

# Appendix A. Bicycle Facilities Toolkit

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# INTRODUCTION

The Bicycle Facility Toolkit provides an overview of the types of bicycle facilities recommended in the Bicycle Master Plan. It is divided into four parts:

- + Facility Types
- + Bicycle Intersection Design & Spot Treatment
- + Facility Implementation Strategies
- + Supportive Amenities

The toolkit profiles best practices for bicycle facility design and application as described in the American Association of State Highway Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities, 4th and 5th Editions, (5th Edition to be released later in 2018), the National Association of Cities and Transportation Officials (NACTO) Urban Bikeway Design Guide, 2nd Edition, the Federal Highway (FHWA) Separated Bike Lane Planning and Design Guide, the Massachusetts Department of Transportation (MassDOT) Separated Bike Lane Planning and Design Guide, and the Caltrans Highway Design manual.

The toolkit's purpose is to provide guidance to designers and planners and is primarily developed as a companion resource to the facility recommendations in the Plan. It provides a description of the treatments and rationale for their use in various contexts. The toolkit is not intended to take the place of design standards prepared by the Napa Valley Transportation Authority or Caltrans.

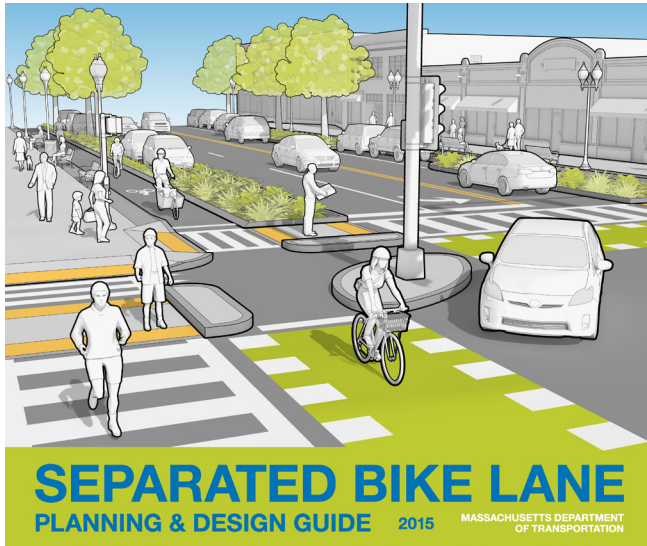
Key principles assumed in the toolkit are that:

- + The bicycling network should accommodate people of all ages and bicycling abilities.
- + Bicycle travel on all streets should be safe, continuous, direct, and convenient.

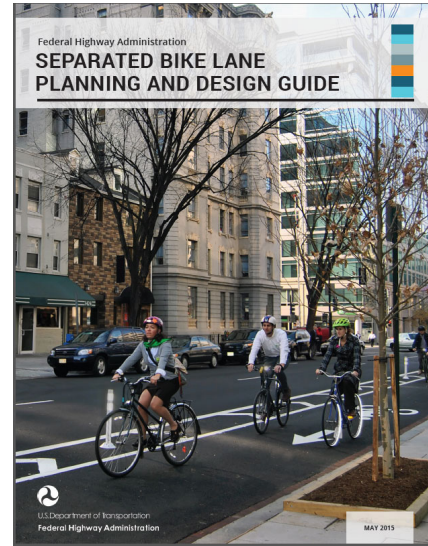
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# NATIONAL STANDARDS AND RESOURCES

The bicycle facilities and amenities included in this toolkit are based on the recommendations from the following state and national standards and resources: the California Highway Design Manual, California Manual on Uniform Traffic Control Devices, American Association of State Highway and Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities, FHWA Separated Bike Lane Planning and Design Guide, National Association of City Transportation Officials (NACTO) Urban Bikeway Design Guide, and the MassDOT Separated Bike Lane Planning and Design Guide.



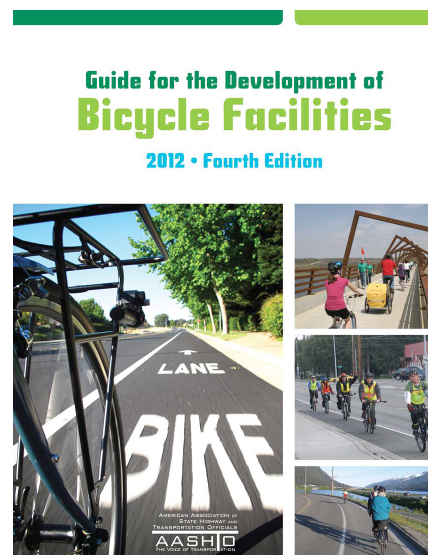
**Massachusetts Department of Transportation (MassDOT)**  
Separated Bike Lane Planning & Design Guide, 2016



**Federal Highway Administration (FHWA)**  
Separated Bike Lane Planning and Design Guide, 2015



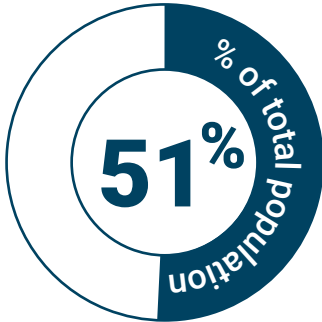
**National Association of City Transportation Officials (NACTO)**  
Urban Street Design Guide, 2013  
Transit Street Design Guide, 2017  
Urban Bikeway Design Guide, 2012



**American Association of State Highway and Transportation Officials (AASHTO)**  
Guide for the Development of Bicycle Facilities, 2012  
Will be updated with a new edition in 2018

# 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—approximately 51%—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, roughly 4% of the population is “Strong and Fearless”, comfortable sharing the road with motorized vehicles. In the middle, approximately 5% are “Enthusiastic and Confident”, comfortable cycling for short distances with motorized vehicles. The remaining portion of the population falls under the category of “Non-Bicyclists”, uncomfortable bicycling in any condition, have no interest in bicycling, or are physically unable to bicycle. See pages 6-7, Bikeway Facilities Selection Chart, to determine which facility types best serve the different types of cyclists. (From the 2018 AASHTO Guide for the Development of Bicycle Facilities)

#### Who are they?

A mother and daughter who enjoy Saturday rides to the park along the Vine Trail 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, 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 worker who just started a new job at Napa State Hospital. He enjoys riding as long as he stays on quiet streets or the sidewalk. He’d like to be able to ride to more destinations, but he’s uncomfortable crossing busy roads and intersections along the way.



LOWER STRESS  
TOLERANCE

# POTENTIAL BICYCLE USERS



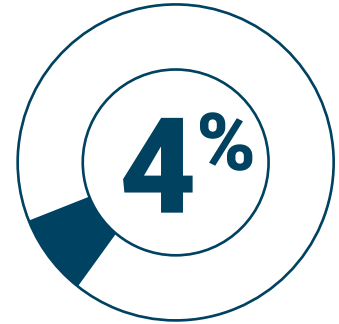
**Enthusiastic and Confident**

## Who are they?

A woman who rides her bike downtown every morning to run errands. 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 Solano Avenue because it has bike lanes.



**Strong and Fearless**

## Who are they?

A recent Napa Valley 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.

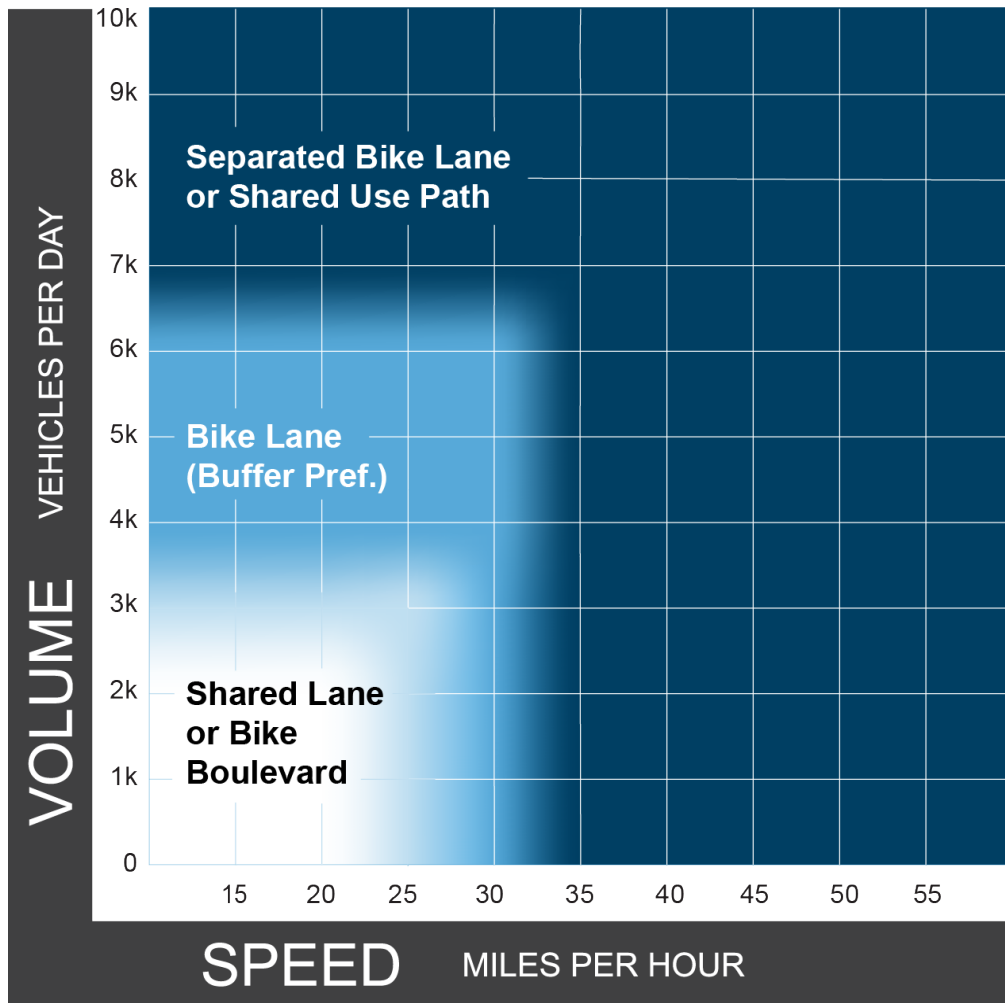


**HIGHER STRESS  
TOLERANCE**

# BICYCLE FACILITY SELECTION

## Designing for Interested but Concerned and Enthusiastic and 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 the operating environment for this bicyclist type at different roadway speeds and traffic volumes. The “enthusiastic and 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.



### Notes

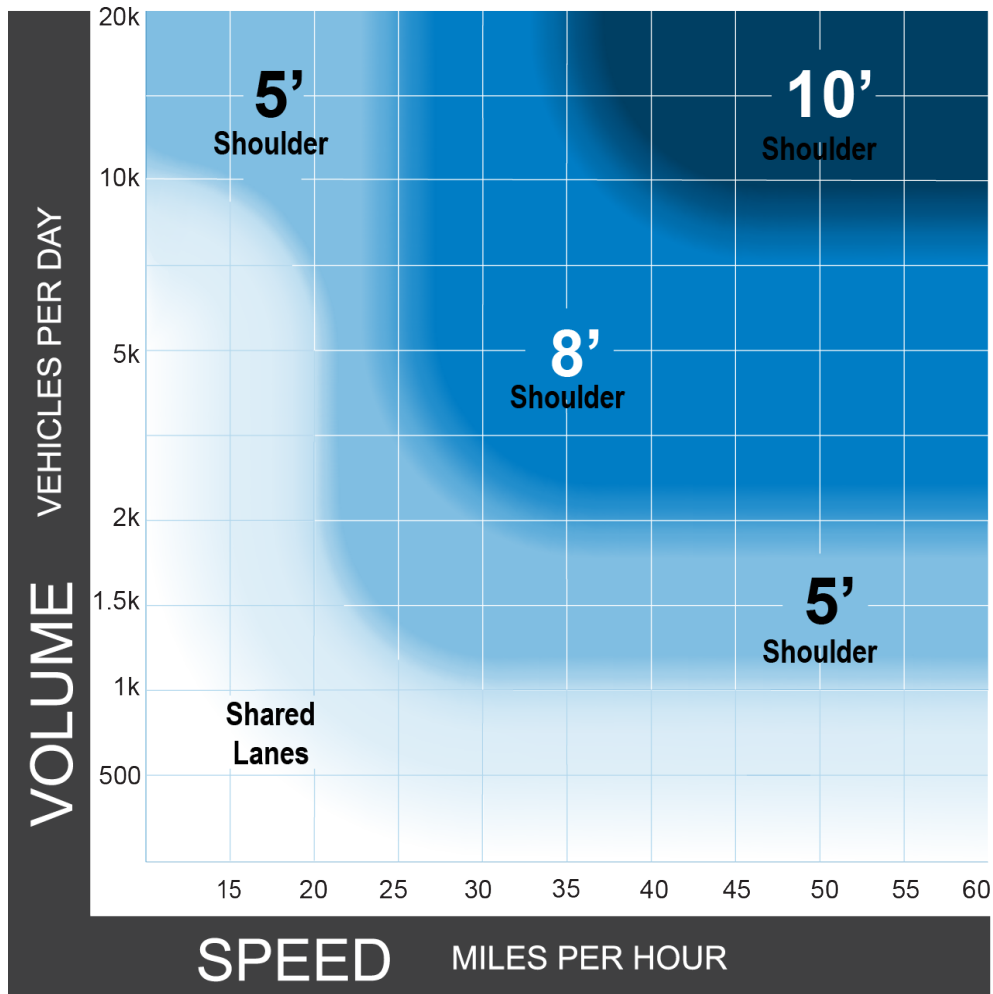
- 1 Chart assumes operating speeds are similar to posted speeds. If they differ, use operating speed rather than posted speed.
- 2 Advisory bike lanes may be an option where traffic volume is <3K ADT.
- 3 See Section 4.4 for a discussion of alternatives if the preferred bikeway type is not feasible.

- + See the Bicycle Facility Overview section on pages 11-12 for explanations of the facilities described in the chart.
- + To determine whether to provide a multi-use path, separated bike lane, or buffered bike lane, consider pedestrian and bicycle volumes or, in the absence of volume, consider land use.

# BICYCLE FACILITY SELECTION

## Shoulder Widths for Rural Roadways

When selecting a minimum shoulder width to accommodate bicyclists, the decision should be based on traffic volumes and posted speeds in the rural context. For the purposes of determining the appropriate shoulder width, it is assumed that posted speeds are approximately the same as operating speeds. If operating speeds differ from posted speeds, then operating speed should be used instead of posted speed.



### Notes

- 1 This chart assumes the project involves reconstruction or retrofit in constrained conditions. For new construction, follow recommended shoulder widths in the AASHTO Green Book.
- 2 A separated shared use pathway is a suitable alternative to providing paved shoulders.
- 3 Chart assumes operating speeds are similar to posted speeds. If they differ, use operating speed rather than posted speed.
- 4 If the percentage of heavy vehicles is greater than 10%, consider providing a wider shoulder or a separated pathway.

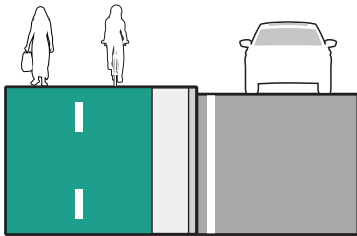
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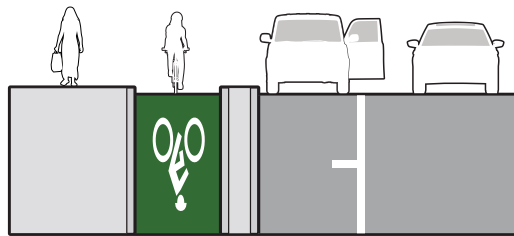
# FACILITY TYPES

# BICYCLE FACILITY OVERVIEW

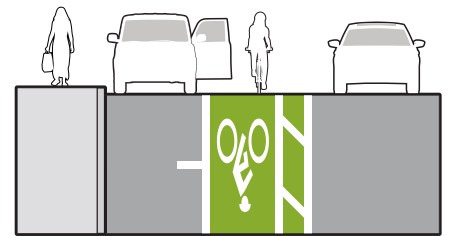
## Multi-Use Path, Class I



## Separated Bike Lane, Class IV



## Buffered Bike Lane, Class II



**MOST SEPARATED**

## TYPICAL APPLICATION

Multi-use paths are an effective treatment on roads with one or more of the following characteristics:

- + Total traffic lanes: 3 lanes or *more*
- + Posted speed limit: 30 mph or *higher*
- + Average Daily Traffic: 6,500 vehicles or more
- + Parking turnover: frequent
- + Bike lane obstruction: likely to be frequent
- + Streets that are designated as truck or bus routes

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

- + Total traffic lanes: 3 lanes or *more*
- + Posted speed limit: 30 mph or *higher*
- + Average Daily Traffic: 6,500 vehicles or more
- + 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 can generally be considered on any road with one or more of the following characteristics:

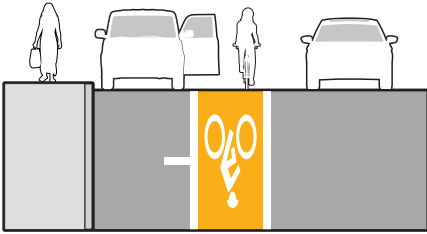
- + Total traffic lanes: 3 lanes or *fewer*
- + Posted speed limit: 30 mph or *lower*
- + Average Daily Traffic: Up to 6,500 vehicles
- + Parking turnover: infrequent
- + Bike lane obstruction: likely to be infrequent
- + Where a separated bike lane or shared use path is infeasible or not desirable due to cost, lack of public support, etc.
- + Buffer may be located on the parking lane side of the bike lane, the travel lane side of the bike lane, or on both sides of the bike lane.

### NOTE

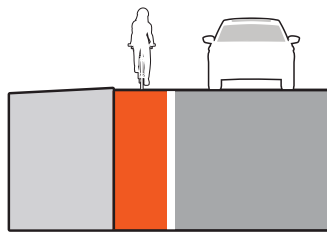
*Contra-flow examples of most of these facilities are possible with consideration given to traffic control, sight lines, placement to the left of oncoming motor vehicle traffic, and low levels of driveway traffic.*

# BICYCLE FACILITY OVERVIEW

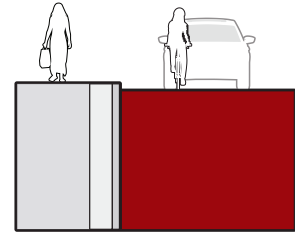
## Bike Lane, Class II



## Shoulder Bikeway, Class III



## Shared Roadway, Class III



LEAST SEPARATED

## TYPICAL APPLICATION

Conventional bike lanes can 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: Up to 6,500 vehicles
- + Parking turnover: infrequent
- + Bike lane obstruction: likely to be infrequent
- + Where a separated bike lane, shared use path, or buffered bike lane are 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 6,500 vehicles
- + Shoulder obstruction: likely to be infrequent
- + Where a separated bike lane or shared use path is infeasible or not desirable.

The minimum width of a shoulder bikeway is 4 feet (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:

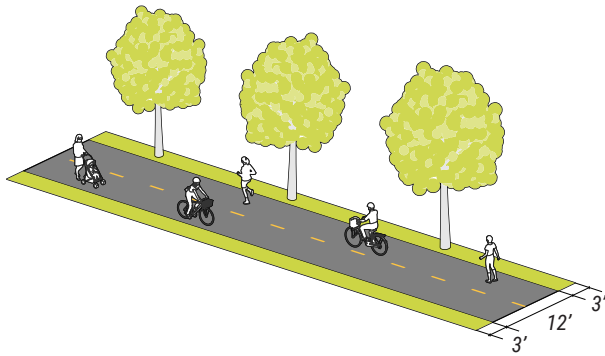
- + Total traffic lanes: 3 lanes or fewer
- + Posted speed limit: 25 mph or lower
- + Average Daily Traffic: Up to 3,000 vehicles
- + Where a separated bike lane or shared use path is infeasible or not desirable.

### NOTE

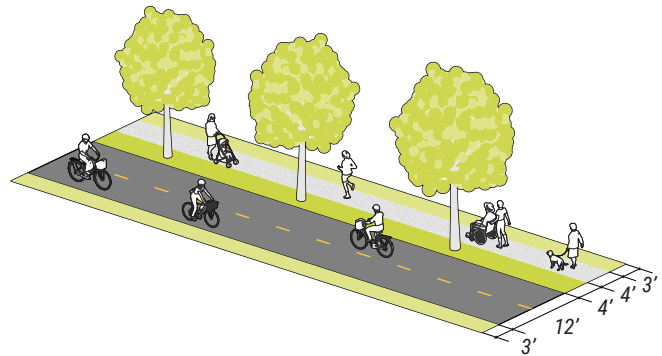
Excluding shared roadways and shoulder bikeways, contra-flow examples of most of these facilities are possible with consideration given to traffic control, sight lines, placement to the left of oncoming motor vehicle traffic, and low levels of driveway traffic.

# MULTI-USE PATHS (CLASS I)

A multi-use path is a two-way facility that is physically separated from motor vehicle traffic and used by bicyclists, pedestrians, and other non-motorized users. Multi-use paths, also referred to as trails, shared-use paths, or Class I paths, are often located in an independent alignment, such as a greenbelt or abandoned railroad right-of-way. Multi-use paths make up a network or system of routes designed specifically for off-street travel. Multi-use paths are used for recreation, leisure activity, and commuting.



*Two-way Shared Use Path Width*



*Two-way Shared Use Path with Parallel Crusher Fines Path*

## CONSIDERATIONS

- + Multi-use paths should not be used to preclude on-street bicycle facilities, but rather to supplement a network of in-street facilities. In some situations it may be appropriate to provide an on-street bikeway in addition to a multi-use path along the same roadway.
- + Multi-use paths are appropriate when an on-street route may be too dangerous due to the speed of the road, the majority of users are recreational or leisure users, or to provide a direct route between points of interest.
- + Multi-use 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 multi-use path 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.
- + Multi-use paths 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.
- + Multi-use paths 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, selecting alignments with fewer crossings, and otherwise providing high-visibility crossing treatments. In areas with high concentrations of driveways and intersections, on-street accommodations (including bike lanes and separated bike lanes) are likely to be safer.
- + Trails with high use may require some form of pedestrian and bicycle separation.
- + Trails on grades greater than 3 to 5 percent should be wider to account for higher bicycle speed in the downhill direction and additional space for faster bicyclists to pass slower bicyclists and pedestrians in the uphill direction.
- + On sections with long steep grades, provide periodic sections with a flat grade to permit users to stop and rest.
- + Consider providing amenities such as restrooms, bike racks, and portable water at trailheads, and covered rest stops along the trail to ensure that paths are welcoming to a variety of user types, including families with children and seniors.
- + Consider providing maps and signs to improve wayfinding for users, such as signs that show trail names, connections to nearby trails, and/or nearby destinations.

### REFERENCES

- AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
- FHWA. *Shared Use Path Level of Service Calculator*. 2006.
- FHWA. *Manual on Uniform Traffic Control Devices*. 2009.

# MULTI-USE PATHS CONTINUED



Vine Trail in the City of Napa

## GUIDANCE

- + Path width should be determined based on the anticipated number of users, types of users, and terrain.
- + The recommended paved width for a trail is 10 feet. The minimum width to enable side-by-side travel and passing is 11 feet; a preferred width is 12 feet. At widths narrower than these, path users will need to yield to oncoming traffic before passing.
- + Although the recommended path width is 10 feet, a path width of 8 feet is the minimum width that may be used for a short distance to accommodate a physical constraint such as an environmental feature.
- + Trails expected to serve a high percentage of pedestrians (30 percent or more) or be used by large maintenance vehicles should be wider than 10 feet.
- + Fourteen feet is the preferred width where volumes are high (> 100 total users in the peak hour), there are steep grades, or high volumes of users who need additional operating width are anticipated (e.g., children or skaters).
- + Maximum grade should not exceed 5 percent. There may be certain situations in which physical constraints prevent compliance with the 5 percent maximum grade, in which case mitigations such as providing additional path width for slower bicyclists to dismount and walk, providing resting intervals with flatter grades, or providing pedestrian handrails should be considered. Grades less than 0.5 percent should be avoided, if possible.
- + Provide protective railings/fences at 42 inches high if the trail and graded shoulder are directly adjacent to a steep slope and drop, as defined in Chapter 5 of the AASHTO Guide for the Development of Bicycle Facilities.
- + Ideally, provide a graded shoulder area of 2 to 5 feet on both sides of a path.
- + Lighting should be provided at path/roadway intersections at a minimum and at other locations where personal security may be an issue.
- + All multi-use paths must conform to the current editions of both the AASHTO and ADA guidelines.
- + Multi-use paths must also conform to Public Rights-of-way Accessibility Guidelines (PROWAG) if in a public right-of-way or Advance Notice of Proposed Rulemaking (ANPRM) on Accessibility Guideline for Shared Use Paths if in a private right-of-way.
- + When accommodating moderate to high volumes of horse back riders, it is recommended to provide a separated unpaved equestrian/jogger path. Six feet of clearance and separation is recommended between the shared use path and the bridle path. Elevation change between the multi-use path and the bridle path can also be considered.

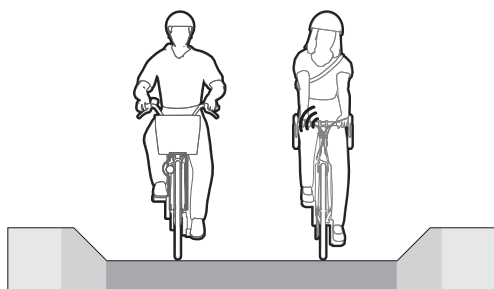
### REFERENCES

- AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
- FHWA. *Shared Use Path Level of Service Calculator*. 2006.
- FHWA. *Manual on Uniform Traffic Control Devices*. 2009.
- CROW. *Design Manual for Bicycle Traffic*. 2007.

# SEPARATED BIKE LANES (CLASS IV)

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

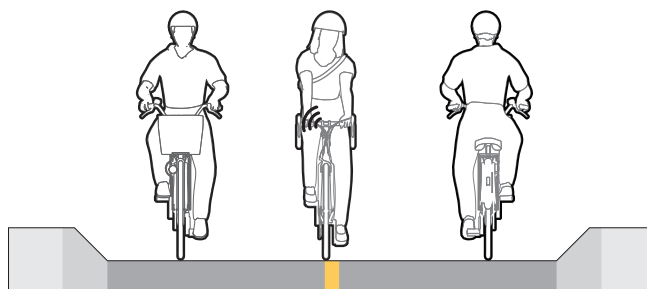
## One-way



at least 6.5 ft. recommended to enable passing movements

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

## Two-way



at least 10 ft. recommended to enable passing movements

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

## GUIDANCE

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

- + Traffic lanes: 3 lanes or greater.
- + Posted speed limit: 30 mph or more.
- + Traffic: 6,000 vehicles per day or greater.
- + 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 multi-use paths 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.

## CONSIDERATIONS

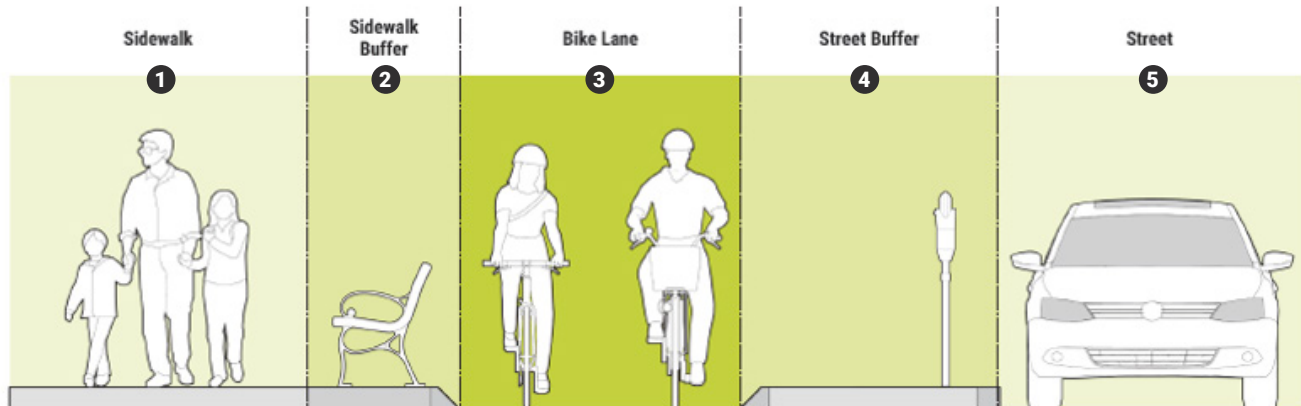
- + Separated bike lanes are more attractive to a wider range of bicyclists than striped bikeways on higher volume and higher speed roads. They eliminate the risk of a bicyclist being hit by an opening car door and prevent motor vehicles from driving, stopping or waiting in the bikeway. They also provide greater comfort to pedestrians by separating them from bicyclists operating at higher speeds.
- + Choice of one- or two-way facility should be based on connectivity, bicyclist desire lines, roadway configuration, and potential intersection conflicts. Generally, one-way facilities are preferred. Where two-way facilities are necessary because of constraints or other factors, special attention must be paid to designing for the contraflow movements created, especially regarding transitions onto and off of the two-way separated bike lane.

### REFERENCES

- NACTO. *Urban Bikeway Design Guide. 2nd Edition.*
- MassDOT. *Separated Bike Lane Planning and Design Guide. 2015*
- Caltrans. *Class IV Bikeway Guidance (Separated Bikeways/Cycle Tracks). 2015.*

# SEPARATED BIKE LANES IN CONSTRAINED CORRIDORS

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



## GUIDANCE

When making space trade-offs, designers should consider minimum zone widths for the options listed below. This general guidance may be flexible and should take adjacent land uses into consideration.

- 1 Narrowing the sidewalk to a minimum width needed to accommodate pedestrian demand, but no less than 5 feet.
- 2 Narrowing or eliminating the sidewalk buffer.
- 3 Narrowing the separated bike lane to a minimum width.
- 4 Narrowing the street buffer to a minimum of 2 feet at midblock locations and a minimum of 6 feet at intersections. These minimums apply in constrained situations, with 3 feet being recommended for mid-block locations in less constrained corridors.
- 5 Narrowing the travel lane to minimum widths (10 or 11 feet); eliminating travel lanes; or eliminating on-street parking. In addition to providing space for separated bike lanes, narrowing the travel lane can reduce the operating speed of the road.

## CONSIDERATIONS

- + The allocation of space can vary from midblock locations to intersection approaches.
- + The street buffer is critical to the safety of separated bike lanes. Narrowing 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 and narrowing or eliminating the sidewalk buffer.
- + In constrained locations where physical separation is desirable because of higher pedestrian demand, raised separation in the sidewalk buffer 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 colored surface materials that provide a high degree of visual contrast between the two.

## REFERENCES

- MassDOT. *Separated Bike Lane Planning and Design Guide*. 2015.
- FHWA. *Separated Bike Lane Planning and Design Guide*. 2015.

# SEPARATED BIKE LANE DESIGN EXAMPLES

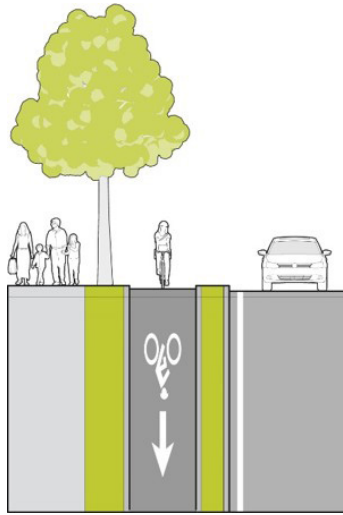
Separated bike lanes may operate as one-way or two-way facilities. Determining the appropriate configuration for separated bike lane requires consideration of street operations, transitions to other bicycle facilities, and connectivity within the larger bicycle network.

## ONE-WAY SEPARATED BIKE LANES

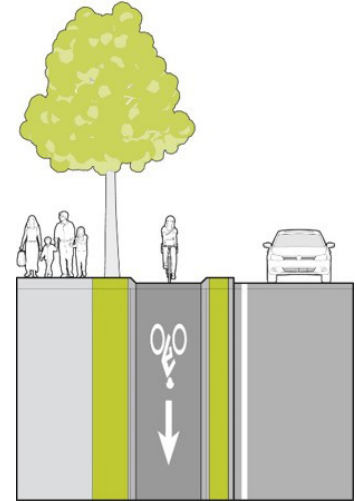
One-way separated bike lanes in the direction of motorized travel provide intuitive and simplified transitions to existing bike lanes and shared travel lanes.



*One-way Sidewalk-level Separated Bike Lane*



*One-way Intermediate-level Separated Bike Lane*

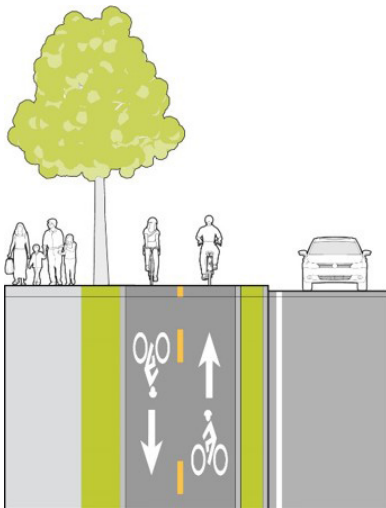


*One-way Street-level Separated Bike Lane*

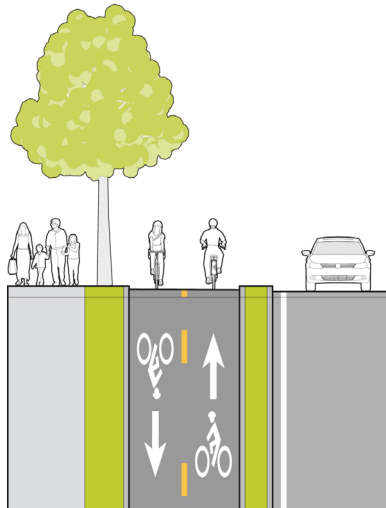
## TWO-WAY SEPARATED BIKE LANES

Two-way separated bike lanes will require special attention to transition bicyclists in and out of these facilities.

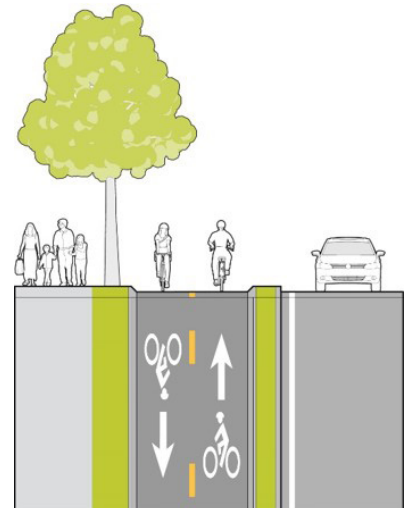
Depending on context, motorists may not expect bicyclists to approach crossings from both directions. For this reason, two-way separated bike lanes may require detailed treatments at alley, driveway, and street crossings to enhance the safety of these crossings for all users.



*Two-way Sidewalk-level Separated Bike Lane*



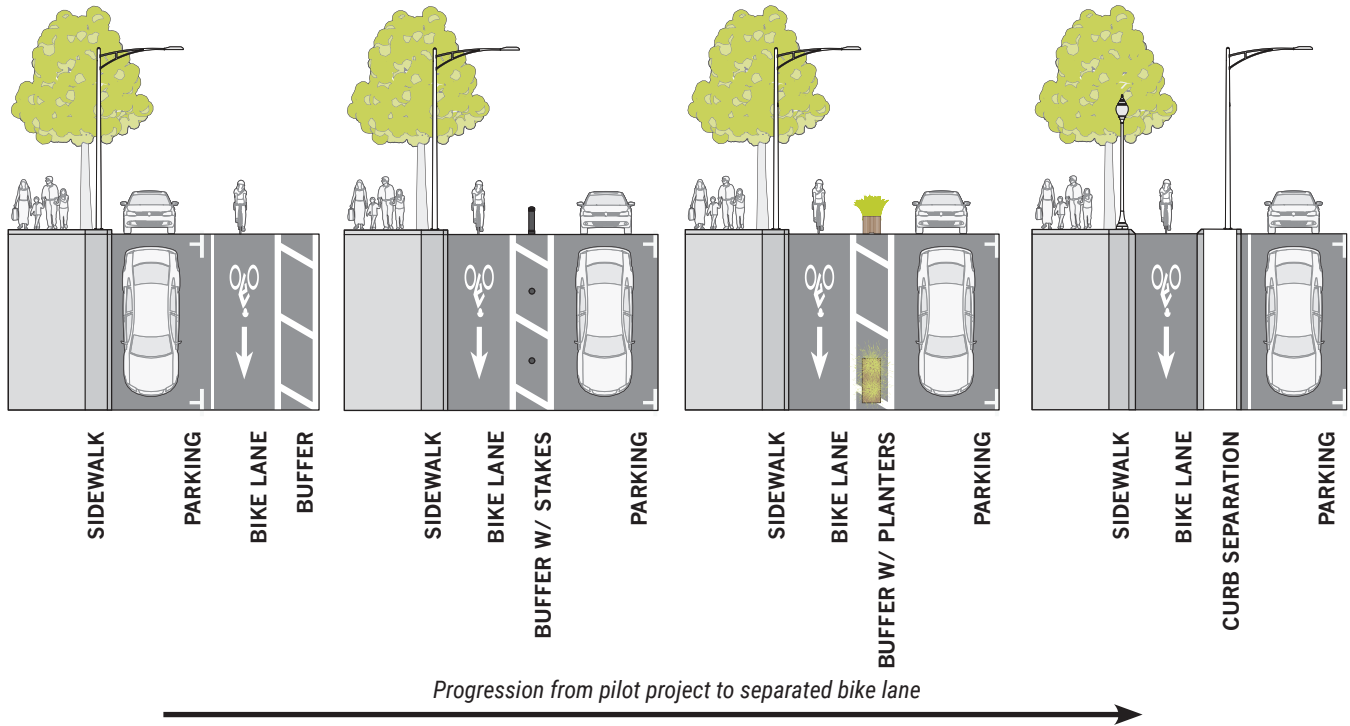
*Two-way Intermediate-level Separated Bike Lane*



*Two-way Street-level Separated Bike Lane*

# LIFE OF A SEPARATED 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-separated bike lanes, cost more and are less flexible once implemented. A phased implementation approach, where “pilot” projects transition to permanent separated bike lanes may solve both of these problems, by implementing the facility slowly and troubleshooting before permanent materials and high costs are necessary.



## GUIDANCE

- + 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 separated bike lanes in roadway reconstruction designs.
- + Examples of permanent separation materials include rigid bollards, raised medians and grade-separated bike lanes at an intermediate or sidewalk level.

## CONSIDERATIONS

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

Separated bike lanes can provide different levels of separation:

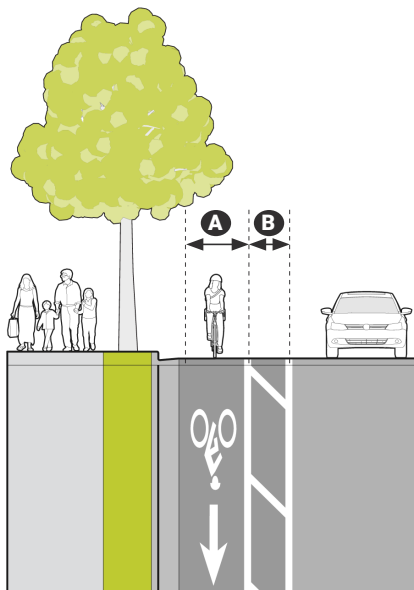
- + Separated bike lanes with flexible delineator posts (“flex posts”) alone offer the least separation from traffic and are appropriate as interim solution.
- + Separated bike lanes that are raised with a wider buffer from traffic provide the greatest level of separation from traffic, but will often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

## REFERENCES

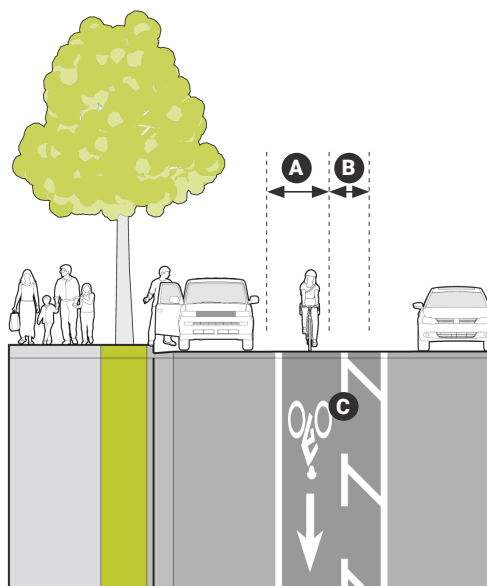
- NACTO *Urban Street Design Guide*. 2013.
- FHWA *Protected Bike Lane Planning and Design Guide*. 2015.
- Caltrans. *Class IV Bikeway Guidance (Separated Bikeways/Cycle Tracks)*. 2015.

# BUFFERED BIKE LANES (CLASS II)

Buffered bike lanes are created by painting or otherwise creating a flush buffer zone between a bike lane and the adjacent travel lane. While buffers are typically used between bike lanes and motor vehicle travel lanes to increase bicyclists' comfort, they can also be provided between bike 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

## GUIDANCE

- A** The minimum width of a buffered bike lane adjacent to a curb or parking is 5 feet, a desirable width is 6 feet.
- B** 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. Buffers are to be broken where curbside parking is present to allow cars to legally cross the bike lane.
- C** Buffers are to be broken where curbside parking is present to allow cars to cross the bike lane.

## CONSIDERATIONS

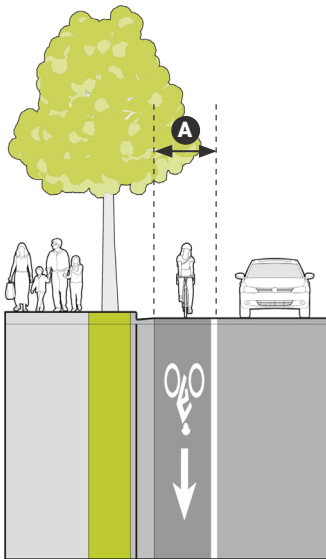
- + Typically installed by reallocating existing street space.
- + Can be used on one-way or two-way streets. Preferable to a conventional bike lane when used as a contra-flow bike lane on one-way streets.
- + Consider placing buffer next to parking lane where there is commercial or metered parking with high turnover.
- + Consider placing buffered or unbuffered bike lanes next to travel lane where speeds are 30 mph or slower and when traffic volume are fewer than 6,000 vehicles per day
- + Where there is 7 feet of roadway width available for a bike 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.
- + Preferable to a conventional bike lanes when used as a contra-flow bike lane on one-way streets.
- + Stopping, standing and parking in bike lanes may be problematic in areas of high parking demand and deliveries, especially in commercial areas.

## REFERENCES

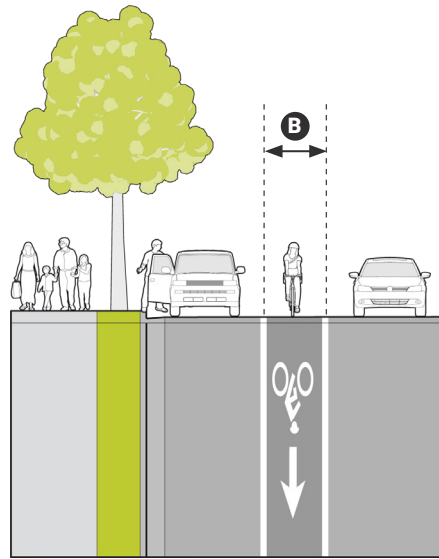
- NACTO. *Urban Bikeway Design Guide*. 2014.
- PSU. *Evaluation of Innovative Bicycle Facilities: SW Broadway Cycle Track & SW Stark/Oak Street Buffered Bike Lanes*. 2011.

# BIKE LANES (CLASS II)

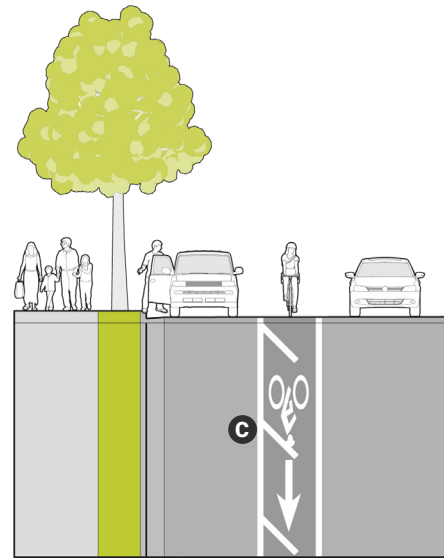
Bike lanes provide an exclusive space for bicyclists in the roadway. Bike lanes are established through the use of lines and symbols on the roadway surface. Bike lanes are for one-way travel and are normally provided in both directions on two-way streets or on one side of a one-way street. Bicyclists are not required to remain in a bike lane when traveling on a street and may leave the bike lane as necessary to make turns, pass other bicyclists, or to properly position themselves for other necessary movements.



*Bike Lane Adjacent to a Curb*



*Bike Lane Adjacent to Parking*



*Bike Lane with Door Zone Marking*

## GUIDANCE

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

## CONSIDERATIONS

- + Typically installed by reallocating existing street space.
- + Can be used on one-way or two-way streets.
- + Contra-flow bike lanes may be used to allow two-way bicycle travel on streets designated for one-way travel for motorists to improve bicycle network connectivity.
- + Consider placing buffered or unbuffered bike lanes next to travel lane where speeds are 30 mph or slower and when traffic volume are fewer than 6,000 vehicles per day.
- + 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.
- + Bike 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.

## REFERENCES

- AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
- NACTO. *Urban Bikeway Design Guide*. 2nd Edition.

# BICYCLE BOULEVARD (CLASS III)

Bicycle boulevards are applied on quiet streets, often through residential neighborhoods. These treatments are designed to prioritize bicycle through-travel, while calming motor vehicle traffic and maintaining relatively low motor vehicle volumes. 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, neighborhood bikeways, among other locally-preferred terms.



## GUIDANCE

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

- + 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.
- + Where these traffic characteristics are not already present, traffic calming and traffic diversion measures should be implemented to reach these desired thresholds.

## CONSIDERATIONS

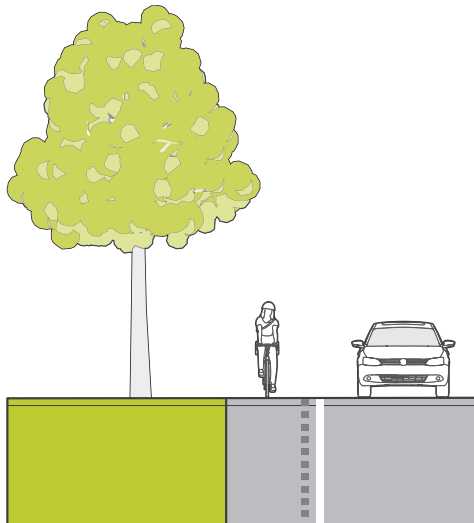
- + Many cities already have signed bike routes along neighborhood streets that provide an alternative to traveling on high-volume, high-speed arterials. Applying bicycle boulevard treatments to these routes makes them more suitable for bicyclists of all abilities and can reduce crashes.
- + Stop signs or traffic signals should be placed along the bicycle boulevard in a way that prioritizes the bicycle movement, minimizing stops for bicyclists whenever possible.
- + 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, rectangular rapid flashing beacons, bicycle signals, and HAWK or half signals.

## 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.*

# RURAL BICYCLE ROUTE (CLASS III)

In many cases, rural routes should provide shoulders to accommodate bicyclists. Shoulders are portions of the roadway that accommodate stopped or parked vehicles, emergency use, bicycles, motor scooters and pedestrians where sidewalks do not exist. This type of facility is applicable in rural areas where dedicated bikeways either will not fit on the street or would not be appropriate given the surrounding context.



## GUIDANCE

- + Shoulder width should be at least 4 feet if the roadway is curbside and there are no vertical obstructions. If curbs or vertical obstructions are present, shoulder width should be 5 feet minimum exclusive of the gutter if present.
- + Shoulders should be wider on roads with high levels of bicycle traffic to accommodate bicyclist passing and facilitate side-by-side bicycling.
- + When posted speed limits or 85th percentile speeds exceed 50 mph and/or if heavy vehicles frequently use the road, shoulders should exceed minimum widths to enhance bicyclist comfort.
- + The width of a shoulder with rumble strips or textured edge lines should be measured from the rightmost side of the rumble strip. Periodic gaps should be provided to allow bicyclists to move across the strip pattern.
- + Edge line rumble strips can provide additional bicyclist space on paved shoulders.

## REFERENCES

- AASHTO. *Guide for the Development of Bicycle Facilities*. 2012
- FHWA. *Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts*. 2016.

## CONSIDERATIONS

For roads that are unable to provide consistent and standard size bikeable shoulders in both directions, prioritize:

- + The uphill direction on hilly roads to reduce conflicts between slow-moving bicyclists and fast-moving motor vehicles.
- + The inside of a horizontal curve and/or the downgrade of a vertical curve where sight distance is restricted.
- + Paved shoulders should be considered on roadways popular with recreational bicyclists that have significant motor vehicle traffic during periods when recreational bicycling is known to occur.
- + Bicyclists will not use a shoulder if it is covered in gravel, glass and other road debris, so regular street sweeping is important.
- + In rural areas, paved shoulders can also provide space for pedestrians on roadways without sidewalks. In situations where a shoulder is intended for pedestrian use, it must meet Americans with Disabilities Act requirements to the maximum extent possible.



## BICYCLE INTERSECTION DESIGN & SPOT TREATMENTS

# BIKE BOXES

A bike box provides dedicated space between the crosswalk and vehicle stop line where bicyclists can wait during the red light at signalized intersections. The bike 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 left turning maneuvers at the intersection, and provide more queuing space for multiple bicyclists than that provided by a typical bike lane.



## GUIDANCE

- + Bike boxes are typically painted green and are a minimum of 10 feet in depth.
- + Bike box design should be supplemented with appropriate signage according to latest version of the MUTCD.
- + Bike box design should include appropriate adjustment in determining the minimum green time.
- + Where right turn lanes for motor vehicles exist, bike lanes should be designed to the left of the turn lane. If right turns on red are permitted, consider ending the bike box at the edge of the bike lane to allow motor vehicles to make this turning movement.
- + Bike boxes are suitable for use across one lane of traffic. Where accommodation for left turn movements is desired on streets with more lanes, consider use of two-stage queue boxes.

## CONSIDERATIONS

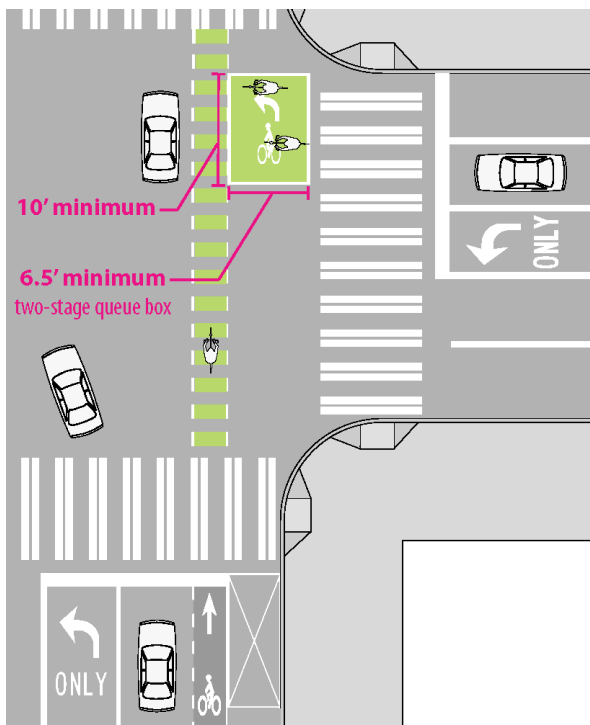
- + In locations with high volumes of turning movements by bicyclists, a bike box should be used to allow bicyclists to shift towards the desired side of the travel way. Depending on the position of the bike lane, bicyclists can shift sides of the street to align themselves with vehicles making the same movement through the intersection.
- + In locations where motor vehicles can continue straight or cross through a right-side bike lane while turning right, the bike box allows bicyclists to move to the front of the traffic queue and make their movement first, minimizing conflicts with the turning vehicle. When a bike 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 once a bike box is installed.
- + Consider addition of “WAIT HERE” pavement marking in advance of bike box to indicate proper motorist waiting area.

## REFERENCES

- NACTO Urban Bikeway Design Guide - Bike Boxes. 2012.*
- FHWA Separated Bike Lane Planning and Design Guide. 2015.*
- MassDOT Separated Bike Lane Planning & Design Guide. 2016.*

# TWO-STAGE TURN QUEUE BOX

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. Two-stage turn queue boxes may be used with any type of bicycle facility. 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.



Jughandle left-turn accommodation on Market St in San Francisco

## GUIDANCE

- + A minimum width of 10 feet is recommended for the queue box.
- + A minimum depth of 6.5 feet is recommended for the queue box.
- + 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.
- + “No turn on red” (R10-11) restrictions shall be used to prevent vehicles from entering the queuing area.
- + Use of two-stage turn boxes is limited to signalized intersections.
- + The use of a supplemental sign instructing bicyclists how to use the box is optional.

## 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. *Interim Approval for Optional Use of Two-Stage Bicycle Turn Boxes (IA-20). 2017.*

## CONSIDERATIONS

**This treatment has been granted interim approval by FHWA and Caltrans.**

- + 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 ‘jughandle’ 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.

Similar to two-stage turn queue boxes, jug handles or bike bays can also be used to assist bicyclists with left turns. These facilities create a physical refuge for bicyclists, typically on the right side of a right-side bike lane that is physically separated from the bike lane by a raised curb or small raised island. These facilities are rare in the U.S. and typically require additional right of way to construct.

# 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.

## 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 length 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.

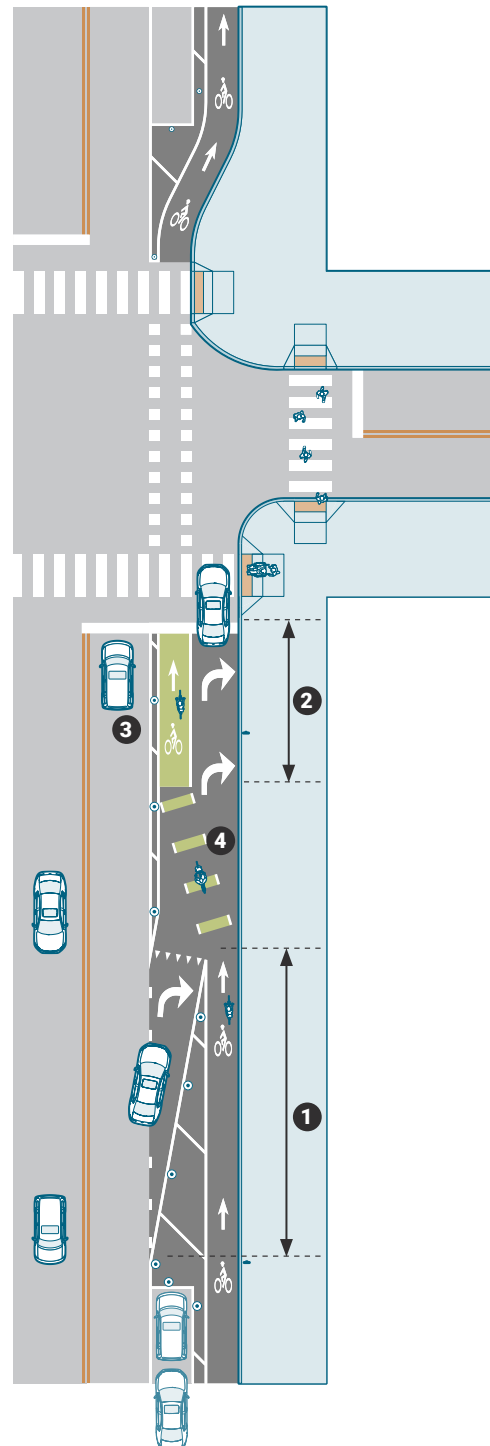
## CONSIDERATIONS

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.

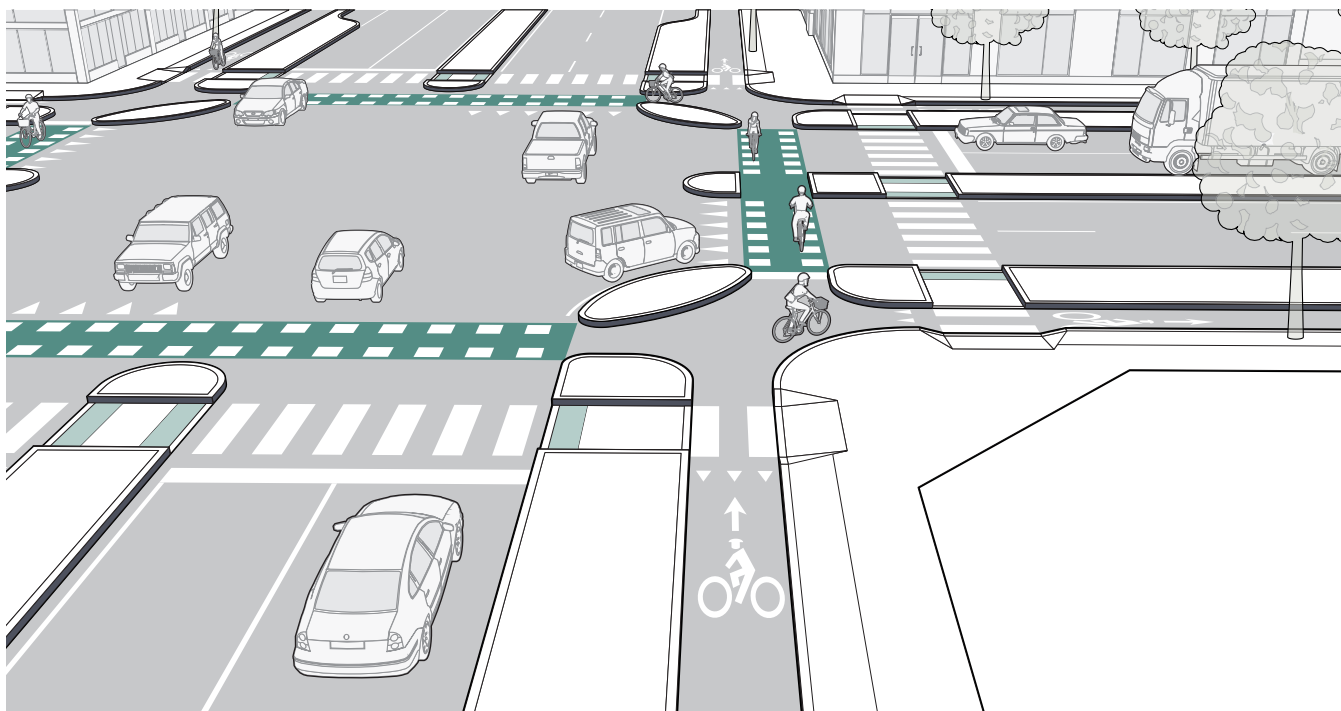
### REFERENCES

- NACTO. *Urban Bikeway Design Guide*. 2012.
- MassDOT. *Separated Bike Lane Planning and Design Guide*. 2015.
- FHWA. *Separated Bike Lane Planning and Design Guide*. 2015.



# SEPARATED BIKE LANES AT INTERSECTIONS

Separated bike 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.



## GUIDANCE

- + At major intersections where space is available, protected intersection designs are preferred because they are intuitive and comfortable, provide clear right-of-way assignment, promote predictability of movement, and allow eye contact between motorists, bicyclists, and pedestrians.
- + Corner refuge islands allow the bike lane to be physically separated up to the intersection crossing point where potential conflicts with turning motorists can be controlled more easily. It serves an important purpose in protecting the bicyclist from right-turning motor vehicle traffic
- + Further details of protected intersection design and dimensions appear in Chapter 4 of the MassDOT Separated Bike Plan Planning & Design Guide.
- + Where space constraints exist and a protected intersection is not feasible, design that maintains separation of the bike lane up to the intersection should be prioritized. Where it is not possible, see guidance on mixing zones (p21)."
- + All intersection designs should provide adequate sight distance. Recessed crossings should be considered at all intersection crossings: streets, driveways or alleys. The recessed crossing creates space for motorist yielding before crossing the bike facility."

## CONSIDERATIONS

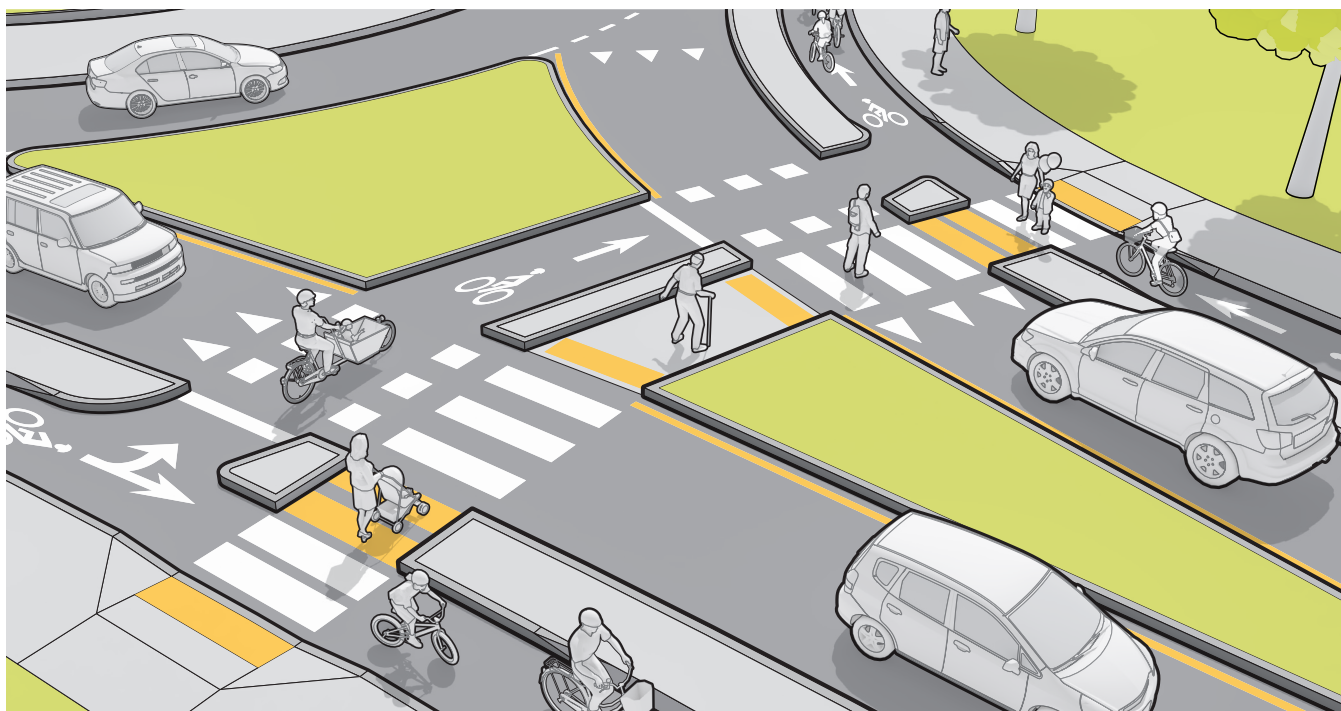
- + One-way directional separated bike lanes are preferred to a two-way SBL on one side of the street for the following reasons:
  - + Follow normal traffic flows, whereas two-way SBLs can create unexpected movements.
  - + Simpler transitions to other facilities.
  - + Less likely need for signal modifications.
- + The operation of one-way separated bike lanes is similar to the normal vehicle operations, which simplifies signal operations.
- + Where two-way separated bike lanes are installed on one side of the street, the contra-flow direction of bicycle travel introduces an unexpected movement at the intersection and requires more complex signal operations.

## REFERENCES

*Bicycle Facilities and the Manual on Uniform Traffic Control Devices*  
*NACTO Urban Bikeway Design Guide. 2012.*  
*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.



## GUIDANCE

- + The bicycle crossing should be immediately adjacent to and parallel with the pedestrian crossing, and both should be at the same elevation.
- + 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.
- + 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.
- + Curb radii should be a minimum of 5 feet 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.

## CONSIDERATIONS

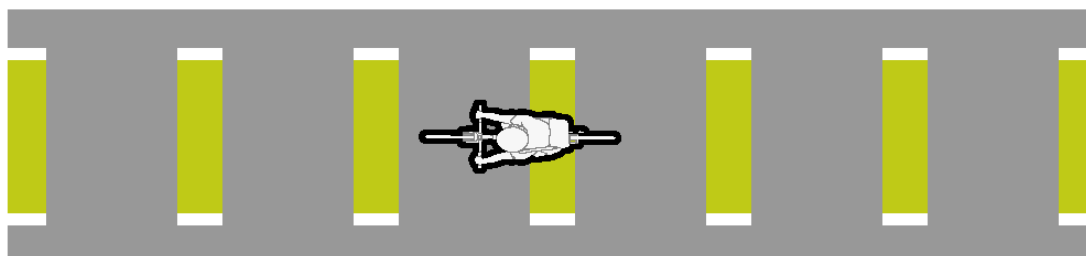
At crossing locations of multi-lane roundabouts or roundabouts where the exit geometry will result in faster exiting speeds by motorists (thus reducing the likelihood that they will yield to bicyclists and pedestrians), additional measures should be considered to induce yielding such as providing an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

## REFERENCES

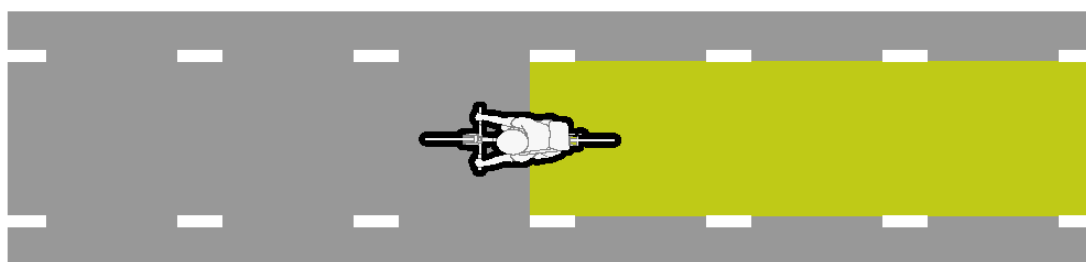
MassDOT Separated Bike Lane Planning & Design Guide. 2016.

# CONFLICT AREA MARKING

Intersection pavement markings are designed to improve visibility, alert all roadway users of expected behaviors, and to reduce conflicts with turning vehicles. They may be used with any Class II or Class IV bike lane across driveways, through intersections, or in separated bike lane mixing zones.



Colored Dash



Colored Conflict Areas

## GUIDANCE

- + Dashed white lane lines 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 may be applied in a solid or dashed pattern within a dashed bicycle lane to indicate conflict areas and where merging maneuvers are permitted, such as across intersections, driveways, and at STOP or YIELD-controlled cross-streets.
- + Green pavement markings shall be placed before the stop bar at the intersection and continue through the intersection; the City of Minneapolis recommends placing the markings at least 30' before the stop bar. Dashed marking should be aligned with the approaching/receiving bike lane.
- + Green dashed pavement markings are typically 2' by 5'-2" with a 6" white edge.
- + The colored markings should be skid-resistant and retro-reflective, made from durable liquid pavement markings, thermoplastic, or colored asphalt.

## CONSIDERATIONS

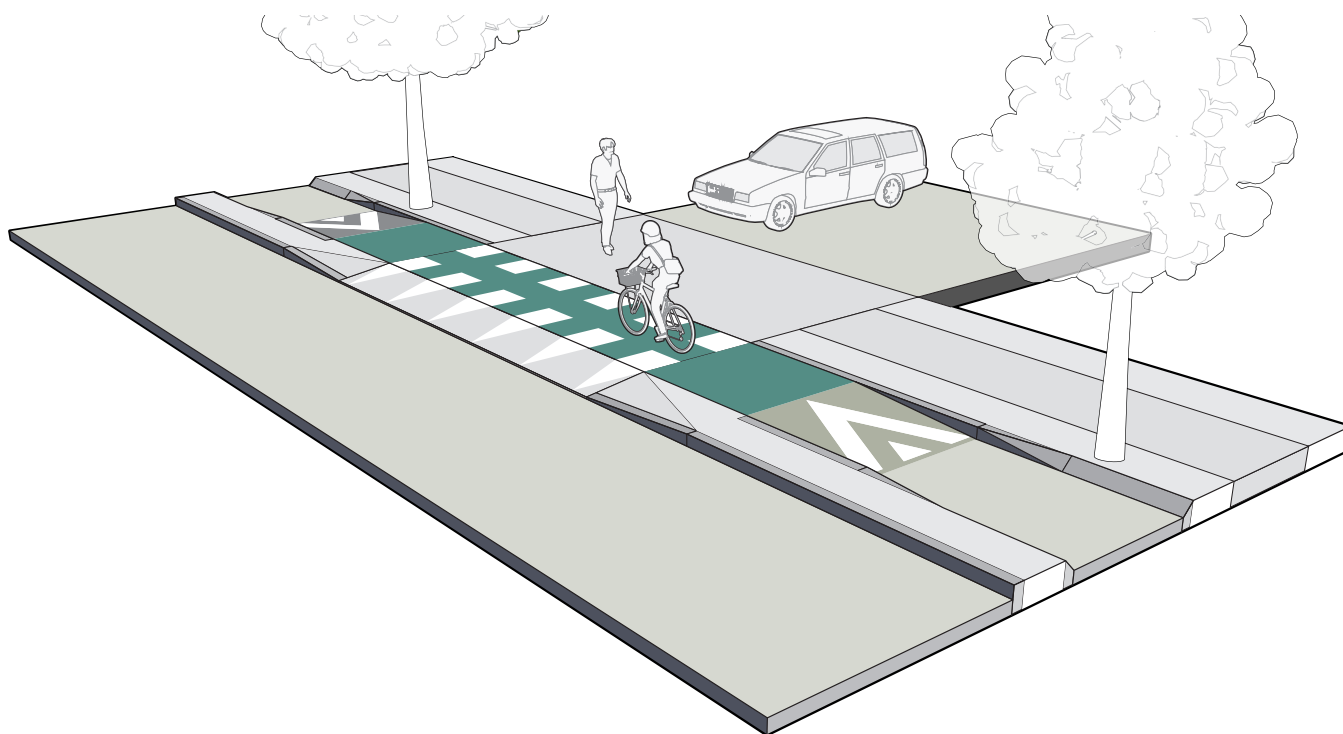
- + Dashed lane lines may be sufficient for guiding bicyclists through intersections; however, consider providing enhanced markings with green pavement and/or symbols at complex intersections or at intersections with documented conflicts and safety concerns.
- + Symbol placement within intersections should consider vehicle wheel paths to minimize 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.

### REFERENCES

- AASHTO Guide for the Development of Bicycle Facilities. 2012.*
- NACTO Urban Bikeway Design Guide. 2012.*
- Manual on Uniform Traffic Control Devices. 2009.*
- City of Minneapolis Public Works*
- FHWA Memorandum – Interim Approval for Optional Use of Green Colored Pavement for Bike Lane. 2011.*

# 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.



## GUIDANCE

- + The bicycle crossing may be bounded by 12 inch (perpendicular) by 24 inch (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 feet wide for one-way travel and 10 feet 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. Two-way crossings should also be indicated with warning signage for drivers entering and exiting the driveway.
- + 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.

## CONSIDERATIONS

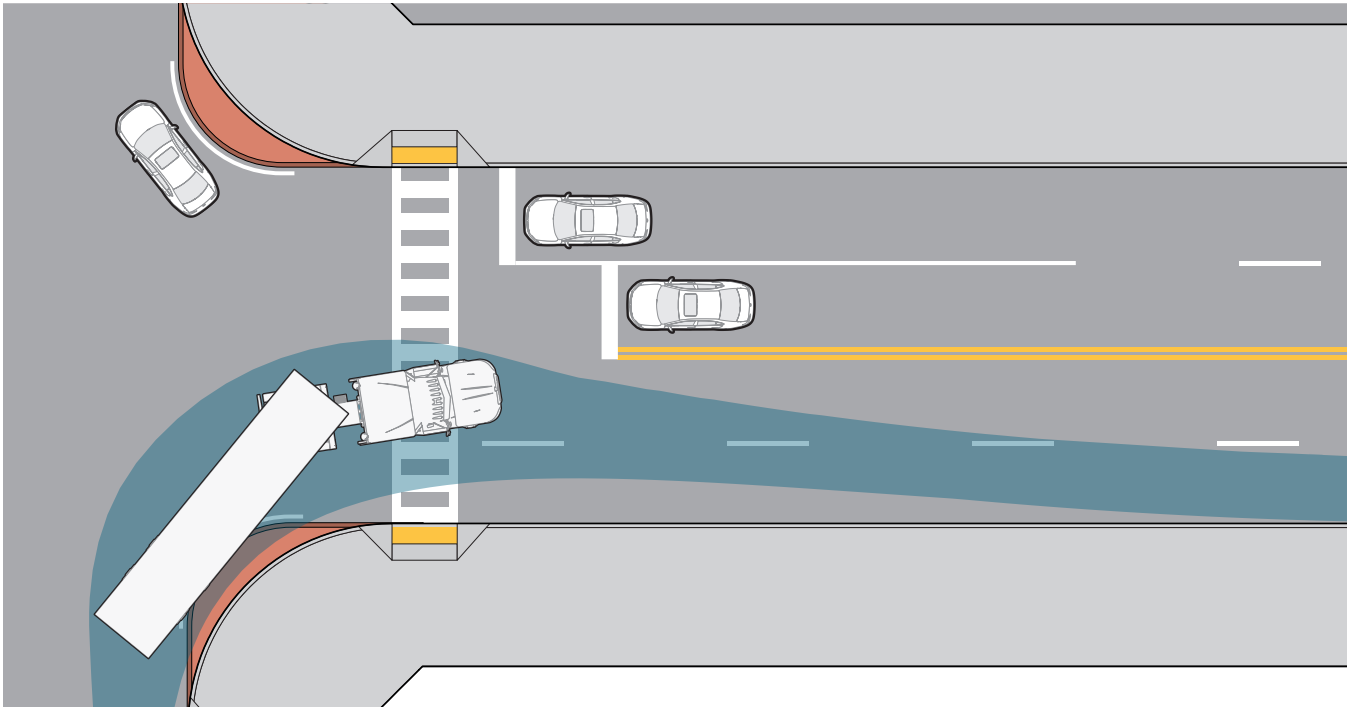
- + Supplemental yield lines, otherwise known as shark's teeth, can be used to indicate priority for people bicycling and may be used in advance of unsignalized crossings at driveways, at signalized intersections where motorists may turn across a bicycle crossing during a concurrent phase, and in advance 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.

## REFERENCES

MassDOT Separated Bike Lane Planning & Design Guide. 2016.  
FHWA Separated Bike Lane Planning and Design Guide. 2015.

# 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, yet 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.



## GUIDANCE

- + 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.
- + Mountable truck aprons reduce the curb radius for non-truck vehicles and thus provide traffic calming by forcing slower turning movements.

## CONSIDERATIONS

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

## REFERENCES

MassDOT Separated Bike Lane Planning & Design Guide. 2016.

FHWA Achieving Multi-modal Networks: Applying Design Flexibility and Reducing Conflicts. 2016.

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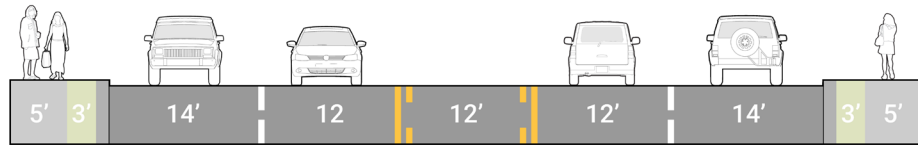


# FACILITY IMPLEMENTATION STRATEGIES

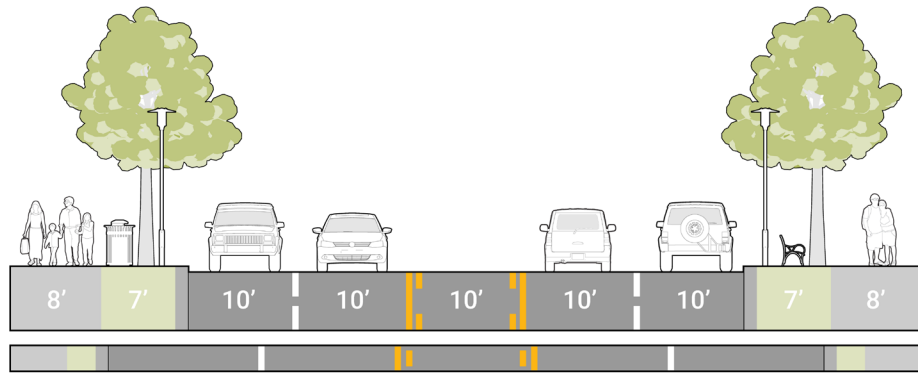
# LANE NARROWING

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.

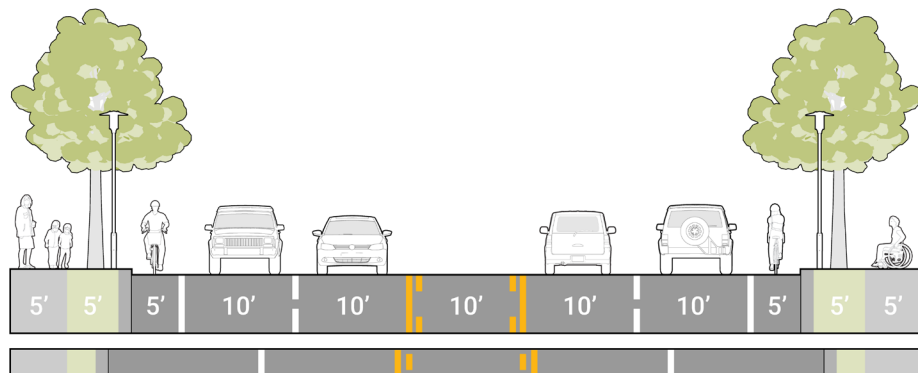
Roadway before narrowing



Narrowing motor vehicle lanes to increase sidewalk and amenity zones



Narrowing motor vehicle lanes to increase amenity zone and add bicycle lanes



## 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 recommended on 4-lane undivided arterial roadways, but may be considered where speeds are 30 mph or less and truck use is low.

## 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.

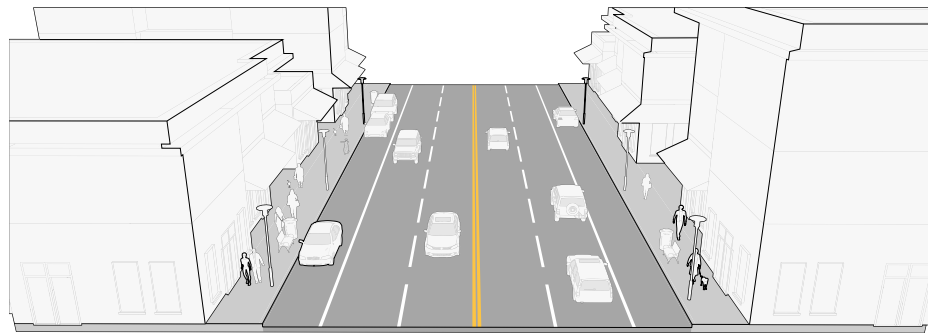
## REFERENCES

- FHWA *Achieving Multi-modal Networks: Applying Design Flexibility and Reducing Conflicts*. 2016.
- AASHTO *Green Book*. 2011.

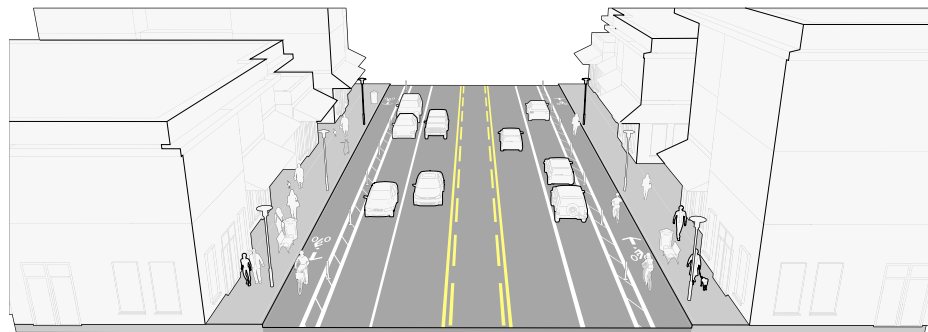
# LANE RECONFIGURATION (ROAD DIET)

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, however, 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 lanes



## GUIDANCE

Lanes greater than 11 feet should not be used as they may encourage unintended speeding

The following lane widths are recommended for each lane type:

- + 10 foot wide travel lanes (11 feet for the curb lane is acceptable when on a designated truck or bus route)
- + 7-9 foot wide parking lanes

## CONSIDERATIONS

Lane reconfiguration is a great tool for reducing collisions and injuries, improving pedestrian crossings and providing designated space for bicyclists. Road diets improve safety as they reduce conflict points and lead to fewer and less severe collisions.

Lane reconfiguration is possible under the following capacities:

- + 3 lane road (one through lane in each direction with a center turn lane): 15,000 or fewer ADT
- + 3 lane road (one through lane in each direction with a center turn lane): 20,000 or fewer ADT, traffic study suggested
- + 5 lane road (two through lanes in each direction with a center turn lane): 35,000 or fewer ADT, traffic study suggested
- + 7 lane road (three through lanes in each direction with a center turn lane): 50,000 or fewer ADT, traffic study suggested

## REFERENCES

FHWA Road Diet Guide. 2014.

NACTO Urban Street Design Guide .2013.

Dr. Ata M. Kahn, P.E., ITE Journal, Washington, D.C.



# SUPPORTIVE AMENITIES

# BICYCLE ROUTING / DESTINATION WAYFINDING

Wayfinding is a highly visible way to improve bicycling in an area because it helps identify the best routes to destinations, helps people overcome a barrier of not knowing where to ride, and reminds motorists to anticipate the presence of bicyclists. A wayfinding system typically combines signage and pavement markings to guide bicyclists along preferred routes to destinations across the community, county, or region. The routes may or may not be numbered, named, or color-coded. Signs may also indicate distances or travel time to destinations. Similar wayfinding systems can be devised for pedestrian travel.



## GUIDANCE

- + Basic bicycle route signs consist of a MUTCD-style “Bike Route” sign (D11-1 shown above) placed every half mile on a bike route and on the approach to bike routes at decision points. Unique numbered routes can be designated and can incorporate a route name or agency logos.
- + Bike route signs can be supplemented with “fingerboard” panels showing destinations, directions, and distances (MUTCD D1 series, shown in photo).
- + Place directional signs on the near side of intersections and confirmation signs on the far side of intersections.

## CONSIDERATIONS

A bicycle wayfinding protocol should coordinate with bicycle route maps and provide three general forms of guidance:

- + Decision assemblies, which consist of Bike Route identification and optional destination fingerboards, placed at decision points where routes intersect or on the approaches to a designated bike route.
- + Turn assemblies, which consist of Bike Route panels and arrow plaques, placed where a designated bike route turns from one street to another.
- + Confirmation assemblies, which consist of Bike Route panels and optional destination fingerboards, placed on the far side of intersections to confirm route choice and the distance (and optionally, time) to destinations.

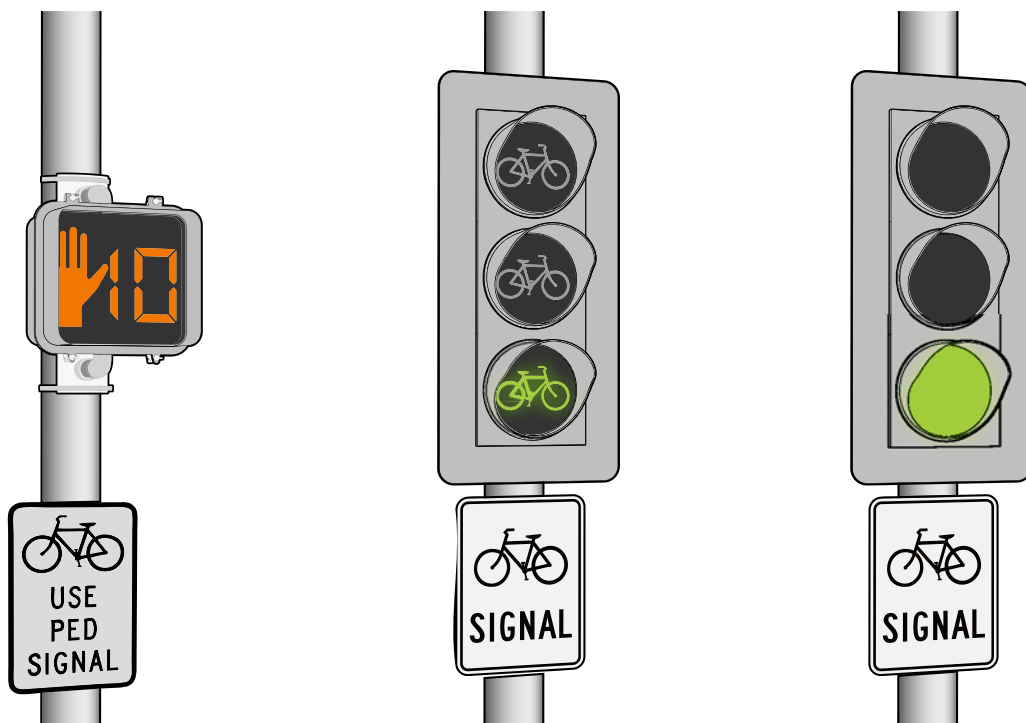
Sign design can be customized to add distinct community branding, but the clarity and accuracy of the information must be the top priority.

## REFERENCES

- NACTO Urban Bikeway Design Guide. 2012.*
- Manual on Uniform Traffic Control Devices. 2009.*

# 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.



## GUIDANCE

- + 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.

## CONSIDERATIONS

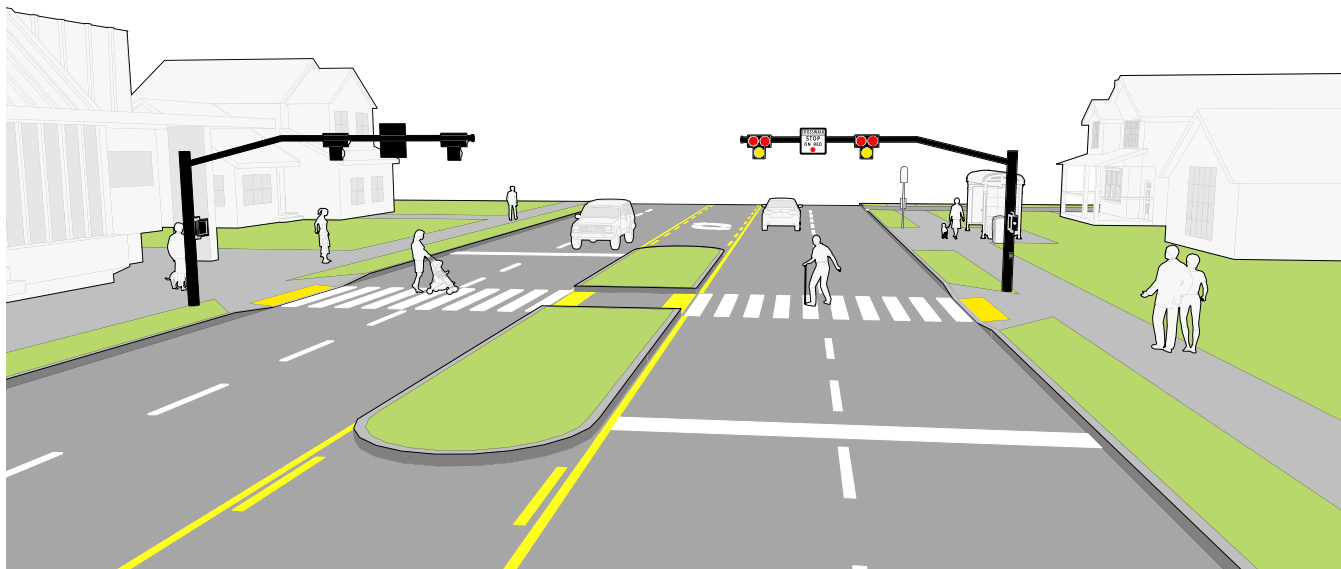
- + Bicycle-specific signals may be appropriate to provide additional guidance or separate phasing for bicyclists per the 2012 AASHTO Guide for the Development of Bicycle Facilities.
- + It may be desirable to install advanced bicycle detection on the intersection approach to extend the phase, or to 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.

## REFERENCES

- AASHTO Guide for the Development of Bicycle Facilities. 2012.*
- NACTO Urban Bikeway Design Guide. 2012.*
- Manual on Uniform Traffic Control Devices. 2009.*

# PEDESTRIAN HYBRID BEACON

This beacon is intended to allow pedestrians and bicyclists to stop traffic to cross high volume arterial streets. The beacon may be used in lieu of a full signal that meets any of the nine warrants in the MUTCD as well as at locations which do not meet traffic signal warrants where it is necessary to provide assistance to cross a high volume arterial.



## GUIDANCE

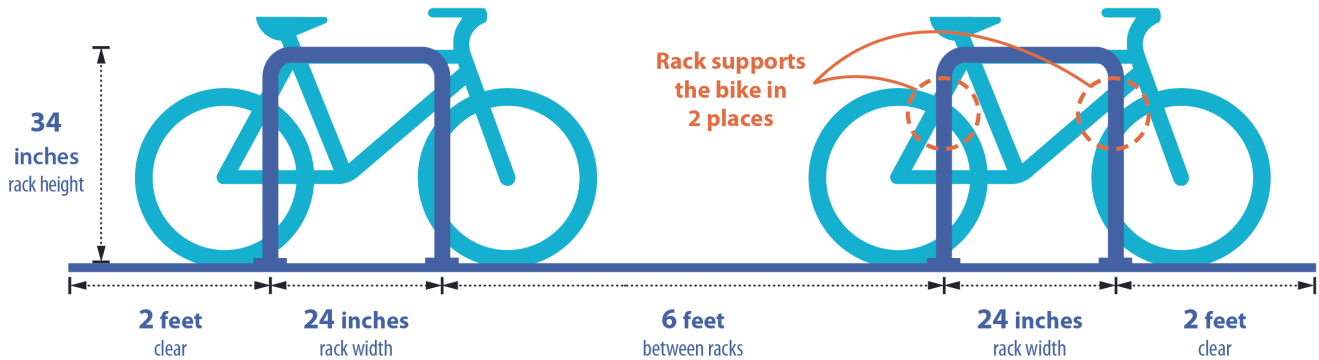
- + The MUTCD provides suggested minimum volumes of 20 pedestrians or cyclists an hour for major arterial crossings (excess of 2,000 vehicles/hour). Pushbuttons should be "hot" (respond immediately), be placed in convenient locations for bicyclists, and abide by other ADA standards.

## CONSIDERATIONS

- + It is recommended that this beacon be considered for all arterial crossings in the bicycle network and for trail crossings if other engineering measures prove inadequate to create safe crossings.
- + Passive signal activation, such as video or infrared may also be considered.
- + Beacon may be supplemented with bicycle signals to communicate green signal to bicyclists.
- + Depending upon the detection design, the city 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.
- + Where the beacon serves both bicyclists and pedestrians, multiple push buttons per approach may be necessary to accommodate on-street bicyclists.

# SHORT-TERM BICYCLE PARKING

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



## GUIDANCE

- + Bicycle parking facility should not obstruct pedestrian traffic or interfering with the use of the pedestrian areas.
- + Each parked bicycle should be accessible without moving another bicycle.
- + Any sidewalk rack that is parallel to the curb should be located at least 2 feet from the curb face.
- + Any sidewalk rack aligned perpendicular to the curb should be located so that the nearest vertical component of the rack is a minimum of 4 feet from the curb.

## CONSIDERATIONS

- + 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.
- + Multiple types of racks exist, but all should adhere to guidance pictured above regarding providing two points of contact for bike frame to prevent bikes from falling.

## REFERENCES

- NACTO Urban Street Design Guide. 2013.*
- Manual on Uniform Traffic Control Devices. 2009.*

### Inverted-U (Staple, Loop)



### Post & Ring



### Wheelwell Secure



### Hanging Loop



# LONG-TERM BICYCLE PARKING

Long-term bicycle parking is intended to provide sheltered and secure bicycle storage for residents, employees and long-term visitors who are leaving their bicycles in a residential or commercial building for several hours or longer and therefore need their bicycles to be protected from vandalism, theft and the elements.



## GUIDANCE

Lockers should be:

- + Clearly marked as a long-term bicycle parking space.
- + Located no lower than the first complete parking level below grade, and no higher than the first complete parking level above grade.
- + Available and accessible to all building tenants during the buildings hours of operation and at all times for residents in residential contexts.
- + Located in a well-lit, visible location near the main entrance or elevators.
- + Separated from vehicle parking by a barrier that minimizes the possibility of a parked bicycle being hit by a car.
- + Securely anchored.
- + Well-maintained and well lit.

## CONSIDERATIONS

A bicycle locker is a secure, locked box that stores a single bicycle and provides:

- + Highly secure bicycle storage in an enclosed box.
- + Direct or indirect access to the street or sidewalk depending on whether it is located in a parking garage or at street level.
- + Varying amount of conflict with automobiles depending on whether it is located in a parking garage or at street level.
- + Long-term bicycle parking can also be provided indoors. This can be located within businesses or offered as a locked public facility, accessible with the same key card technology as bicycle lockers.

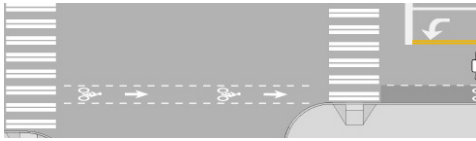
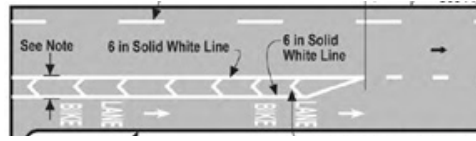



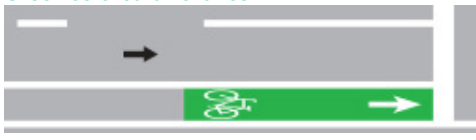
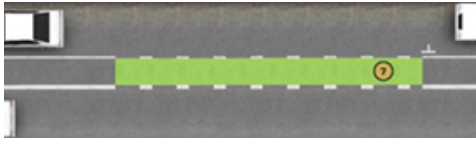
## REFERENCES

*NACTO Urban Street Design Guide. 2013.*

*Manual on Uniform Traffic Control Devices. 2009.*

# STATUS OF EXPERIMENTAL TREATMENTS

Several common traffic control devices are under experimentation or not explicitly covered in the MUTCD. The following chart shows the current status of these devices.

ITEM	Approved in FHWA MUTCD	FHWA Interim Approval Granted	Approved by NCUTCD	Approved in CA MUTCD	Projects Currently Under Experiment in CA	Requires "Request for Experimentation" from FHWA
<b>Extended bicycle lanes through intersections</b> 	✓			✓		
<b>Buffer-separated bicycle lanes</b> 	✓			✓		
<b>Bicycle lanes on the left-hand side of one-way streets</b> 	✓			✓		
<b>Shared-lane markings in exclusive turn lanes</b> 	✓					
<b>EXCEPT bicycle plaque (R118(CA))</b> 			✓	✓		
<b>Green colored bike lanes</b> 		✓		✓		
<b>Solid green colored bike lanes through intersections and conflict areas</b> 		✓		✓		

ITEM	Approved in FHWA MUTCD	FHWA Interim Approval Granted	Approved by NCUTCD	Approved in CA MUTCD	Projects Currently Under Experiment in CA	Requires "Request for Experimentation" from FHWA
<b>Dashed green colored bike lanes through</b> 		✓		✓		
<b>Bike signal faces for protected phases</b> 		✓	✓	✓		
<b>Shared-lane with green pavement background</b> 			✓		✓	✓
<b>Bicycle box</b> 		✓	✓		✓	✓
<b>Two-stage turn box</b> 		✓	✓		✓	✓
<b>Left turn queue box sign</b> 						✓
<b>Flashing yellow arrow for permissive bike signal conflicts</b> 					✓	✓
<b>Merging vehicles yield to bikes sign</b> 						✓
<b>Actuated turning traffic yield to bike sign</b>  <i>Photo Credit: bikeportland.org</i>						✓
<b>Turning vehicles yield to bikes sign</b> <b>R10-15a and R10-15b</b> 			✓			✓



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