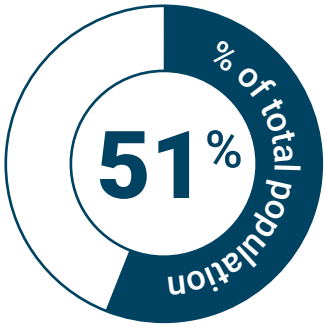
DESIGN GUIDANCE

APPENDIX D

POTENTIAL BICYCLE USERS

Interested but Concerned



Types of Cyclists

The figure below illustrates a typical range of cyclists. Estimates show the greatest percentage of the population—upwards of 60-70%—fall into the "Interested but Concerned" category. The "Interested but Concerned" are most comfortable cycling separated from motorized vehicles. On the other end of the spectrum, only roughly 1% of the population is "Experienced and Confident", comfortable sharing the road with motorized vehicles. In the middle, approximately 7% are "Casual and Confident", comfortable cycling for short distances with motorized vehicles. See Page 22-23, Bikeway Facilities Selection Chart to determine which facility types best serve the different types of cyclists.

Who are they?

A mother and daughter who enjoy Saturday rides to the library along the shared-use path that runs near their house. Concern over crossing a busy road prevents them from riding together to elementary school during the week.

Who are they?

A 45-year-old father of two who was just diagnosed with pre-diabetes. His doctor encouraged him to be more active. He doesn't think he has time to go to the gym, so he's been thinking about commuting to work by bike.

As a motorist he feels uncomfortable passing bicyclists, so he isn't sure he'd feel comfortable as a bicyclist sharing the road with cars.

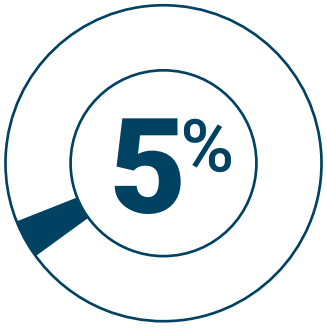
Who are they?

A resident who just moved to the US. He's used bike share a few times to ride home from the train station. He enjoys riding as long as he stays on quiet streets or the sidewalk. He'd like to be able to ride to the grocery store, but he's uncomfortable crossing busy roads and intersections along the way.

LOWER STRESS TOLERANCE

POTENTIAL BICYCLE USERS

Casual and Somewhat Confident

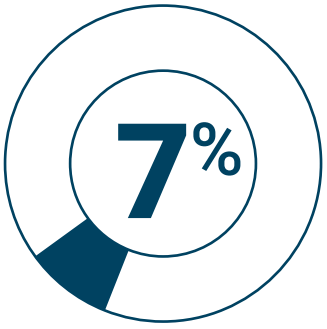


Who are they?

A woman who rides her bike downtown every morning to her job at the hospital. She prefers to ride on neighborhood streets, but doesn't mind riding the last few blocks on a busy street since there's a bike lane.

Who are they?

A lower-income resident who rides a bicycle to save money for other household expenses. He's comfortable riding on Main Street without a conventional bike lane because it's a two-lane road and motorists usually don't pass him.



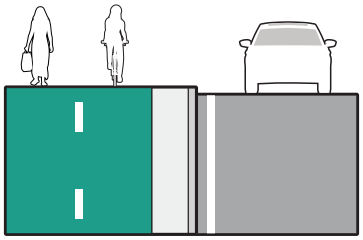
Who are they?

A recent college grad who can't wait to hit the road this weekend for a 100-mile ride on his brand new road bike. He helped pay his way through college as a bike messenger, and loves the rush that he gets from racing.

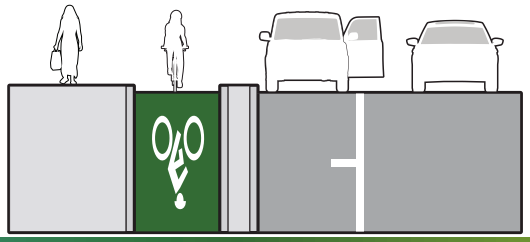
HIGHER STRESS TOLERANCE

BICYCLE FACILITY OVERVIEW

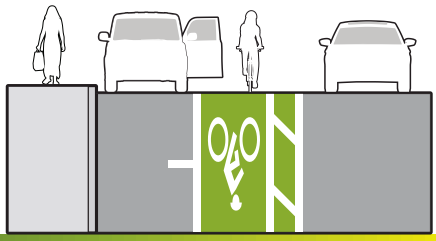
Shared Use Path SUP



Separated Bike Lane SBL



Buffered Bike Lane BBL



MOST SEPARATED

TYPICAL APPLICATION

Shared use paths will generally be considered on any road with one or more of the following characteristics:

- Total traffic lanes: 3 lanes or greater
- Posted speed limit: 30 mph or greater
- Average Daily Traffic: 9,000 vehicles or greater
- Parking turnover: frequent
- Bike lane obstruction: likely to be frequent
- Streets that are designated as truck or bus routes

Shared use paths may be preferable to separated bike lanes in low density areas where pedestrian volumes are anticipated to be fewer than 200 people per hour on the path.

Separated bike lanes will generally be considered on any road with one or more of the following characteristics:

- Total traffic lanes: 3 lanes or greater
- Posted speed limit: 30 mph or more
- Average Daily Traffic: 9,000 vehicles or greater
- Parking turnover: frequent
- Bike lane obstruction: likely to be frequent
- Streets that are designated as truck or bus routes

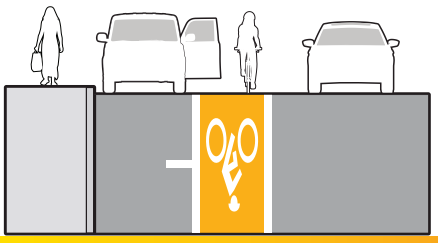
Preferred in higher density areas, adjacent to commercial and mixed-use development, and near major transit stations or locations where observed or anticipated pedestrian volumes will be higher.

Buffered bike lanes will generally be considered on any road with one or more of the following characteristics:

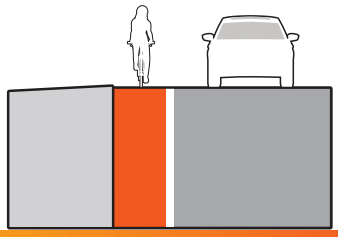
- Total traffic lanes: 3 lanes or fewer
- Posted speed limit: 30 mph or lower
- Average Daily Traffic: 9,000 vehicles or fewer
- Parking turnover: infrequent.
- Bike lane obstruction: likely to be infrequent
- Where a separated bike lane or sidepath is infeasible or not desirable

BICYCLE FACILITY OVERVIEW

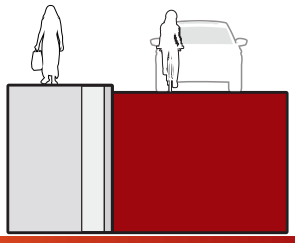
Bike Lane BL



Shoulder Bikeway SB



Shared Roadway SR



LEAST SEPARATED

TYPICAL APPLICATION

Conventional bike lanes will generally be considered on any road with one or more of the following characteristics:

- Total traffic lanes: 3 lanes or fewer
- Posted speed limit: 30 mph or lower
- Average Daily Traffic: 9,000 vehicles or fewer
- Parking turnover: infrequent
- Bike lane obstruction: likely to be infrequent
- Where a separated bike lane or sidepath is infeasible or not desirable

Shoulder bike lanes can generally be considered on any road without on-street parking and one or more of the following characteristics:

- Total traffic lanes: 3 lanes or fewer
- Average Daily Traffic: Up to 8,000 vehicles
- Shoulder obstruction: likely to be infrequent
- Where a separated bike lane or sidepath is infeasible or not desirable

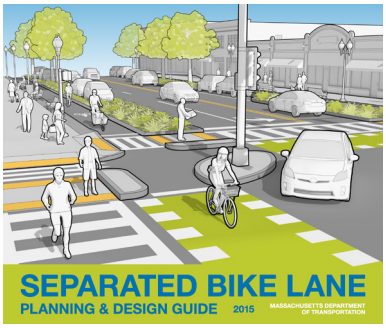
The minimum width of a shoulder bikeway is 4' (exclusive of the gutter if one exists). Wider shoulders should be provided on streets or roads with average daily traffic higher than 3,500 vehicles.

Shared roadways can be considered on any road with one or more of the following characteristics:

- Total traffic lanes: 3 lanes or fewer
- Posted speed limit: 25 mph or lower
- Average Daily Traffic: Up to 3,000 vehicles
- Where a separated bike lane or sidepath is infeasible or not desirable

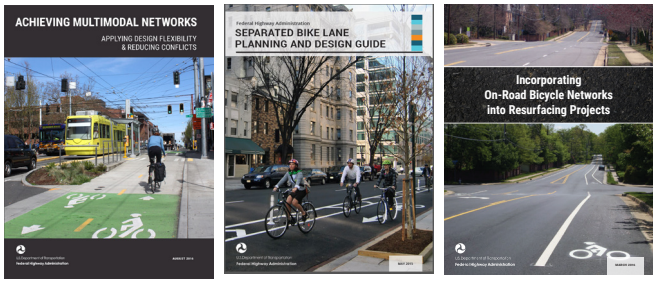
NATIONAL STANDARDS AND RESOURCES

The publications listed here are excellent resources for planning and design guidance in implementing safe, comfortable accommodations for pedestrians and bicyclists in a variety of environments. Many of these resources are available online at no cost.



Massachusetts Department of Transportation (MassDOT)

Separated Bike Lane Planning & Design Guide, 2016



Federal Highway Administration (FHWA)

Separated Bike Lane Planning and Design Guide, 2015

Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts (2016)

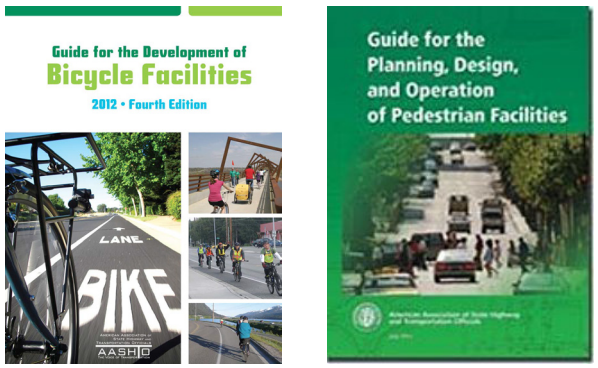
Incorporating On-Road Bicycle Networks into Resurfacing Projects (2016)

National Association of City Transportation Officials (NACTO)

Urban Street Design Guide

Transit Street Design Guide

Urban Bikeway Design Guide



American Association of State Highway and Transportation Officials (AASHTO)

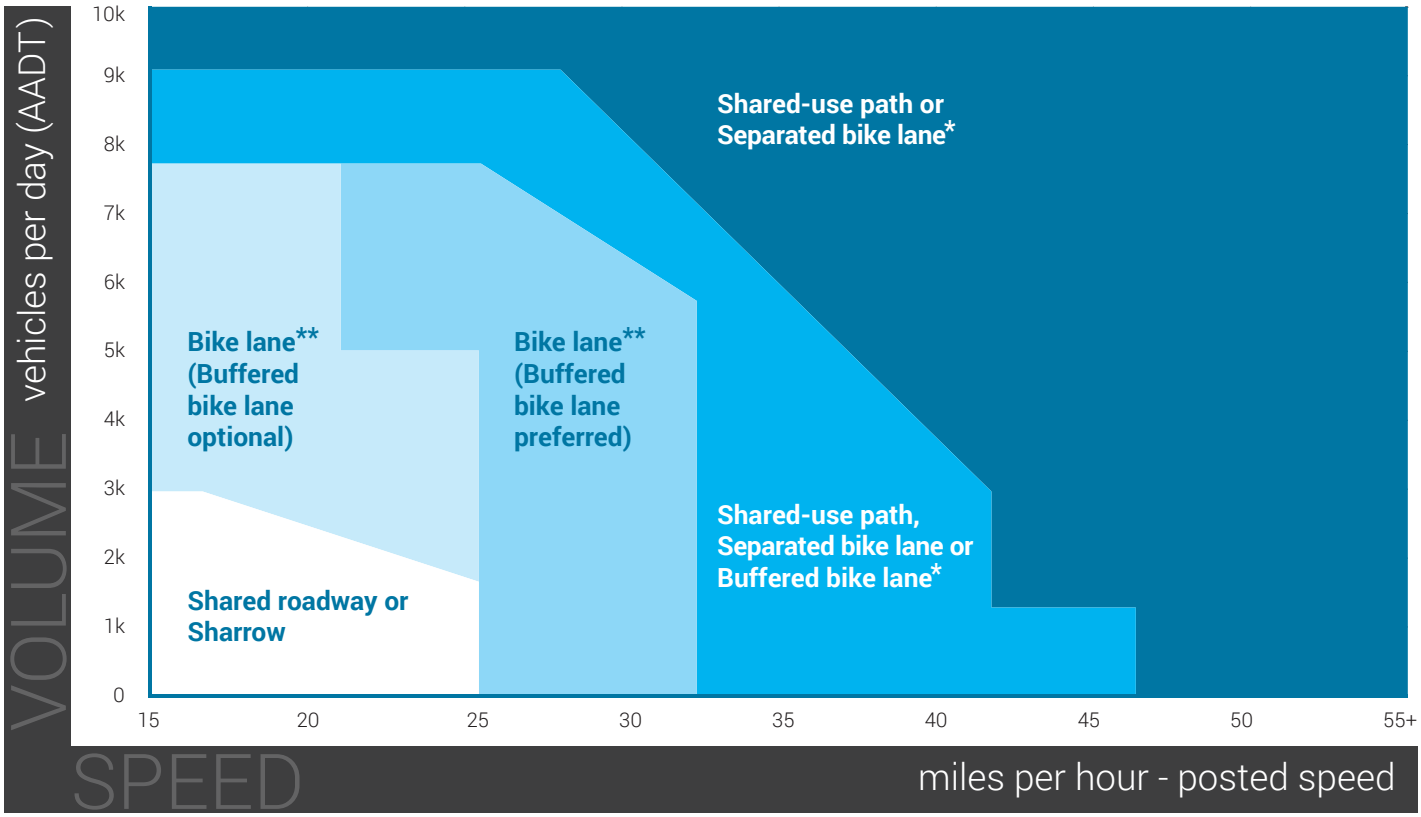
Guide for the Development of Bicycle Facilities, 2012

Guide for the Planning, Design, and Operation of Pedestrian Facilities, 2004

BICYCLE FACILITY SELECTION

Designing for Interested but Concerned and Casual and Somewhat Confident Bicyclists

"Interested but concerned" bicyclists prefer physical separation as traffic volumes and speeds increase. The bikeway facility selection chart below identifies bikeway facilities that improve operating environment for this bicyslist type at different roadway speeds and traffic volumes. The "casual" and "somewhat confident" bicyclist will also prefer bikeway treatments noted in this chart. If a community's goal is to increase bicycling, it is appropriate to select facility types based on this chart.



* To determine whether to provide a shared-use path, separated bike lane, or buffered bike lane, consider pedestrian and bicycle volumes or, in the absence of volume, consider land use.

** Can use a shoulder bikeway as necessary

FACILITY DETAILS:

- **Physically separated facility:**
  - Separated bike lane or shared-use path, separated from traffic by parking, posts, curb, etc.
  - For two-way facility: 10 to 12 ft preferred, 8 ft minimum
- **Bike lane:** 5 to 7 ft
- **Buffered bike lane:** 8 to 9 ft total
- **Shoulder bikeway:** 4 to 10 ft paved

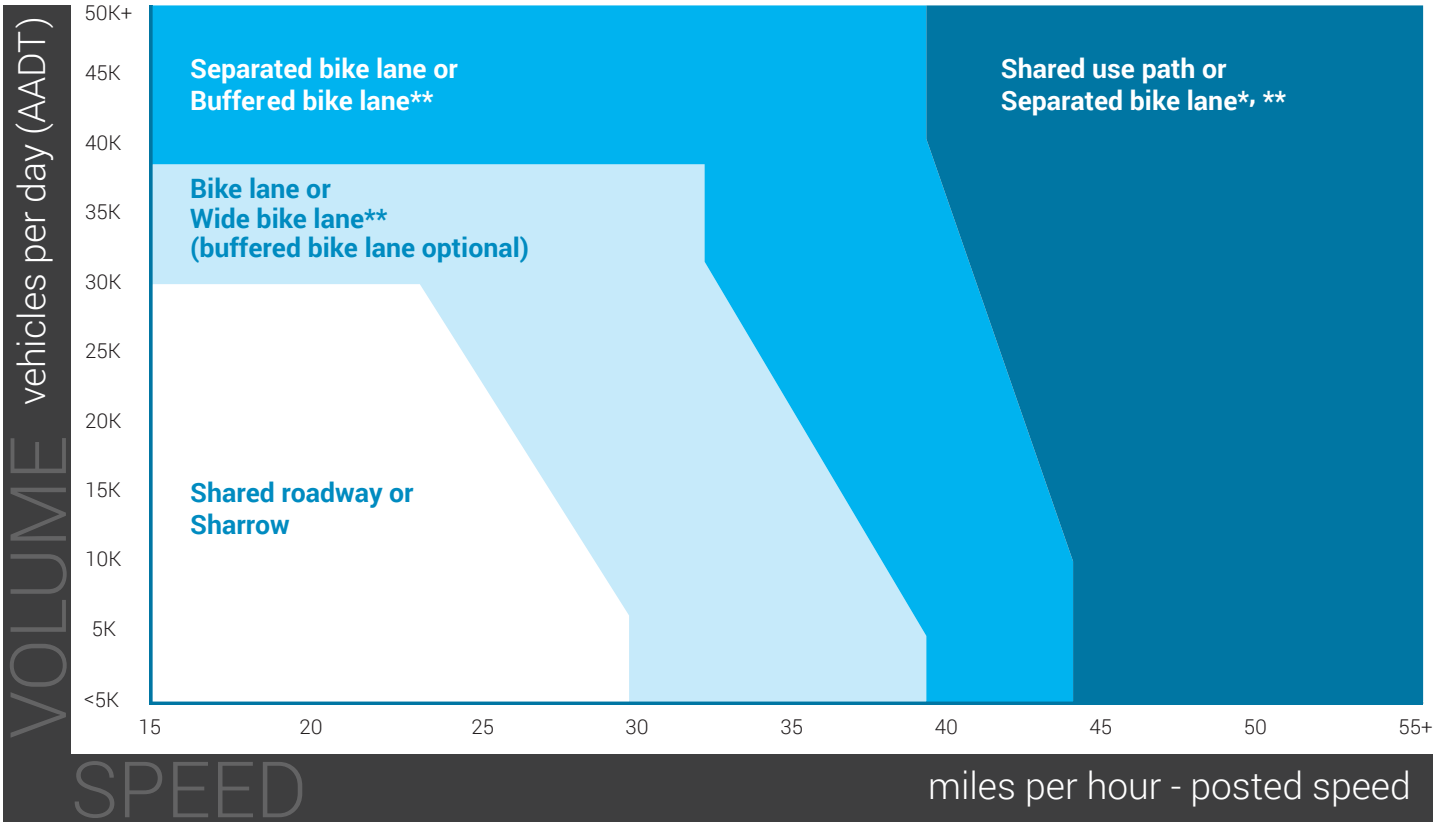
CHART REFERENCES

- Transitions are based on a shift in the Highway Capacity Manual (HCM) bike Level of Service (LOS) from A to B (assuming no parking, 12 ft outside travel lane, 6 ft bike lane, 8 ft buffered bike lane). This roughly translates to a C to D transition with on-street parking (8 ft parking lane).
- Speed thresholds based on Level of Traffic Stress. "Interested but Concerned" riders are sensitive to increases in volume or speed, based on Dill's research, *Categorizing Cyclists: What Do We Know? Insights from Portland, OR* on the four types of cyclists.

BICYCLE FACILITY SELECTION

Designing for Experienced and Confident Bicyclists

"Experienced and confident" bicyclists have a greater tolerance and willingness to operate with higher motor vehicle traffic volumes and speeds. The bikeway facility selection chart below identifies bikeway facilities that improve the operating environment for this bicyclist type at different roadway speeds and traffic volumes. The "casual and somewhat confident" bicyclist may tolerate bikeway treatments based on this chart for limited distances, while "interested but concerned" bicyclists may not.



* To determine whether to provide a shared-use path, separated bike lane, or buffered bike lane, consider pedestrian and bicycle volumes or, in the absence of volume, consider land use.

** Can use a shoulder bikeway as necessary

FACILITY DETAILS:

- **Physically separated facility:**
  - Separated bike lane or shared-use path, separated from traffic by parking, posts, curb, etc.
  - For two-way facility: 10 to 12 ft preferred, 8 ft minimum
- **Bike lane:** 5 to 7 ft
- **Buffered bike lane:** 8 to 9 ft total
- **Shoulder bikeway:** 4 to 10 ft paved

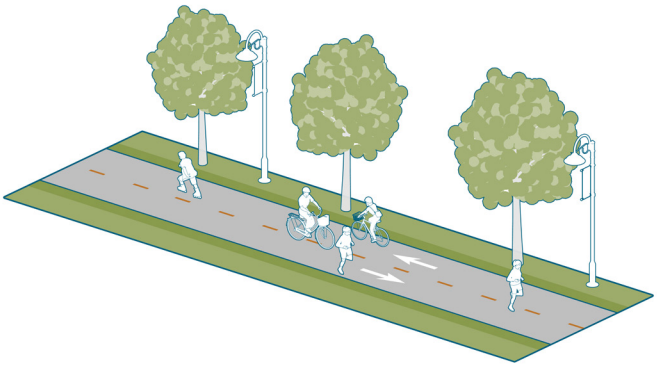
CHART REFERENCES

- Transitions are based on a shift in the Highway Capacity Manual (HCM) bike Level of Service (LOS) from A to B (assuming no parking, 12 ft outside travel lane, 6 ft bike lane, 8 ft buffered bike lane). This roughly translates to a C to D transition with on-street parking (8 ft parking lane).
- "Enthusiastic and Confident" bicyclists are more concerned with speed than volume; therefore the volume scale on the chart is significantly higher than in the bikeway facility selection chart (up to 50,000) and the thresholds are more sensitive to increases in speed than to increases in volume.

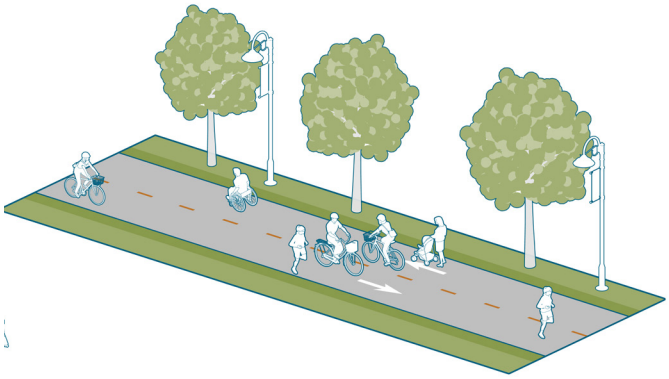
SHARED USE PATHS AND SIDEPATHS

A shared use path is a two-way facility physically separated from motor vehicle traffic and used by bicyclists, pedestrians, and other non-motorized users. Shared use paths, also referred to as trails, are often located in an independent alignment, such as a greenbelt or abandoned railroad. However, they are also regularly constructed along roadways; often bicyclists and pedestrians will have increased interactions with motor vehicles at driveways and intersections on these "sidepaths."

- According to the AASHTO, "Shared use paths should not be used to preclude on-road bicycle facilities, but rather to supplement a network of on-road bike lanes, shared roadways, bicycle boulevards, and paved shoulders." In other words, in some situations it may be appropriate to provide an on-road bikeway in addition to a sidepath along the same roadway.
- Many people express a strong preference for the separation between bicycle and motor vehicle traffic provided by paths when compared to on-street bikeways. Sidepaths may be desirable along high-volume or high-speed roadways, where accommodating the targeted type of bicyclist within the roadway in a safe and comfortable way is impractical. However, sidepaths may present increased conflicts between path users and motor vehicles at intersections and driveway crossings. Conflicts can be reduced by minimizing the number of driveway and street crossings present along a path and otherwise providing high-visibility crossing treatments.
- Paths typically have a lower design speed for bicyclists than on-street facilities and may not provide appropriate accommodation for more confident bicyclists who desire to travel at greater speeds. In addition, greater numbers of driveways or intersections along a sidepath corridor can decrease bicycle travel speeds and traffic signals can increase delay for bicyclists on off-street paths compared to cyclists using in-street bicycle facilities such as bike lanes. Therefore, paths should not be considered a substitute to accommodating more confident bicyclists within the roadway.



Path Width for One-way Passing



Path Width for Two-way Passing

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)

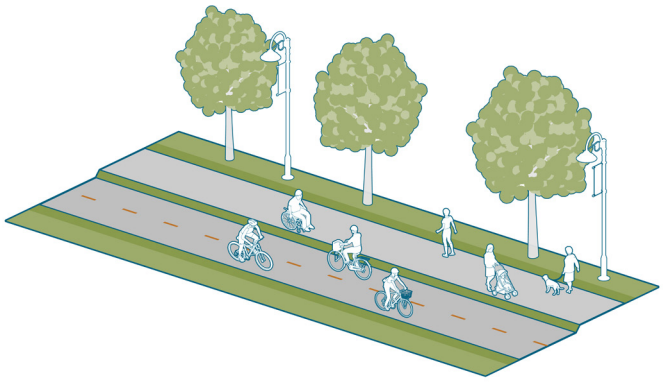
FHWA Shared-Use Path Level of Service Calculator (2006)

Manual on Uniform Traffic Control Devices (2009)

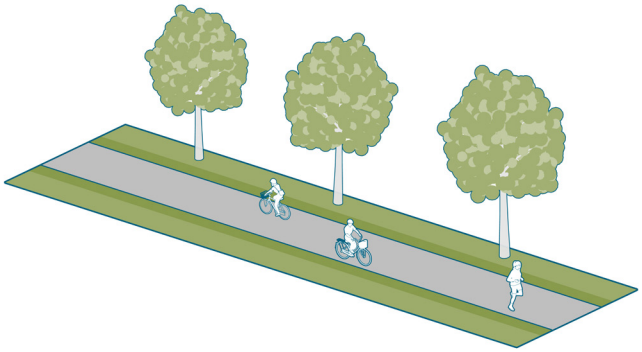
PATH WIDTH CONSIDERATIONS

Path width should be determined based on three main characteristics: the number of users, the types of users, and the differences in their speeds. For example, a path that is used by higher-speed bicyclists and children walking to school may experience conflicts due to their difference in speeds. By widening the path to provide space to accommodate passing movements, conflicts can be reduced.

- Widths as narrow as 8 feet are acceptable for short distances under physical constraint. Warning signs should be considered at these locations.
- In locations with heavy volumes or a high proportion of pedestrians, widths exceeding 10 feet are recommended. A minimum of 11 feet is required for users to pass with a user traveling in the other direction. It may be beneficial to separate bicyclists from pedestrians by constructing parallel paths for each mode.
- Paths must be designed according to state and national standards. This includes establishing a design speed (typically 18 mph) and designing path geometry accordingly. Consult the AASHTO Guide for the Development of Bicycle Facilities for guidance on geometry, clearances, traffic control, railings, drainage, and pavement design.
- On hard surfaces it can be useful to include soft surface parallel paths which are preferred by some users, such as runners.
- Path clearances are an important element in path design and reducing user conflicts. Vertical objects close to the path edge can endanger users and reduce the comfortable usable width of the path. Along the path, vertical objects should be set back at least two feet from the edge of the path. Path shoulders may also reduce conflicts by providing space for users who step off the path to rest, allowing users to pass one another, or providing space for viewpoints.



Shared Use Path Physical Separation



Minimum Path Width Limits Passing

REFERENCES

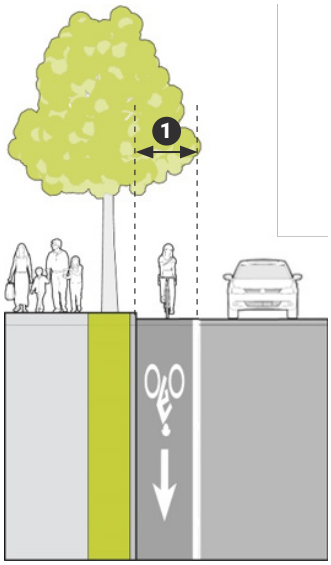
AASHTO Guide for the Development of Bicycle Facilities (2012)

FHWA Shared-Use Path Level of Service Calculator (2006)

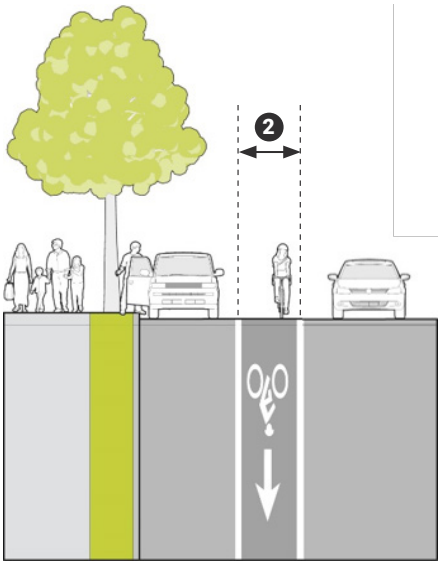
Manual on Uniform Traffic Control Devices (2009)

BIKE LANES

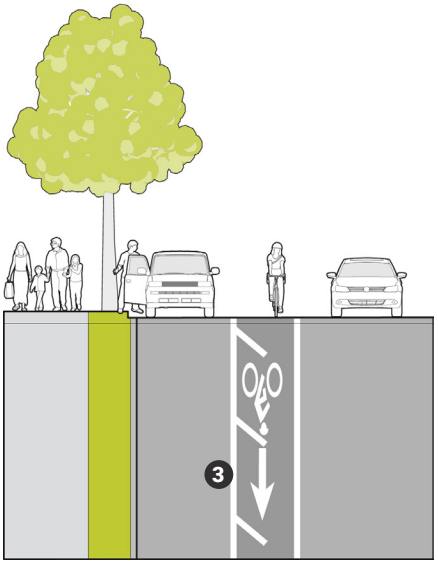
Bicycle lanes provide an exclusive space for bicyclists in the roadway. Bicycle lanes are established through the use of lines and symbols on the roadway surface. Bicycle lanes are for one-way travel and are normally provided in both directions on two-way streets and/or on one side of a one-way street. Bicyclists are not required to remain in a bicycle lane when traveling on a street and may leave the bicycle lane as necessary to make turns, pass other bicyclists, or to properly position themselves for other necessary movements. Bicycle lanes may only be used temporarily by vehicles accessing parking spaces and entering and exiting driveways and alleys. Stopping, standing and parking in bike lanes is prohibited.



Bike Lane Adjacent to Parking



Bike Lane Adjacent to a Curb



Bike Lane with Door Zone Marking

- Typically installed by reallocating existing street space.
- Can be used on one-way or two-way streets.
- Contra-flow bicycle lanes may be used to allow two-way bicycle travel on streets designated for one-way travel for motorists to improve bicycle network connectivity.
- Stopping, standing and parking in bike lanes may be problematic in areas of high parking demand and deliveries, especially in commercial areas.
- Wider bike lanes or buffered bike lanes are preferable at locations with high parking turnover.

1. The minimum width of a bike lane adjacent to a curb is 5 feet exclusive of a gutter, a desirable width is 6 feet.
2. The minimum width of a bike lane adjacent to parking is 5 feet, a desirable width is 6 feet.
3. Parking T's or hatch marks can highlight the door zone on constrained corridors with high parking turnover to guide bicyclists away from doors.

REFERENCES

AASHTO. Guide for the Development of Bicycle Facilities. 2012.

NACTO. Urban Bikeway Design Guide. 2nd Edition.

LEFT SIDE BIKE LANE

In some locations, bicycle lanes placed on the left-side of the roadway can result in fewer conflicts between bicyclists and motor vehicles, particularly on streets with heavy right-turn volumes or frequent bus service and stops where buses operate in the right-side curb lane. Other occasions may be where parking is provided only on the right side of the street or where loading predominantly occurs on the right. Left-side bike lanes can increase visibility between motorists and bicyclists at intersections due to the location of the rider on the left-side of the vehicle. However, left-side bike lanes are often an unfamiliar orientation for both bicyclists and drivers and may be less intuitive.

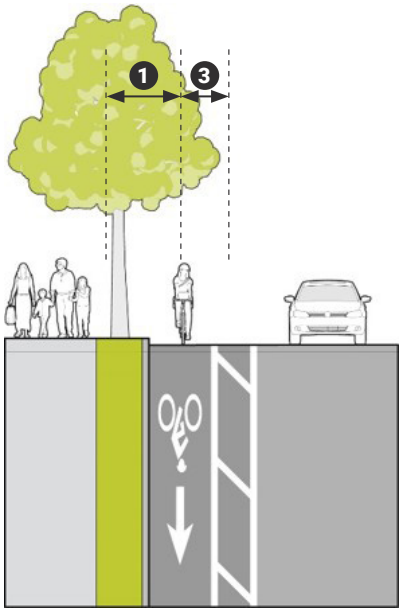
- On one-way streets with parking on both sides, bicyclists will typically encounter fewer conflicts with car doors opening on the passenger side.
- Colored pavement should be considered in curbside locations to increase awareness of the restriction against parking or stopping in the bicycle lane.
- Left-side placement may not be appropriate in locations where the street switches from one-way to two-way operation.
- Left-side bicycle lanes may not be appropriate near the center or left-side of free flow ramps or along medians with streetcar operations, unless appropriate physical separation and signal protection can be provided.
- Consider dominant bicycle routes. Where a large proportion of bicyclists make right hand turns, conventional bike lanes may be preferable.
- Left-side bicycle lanes generally may only be used on one-way streets or on median divided streets.
- Left-side bicycle lanes have the same design requirements as right-side bicycle lanes.

REFERENCES

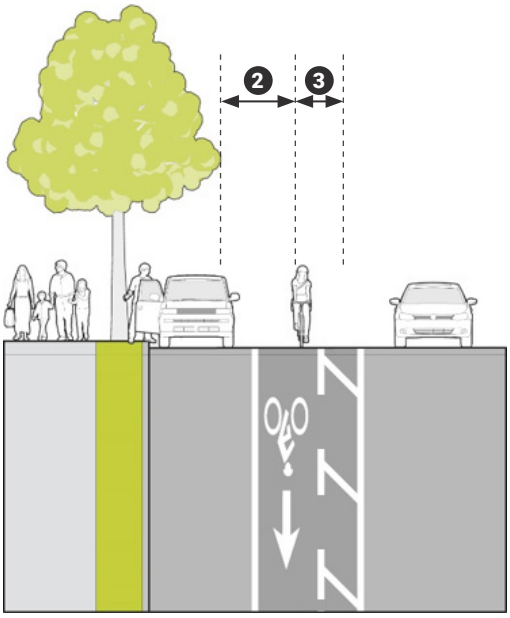
AASHTO. Guide for the Development of Bicycle Facilities. 2012..

BUFFERED BIKE LANES

Buffered bicycle lanes are created by painting or otherwise creating a flush buffer zone between a bicycle lane and the adjacent travel lane. While buffers are typically used between bicycle lanes and motor vehicle travel lanes to increase bicyclists' comfort, they can also be provided between bicycle lanes and parking lanes in locations with high parking turnover to discourage bicyclists from riding too close to parked vehicles.



Buffered Bike Lane Adjacent to a Curb



Buffered Bike Lane Adjacent to Parking

- Preferable to a conventional bicycle lanes when used as a contra-flow bike lane on one-way streets.
- Typically installed by reallocating existing street space.
- Can be used on one-way or two-way streets.
- Consider placing buffer next to parking lane where there is commercial or metered parking.
- Consider placing buffer next to travel lane where speeds are 30 mph or greater or when traffic volume exceeds 6,000 vehicles per day.
- Where there is 7 feet of roadway width available for a bicycle lane, a buffered bike lane should be installed instead of a conventional bike lane
- Buffered bike lanes allow bicyclists to ride side by side or to pass slower moving bicyclists.
- Research has documented buffered bicycle lanes increase the perception of safety.

1. The minimum width of a buffered bike lane adjacent to parking is 4 feet, a desirable width is 6 feet.
2. Buffers are to be broken where curbside parking is present to allow cars to cross the bike lane.
3. The minimum buffer width is 18 inches. There is no maximum. Diagonal cross hatching should be used for buffers <3 feet in width. Chevron cross hatching should be used for buffers >3 feet in width.

REFERENCES

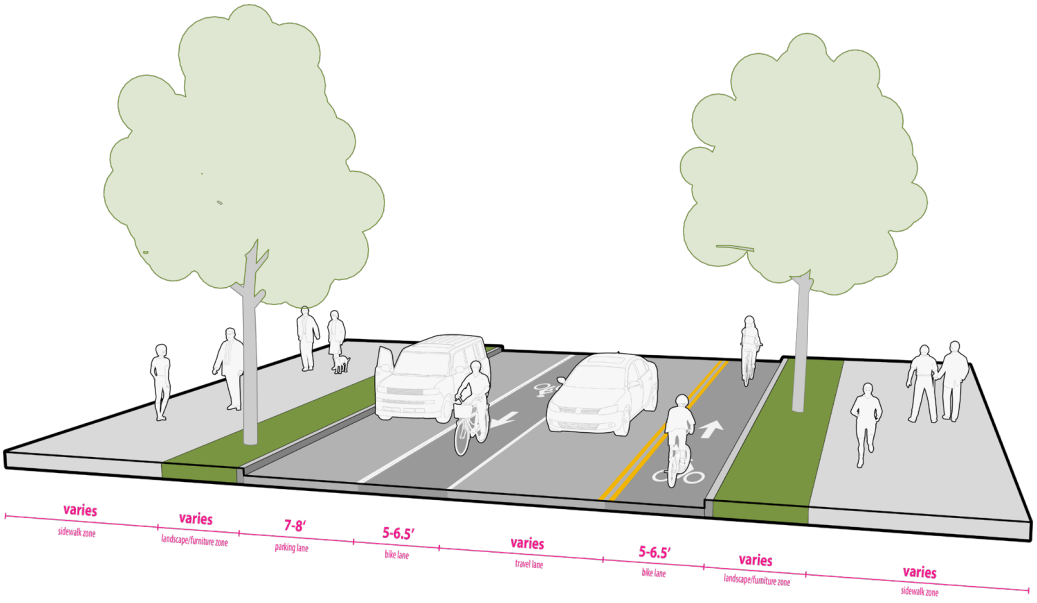
AASHTO. Guide for the Development of Bicycle Facilities. 2012.

NACTO. *Urban Bikeway Design Guide.* 2nd Edition.

Portland State University, Center for Transportation Studies. *Evaluation of Innovative Bicycle Facilities: SW Broadway Cycle Track & SW Stark/Oak Street Buffered Bike Lanes FINAL REPORT.* 2011.

CONTRA-FLOW BIKE LANE

One-way streets and irregular street grids can make bicycling to specific destrinatinos within short distances difficult. Contra-flow bicycle lanes can help to solve this problem by enabling only bicyclists to operate in two directions on one-way streets. Contra-flow lanes are useful to reduce distances bicyclists must travel and can make bicycling safer by creating facilities that help other roadway users understand where to expect bicyclists.



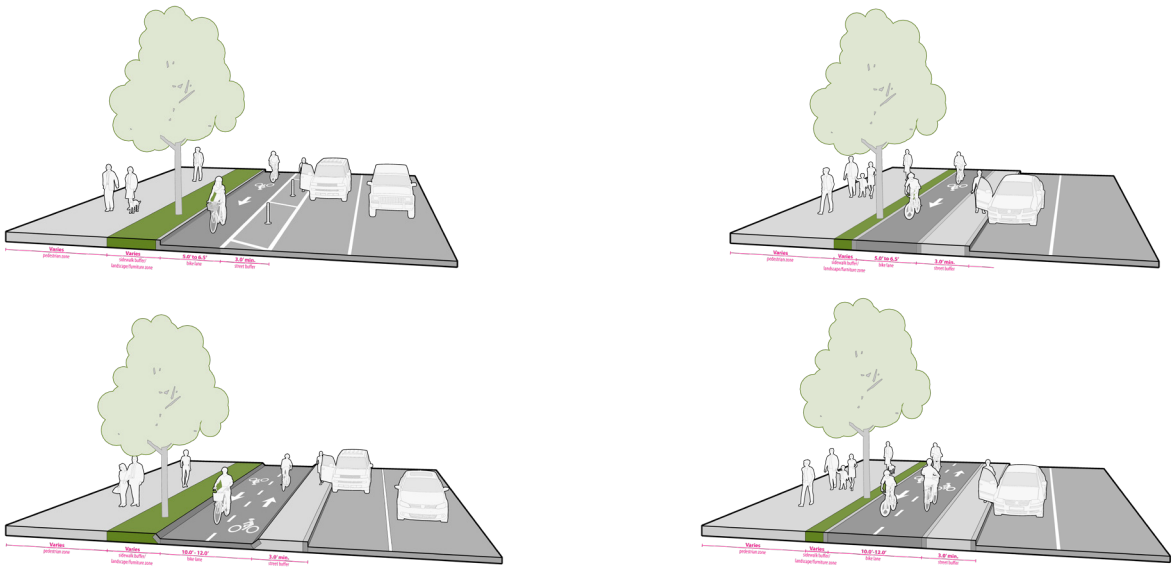
- Contra-flow lanes follow the same design parameters as conventional bicycle lanes: however, the left side marking is a double yellow line. The line should be dashed if parking is provided on both sides of the street. Contra-flow lanes may also be separated by a buffer or vertical separation such as a curb.
- Contra-flow lanes must be placed to the motorist's left.
- A bicycle lane or other marked bicycle facility should be provided for bicyclists traveling in the same direction as motor vehicle traffic on the street to discourage wrong way riding in the contra-flow lane.
- Parking is discouraged against the contra-flow lane as drivers' view of oncoming bicyclists would be blocked by other vehicles. If parking is provided, a buffer is recommended to increase the visibility of bicyclists. On-street parking should be restricted at corners.
- Contra-flow lanes are less desirable on-streets with frequent and/or high-volume driveways or alley entrances on the side with the proposed contraflow lane. Drivers may neglect to look for opposing direction bicyclists on a one-way street.
- Contra-flow bicycle lanes are used on one-way streets that provide more convenient or direct connections for bicyclists where other alternative routes are less desirable or inconvenient.
- Contra-flow lanes should be used where there is a clear and observed need for the connection as evidenced by a number of "wrong way riding" bicyclists or bicyclists riding on sidewalks in the opposing direction.
- Contra-flow lanes are often short, connecting segments. They are not typically used along extended corridors.
- Contra-flow lanes may only be established where there is adequate roadway width for an exclusive lane.
- Care should be taken in the design of contra-flow lane termini. Bicyclists should be directed to the proper location on the receiving roadway.

REFERENCES

AASHTO. Guide for the Development of Bicycle Facilities. 2012..

SEPARATED BIKE LANES

Separated Bike Lanes are an exclusive bikeway facility type that combines the user experience of a sidepath with the on-street infrastructure of a conventional bike lane. They are physically separated from motor vehicle traffic and distinct from the sidewalk.



Separated bike lanes are more attractive to a wider range of bicyclists than striped bikeways on higher volume and higher speed roads. They eliminate the risk of a bicyclist being hit by an opening car door and prevent motor vehicles from driving, stopping or waiting in the bikeway. They also provide greater comfort to pedestrians by separating them from bicyclists operating at higher speeds.

Separated bike lanes can provide different levels of separation:

- Separated bike lanes with flexible delineator posts ("flex posts") alone offer the least separation from traffic and are appropriate as interim solution.
- Separated bike lanes that are raised with a wider buffer from traffic provide the greatest level of separation from traffic, but will often require road reconstruction.
- Separated bike lanes that are protected from traffic by a row of on-street parking offer a high-degree of separation.

Separated bike lanes can generally be considered on any road with one or more of the following characteristics:

- Traffic lanes: 3 lanes or more.
- Posted speed limit: 30 mph or more.
- Traffic: 9,000 vehicles per day or more.
- On-Street parking turnover: frequent.
- Bike lane obstruction: likely to be frequent.
- Streets that are designated as truck or bus routes.

Separated bike lanes are preferred over sidepaths in higher density areas, commercial and mixed-use development, and near major transit stations or locations where pedestrian volumes are anticipated to exceed 200 people per hour on a shared use path.

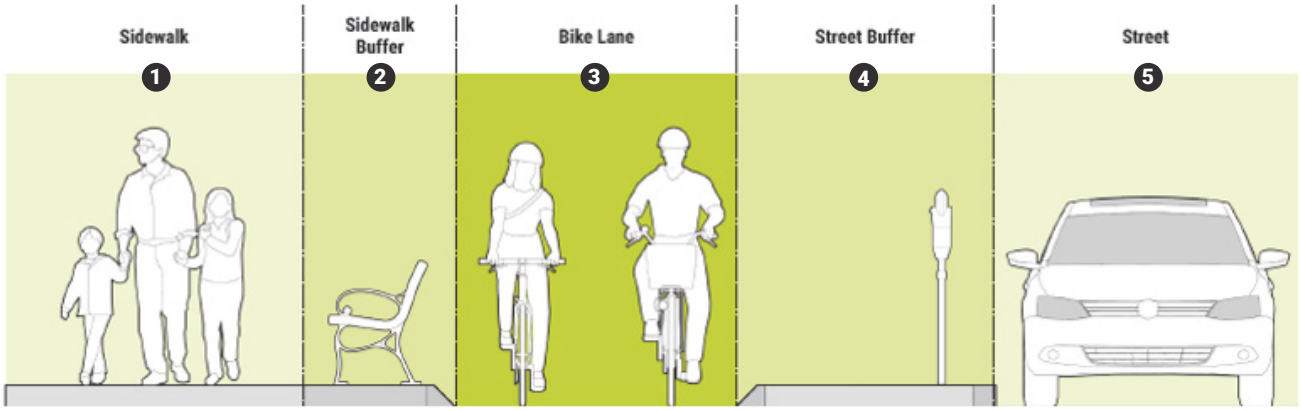
REFERENCES

NACTO. Urban Bikeway Design Guide. 2nd Edition.

MassDOT. Separated Bike Lane Planning and Design Guide. 2015

SEPARATED BIKE LANE ZONES

The cross section of a separated bike lane is composed of three separate zones:
Bike lane: the bicyclist operating space between the street buffer and the sidewalk buffer.
Street buffer: the street buffer separates the bike lane from motor vehicle traffic.
Sidewalk buffer: the sidewalk buffer separates the bike lane from the sidewalk.



The width of the bike lane zone is impacted by the elevation of the bike lane and the volume of users. Separated bike lanes generally attract a wider spectrum of bicyclists, some of whom operate at slower speeds, such as children or seniors. Because of the elements used to separate the bike lane from the adjacent motor vehicle lane, bicyclists usually do not have the option to pass each other by moving out of the separated bike lane. The bike lane zone should therefore be sufficiently wide to enable passing maneuvers between bicyclists.

The goal of the street buffer is to maximize the safety and comfort of people bicycling and driving by physically separating these roadway users with a vertical object or a raised median. The width of the street buffer also influences intersection operations and bicyclists safety, particularly at locations where motorists may turn across the bike lane. The street buffer can consist of parked cars, vertical objects, raised medians, landscape medians, and a variety of other elements.

The sidewalk buffer zone separates the bike lane from the sidewalk, communicating each as distinct spaces. By separating people walking and bicycling, encroachment into these spaces is minimized and the safety and comfort is enhanced for both users.

1. The sidewalk width should be determined by the anticipated peak hour pedestrian volume.
2. The sidewalk buffer is desirable, but not required.
3. The bike lane is required and may be at street level, intermediate level, or sidewalk level. (See pages x-x).
   - Bike lane width should be determined by the anticipated peak hour bicycle volume. (See pages x-x).
   - A minimum shy distance of 1 foot should be provided between any vertical objects in the sidewalk or street buffer to the bike lane.
4. The street buffer is required and should be separated from the street by vertical objects or a median.
5. Travel lanes and parking should be narrowed to the minimum widths in constrained corridors.

REFERENCES

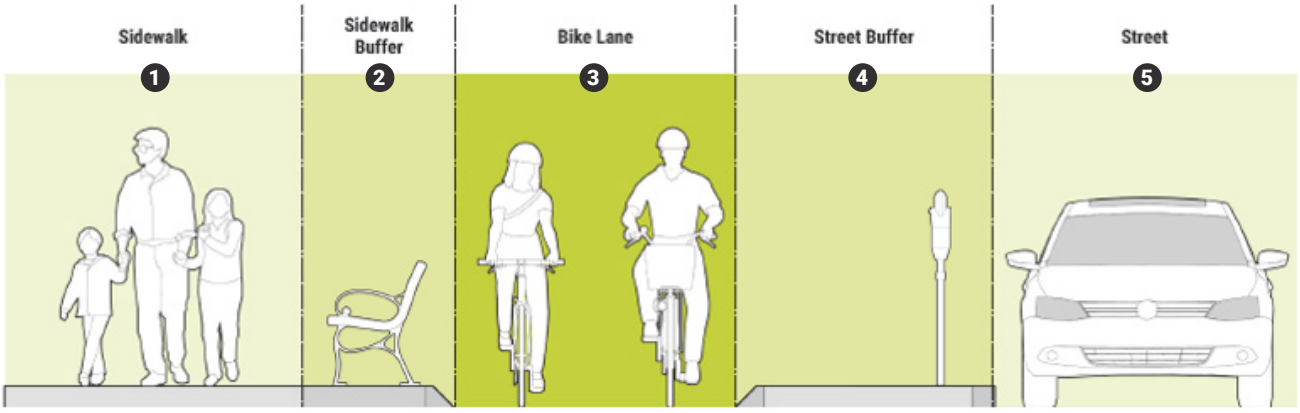
AASHTO. Guide for the Development of Bicycle Facilities. 2012..

NACTO. Urban Bikeway Design Guide. 2nd Edition.

MassDOT. Separated Bike Lane Planning and Design Guide. 2015

DETERMINING ZONE WIDTHS IN CONSTRAINED CORRIDORS

When designing separated bike lanes in constrained corridors, designers may need to minimize some portions of the cross section, including separated bike lane zones, to achieve a context-sensitive design that safely and comfortably accommodates all users.



CONSIDERATIONS

+ The allocation of space can vary from midblock locations to intersection approaches. It may be beneficial to narrow midblock street buffers to provide sidewalk buffers or a wider bike lane. At approaches to intersections the midblock sidewalk buffer can be eliminated to provide a wider street buffer to improve intersection safety.

+ The street buffer is critical to the safety of separated bike lanes. Narrowing or eliminating it should be avoided wherever possible, especially at intersections. Providing a larger street buffer at intersections can be achieved by tapering the bike lane toward the sidewalk as it approaches the intersection, or by narrowing or eliminating the sidewalk buffer.

+ In constrained locations where physical separation is desirable because of higher pedestrian demand, such as commercial areas, raised separation between the sidewalk buffer and bike lane is preferable to ensure pedestrians do not walk in the bike lane, and bicyclists do not ride on the sidewalk. Where it is not feasible to provide raised separation, it will be necessary to distinguish the bike lane from the sidewalk through the use of stained surfaces or applied surface colorization materials that provide a high degree of visual contrast between the two.

GUIDANCE

Zone spatial tradeoff prioritization (1 is lowest-priority use, 5 is highest-priority use):

1. Designers should prioritize reduction of the space allocated to the street before narrowing other spaces. This reduction can include decreasing the number of travel lanes, narrowing existing lanes or adjusting on-street parking.

2. The sidewalk should not be narrowed beyond the minimum necessary to accommodate pedestrian demand.

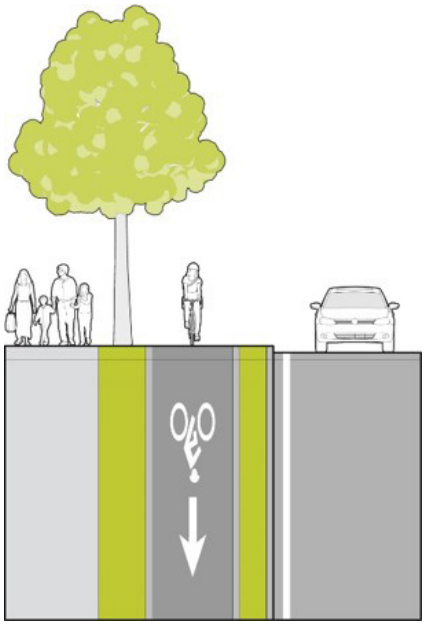
3. The sidewalk buffer may be eliminated at locations with low pedestrian volume. At locations with increased pedestrian volume, it is desirable to provide vertical separation and/or clear delineation between the bicycle lane and the sidewalk.

4. The street buffer is critical to the safety of separated bike lanes; narrowing or eliminating it should be avoided wherever possible. The buffer should not be reduced below 2 feet at midblock locations and should be between 6 feet and 20 feet at intersections to provide maximum safety benefits. Where the buffer is reduced below 6 feet, a raised bicycle crossing or signal phase separation should be considered.

+ 5. The bike lane width should not be reduced below 6.5 feet for one-way bike lanes and 8 feet for two-way bikeways, to ensure bicyclists can safely pass other bicyclists.

SEPARATED BIKE LANE - ONE-WAY SIDEWALK LEVEL

This treatment provides an exclusive, uni-directional operating space for bicyclists between the street and sidewalk that is at the same elevation as the sidewalk. It is physically separated from motor vehicles and pedestrians by vertical and horizontal elements.



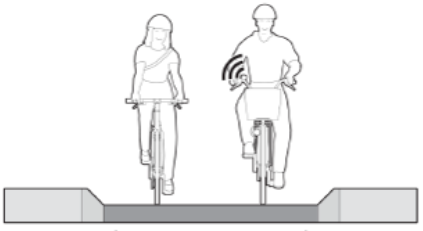
Sidewalk-level bike lanes:

- May encourage pedestrian and bicyclist encroachment unless a continuous sidewalk buffer is provided.
- Allow separation from motor vehicles in locations with limited right-of-way.
- Maximize usable bike lane width.
- Require no transition for raised bicycle crossings at driveways, alleys or cross streets.
- May provide level landing areas for parking, loading or bus stops along the street buffer.
- May reduce maintenance needs by prohibiting debris build up from roadway runoff.
- May simplify plowing operations.
- Allow bicyclists to use a portion of the sidewalk or street buffer to pass other bicyclists in constrained corridors where sidewalk buffers are eliminated.

One-way separated bike lanes in the direction of motorized travel provide intuitive and simplified transitions to existing bike lanes and shared travel lanes.

GUIDANCE

- The recommended minimum width of the bicycle lane is:



Same Direction Bicyclists/ Peak Hour	Bike Lane Width (ft.)	
	Rec.	Min.*
<150	6.5	5.0
150-750	8.0	6.5
>750	10.0	8.0

- A constrained bicycle lane width of 4 feet may be used for short distances to navigate around transit stops or accessible parking spaces.

REFERENCES

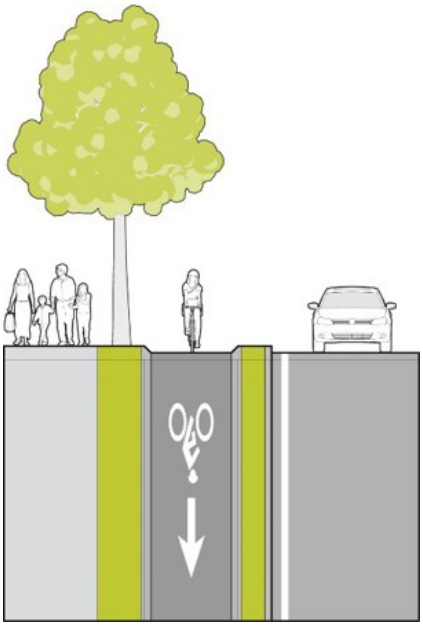
NACTO. *Urban Bikeway Design Guide. 2nd Edition.*

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

SEPARATED BIKE LANE - ONE-WAY STREET LEVEL

This treatment provides an exclusive, uni-directional operating space for bicyclists between the street and sidewalk that is located at the same elevation as the street. It is physically separated from motor vehicles and pedestrians by vertical and horizontal elements.



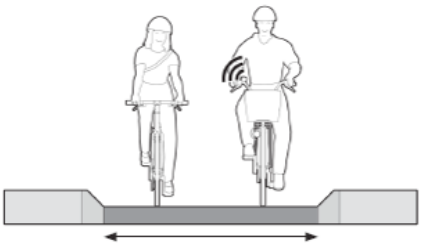
Street-level bike lanes:

+ Preserve separation between bicyclists and pedestrians where sidewalk buffers are eliminated.
+ Ensures a detectable edge is provided for people with vision disabilities.
+ May increase maintenance needs to remove debris from roadway runoff unless street buffer is raised.
+ May complicate snow plowing operations.
+ May require careful consideration of drainage design and in some cases may require catch basins to manage bike lane runoff.

One-way separated bike lanes in the direction of motorized travel are provide intuitive and simplified transitions to existing bike lanes and shared travel lanes.

GUIDANCE

+ The recommended minimum width of the bicycle lane is:



Same Direction Bicyclists/ Peak Hour	Bike Lane Width (ft.)	
	Rec.	Min.*
<150	6.5	5.0
150-750	8.0	6.5
>750	10.0	8.0

+ A constrained bicycle lane width of 4 feet may be used for short distances to navigate around transit stops or accessible parking spaces.

REFERENCES

NACTO. Urban Bikeway Design Guide. 2nd Edition.

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

SEPARATED BIKE LANE - TWO-WAY SIDEWALK LEVEL

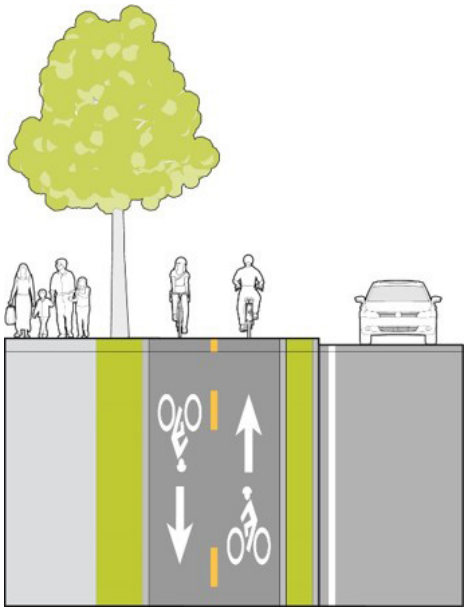
This treatment provides an exclusive, bi-directional operating space for bicyclists between the street and sidewalk that is at the same elevation as the sidewalk. It is physically separated from motor vehicles and pedestrians by vertical and horizontal elements.

Sidewalk-level bike lanes:

- May encourage pedestrian and bicyclist encroachment unless discouraged with a continuous sidewalk buffer.
- Requires no transition for raised bicycle crossings at driveways, alleys or streets.
- May provide level landing areas for parking, loading or bus stops along the street buffer.
- May reduce maintenance needs by prohibiting debris build up from roadway runoff.
- May simplify snow plowing operations.
- Allow bicyclists to use a portion of the sidewalk or street buffer to pass other bicyclists in constrained corridors where sidewalk buffers are eliminated.

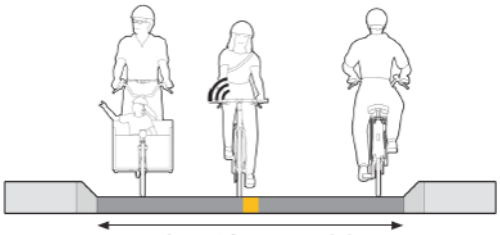
Two-way separated bike lanes will require special attention to transition the contra-flow bicyclist into existing bike lanes and shared travel lanes.

Depending on context, motorists may not expect bicyclists to approach crossings from both directions. For this reason, two-way separated bike lanes may require detailed treatments at alley, driveway, and cross street crossings to enhance the safety of these crossings



GUIDANCE

- The recommended minimum width of the bicycle lane is:



Bidirectional Bicyclists/ Peak Hour	Bike Lane Width (ft.)	
	Rec.	Min.*
<150	10.0	8.0
150-400	11.0	10.0
>400	14.0	11.0

REFERENCES

NACTO. Urban Bikeway Design Guide. 2nd Edition.

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

SEPARATED BIKE LANE - TWO-WAY STREET LEVEL

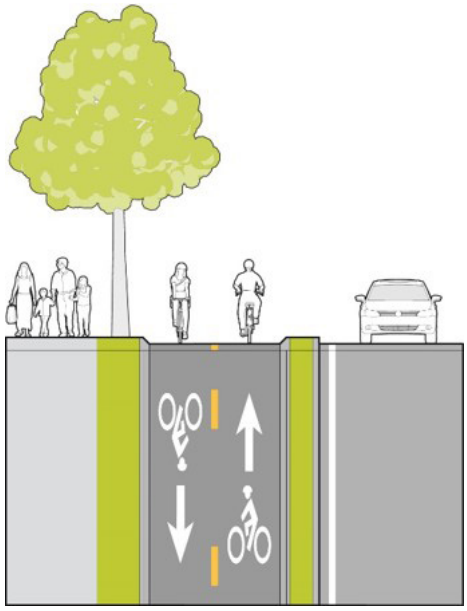
This treatment provides an exclusive, bi-directional operating space for bicyclists between the street and sidewalk that is located at the same elevation as the street. It is physically separated from motor vehicles and pedestrians by vertical and horizontal elements.

Street-level bike lanes:

+ Preserve separation between bicyclists and pedestrians where sidewalk buffers are eliminated.
+ Ensures a detectable edge is provided for people with vision disabilities.
+ May increase maintenance needs to remove debris from roadway runoff unless street buffer is raised.
+ May complicate snow plowing operations.
+ May require careful consideration of drainage design and in some cases may require catch basins to manage bike lane runoff.

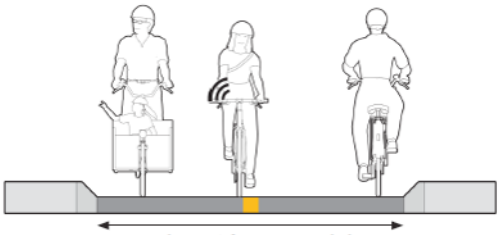
Two-way separated bike lanes will require special attention to transition the contra-flow bicyclist into existing bike lanes and shared travel lanes.

Depending on context, motorists may not expect bicyclists to approach crossings from both directions. For this reason, two-way separated bike lanes may require detailed treatments at alley, driveway, and cross street crossings to enhance the safety of these crossings.



GUIDANCE

+ The recommended minimum width of the bicycle lane is:



Bidirectional Bicyclists/ Peak Hour	Bike Lane Width (ft.)	
	Rec.	Min.*
<150	10.0	8.0
150-400	11.0	10.0
>400	14.0	11.0

REFERENCES

NACTO. Urban Bikeway Design Guide. 2nd Edition.

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

BICYCLE BOULEVARD TREATMENTS

Bicycle boulevard treatments are applied on quiet streets, often through residential neighborhoods. These treatments are designed to prioritize bicycle through-travel, while discouraging motor vehicle traffic and maintaining relatively low motor vehicle speeds. Treatments vary depending on context, but often include elements of traffic calming, including traffic diverters, speed attenuators such as speed humps or chicanes, pavement markings, and signs. Bicycle boulevards are also known as neighborhood greenways, and neighborhood bikeways, among other locally-preferred terms.

Many cities already have signed bike routes along neighborhood streets that provide an alternative to traveling on high-volume, high-speed arterials. Applying bicycle boulevard treatments to these routes makes them more suitable for bicyclists of all abilities and can reduce crashes as well.

Stop signs or traffic signals should be placed along the bicycle boulevard in a way that prioritizes the bicycle movement, minimizing stops for bicyclists whenever possible.

Bicycle boulevard treatments include traffic calming measures such as street trees, traffic circles, chicanes, and speed humps. Traffic management devices such as diverters or semi-diverters can redirect cut-through vehicle traffic and reduce traffic volume while still enabling local access to the street.

Communities should begin by implementing bicycle boulevard treatments on one pilot corridor to measure the impacts and gain community support. The pilot program should include before-and-after crash studies, motor vehicle counts, and bicyclist counts on both the bicycle boulevard and parallel streets. Findings from the pilot program can be used to justify bicycle boulevard treatments on other neighborhood streets.

Additional treatments for major street crossings may be needed, such as median refuge islands, rapid flash beacons, bicycle signals, and HAWK or half signals.

+ Maximum Average Daily Traffic (ADT): 3,000
+ Preferred ADT: up to 1,000
+ Target speeds for motor vehicle traffic are typically around 20 mph; there should be a maximum < 15 mph speed differential between bicyclists and vehicles.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)

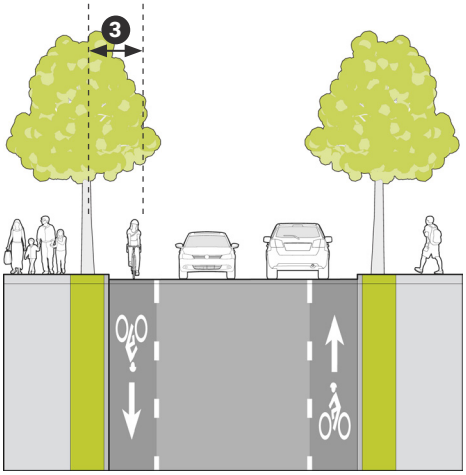
NACTO Urban Bikeway Design Guide (2012)

Manual on Uniform Traffic Control Devices (2009)

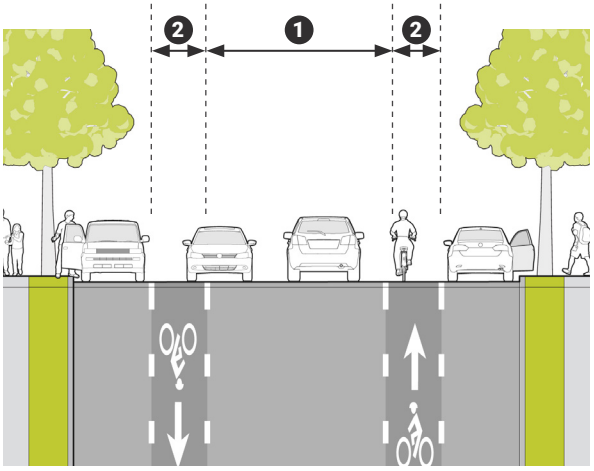
Fundamentals of Bicycle Boulevard Planning & Design (2009)

ADVISORY BIKE LANES

Advisory bicycle lanes (ABLs) are used to create narrow streets where bicyclists are provided priority movement and motorists are compelled to yield to bicyclists as well as drivers approaching in the opposing direction. ABLs use dotted lane lines, allowing motorists to enter them to yield, and are designed using dimensions based on conventional bicycle lanes. ABLs are reserved for use on low-volume, low-speed streets.



Advisory Bike Lane without Parking



Advisory Bike Lane with Parking

CONSIDERATIONS

+ **Treatment requires FHWA permission to experiment**
+ For use on streets too narrow for bike lanes and normal-width travel lanes.
+ Provide two separate minimum-width bicycle lanes, on either side of a single shared (unlaned) two-way "yielding" motorist travel space.
+ Motorists must yield to on-coming motor vehicles by pulling into the bicycle lane.
+ To reduce motorist speeds, and to encourage yielding, the unmarked space between the two advisory bike lanes should be no wider than 18 feet.
+ This treatment should only be used on streets with >60% continuous daytime parking occupancy.
+ Where parking occupancy is continuously <50%, it is preferable to consolidate it to one side of the street or remove it.
+ A Two-Way Traffic warning sign (W6-3) may increase motorists understanding of the intended two-way operation of the street.

GUIDANCE

1. The minimum width of the unlaned motorist space should be 12 feet between the bicycle lanes. The maximum width should be no more than 18 feet.
2. The minimum width of an advisory bike lane adjacent to parking is 5 feet; a desirable width is 6 feet.
3. The minimum width of an advisory bike lane adjacent to a curb is 4 feet exclusive of a gutter; a desirable width is 6 feet.

Advisory bikeways can generally be considered on any road with one or more of the following characteristics:

+ Traffic lanes: 2 lanes or less.
+ Posted speed limit: 25 mph or less.
+ Traffic: 6,000 vehicles per day or less or 300 vehicles or less during the peak hour
+ On-Street parking turnover: infrequent.
+ Street is not a designated truck or bus route.

REFERENCES

AASHTO. Guide for the Development of Bicycle Facilities. 2012..

http://www.fhwa.dot.gov/environment/bicycle_pedestrian/guidance/mutcd/dashed_bike_lanes.cfm

PAVED SHOULDERS

Paved shoulders provide a range of benefits: they reduce motor vehicle crashes, reduce long-term roadway maintenance, ease short-term maintenance such as snow plowing, and provide space for bicyclists and pedestrians (although paved shoulders typically do not meet accessibility requirements for pedestrians). Paved shoulders are typically reserved for rural road cross-sections.

Where 4-foot or wider paved shoulders exist already, it is acceptable or even desirable to mark them as bike lanes in various circumstances, such as to provide continuity between other bikeways. If paved shoulders are marked as bike lanes, they need to also be designed as bike lanes at intersections. Where a roadway does not have paved shoulders already, paved shoulders can be retrofitted to the existing shoulder when the road is resurfaced or reconstructed. In some instances, adequate shoulder width can be provided by narrowing travel lanes to 11 feet.

Reducing travel lane width on existing roads—also known as a "lane diet"—is one way to increase paved shoulder width.

There are several situations in which additional shoulder width should be provided, including motor vehicle speeds exceeding 50 mph, moderate to heavy volumes of traffic, and above-average bicycle or pedestrian use.

The placement of rumble strips may significantly degrade the functionality of paved shoulders for bicyclists. Rumble strips should be placed as close to the edge line as practicable and four feet of usable space should be provided for bicyclists. Where rumble strips are present, gaps of at least 12' should be provided every 40-60'.

GUIDANCE

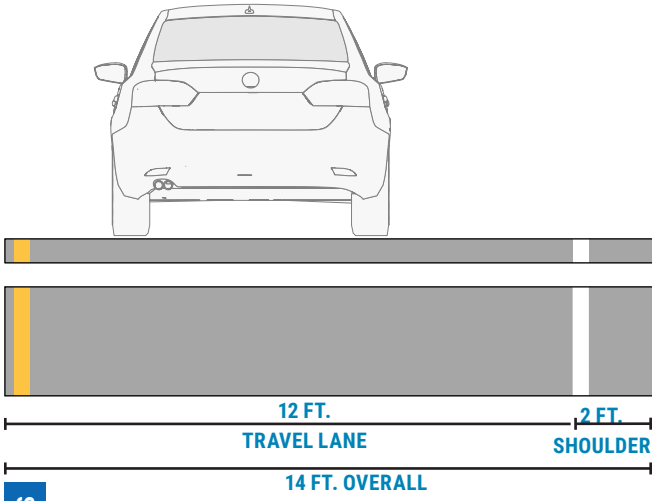
Sufficiently wide shoulders can greatly improve bicyclist safety and comfort, particularly on higher-speed, higher-volume roadways. Shoulders are most often found on rural roadways and less often on urban roadways.

To accommodate bicyclists, provide a minimum 4-foot paved shoulder width, continuous along the length of the roadway and through intersections.

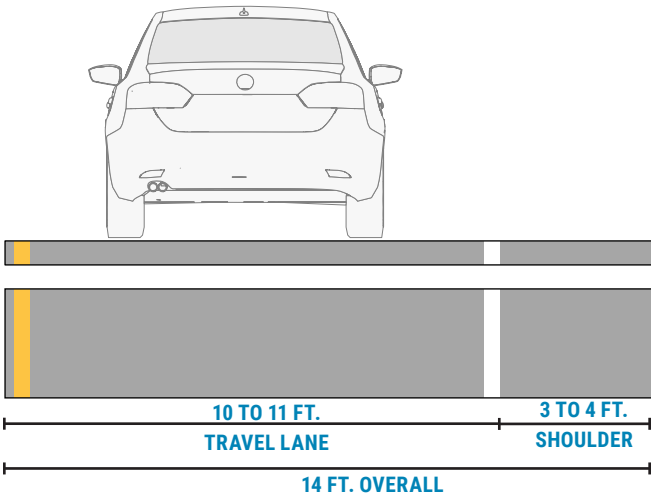
Use at least 5 feet where guardrails, curbs, or other roadside barriers are present.

Designers should consider wider shoulders if vehicle speeds are greater than 50 mph (AASHTO Bike Guide). Designers may use the Bicycle Level of Service model, which includes factors for vehicle speeds, traffic volumes, and lane widths to determine the appropriate shoulder width (AASHTO Bike Guide).

EXISTING CONFIGURATION



BICYCLE-FRIENDLY CONFIGURATION



Graphic: FHWA Multimodal Networks

REFERENCES

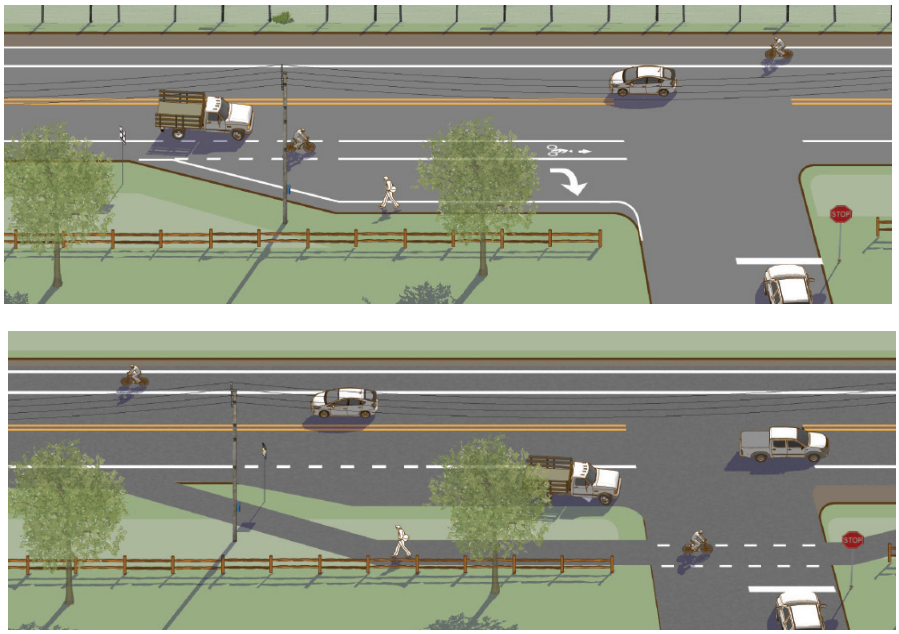
FHWA Achieving Multimodal Networks

AASHTO Guide for the Development of Bicycle Facilities (2012)

AASHTO Policy on Geometric Design of Highways and Streets (2013)

PAVED SHOULDERS AT INTERSECTIONS

Shoulders are often narrowed or removed entirely through intersections, so it is important to carefully design rural intersections to allow for safe bicycle travel.



Transitions from paved shoulder to bike lanes or separated bike lane/shared use path (FHWA Rural Design Guide).

At auxiliary bypass lanes, it is important to consider the needs of bicyclists and continue the shoulder area outside the bypass lane (See 2012 AASHTO Bike Guide).

There are several options to reconfigure paved shoulders through intersections (as the curb lane often accommodates a right-turn lane):

- On-street bike lanes
- Separated bike lanes or shared use paths

At auxiliary bypass lanes or center turn lanes, preserve 6 ft of the shoulder for bicyclist travel, a minimum shoulder witdth of 4 feet.

As rural roadways accommodate right-turn lanes, reconfigure the paved shoulder as a bike lane or separated bike lane/path:

- For a bike lane, add a right turn lane to the right of the bike lane. Use dotted line extensions to define the tapered entrance into the right-turn lane. For more information, refer to the guidance on bike lanes and FHWA MUTCD Figure 9C-4.
- For a one-way separated bike lane or shared use path, transition the paved shoulder in advance of the intersection and continue through the intersection (see figure above and guidance on separated bike lanes).

REFERENCES

FHWA Rural Design Guide (2016)

AASHTO Guide for the Development of Bicycle Facilities (2012)

MUTCD (2009)

RUMBLE STRIP DESIGN

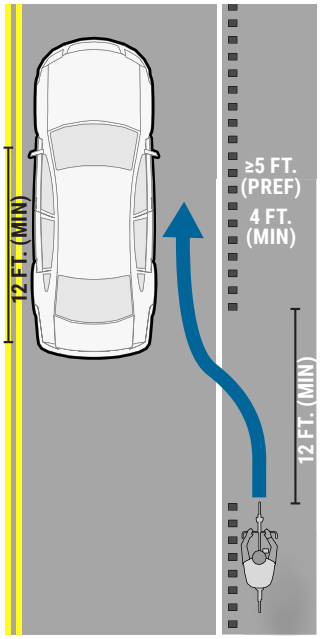
Rumble strips are an important safety feature on rural roadways due to their effectiveness in reducing run-off-road crashes. However, it is important to design rumble strips carefully to ensure the safety and comfort of bicyclists.

Rumble strips are a Proven Safety Countermeasure. Designers have flexibility on the placement and configuration of roadway rumble strips. Therefore, it is important that rumble strips are designed with bicyclist safety in mind. The AASHTO Bike Guide recommends providing a 4-foot clear space from the rumble strip to the outside edge of a paved shoulder, or 5 feet to an adjacent curb, guardrail, or other obstacle. A reduced rumble strip length (measured perpendicular to the roadway) or edge line rumble strips, sometimes referred to as a rumble stripes , can be considered to provide additional shoulder width for bicyclists. The AASHTO Bike Guide recommends providing 12-foot minimum gaps in rumble strips spaced every 40–60 feet to allow bicyclists to enter or exit the shoulder as needed (2012, p. 4-9). Designers should consider longer gaps in locations where bicyclists are traveling at relatively high speeds.

Designers may also consider bicycle-tolerable rumble strips. Even though the strips can be made more tolerable, they are not considered to be rideable by bicyclists. Additional information on rumble strip design can be found in the AASHTO Bike Guide 2012 and the FHWA Rumble Strips and Rumble Stripes Website (http://safety.fhwa.dot.gov/roadway_dept/pavement/rumble_strips/).

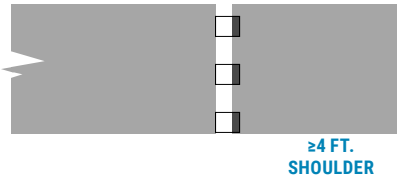
In constrained locations with a paved shoulder width less than 4 feet, designers should consider placing rumble strips at the far right edge of the pavement to give bicyclists additional space near the edge of the lane. Results from NCHRP Report 641: Guidance for the Design and Application of Shoulder and Centerline Rumble Strips 2009 indicate that there may not be a practical difference in the effectiveness of rumble strips placed on the edge line or 2 feet or more beyond the edge line on two-lane rural roads.

DESIRABLE (FOR BICYCLISTS) CROSS SECTION



UNDESIRABLE (FOR BICYCLISTS) CROSS SECTION

ADEQUATE CROSS SECTION



CONSTRAINED CROSS SECTION

Graphics: FHWA Multimodal Networks

REFERENCES

FHWA Achieving Multimodal Networks

AASHTO Guide for the Development of Bicycle Facilities (2012)

FHWA Rumble Strips and Rumble Stripes Website

Pedestrian Facility Types

SIDEWALKS

Sidewalks play a critical role in the character, function, enjoyment, and accessibility of neighborhoods, main streets, and other community destinations. Sidewalks are the place typically reserved for pedestrians within the public right-of-way, adjacent to property lines or the building face. In addition to providing vertical and/or horizontal separation between vehicles and pedestrians, the spaces between sidewalks and roadways also accommodate street trees and other plantings, stormwater infrastructure, street lights, and bicycle racks.

Frontage Zone:

the Frontage Zone is the area of sidewalk that immediately abuts buildings along the street. In residential areas, the Frontage Zone may be occupied by front porches, stoops, lawns, or other landscape elements that extend from the front door to the sidewalk edge. The Frontage Zone of commercial properties may include architectural features or projections, outdoor retailing displays, café seating, awnings, signage, and other intrusions into or use of the public right-of-way. Frontage Zones may vary widely in width from just a few feet to several yards.

Pedestrian Zone:

Also known as the "walking zone," the Pedestrian Zone is the portion of the sidewalk space used for active travel. For it to function, it must be kept clear of any obstacles and be wide enough to comfortably accommodate expected pedestrian volumes includeing those using mobility assistance devices, pushing strollers, or pulling carts. To maintain the social quality of the street, the width should accommodate pedestrians passing singly, in pairs, or in small groups as anticipated by density and adjacent land use.

Amenity Zone:

The Amenity Zone, or "landscape zone," lies between the curb and the Pedestrian Zone. This area is occupied by a number of street fixtures such as street lights, street trees, bicycle racks, parking meters, signposts, signal boxes, benches, trash and recycling receptacles, and other amenities. In commercial areas, it is typical for this zone to be hardscape pavement, pavers, or tree grates. In residential, or lower intensity areas, it is commonly a planted strip.

The Amenity Zone can provide an emergency reposi- tory for snow cleared from streets and sidewalks, although snow storage should not impede access to or use of important mobility fixtures such as parking meters, bus stops, and curb ramps. Stormwater Best Management Practices (BMPs) are commonly located in the Amenity Zone.

The Curb:

Although not a zone per se, the curb is a unique and vital element of the street. It is the demarcation line between the pedestrian domain and the vehicular domain. The curb is typically a physical barrier providing vertical separation between the street and sidewalk. The curb coupled with adjacent gutter and stormwater inlets also plays a specific role in the drainage of the sidewalk and roadway and even of the adjacent property at times.

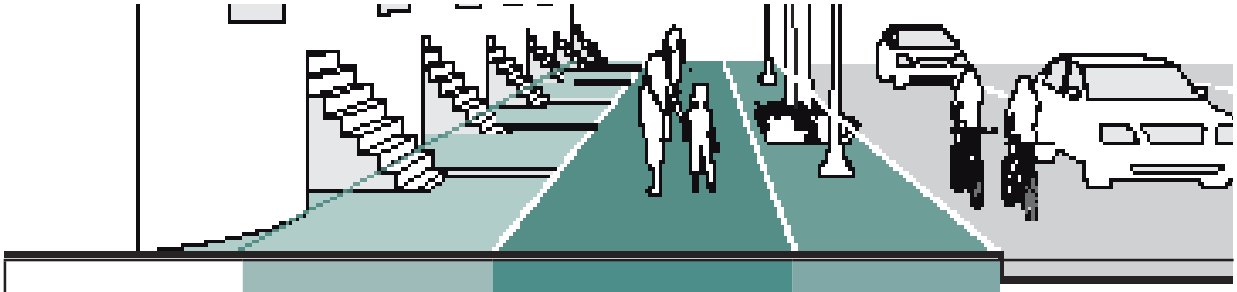
REFERENCES

NACTO Urban Street Design Guide (2013)

Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG; 2011)

PREFERRED WIDTHS FOR SIDEWALK ZONES

The width of the various sidewalk zones will vary given the street type, the available right-of-way, scale of the adjoining buildings and the intensity and type of uses expected along a particular street segment. A balanced approach for determining the sidewalk width should consider the character of the surrounding area and the anticipated pedestrian activities. For example, is the street lined with retail that encourages window shopping or does it connect a residential neighborhood to a commercial area where pedestrians frequently need to pass one another? Does the scale of the buildings and the character of the street indicate a need for a wider sidewalk?



Street Type	Frontage Zone[1] Door swings, Awnings, Café seating, Retail signage and displays, Building projections	Pedestrian Zone[2] Zone should be clear of any and all fixed obstacles. Clear space for pedestrian travel only.	Amenity Zone[3] Street lights and utility poles, Street trees, Bicycle racks, Parking meters, Transit stops, BMPs, Street furniture and signage	Total Width
Commercial Connector	2'-5'	6'-15'	6'-10'	14'-30'
Main Street	2'- 6'	6'-10'	6'-10'	14'-22'
Mixed Use Boulevard	2'- 6'	6'-18'	6'-10'	14'-30'
Neighborhood Connector	2'	6'-8'	6'-7'	14'-17'
Neighborhood Residential	2'	6'	5'-7'	11'-13'
Parkway	N/A	6'-10'	5'-10'	11'-20'
Industrial	2' or N/A	6'	5'-7'	11'-15'
Shared Streets	2'	N/A	N/A	N/A

NOTES SPECIFIC TO ZONES:

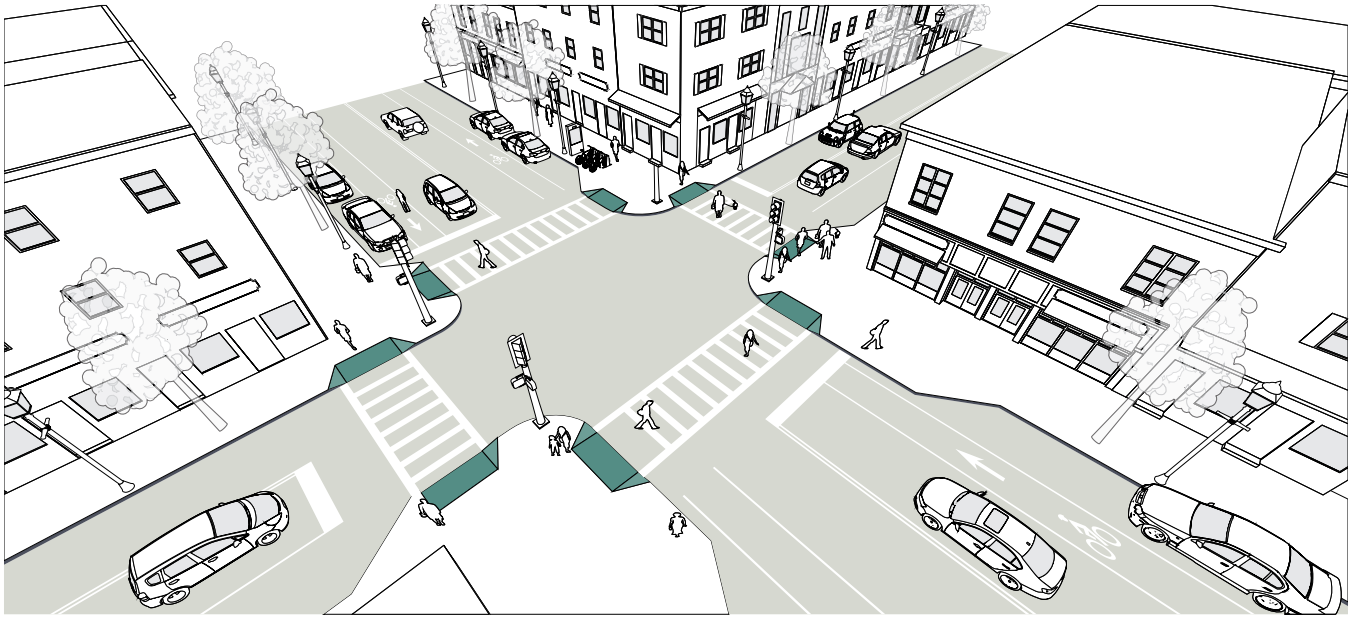
- Frontage Zones used for sidewalk cafés are a special condition and should generally be no less than 6' in width.
- In locations with severely constrained rights-of-way, it is possible to provide a narrower Frontage Zone and Pedestrian Zone. Sidewalk width is based on the context, therefore in retrofit locations where development is not occurring and where existing building are antici- pated to remain, 5' wide sidewalks may be adequate.
- Sidewalk BMPs require a minimum of 7' of width for the Amenity Zone. The final dimensions will be established based on the context of each landscape area. Where BMPs are not provided in the Amenity Zone, this area may be at the lower end of the range.

GENERAL NOTES:

- Where on-street parking is not present, the wider dimensions should be provided.
- The provision of tree well or landscape strip within the Amenity Zone will be based on the existing or planned character of the neighborhood.

CURB RAMPS

The transition for pedestrians from the sidewalk to the street is provided by a curb ramp. The designs of curb ramps are critical for all pedestrians, but particularly for people with disabilities. The ADA Standards require all pedestrian crossings be accessible to people with disabilities by providing curb ramps at intersections and midblock crossings as well as other locations where pedestrians can be expected to enter the street. Curb ramps also benefit people pushing strollers, grocery carts, suitcases, or bicycles.



Furnishing zones or terraces (the space between the curb and sidewalk) of 7' of width provide just enough space at intersections for curb ramps to gain sufficient elevation to a sidewalk.

Separate curb ramps should be provided for each crosswalk at an intersection rather than a single ramp at a corner for both crosswalks. The separate curb ramps improve orientation for visually impaired pedestrians by directing them toward the correct crosswalk.

Curb ramps are required to have landings. Landings provide a level area with a cross slope of 2% or less in any direction for wheelchair users to wait, maneuver into or out of a ramp, or bypass the ramp altogether. Landings should be 5' by 5' and shall, at a minimum, be 4' by 4'.

Consider providing wider curb ramps in areas of high pedestrian volumes and crossing activities.

Flares are required when the surface adjacent to the ramp's sides is walkable, however, they are unnecessary when this space is occupied by a landscaped buffer. Excluding flares can also increase the overall capacity of a ramp in high-pedestrian areas.

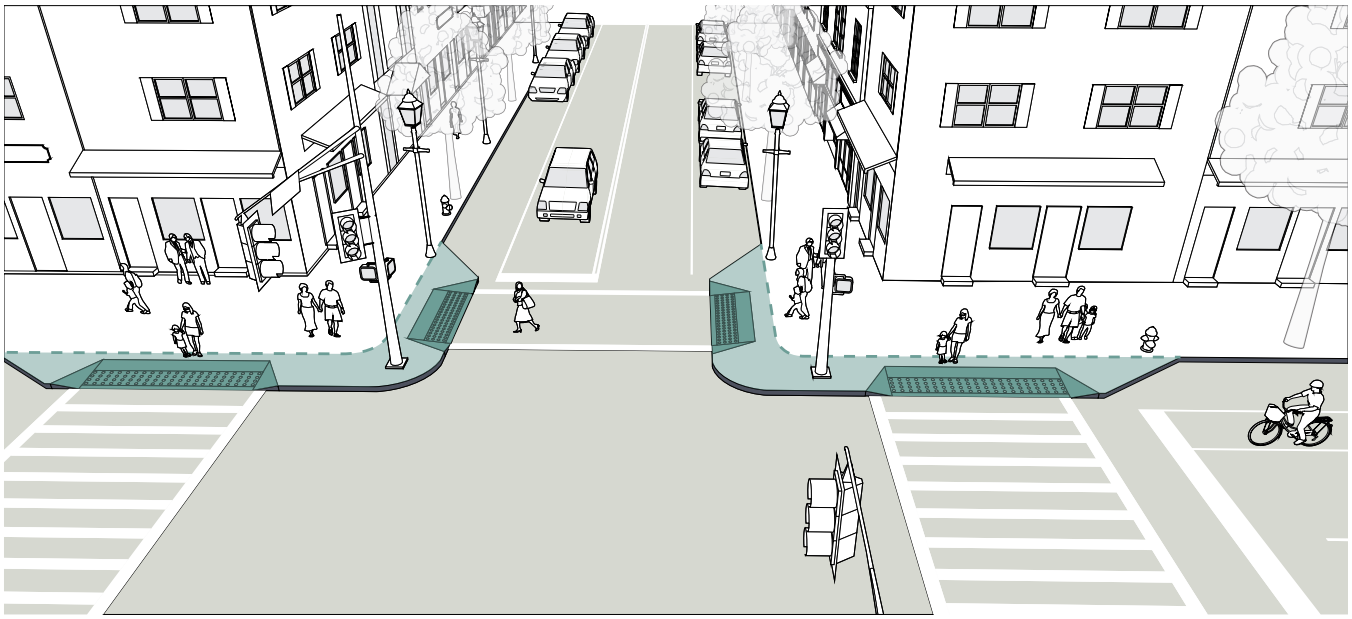
- Maximum slope: 1:12 (8.33%).
- Maximum slope of side flares: 1:10 (10%).
- Maximum cross-slope: 2% (1–2% with tight tolerances recommended).
- Should direct pedestrians into the crosswalk. The bottom of the ramp should lie within the area of the crosswalk.
- Truncated domes (the only permitted detectable warning device) must be installed on all new curb ramps to alert pedestrians to the sidewalk and street edge.
- Type II ramps, which provide one ramp leading to each crosswalk at an intersection, are strongly preferred over Type I ramps that only provide a single ramp for multiple crosswalks.

REFERENCES

Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG; 2011)

CURB EXTENSIONS

Curb extensions, also known as neckdowns, bulb-outs, or bump-outs, are created by extending the sidewalk at corners or mid-block. Curb extensions are intended to increase safety, calm traffic, and provide extra space along sidewalks for users and amenities.



- The turning needs of emergency and larger vehicles should be considered in curb extension design.
- Care should be taken to maintain direct routes across intersections aligning pedestrian desire lines on either side of the sidewalk. Curb extensions often make this possible as they provide extra space for grade transitions.
- Consider providing a 20' long curb extension to restrict parking within 20' of an intersection.
- When curb extensions conflict with turning movements, the reduction of width and/or length should be prioritized over elimination.
- Emergency access is often improved through the use of curb extensions as intersections are kept clear of parked cars.
- Curb extensions should be considered only where parking is present or where motor vehicle traffic deflection is provided through other curbside uses such as bicycle share stations or parklets.
- Curb extensions are particularly valuable in locations with high volumes of pedestrian traffic, near schools, at unsignalized pedestrian crossings, or where there are demonstrated pedestrian safety issues.
- A typical curb extension extends the approximate width of a parked car (or about 6' from the curb).
- The minimum length of a curb extension is the width of the crosswalk, allowing the curvature of the curb extension to start after the crosswalk, which should deter parking; NO STOPPING signs should also be used to discourage parking. The length of a curb extension can vary depending on the intended use (i.e., stormwater management, transit stop waiting areas, restrict parking).
- Curb extensions should not reduce a travel lane or a bicycle lane to an unsafe width.

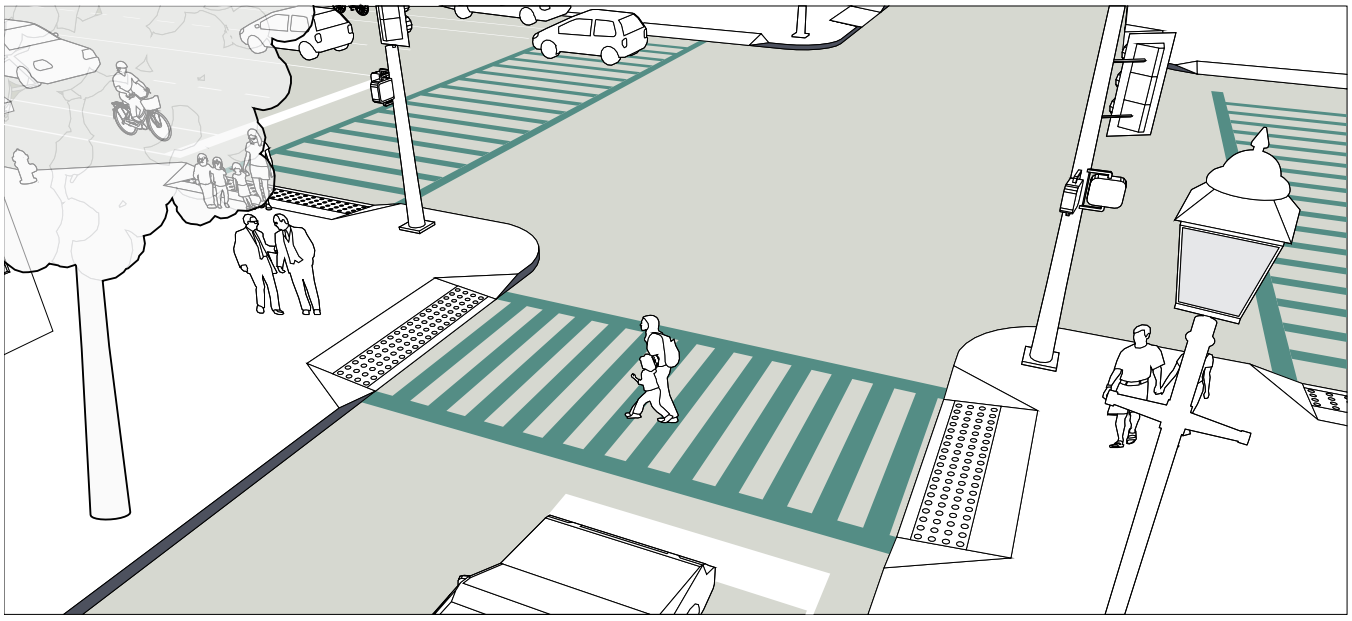
REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)

NACTO Urban Streets Design Guide (2012) - Curb Extensions

MARKED CROSSWALKS

Legal crosswalks exist at all locations where sidewalks meet the roadway, regardless of whether pavement markings are present. Drivers are legally required to yield to pedestrians at intersections, even when there are no pavement markings. Providing marked crosswalks communicates to drivers that pedestrians may be present, and helps guide pedestrians to locations where they should cross the street. In addition to pavement markings, crosswalks may include signals/beacons, warning signs, and raised platforms.



There are many different styles of crosswalk striping and some are more effective than others. Ladder and continental striping patterns are more visible to drivers.

Signal phasing is very important. Pedestrian signal phases must be timed based on the length of the crossing. If pedestrians are forced to wait longer than 40 seconds, non-compliance is more likely.

Raised crossings calm traffic and increase the visibility of pedestrians.

Curb extensions, also known as bulb-outs and bump-outs, reduce the distance pedestrians have to cross and calm traffic.

- Place on all legs of signalized intersections, in school zones, and across streets with more than minor levels of traffic.
- Crosswalks should be at least 10 feet wide or the width of the approaching sidewalk if it is greater. In areas of heavy pedestrian volumes, crosswalks can be up to 25 feet wide.
- Stop lines at stop-controlled and signalized intersections should be striped no less than 4 feet and no more than 30 feet from the approach of crosswalks.
- Add rapid-flash beacons, signals, crossing islands, curb extensions, and/or other traffic-calming measures when ADT exceeds 12,000 on 4-lane roads or speeds exceed 40 mph on any road.
- Designs should balance the need to reflect the desired pedestrian walking path with orienting the crosswalk perpendicular to the curb; perpendicular crosswalks minimize crossing distances and therefore limit the time that pedestrians are exposed.

REFERENCES

NACTO Urban Street Design Guide (2013)

Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations: Final Report and Recommended Guidelines (2005)

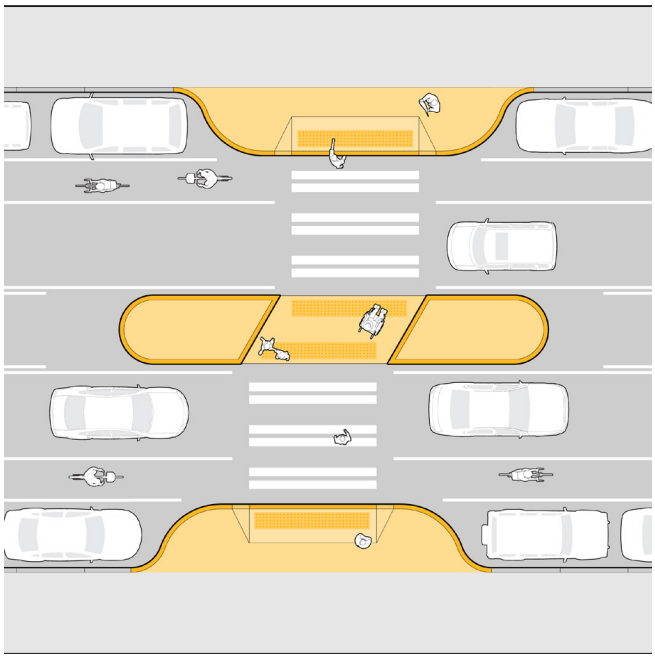
Proposed Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG; 2011)

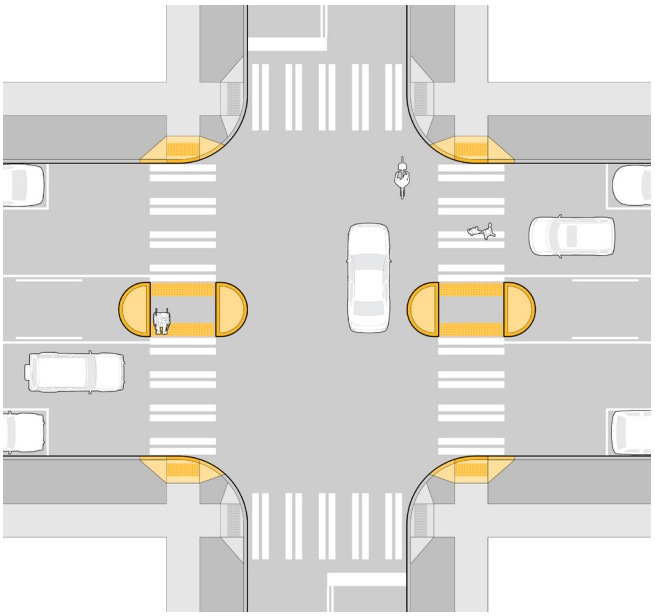
ADA Accessibility Guidelines (2004)

Manual on Uniform Traffic Control Devices (2009)

CROSSING/REFUGE ISLAND

Crossing islands are raised islands that provide a pedestrian refuge and allow multi-stage crossings of wide streets. They can be located along the centerline of a street, as roundabout splitter islands, or as "pork chop" islands where right-turn slip lanes are present.





There are two primary types of crossing islands. The first provides a cut-through of the island, keeping pedestrians at street-grade. The second ramps pedestrians up above street grade and may present challenges to constructing accessible curb ramps unless they are more than 17' wide.

Crossing islands should be considered where crossing distances are greater than 50 feet to allow multi-stage crossings, which in turn allow shorter signal phases.

Cut-through widths should equal the width of the crosswalk. Cut-throughs may be wider in order to allow the clearing of debris and snow, but should not encourage motor vehicles to use the space for U-turns.

Crossing islands can be coupled with other traffic-calming features, such as partial diverters.

At mid-block crossings where width is available, islands should be designed with a stagger, or in a "Z" pattern, encouraging pedestrians to face oncoming traffic before crossing the other side of the street.

- Minimum width: 6 feet
- Preferred Width: 8 feet (to accommodate bicyclists and wheelchair users)
- Curb ramps with truncated dome detectable warnings and 5' by 5' landing areas are required.
- A "nose" that extends past the crosswalk is not required, but is recommended to protect people waiting on the crossing island and to slow turning drivers.
- Vegetation and other aesthetic treatments may be incorporated, but must not obscure visibility.

REFERENCES

NACTO Urban Street Design Guide (2013)

Manual on Uniform Traffic Control Devices (2009)

SIGNAL TIMING FOR PEDESTRIANS

Signal timing for pedestrians is provided through the use of pedestrian signal heads. Pedestrian signal heads display the three intervals of the pedestrian phase: The Walk Interval, signified by the WALK indication— the walking person symbol—alerts pedestrians to begin crossing the street. The Pedestrian Change Interval, signified by the flashing DON'T WALK indication—the flashing hand symbol accompanied by a countdown display—alerts pedestrians approaching the crosswalk that they should not begin crossing the street. The Don't Walk Interval, signified by a steady DON'T WALK indication—the steady upraised hand symbol–alerts pedestrians that they should not cross the street.

One of primary challenges for traffic signal design is to balance the goals of minimizing conflicts between turning vehicles with the goal of minimizing the time required to wait at the curb for a WALK indication.

Intersection geometry and traffic controls should encourage turning vehicles to yield the right-of-way to pedestrians.

Requiring pedestrians to wait for extended periods can encourage crossing against the signal. The 2010 Highway Capacity Manual states that pedestrians have an increased likelihood of risk-taking behavior (e.g., jay-walking) after waiting longer than 30 seconds at signalized intersections.

Opportunities to provide a WALK indication should be maximized whenever possible. Vehicular movements should be analyzed at every intersection in order to utilize non-conflicting phases to implement Walk Intervals. For example, pedestrians can always cross the approach where vehicles cannot turn at a four-leg intersection with the major road intersecting a one-way street when the major road has the green indication.

Intersection geometry and traffic controls should encourage turning vehicles to yield the right-of-way to pedestrians. Traffic movements should be analyzed at intersections in order to utilize non-conflicting phases to implement one or more WALK intervals per cycle.

Signal design should also minimize the time that pedestrians must wait. Requiring pedestrians to wait for extended periods can encourage crossing against the signal. The 2010 Highway Capacity Manual states that pedestrians have an increased likelihood of risk-taking behavior (crossing against the signal) after waiting longer than 30 seconds.

Free-flowing right-turn lanes are discouraged at signalized intersections. Where they are present and unsignalized, the pedestrian signal and pushbutton should be located on the channelization ("pork chop") island. A yield or crosswalk warning sign should then be placed in advance of the crosswalk.

GUIDANCE

- Pedestrian signals should allocate enough time for pedestrians of all abilities to safely cross the` roadway. The MUTCD specifies a pedestrian walking speed of 3.5 feet per second to account for an aging population. The minimum pedestrian clearance time, which is the total time for the pedestrian change interval plus the buffer interval, is calculated using the pedestrian walking speed and the distance a pedestrian has to cross the street. To the extent feasible, pedestrian clearance time should be maximized.
- Countdown pedestrian displays inform pedestrians the amount of time in seconds available to safely cross during the flashing DON'T WALK (or upraised hand) interval. All pedestrian signal heads should contain a countdown display provided with the DON'T WALK indication.
- In areas with higher pedestrian activity, such as near transit stations, and main streets, push button actuators may not be appropriate. People should expect to get a pedestrian cycle at every signal phase, rather than having to push a button to call for a pedestrian phase.

LEADING PEDESTRIAN INTERVAL

The Leading Pedestrian Interval initiates the pedestrian WALK indication three to seven seconds before motor vehicles traveling in the same direction are given the green indication. This signal timing technique allows pedestrians to enter the intersection prior to turning vehicles, increasing visibility between all modes.

- The LPI should be used at intersections with high volumes of pedestrians and conflicting turning vehicles and at locations with a large population of older adults or school children who tend to walk slower.
- A lagging protected left arrow for vehicles should be provided to accommodate the LPI.

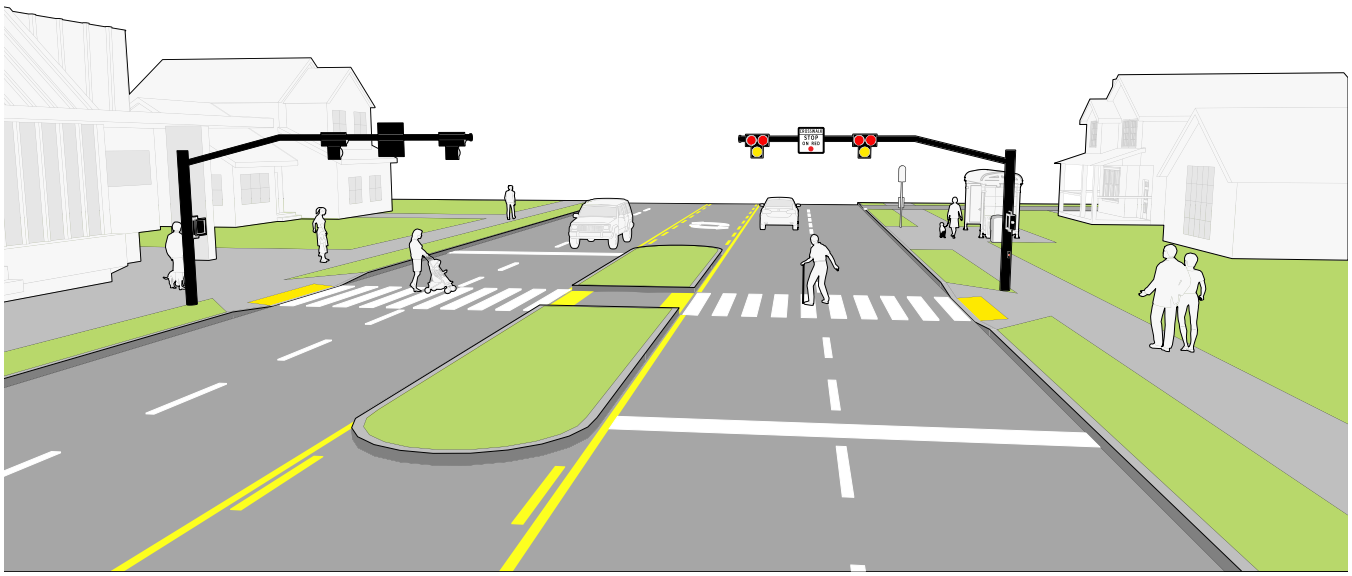
REFERENCES

NACTO Urban Streets Design Guide (2013)

MUTCD (2009)

HIGH-INTENSITY ACTIVATED CROSSWALK BEACON

Pedestrian-activated beacons, including the High-intensity Activated Crosswalk Beacon (HAWK), are a type of hybrid signal intended to allow pedestrians and bicyclists to stop traffic to cross high-volume arterial streets. This type of signal may be used in lieu of a full signal that meets any of the traffic signal control warrants in the MUTCD. It may also be used at locations which do not meet traffic signal warrants but where assistance is needed for pedestrians or bicyclists to cross a high-volume arterial street.



While this type of device is intended for pedestrians, it would be beneficial to retrofit it for bicyclists as the City of Portland, Oregon has, using bicycle detection and bicycle signal heads on major cycling networks. Depending upon the detection design, the agency implementing these devices may have the option to provide different clearance intervals for bicyclists and pedestrians. The provision of bicycle signal heads would require permission to experiment from FHWA.

- The MUTCD recommends minimum volumes of 20 pedestrians or bicyclists an hour for major arterial crossings (volumes exceeding 2,000 vehicles/hour).
- This type of device should be considered for all arterial crossings in a bicycle network and for path crossings if other engineering measures are found inadequate to create safe crossings.
- Pushbutton actuators should be "hot" (respond immediately when pressed), be placed in convenient locations for all users, and abide by other ADA standards. Passive signal activation, such as video or infrared detection, may also be considered.
- See FHWA's Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations publication and theManual of Uniform Traffic Control Devices to determine warrants for traffic control at midblock crossings. from FHWA.

REFERENCES

NACTO Urban Street Design Guide (2013)

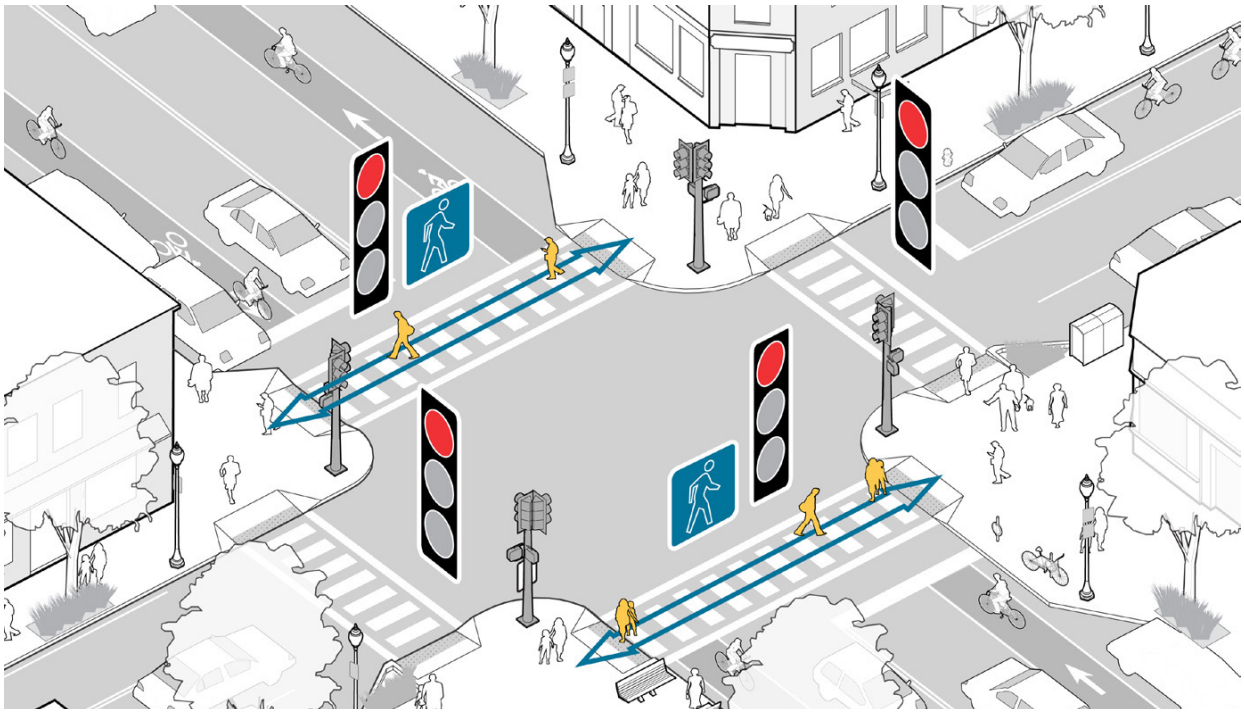
Manual on Uniform Traffic Control Devices (2009)

CDOT Roadway Design Guide, Chapter 14 (2015)

Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations (2005)

PEDESTRIAN "SCRAMBLE" AT INTERSECTIONS

Pedestrian crossings in all directions, including diagonally across the intersection, is often called a pedestrian scramble. These facilities include painted crosswalks at all four legs of the intersection and diagonally, and they are usually supplemented with pedestrian-only phasing



- "Pedestrian scrambles" should be considered at intersections where there are high volumes of pedestrians in all directions. Intersections near schools, senior housing, recreation areas, medical facilities, or other major vulnerable pedestrian attractors are potential locations for scramble designs and signaling.
- Removing permissive turning movements can have added safety benefits during a pedestrian-only phase.
- Typically, these designs increase wait-times for all users—including pedestrians—so scrambles should be considered in places where there is necessity for pedestrian only movements.

GUIDANCE

- These designs are suitable at intersections with significant pedestrian use and high conflicting vehicular movements (greater than 250 per hour or meeting other local/state requirements).
- Use 3.5 feet per second as a measure of pedestrian travel time to determine timing for pedestrians crossing intersections diagonally.
- All bicycle movements must yield to pedestrian movements at these intersections.
- Designated crossing areas in all directions should be striped (as specified in this guide) and equipped ADA ramps.

REFERENCES

http://streetsillustrated.seattle.gov/design-standards/intersections/its/

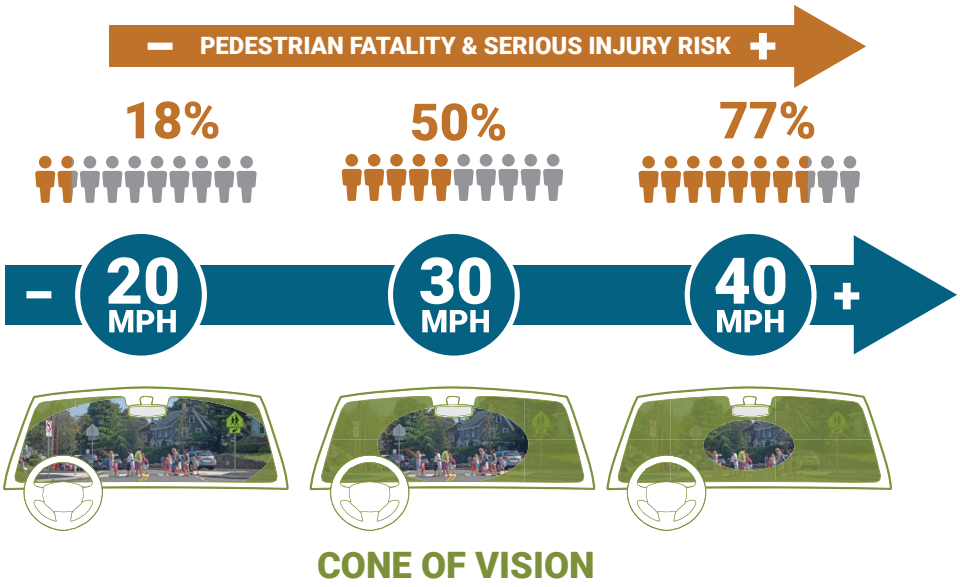
http://streetsillustrated.seattle.gov/design-standards/bicycle/bike-intersection-design/

Exclusive Pedestrian Phase Design Element, LADOT Complete Streets Committee, Jan 2017.

Supporting Elements for Bicycle Facilities

TRAFFIC CALMING

Traffic calming aims to slow the speeds of motorists to a “desired speed” (usually 20 mph or less for residential streets and 25 to 35 mph for collectors and minor arterials). The greatest benefit of traffic calming is increased safety and comfort for all users on and crossing the street. Compared with conventionally-designed streets, traffic calmed streets typically have fewer collisions and far fewer injuries and fatalities. These safety benefits are the result of slower speeds for motorists that result in greater driver awareness, shorter stopping distances, and less kinetic energy during a collision.



Prior to permanently implementing a traffic calming measure, it may be useful to introduce a temporary measure using paint, cones, or street furniture, as changes can easily be made to the design.

A formal policy or procedure can help a community objectively determine whether traffic calming measures should be installed on a street or in a neighborhood. Such a procedure should include traffic and speed studies and a way to gather input and approval from neighborhood residents.

+ Vertical deflections such as speed humps and speed cushions should have a smooth leading edge, a parabolic rise, and be engineered for a speed of 25 to 30 mph. Speed humps should be clearly marked with reflective markings and signs.

+ Typically speed humps are 22 feet in length, with a rise of 6 inches above the roadway. They should extend the full width of the roadway and should be tapered to the gutter to accommodate drainage. Speed humps are not typically used on roads with rural cross-sections; however, if they are used on such roads, they should match the full pavement width (including paved shoulders).

+ Speed humps or speed cushions are not typically used on collector or arterial streets.

+ The size of chicanes will vary based on the targeted design speed and roadway width, but must be 20 feet wide curb-to-curb at a minimum to accommodate emergency vehicles.

+ A typical curb radius of 20 feet should be used wherever possible, including where there are higher pedestrian volumes and fewer larger vehicles.

REFERENCES

Huang and Cynecki (2001). The Effects of Traffic Calming Measures on Pedestrian and Motorist Behavior. FHWA

ITE Traffic Calming Web site

NACTO Urban Street Design Guide (2013)

TRAFFIC CALMING - VERTICAL DEFLECTION TREATMENTS

Vertical traffic calming treatments compel motorists to slow speeds. By lowering the speed differential between bicyclists and motorists, safety and bicyclist comfort is increased. These treatments are typically used where other types of traffic controls are less frequent, for instance along a segment where stop signs may have been removed to ease bicyclist travel.

Speed cushion

Speed hump

Raised crosswalk

Curve profile options

- Speed humps and raised crosswalks impact bicyclist comfort. The approach profile should preferably be sinusoidal or flat.
- Where traffic calming must not slow an emergency vehicle, speed cushions or raised tables (crosswalks) should be considered. Speed cushions provide gaps spaced for an emergency vehicle's wheelbase to pass through without slowing.
- Consider using raised crosswalks at intersections to slow traffic turning onto the neighborhood greenway from a major street.

Vertical traffic calming will not be necessary on all neighborhood greenways but should be considered on any road with the following characteristic:

- Locations with measured or observed speeding issues, with 50th percentile of traffic exceeding 25mph.

Continuous devices, such as speed humps and raised crosswalks, are more effective to achieve slower speeds than speed cushions.

REFERENCES

NACTO. Urban Bikeway Design Guide. 2nd Edition.

Portland Bureau of Transportation. Neighborhood Greenway Assessment Report. 2015.

TRAFFIC CALMING - HORIZONTAL TREATMENTS

Horizontal traffic calming reduces speeds by narrowing lanes, which creates a sense of enclosure and additional friction between passing vehicles. Narrower conditions require more careful maneuvering around fixed objects and when passing bicyclists or oncoming automobile traffic. Some treatments may slow traffic by creating a yield situation where one driver must wait to pass.

Chicane

Neckdown

Curb extension

Neighborhood traffic circle

- Horizontal traffic calming treatments must be designed to deflect motor vehicle traffic without forcing the bicycle path of travel to be directed into a merging motorist.
- Neighborhood traffic circles should be considered at local street intersections to prioritize the through movement of bicyclists (by removing stop control or converting to yield control) without enabling an increase in motorist's speeds.
- Infrastructure costs will range dependent upon the complexity and permanence of design. Simple, interim treatments such as striping and flexposts are low-cost. Curbed, permanent treatments that integrate plantings or green infrastructure are higher-cost.

Horizontal traffic calming treatments can be appropriate along street segments or at intersections where width contributes to higher motor vehicle speeds. It can be particularly effective at locations where:

- On-street parking is low-occupancy during most times of day.
- There is desire to remove or decrease stop control at a minor intersection.

Horizontal treatments are most effective if they deflect motorists midblock (with chicanes) or within intersections (with neighborhood traffic circles).

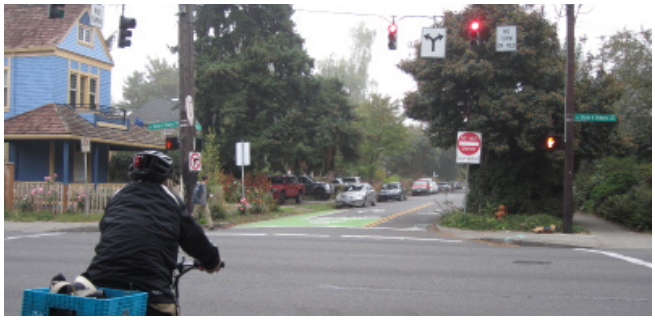
REFERENCES

NACTO. Urban Bikeway Design Guide. 2nd Edition.

Portland Bureau of Transportation. Neighborhood Greenway Assessment Report. 2015.

TRAFFIC DIVERSION

Traffic diversion strategies are used to reroute traffic from a neighborhood greenway onto other adjacent streets by installing design treatments that restrict motorized traffic from passing through.



Partial closure - permanent, signalized

Diagonal diverter

Partial closure - interim, stop-control

Full closure

- Diversion necessarily moves trips from the neighborhood greenway onto adjacent streets. This change in traffic volume on other local streets must be identified and addressed during the planning, design and evaluation process.
- Other traffic calming tools should be explored for their effectiveness before implementing traffic diversion measures. In communities where the street network is not a traditional grid, the impacts of diversion to the larger street network will be greater, due to the inability of traffic to easily disperse and find alternate routes.
- Temporary materials may be used to test diversion impacts before permanent, curbed diverters are installed.
- Consultation with emergency services will be necessary to understand their routing needs.
- Preferred motor vehicle volumes are in the range of 1,000 to 1,500 per day, while up to 3,000 automobiles is acceptable.
- Diversion devices must be designed to provide a minimum clear width of 6 feet for a bicyclist to pass through.
- Some treatments may require a separate pedestrian accommodation.

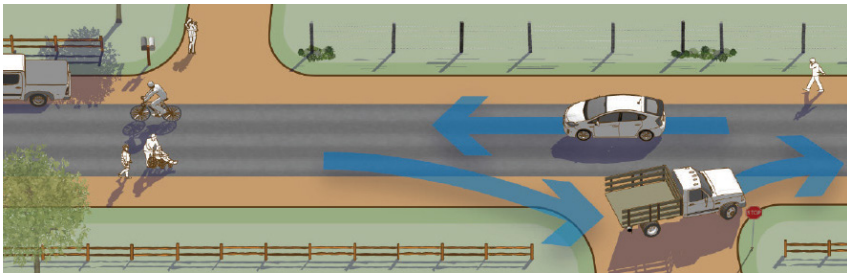
REFERENCES

NACTO. Urban Bikeway Design Guide. 2nd Edition.

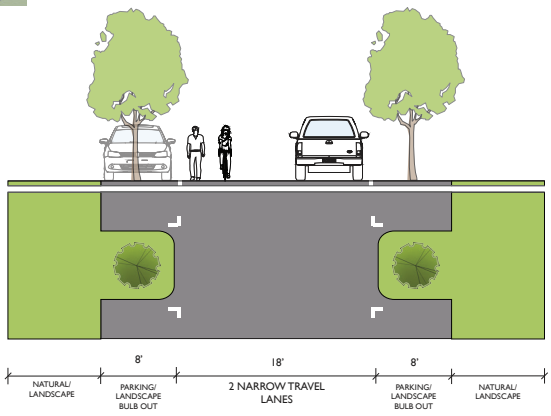
Portland Bureau of Transportation. Neighborhood Greenway Assessment Report. 2015.

"YIELD" STREET

A "yield" street is a non-arterial street that allows for one-way vehicle movement due to traffic calming and/or the presence of on-street parking.



Yield Street as shown in FHWA's Small Town and Rural Multimodal Networks.



YIELD ROADWAY

"Yield" streets typically allow for single-direction vehicle movement due to the presence of on-street parking and/or traffic calming devices. Yield streets often have sidewalks buffered by planting strips that support a wide range of treatments including gardening, green stormwater infrastructure and large canopy street trees. Yield streets also are conducive for bicycle boulevards.

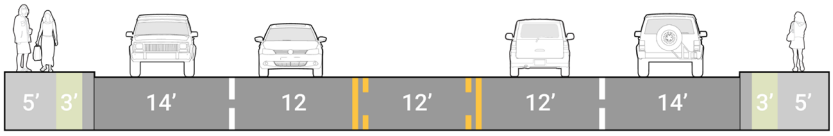
When implementing yield streets, consider emergency vehicle, pedestrian, and bicyclist access and safety.

- Yield streets should be non-arterial streets at at least 40 feet in width. These streets are not appropriate for transit routes or freight routes, but should accommodate local deliveries by SU-30.
- Yield streets should have a traveled way narrower than 20 feet. Total traveled way width varies between 12 feet and 20 feet. According to the AASHTO Low Volume Roads guidelines, streets 15 feet or narrower function as a two-way roadway and should provide pull-out areas every 200-300 feet.
- Yield streets may consist of one 11-foot travel lane with 7-foot flexible zones on each side (typically occupied by on-street parking, but may be programmed with other uses.
- According to the FHWA Small Town and Rural Multimodal Networks guide, parking lanes on yield streets should be constructed with a contrasting material when possible.
- The MUTCD does not recommend centerline markings on two-way streets narrower than 16 feet wide or below 3,000 ADT.

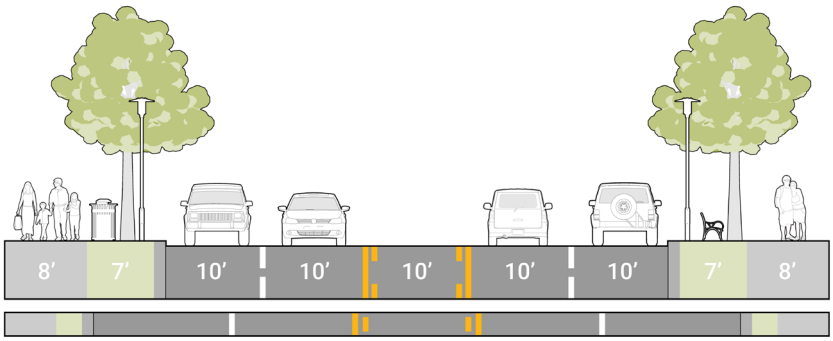
LANE NARROWING

Lane narrowing can improve comfort and safety for vulnerable road users. Narrowing lanes creates space that can be reallocated to other modes, in the form of wider sidewalks, bike lanes, and buffers between cyclists, pedestrians and motor vehicles. Space can also be dedicated to plantings and amenity zones, and reduces crossing distances at intersections.

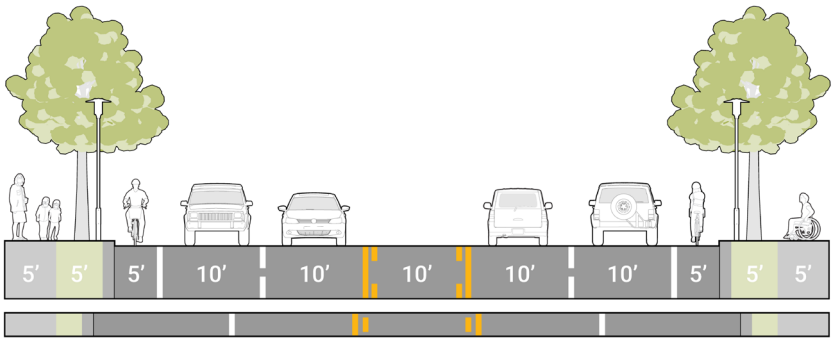
Roadway Before Narrowing



Narrowing Motor Vehicle Lanes to increase Sidewalk and Amenity Zones



Narrowing Motor Vehicle Lanes to increase Amenity Zone and add Bicycle Lanes



CONSIDERATIONS

Narrowing existing motor vehicle lanes may result in enough space to create separated bicycle lanes, widened sidewalks and buffers, or a combination of on-street bike lanes and enhancements to the pedestrian corridor.

Narrower lanes can contribute to lower operating speeds along the roadway, which may be appropriate in dense, walkable corridors.

GUIDANCE

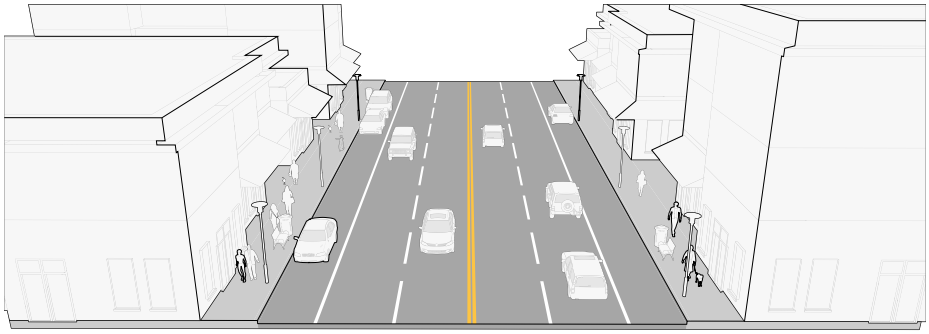
+ Motor vehicle travel lanes as narrow as 10 feet are allowed in low-speed environments (45 mph or less) according to the AASHTO Green Book.
+ 10-foot travel lanes are not appropriate on 4-lane undivided arterial roadways.

REFERENCES

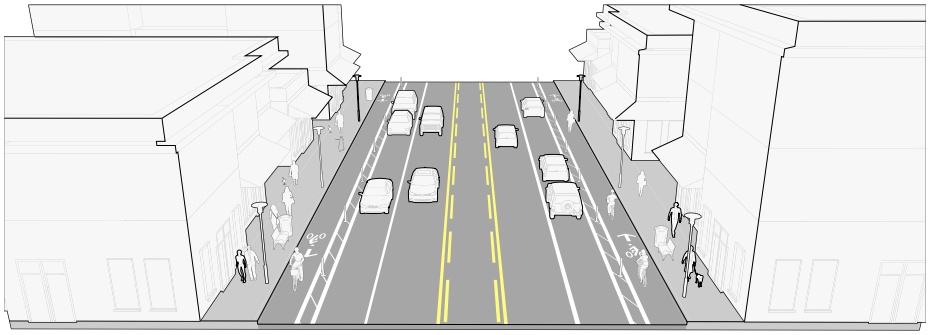
FHWA Achieving Multimodal Networks

LANE RECONFIGURATION

Road Diets are the reconfiguration of one or more travel lanes to calm traffic and provide space for bicycle lanes, turn lanes, streetscapes, wider sidewalks, and other purposes. Four- to three-lane conversions are the most common Road Diet, but there are numerous types (e.g., three to two lanes, or five to three lanes).



Typical 4-lane Road with on-street parking



Three-lane Road Diet (with center two-way left-turn lane), with on-street parking and separated bicycle lane

The most common road diet configuration involves converting a four-lane road to three lanes: two travel lanes with a turn lane in the center of the roadway. The center turn lane at intersections often provides a great benefit to traffic congestion. A three-lane configuration with one lane in each direction and a center turn lane is often as productive (or more productive) than a four-lane configuration with two lanes in each direction and no dedicated turn lane.

The space gained for a center turn lane is often supplemented with painted, textured, or raised center islands. If considered during reconstruction, raised center islands may be incorporated in between intersections to provide improved pedestrian crossings, incorporate landscape elements and reduce travel speeds.

- Four-lane streets with volumes less than 15,000 vehicles per day are generally good candidates for four- to three-lane conversions.
- Four-lane streets with volumes between 15,000 to 20,000 vehicles per day may be good candidates for four- to three-lane conversions. A traffic analysis is needed to determine feasibility.
- Six-lane streets with volumes less than 35,000 vehicles per day may be good candidates for six- to five-lane (including two-way center turn lane) conversions. A traffic analysis is needed to determine feasibility.

REFERENCES

FHWA Road Diet Guide (2014)

NACTO Urban Street Design Guide (2013)

Manual on Uniform Traffic Control Devices (2009)

Bicycle Intersection Design & Spot Treatments

BIKE BOXES

A bicycle box provides dedicated space between the crosswalk and vehicle stop line where bicyclists can wait during the red light at signalized intersections. The bicycle box allows a bicyclist to take a position in front of motor vehicles at the intersection, which improves visibility and motorist awareness, and allows bicyclists to "claim the lane" if desired. Bike boxes aid bicyclists in making turning maneuvers at the intersection, and provide more queuing space for multiple bicyclists than that provided by a typical bicycle lane.

- Bicycle boxes are typically painted green and are a minimum of 10 feet in depth.
- Bicycle box design should be supplemented with appropriate signage according to latest version of the MUTCD.
- Bicycle box design should include appropriate adjustement in determining the minimum green time.
- Where right turn lanes for motor vehicles exist, bicycle lanes should be designed to the left of the turn lane. If right turns on red are permitted, consider ending the bicycle box at the edge of the bicycle lane to allow motor vehicles to make this turning movement.
- In locations with high volumes of turning movements by bicyclists, a bicycle box should be used to allow bicyclists to shift towards the desired side of the travel way. Depending on the position of the bicycle lane, bicyclists can shift sides of the street to align themselves with vehicles making the same movement through the intersection.
- In locations where motor vehicles can continue straight or cross through a right-side bicycle lane while turning right, the bicycle box allows bicyclists to move to the front of the traffic queue and make their movement first, minimizing conflicts with the turning. When a bicycle box is implemented in front of a vehicle lane that previously allowed right turns on red, the right turn on red movement must be restricted using signage and enforcement following installation of the bike box.

REFERENCES

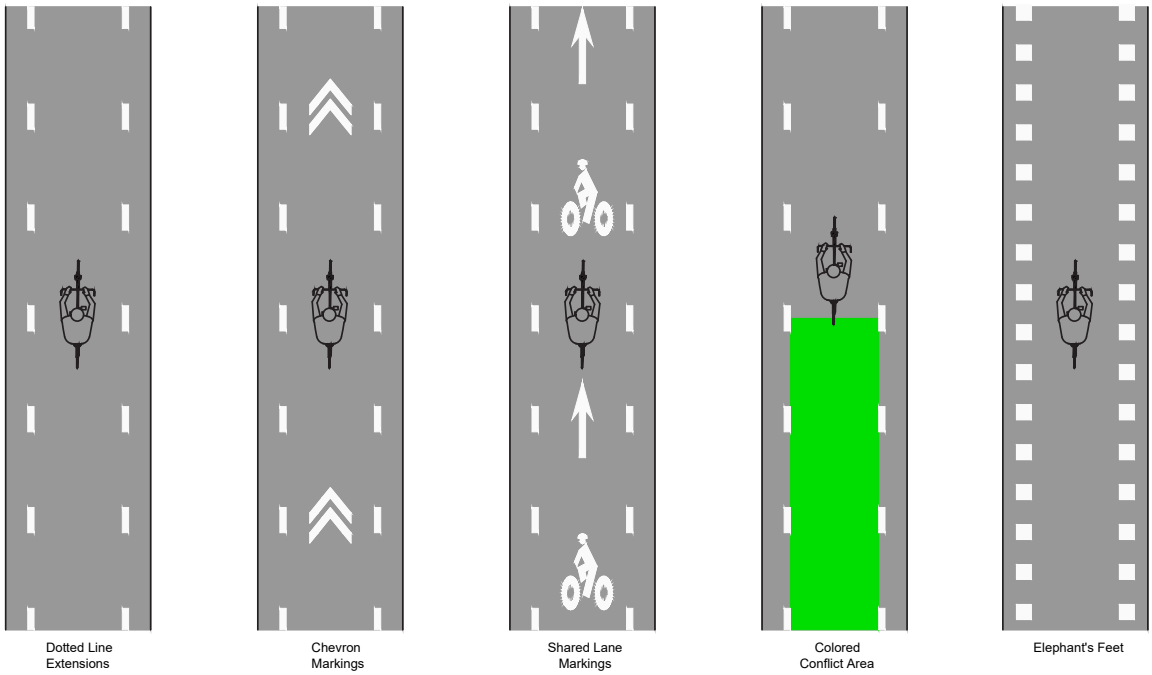
NACTO Urban Bikeway Design Guide - Bike Boxes

FHWA Separated Bike Lane Planning and Design Guide (2015)

MassDOT Separated Bike Lane Planning & Design Guide (2016)

CONFLICT AREA MARKING

Intersection pavement markings designed to improve visibility, alert all roadway users of expected behaviors, and to reduce conflicts with turning vehicles.



- The level of emphasis and visibility: dashed lane lines may be sufficient for guiding bicyclists through intersections; however, consider providing enhanced markings with green pavement and/or symbols at complex intersections or at intersections with documented conflicts and safety concerns.
- Symbol placement within intersections should consider vehicle wheel paths for maintenance.
- Driveways with higher volumes may require additional pavement markings and signage.
- Consideration should be given to using intersection pavement markings as spot treatments or standard intersection treatments. A corridor wide treatment can maintain consistency; however, spot treatments can be used to highlight conflict locations.
- Dashed white lane lanes should conform to the latest edition of the MUTCD. These can be used through different types of intersections based on engineering judgment.
- A variety of pavement marking symbols can enhance intersection treatments to guide bicyclists and warn of potential conflicts.
- Green pavement markings can be used along the length of a corridor or in select conflict locations.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)

NACTO Urban Bikeway Design Guide (2012)

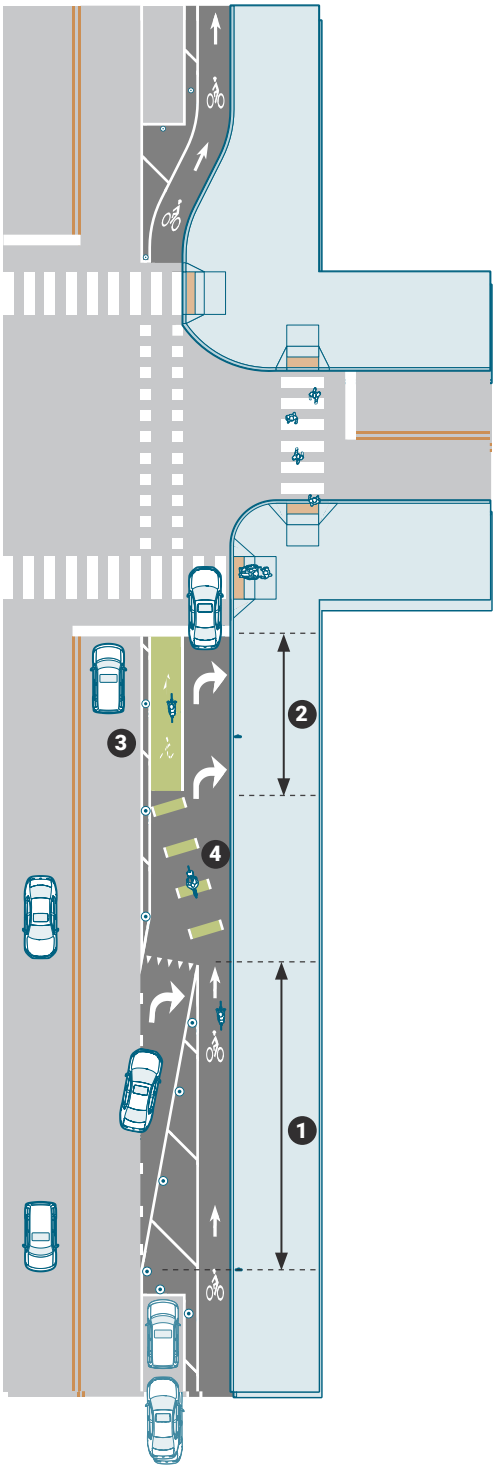
Manual on Uniform Traffic Control Devices (2009)

MIXING ZONES

A mixing zone requires turning motorists to merge across a separated bike lane at a defined location in advance of an intersection. Unlike a standard bike lane, where a motorist can merge across at any point, a mixing zone design limits bicyclists' exposure to motor vehicles by defining a limited merge area for the turning motorist. Mixing zones are compatible only with one-way separated bike lanes.

Protected intersections are preferable to mixing zones. Mixing zones are generally appropriate as an interim solution or in situations where severe right-of-way constraints make it infeasible to provide a protected intersection.

Mixing zones are only appropriate on street segments with one-way separated bike lanes. They are not appropriate for two-way separated bike lanes due to the contra-flow bicycle movement.



GUIDANCE

1. Locate merge points where the entering speeds of motor vehicles will be 20 mph or less by (a) minimizing the length of the merge area and (b) locating the merge point as close as practical to the intersection.
2. Minimize the lenth of the storage portion of the turn lane
3. Provide a buffer and physical separation (e.g. flexible delineator posts) from the adjacent through lane after the merge area, if feasible.
4. Highlight the conflict area with green surface coloring and dashed bike lane markings, as necessary, or shared lane markings placed on a green box.

+ Provide a BEGIN RIGHT (or LEFT) TURN LANE YIELD TO BIKES sign (R4-4) at the beginning of the merge area.
+ Restrict parking within the merge area
+ At locations where raised separated bike lanes approach the intersection, the bike lane should transition to street elevation at the point where parking terminates.
+ Where posted speeds are 35 mph or higher, or at locations where it is necessary to provide storage for queued vehicles, it may be necessary to provide a deceleration/storage lane in advance of the merge point.

REFERENCES

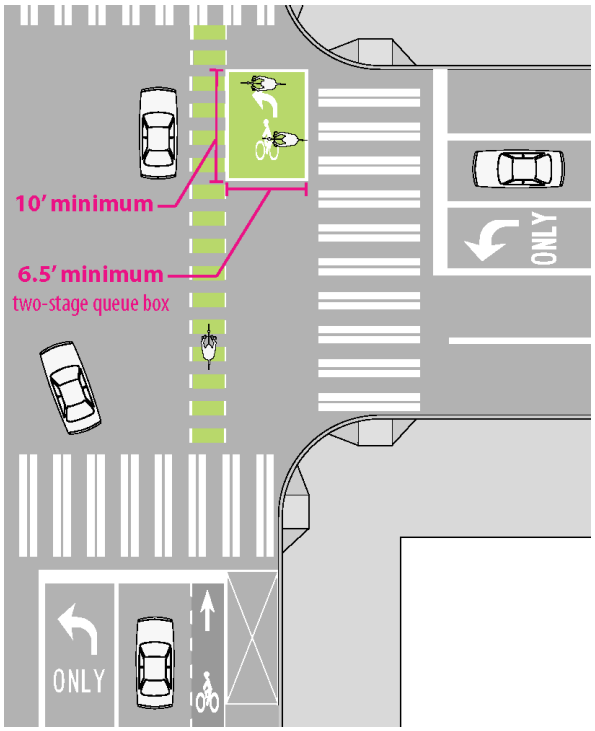
NACTO. *Urban Bikeway Design Guide. 2nd Edition.*

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

TWO-STAGE TURN QUEUE BOX

A two-stage turn queue box should be considered where separated bike lanes are continued up to an intersection and a protected intersection is not provided. The two-stage turn queue box designates a space for bicyclists to wait while performing a two-stage turn across a street at a location outside the path of traffic.



The use of a two-stage turn queue box requires FHWA permission to experiment.

- Two-stage turn queue box dimensions will vary based on the street operating conditions, the presence or absence of a parking lane, traffic volumes and speeds, and available street space. The turn box may be placed in a variety of locations including in front of the pedestrian crossing (the crosswalk location may need to be adjusted), in a 'jug-handle' configuration within a sidewalk, or at the tail end of a parking lane or a median island.
- Dashed bike lane extension markings may be used to indicate the path of travel across the intersection.
- A minimum width of 10 feet is recommended.
- A minimum depth of 6.5 feet is recommended.
- NO TURN ON RED (R10-11) restrictions should be used to prevent vehicles from entering the queuing area.
- The use of a supplemental sign instructing bicyclists how to use the box is optional.
- The box should consist of a green box outlined with solid white lines supplemented with a bicycle symbol and a turn arrow to emphasize the crossing direction.

REFERENCES

NACTO. *Urban Bikeway Design Guide. 2nd Edition.*

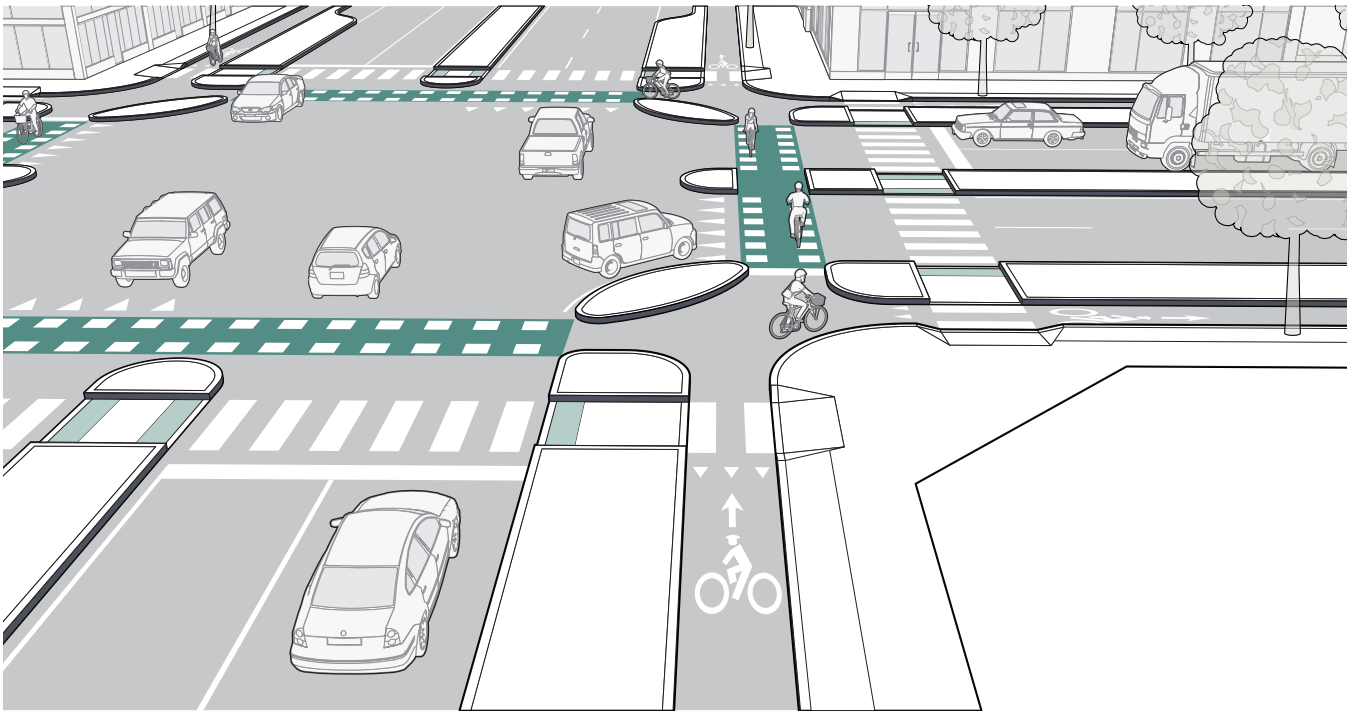
MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

FHWA. Bicycle Facilities and the Manual on Uniform Traffic Control Devices - Two-Stage Turn Box. 2015.

SEPARATED BIKE LANES AT INTERSECTIONS

Separated bicycle lanes provide an exclusive travel way for bicyclists alongside roadways that is separate from motor vehicle travel lanes, parking lanes, and sidewalks. Separated bike lane designs at intersections should manage conflicts with turning vehicles and increase visibility for all users.



Separated bicycle lane designs at intersections should give consideration to signal operation and phasing in order to manage conflicts between turning vehicles and bicyclists. Bicycle signal heads should be considered to separate conflicts.

Shared lane markings and/or colored pavement can supplement short dashed lines to demark the protected bike lane through intersections, where engineering judgment deems appropriate.

At non-signalized intersections, design treatments to increase visibility and safety include:

+ Warning signs
+ Raised intersections
+ Special pavement markings (including colored surface treatment)
+ Removal of parking prior to the intersection
+ It is preferable to maintain the separation of the bike lane through the intersection rather than introduce the bicyclist into the street with a merge lane. Where this is not possible, see guidance on Mixing Zones.
+ Increasing visibility and awareness are two key design goals for separated bike lanes at intersections. In some cases, parking restrictions between 20' to 40' are needed to ensure the visibility of bicyclists at intersections.
+ Separated bike lanes should typically be routed behind transit stops (i.e., the transit stop should be between the bike lane and motor vehicle travel lanes). If this is not feasible, the separated bike lane should be designed to include treatments such as signage and pavement markings to alert the bicyclist to stop for buses and pedestrians accessing transit stops.
+ Markings and signage should be used at intersections to give priority to separated bicycle lanes.

REFERENCES

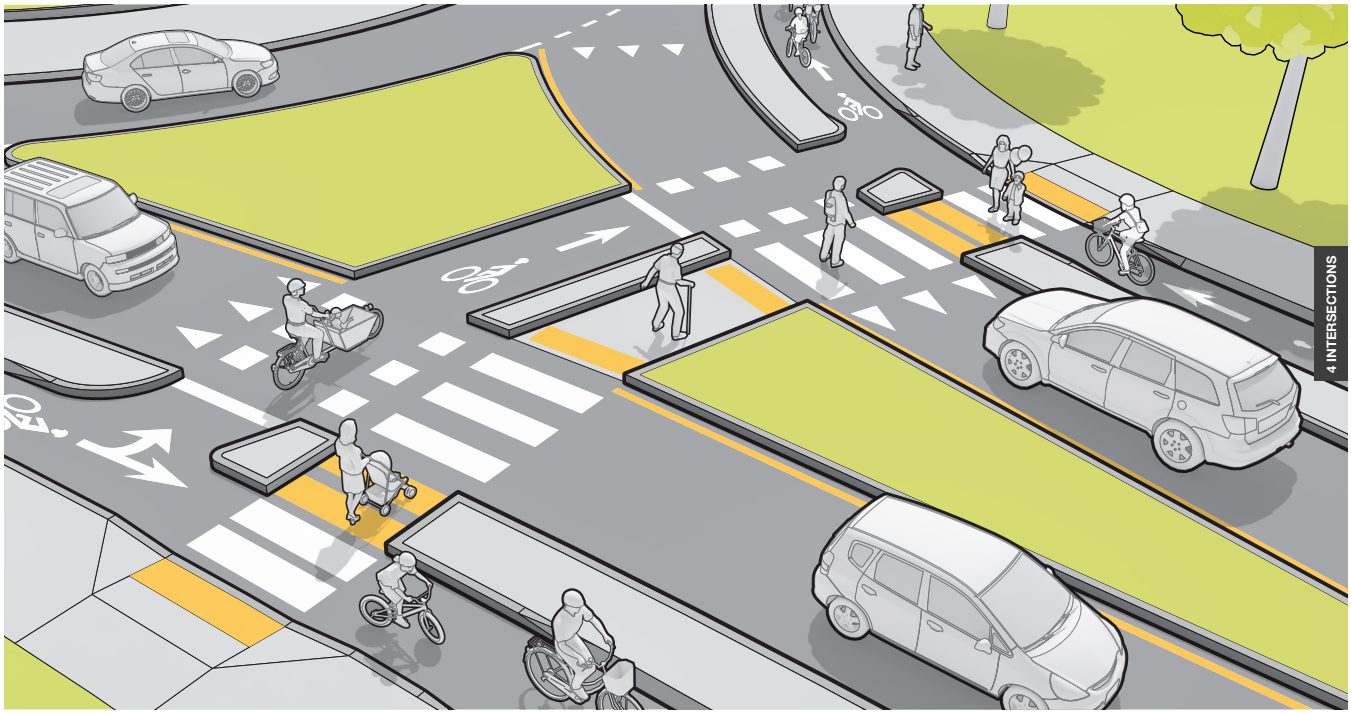
Bicycle Facilities and the Manual on Uniform Traffic Control Devices

NACTO Urban Bikeway Design Guide

FHWA Separated Bike Lane Planning and Design Guide (2015)

SEPARATED BIKE LANES AT ROUNDABOUTS

When separated bike lanes are provided at roundabouts, they should be continuous around the intersection, and parallel to the sidewalk. Separated bike lanes should generally follow the contour of the circular intersection.



At crossing locations of multi-lane roundabouts or roundabouts where the exit geometry will result in faster exiting speeds by motorists (thus reducing the likelihood that they will yield to bicyclists and pedestrians), additional measures should be considered to induce yielding such as providing an actuated device such as a Rapid Flashing Beacon or Pedestrian Hybrid Beacon.

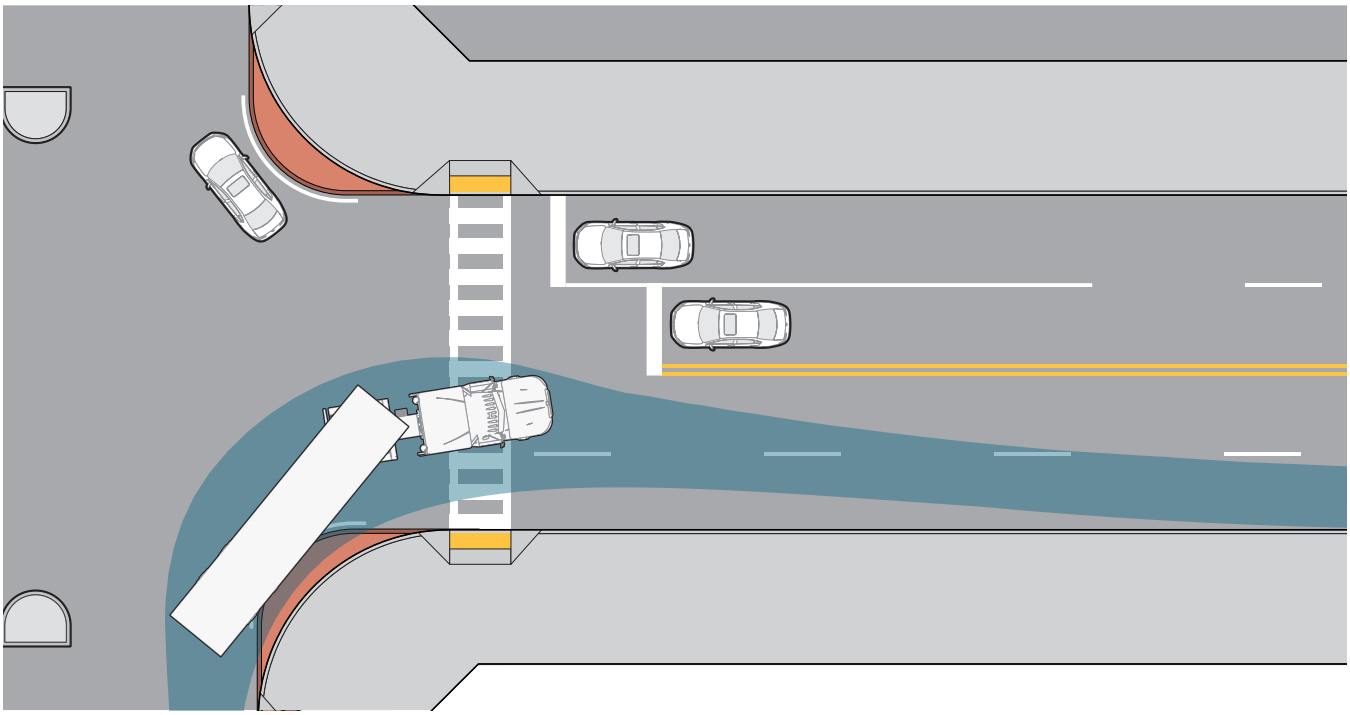
- The bicycle crossing should be immediately adjacent to and parallel with the pedestrian crossing, and both should be at the same elevation.
- Consider providing supplemental yield lines at roundabout exits to indicate priority at these crossings.
- The decision of whether to use yield control or stop control at the bicycle crossing should be based on available sight distance.
- The separated bike lane approach to the bicycle crossing should result in bicyclists arriving at the queuing area at a perpendicular angle to approaching motorists.
- Curb radii should be a minimum of 5 ft. to enable bicyclists to turn into the queuing area.
- Channelizing islands are preferred to maintain separation between bicyclists and pedestrians, but may be eliminated if different surface materials are used.

REFERENCES

MassDOT Separated Bike Lane Planning & Design Guide (2016)

TRUCK APRONS

In locations where large vehicles make occasional turns, designers can consider mountable truck aprons. Mountable truck aprons deter passenger vehicles from making higher-speed turns, but accommodate the occasional large vehicle without encroachment or off-tracking into pedestrian waiting areas. Mountable truck aprons should be visually distinct from the adjacent travel lane and sidewalk.



While bicyclist and pedestrian safety is negatively impacted by wide crossings, bicyclists and pedestrians are also at risk if the curb radius is too small. Curb radii that are too small for large vehicels to navigate can result in the rear wheels of a truck tracking over queuing areas at the corner. Maintenance problems are also caused when trucks must regularly drive over street corners to make turns.

Mountable truck aprons are a solution that can reduce turning speeds for passenger vehicles while accommodating the offtracking of larger vehicles where s larger corner radius is necessary.

+ Mountable truck aprons are part of the traveled way and as such should be designed to discourage pedestrian or bicycle refuge. Bicycle stop bars, detectable warning panels, traffic signal equipment and other intersection features must be located behind the mountable surface area. The mountable surface should be visually distinct from the adjacent travel lane, sidewalk and separated bike lane. The heights of mountable areas and curbs should be no more than 3 inches above the travel lane to accommodate lowboy trailers.

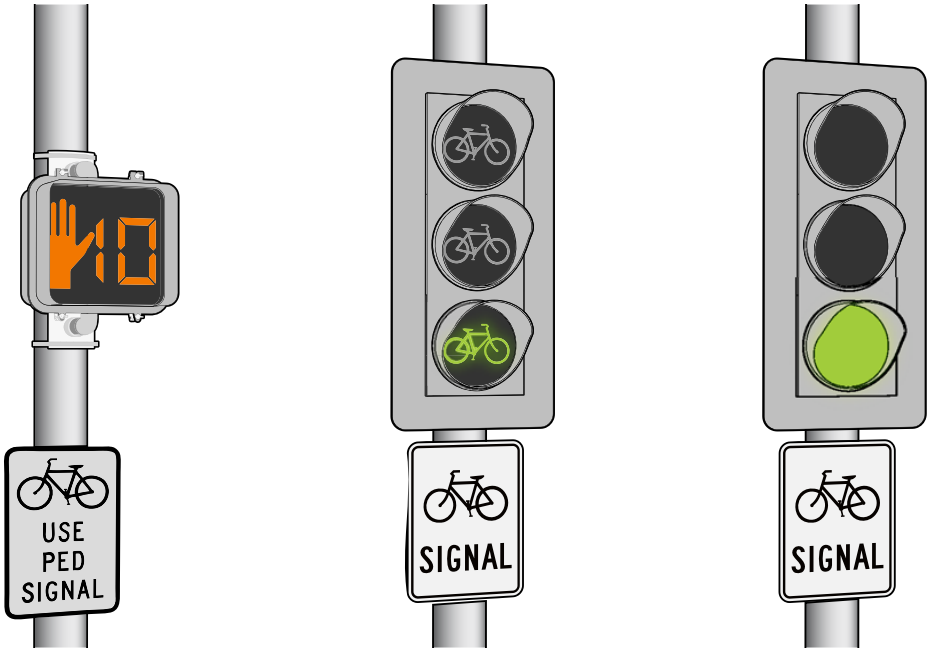
REFERENCES

MassDOT Separated Bike Lane Planning & Design Guide (2016)

FHWA Achieving Multimodal Networks

BICYCLE SIGNALS, DETECTION, ACTUATION

Bicyclists have unique needs at signalized intersections. Bicycle movements may be controlled by the same indications that control motor vehicle movements, by pedestrian signals, or by bicycle-specific traffic signals. The introduction of separated bike lanes creates situations that may require leading or protected phases for bicycle traffic, or place bicyclists outside the cone of vision of existing signal equipment. In these situations, provision of signals for bicycle traffic will be required.



- Bicycle-specific signals may be appropriate to provide additional guidance or separate phasing for bicyclists per the 2012 AASHTO Guide for the Development of Bicycle Facilities.
- It may be desirable to install advanced bicycle detection on the intersection approach to extend the phase, or to prompt the phase and allow for continuous bicycle through movements.
- Video detection, microwave and infrared detection can be an alternate to loop detectors.
- Another strategy in signal timing is coordinating signals to provide a "green wave", such that bicycles will receive a green indication and not be required to stop. Several cities including Portland, OR and San Francisco, CA have implemented "green waves" for bicycles.
- A stationary, or "standing", cyclist entering the intersection at the beginning of the green indication can typically be accommodated by increasing the minimum green time on an approach per the 2012 AASHTO Guide for the Development of Bicycle Facilities.
- A moving, or "rolling", bicyclist approaching the intersection towards the end of the phase can typically be accommodated by increases to the red times (change and clearance intervals) per the 2012 AASHTO Guide for the Development of Bicycle Facilities.
- Set loop detectors to the highest sensitivity level possible without detecting vehicles in adjacent lanes and field check. Type D and type Q loops are preferred for detecting bicyclists.
- Install bicycle detector pavement markings and signs per the MUTCD, 2012 AASHTO Guide for the Development of Bicycle Facilities, and the NACTO Urban Bikeway Design Guide.

REFERENCES

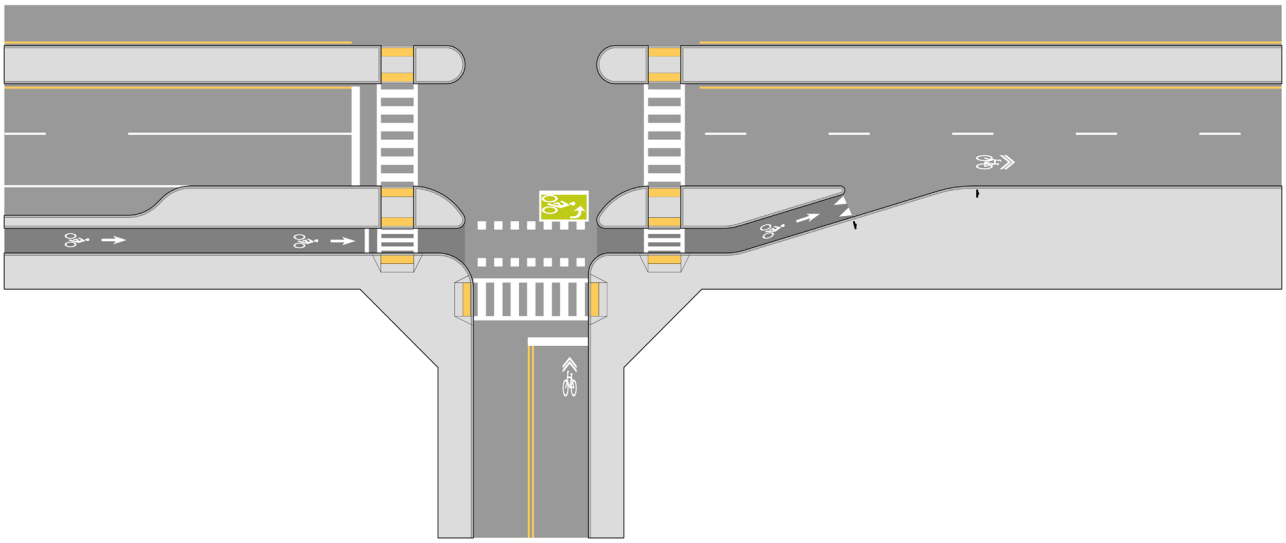
AASHTO Guide for the Development of Bicycle Facilities (2012)

NACTO Urban Bikeway Design Guide (2012)

Manual on Uniform Traffic Control Devices (2009)

TRANSITIONS BETWEEN BICYCLE FACILITIES

Facility types may vary along a roadway corridor based on land use, parking needs, right-of-way constraints and other characteristics. Additionally, a common or logical route for bicyclists may turn at an intersection. It is important to provide transitions between different types of facilities (e.g. wayfinding signage, pavement markings, turn-queue boxes).



Planning for appropriate connections and transitions between facility types should be conducted as a part of network planning. It is important that facilities have logical termini and a network is planned that serves a range of users.

Enhance visibility with green pavement markings and/or bicycle symbols at conflict locations.

Two-stage left turn movements can be accommodated using two-stage turn queue boxes (see page 60). These movements can be easier for some bicyclists to execute. Two-stage left turns may be more comfortable for many bicyclists because the maneuver does not require waiting for gaps in the adjacent same-direction traffic stream before merging laterally to reach a left-turn lane.

- Always carry bicycle facilities to a logical terminus. Specifically, designers should avoid abruptly ending facilities without considering transitions and interactions with vehicles.
- At locations where bicycle lanes transition to shared lanes, it may be desirable to provide a transition to a short segment of shared lane markings, even if the shared lane markings will not continue.
- Signage should be provided per recommendations in the latest edition of the MUTCD and AASHTO Bike Guide. Pavement markings should alert motorists of the change in facility and intended shared use of travel lanes.
- Taper lengths for lane drops and transitions should follow the MUTCD and AASHTO Green Book recommendations.
- Bicycle boxes and turn-queue boxes should be placed out of vehicle paths and be wide/long enough to support multiple bicyclists queuing at intersections. Bicycle boxes should only be used where a dedicated facility is provided prior to the intersection (bicycle lane); however, queue boxes may be used at a variety of locations with or without dedicated facilities.

REFERENCES

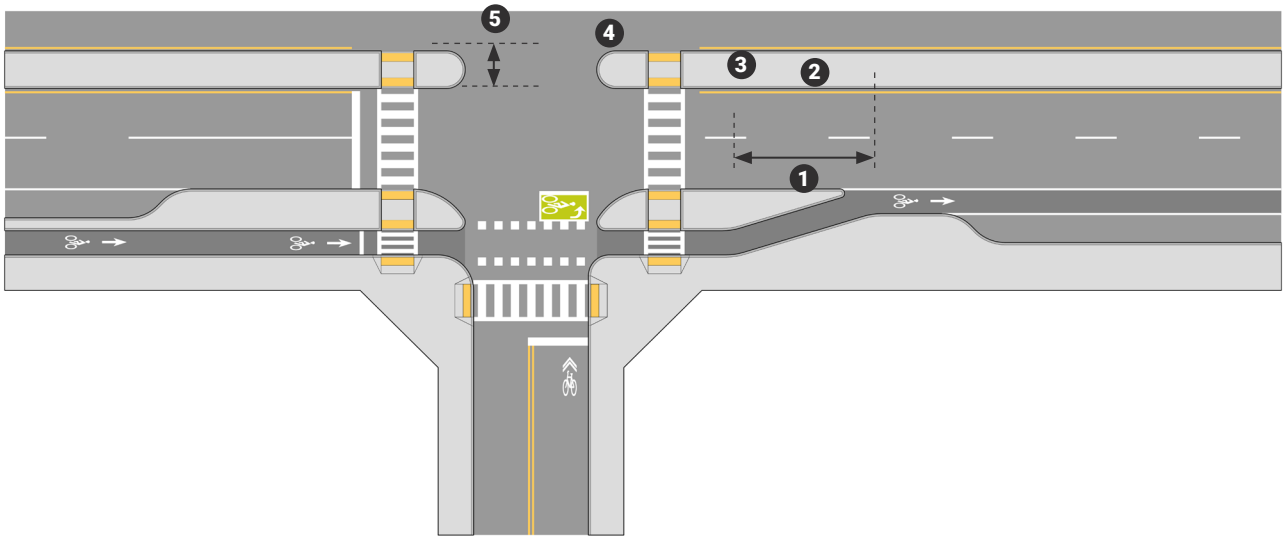
NACTO. *Urban Bikeway Design Guide. 2nd Edition.*

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

TRANSITION FROM ONE-WAY SEPARATED BIKE LANE TO CONVENTIONAL BIKE LANE ON SAME STREET

This treatment provides an example of a preferred design of a separated bike lane transition to a conventional bicycle lane.



To convey which user has the right-of-way, intersections with separated bike lanes should be designed to minimize bicyclist exposure to motorized traffic and should minimize the speed differential at conflict points. The goal is to provide clear messages regarding right-of-way to all users moving through the intersection in conjunction with geometric features that result in higher compliance where users are expected to yield.

The transition should:

+ Maintain separation through the intersection.
+ Occur on the far side of intersections to reduce conflicts with turning vehicles within the intersection.
+ Maintain a vertical or visual separation between bicyclists and pedestrians where sidewalk buffers are eliminated.
+ Clearly communicate how bicyclists should enter and exit the separated bike lane minimizing conflicts with other users.

1. Maximum 3:1 lateral taper.
2. A bike lane width of 6.5 feet is required to allow passing.
3. A protecting island should be provided to shadow the bicycle lane on the far side and to create protection for queueing left turn bicyclists waiting in the turn box.
4. Provide a two-stage turn queue box at intersections with cross streets that have bicycle lanes or shared lanes.
5. Minimum offset is 6 feet, desirable 16.5 feet.

REFERENCES

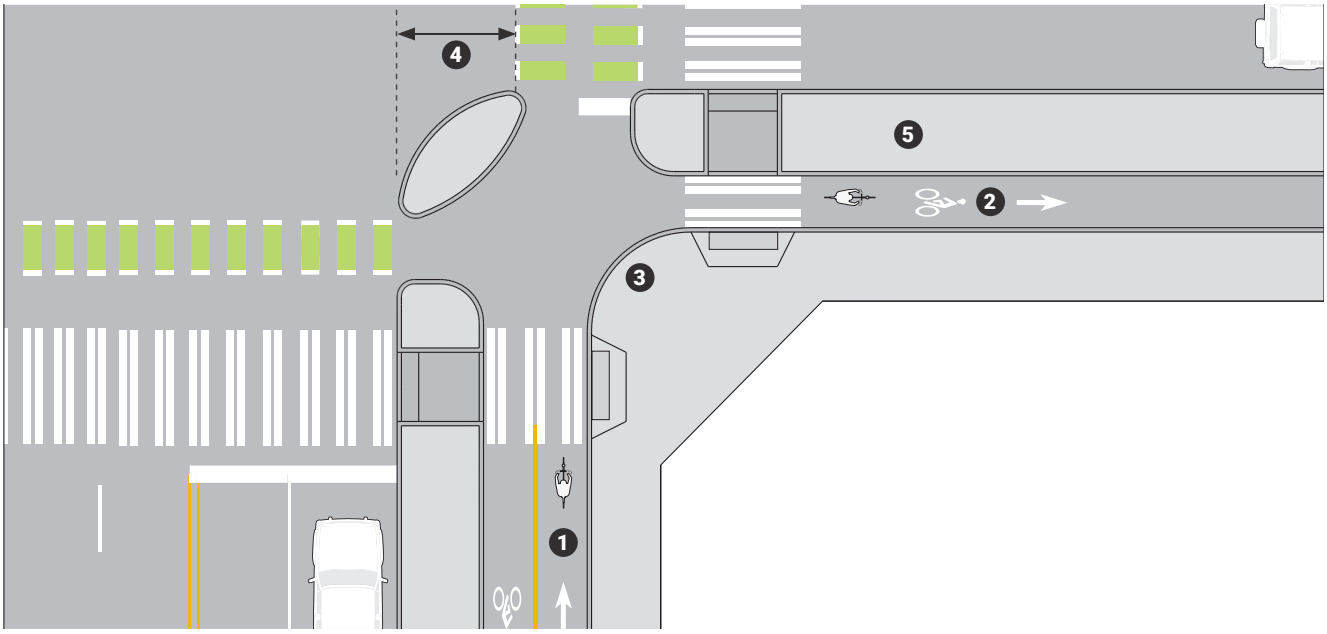
NACTO. *Urban Bikeway Design Guide. 2nd Edition.*

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

TRANSITION FROM TWO-WAY SEPARATED BIKE LANE TO CONVENTIONAL BIKE LANE ON INTERSECTING STREET

This treatment provides an example of a typical design of a two-way separated bike lane transition to a one-way separated bicycle lane on a cross street.



Intersections with separated bike lanes should be designed to minimize bicyclist exposure to motorized traffic and should minimize the speed differential at the points where travel movements intersect. The goal is to provide clear messages regarding right-of-way to all users moving through the intersection in conjunction with geometric features that result in higher compliance where users are expected to yield.

The transition design should:

+ Maintain separation through the intersection.
+ Occur on the far side of intersections to reduce conflicts with turning vehicles within the intersection.
+ Maintain a vertical or visual separation between bicyclists and pedestrians where sidewalk buffers are eliminated.
+ Clearly communicate how bicyclists are intended to enter and exit the separated bike lane minimizing conflicts with other users.

1. A minimum two-way separated bike lane width of 10 feet is recommended.
2. A minimum one-way separated bike lane width of 6.5 feet is recommended.
3. A 15-foot corner radius is recommended for turns from the two-way bike lane onto the one-way bike lane.
4. Minimum offset is 6 feet, desirable 16.5 feet.
5. A minimum street buffer of 6 feet is recommended.

REFERENCES

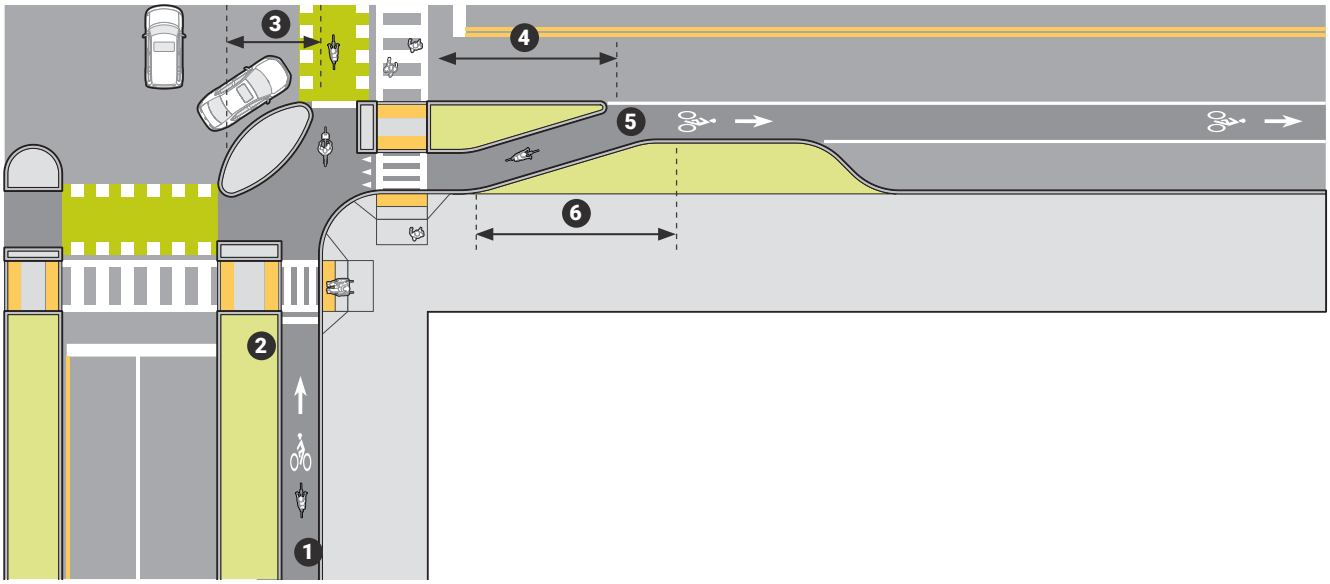
NACTO. *Urban Bikeway Design Guide. 2nd Edition.*

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

TRANSITION FROM ONE-WAY SEPARATED BIKE LANE TO CONVENTIONAL BIKE LANE ON INTERSECTING STREET

This treatment provides an example of a typical design of a one-way separated bike lane transition to a one-way separated bicycle lane on a cross street.



Intersections with separated bike lanes should be designed to minimize bicyclist exposure to motorized traffic and should minimize the speed differential at the points where travel movements intersect. The goal is to provide clear messages regarding right-of-way to all users moving through the intersection in conjunction with geometric features that result in higher compliance where users are expected to yield.

The transition design should:

+ Maintain separation through the intersection.
+ Occur on the far side of intersections to reduce conflicts with turning vehicles within the intersection.
+ Maintain a vertical or visual separation between bicyclists and pedestrians where sidewalk buffers are eliminated.
+ Clearly communicate how bicyclists are intended to enter and exit the separated bike lane minimizing conflicts with other users.

1. A minimum one-way separated bike lane width of 6.5 feet is recommended.
2. A minimum street buffer of 6 feet is recommended.
3. Minimum offset is 6 feet, desirable 16.5 feet.
4. Recommended minimum transition is 25 feet to ensure a bicyclist has time to react to an approaching vehicle.
5. A one-way separated bike lane and conventional bike lane width of 6.5 feet is recommended.
6. Maximum 3:1 lateral taper.

REFERENCES

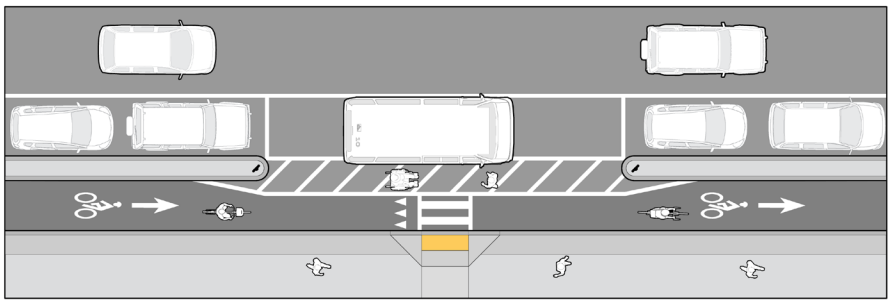
NACTO. *Urban Bikeway Design Guide. 2nd Edition.*

MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

FHWA. Separated Bike Lane Planning and Design Guide. 2015.

LOADING ZONES

Truck loading operations typically involve pulling over to the side of the roadway. This action may result in blocking a bike lane or crossing through a bike lane to access a loading zone. Dedicated commercial loading zones can save trucking companies time and money and improve air quality. Commercial loading zones should be designated where they will provide convenient access to businesses, while causing minimal conflict with bicycle facilities. This should be balanced with providing convenient dedicated loading zones.



Consider consolidating commercial loading zones to a single location on each block to reduce potential conflicts.

Consider the length of typical loading vehicles that use the space when determining the length of the loading zone.

A curb ramp with a separated bike lane crosswalk can simplify loading and unloading activity.

Green-colored pavement can be used to notify freight operators of a potential conflict with a bicyclist.

Consider locating a commercial loading zone on an adjacent block or alley where a loading zone is desired but on-street parking is not present.

A lateral shift of the separated bike lane and the sidewalk should be considered as a last resort.

+ Streets with heavy freight usage, high parking demand, and bike lanes benefit from dedicated commercial loading zones after an intersection. Loading zones may help reduce obstruction of the bike lane and make deliveries easier for businesses. These zones can be striped and signed, or managed for off-peak deliveries.

+ Where on-street parking and separated bike lanes are provided, consider a 5-foot minimum access aisle between the commercial loading zone and the bike lane. Vertical objects used to delineate the bike lane should be discontinued where an access aisle is provided.

+ The loading zone should be 8–10 feet wide.

REFERENCES

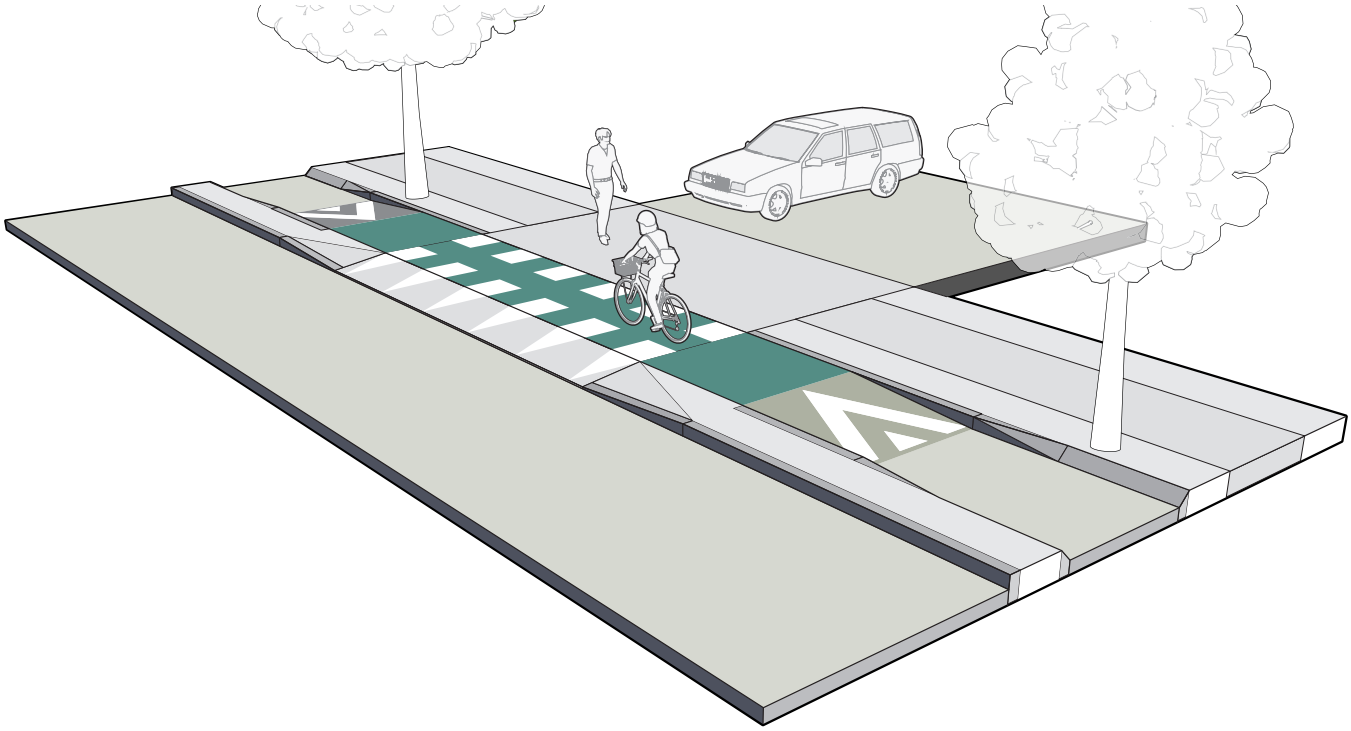
NACTO Urban Bikeway Design Guide (2012)

MassDOT Separated Bicycle Lane Planning & Design Guide (2016)

FHWA Separated Bicycle Lane Planning and Design Guide (2015)

DRIVEWAYS

Most bicycle facilities will need to cross streets, driveways, or alleys at multiple locations along a corridor. At these locations, the crossings should be designed to 1) delineate a preferred path for people bicycling through the intersection and 2) to encourage driver yielding behavior, where applicable. Bicycle crossings may be supplemented with green pavement, yield lines, and/or regulatory signs.



- Supplemental yield lines, otherwise known as shark's teeth, can be used to indicate priority for people bicycling and may be used in advance of unsignalized crossings at driveways, at signalized intersections where motorists may turn across a bicycle crossing during a concurrent phase, and in advance of bicycle crossings located within roundabouts.
- Raised bicycle crossings further promote driver yielding behavior by slowing their speed before the crossing and increasing visibility of people bicycling.
- The bicycle crossing may be bounded by 12" (perpendicular) by 24" (parallel) white pavement dashes, otherwise known as elephant's feet. Spacing for these markings should be coordinated with zebra, continental, or ladder striping of the adjacent crosswalk.
- The bicycle crossing should be a minimum of 6' wide for one-way travel and 10' wide for two-way travel, as measured from the outer edge of the elephant's feet. Bicycle lane symbol markings should be avoided in bicycle crossings. Directional arrows are preferred within two-way bicycle crossings.
- Dashed green colored pavement may be utilized within the bicycle crossing to increase the conspicuity of the crossing where permitted conflicts occur. Green color may be desirable at crossings where concurrent vehicle crossing movements are allowed and where sightlines are constrained, or where motor vehicle turning speeds exceed 10 mph.

REFERENCES

MassDOT Separated Bike Lane Planning & Design Guide (2016)

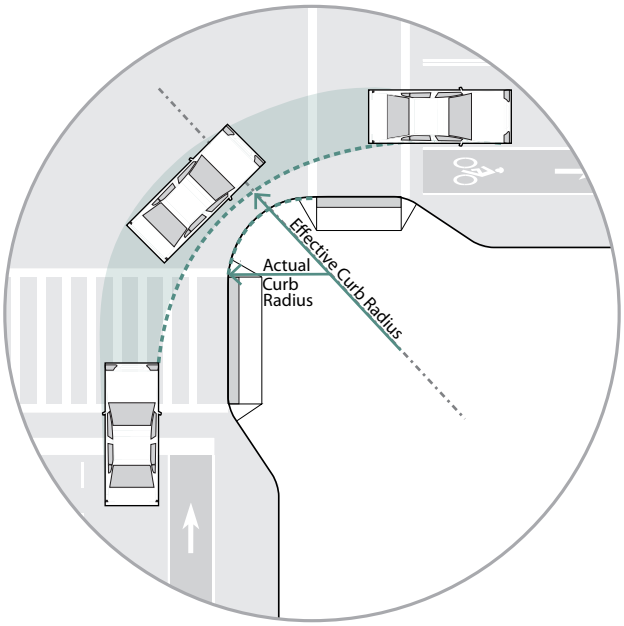
FHWA Separated Bike Lane Planning and Design Guide (2015)

CORNERS AND CURB RADII

Pedestrian safety and comfort is directly impacted by the width and configuration of street corners; however, streets must accommodate large turning vehicles, including school buses and transit vehicles. One of the most challenging aspects of intersection design is to determine methods of accommodating large vehicles while keeping intersections as compact as possible. This requires a great deal of design flexibility and engineering judgment, as each intersection is unique in terms of the angles of the approach and departure, the number of travel lanes, the presence of a median, and a number of other features that fundamentally impact corner design.

A variety of strategies can be employed to minimize curb radii:

- On-street parking and bicycle lanes may provide the larger effective radii to accommodate the appropriate design vehicle.
- On low volume (less than 4,000 vehicles per day), two-lane streets, corner design should assume that a large vehicle will use the entire width of the departing and receiving travel lanes, including the oncoming traffic lane.
- At signalized intersections, corner design should assume the large vehicle will use the entire width of the receiving lanes on the intersecting street.
- At signalized intersections where additional space is needed to accommodate turning vehicles, consideration can be given to recessing the stop bar on the receiving street to enable the vehicle to use the entire width of the receiving roadway (encroaching on the opposing travel lane).
- In some cases, it may be possible to allow a large turning vehicle to encroach on the adjacent travel lane on the departure side (on multi-lane roads) to make the turn.
- A compound curve can be used to vary the actual curb radius over the length of the turn so that the radius is smaller as vehicles approach a crosswalk and larger when making the turn.
- In some cases where there are alternative access routes, it may be possible to restrict turning movements by large vehicles at certain intersections and driveways to enable tighter curb radii.
- Turn restrictions and alternate access routes should be properly signed and must be approved by T&ES.

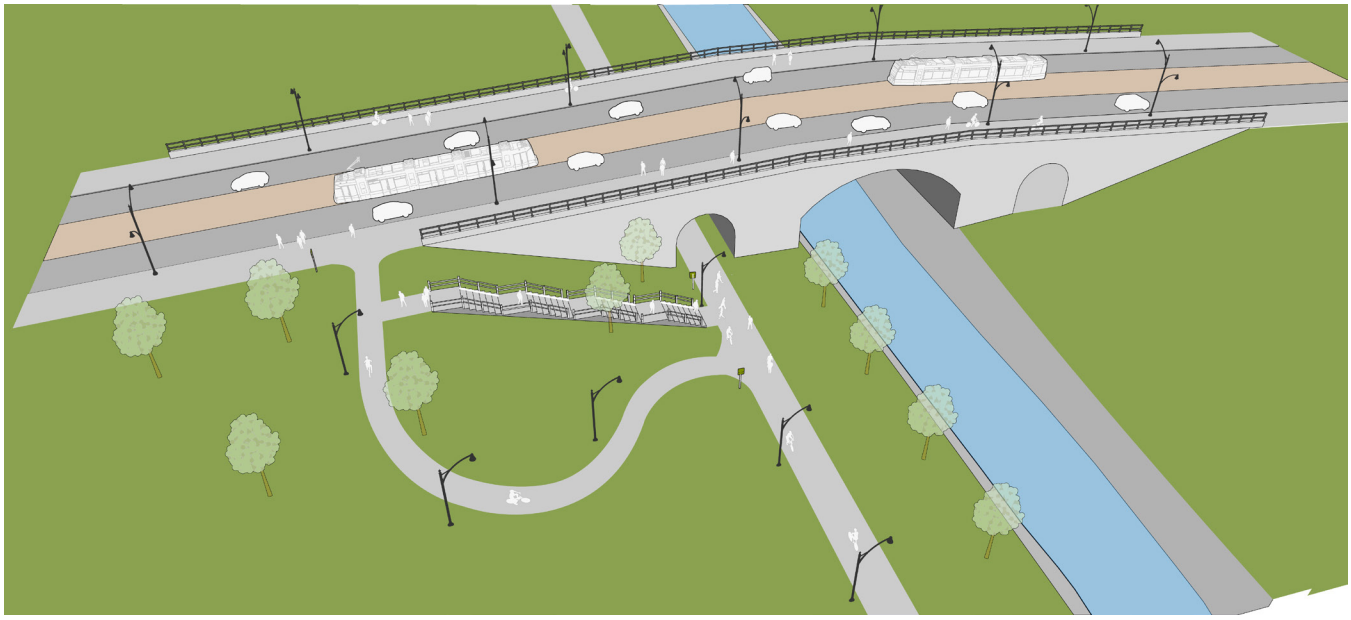


GUIDANCE

- The design vehicle should be selected according to the types of vehicles using the intersection with considerations to relative volumes and frequencies. In most cases, the curb radii are based on a Single Unit vehicle with a 42' turning radius. If the City anticipates the need to accommodate a larger design vehicle, a radius evaluation based on this larger vehicle would be required. Examples of typical turning templates would include a SU, WB-40, WB-50, WB-60 and WB-62.
- Intersection design should strive for an actual curb radii that is between 10' to 25'. The default curb radii for two intersecting Neighborhood Residential Streets is 10' (exceptions apply for angled streets). For all other street classifications, including streets that intersect with Neighborhood Residential Streets, corner design should strive for an actual curb radius that is no more than 15' (exceptions apply for angled streets). Methods to minimize curb radii are described below.

BRIDGE DESIGN

Bridge crossings are significant investments and therefore typically occur infrequently. However, bridges provide critical access linkages in a community and when they are designed, it is important that they accommodate pedestrians and bicyclists. A bridge without walking and bicycling access can result in a lengthy detour that discourges the trip, or requires the use of unsafe facilities.



Accommodations for pedestrian and bicycle travel should be provided on both sides of bridges. These facilities should be bi-directional where possible, in order to increase mobility and limit the need for vulnerable road users to cross the street. When planning for bicycle and pedestrian facilities on or beneath bridges, the facility design should account for existing and projected user volumes. The design should also consider whether to provide separate bicycle and pedestrian accommodations or combine these uses with a shared use path.

While an accessible route will be required to access a bridge, stairs may provide a more direct and shorter route, and should be considered to complement the accessible route. Stairs can accommodate bicycles by providing a bike channel. The handrail must be designed such that pedestrians are easily able to reach the railing without conflict with the bike channel.

Bridges may provide needed connectivity within a community, but opportunities to rebuild them are infrequent. Therefore, when such opportunities arise, the new design should account for all anticipated future uses and connectivity needs. Waterways, railroads and highways may provide a desirable corridor for future shared use paths.

- The desirable clear width for a sidewalk on a bridge is 8 feet.
- The minimum width for one-way bicycle travel is 4 feet.
- Shy distances should be accounted for when providing the clear width. 1.5 feet is generally needed to provide shy distance from railings and other vertical objects.
- On bridges that accommodate both vehicular and pedestrian/bicycle travel, only crash-tested railing should be installed.

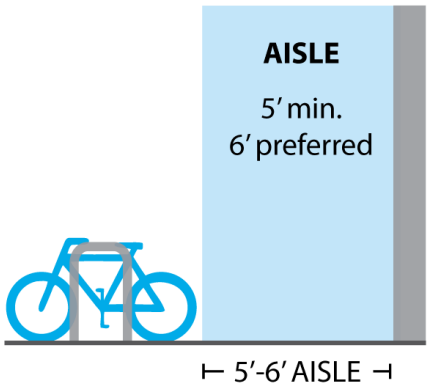
REFERENCES

NACTO Urban Street Design Guide (2012)

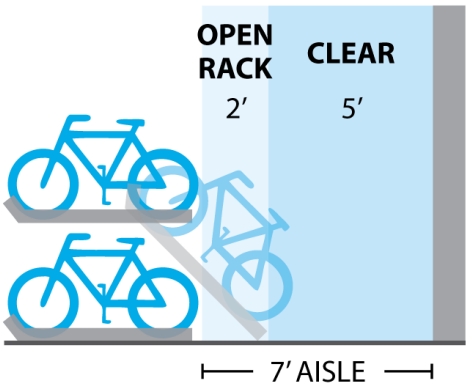
FHWA Achieving Multimodal Networks (2016)

BIKE PARKING

Bicycle parking enhances the usefulness of bicycle networks by providing locations for the secure storage of bicycles during a trip. Bicycle parking enables bicyclists to secure their bicycles while enjoying the offerings of a street or patronizing businesses and destinations in the city. Bicycle parking requires far less space than automobile parking-- in fact, 10 bicycles can typically park in the area needed for a single car.



Single Tier/Single Loaded



Two Tier/Single Loaded

Bicycle parking consists of a rack that supports the bicycle upright and provides a secure place for locking. Bicycle racks should be permanently affixed to a paved surface. Movable bicycle racks are only appropriate for temporary use, such as at major community gatherings.

On-street bicycle parking is intended for short term use. Bicyclists parking overnight should utilize offstreet bicycle parking facilities. Bicyclists typically find a variety of fixed objects in the street to which they lock their bicycles. These include parking meters, tree well fences, lawn fences or other objects. These objects may satisfy the need for bicycle parking, but if this is the intent, they should be designed and located with this use specifically in mind. Otherwise, the use of such objects for parking may indicate insufficient or inappropriately located bicycle parking facilities.

- Bicycle racks should provide two points of support for bicycles to prevent locked bicycles from falling over.
- Bicycle rack footings can be mounted in soil, concrete, or asphalt, or mounted to stable surfaces using anchors.

REFERENCES

NACTO Urban Street Design Guide (2013)

Manual on Uniform Traffic Control Devices (2009)

APBP Bicycle Parking Guidelines (2010)

APBP Essentials of Bike Parking: Selecting and Installing Bike Parking that Works (2015)

SEPARATED BIKE LANE MAINTENANCE

Separated bike lanes require routine maintenance to ensure they provide safe bicycling conditions. Because of their location on the edge of the roadway, separated bike lanes are more likely to accumulate debris in all seasons. During the freeze/thaw cycles of the winter months, separated bike lanes are particularly susceptible to icing. As bicyclists are typically inhibited from exiting separated bike lanes, they may have no opportunity to avoid obstacles such as debris, obstructions, slippery surfaces, and pavement damage and defects.

An example of separated bike lane maintenance needs (Atlanta, GA)

CONSIDERATIONS

A separated bike lane should be maintained in a similar manner as the adjacent roadway, regardless of whether the separated bike lane is at street level or sidewalk level. Maintenance of separated bike lanes is therefore the responsibility of the public or private agency that is responsible for maintaining the adjacent roadway. This practice may contrast with responsibility for maintaining the adjacent sidewalk, which in some cases will be that of the abutting landowner.

Generally, separated bike lane widths of 8 feet or more are compatible with smaller sweepers and plows, but responsible parties may have larger and incompatible maintenance fleets. Narrower sweepers and plows (approximately 4 feet to 5 feet minimum operating width) may be required to clear one-way separated bike lanes.

Trash Collection

Where separated bike lanes are introduced, the general public, public works staff and contractors should be trained to place garbage bins in the street buffer zone to avoid obstructing the bike lane. Sidewalk buffers may be used to store bins where street buffers are too narrow. Special consideration may be required in separated bike lane design for access to large dumpsters which require the use of automated arms. This may require spot restrictions of on-street parking or curb cuts to dumpster storage in order to accommodate access.

Winter Maintenance

Snow and ice should be cleared from separated bike lanes to maintain safe and comfortable access by bicycle during winter weather events. A minimum 4 feet clearance per direction (i.e., 8 feet minimum for two-way facilities) should be provided in the bike lane zone as soon as practical after snow events. Snow from the separated bike lane should not be placed in the clear width of the sidewalk or vice versa.

Sweeping and Debris Removal

For street-level separated bike lanes without raised medians, debris can collect in the street buffer area between vertical objects and can migrate into the bike lane if not routinely collected. Landscaped areas, including green stormwater infrastructure, can also collect debris and require regular attention. Fine debris can settle into permeable pavement and inhibit surface infiltration unless vacuumed on a routine basis. At a minimum, permeable pavement should be vacuumed several times per year, depending on material type.

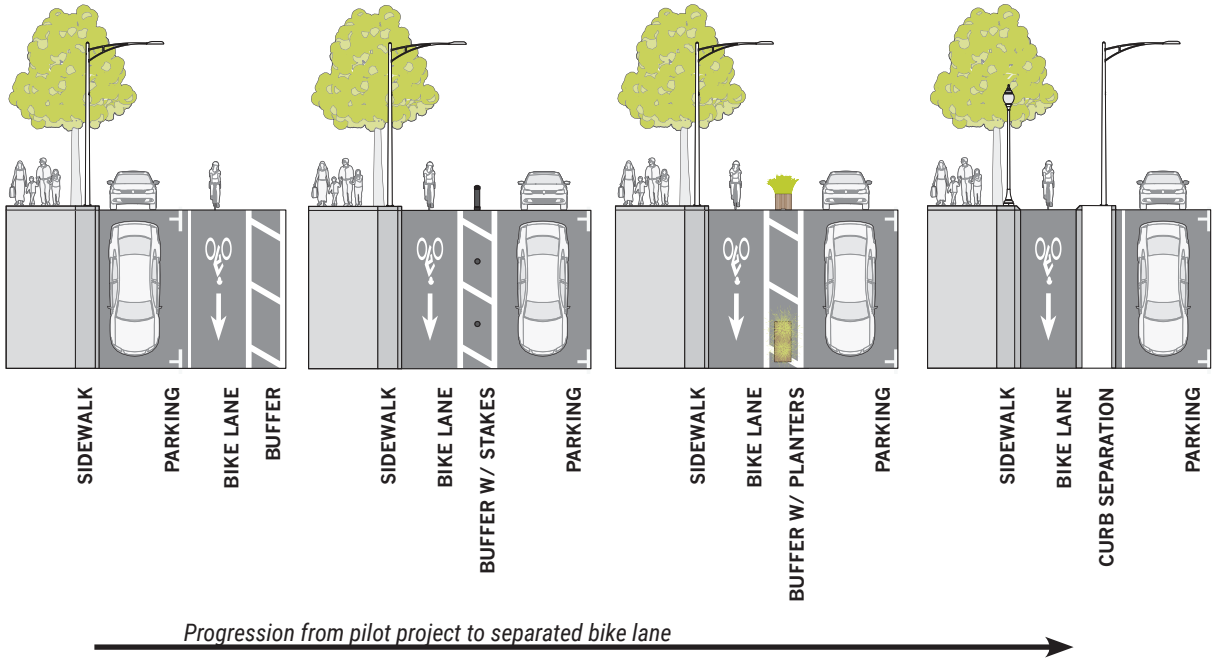
REFERENCES

NACTO Urban Streets Design Guide (2012)

MassDOT Separated Bicycle Lane Planning & Design (2016)

LIFE OF A BIKE LANE

Separated bike lanes have been implemented in many cases as low-cost retrofit projects (e.g. using flex posts and paint within the existing right-of-way). More permanent forms of separation, such as curb-protected bike lanes, cost more and are less flexible once implemented. A phased implementation approach, where "pilot" projects transition to permanent protected bike lanes may solve both of these problems, by implementing the facility slowly and troubleshooting before permanent materials and high costs are necessary.



Lower-cost retrofits or demonstration projects allow for quick implementation, responsiveness to public perception and ongoing evaluation. Separation types for short-term separated bike lane designs often include non-permanent separation, such as flexible delineator posts, planters or parking stops. Pilot projects allow the agency to:

- Test the separated bike lane configuration for bicyclists and traffic operations
- Evaluate public reaction, design performance, and safety effectiveness
- Make changes if necessary
- Transition to permanent design

- Permanent separation designs provide a high level of protection and often have greater potential for placemaking, quality aesthetics, and integration with features such as green stormwater infrastructure. Agencies often implement permanent separation designs by leveraging private development (potentially through developer contribution), major capital construction, and including protected bike lanes in roadway reconstruction designs. Examples of permanent separation materials include rigid bollards, raised medians and grade-protected bike lanes at an intermediate or sidewalk level.

REFERENCES

NACTO Urban Street Design Guide (2013)

FHWA Protected Bike Lane Planning and Design Guide (2015)