for bicyclists to ride side-by-side or pass each other without leaving the bike lane, thereby increasing the capacity of the lane.



Discussion

Wider bicycle lanes are desirable in certain situations such as on higher speed arterials (45 mph+) where use of a wider bicycle lane would increase separation between passing vehicles and bicyclists. Appropriate signing and stenciling is important with wide bicycle lanes to ensure motorists do not mistake the lane for a vehicle lane or parking lane. Consider **Buffered Bicycle Lanes** when further separation is desired.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates. Bicycle lanes should be cleared of snow through routine snow removal operations.

Bike Lane Adjacent to On-Street Parallel Parking

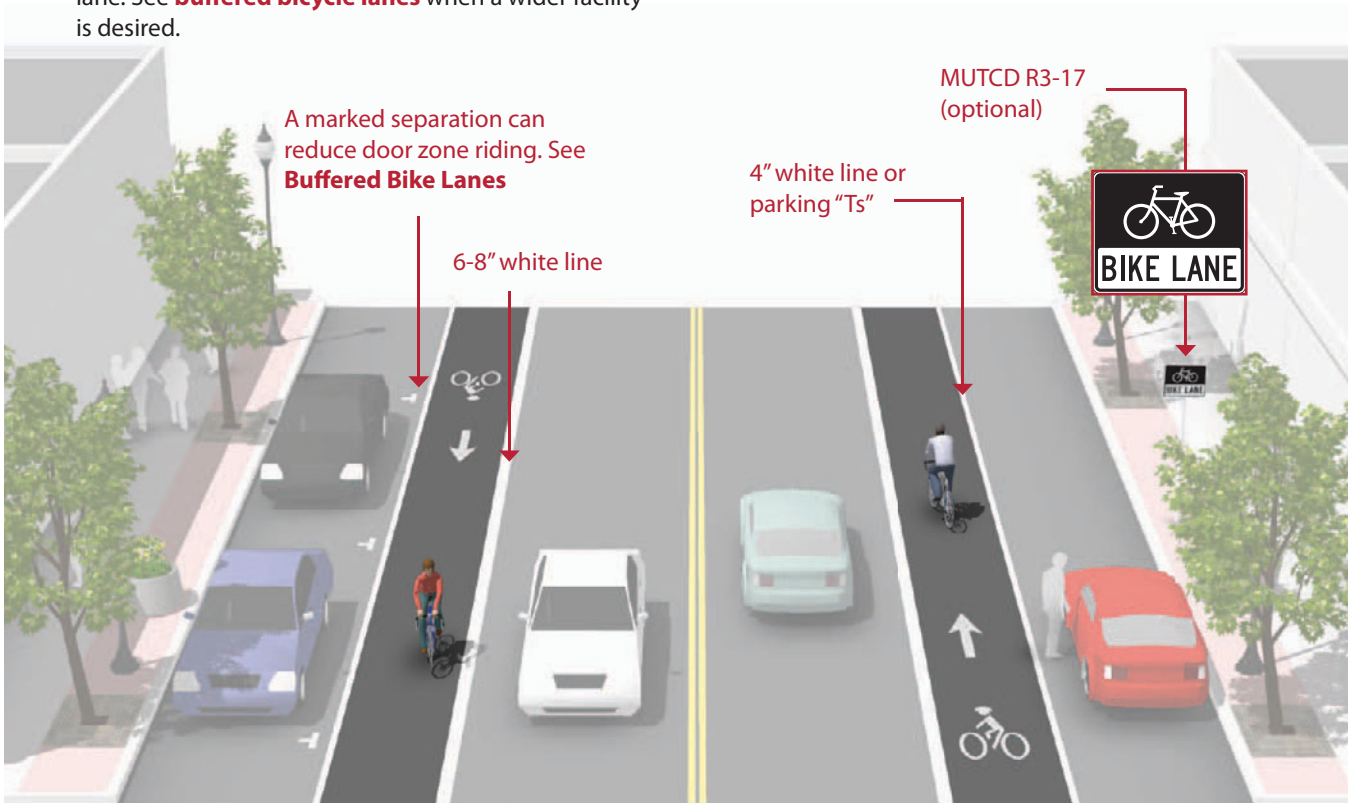
Guidance

- 12 foot minimum from curb face to edge of bike lane.
- 14.5 foot preferred from curb face to edge of bike lane.
- 7 foot maximum for marked width of bike lane. Greater widths may encourage vehicle loading in bike lane. See **buffered bicycle lanes** when a wider facility is desired.

Description

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

Many bicyclists, particularly less experienced riders, are more comfortable riding on a busy street if it has a striped and signed bikeway than if they are expected to share a lane with vehicles.



Discussion

Bike lanes adjacent to on-street parallel parking require special treatment in order to avoid crashes caused by an open vehicle door. The bike lane should have sufficient width to allow bicyclists to stay out of the door zone while not encroaching into the adjacent vehicular lane. Parking stall markings, such as parking "Ts" and double white lines create a parking side buffer that encourages bicyclists to ride farther away from the door zone.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates. Bicycle lanes should be cleared of snow through routine snow removal operations.

Bike Lane Adjacent to On-Street Back-in Diagonal Parking

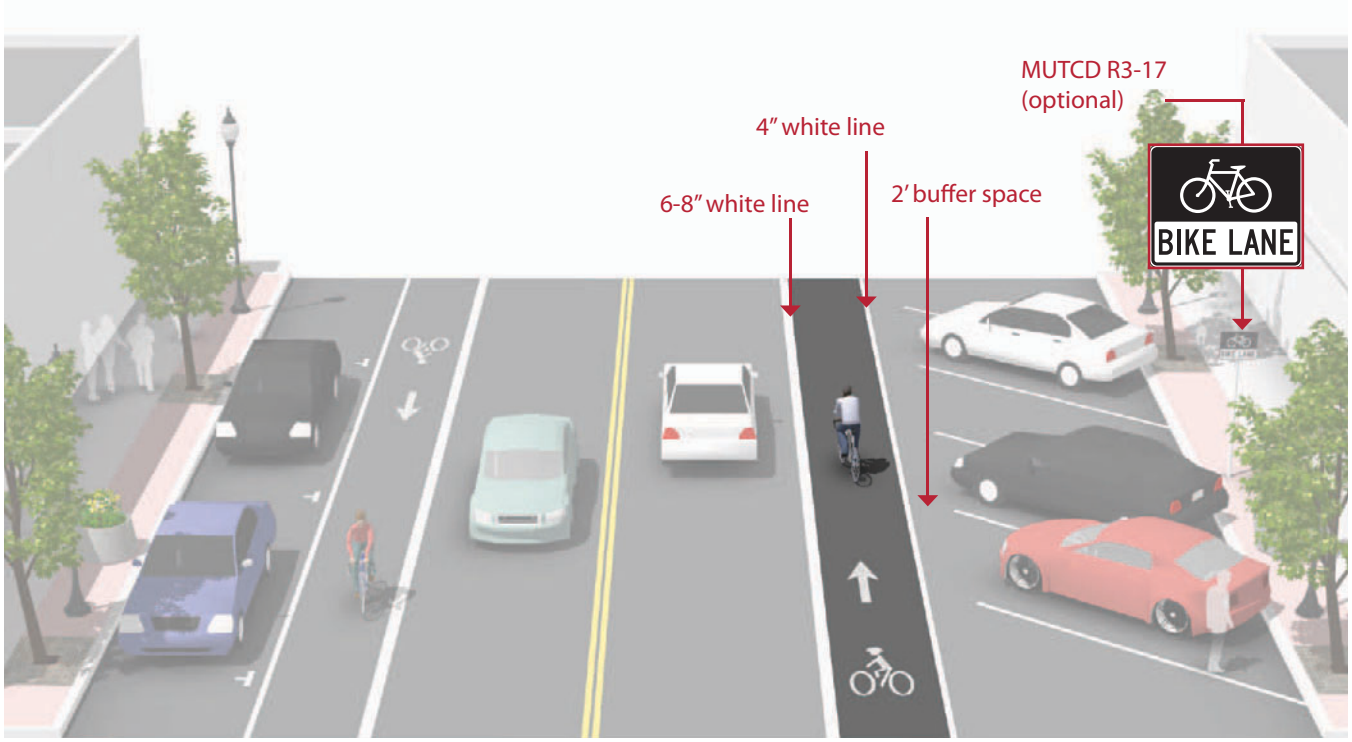
Guidance

- 5 foot minimum marked width of bike lane.
- Parking bays are sufficiently long to accommodate most vehicles (so vehicles do not block bike lane).

Description

In certain areas with high parking demand such as urban commercial areas, diagonal parking can be used to increase parking supply.

Back-in diagonal parking improves sight distances between drivers and bicyclists when compared to conventional head-in diagonal parking. Back-in diagonal parking provides other benefits including loading and unloading of the trunk at the curb rather than in the street, passengers (including children) are directed by open doors towards the curb and there is no door conflict with bicyclists. While there may be a learning curve for some drivers, back-in diagonal parking is typically an easier maneuver than conventional parallel parking.



Discussion

Conventional front-in diagonal parking is not compatible or recommended in conjunction with high levels of bicycle traffic or with the provision of bike lanes, as drivers backing out of conventional diagonal parking have limited visibility of approaching bicyclists.

Additional References and Guidelines

There is no currently adopted Federal or State guidance for this treatment.

Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates. Bicycle lanes should be cleared of snow through routine snow removal operations.

Buffered Bike Lane

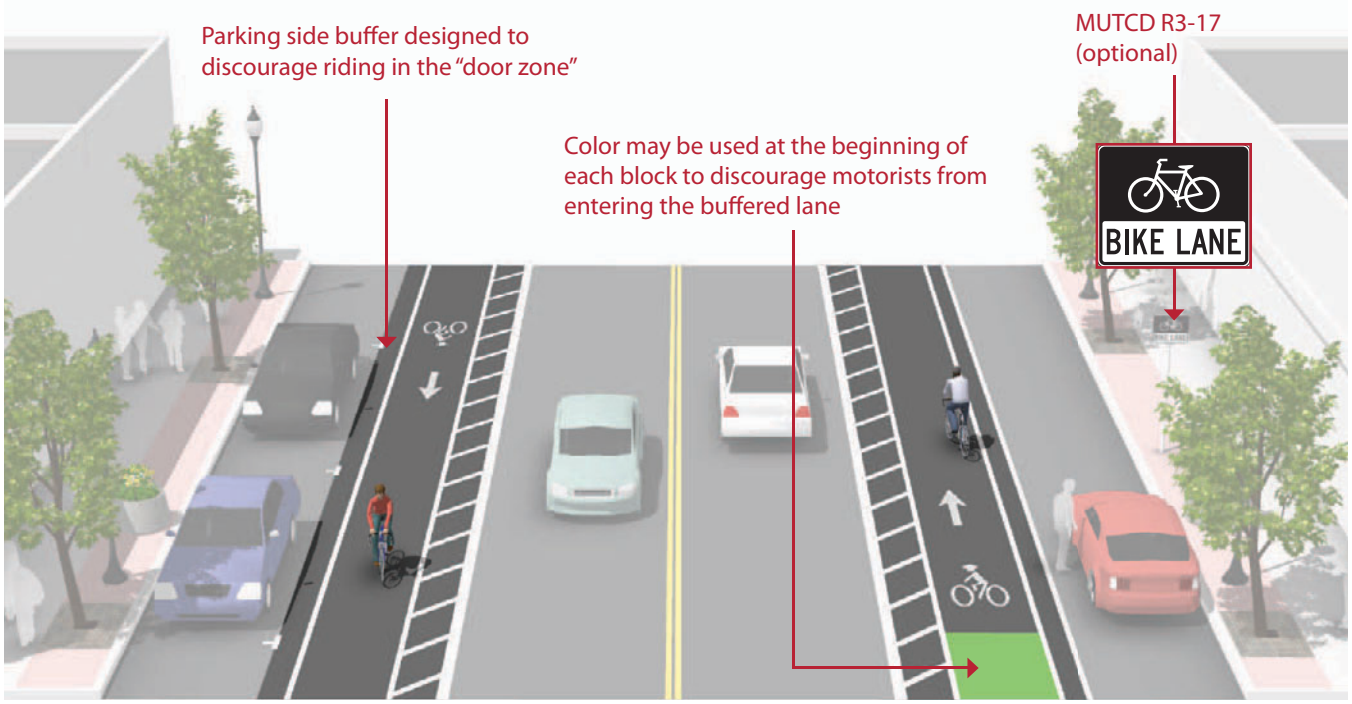
Guidance

- Where bicyclist volumes are high or where bicyclist speed differentials are significant, the desired bicycle travel area width is 7 feet.
- Buffers should be at least 2 feet wide. If 3 feet or wider, mark with diagonal or chevron hatching. For clarity at driveways or minor street crossings, consider a dotted line for the inside buffer boundary where cars are expected to cross.

Description

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 are allowed as per MUTCD guidelines for buffered preferential lanes (section 3D-01).

Buffered bike lanes are designed to increase the space between the bike lane and the travel lane 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.



Discussion

Frequency of right turns by motor vehicles at major intersections should determine whether continuous or truncated buffer striping should be used approaching the intersection. Commonly configured as a buffer between the bicycle lane and motor vehicle travel lane, a parking side buffer may also be provided to help bicyclists avoid the 'door zone' of parked cars.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices. (3D-01)
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Paint can wear more quickly in high traffic areas or in winter climates. Bicycle lanes should be cleared of snow through routine snow removal operations.

Cycle Tracks

A cycle track 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 cycle track is physically separated from motor traffic and distinct from the sidewalk. Cycle tracks 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, cycle tracks are located to the curb-side of the parking, (in contrast to bike lanes).

Cycle tracks may be one-way or two-way, and may be at street level, sidewalk level or at an intermediate level. If at sidewalk level, a curb or median separates them from motor traffic, while different pavement color/texture separates the cycle track from the sidewalk. If at street level, they can be separated from motor traffic by raised medians, on-street parking or bollards.

A two-way cycle track is desirable when more destinations are on one side of a street (therefore preventing additional crossings), if the facility connects to a path or other bicycle facility on one side of the street, or if there is not enough room for a cycle track on both sides of the road.

By separating bicyclists from motor traffic, cycle tracks can offer a higher level of comfort than bike lanes and are attractive to a wider spectrum of the public.

Intersections and approaches must be carefully designed to promote safety and facilitate left-turns from the right side of the street. See **separated bikeways at intersections** for more information.

One Way Cycle Tracks

Two-Way Cycle Tracks

This section includes:

Cycle Tracks

- Cycle Track Separation and Placement
- One-Way Cycle Tracks
- Two-Way Cycle Tracks

Cycle Tracks

Cycle Track Separation and Placement

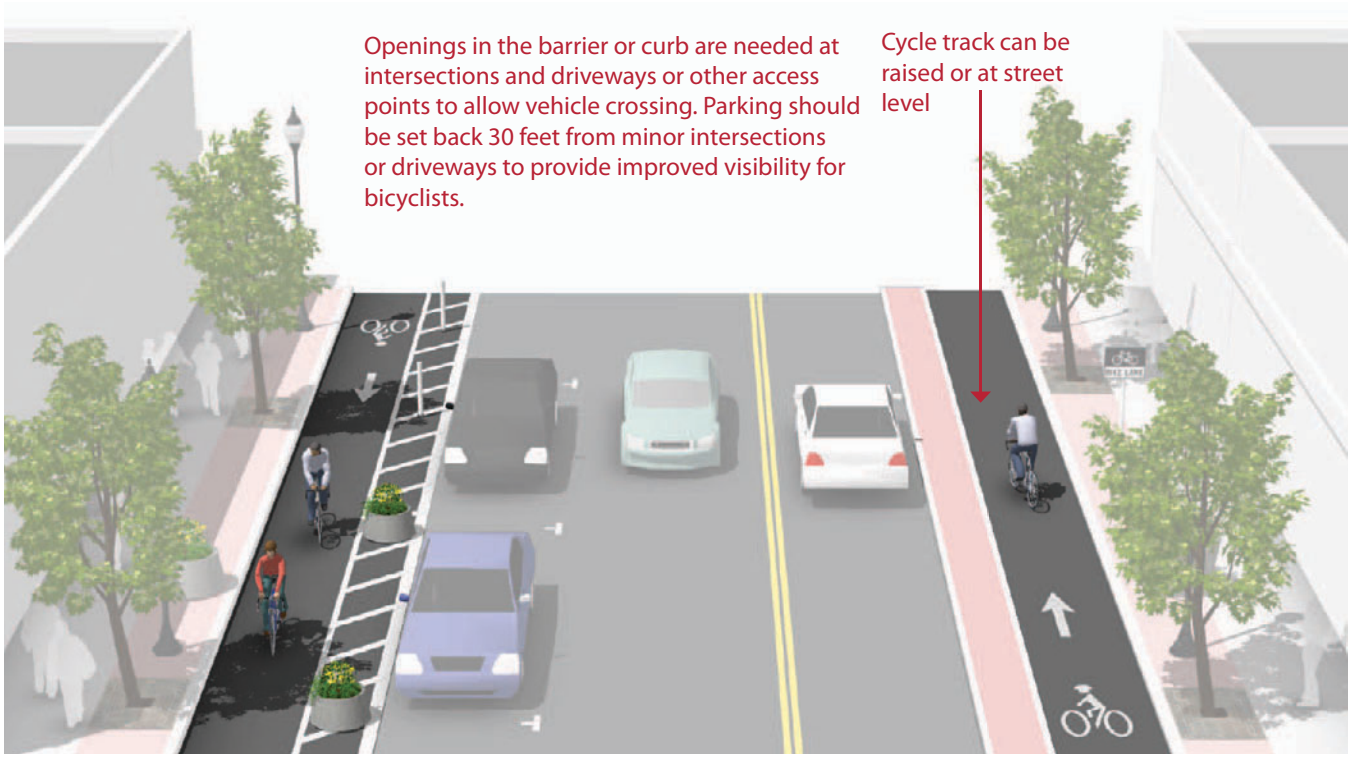
Guidance

- Cycle tracks should ideally be placed along streets with long blocks and few driveways or mid-block access points for motor vehicles. Cycle tracks located on one-way streets have fewer potential conflict areas than those on two-way streets.
- In situations where on-street parking is allowed, cycle tracks shall be located between the parking lane and the sidewalk (in contrast to bike lanes).

Description

Protection is provided through physical barriers and can include bollards, parking, a planter strip, an extruded curb, or on-street parking. Cycle tracks using these protection elements typically share the same elevation as adjacent travel lanes.

Raised cycle tracks may be at the level of the adjacent sidewalk or set at an intermediate level between the roadway and sidewalk to separate the cycle track from the pedestrian area.



Discussion

Sidewalks or other pedestrian facilities should not be narrowed to accommodate the cycle track as pedestrians will likely walk on the cycle track if sidewalk capacity is reduced. Visual and physical cues (e.g., pavement markings & signage) should be used to make it clear where bicyclists and pedestrians should be travelling. If possible, separate the cycle track and pedestrian zone with a furnishing zone.

Additional References and Guidelines

NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

In cities with winter climates barrier separated and raised cycle tracks may require special equipment for snow removal.

Cycle Tracks

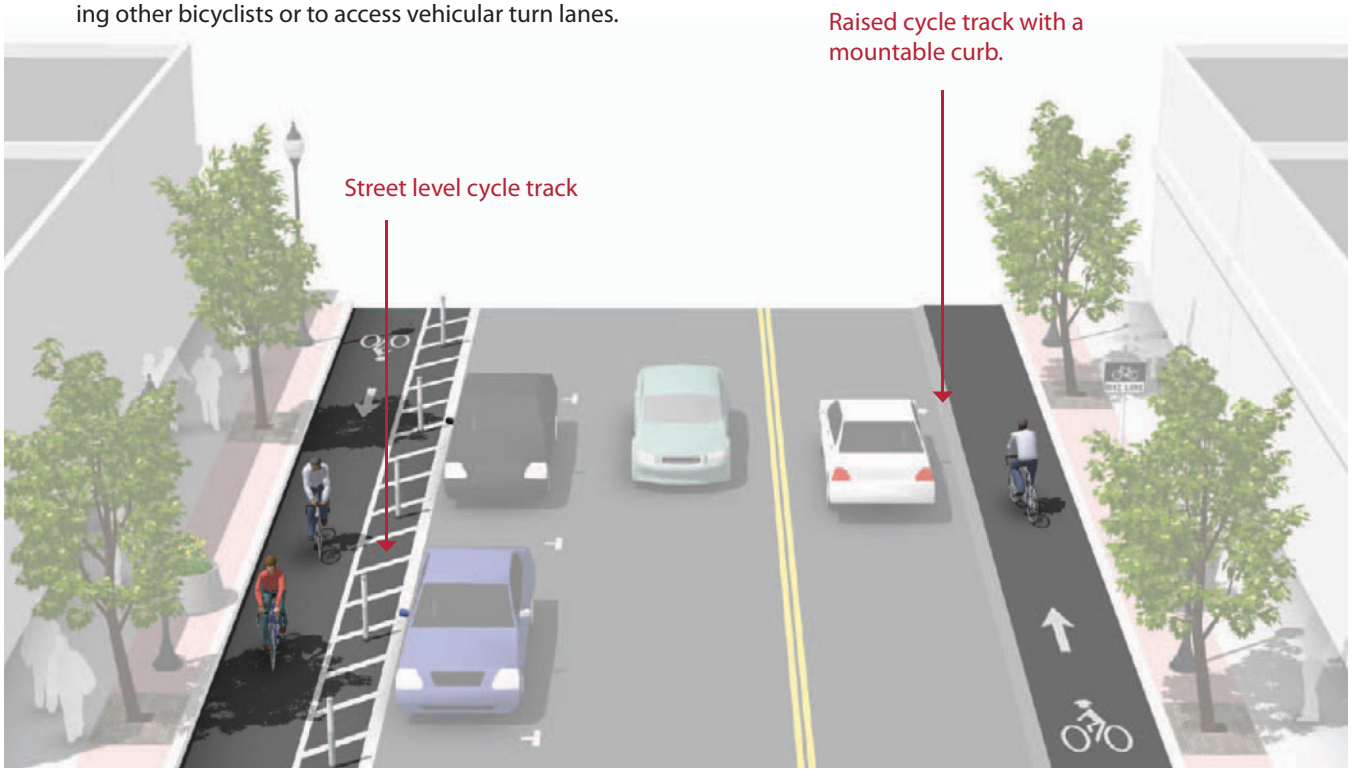
One-Way Cycle Tracks

Guidance

- 7 foot recommended minimum to allow passing.
- 5 foot minimum width in constrained locations.
- When placed adjacent to parking, the parking buffer should be three feet wide to allow for passenger loading and to prevent door collisions.
- When placed adjacent to a travel lane, one-way raised cycle tracks may be configured with a mountable curb to allow entry and exit from the bicycle lane for passing other bicyclists or to access vehicular turn lanes.

Description

One-way cycle tracks are physically separated from motor traffic and distinct from the sidewalk. Cycle tracks are either raised or at street level and use a variety of elements for physical protection from passing traffic.



Discussion

Special consideration should be given at transit stops to manage bicycle and pedestrian interactions. Driveways and minor street crossings are unique challenges to cycle track design. Parking should be prohibited within 30 feet of the intersection to improve visibility. Color, yield markings and "Yield to Bikes" signage should be used to identify the conflict area and make it clear that the cycle track has priority over entering and exiting traffic. If configured as a raised cycle track, the crossing should be raised so that the sidewalk and cycle track maintain their elevation through the crossing.

Additional References and Guidelines

NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

In cities with winter climates barrier separated and raised cycle tracks may require special equipment for snow removal.

Cycle Tracks

Two-Way Cycle Tracks

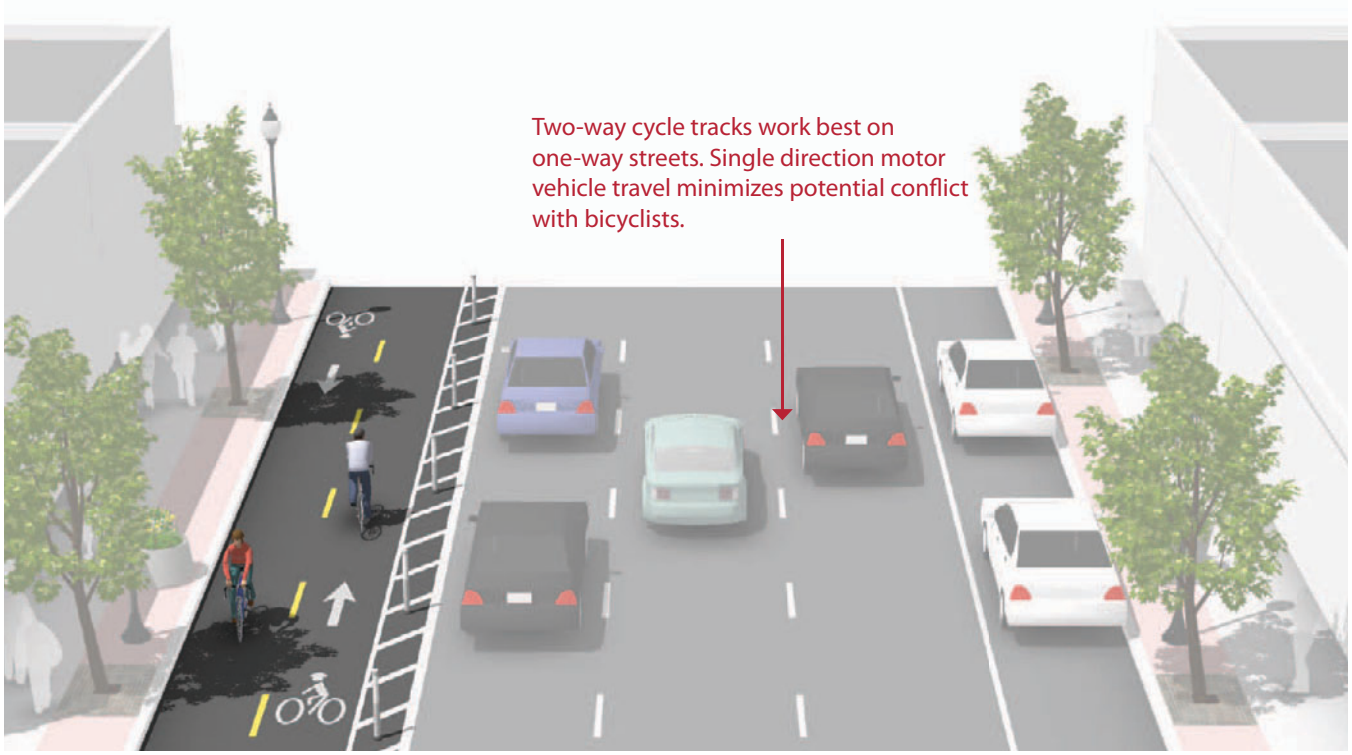
Guidance

- 12 foot recommended minimum for two-way facility
- 8 foot minimum in constrained locations
- When placed adjacent to parking, the parking buffer should be three feet wide to allow for passenger loading and to prevent door collisions.

Description

Two-way cycle tracks are physically separated cycle tracks that allow bicycle movement in both directions on one side of the road. Two-way cycle tracks share some of the same design characteristics as **one-way cycle tracks**, but may require additional considerations at driveway and side-street crossings.

A two-way cycle track may be configured as a protected cycle track at street level with a parking lane or other barrier between the cycle track and the motor vehicle travel lane and/or as a raised cycle track to provide vertical separation from the adjacent motor vehicle lane.



Discussion

Two-way cycle tracks require a higher level of control at intersections to allow for a variety of turning movements. These movements should be guided by separated signals for bicycles and motor vehicles. Transitions into and out of two-way cycle tracks should be simple and easy to use to deter bicyclists from continuing to ride against the flow of traffic.

At driveways and minor intersections, bicyclists riding against roadway traffic in two-way cycle tracks may surprise pedestrians and drivers not expecting bidirectional travel. Appropriate signage is recommended.

Additional References and Guidelines

NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

In cities with winter climates barrier separated and raised cycle tracks may require special equipment for snow removal.

Separated Bikeways at Intersections

Intersections are junctions at which different modes of transportation meet and facilities overlap. An intersection facilitates the interchange between bicyclists, motorists, pedestrians and other modes in order to advance traffic flow in a safe and efficient manner. Designs for intersections with bicycle facilities should reduce conflict between bicyclists (and other vulnerable road users) and vehicles by heightening the level of visibility, denoting clear right-of-way and facilitating eye contact and awareness with other modes. Intersection treatments can improve both queuing and merging maneuvers for bicyclists, and are often coordinated with timed or specialized signals.

The configuration of a safe intersection for bicyclists may include elements such as color, signage, medians, signal detection and pavement markings. Intersection design should take into consideration existing and anticipated bicyclist, pedestrian and motorist movements. In all cases, the degree of mixing or separation between bicyclists and other modes is intended to reduce the risk of crashes and increase bicyclist comfort. The level of treatment required for bicyclists at an intersection will depend on the bicycle facility type used, whether bicycle facilities are intersecting, and the adjacent street function and land use.

This section includes:

- Bike Boxes
- Bike Lanes at Right Turn Only Lanes
- Colored Bike Lanes in Conflict Areas
- Shared Bicycle/Right Turn Lanes
- Intersection Crossing Markings
- Bicycles at Single Lane Roundabouts
- Bicycles at High Speed Interchanges

Bike Boxes

Colored Bike Lanes in Conflict Areas

Bike Lanes at Right Turn Only Lanes

Shared Bicycle/Right Turn Lane

Intersection Crossing Markings

Bicycles at Roundabouts

Separated Bikeways at Intersections

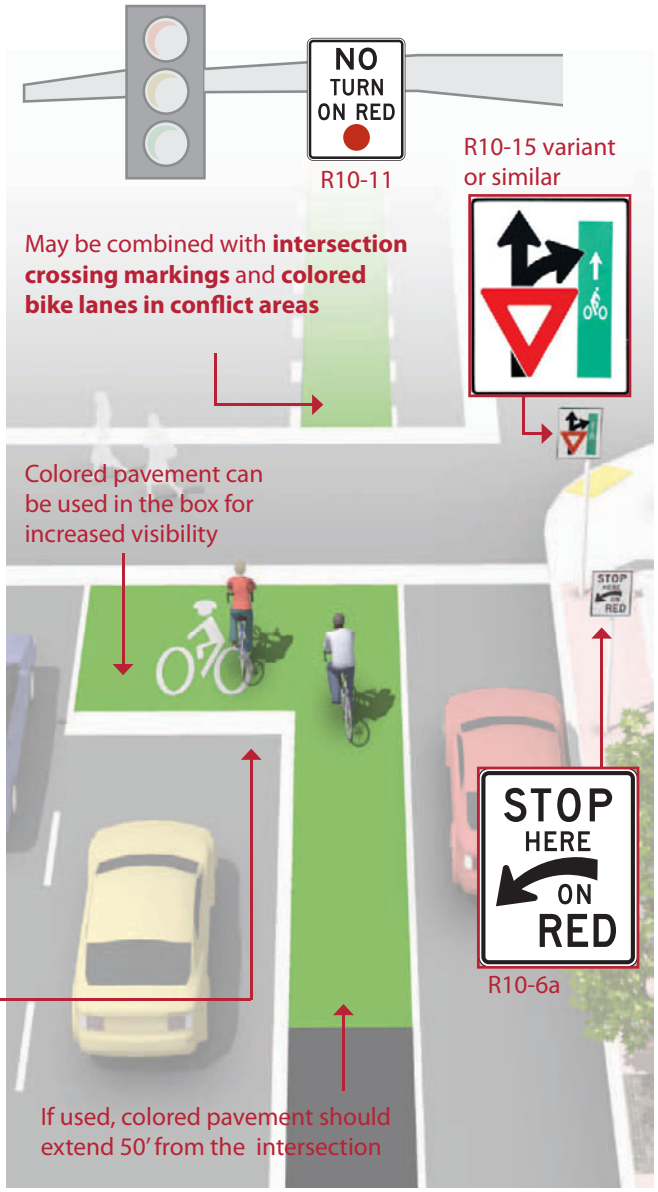
Bike Box

Description

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.

Guidance

- 14' minimum depth
- A "No Turn on Red" (MUTCD R10-11) sign shall be installed overhead to prevent vehicles from entering the Bike Box.
- A "Stop Here on Red" sign should be post-mounted at the stop line to reinforce observance of the stop line.
- A "Yield to Bikes" sign should be post-mounted in advance of and in conjunction with an egress lane to reinforce that bicyclists have the right-of-way going through the intersection.
- An ingress lane should be used to provide access to the box.
- A supplemental "Wait Here" legend can be provided in advance of the stop bar to increase clarity to motorists.



Discussion

Bike boxes should be placed only at signalized intersections, and right turns on red shall be prohibited for motor vehicles. Bike boxes should be used in locations that have a large volume of bicyclists and are best utilized in central areas where traffic is usually moving more slowly. Prohibiting right turns on red improves safety for bicyclists yet does not significantly impede motor vehicle travel.

Additional References and Guidelines

NACTO. (2011). Urban Bikeway Design Guide.
FHWA. (2011). Interim Approval (IA-14) has been granted. Requests to use green colored pavement need to comply with the provisions of Paragraphs 14 through 22 of Section 1A.10

Materials and Maintenance

Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

Separated Bikeways at Intersections

Bike Lanes at Right Turn Only Lanes

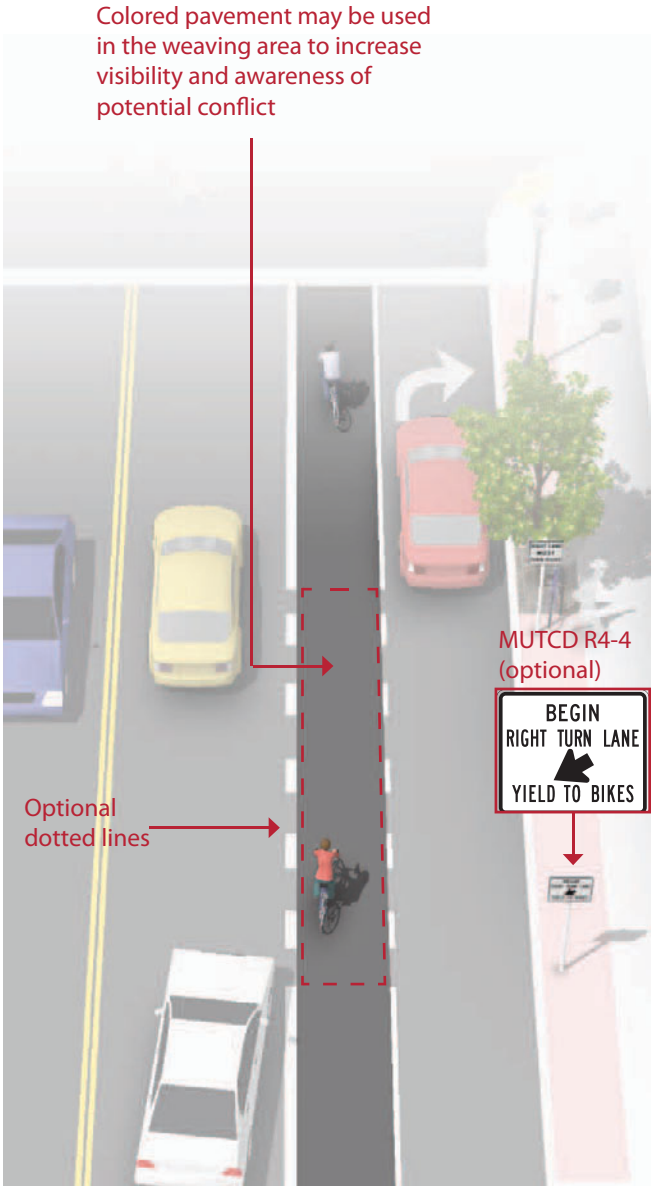
Description

The appropriate treatment at right-turn lanes is to place the bike lane between the right-turn lane and the right-most through lane or, where right-of-way is insufficient, to use a **shared bike lane/turn lane**.

The design (right) illustrates a bike lane pocket, with signage indicating that motorists should yield to bicyclists through the conflict area.

Guidance

- Continue existing bike lane width; standard width of 5 to 6 feet or 4 feet in constrained locations.
- Use signage to indicate that motorists should yield to bicyclists through the conflict area.
- Consider using **colored conflict areas** to promote visibility of the mixing zone.



Discussion

For other potential approaches to providing accommodations for bicyclists at intersections with turn lanes, please see **shared bike lane/turn lane**, bicycle signals, and **colored bike facilities**.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

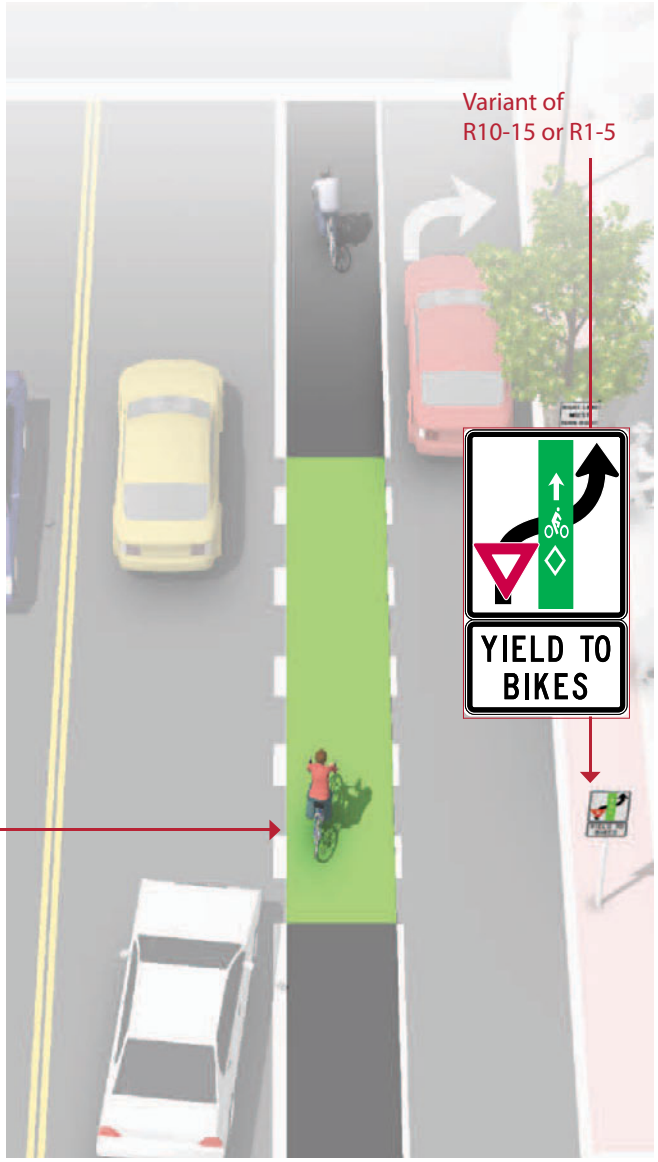
Colored Bike Lanes in Conflict Areas

Description

Colored pavement within a bicycle lane increases the visibility of the facility and reinforces priority of bicyclists in conflict areas.

Guidance

- Green colored pavement was given interim approval by the Federal Highways Administration in March 2011. See interim approval for specific color standards.
- The colored surface should be skid resistant and retro-reflective.
- A "Yield to Bikes" sign should be used at intersections or driveway crossings to reinforce that bicyclists have the right-of-way in colored bike lane areas.



Discussion

Evaluations performed in Portland, OR, St. Petersburg, FL and Austin, TX found that significantly more motorists yielded to bicyclists and slowed or stopped before entering the conflict area after the application of the colored pavement when compared with an uncolored treatment.

Additional References and Guidelines

FHWA. (2011). Interim Approval (IA-14) has been granted. Requests to use green colored pavement need to comply with the provisions of Paragraphs 14 through 22 of Section 1A.10
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Because the effectiveness of markings depends entirely on their visibility, maintaining markings should be a high priority.

Separated Bikeways at Intersections

Shared Bike Lane / Turn Lane

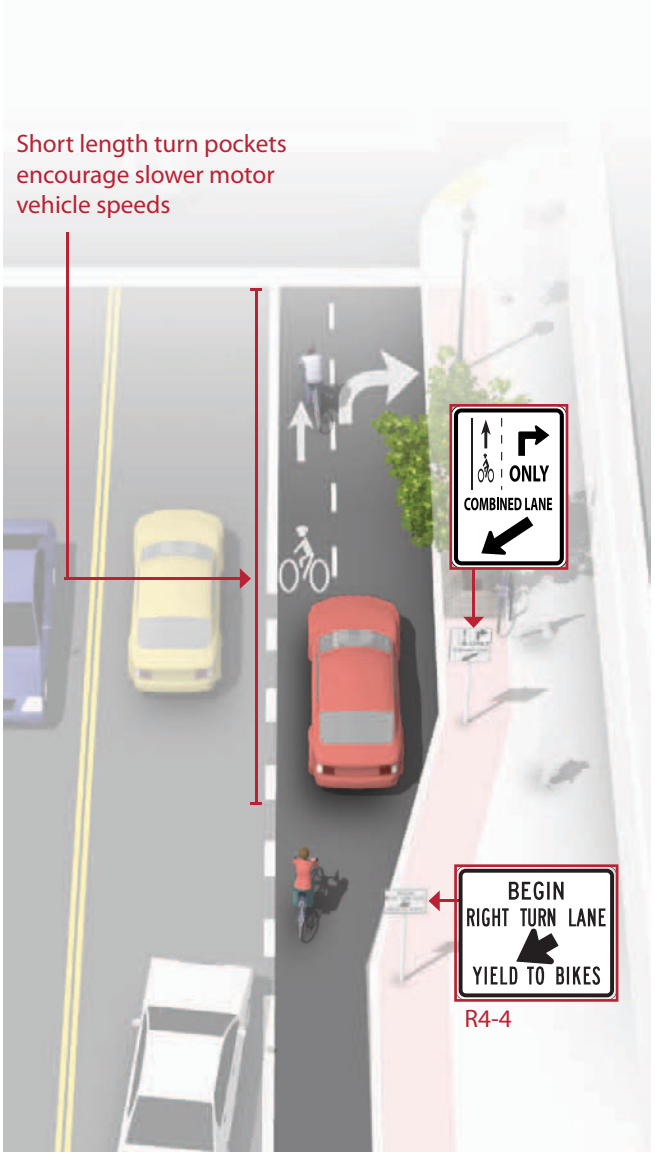
Description

The shared bicycle/right turn lane places a standard-width bike lane on the left side of a dedicated right turn lane. A dotted line delineates the space for bicyclists and motorists within the shared lane. This treatment includes signage advising motorists and bicyclists of proper positioning within the lane.

This treatment is recommended at intersections lacking sufficient space to accommodate both a standard **through bike lane** and right turn lane.

Guidance

- Maximum shared turn lane width is 13 feet.
- Bike Lane pocket should have a minimum width of 4 feet with 5 feet preferred.
- A dotted 4 inch line and bicycle lane marking should be used to clarify bicyclist positioning within the combined lane, without excluding cars from the suggested bicycle area.
- A "Right Turn Only" sign with an "Except Bicycles" plaque may be needed to make it legal for through bicyclists to use a right turn lane.



Discussion

Case studies cited by the Pedestrian and Bicycle Information Center indicate that this treatment works best on streets with lower posted speeds (30 MPH or less) and with lower traffic volumes (10,000 ADT or less). May not be appropriate for high-speed arterials or intersections with long right turn lanes. May not be appropriate for intersections with large percentages of right-turning heavy vehicles.

Additional References and Guidelines

NACTO. (2011). Urban Bikeway Design Guide.
This treatment is currently slated for inclusion in the next edition of the AASHTO Guide for the Development of Bicycle Facilities

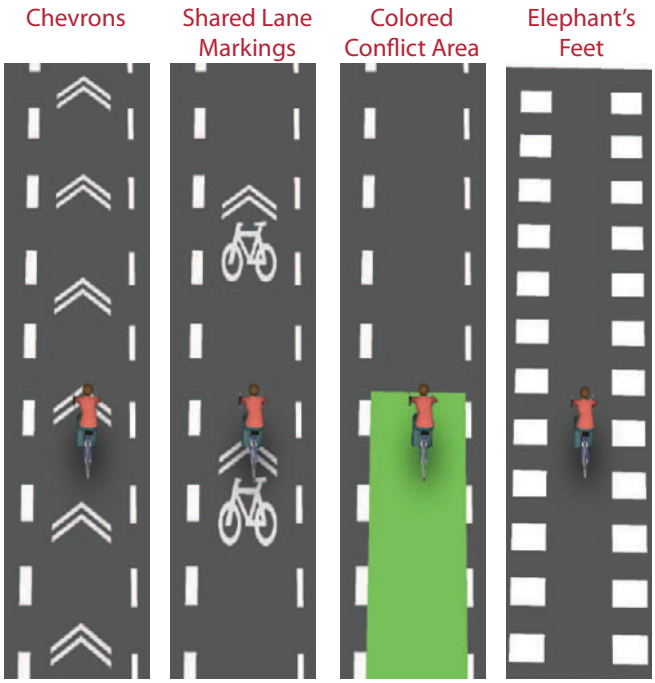
Materials and Maintenance

Locate markings out of tire tread to minimize wear. Because the effectiveness of markings depends on their visibility, maintaining markings should be a high priority.

Intersection Crossing Markings

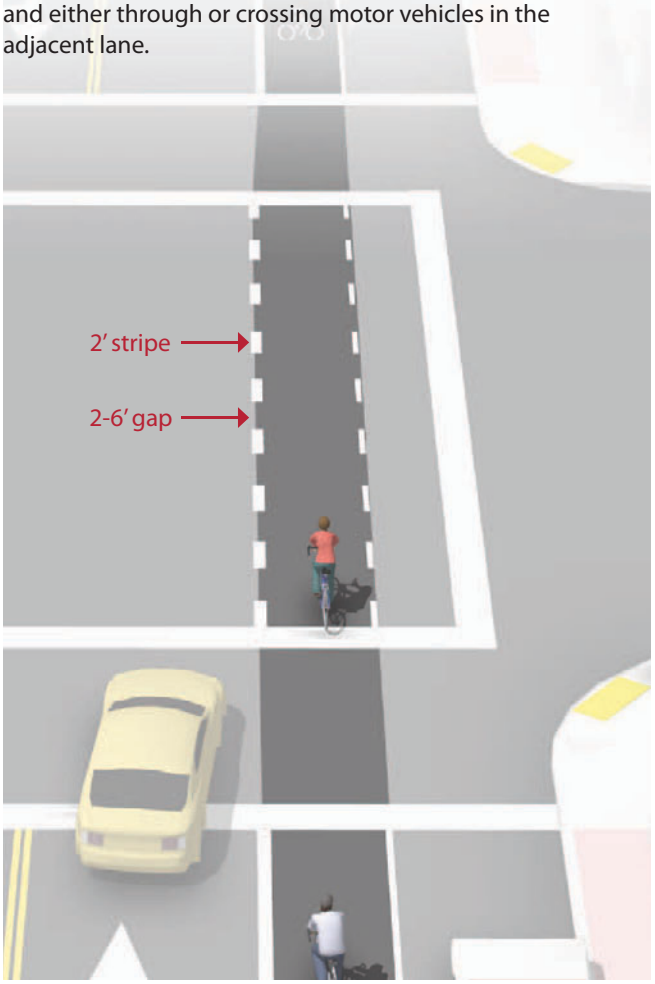
Guidance

- See MUTCD Section 3B.08: "dotted line extensions"
- Crossing striping shall be at least six inches wide when adjacent to motor vehicle travel lanes. Dotted lines should be two-foot lines spaced two to six feet apart.
- Chevrons, shared lane markings, or **colored bike lanes in conflict areas** may be used to increase visibility within conflict areas or across entire intersections. Elephant's Feet markings are common in Europe and Canada.



Description

Bicycle pavement markings through intersections indicate the intended path of bicyclists through an intersection or across a driveway or ramp. They guide bicyclists on a safe and direct path through the intersection and provide a clear boundary between the paths of through bicyclists and either through or crossing motor vehicles in the adjacent lane.



Discussion

Additional markings such as chevrons, shared lane markings, or **colored bike lanes in conflict areas** are strategies currently in use in the United States and Canada. Cities considering the implementation of markings through intersections should standardize future designs to avoid confusion.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices. (3A.06)
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Because the effectiveness of marked crossings depends entirely on their visibility, maintaining marked crossings should be a high priority.

Separated Bikeways at Intersections

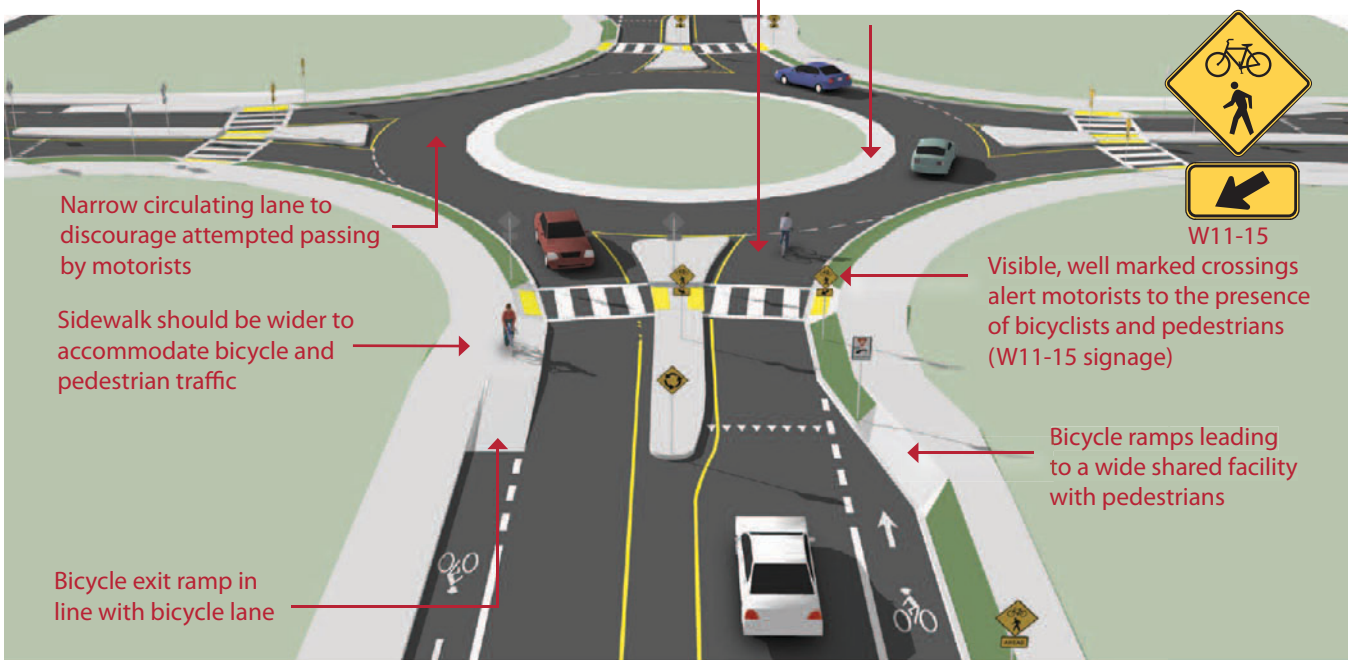
Bicyclists at Single Lane Roundabouts

Guidelines

- 25 mph maximum circulating design speed.
- Design approaches/exits to the 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 navigate the roundabout on the roadway.

Description

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



Discussion

Research indicates that while single-lane roundabouts may benefit bicyclists and pedestrians by slowing traffic, multi-lane roundabouts may present greater challenges and significantly increase safety problems for these users.

Additional References and Guidelines

FHWA. (2000). Roundabouts: An Informational Guide
FHWA. (2010). Roundabouts: An Informational Guide, Second Edition. NCHRP 672

Materials and Maintenance

Signage and striping require routine maintenance.

Separated Bikeways at Intersections

Bike Lanes at High Speed Interchanges

Guidance

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.

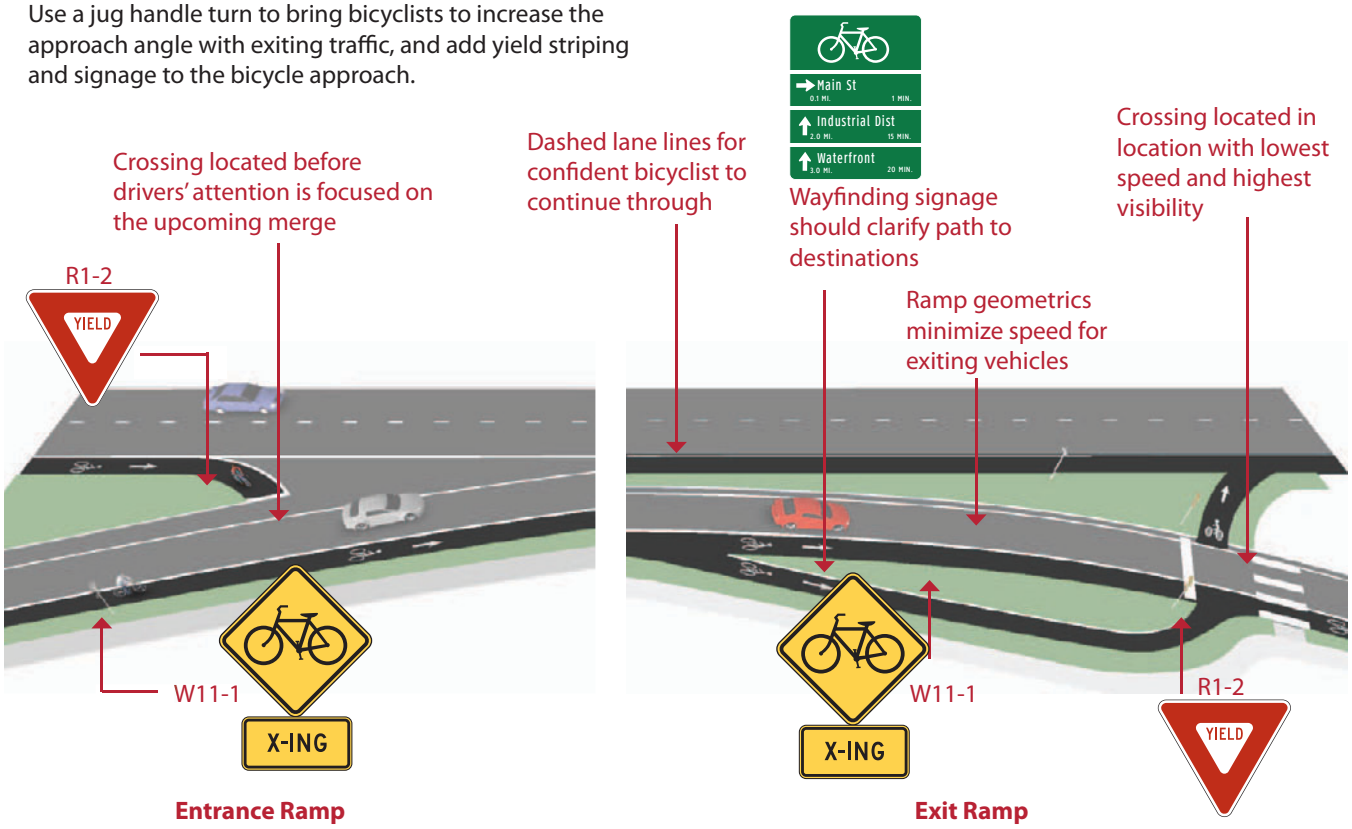
Exit Ramps:

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.

Description

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.



Discussion

While the jug-handle approach is the preferred configuration at exit ramps, provide the option for through bicyclists to perform a vehicular merge and proceed straight through under safe conditions.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices.
Bicycle and Pedestrian Transportation. Lesson 15: Bicycle Lanes

Materials and Maintenance

Locate markings out of wheel tread when possible to minimize wear and maintenance costs.

Bikeway Signing

The ability to navigate through a city is informed by landmarks, natural features and other visual cues. Signs throughout the city should indicate to bicyclists:

- Direction of travel
- Location of destinations
- Travel time/distance to those destinations

These signs will increase users' comfort and accessibility to the bicycle systems.

Signage can serve both wayfinding and safety purposes including:

- Helping to familiarize users with the bicycle network
- Helping users identify the best routes to destinations
- Helping to address misperceptions about time and distance
- Helping overcome a "barrier to entry" for people who are not frequent bicyclists (e.g., "interested but concerned" bicyclists)

A community-wide bicycle wayfinding signage plan would identify:

- Sign locations
- Sign type – what information should be included and design features
- Destinations to be highlighted on each sign – key destinations for bicyclists
- Approximate distance and travel time to each destination

Bicycle wayfinding signs also visually cue motorists that they are driving along a bicycle route and should use caution. Signs are typically placed at key locations leading to and along bicycle routes, including the intersection of multiple routes. Too many road signs tend to clutter the right-of-way, and it is recommended that these signs be posted at a level most visible to bicyclists rather than per vehicle signage standards.

Wayfinding Sign Types

Wayfinding Sign Placement

This section includes:

- Wayfinding Sign Types
- Wayfinding Sign Placement

Bikeway Signing

Wayfinding Sign Types

Description

A bicycle wayfinding system consists of comprehensive signing and/or pavement markings to guide bicyclists to their destinations along preferred bicycle routes. There are three general types of wayfinding signs:

Confirmation Signs

Indicate to bicyclists that they are on a designated bikeway. Make motorists aware of the bicycle route.

Can include destinations and distance/time. Do not include arrows.

Turn Signs

Indicate where a bikeway turns from one street onto another street. Can be used with pavement markings.

Include destinations and arrows.

Decisions Signs

Mark the junction of two or more bikeways.

Inform bicyclists of the designated bike route to access key destinations.

Destinations and arrows, distances and travel times are optional but recommended.

Discussion

There is no standard color for bicycle wayfinding signage. Section 1A.12 of the MUTCD establishes the general meaning for signage colors. Green is the color used for directional guidance and is the most common color of bicycle wayfinding signage in the US, including those in the MUTCD.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices.
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Maintenance needs for bicycle wayfinding signs are similar to other signs and will need periodic replacement due to wear.

Bikeway Signing

Wayfinding Sign Placement

Guidance

Signs are typically placed at decision points along bicycle routes – typically at the intersection of two or more bikeways and at other key locations leading to and along bicycle routes.

Decisions Signs

Near-side of intersections in advance of a junction with another bicycle route.

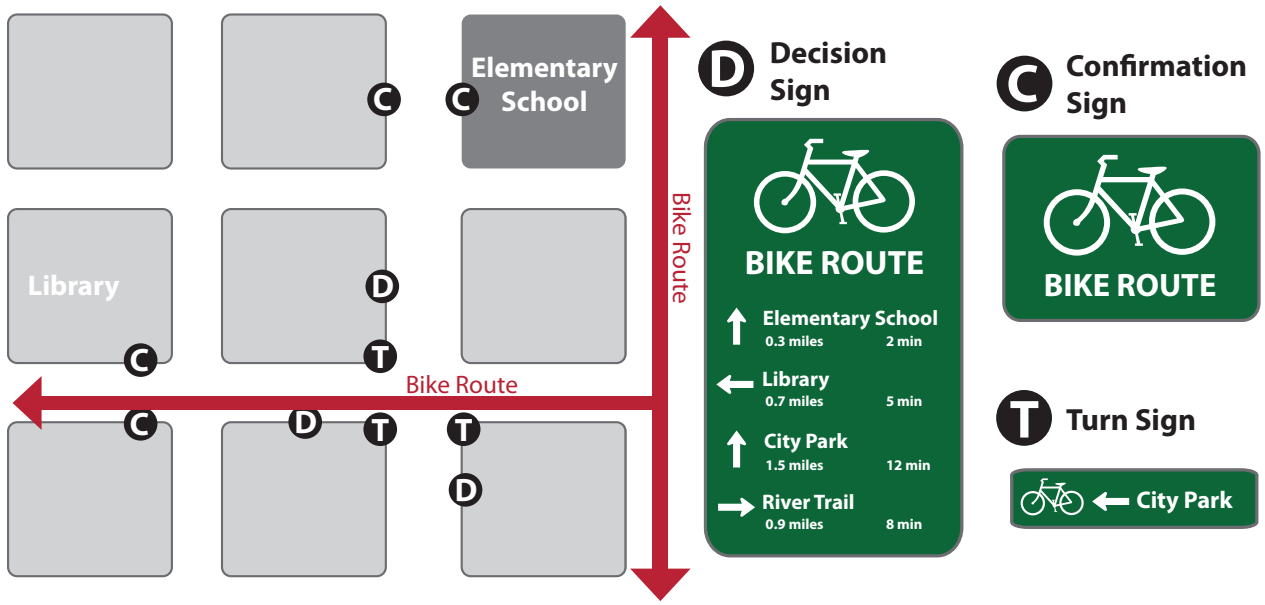
Along a route to indicate a nearby destination.

Confirmation Signs

Every ¼ to ½ mile on off-street facilities and every 2 to 3 blocks along on-street bicycle facilities, unless another type of sign is used (e.g., within 150 ft of a turn or decision sign). Should be placed soon after turns to confirm destination(s). Pavement markings can also act as confirmation that a bicyclist is on a preferred route.

Turn Signs

Near-side of intersections where bike routes turn (e.g., where the street ceases to be a bicycle route or does not go through). Pavement markings can also indicate the need to turn to the bicyclist.



Discussion

It can be useful to classify a list of destinations for inclusion on the signs based on their relative importance to users throughout the area. A particular destination's ranking in the hierarchy can be used to determine the physical distance from which the locations are signed. For example, primary destinations (such as the downtown area) may be included on signage up to five miles away. Secondary destinations (such as a transit station) may be included on signage up to two miles away. Tertiary destinations (such as a park) may be included on signage up to one mile away.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices.
NACTO. (2011). Urban Bikeway Design Guide.

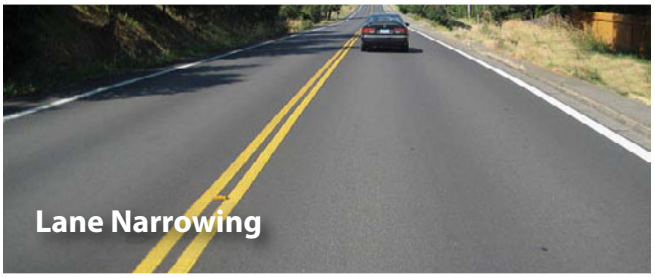
Materials and Maintenance

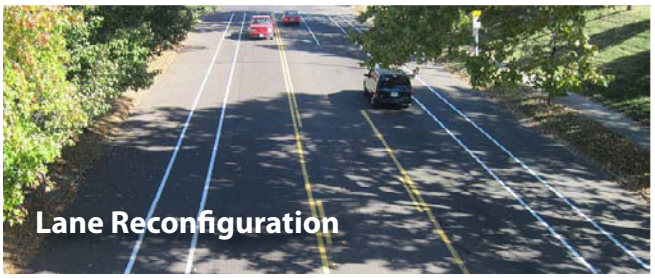
Maintenance needs for bicycle wayfinding signs are similar to other signs and will need periodic replacement due to wear.

Retrofitting Existing Streets to add Bikeways

Most major streets are characterized by conditions (e.g., high vehicle speeds and/or volumes) for which dedicated bike lanes are the most appropriate facility to accommodate safe and comfortable riding. Although opportunities to add bike lanes through roadway widening may exist in some locations, many major streets have physical and other constraints that would require street retrofit measures within existing curb-to-curb widths. As a result, much of the guidance provided in this section focuses on effectively reallocating existing street width through striping modifications to accommodate dedicated bike lanes.

Although largely intended for major streets, these measures may be appropriate for any roadway where bike lanes would be the best accommodation for bicyclists.





This section includes:

- Roadway Widening
- Lane Narrowing
- Lane Reconfiguration
- Parking Reduction

Retrofitting Existing Streets

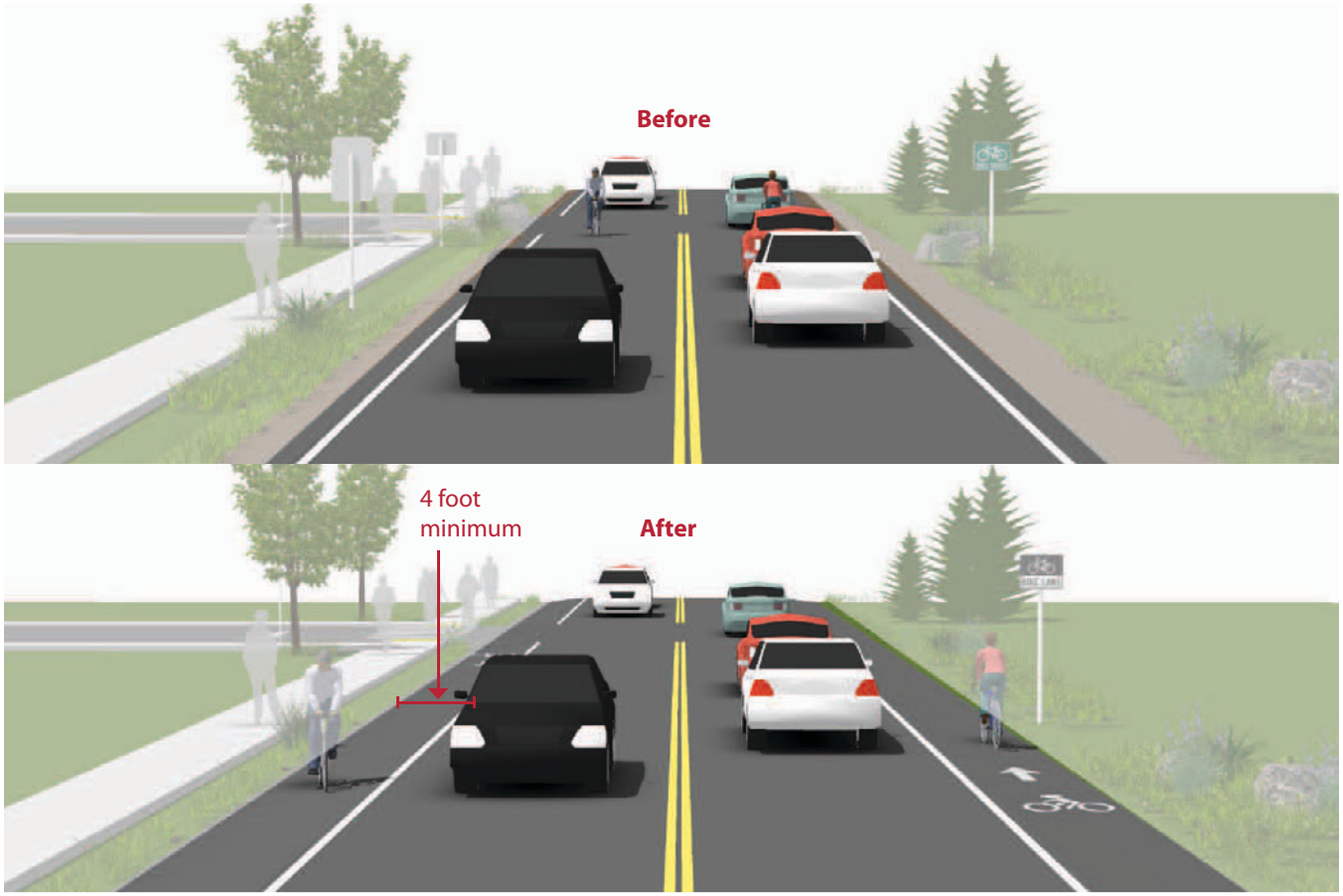
Roadway Widening

Guidance

- Guidance on **bicycle lanes** applies to this treatment.
- 4 foot minimum width when no curb and gutter is present.
- 6 foot width preferred.

Description

Bike lanes can be accommodated on streets with excess right-of-way through shoulder widening. Although roadway widening incurs higher expenses compared with re-striping projects, bike lanes can be added to streets currently lacking curbs, gutters and sidewalks without the high costs of major infrastructure reconstruction.



Discussion

Roadway widening is most appropriate on roads lacking curbs, gutters and sidewalks.

If it is not possible to meet minimum bicycle lane dimensions, a reduced width paved shoulder can still improve conditions for bicyclists on constrained roadways. In these situations, a minimum of 3 feet of operating space should be provided.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.

Materials and Maintenance

The extended bicycle area should not contain any rough joints where bicyclists ride. Saw or grind a clean cut at the edge of the travel lane, or feather with a fine mix in a non-ridable area of the roadway.

Retrofitting Existing Streets

Lane Narrowing

Guidance

Vehicle lane width:

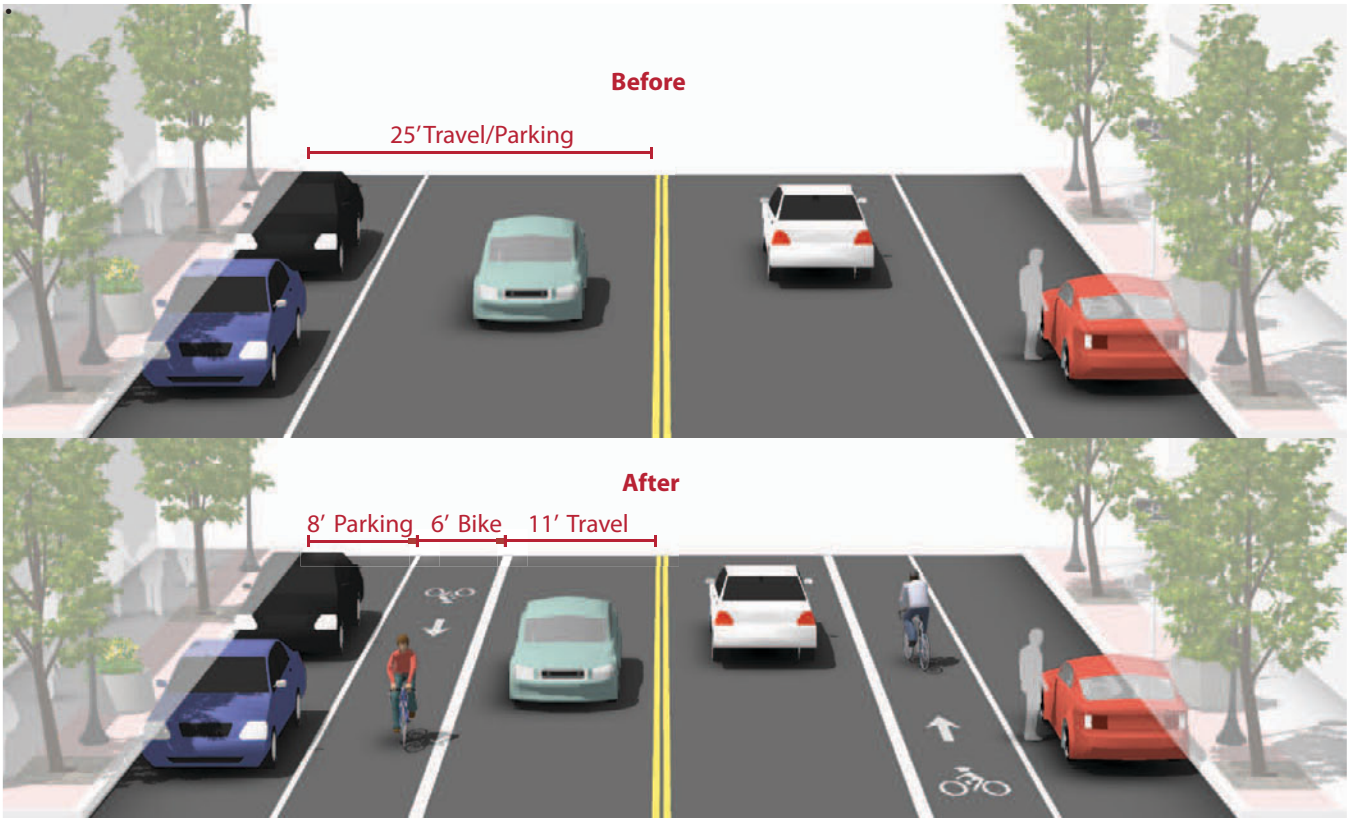
- Before: 10-15 feet
- After: 10-11 feet

Bicycle lane width:

- Guidance on **Bicycle Lanes** applies to this treatment.

Description

Lane narrowing utilizes roadway space that exceeds minimum standards to provide the needed space for bike lanes. Many roadways have existing travel lanes that are wider than those prescribed in local and national roadway design standards, or which are not marked. Most standards allow for the use of 11 foot and sometimes 10 foot wide travel lanes to create space for bike lanes.



Discussion

Roadways designated as being on the National Truck Network or South Carolina Truck Network or roadways where the percentage of trucks, buses, and recreational vehicles is greater than 5 percent of the ADT should have lane widths of 12 feet. Guidance on selecting the proper lane width for a roadway can be found in Chapters 19 through 22 of the SCDOT Highway Design Manual. In Georgia, GDOT requires design variances for lane width reductions below 12' unless a street meets specific criteria, such as low speeds and CBD/Historic District characteristics. AASHTO supports reduced width lanes in *A Policy on Geometric Design of Highways and Streets: "On interrupted-flow operation conditions at low speeds (45 mph or less), narrow lane widths are normally adequate and have some advantages."*

Additional References and Guidelines

AASHTO. (2004). A Policy on Geometric Design of Highways and Streets.
GDOT. (2003). Georgia DOT Bike/Ped Design Policy Memo

Materials and Maintenance

Repair rough or uneven pavement surface. Use bicycle compatible drainage grates. Raise or lower existing grates and utility covers so they are flush with the pavement.

Retrofitting Existing Streets

Lane Reconfiguration

Guidance

Vehicle lane width:

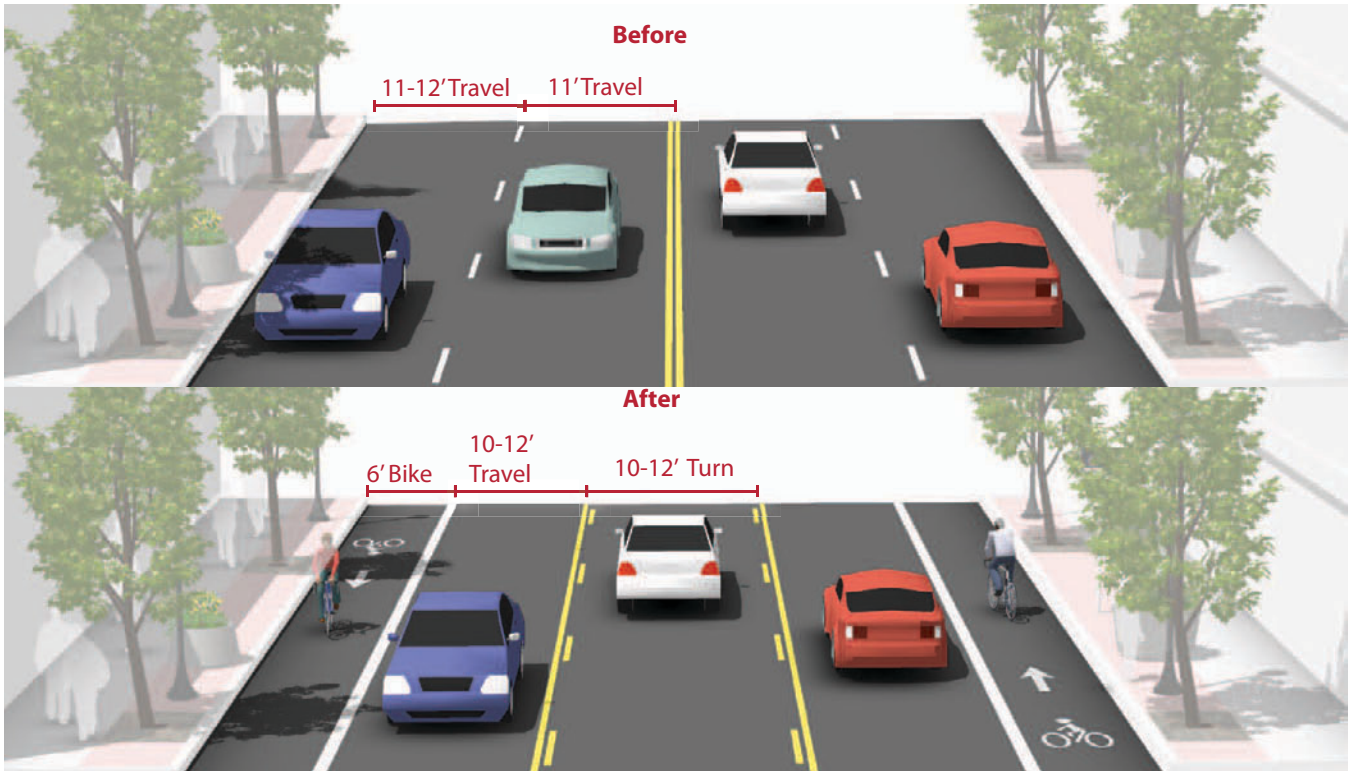
- Width depends on project. No narrowing may be needed if a lane is removed.

Bicycle lane width:

- Guidance on **Bicycle Lanes** applies to this treatment.

Description

The removal of a single travel lane will generally provide sufficient space for bike lanes on both sides of a street. Streets with excess vehicle capacity provide opportunities for bike lane retrofit projects.



Discussion

Depending on a street's existing configuration, traffic operations, user needs and safety concerns, various lane reduction configurations may apply. For instance, a four-lane street (with two travel lanes in each direction) could be modified to provide one travel lane in each direction, a center turn lane, and bike lanes. Prior to implementing this measure, a traffic analysis should identify potential impacts.

Additional References and Guidelines

FHWA. (2010). Evaluation of Lane Reduction "Road Diet" Measures on Crashes. Publication Number: FHWA-HRT-10-053
GDOT. (2003). Georgia DOT Bike/Ped Design Policy Memo

Materials and Maintenance

Repair rough or uneven pavement surface. Use bicycle compatible drainage grates. Raise or lower existing grates and utility covers so they are flush with the pavement.

Retrofitting Existing Streets

Parking Reduction

Guidance

Vehicle lane width:

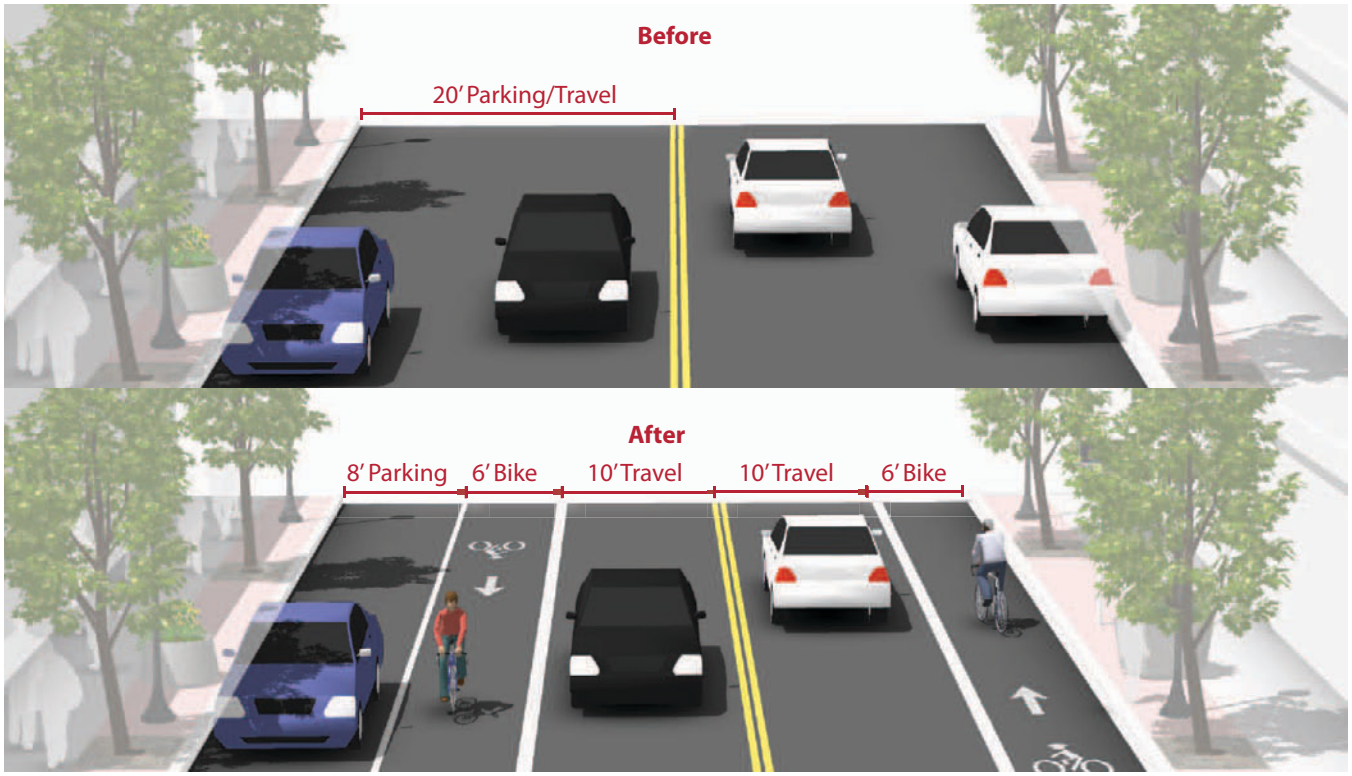
- Parking lane width depends on project. No travel lane narrowing may be required depending on the width of the parking lanes.

Bicycle lane width:

- Guidance on **Bicycle Lanes** applies to this treatment.

Description

Bike lanes can replace one or more on-street parking lanes on streets where excess parking exists and/or the importance of bike lanes outweighs parking needs. For example, parking may be needed on only one side of a street. Eliminating or reducing on-street parking also improves sight distance for bicyclists in bike lanes and for motorists on approaching side streets and driveways.



Discussion

Removing or reducing on-street parking to install bike lanes requires comprehensive outreach to the affected businesses and residents. Prior to reallocating on-street parking for other uses, a parking study should be performed to gauge demand and to evaluate impacts to people with disabilities.

Additional References and Guidelines

AASHTO. (2004). A Policy on Geometric Design of Highways and Streets.

There is no currently adopted Federal or State guidance for this treatment.

Materials and Maintenance

Repair rough or uneven pavement surface. Use bicycle compatible drainage grates. Raise or lower existing grates and utility covers so they are flush with the pavement

Bicycle Support Facilities

Bicycle Parking

Bicyclists expect a safe, convenient place to secure their bicycle when they reach their destination. This may be short term parking of 2 hours or less, or long-term parking for employees, students, residents, and commuters.

Access to Transit

Safe and easy access to bicycle parking facilities is necessary to encourage commuters to access transit via bicycle. Providing bicycle access to transit and space for bicycles on buses can increase the feasibility of transit in lower-density areas, where transit stops are beyond walking distance of many residences. People are often willing to walk only a quarter- to half-mile to a bus stop, while they might bike as much as two or more miles to reach a transit station.

Roadway Construction and Repair

Safety of all roadway users should be considered during road construction and repair. Wherever bicycles are allowed, measures should be taken to provide for the continuity of a bicyclist's trip through a work zone area.

Only in rare cases should pedestrians and bicyclists be detoured to another street when travel vehicle lanes remain open. Contractors performing work should be made aware of the needs of bicyclists and be properly trained in how to safely route bicyclists through or around work zones.

This Section Includes:

- Bicycle Parking
  - Bicycle Racks
  - On-Street Bicycle Corral
  - Bicycle Lockers
- Bicycle Access through Construction Areas
- Bicycle Access to Transit

Short Term Bicycle Parking

Bicycle Racks

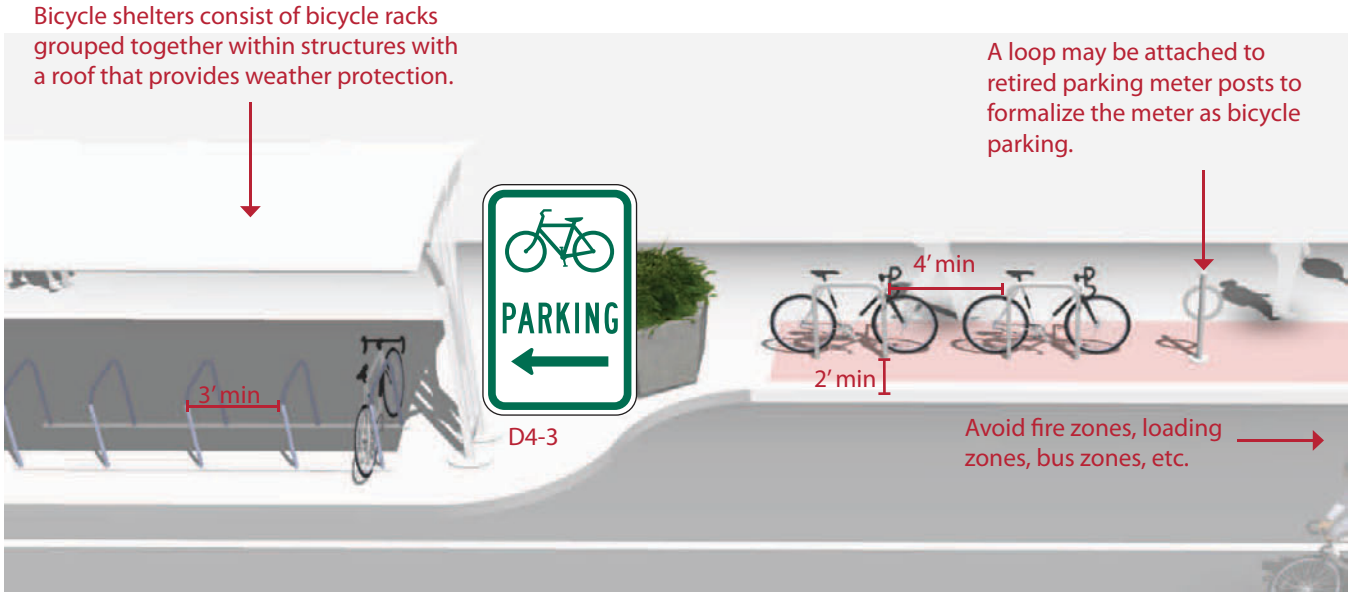
Guidance

- 2' minimum from the curb face to avoid 'dooring.'
- Close to destinations; 50' maximum distance from main building entrance.
- Minimum clear distance of 6' should be provided between the bicycle rack and the property line.
- Should be highly visible from adjacent bicycle routes and pedestrian traffic.
- Locate racks in areas that cyclists are most likely to travel.

Description

Short-term bicycle parking is meant to accommodate visitors, customers, and others expected to depart within two hours. It should have an approved standard rack, appropriate location and placement, and weather protection. The Association for Pedestrian and Bicycle Professionals (APBP) recommends selecting a bicycle track that:

- Supports the bicycle in at least two places, preventing it from falling over.
- Allows locking of the frame and one or both wheels with a U-lock.
- Is securely anchored to ground.
- Resists cutting, rusting and bending or deformation.



Discussion

Where the placement of racks on sidewalks is not possible (due to narrow sidewalk width, sidewalk obstructions, street trees, etc.), bicycle parking can be provided in the street where on-street vehicle parking is allowed in the form of **on-street bicycle corrals**.

Some types of bicycle racks may meet design criteria, but are discouraged except in limited situations. This includes undulating "wave" racks, schoolyard "wheel bender" racks, and spiral racks.

Additional References and Guidelines

APBP. (2010). Bicycle Parking Guide 2nd Edition.

Materials and Maintenance

Use of proper anchors will prevent vandalism and theft. Racks and anchors should be regularly inspected for damage. Educate snow removal crews to avoid burying racks during winter months.

Short Term Bicycle Parking

On-Street Bicycle Corral

Guidance

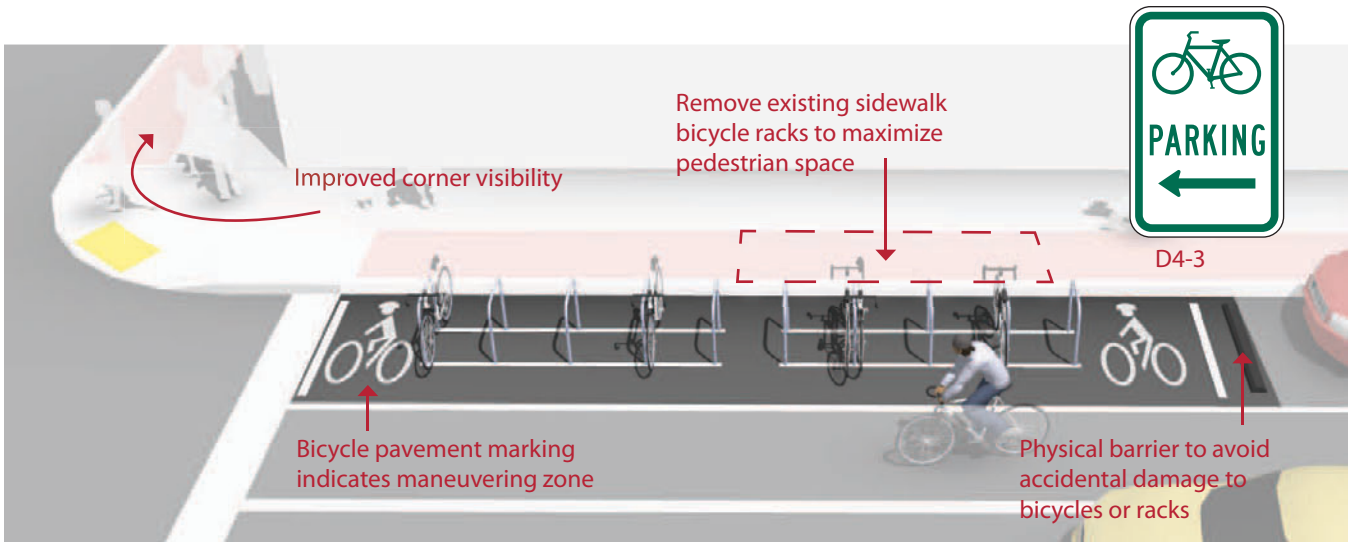
See guidelines for sidewalk **bicycle rack** placement and clear zones.

- Bicyclists should have an entrance width from the roadway of 5′ – 6′.
- Can be used with parallel or angled parking.
- Parking stalls adjacent to curb extensions are good candidates for bicycle corrals since the concrete extension serves as delimitation on one side.

Description

Bicycle corrals (also known as "on-street" bicycle parking) consist of bicycle racks grouped together in a common area within the street traditionally used for automobile parking. Bicycle corrals are reserved exclusively for bicycle parking and provide a relatively inexpensive solution to providing high-volume bicycle parking. Bicycle corrals can be implemented by converting one or two on-street motor vehicle parking spaces into on-street bicycle parking. Each motor vehicle parking space can be replaced with approximately 6-10 bicycle parking spaces.

Bicycle corrals move bicycles off the sidewalks, leaving more space for pedestrians, sidewalk café tables, etc. Because bicycle parking does not block sightlines (as large motor vehicles would do), it may be possible to locate bicycle parking in 'no-parking' zones near intersections and crosswalks.



Discussion

In many communities, the installation of bicycle corrals is driven by requests from adjacent businesses, and is not a city-driven initiative. In such cases, the city does not remove motor vehicle parking unless it is explicitly requested. In other areas, the city provides the facility and business associations take responsibility for the maintenance of the facility. Communities can establish maintenance agreements with the requesting business. Bicycle corrals can be especially effective in areas with high bicycle parking demand or along street frontages with narrow sidewalks where parked bicycles would be detrimental to the pedestrian environment.

Additional References and Guidelines

APBP. (2010). Bicycle Parking Guide 2nd Edition.

Materials and Maintenance

Physical barriers may obstruct drainage and collect debris. Establish a maintenance agreement with neighboring businesses. In snowy climates the bicycle corral may need to be removed during the winter months.

Long Term Bicycle Parking

Bicycle Lockers

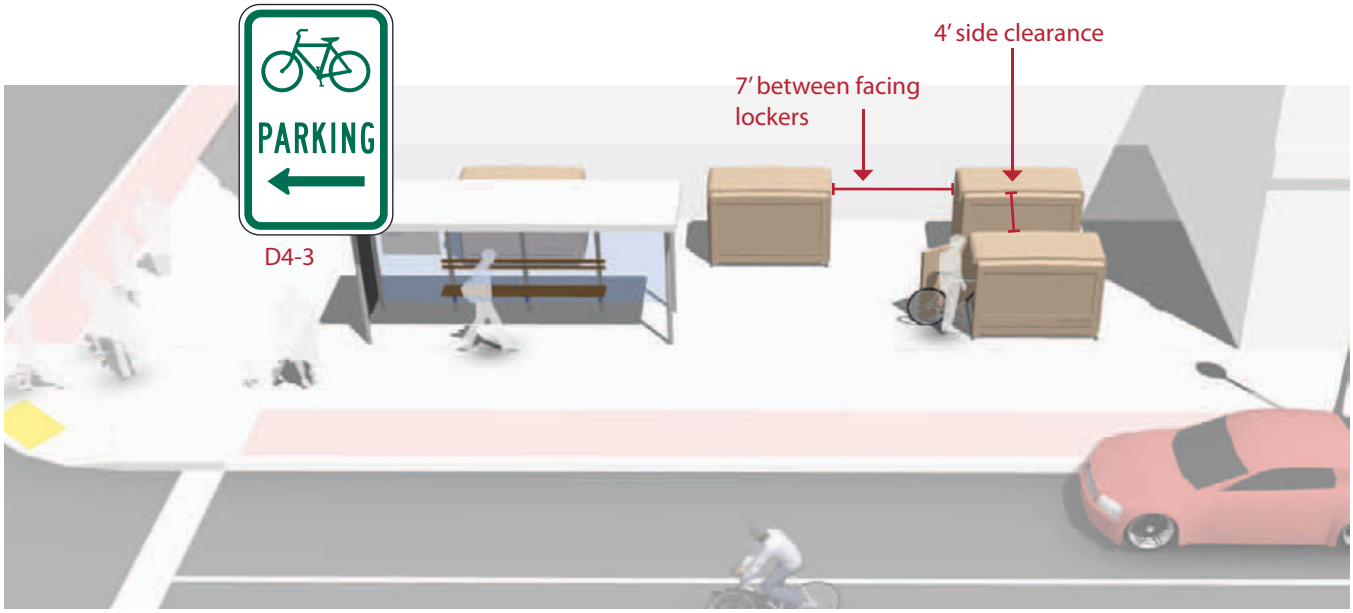
Guidance

- Minimum dimensions: width (opening) 2.5'; height 4'; depth 6'.
- 4 foot side clearance and 6 foot end clearance
- 7 foot minimum distance between facing lockers
- Locker designs that allow visibility and inspection of contents are recommended for increased security.
- Access is controlled by a key or access code.

Description

Bicycle lockers are intended to provide long-term bicycle storage for employees, students, residents, commuters, and others expected to park more than two hours. Long-term facilities protect the entire bicycle, its components and accessories against theft and against inclement weather, including snow and wind-driven rain.

Bicycle lockers provide space to store a few accessories or rain gear in addition to containing the bicycle. Some lockers allow access to two users - a partition separating the two bicycles can help users feel their bike is secure. Lockers can also be stacked, reducing the footprint of the area, although that makes them more difficult to use.



Discussion

Long-term parking facilities are more expensive to provide than short-term facilities, but are also significantly more secure. Although many bicycle commuters would be willing to pay a nominal fee to guarantee the safety of their bicycle, long-term bicycle parking should be free wherever automobile parking is free. Potential locations for long-term bicycle parking include transit stations, large employers, and institutions where people use their bikes for commuting and not consistently throughout the day.

Additional References and Guidelines

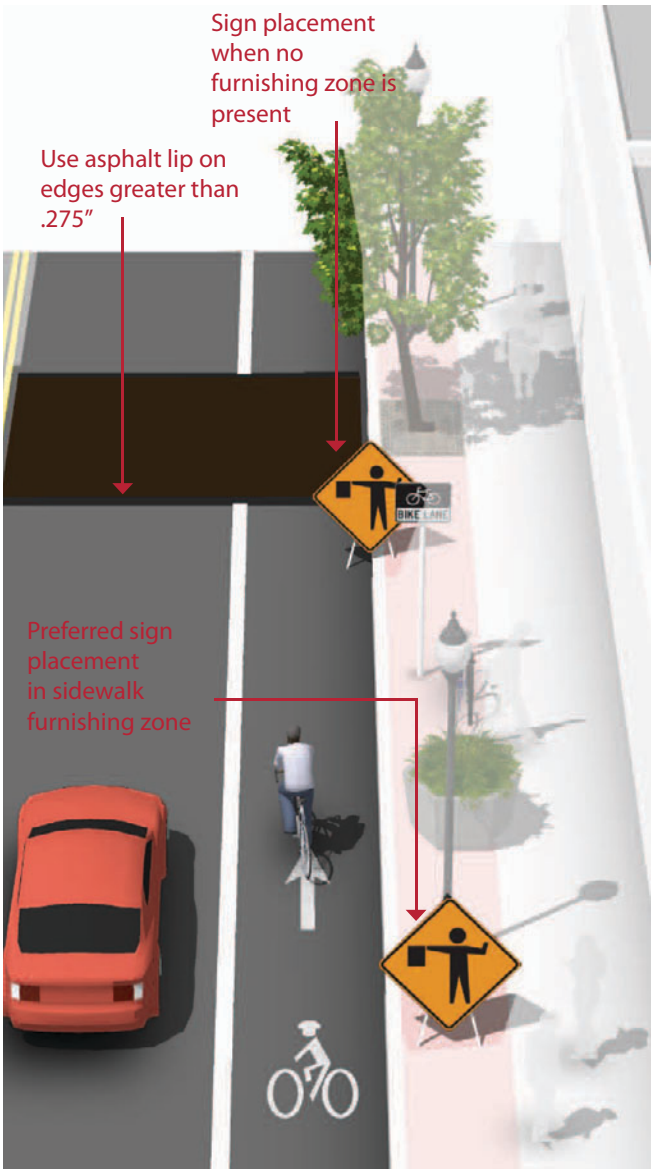
APBP. (2010). Bicycle Parking Guide 2nd Edition.

Materials and Maintenance

Regularly inspect the functioning of moving parts and enclosures. Change keys and access codes periodically to prevent access to unapproved users.

Street Construction and Repair

Bicycle Access Through Construction Areas



Description

Wherever bicycles are allowed, measures should be taken to provide for the continuity of a bicyclist's trip through a work zone area. Bicyclists should not be led into conflicts with work site vehicles, equipment, moving vehicles, open trenches, or temporary construction signage.

Efforts should be made to re-create a bike lane (if one exists) to the left of the construction zone. If this is impossible, then a standard-width travel lane should be considered.

Guidance

Construction Signage

- Place in a location that does not obstruct the path of bicyclists or pedestrians.
- Detour and closure signs related to bicycle travel may be included on all bikeways where construction activities occur. Signage should also be provided on all other roadways.

Bicycle Travel around Steel Grates

- Require temporary asphalt (cold mix) around plates to create a smooth transition.
- Use steel plates only as a temporary measure during construction, not for extended periods.
- Use warning signs where steel plates are in use.
- Require both temporary and final repaving to provide a smooth surface without abrupt edges.

Discussion

Plates used to cover trenches tend to not be flush with pavement and have a 1"-2" vertical transition on the edges. This can puncture a hole in a bicycle tire and cause a bicyclist to lose control. Although it is common to use steel plates during non-construction hours, these plates can be dangerously slippery, particularly when wet.

Contractors performing work should be made aware of the needs of bicyclists and be properly trained in how to safely route bicyclists through or around work zones.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices.
FHWA. (2006). Federal Highway Administration University Course on Bicycle and Pedestrian Transportation. Lesson 21: Bicycle and Pedestrian Accommodation in Work Zones

Materials and Maintenance

Debris should be swept to maintain a reasonably clean riding surface in the outer 5 - 6 ft of roadway.

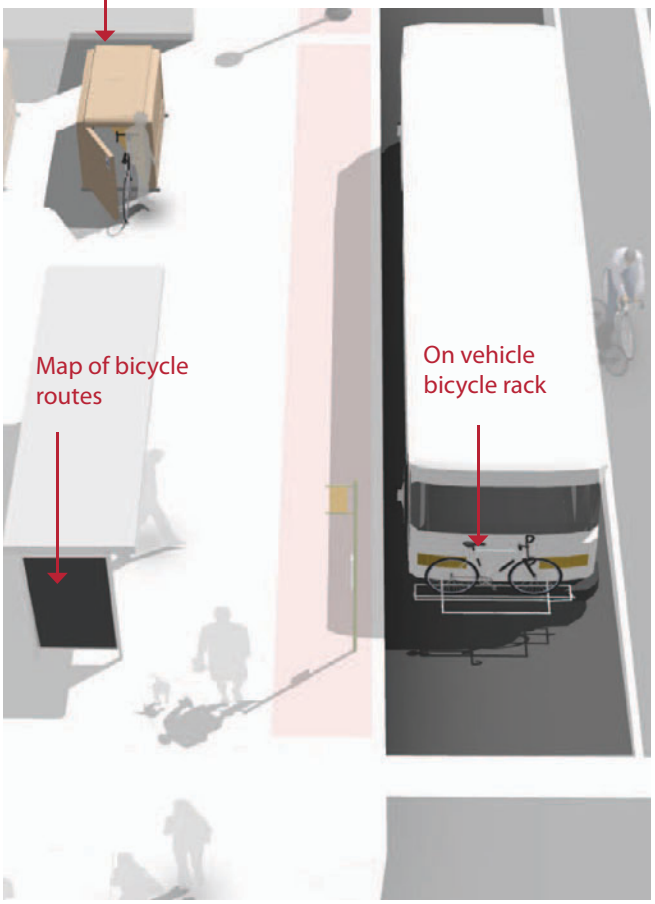
Support Facilities

Bicycle Access to Transit

Description

Safe and easy access transit stations and secure bicycle parking facilities is necessary to encourage commuters to access transit via bicycle. Bicycling to transit reduces the need to provide expensive and space consuming car parking spaces.

Many people who ride to a transit stop will want to bring their bicycle with them on the transit portion of their trip, so buses and other transit vehicles should be equipped accordingly.



Guidance

Access

- Provide direct and convenient access to transit stations and stops from the bicycle and pedestrian networks.
- Provide maps at major stops and stations showing nearby bicycle routes.
- Provide wayfinding signage and pavement markings from the bicycle network to transit stations.
- Ensure that connecting bikeways offer proper **bicycle actuation and detection**.

Bicycle Parking

- The route from bicycle parking locations to station/stop platforms should be well-lit and visible.
- Signing should note the location of bicycle parking, rules for use, and instructions as needed.
- Provide safe and secure long term parking such as **bicycle lockers** at transit hubs. Parking should be easy to use and well maintained.

Discussion

Providing bicycle routes to transit helps combine the long-distance coverage of bus travel with the door-to-door service of bicycle riding. Transit use can overcome large obstacles to bicycling, including distance, hills, riding on busy streets, night riding, inclement weather, and breakdowns. High-visibility crosswalks and mid-block crossings are often appropriate treatments to provide safer bicycle and pedestrian access to bus stops, particularly at high-usage transit stops. If a bus stop is located mid-block, adequate crossing treatments should be provided, based on the level of traffic on the roadway. All transit riders will need to cross the street to access or leave the bus stop.

Additional References and Guidelines

APBP. (2010). Bicycle Parking Guide 2nd Edition.
FHWA. (2006). Federal Highway Administration University Course on Bicycle and Pedestrian Transportation. Lesson 18: Bicycle and Pedestrian Connections to Transit

Materials and Maintenance

Regularly inspect the functioning of long-term parking moving parts and enclosures. Change keys and access codes periodically to prevent access to unapproved users.

Bikeway Maintenance

Regular bicycle facility maintenance includes sweeping, maintaining a smooth roadway, ensuring that the gutter-to-pavement transition remains relatively flat, and installing bicycle-friendly drainage grates. Pavement overlays are a good opportunity to improve bicycle facilities. The following recommendations provide a menu of options to consider to enhance a maintenance regimen.

Recommended Walkway and Bikeway Maintenance Activities

Maintenance Activity	Frequency
Inspections	Seasonal – at beginning and end of Summer
Pavement sweeping/ blowing	As needed, with higher frequency in the early Spring and Fall
Pavement sealing	5 - 15 years
Pothole repair	1 week – 1 month after report
Culvert and drainage grate inspection	Before Winter and after major storms
Pavement markings replacement	As needed
Signage replacement	As needed
Shoulder plant trimming (weeds, trees, brambles)	Twice a year; middle of growing season and early Fall
Tree and shrub plantings, trimming	1 – 3 years
Major damage response (washouts, fallen trees, flooding)	As soon as possible

This Section Includes:

- Sweeping
- Roadway Surface
- Pavement Overlays
- Drainage Grates
- Gutter to Pavement Transition
- Maintenance Management Plan

Bikeway Maintenance

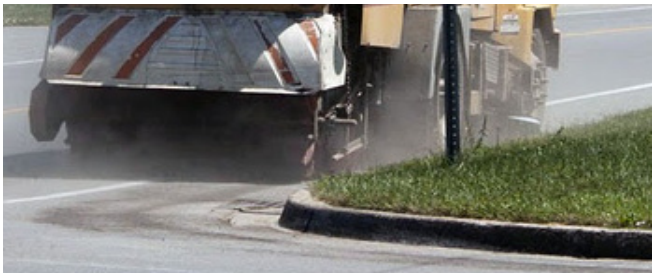
Sweeping

Guidance

- Establish a seasonal sweeping schedule that prioritizes roadways with major bicycle routes.
- Sweep walkways and bikeways whenever there is an accumulation of debris on the facility.
- In curbed sections, sweepers should pick up debris; on open shoulders, debris can be swept onto gravel shoulders.
- Pave gravel driveway approaches to minimize loose gravel on paved roadway shoulders.
- Perform additional sweeping in the Spring to remove debris from the Winter.
- Perform additional sweeping in the Fall in areas where leaves accumulate .

Description

Bicyclists often avoid shoulders and bike lanes filled with gravel, broken glass and other debris; they will ride in the roadway to avoid these hazards, potentially causing conflicts with motorists. Debris from the roadway should not be swept onto sidewalks (pedestrians need a clean walking surface), nor should debris be swept from the sidewalk onto the roadway. A regularly scheduled inspection and maintenance program helps ensure that roadway debris is regularly picked up or swept.



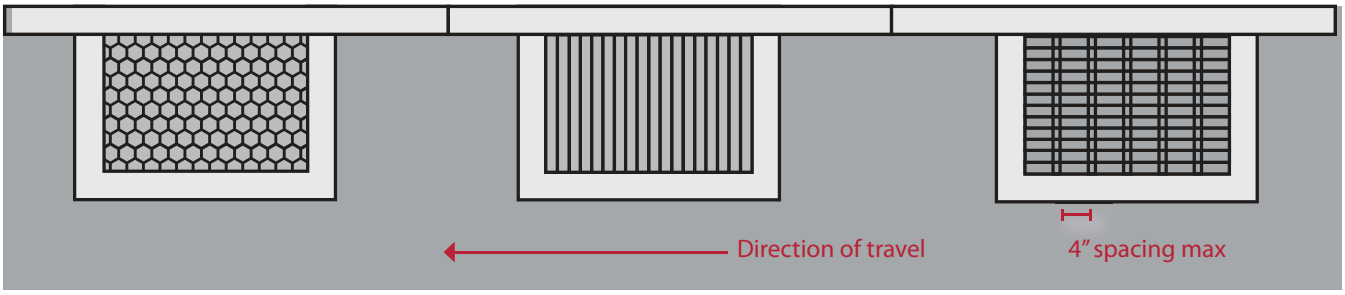
Drainage Grates

Guidance

- Where practical, drainage inlets should be placed outside of the bicycle facility. Where this is not practical, hydraulically efficient, bicycle-safe grates should be utilized and should be placed or adjusted to be flush with the adjacent pavement surface. On bridges, a minimum of 4 feet from the edge of the travel lane should be clear of drainage inlets.
- Create a program to inventory all existing drainage grates, and replace hazardous grates as necessary.

Description

Drainage grates are typically located in the gutter area near the curb of a roadway. Drainage grates typically have slots through which water drains into the municipal storm sewer system. Many older grates were designed with linear parallel bars spread wide enough for a tire to become caught so that if a bicyclist were to ride on them, the front tire could become caught in the slot. This would cause the bicyclist to tumble over the handlebars and sustain potentially serious injuries.



Bikeway Maintenance

Roadway Surface

Guidance

- Maintain a smooth surface on all bikeways that is free of potholes
- Ensure that on new roadway construction, the finished surface on bikeways does not vary more than ¼".
- Maintain pavement so ridge buildup does not occur at the gutter-to-pavement transition or adjacent to railway crossings.
- Inspect the pavement 2 to 4 months after trenching construction activities are completed to ensure that excessive settlement has not occurred.
- If chip sealing is to be performed, use the smallest possible chip on bike lanes and shoulders. Sweep loose chip regularly following application.
- During chip seal maintenance projects, if the pavement condition of the bike lane is satisfactory, it may be appropriate to chip seal the travel lanes only.

Description

Bicycles are much more sensitive to subtle changes in roadway surface than are motor vehicles. Various materials are used to pave roadways, and some are smoother than others. Compaction is also an important issue after trenches and other construction holes are filled. Uneven settlement after trenching can affect the roadway surface nearest the curb where bicycles travel. Sometimes compaction is not achieved to a satisfactory level, and an uneven pavement surface can result due to settling over the course of days or weeks. When resurfacing streets, use the smallest chip size and ensure that the surface is as smooth as possible to improve safety and comfort for bicyclists.

Pavement Overlays

Guidance

- Extend the overlay over the entire roadway surface to avoid leaving an abrupt edge.
- If the shoulder or bike lane pavement is of good quality, it may be appropriate to end the overlay at the shoulder or bike lane stripe provided no abrupt ridge remains.
- Ensure that inlet grates, manhole and valve covers are within ¼ inch of the finished pavement surface and are made or treated with slip resistant materials.
- Pave gravel driveways to property line to prevent gravel from being tracked onto shoulders or bike lanes.

Description

Pavement overlays represent good opportunities to improve conditions for bicyclists if done carefully. A ridge should not be left in the area where bicyclists ride (this occurs where an overlay extends part-way into a shoulder bikeway or bike lane). Overlay projects also offer opportunities to widen a roadway, or to re-stripe a roadway with bike lanes.

Bikeway Maintenance

Gutter to Pavement Transition

Guidance

- Ensure that gutter-to-pavement transitions have no more than a ¼" vertical transition.
- Examine pavement transitions during every roadway project for new construction, maintenance activities, and construction project activities that occur in streets.
- Inspect the pavement 2 to 4 months after trenching construction activities are completed to ensure that excessive settlement has not occurred.
- Provide at least 3 feet of pavement outside of the gutter seam.

Description

On streets with concrete curbs and gutters, 1 to 2 feet of the curbside area is typically devoted to the gutter pan, where water collects and drains into catch basins. On many streets, the bikeway is situated near the transition between the gutter pan and the pavement edge. This transition can be susceptible to erosion, creating potholes and a rough surface for travel.

The pavement on many streets is not flush with the gutter, creating a vertical transition between these segments. This area can buckle over time, creating a hazardous condition for bicyclists.

Maintenance Management Plan

Guidance

- Provide fire and police departments with map of system, along with access points to gates/bollards
- Enforce speed limits and other rules of the road
- Enforce all trespassing laws for people attempting to enter adjacent private properties

Description

Bikeway users need accommodation during construction and maintenance activities when bikeways may be closed or unavailable. Users must be warned of bikeway closures and given adequate detour information to bypass the closed section. Users should be warned through the use of standard signing approaching each affected section (e.g., "Bike Lane Closed," "Trail Closed"), including information on alternate routes and dates of closure. Alternate routes should provide reasonable directness, equivalent traffic characteristics, and be signed.

Greenways and Off-Street Facilities

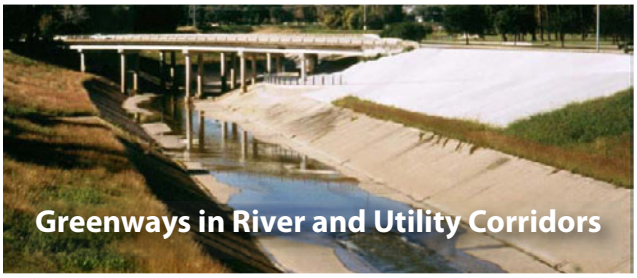
A greenway (also known as a multi-use path) allows for two-way, off-street bicycle use and also may be used by pedestrians, skaters, wheelchair users, joggers and other non-motorized users. These facilities are frequently found in parks, along rivers, beaches, and in greenbelts or utility corridors where there are few conflicts with motorized vehicles. Path facilities can also include amenities such as lighting, signage, and fencing (where appropriate).

Key features of greenways include:

- Frequent access points from the local road network.
- Directional signs to direct users to and from the path.
- A limited number of at-grade crossings with streets or driveways.
- Terminating the path where it is easily accessible to and from the street system.
- Separate treads for pedestrians and bicyclists when heavy use is expected.

This Section Includes:

- General Design Practices
- Greenways in River and Utility Corridors
- Greenways in Abandoned Rail Corridors
- Greenways in Existing Active Rail Corridors
- Trailheads
- Local Neighborhood Accessways
- Shared Use Paths Along Roadways



Greenways and Off-Street Facilities

General Design Practices

Description

Greenways can provide a desirable facility for users of all skill levels preferring separation from traffic. Greenways should generally provide directional travel opportunities not provided by existing roadways.

Guidance

Width

- 8 feet is the minimum allowed for a two-way and is only recommended for low traffic situations.
- 10 feet is recommended in most situations and will be adequate for moderate to heavy use.
- 12 feet is recommended for heavy use situations with high concentrations of multiple users. A separate track (5' minimum) can be provided for pedestrian use.

Lateral Clearance

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

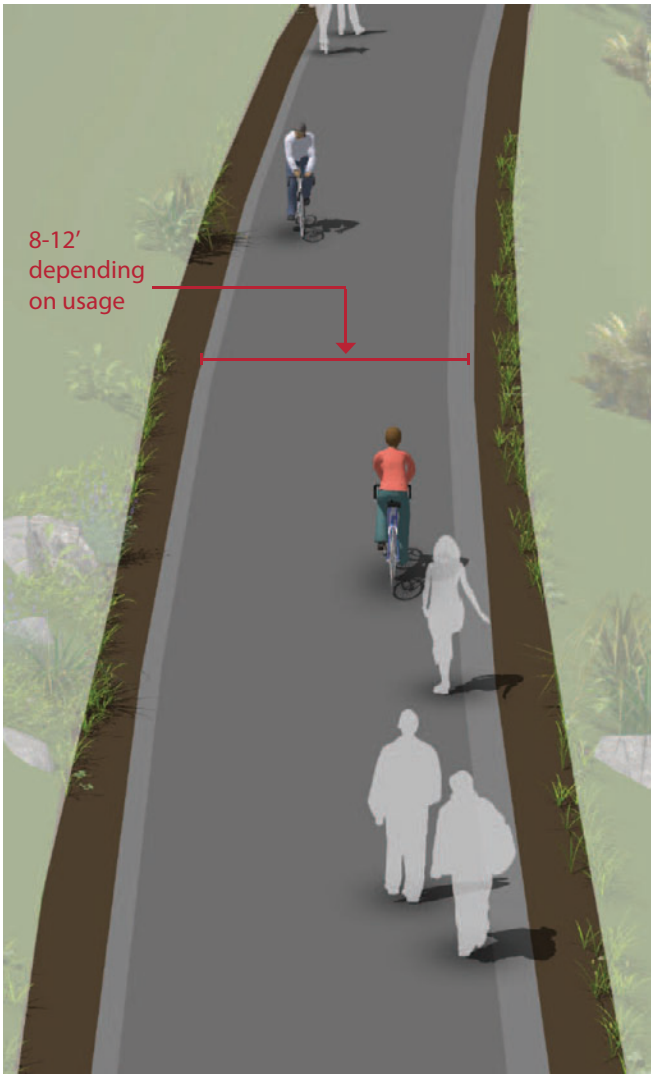
Overhead Clearance

- Clearance to overhead obstructions should be 8 feet minimum, with 10 feet recommended.

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.

Terminate the path where it is easily accessible to and from the street system, preferably at a controlled intersection or at the beginning of a dead-end street.



Discussion

The AASHTO Guide for the Development of Bicycle Facilities generally recommend against the development of **shared use paths along roadways**. Also known as "sidepaths", these facilities create a situation where a portion of the bicycle traffic rides against the normal flow of motor vehicle traffic and can result in wrong-way riding when either entering or exiting the path.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.
Flink, C. (1993). Greenways: A Guide To Planning Design And Development.

Materials and Maintenance

Asphalt is the most common surface for bicycle paths. The use of concrete for paths has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of path users.

Greenways and Off-Street Facilities

Greenways in River and Utility Corridors

Guidance

Greenways in utility corridors should meet or exceed **general design practices**. If additional width allows, wider paths, and landscaping are desirable.

Access Points

Any access point to the path should be well-defined with appropriate signage designating the pathway as a bicycle facility and prohibiting motor vehicles.

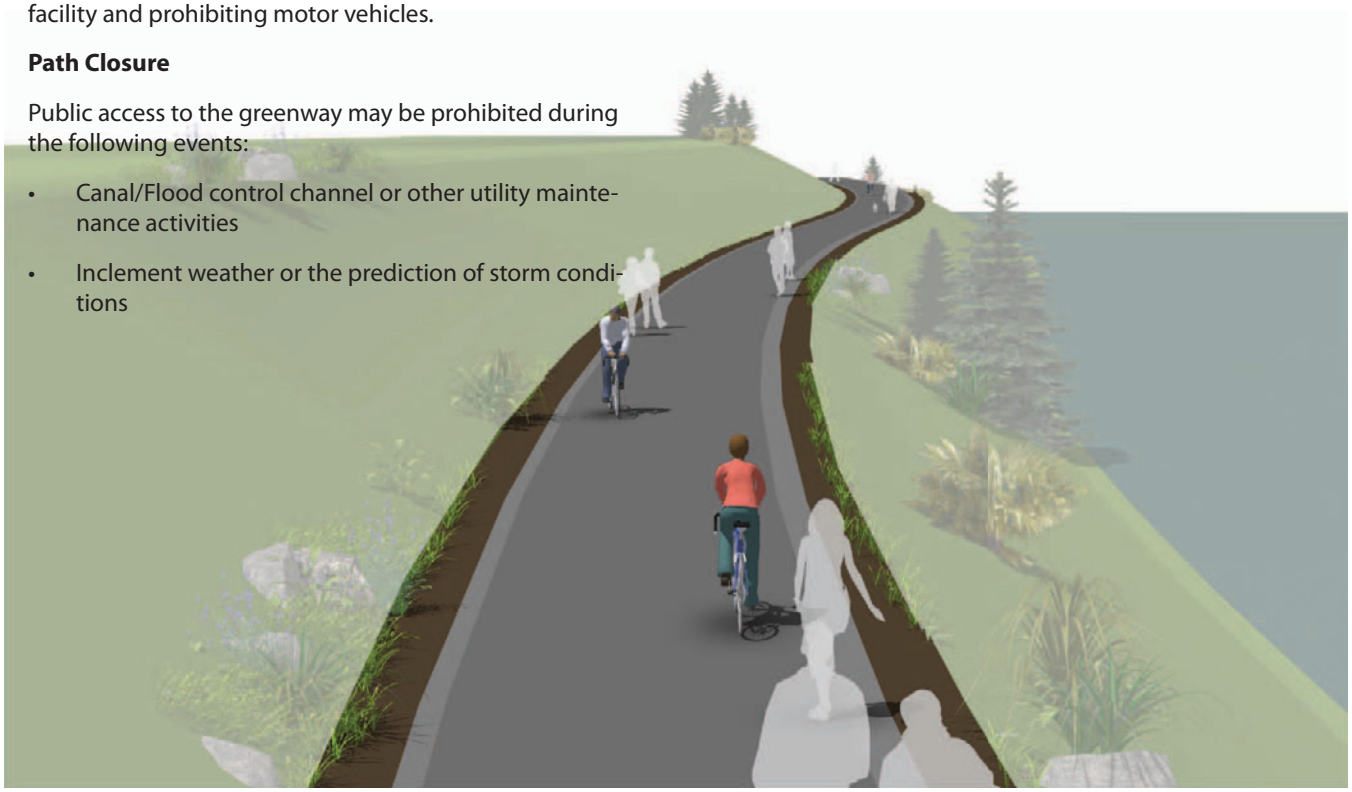
Path Closure

Public access to the greenway may be prohibited during the following events:

- Canal/Flood control channel or other utility maintenance activities
- Inclement weather or the prediction of storm conditions

Description

Utility and waterway corridors often offer excellent greenway development and bikeway gap closure opportunities. Utility corridors typically include powerline and sewer corridors, while waterway corridors include canals, drainage ditches, rivers, and beaches. These corridors offer excellent transportation and recreation opportunities for bicyclists of all ages and skills.



Discussion

Similar to railroads, public access to flood control channels or canals is undesirable by all parties. Hazardous materials, deep water or swift current, steep, slippery slopes, and debris all constitute risks for public access. Appropriate fencing may be required to keep path users within the designated travel way. Creative design of fencing is encouraged to make the path facility feel welcoming to the user.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.
Flink, C. (1993). Greenways: A Guide To Planning Design And Development.

Materials and Maintenance

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Greenways in Abandoned Rail Corridors

Guidance

Greenways in abandoned rail corridors should meet or exceed **general design practices**. If additional width allows, wider paths, and landscaping are desirable.

In full conversions of abandoned rail corridors, the sub-base, superstructure, drainage, bridges, and crossings are already established. Design becomes a matter of working with the existing infrastructure to meet the needs of a rail-trail.

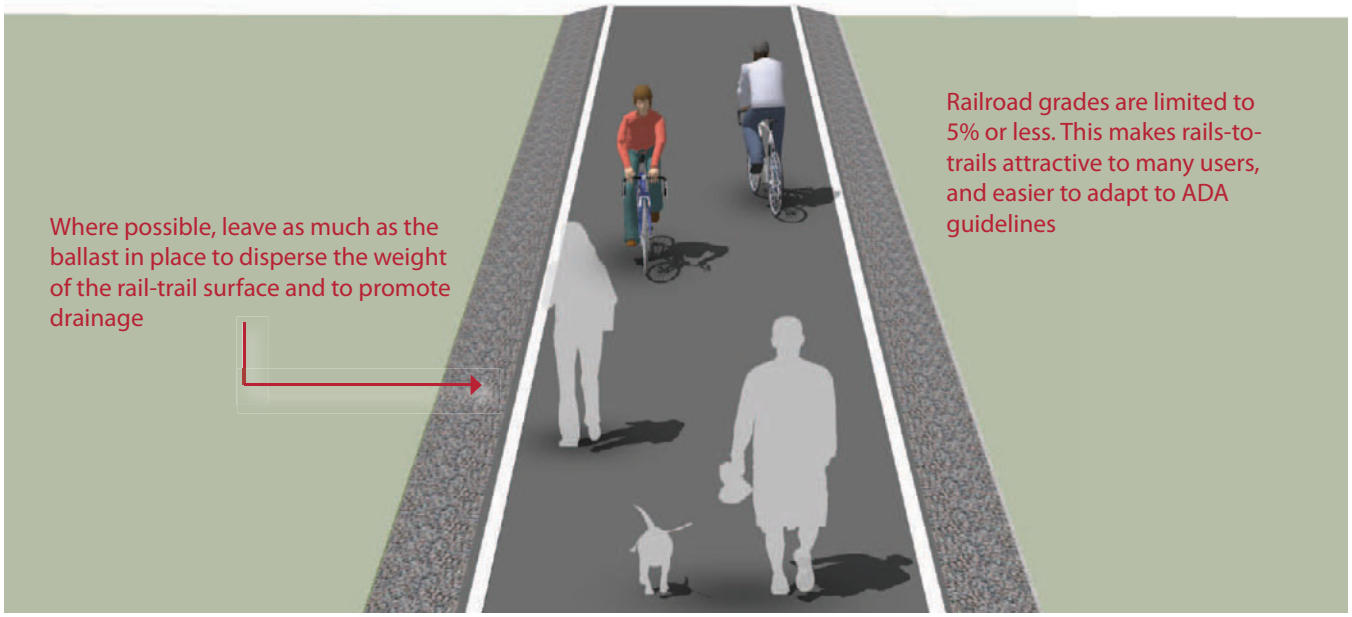
If converting a rail bed adjacent to an active rail line, see **Greenways in Existing Active Rail Corridors**.

Description

Commonly referred to as Rails-to-Trails or Rail-Trails, these projects convert vacated rail corridors into off-street paths. Rail corridors offer several advantages, including relatively direct routes between major destinations, and following generally flat terrain that typically does not exceed 2 percent grade.

In some cases, rail owners may rail-bank their corridors as an alternative to a complete abandonment of the line, thus preserving the rail corridor for possible future use.

The railroad may form an agreement with any person, public or private, who would like to use the banked rail line as a greenway or linear park until it is again needed for rail use. Municipalities should acquire abandoned rail rights-of-way whenever possible to preserve the opportunity for greenway development.



Discussion

It is often impractical and costly to add material to existing railroad bed fill slopes. This results in greenways that meet minimum path widths, but often lack preferred shoulder and lateral clearance widths.

Rail-trails can involve many challenges including the acquisition of the right of way, cleanup and removal of toxic substances, and rehabilitation of tunnels, trestles and culverts. A structural engineer should evaluate existing railroad bridges for structural integrity to ensure they are capable of carrying the appropriate design loads.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.
Flink, C. (1993). Greenways: A Guide To Planning Design And Development.

Materials and Maintenance

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Greenways and Off-Street Facilities

Greenways in Existing Active Rail Corridors

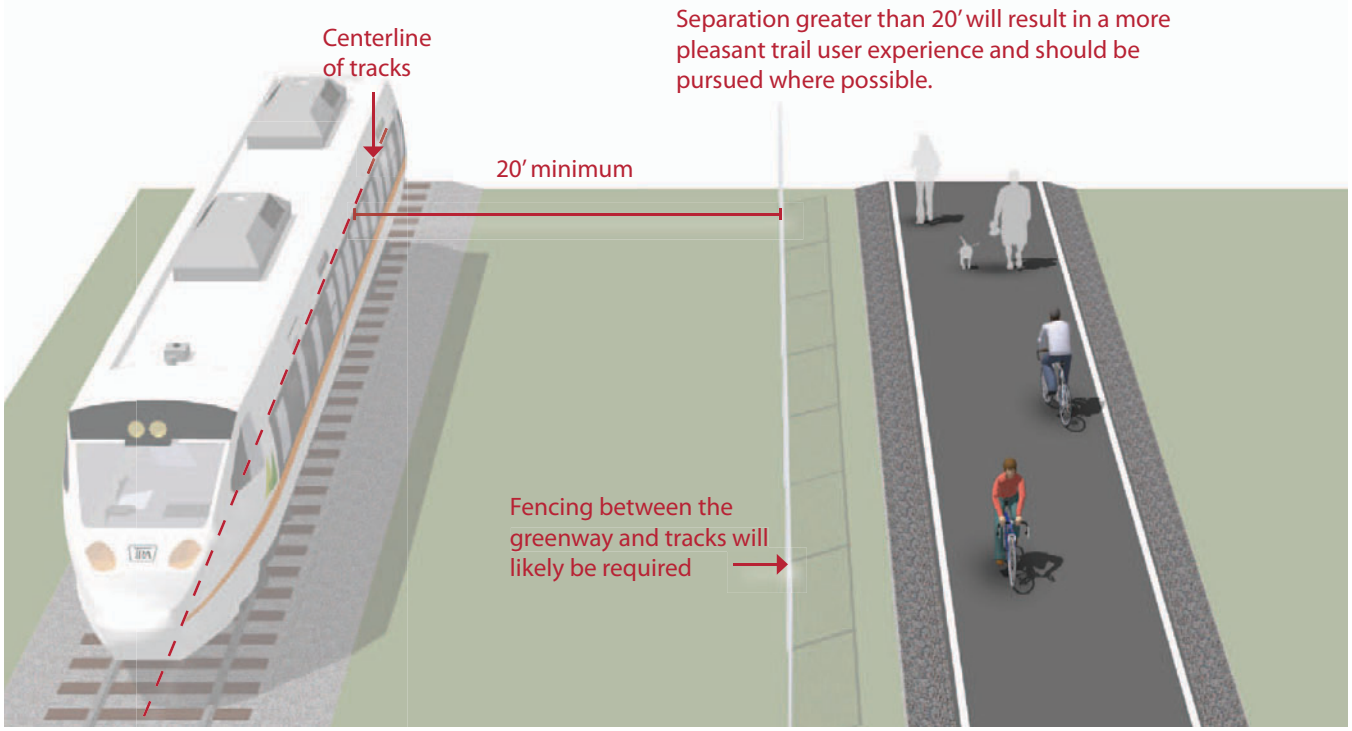
Guidance

Greenways in active rail corridors should meet or exceed **general design practices**. If additional width allows, wider paths, and landscaping are desirable.

If required, fencing should be a minimum of 5 feet in height with higher fencing usual next to sensitive areas such as switching yards. Setbacks from the active rail line will vary depending on the speed and frequency of trains, and available right-of-way.

Description

Rails-with-Trails projects typically consist of paths adjacent to active railroads. It should be noted that some constraints could impact the feasibility of rail-with-trail projects. In some cases, space needs to be preserved for future planned freight, transit or commuter rail service. In other cases, limited right-of-way width, inadequate setbacks, concerns about safety/trespassing, and numerous mid-block crossings may affect a project's feasibility.



Discussion

Railroads typically require fencing with all rail-with-trail projects. Concerns with trespassing and security can vary with the amount of train traffic on the adjacent rail line and the setting of the bicycle path, i.e. whether the section of track is in an urban or rural setting.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.
FHWA. (2002). Rails-with-Trails: Lessons Learned.

Materials and Maintenance

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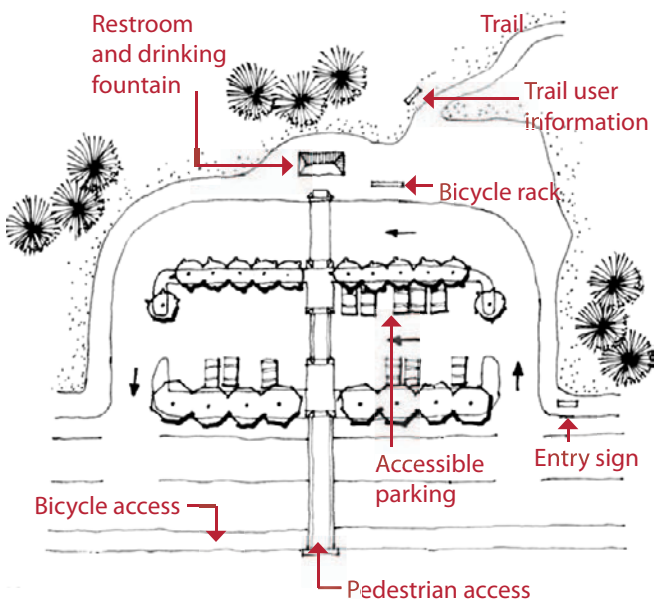
Trailheads

Guidance

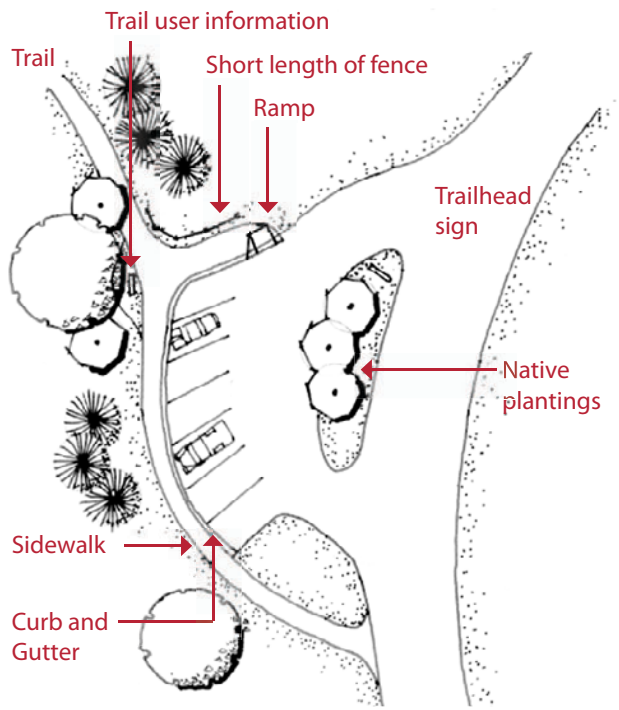
- Major trailheads should include automobile and bicycle parking, trail information (maps, user guidelines, wildlife information, etc.), garbage receptacles and restrooms.
- Minor trailheads can provide a subset of these amenities.

Description

Good access to a path system is a key element for its success. Trailheads serve the local and regional population arriving to the path system by car, transit, bicycle or other modes. Trailheads provide essential access to the shared-use path system and include amenities like parking for vehicles and bicycles, restrooms (at major trailheads), and posted maps.



Major Trailhead



Minor Trailhead

Discussion

Trailheads with a small motor vehicle parking area should additionally include bicycle parking and accessible parking.

Neighborhood access should be achieved from all local streets crossing the path. No parking needs to be provided, and in some situations "No Parking" signs will be desirable to minimize impact on the neighborhood. See **Local Neighborhood Accessways** for neighborhood connection guidance.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.

Materials and Maintenance

Trailhead signage and lighting will require regular maintenance. Major trailheads will require regularg servicing.

Greenways and Off-Street Facilities

Local Neighborhood Accessways

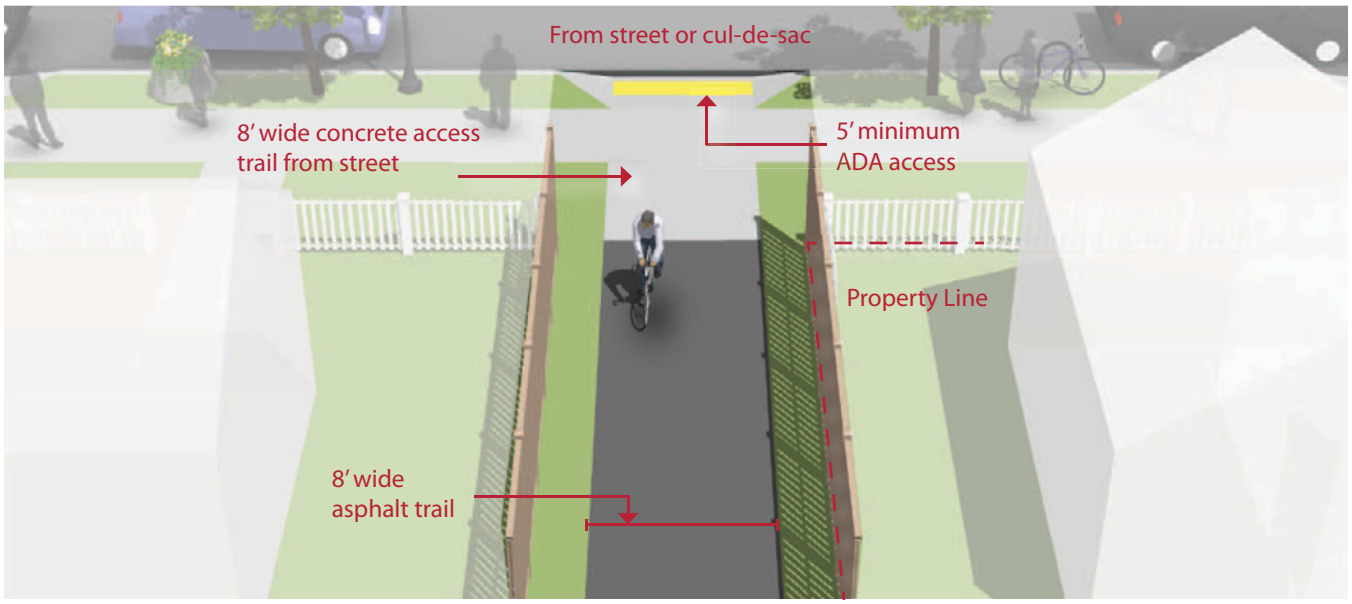
Guidance

- Neighborhood accessways should remain open to the public.
- Trail pavement shall be at least 8′ wide to accommodate emergency and maintenance vehicles, meet ADA requirements and be considered suitable for multi-use.
- Trail widths should be designed to be less than 8′ wide only when necessary to protect large mature native trees over 18″ in caliper, wetlands or other ecologically sensitive areas.
- Accessways should slightly meander whenever possible.

Description

Neighborhood accessways provide residential areas with direct bicycle and pedestrian access to parks, trails, greenspaces, and other recreational areas. They most often serve as small trail connections to and from the larger greenway network, typically having their own rights-of-way and easements.

Additionally, these smaller trails can be used to provide bicycle and pedestrian connections between dead-end streets, cul-de-sacs, and access to nearby destinations not provided by the street network.



Discussion

Neighborhood accessways should be designed into new subdivisions at every opportunity and should be required by City/County subdivision regulations.

For existing subdivisions, Neighborhood and homeowner association groups are encouraged to identify locations where such connects would be desirable. Nearby residents and adjacent property owners should be invited to provide landscape design input.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.
FHWA. (2006). Federal Highway Administration University Course on Bicycle and Pedestrian Transportation. Lesson 19: Greenways and Shared Use Paths.

Materials and Maintenance

Asphalt is the most common surface for bicycle paths. The use of concrete for paths has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of path users.

Greenways and Off-Street Facilities

Shared Use Paths Along Roadways

Description

A shared use path allows for two-way, off-street bicycle use and also may be used by pedestrians, skaters, wheelchair users, joggers and other non-motorized users. These facilities are frequently found in parks, along rivers, beaches, and in greenbelts or utility corridors where there are few conflicts with motorized vehicles.

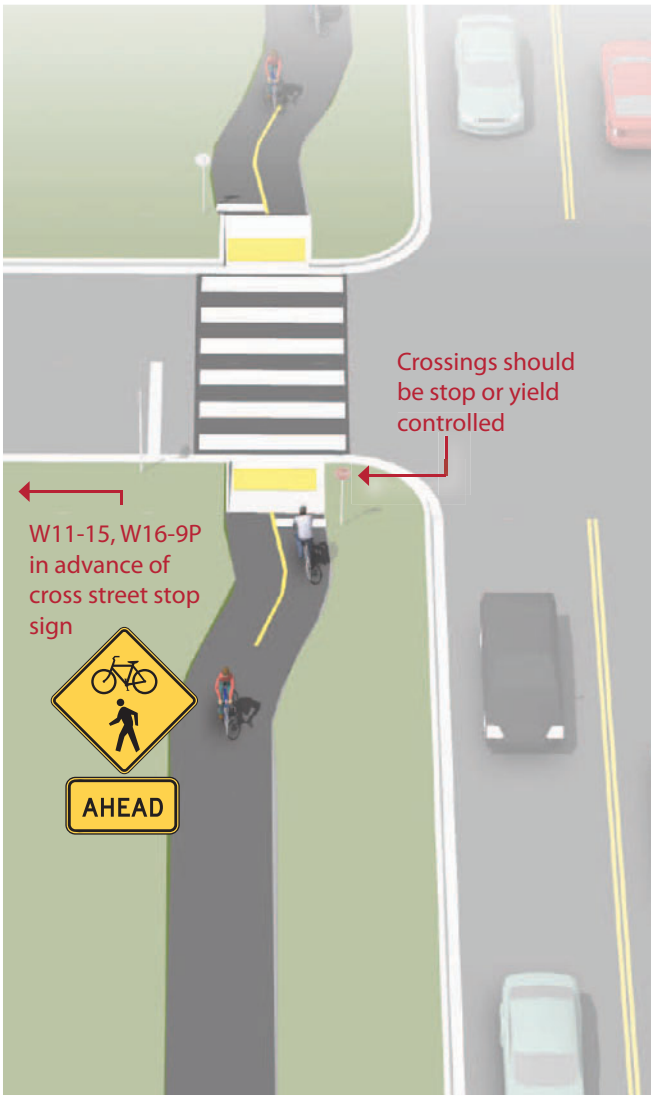
Along roadways, these facilities create a situation where a portion of the bicycle traffic rides against the normal flow of motor vehicle traffic and can result in wrong-way riding where bicyclists enter or leave the path.

The AASHTO Guide for the Development of Bicycle Facilities generally recommends against the development of shared-use paths directly adjacent to roadways.

Guidance

- 8 feet is the minimum allowed for a two-way bicycle path and is only recommended for low traffic situations.
- 10 feet is recommended in most situations and will be adequate for moderate to heavy use.
- 12 feet is recommended for heavy use situations with high concentrations of multiple users such as joggers, bicyclists, rollerbladers and pedestrians. A separate track (5' minimum) can be provided for pedestrian use.
- Bicycle lanes should be provided as an alternate (more transportation-oriented) facility whenever possible.

Pay special attention to the entrance/exit of the path as bicyclists may continue to travel on the wrong side of the street.



Discussion

When designing a bikeway network, the presence of a nearby or parallel path should not be used as a reason to not provide adequate shoulder or bicycle lane width on the roadway, as the on-street bicycle facility will generally be superior to the "sidepath" for experienced bicyclists and those who are cycling for transportation purposes.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
NACTO. (2011). Urban Bikeway Design Guide. See entry on Raised Cycle Tracks.

Materials and Maintenance

Asphalt is the most common surface for bicycle paths. The use of concrete for paths has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of path users.

Greenway/Roadway Crossings

At-grade roadway crossings can create potential conflicts between greenway users and motorists, however, well-designed crossings can mitigate many operational issues and provide a higher degree of safety and comfort for path users. This is evidenced by the thousands of successful facilities around the United States with at-grade crossings. In most cases, at-grade greenway crossings can be properly designed to provide a reasonable degree of safety and can meet existing traffic and safety standards. Greenways that cater to bicyclists can require additional considerations due to the higher travel speed of bicyclists versus pedestrians.

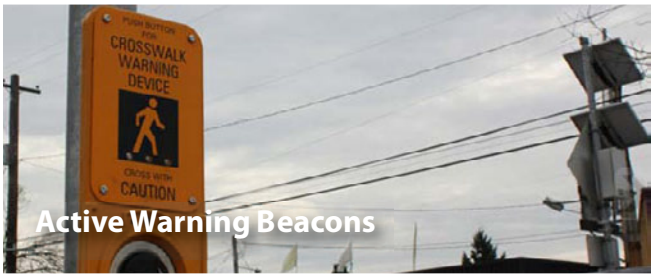
Consideration must be given to adequate warning distance based on vehicle speeds and line of sight, with the visibility of any signs absolutely critical. Directing the active attention of motorists to roadway signs may require additional alerting devices such as a flashing beacon, roadway striping or changes in pavement texture. Signing for path users may include a standard "STOP" or "YIELD" sign and pavement markings, possibly combined with other features such as bollards or a bend in the greenway to slow bicyclists. Care must be taken not to place too many signs at crossings lest they begin to lose their visual impact.

A number of striping patterns have emerged over the years to delineate greenway crossings. A median stripe on the path approach will help to organize and warn path users. Crosswalk striping is typically a matter of local and State preference, and may be accompanied by pavement treatments to help warn and slow motorists. In areas where motorists do not typically yield to crosswalk users, additional measures may be required to increase compliance.

This section includes:

- Marked/Unsignalized Crossings
- Active Warning Beacons
- Route Users to Existing Signalized Intersections
- Signalized/Controlled Crossings
- Undercrossings
- Overcrossings

Marked/Unsignalized Crossings



Active Warning Beacons

Route Users to Existing Signals

Signalized/Controlled Crossings

Undercrossings

Overcrossings

Greenway/Roadway Crossings

Marked/Unsignalized Crossings

Guidance

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

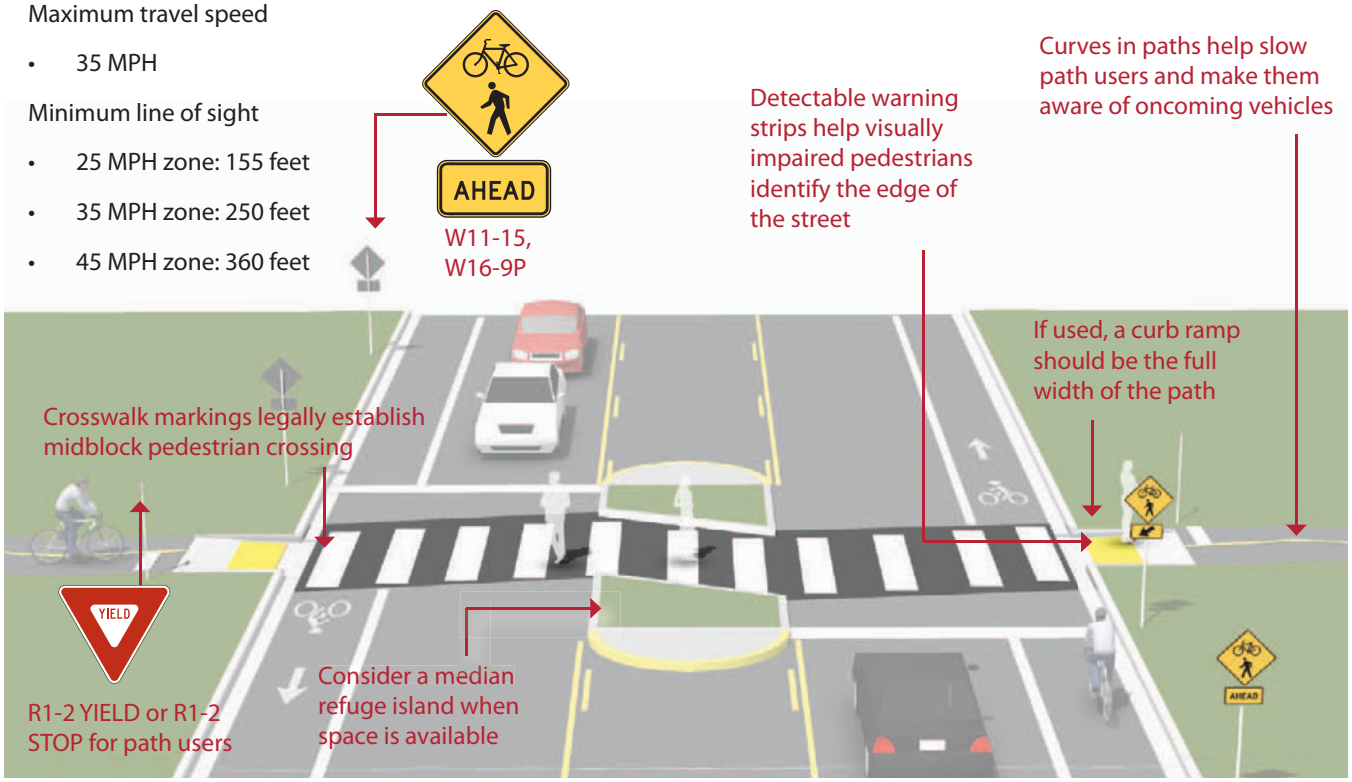
Minimum line of sight

- 25 MPH zone: 155 feet
- 35 MPH zone: 250 feet
- 45 MPH zone: 360 feet

Description

A marked/unsignalized crossing typically consists of a marked crossing area, signage and other markings to slow or stop traffic. The approach to designing crossings at mid-block locations depends on an evaluation of vehicular traffic, line of sight, pathway traffic, use patterns, vehicle speed, road type, road width, and other safety issues such as proximity to major attractions.

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.



Discussion

Unsignalized crossings of multi-lane arterials over 15,000 ADT may be possible with features such as sufficient crossing gaps (more than 60 per hour), median refuges, and/or active warning devices like rectangular rapid flash beacons or in-pavement flashers, and excellent sight distance. For more information see the discussion of **active warning beacons**.

On roadways with low to moderate traffic volumes (<12,000 ADT) and a need to control traffic speeds, a raised crosswalk may be the most appropriate crossing design to improve pedestrian visibility and safety.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
FHWA. (2009). Manual of Uniform Traffic Control Devices.

Materials and Maintenance

Locate markings out of wheel tread when possible to minimize wear and maintenance costs.

Greenway/Roadway Crossings

Active Warning Beacons

Guidance

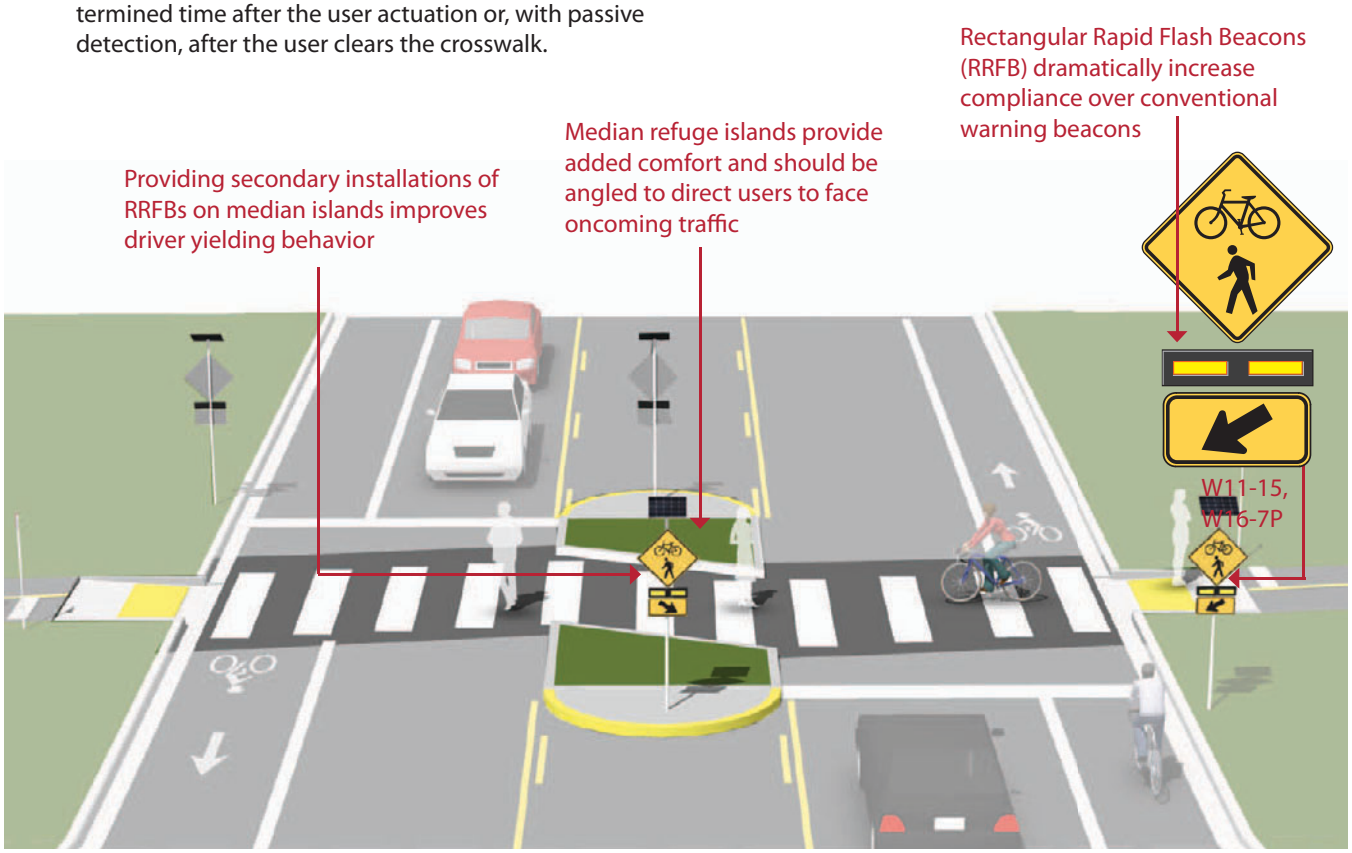
Guidance for **Marked/Unsignalized Crossings** applies.

- Warning beacons shall not be used at crosswalks controlled by YIELD signs, STOP signs, or traffic control signals.
- Warning beacons shall initiate operation based on user actuation and shall cease operation at a predetermined time after the user actuation or, with passive detection, after the user clears the crosswalk.

Description

Enhanced marked crossings are unsignalized crossings with additional treatments designed to increase motor vehicle yielding compliance on multi-lane or high volume roadways.

These enhancements include pathway user or sensor actuated warning beacons, Rectangular Rapid Flash Beacons (RRFB) shown below, or in-roadway warning lights.



Discussion

Rectangular rapid flash beacons show the most increased compliance of all the warning beacon enhancement options.

A study of the effectiveness of going from a no-beacon arrangement to a two-beacon RRFB installation increased yielding from 18 percent to 81 percent. A four-beacon arrangement raised compliance to 88%. Additional studies of long term installations show little to no decrease in yielding behavior over time.

Additional References and Guidelines

NACTO. (2011). Urban Bikeway Design Guide.
FHWA. (2009). Manual of Uniform Traffic Control Devices.
FHWA. (2008). MUTCD - Interim Approval for Optional Use of Rectangular Rapid Flashing Beacons (IA-11)

Materials and Maintenance

Locate markings out of wheel tread when possible to minimize wear and maintenance costs. Signing and striping need to be maintained to help users understand any unfamiliar traffic control.

Greenway/Roadway Crossings

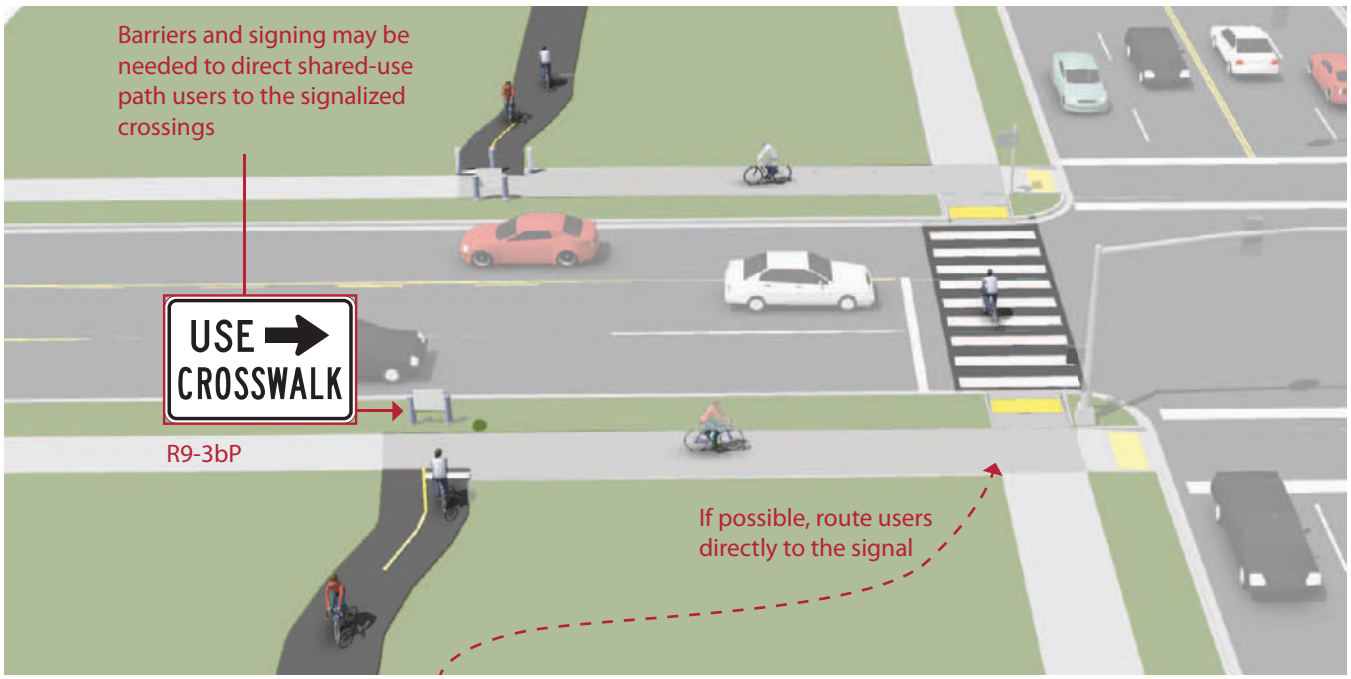
Route Users to Signalized Crossings

Guidance

Greenway crossings should not be provided within approximately 400 feet of an existing signalized intersection. If possible, route path directly to the signal.

Description

Greenway crossings within approximately 400 feet of an existing signalized intersection with pedestrian crosswalks are typically diverted to the signalized intersection to avoid traffic operation problems when located so close to an existing signal. For this restriction to be effective, barriers and signing may be needed to direct greenway users to the signalized crossing. If no pedestrian crossing exists at the signal, modifications should be made.



Discussion

In the US, the minimum distance a marked crossing can be from an existing signalized intersection varies from approximately 250 to 660 feet. Engineering judgement and the context of the location should be taken into account when choosing the appropriate allowable setback. Pedestrians are particularly sensitive to out of direction travel and jaywalking may become prevalent if the distance is too great.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.

Materials and Maintenance

If a sidewalk is used for crossing access, it should be kept clear of snow and debris and the surface should be level for wheeled users.

Greenway/Roadway Crossings

Signalized/Controlled Crossings

Guidance

Traffic signal installations must meet MUTCD pedestrian, school or modified warrants.

Hybrid beacons may be installed without meeting traffic signal control warrants if roadway speed and volumes are excessive for comfortable path crossings.

Additional guidance for signalized crossings:

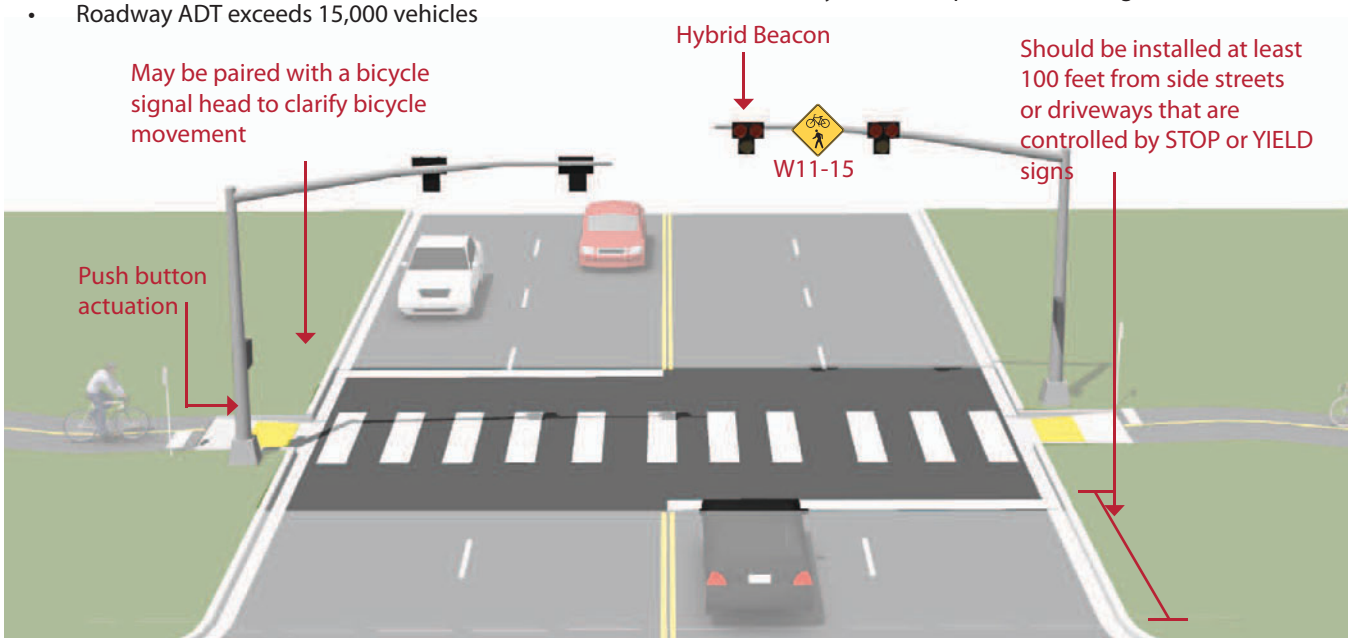
- Located more than 300 feet from an existing signalized intersection
- Roadway travel speeds of 40 MPH and above
- Roadway ADT exceeds 15,000 vehicles

Description

Signalized crossings provide the most protection for crossing greenway users through the use of a red-signal indication to stop conflicting motor vehicle traffic. The two types of path signalization are full traffic signal control and hybrid signals.

A full traffic signal installation treats the greenway crossing as a conventional 4-way intersection and provides standard red-yellow-green traffic signal heads for all legs of the intersection.

Hybrid beacon installation (shown below) faces only cross motor vehicle traffic, stays dark when inactive, and uses a unique 'wig-wag' signal phase to indicate activation. Vehicles have the option to proceed after stopping during the final flashing red phase, which can reduce motor vehicle delay when compared to a full signal installation.



Discussion

Shared-use path signals are normally activated by push buttons but may also be triggered by embedded loop, infrared, microwave or video detectors. The maximum delay for activation of the signal should be two minutes, with minimum crossing times determined by the width of the street.

Each crossing, regardless of traffic speed or volume, requires additional review by a registered engineer to identify sight lines, potential impacts on traffic progression, timing with adjacent signals, capacity and safety.

Additional References and Guidelines

FHWA. (2009). Manual of Uniform Traffic Control Devices.
NACTO. (2011). Urban Bikeway Design Guide.

Materials and Maintenance

Hybrid beacons are subject to the same maintenance needs and requirements as standard traffic signals. Signing and striping need to be maintained to help users understand any unfamiliar traffic control.

Greenway/Roadway Crossings

Undercrossings

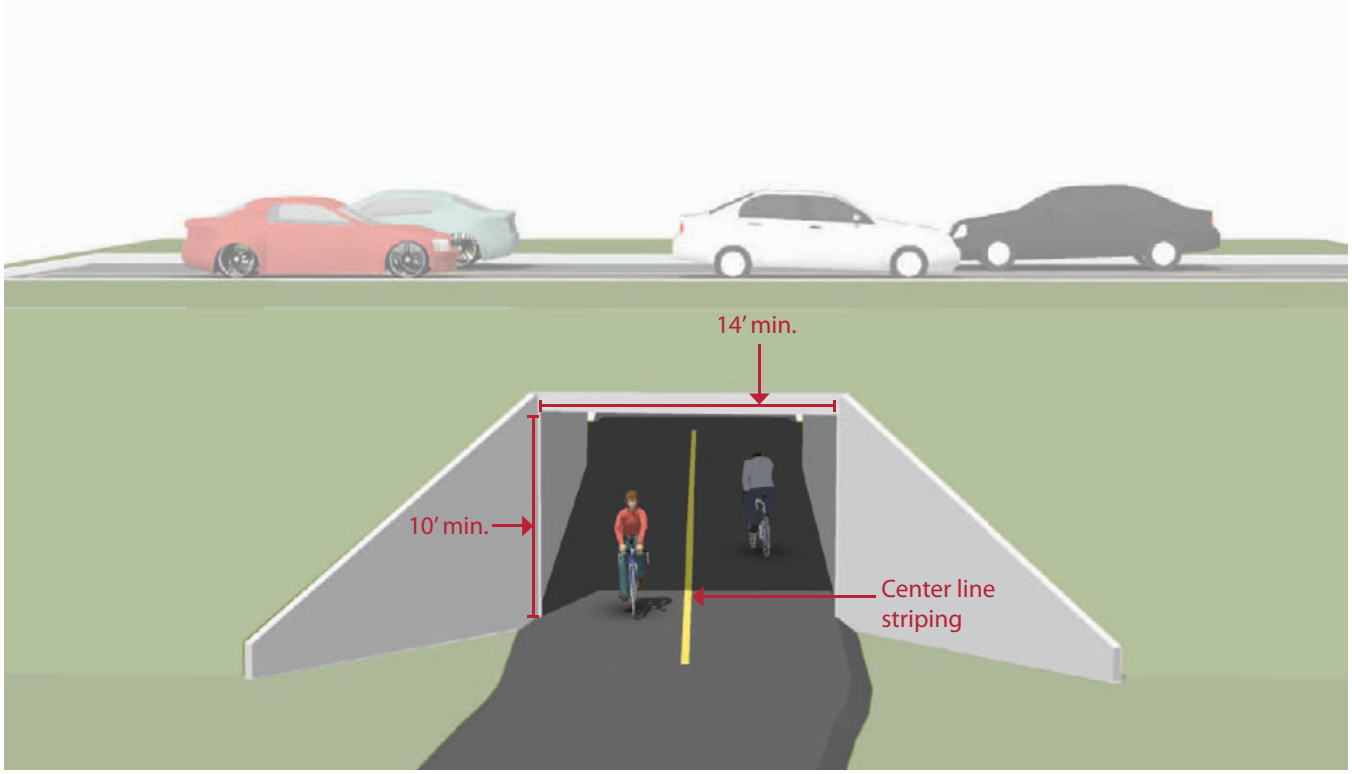
Guidance

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

Description

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

Grade-separated crossings are advisable where existing bicycle/pedestrian crossings do not exist, where ADT exceeds 25,000 vehicles and where 85th percentile speeds exceed 45 miles per hour.



Discussion

Safety is a major concern with undercrossings. Shared-use path users may be temporarily out of sight from public view and may experience poor visibility themselves. To mitigate safety concerns, an undercrossing should be designed to be spacious, well-lit, equipped with emergency cell phones at each end and completely visible for its entire length from end to end.

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.

Materials and Maintenance

14 foot width allows for maintenance vehicle access.

Potential problems include conflicts with utilities, drainage, flood control and vandalism.

Greenway/Roadway Crossings

Overcrossings

Guidance

8 foot minimum width, 14 feet preferred. If overcrossing has any scenic vistas additional width should be provided 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 overcrossing; clearance below will vary depending on feature being crossed.

Roadway:	17 feet
Freeway:	18.5 feet
Heavy Rail Line:	23 feet

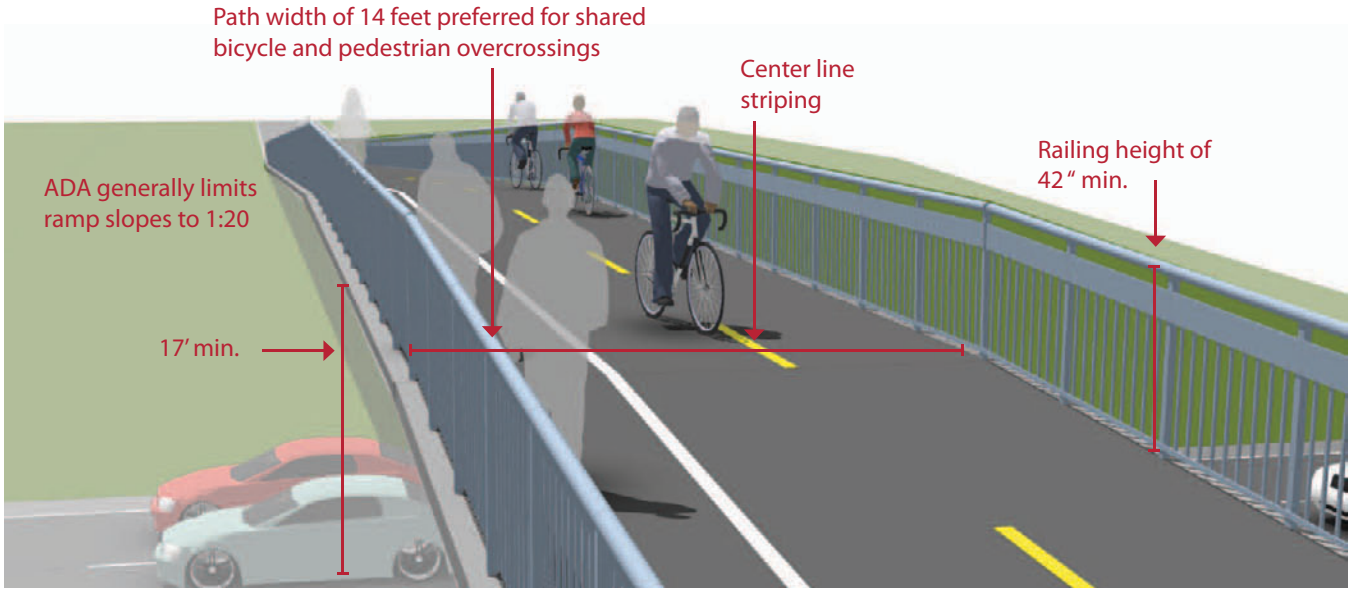
The overcrossing should have a centerline stripe even if the rest of the path does not have one.

Description

Bicycle/pedestrian overcrossings provide critical non-motorized system links by joining areas separated by barriers such as deep canyons, 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.

Grade-separated crossings may be needed where existing bicycle/pedestrian crossings do not exist, where ADT exceeds 25,000 vehicles, and where 85th percentile speeds exceed 45 miles per hour.

Overcrossings require a minimum of 17 feet of vertical clearance to the roadway below versus a minimum elevation differential of around 12 feet for an undercrossing. This results in potentially greater elevation differences and much longer ramps for bicycles and pedestrians to negotiate.



Discussion

Overcrossings 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.

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

Additional References and Guidelines

AASHTO. (1999). Guide for the Development of Bicycle Facilities.
AASHTO. (2004). Guide for the Planning, Design, and Operation of Pedestrian Facilities.

Materials and Maintenance

Potential issues with vandalism.

Overcrossings can be more difficult to clear of snow than undercrossings.