APPENDIX B

BICYCLE FACILITY DESIGN TOOLKIT

INTRO

The Montgomery County Planning Department's Bicycle Facility Design Toolkit provides an overview of the types of bicycle facilities recommended in the Bicycle Master Plan. It is divided into four parts:

1. Bikeway Facility Types
2. Additional Guidance on Separated Bike Lanes
3. Additional Guidance on Neighborhood Greenways
4. Intersections Treatments

The toolkit profiles best practices for bicycle facility design and application as described in 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 American Association of State Highway Transportation Officials (AASHTO) Guide for the Development of Bicycle Facilities, 4th Edition.

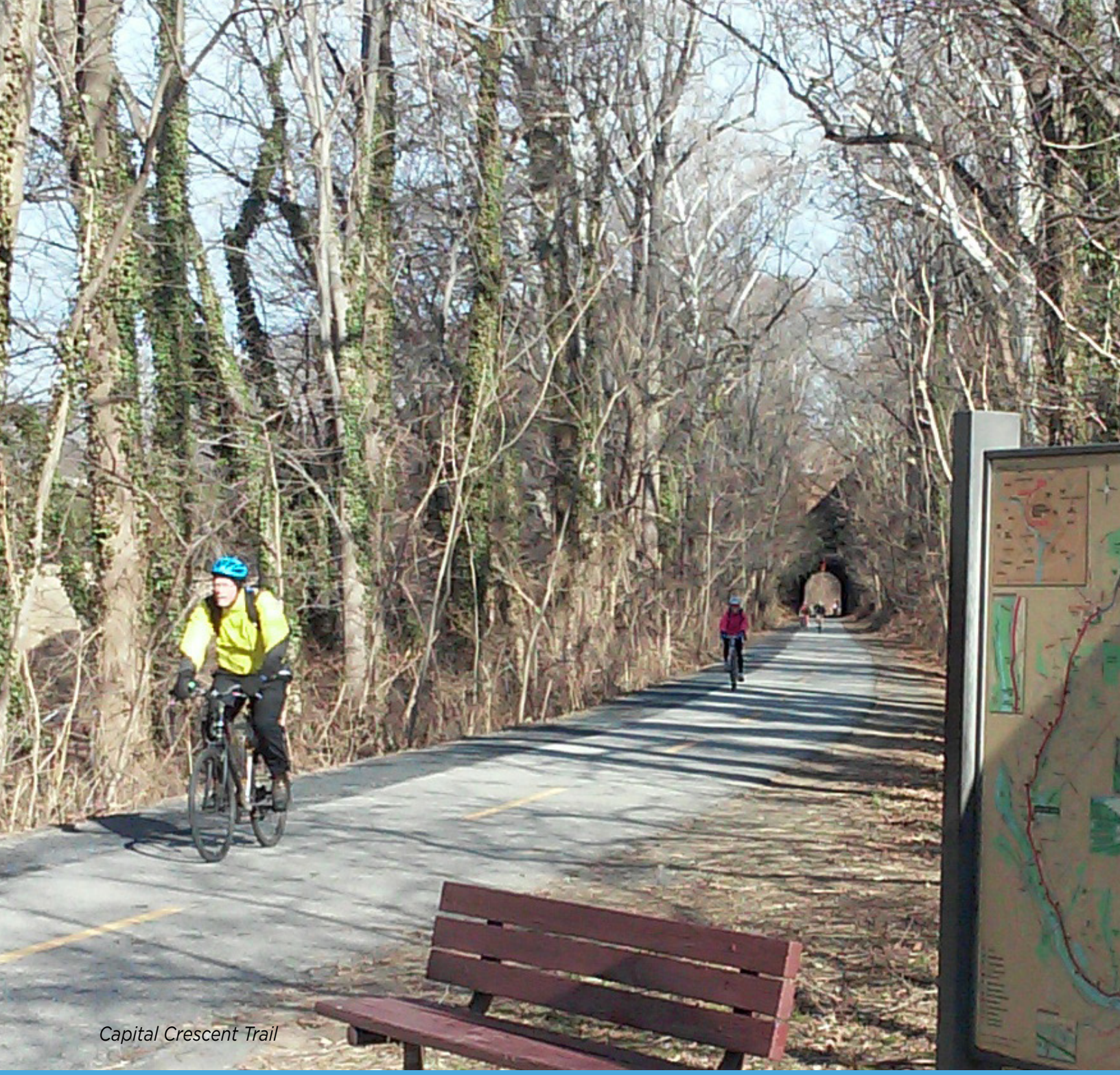
The toolkit's purpose is to provide guidance to designers and planners and is not intended to take the place of design standards prepared by the Montgomery County Department of Transportation or the Maryland State Highway Administration.

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.

BIKEWAY FACILITY TYPES

BICYCLE FACILITY CLASSIFICATION



Capital Crescent Trail

TRAILS

OFF-STREET TRAILS

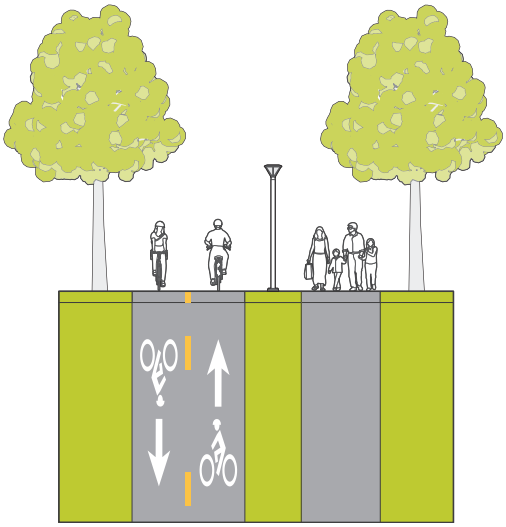
STREAM VALLEY PARK TRAILS

NEIGHBOR-HOOD CONNECTOR

OFF-STREET TRAILS

Off-street trails are shared use paths located outside of the road right-of-way and provide two-way travel for people walking, bicycling and other non-motorized users. Trails specifically along stream valleys are discussed in the stream valley park trails section (page 8).

OFF-STREET TRAILS



TYPICAL APPLICATION

Off-street trails can be located along railway or utility corridors, land dedicated for planned but unbuilt "paper" streets and through public land.

GUIDANCE

- The minimum paved width for a trail is 10 feet. Anticipated future traffic volumes should be used to guide design decisions. The minimum width to enable side-by-side travel and passing is 11 feet.
- Maximum grade should not exceed 5 percent. Grades less than 0.5 percent should be avoided.
- Ideally, provide a graded shoulder area of 3 - 5 feet.
- Lighting should be provided at path/roadway intersections at a minimum and at other locations where personal security may be an issue or where nighttime use is likely to be high.
- Sight distances are based on site conditions and user-based factors. Ensure sight distances are designed per the AASHTO Bike Guide.
- Provide protective railings/fences at 42 inches high if the trail is adjacent to a steep slope.

CONSIDERATIONS

- 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.
- Trails with high use may require pedestrian and bicycle separation. This separation can take the form of pavement markings or separate parallel paths for each user group. If separation is achieved by pavement markings, the bicycle side of the pathway should be no less than 10 feet wide and the pedestrian side should be no less than 5 feet wide.
- Trails on steep grades (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.
- Lighting should be pedestrian-scale, with fixtures located about 15 feet above the trail and with 0.5 to 2.0 foot candles.
- Where lighting is not provided, reflective edge lines should be marked on the pavement.

REFERENCES

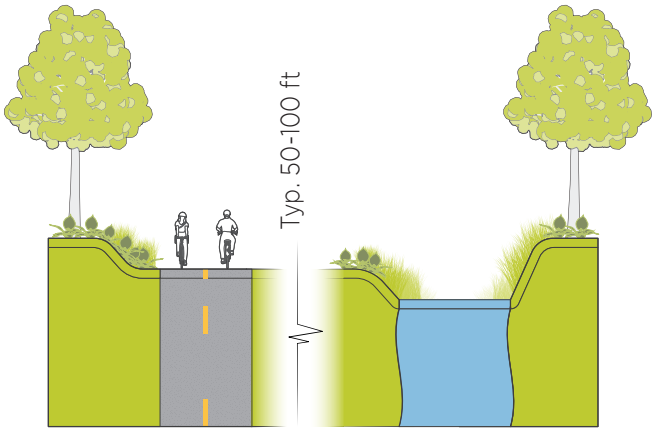
AASHTO. Guide for the Development of Bicycle Facilities. 2012.

United States Access Board. Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way; Shared Use Paths. Washington, DC, February, 2013. https://www.access-board.gov/guidelines-and-standards/streets-sidewalks/shared-use-paths/supplemental-notice

STREAM VALLEY PARK TRAILS

Stream valley park trails are shared use paths located within a M-NCPPC stream valley park that provide two-way travel for people walking and bicycling, and other non-motorized users.

NEIGHBOR-HOOD CONNECTOR



TYPICAL APPLICATION

Stream valley park trails in Montgomery County include Rock Creek Trail, Matthew Henson Trail and Sligo Creek Trail.

GUIDANCE

Stream valley park trails are often located in environmentally sensitive areas. This location will affect design/construction in a number of ways:

- Alignment should avoid or minimize impacts to sensitive natural resources, such as floodplains, stream buffers, steep slopes, highly erodible soils, wetlands and rare, threatened and endangered (RTE) habitat. Alignment should also avoid and/or minimize impacts to cultural, historical and archeological resources.
- To reduce disturbance during trail construction/enhancement, follow existing land contours and reduce the use of grading to the extent possible.
- Distance between the trail and stream is typically 50 to 100 feet to avoid construction in the 100-year floodplain where feasible.

CONSIDERATIONS

- Adequate sight distance may be difficult to achieve along stream valley park trails due to natural features, like trees or rock outcroppings.
- These trails may be disconnected from surrounding neighborhoods due to topography and the existing street grid. To improve connectivity and access, consider providing bridges or trail spurs to connect to nearby bicycle corridors, trails and neighborhood streets.
- Care should be taken at street intersections to ensure crossings are logical, sightlines are adequate, and transitions to on-street bikeways are provided.

REFERENCES

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

Amended Countywide Park Trails Plan. 2016

Separated Bike Lanes on Woodglen Drive, North Bethesda

SEPARATED BIKEWAYS

SEPARATED BIKEWAYS

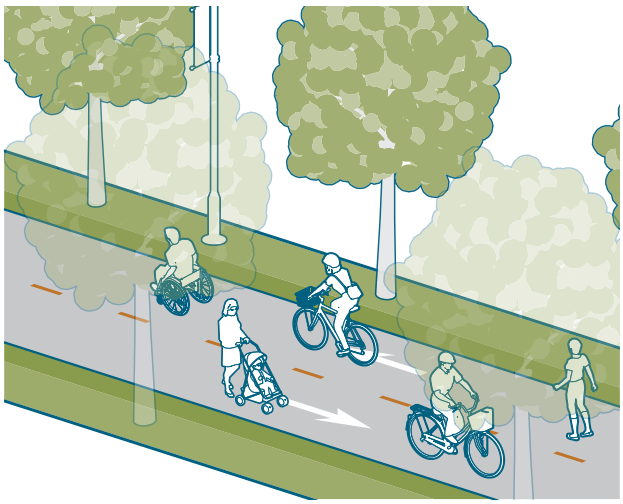
SIDEPATHS

SEPARATED BIKE LANES

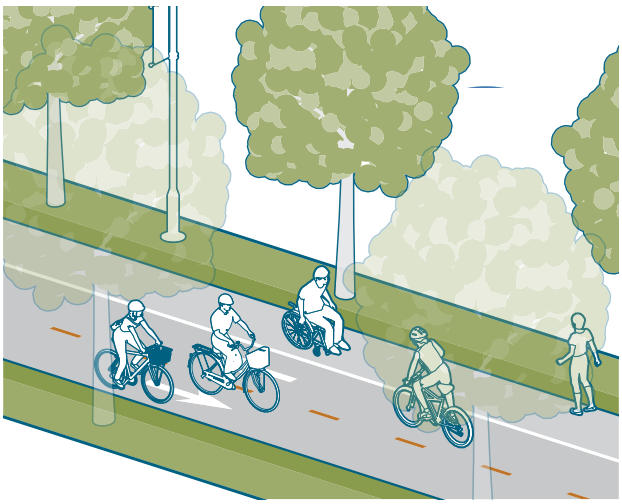
SIDEPATHS

Sidepaths are shared use paths located parallel to and within the road right-of-way, providing two-way travel for walking, bicycling, jogging and skating.

SIDEPATHS



Sidepath with mixed use



Sidepath with separate uses

TYPICAL APPLICATION

Generally 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 faster.
- Average daily traffic: 6,000 vehicles or greater.
- Parking turnover: frequent.
- Bike lane obstruction: likely to be frequent.
- Designated as truck or bus routes.

Sidepaths may be preferable to separated bike lanes if low pedestrian volumes are anticipated in order to minimize right-of-way impacts.

GUIDANCE

- A minimum of a 2 foot graded area with clearance from lateral obstructions, such as bushes, large rocks, bridge piers, abutments and poles.
- A minimum 1 foot clearance from "smooth" features, such as bicycle railings or fences with appropriate flaring and treatments.
- Ideally, a graded shoulder area of 3 - 5 feet, with a 5 foot minimum buffer from traffic.
- Separation of modes in areas with existing or anticipated higher levels of activity, including a 10 foot (min) bikeway and a 5 foot (min) walkway.
- Adequate widths to enable side-by-side travel and passing, typically at least 11 feet wide.

CONSIDERATIONS

Sidepaths are attractive to a wider range of bicyclists compared to striped bikeways (see pages 12-15). Sidepath design requires:

- High-quality construction and maintenance that avoids pavement cracking and buckling.
- Asphalt is the preferred surface material. If concrete, use longer sections with small joints for a smoother riding experience.
- Intuitive and safe intersection crossings.
- Straight alignments to allow direct and higher speed travel.
- Removal of poles, trees or other obstructions that are present in many existing sidepath locations.
- Adequate lighting for nighttime use.

REFERENCES

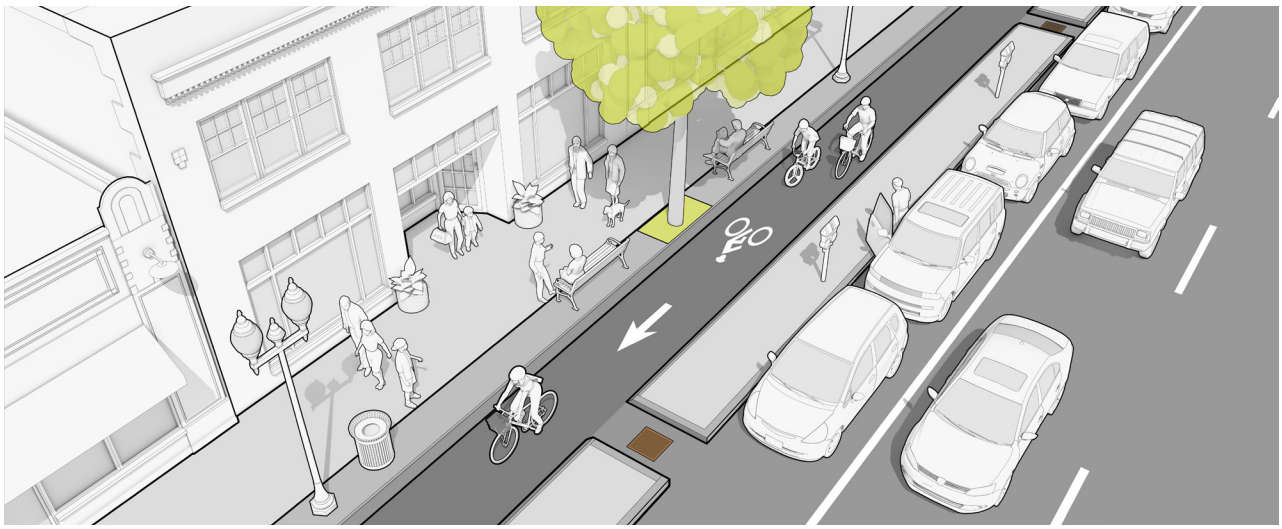
MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

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

SEPARATED BIKE LANES

Separated bike lanes are exclusive bikeways that combine 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



TYPICAL APPLICATION

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 faster.
- Average daily traffic: 6,000 vehicles or greater.
- Parking turnover: frequent.
- Bike lane obstruction: likely to be frequent.
- 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.

GUIDANCE

On roads with two to four through lanes, one-way directional separated bike lanes are preferred to a two-way separated bike lane on one side of the street for the following reasons:

- Follow normal traffic flows, whereas two-way separated bike lanes can create unexpected movements.
- Simpler transitions to other facilities.
- Less likely need for signal modifications.

Separated bike lanes can provide different levels of separation:

- Flexible delineator posts ("flex posts") offer the least separation and are appropriate as an interim solution.
- Raised buffers provide the greatest level of separation from traffic, but will often require road reconstruction.
- On-street parking offers a high-degree of separation, but may require raised buffer treatments at intersections.

See pages 32-41.

CONSIDERATIONS

- More attractive to a wider range of bicyclists than striped bikeways on higher volume and faster speed roads.
- Prevent motor vehicles from driving, stopping or waiting in the bikeway.
- Provide greater comfort to pedestrians by separating them from bicyclists.

REFERENCES

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

NACTO. Urban Bikeway Design Guide. 2nd Edition.

Bike Lanes on Battery Lane, Bethesda

STRIPED BIKEWAYS

STRIPED BIKEWAYS

BUFFERED BIKE LANES

BIKE LANES

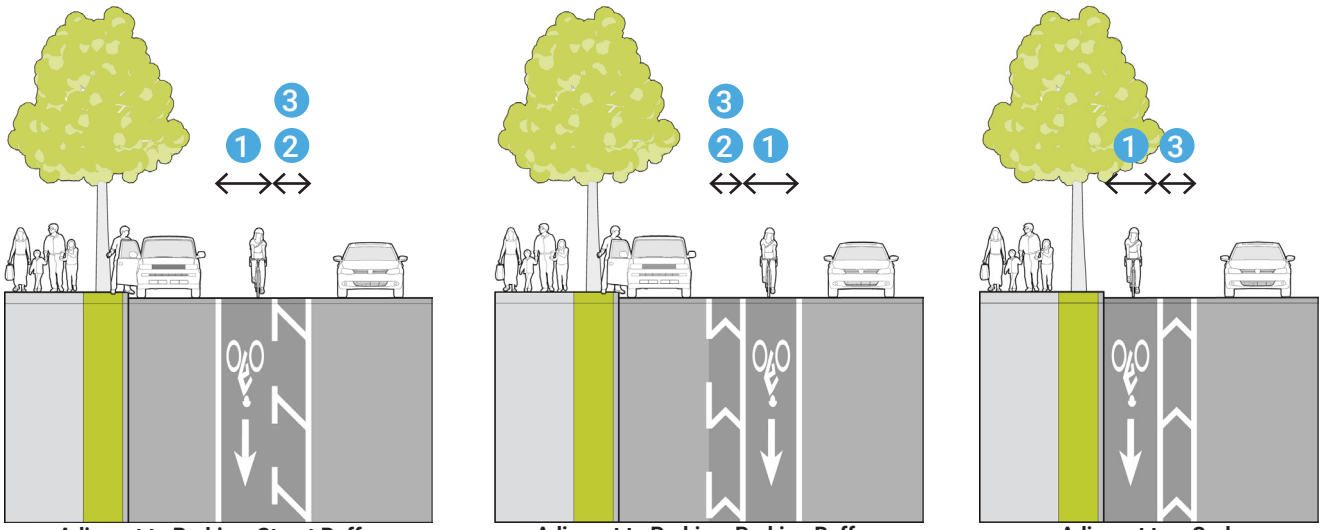
ADVISORY BIKE LANES

CONTRA FLOW BIKE LANES

BUFFERED BIKE LANES

Buffered bike lanes are conventional bike lanes paired with a designated buffer space separating the bike lane from the adjacent motor vehicle travel lane and/or parking lane to increase the comfort of bicyclists.

BUFFERED BIKE LANES



Adjacent to Parking, Street Buffer | Adjacent to Parking, Parking Buffer | Adjacent to a Curb

TYPICAL APPLICATION

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 slower.
- 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 undesirable.

GUIDANCE

1. Minimum buffered bike lane width, exclusive of buffer, is 4 feet with a parking-adjacent buffer and 5 feet with a travel-lane-adjacent buffer or where bike lane is adjacent to curb. Desirable width is 6 feet.
2. Buffers should be broken along curbside parking to allow cars to cross the bike lane.
3. Minimum buffer width is 2 feet. There is no maximum. Diagonal crosshatching should be used for buffers less than 3 feet wide. Chevron crosshatching should be used for buffers greater than 3 feet.

CONSIDERATIONS

- Consider placing buffer next to parking lane where there is high turnover parking.
- Consider placing buffer next to travel lane where speeds are 30 mph or faster, or when traffic volume exceeds 6,000 vehicles per day.
- Preferable to conventional bike lanes when used as a contra-flow bike lane on one-way streets.
- Can be used on one-way or two-way streets.
- Where there is 7 feet of roadway width available, a buffered bike lane should be installed instead of a conventional bike lane.
- If there is sufficent width and a separated bike lane is not being considered, buffers may be installed on both sides of the bike lane.
- Allow bicyclists to ride side by side or to pass slower moving bicyclists.
- Research has documented buffered bike lanes increase safety and the perception of safety.

REFERENCES

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

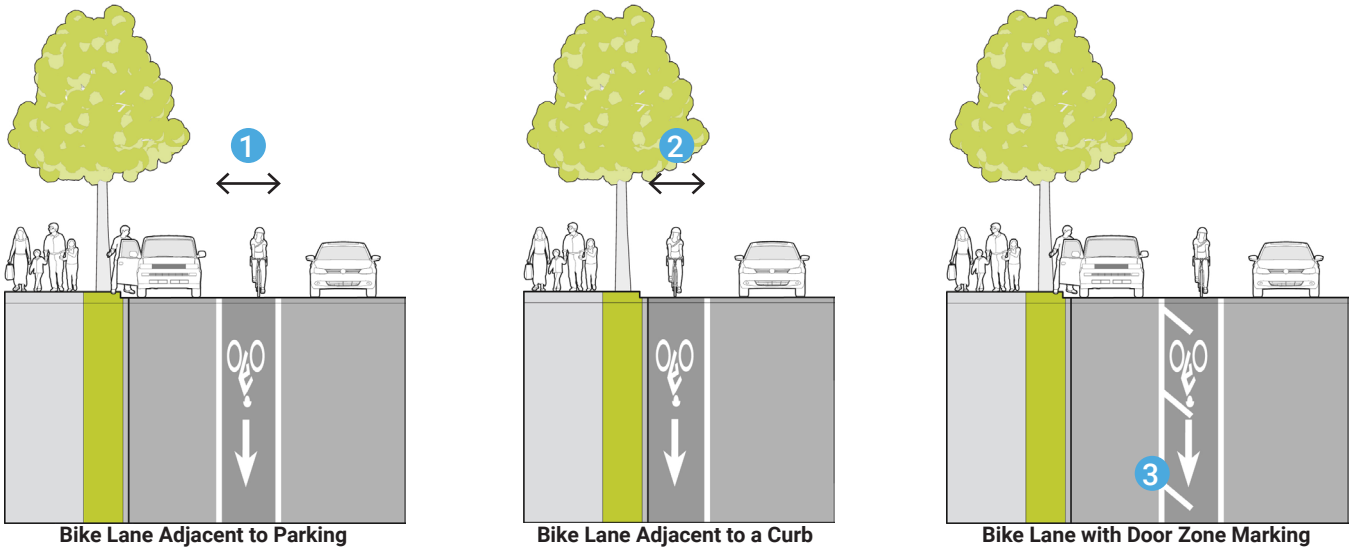
NACTO. Urban Bikeway Design Guide. 2nd Edition.

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.

CONVENTIONAL BIKE LANES

A conventional bike lane is a portion of a street designated for the exclusive use of bicycles and distinguished from traffic lanes by striping, signing and pavement markings.

BIKE LANES



Bike Lane Adjacent to Parking | Bike Lane Adjacent to a Curb | Bike Lane with Door Zone Marking

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 slower.
- 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 undesirable.

CONSIDERATIONS

- Typically installed by reallocating 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 one-way streets for motorists, improving 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 preferred at locations with high parking turnover.

GUIDANCE

1. The minimum width of a bike lane adjacent to parking is 5 feet, a desirable width is 6 feet.
2. The minimum width of a bike lane adjacent to a curb is 5 feet exclusive of a gutter, a desirable width is 6 feet.
3. Parking Ts or hatch marks can highlight the vehicle door zone on constrained corridors with high parking turnover to guide bicyclists away from doors.

- See the NACTO and AASHTO design guides for more information on bike lane widths.

REFERENCES

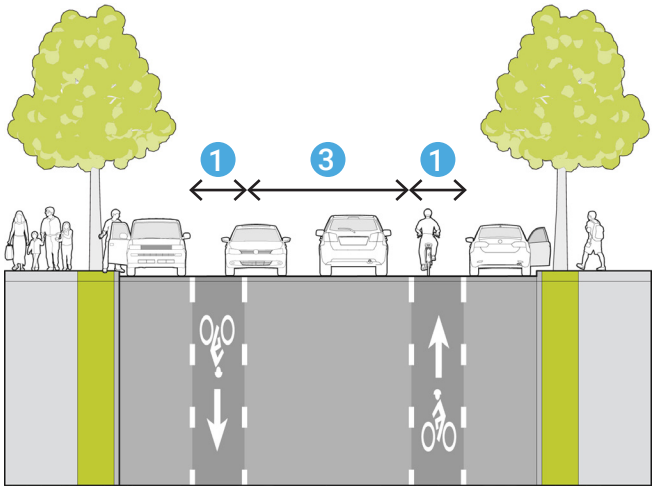
AASHTO. Guide for the Development of Bicycle Facilities. 2012.

NACTO. Urban Bikeway Design Guide. 2nd Edition.

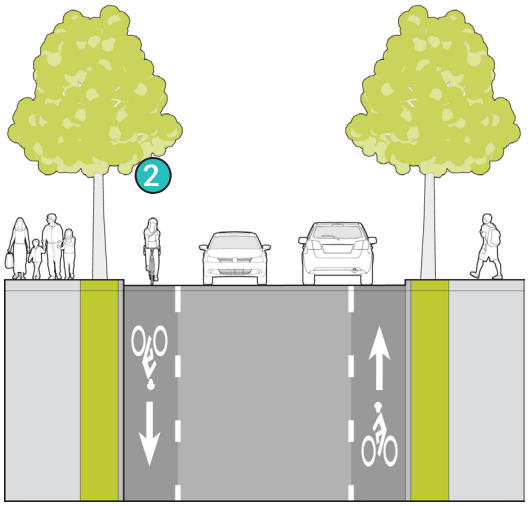
ADVISORY BIKE LANES

Advisory bike lanes are dashed bike lanes that allow motorists to temporarily enter the bike lane to provide sufficient space for oncoming traffic to safely pass on narrow unlaned roads in residential contexts.

ADVISORY BIKE LANES



Advisory Bike Lane with Parking



Advisory Bike Lane without Parking

TYPICAL APPLICATION

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

- Total traffic lanes: 2 lanes or fewer.
- Posted speed limit: 30 mph or slower.
- Average daily taffic: 2,000-4,000 vehicles per day desirable, 6,000 vehicles per day or 300 vehicles or fewer maximum during the peak hour.
- Parking turnover: infrequent.
- Street is not a designated truck or bus route.

GUIDANCE

1. The minimum width of an advisory bike lane is:
   - 5 feet adjacent to parking.
   - 4 feet curb-adjacent exclusive of gutter.
2. A desirable width is 6 feet.
3. The minimum width of the unlaned motorist space should be 12 feet between the bike lanes. The maximum width should be 18 feet.

CONSIDERATIONS

- **Requires FHWA permission to experiment.**
- For use on streets too narrow for bike lanes and normal width travel lanes.
- Provide two separate minimum width bike 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 bike lane.
- This treatment should only be used on streets with greater than 60 percent continuous daytime parking occupancy.
- Where parking occupancy is continuously less than 50 percent, consolidate the parking to one side of the street.
- A two-way traffic warning sign (W6-3) may increase motorists understanding of the intended two-way operation of the street.
- The combined bike lanes and unlaned travel area must meet the minimum requirements set out by the fire code.

MUTCD W6-3 Sign

REFERENCES

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

FHWA. Bicycle Facilities and the Manual on Uniform Traffic Control Devices – Dashed Bicycle Lanes. 2015.

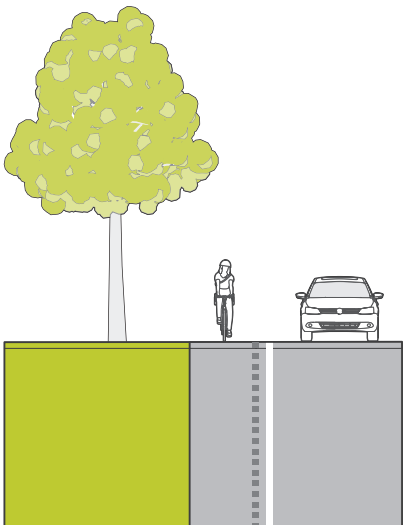
Bikeable Shoulders On Clarksburg Road in Boyds

BIKEABLE SHOULDERS

BIKEABLE SHOULDERS

BIKEABLE SHOULDERS

Bikeable shoulders are portions of the roadway that accommodate stopped or parked vehicles, emergency use, bicycles, motor scooters and pedestrians where sidewalks do not exist.



TYPICAL APPLICATION

Rural areas of Montgomery County 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 curbless 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 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.

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 bicyclsts 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 wit Disabilities Act requirements to the maximum extent possible.

REFERENCES

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

FHWA. Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts. 2016.

SHARED ROADS

SHARED ROADS

SHARED STREETS

NEIGHBOR-HOOD GREENWAYS

PRIORITY SHARED LANE MARKINGS

SHARED STREETS

Shared streets prioritize pedestrian and bicycle movement by slowing vehicular speeds and communicating clearly through design features that motorists must yield to all other users. The design should create conditions where pedestrians and bicyclists can walk or ride on the street and cross at any location, rather than at designated locations.

SHARED STREETS

TYPICAL APPLICATION

Urban streets where it is desirable to prioritize walkability and slow traffic speeds to enhance livability and economic development goals.

GUIDANCE

- Shared streets should not have vertical curbs allowing pedestrians to use the entire right-of-way. A lack of curbs encourages cautious behavior on the part of all users, which in turn reinforces slower speeds and comfortable walking and bicycling conditions.
- Motor vehicle speeds should not exceed 15 mph at any time.
- Shared street gateway treatments should inform drivers they are entering a shared space. Common ways to do so include:
  - Narrowing entrances to one lane.
  - Elevating the street to the pedestrian level.
  - Using a colored or textured pavement.
- Traffic volumes should not exceed 100 vehicles in the peak hour.

CONSIDERATIONS

- The curbless nature of shared streets enhances universal access.
- Street zones may be delineated with pavement materials, color, bollards or street furniture.
- Sidewalk space in front of buildings should be paved with a surface that is smooth and vibration-free.
- Stormwater on shared streets can be captured using valley gutters, additional inlets and/or bioswales or other green infrastructure.
- A shared street may be closed to motor vehicles to host public events. Care should be taken to maintain access for bicyclists when it is closed to vehicles.
- If traffic volumes exceed thresholds, consider limiting access to only taxis, deliveries and paratransit.

REFERENCES

FHWA. Achieving Multimodal Networks: Applying Design Flexibility and Reducing Conflicts. 2016.

Boston. Complete Streets Design Guidelines. 2013.

NEIGHBORHOOD GREENWAY

Neighborhood greenways are streets with low motorized vehicle traffic volumes and speeds, designed and designated to give walking and bicycling priority. They use signs, pavement markings and speed and volume management measures to discourage through trips by motor vehicles and create safe, comfortable crossings of busy arterial streets.

NEIGHBOR-HOOD GREENWAYS

TYPICAL APPLICATION

- Neighborhood greenways use existing low-stress streets that parallel a major corridor.
- Roads with speeds less than or equal to 25 mph and volumes less than 3,000 ADT.
- If these conditions are not met, the treatments explained on pages 42 to 46 should be employed to reach these guidelines.

GUIDANCE

- Each of the subsequent pages provide additional guidance for implementation:
  - Traffic calming via raised pavement (page 43).
  - Traffic calming via street narrowing (page 44).
  - Traffic diversion (page 45).
  - Crossing treatments (page 46).

CONSIDERATIONS

- Given Montgomery County's non-grid street network, identification of connected, parallel routes may be difficult in some areas. It may be necessary to re-route short segments of neighborhood greenways along higher-stress routes, in which case separated bikeways, such as sidepaths or separated bike lanes, will be necessary.

REFERENCES

IPBI, Alta Planning + Design, Portland State University. Bicycle Boulevard Planning and Design Guidebook. 2009.

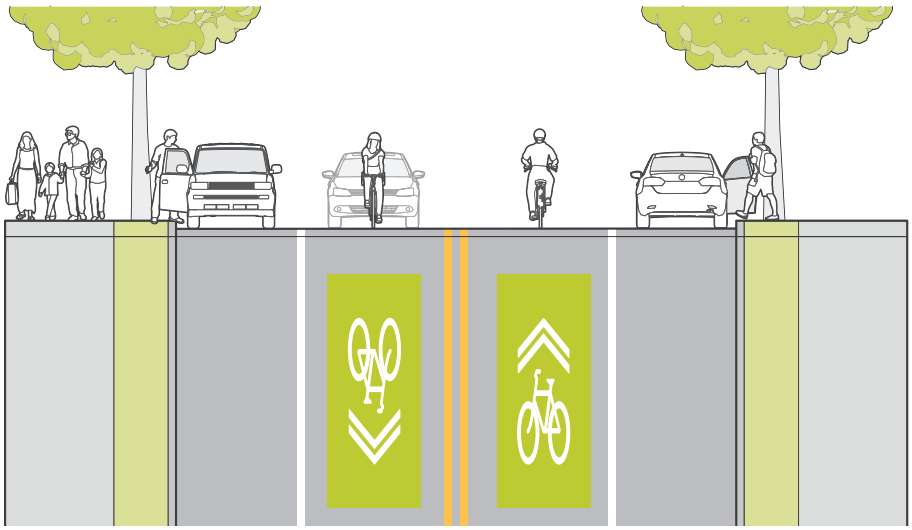
NACTO. Urban Bikeway Design Guide. 2nd Edition.

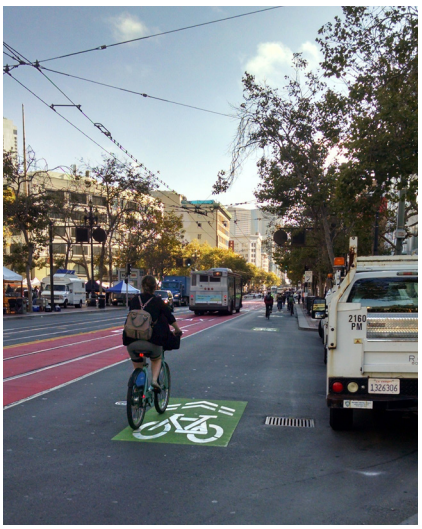
Portland Bureau of Transportation. Neighborhood Greenway Assessment Report. 2015.

PRIORITY SHARED LANES

Priority shared lane markings communicate bicyclist priority within a shared lane and guide bicyclists to ride outside of the door zone. Colored backing and more frequent spacing make priority shared lane markings more conspicuous than standard shared lane markings (also known as sharrows). This treatment does not improve most bicyclists' comfort in shared lanes with traffic.

PRIORITY SHARED LANE MARKINGS





TYPICAL APPLICATION

On roadways where it is infeasible to install bike lanes, separated bike lanes or sidepath, but it is desirable to communicate bicyclists priority within a shared lane.

Common applications will be streets with high on-street parking turnover, typically those with ground-floor retail and dining, or on low-speed, low-volume frontage roads. They may also be used in separated bike lane mixing zones where a protected intersection is not provided.

CONSIDERATIONS

Requires FHWA permission to experiment.

- Green background color should underlay the entirety of the priority shared lane marking area.
- Priority Shared Lane markings can be supplemented with R4-11, BICYCLES MAY USE FULL LANE signage.
- Where volumes exceed approximately 1,500 vehicles per day, this facility may not be comfortable for all "Interested but Concerned" bicyclists.

GUIDANCE

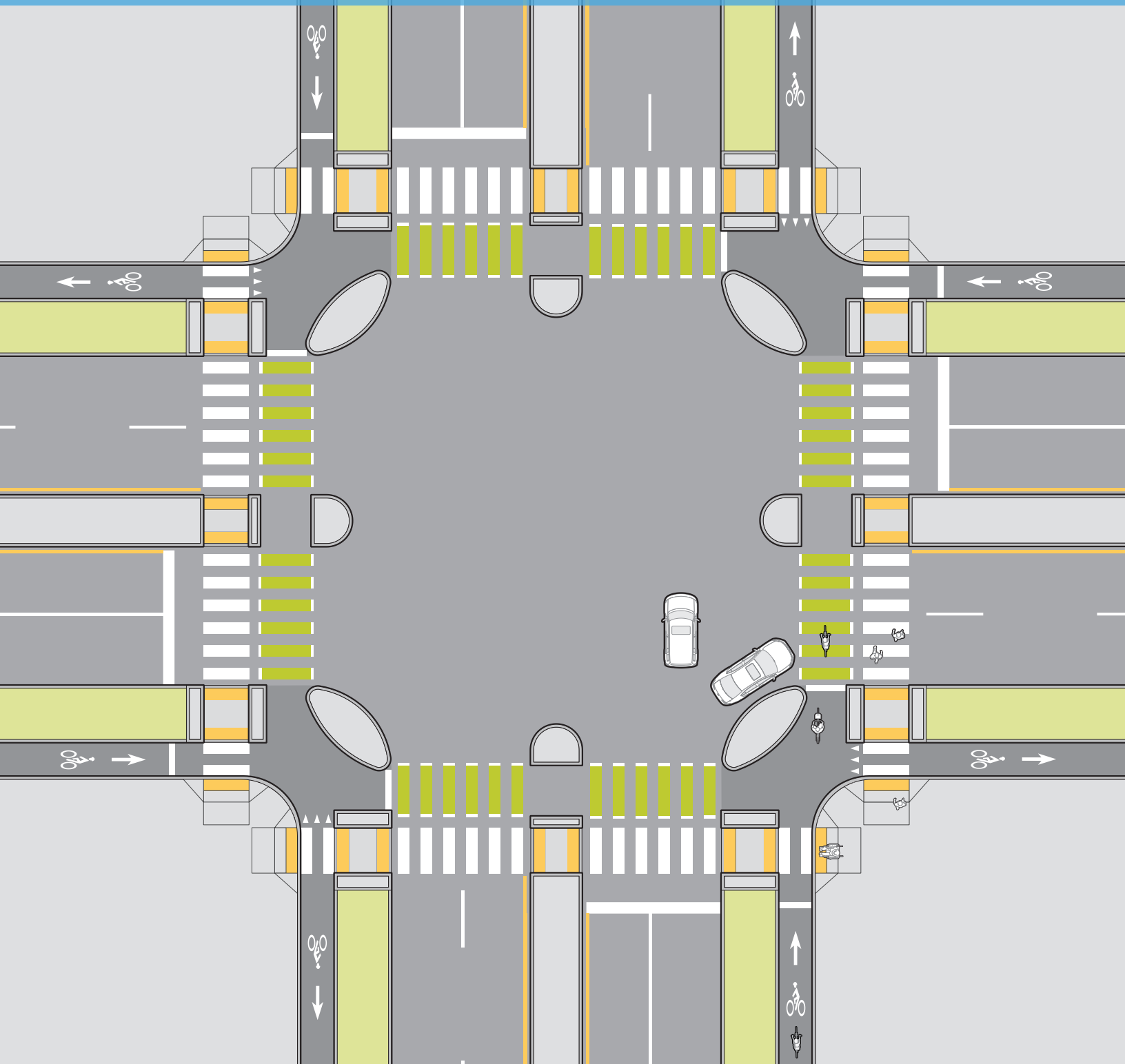
- Ideally placed on streets with speeds 25 mph or less with average daily traffic less than 3,000 vehicles per day.
- May be used on streets with higher volumes and/or speeds (up to 6,000 average daily traffic at 30 mph, or 20,000 at 25 mph), but streets will not be comfortable for the "Interested but Concerned" rider.
- May be used as an interim measure on any roadway where it is desirable to communicate bicycle priority within a shared lane to close gaps in a bicycle network.
- May be used on two-lane or multi-lane streets.
- Should be placed in the center of travel lane to avoid wear in the wheel path and guide bicyclists' positioning.
- Should be spaced 100 feet apart or less.

REFERENCES

AASHTO. Guide for the Development of Bicycle Facilities. 2017.

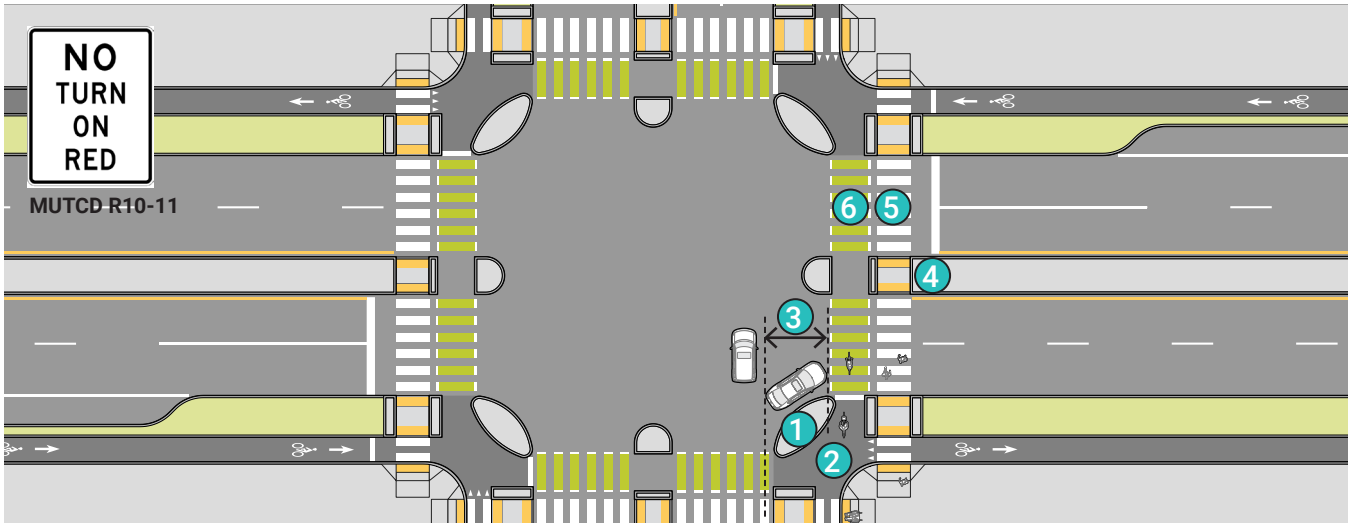
Montgomery County Bicycle Planning Guidance. 2014

INTERSECTION TREATMENTS



SEPARATED BIKE LANE - PROTECTED INTERSECTION

Protected intersections are a type of intersection design that improves safety by reducing the speed of turning traffic, improving sightlines and designating space for all road users. Protected intersections reduce conflict points between motorists and bicyclists.



TYPICAL APPLICATION

All separated bike lane intersections.

GUIDANCE

1. Corner refuge island size may vary. The curb radius along the path of motor vehicle travel should minimize turning motorist speeds to 15 mph or less.
2. The forward bicycle queuing area should allow at least one bicyclist to wait without obstructing crossing bicyclists or pedestrians.
3. The motorist yield zone should be 6 feet in length minimum, up to a typical car length (16.5 feet), to create space for a turning motorist to yield to a through moving bicyclist.
4. A pedestrian crossing island should be a minimum of 6 feet in width to minimize pedestrian crossing distances of the street.
5. Marked pedestrian crosswalks should be provided across all bike lane crossings.
6. Bicycle crossings should be separate from pedestrian crossings. They can be supplemented with green pavement to improve contrast.

CONSIDERATIONS

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. This condition can be accomplished by:

- Creating space for a motorist to yield to bicyclists and pedestrians. Research has found crashes are reduced at locations where bicycle crossings are set back from the motorist travel way by a distance of 6 to 20 feet, creating space for turning motorists to yield. At locations where the street buffer is less than 6 feet midblock, additional dedication from developments may be necessary at intersections to create a greater than or equal to 6 foot setback.
- Minimizing the turning speed of motor vehicles through the use of small curb radii (less than 20 feet) along the corner refuge island. Where larger radii are required to accommodate oversized vehicles, such as buses and trucks, provide mountable aprons to maintain the smaller curb radii for most vehicles
- Providing a “No Turn On Red” sign where turning motorists are likely to block crosswalks or where protected signal phasing is provided.

REFERENCES

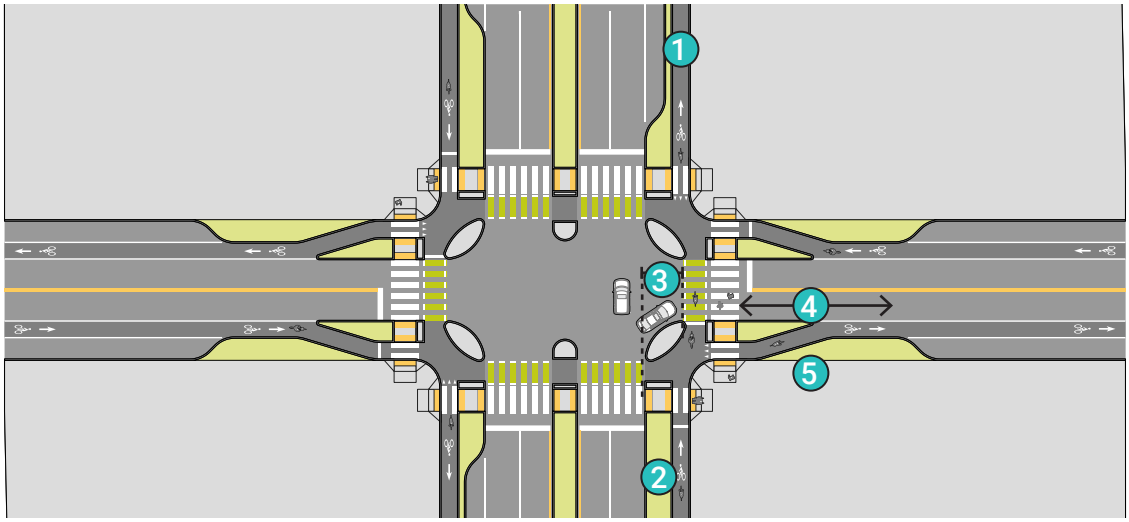
NACTO. Urban Bikeway Design Guide. 2nd Edition.

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 conventional bike lane on an intersecting street.



TYPICAL APPLICATION

- All one-way separated bike lane locations that require a transition to a cross street conventional bike lane.

GUIDANCE

1. For separated bike lane widths, see page 34.
2. A minimum street buffer of 6 feet is recommended.
3. Minimum offset is 6 feet, desirable is 16.5 feet.
4. Recommended minimum transition is 25 feet to ensure a bicyclist has time to react to an approaching vehicle.
5. Maximum 3:1 lateral taper.

CONSIDERATIONS

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.
- Maintain a vertical or a 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 using signage and markings to minimize conflicts with other users.

REFERENCES

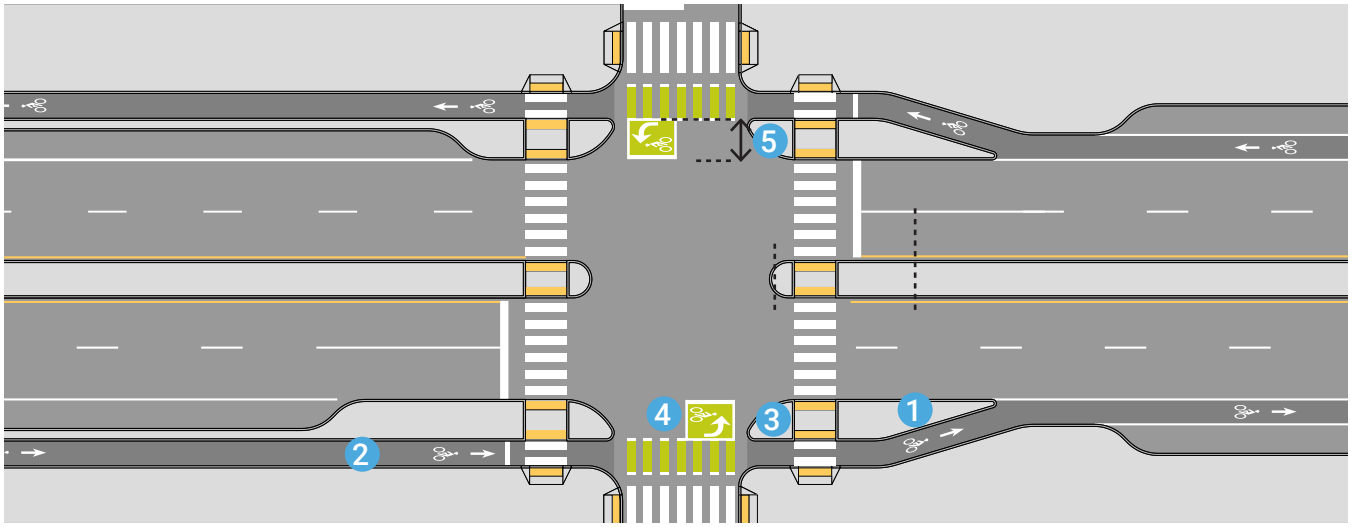
NACTO. Urban Bikeway Design Guide. 2nd Edition.

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 typical design of a one-way separated bike lane transition to a conventional bike lane on the same street.



TYPICAL APPLICATION

- All one-way separated bike lane locations that require a transition to a conventional bike lane on the same street.

GUIDANCE

1. Maximum 3:1 lateral taper.
2. For separated bike lane widths, see page 34.
3. A protecting island should be provided to shadow the bike lane on the far side of the intersection 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 bike lanes or shared lanes.
5. Bicycle crossing is offset a minimum of 6 feet from the outside edge of travel lane, desirable is 16.5 feet.

CONSIDERATIONS

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. Maintaining the offset through the crossing improves the sightlines bewteen right-turning drivers and through bicyclists.
- 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.

REFERENCES

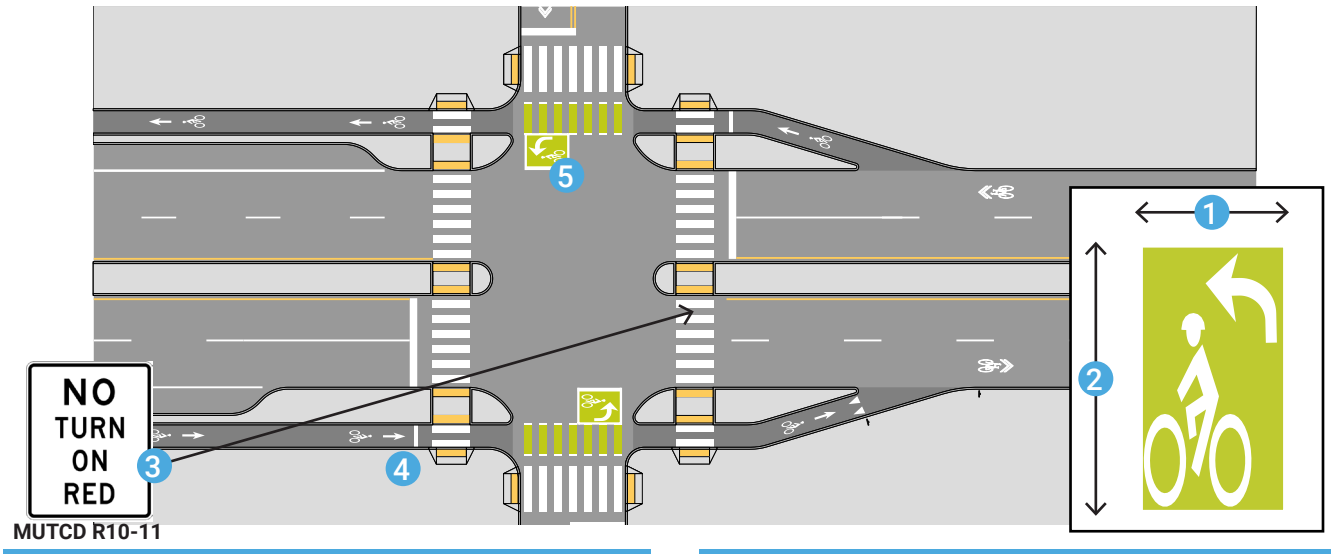
NACTO. Urban Bikeway Design Guide. 2nd Edition.

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 INTERSECTING STREET WITH TWO-STAGE TURN QUEUE BOX

This treatment provides an example of a typical design of a one-way separated bike lane transition to a conventional bike lane or a shared lane on a cross street using a two-stage turn queue box.



MUTCD R10-11

TYPICAL APPLICATION

All separated bike lane locations that require a transition to a cross street conventional bike lane or shared lane.

GUIDANCE

1. A minimum width of 6.5 feet is recommended.
2. A minimum length of 6.5 feet is recommended.
3. "No Turn On Red" (R10-11) sign restrictions should be used to prevent vehicles from entering the queuing area at signalized intersections.
4.
   - The use of a supplemental sign instructing bicyclists how to use the bike box is optional.
5.
   - The bike box should consist of a green box outlined with solid white lines and supplemented with a bicycle symbol and a turn ar-

CONSIDERATIONS

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 into the turn queue box.

REFERENCES

NACTO. Urban Bikeway Design Guide. 2nd Edition.

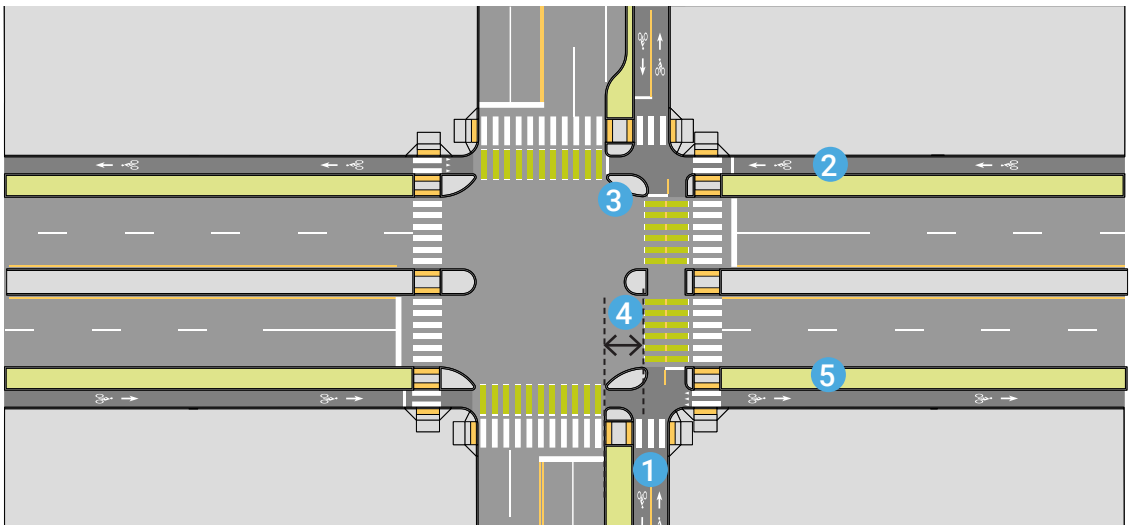
MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

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.

TRANSITION FROM TWO-WAY SEPARATED BIKE LANE TO ONE-WAY SEPARATED 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 bike lane on an intersecting street.



TYPICAL APPLICATION

- All two-way separated bike lane locations that require a transition to a cross street one-way separated bike lane.

GUIDANCE

1. A minimum two-way separated bike lane width of 10 feet is recommended.
2. For separated bike lane widths, see page 34.
3. A 15-foot corner radius is recommended for turns from the two-way bike lane onto the one-way bike lane.
4. Bicycle crossing is off set by a minimum of 6 feet from the outside edge of travel lane, a desirable offset is 16.5 feet.
5. A minimum street buffer of 6 feet is recommended.

CONSIDERATIONS

Intersections with separated bike lanes should be designed to minimize bicyclist exposure to motorized traffic and 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. The separated bike lane is designed with geometric features that result in higher compliance where users are expected to yield.

The transitional design should:

- Maintain separation through 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.

REFERENCES

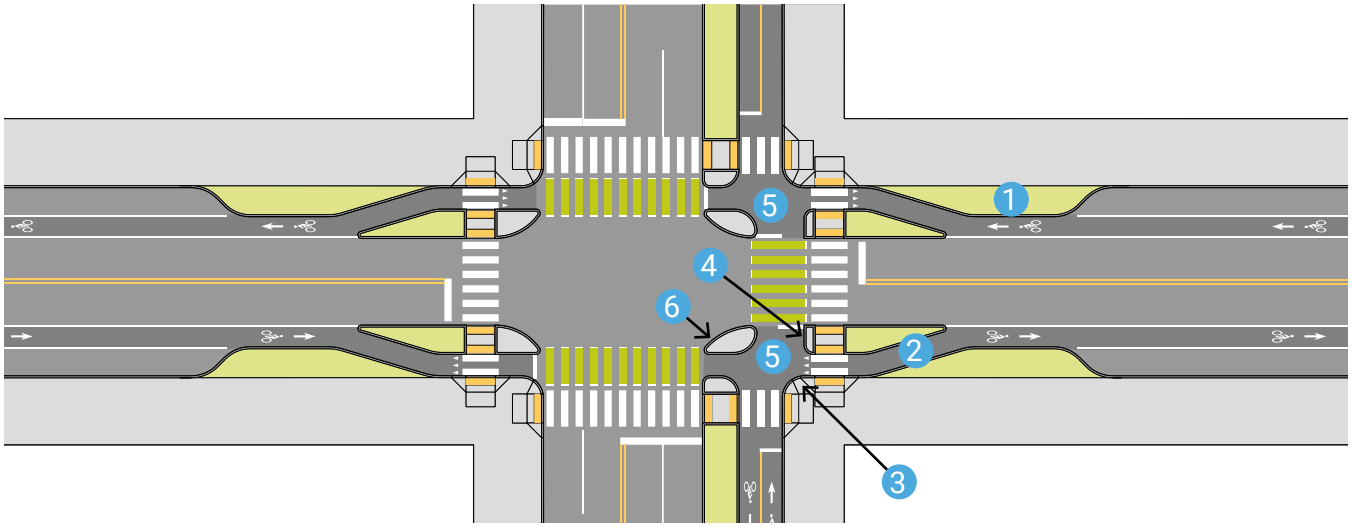
NACTO. Urban Bikeway Design Guide. 2nd Edition.

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 conventional bike lanes on an intersecting street.



TYPICAL APPLICATION

All two-way separated bike lane locations that require a transition to conventional bike lanes on a cross street.

GUIDANCE

1. Conventional bike lanes should transition to separated bike lanes as they approach the intersection.
2. For separated bike lane widths, see page 34.
3. A 15-foot corner radius is recommended for turns between the two-way bike lane and the one-way bike lane.
4. Provide a minimum 10 foot curb radius to allow left turning bicyclists to enter the one-way bike lane.
5. Ensure the forward bicycle queuing area is sufficiently sized to accomodate predicted bicycle volumes, especially for those bicyclists turning from the conventional bike lanes.
6. Construct outside curb radii based on MCDOT and/or SHA standards.

- For guidance on protected intersection dimensions, see page 23.

CONSIDERATIONS

The transition design should:

- Maintain separation through the intersection.
- Guide right turning bicyclists to turn slowly at all times, yielding to pedestrians in crosswalks.
- 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.
- Where outside turn radii are greater than 15 feet for right turning motorist across the separated bike lane, consideration should be given to installing a truck apron to accommodate the larger turn radius.

If conventional bike lanes are on roadways without on-street parking, it may be necessary to provide additional right-of-way or convert sidewalk space to bicycling space to accommodate transitions to a protected intersection.

REFERENCES

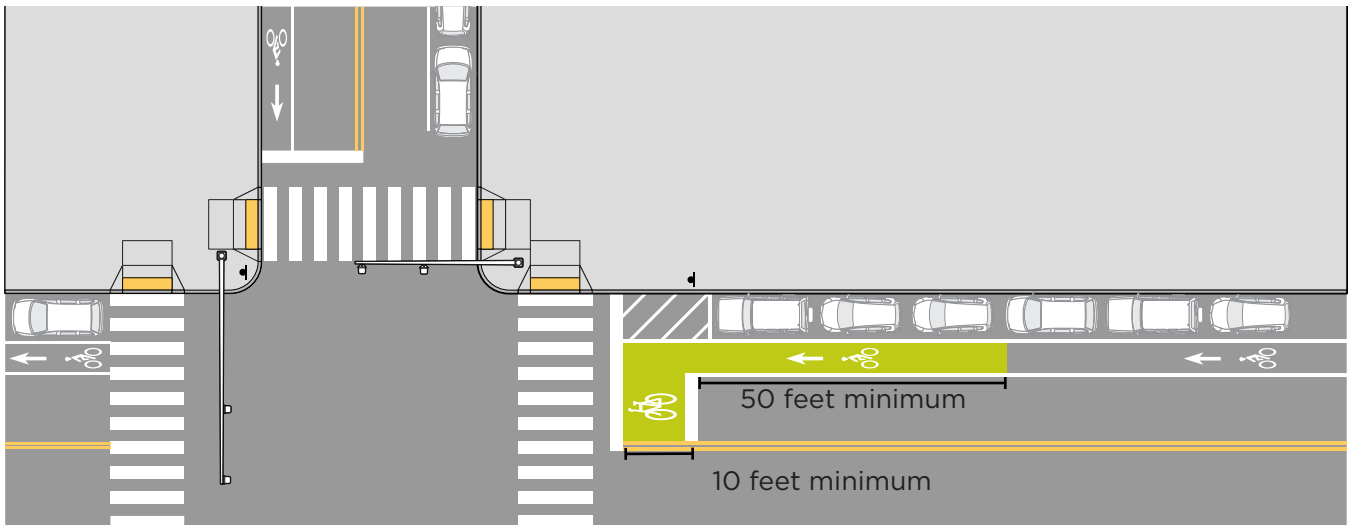
NACTO. Urban Bikeway Design Guide. 2nd Edition.

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

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

BIKE BOXES

A bike box is a designated area at the head of a traffic lane at a signalized intersection that provides bicyclists with a safe and visible way to get ahead of queuing traffic during the red signal phase.



TYPICAL APPLICATION

- Where through bicyclists and right-turning motorists conflict.
- Where a bicycle lane does not continue across an intersection.

GUIDANCE

- Bike boxes are primarily installed at signalized intersections.
- Bike boxes should be a minimum of 10 feet deep from the stop bar.
- A bike box should only extend across one travel lane. Bike boxes should not be used to facilitate bicycle left turns. A two-stage turn queue box is the preferred method of accommodating left turns.
- Green pavement can be used within the bicycle box to deter motor vehicles from encroaching.
- At least 50 feet of bicycle lane should connect the the approach leg of the intersection to the bike box so bicyclists do not have to weave between queueing motor vehicles to access it.

CONSIDERATIONS

- Bicyclists waiting in front of stopped motorists gain a head start by being 10-15 feet in front of stopped vehicles. This head start can be extended with a leading bicycle and/or pedestrian phase.
- Motorists should be discouraged from merging into the bicycle lane with a solid bicycle lane line to ensure bicyclists can enter the bike box.
- At locations where there are high volumes of turning traffic or frequent conflicts between turning motorists and bicyclists during stale green portions of the signal phase, it may be advisable to consider a right turn lane or separate phasing to mitigate conflicts in lieu of or in addition to a bike box.

REFERENCES

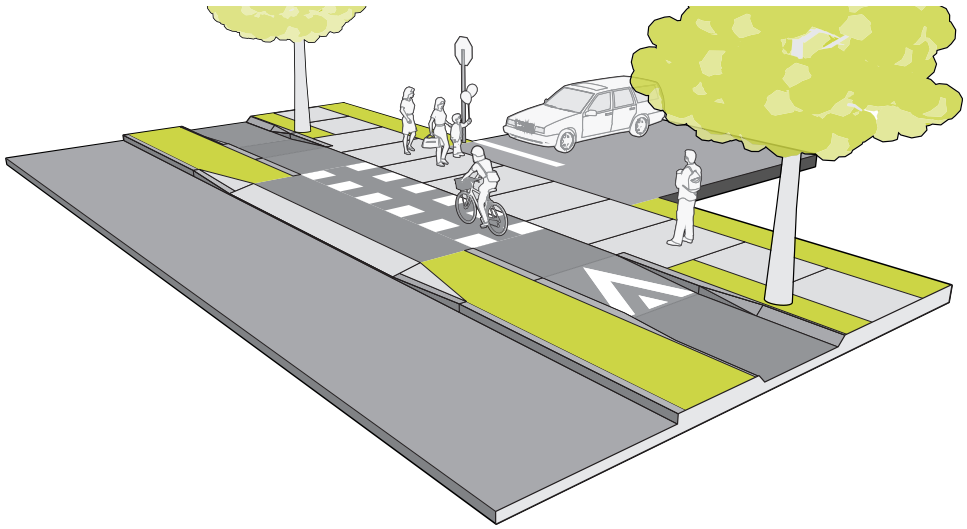
Boston. Complete Streets Design Guidelines. 2013.

NACTO. Urban Bikeway Design Guide. 2nd Edition.

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

RAISED DRIVEWAYS

This treatment raises the bikeway to a driveway level to help mitigate the conflicts between bicyclists on shared use paths or separated bike lanes and motor vehicles entering or exiting driveways that cross the bikeway.



TYPICAL APPLICATION

Where driveways cross separated bike lanes, sidepaths or shared use paths.

GUIDANCE

- All separated bike lane and sidepath driveway crossings should be raised. If the separated bike lane is street-level at driveways, it should be raised to sidewalk-level. In these situations, the transition ramp for bicyclists from street- to sidewalk-level should have a maximum 10 percent slope.
- Driveway approach ramps from street-level should be built at 5 to 15 percent slope.
- Sight triangles must be maintained, based on traffic speeds and volumes per the MCDOT or SHA standards as applicable.
- Driveway curb radii should encourage motorists to slow down and yield as they exit the roadway.
- Separated bike lane/sidepath surface material, paint color and texture should continue across the driveway to emphasize bikeway priority and encourage motor vehicle yielding. Dual rows of painted squares can be used across driveways (as shown). Green bars are also acceptable.

CONSIDERATIONS

- If the bicyclist transition ramp is longer than 6 feet with a slope greater than 5 percent, speed hump markings are recommended.
- If there are many driveways in quick succession, designers should consider an intermediate or sidewalk-level bikeway because frequent transitional ramps are not comfortable for bicyclists.
- Recommended driveway widths within public rights-of-way are specified in the Montgomery County Standard Detail for Residential and Commerical Driveways.
- At uncontrolled commercial and high-volume residential driveways, bicycle warning or bicycle/pedestrian warning signage (W11-15) should be installed facing those exiting the driveway. If the separated bike lane is two-way, a two-directional plaque should be added (W1-7 alt.).
- Controlled commercial and high-volume residential driveway function more similarly to streets. They should be designed with protected intersection geometries. See page 23 for more information.

REFERENCES

NACTO. Urban Bikeway Design Guide. 2nd Edition.

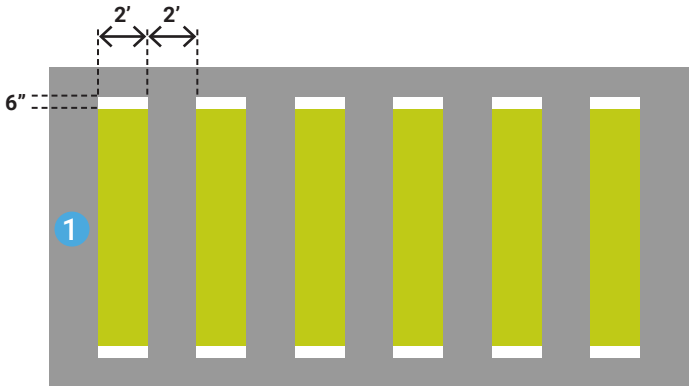
MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

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

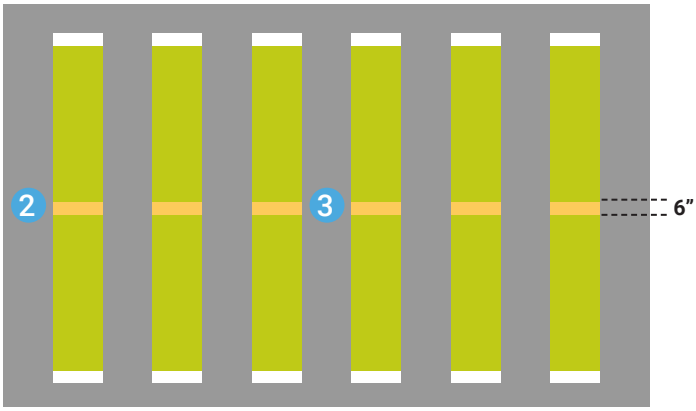
SEPARATED BIKE LANE: BIKE CROSSINGS

A bicycle crosswalk is a marked crossing of an intersection with a street, driveway or alley that delineates a preferred path for people bicycling through the intersection.

One-way SBL Crosswalk



Two-way SBL Crosswalk



TYPICAL APPLICATION

All separated bike lane crossings of streets, alleys and driveways serving greater than 10 vehicles per day.

CONSIDERATIONS

The bicycle crossing may be supplemented with a green-colored surface to improve contrast with the surrounding roadway and adjacent pedestrian crossing, if present. Green surfacing may be desirable at crossings where concurrent vehicle turning movements are allowed.

GUIDANCE

1. For separated bike lane widths, see page 34.
2. A minimum width of 10 feet is recommended for two-way separated bike lanes.
3. A centerline is recommended for two-way separated bike lanes. It should be marked with a 3-foot solid yellow line, with a 9-foot gap.

REFERENCES

NACTO. Urban Bikeway Design Guide. 2nd Edition.

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

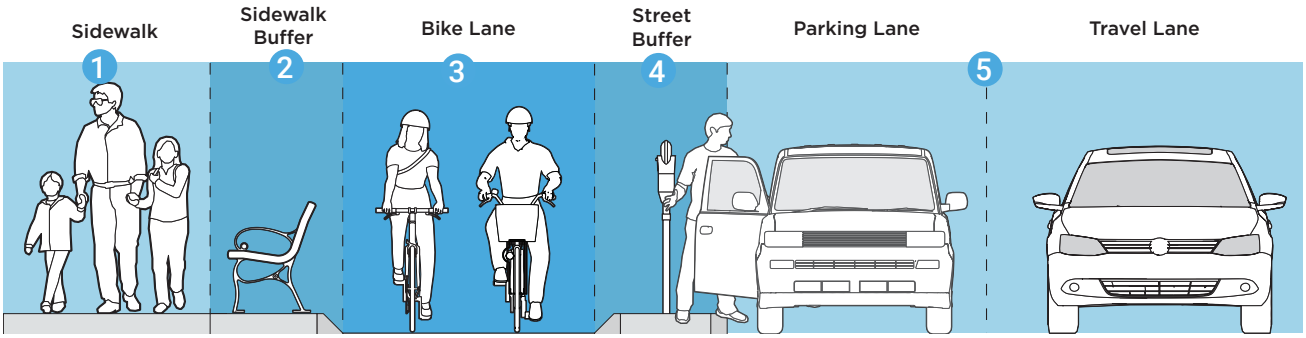
FHWA. Separated Bike Lane Planning and Design Guide. 2015.

DETAILS ON SEPARATED BIKE LANES

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.**



TYPICAL APPLICATION

All separated bike lanes.

GUIDANCE

1. The sidewalk width should be determined by the anticipated peak hour pedestrian volume.
2. The sidewalk buffer is desirable.
3. The bike lane is required and may be at street level, intermediate level or sidewalk level. (See pages 36-41)
   - Bike lane width should be determined by the anticipated peak hour bicycle volume. (See page 34)
   - A minimum shy distance of 1 foot should be provided between any vertical objects in the sidewalk or street buffer and the bike lane.
4. The street buffer is required and should be separated from the street by a median and/or other vertical objects. For minimum dimensions, see page 35.
5. Consider narrowing travel and parking lanes to the minimum widths in constrained corridors.

CONSIDERATIONS

- The street buffer provides safety and comfort for people bicycling and driving by physically separating them from motor vehicles with a series of vertical objects or a raised median.
- The street buffer eliminates the risk of a bicyclist being hit by an opening car door.
- The width of the street buffer influences intersection operations and bicyclist safety.
- A sidewalk buffer minimizes encroachment between the bike lane and sidewalk zones.
- In addition to helping provide space for separated bike lanes, narrowing travel lanes can reduce the operating speed of the roadway.

REFERENCES

NACTO. Urban Bikeway Design Guide. 2nd Edition.

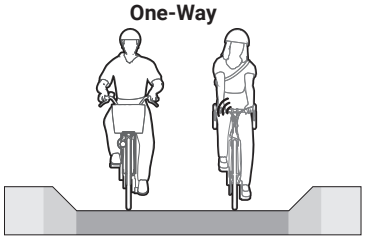
MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

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

SEPARATED BIKE LANE WIDTHS

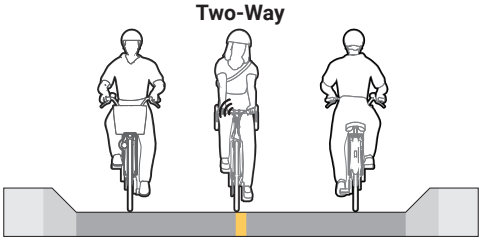
Separated bike lane widths should be chosen based on the anticipated number of bicyclists in the typical peak hour.

One-Way



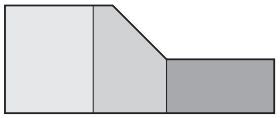
at least 6.5 ft. recommended to enable passing movements

Two-Way

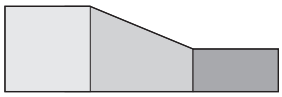


at least 10 ft. recommended to enable passing movements

SBL Curb Options



Beveled slope = 1V:1H



Mountable slope = 1V:4H maximum

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**

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**

TYPICAL APPLICATION

- All separated bike lanes.

GUIDANCE

- Bike lane width should be determined by the anticipated peak hour bicycle volume shown in the tables above.
- The bike lane zone should be sufficiently wide to enable passing maneuvers between bicyclists.
- Beveled or mountable curbs are recommended adjacent to shops and other destinations to ease access to the adjacent sidewalks.
- Standard 6-inch vertical curbs are recommended adjacent to motor vehicle travel lanes and on-street parking to discourage encroachment into the separated bike lane.
- In major activity centers, it is likely that peak hour volumes will exceed 150 bicyclists per hour over time and necessitate wider lanes.

CONSIDERATIONS

- The effective width of the bike lane zone is impacted by the elevation of the bike lane and the design of curbs adjacent to the bike lane.
  - Beveled and mountable curbs provide a forgiving edge, reducing the likelihood of a bicycle crash due to striking a vertical curb.
  - Sidewalk-level bike lanes may allow bicyclists to use part of the street or sidewalk buffer in constrained locations.
- Separated bike lanes generally attract a wider spectrum of bicyclists, some of whom, such as children and seniors, ride at slower speeds.
- Separated bike lanes have been documented to significantly increase bicycling.
- Proximity to objects or vertical curbs along the bike lane edge can reduce the effective width of the bike lane and user comfort.

REFERENCES

NACTO. Urban Bikeway Design Guide. 2nd Edition.

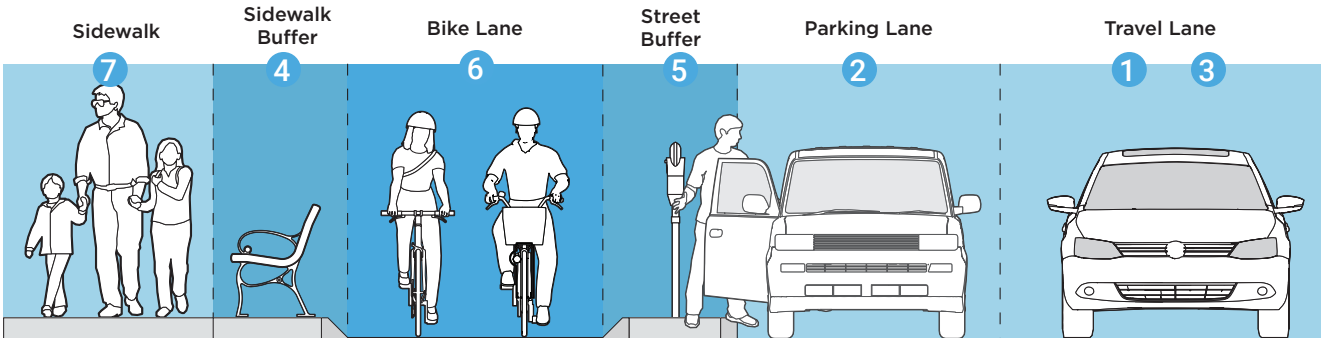
MassDOT. Separated Bike Lane Planning and Design Guide. 2015.

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

People for Bikes. The First Major Academic Study of Protected Bike Lanes in the U.S. is Out. 2014.

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 to achieve a context-sensitive design that safely and comfortably accommodates all users.



GUIDANCE

When making space trade-offs, designers should prioritize maintenance of desired and minimum zone widths in the following order. This general guidance may be flexible, based on adjacent land uses.

1. Narrowing the **travel lane** to minimum widths (10 or 11 feet). In addition to providing space for separated bike lanes, narrowing the travel lane can reduce the operating speed of the road.
2. Eliminating **on-street parking.**
3. Eliminating **travel lanes.**
4. Narrowing or eliminating the sidewalk buffer.
5. 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. See page 23 for intersection dimensions.
6. Narrowing the **separated bike lane** to a minimum width. See page 34 for bike lane widths.
7. Narrowing the **sidewalk** to a minimum width needed to accommodate pedestrian demand, but no less than 5 feet.

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.

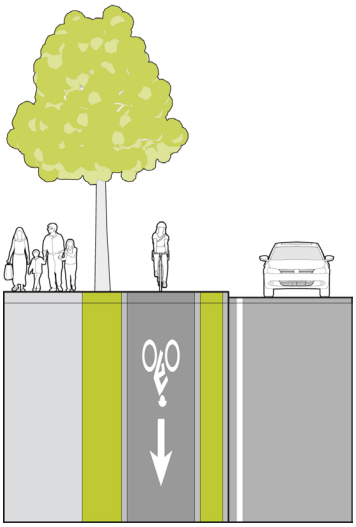
REFERENCES

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

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

SEPARATED BIKE LANES: ONE-WAY AT SIDEWALK LEVEL

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



TYPICAL APPLICATION

- Both sides of two-way streets.
- Right side of one-way streets.

GUIDANCE

- For separated bike lane widths, see page 34.
- To determine priorities in constrained corridors, see page 35.
- A constrained bike lane with of 4 feet may be used for short distances immediately adjacent to transit stops or accessible parking spaces to navigate around them. This constrained bike lane may only occur for the length of the transit stop or accessible parking space(s).
- A significant visual contrast between the sidewalk and bike lane is required when the sidewalk buffer is eliminated.

CONSIDERATIONS

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 rights-of-way.
- Requires no transition for raised bicycle crossings at driveways, alleys or streets.
- Allow use of bike lane as a level landing area for bus stops in constrained corridors with narrow street buffers.
- May reduce maintenance needs by preventing debris build-up from roadway run-off.
- 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.
- Provide intuitive and simplified transitions to existing bike lanes and shared travel lanes (see pages 24-26).

REFERENCES

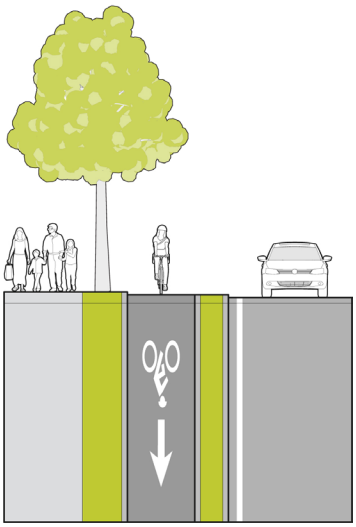
NACTO. Urban Bikeway Design Guide. 2nd Edition.

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

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

SEPARATED BIKE LANES: ONE-WAY AT INTERMEDIATE LEVEL

This treatment provides an exclusive, unidirectional operating space for bicyclists between the street and sidewalk that is physically separated from motor vehicles and pedestrians by vertical and horizontal elements at an elevation below the sidewalk, but above the street.



TYPICAL APPLICATION

- Both sides of two-way streets.
- Right side of one-way streets.

GUIDANCE

- A minimum curb reveal of 2 inches below sidewalk level is required to provide a detectable edge for visually impaired pedestrians.
- The recommended minimum width is 6.5 feet, which allows for passing.
- A constrained bike lane with of 4 feet may be used for short distances immediately adjacent to transit stops or accessible parking spaces to navigate around them. This constrained bike lane may only occur for the length of the transit stop or accessible parking space(s).
- For additional information on separated bike lane width, see page 34.
- To determine priorities in constrained corridors, see page 35.

CONSIDERATIONS

Intermediate level bike lanes:

- Create a separation between bicyclists and pedestrians where sidewalk buffers are eliminated.
- Ensure a detectable edge is provided for people with vision disabilities.
- Make it easier to create raised bicycle crossings at driveways, alleys or streets.
- May reduce maintenance needs by preventing debris build-up from roadway run-off.
- May complicate snow plowing operations.
- May require careful consideration of drainage design and, in some cases, may require catch basins to manage bike lane run-off.
- Provide intuitive and simplified transitions to existing bike lanes and shared travel lanes (see pages 24-26).

REFERENCES

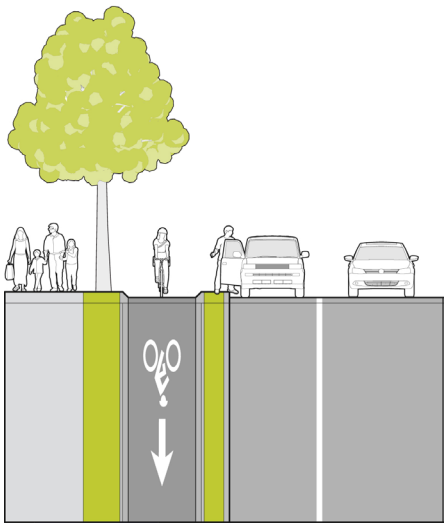
NACTO. Urban Bikeway Design Guide. 2nd Edition.

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

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

SEPARATED BIKE LANES: ONE-WAY AT STREET LEVEL

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



TYPICAL APPLICATION

- Both sides of two-way streets.
- Right side of one-way streets.

GUIDANCE

- The recommended minimum width is 6.5 feet, which allows for passing.
- A constrained bike lane width of 4 feet may be used for short distances immediately adjacent to transit stops or accessible parking spaces to navigate around them. This constrained bike lane may only occur for the length of the transit stop or accessible parking space(s).
- For additional information on separated bike lane width, see page 34.
- To determine priorities in constrained corridors, see page 35.

CONSIDERATIONS

Street-level bike lanes:

- Create a separation between bicyclists and pedestrians where sidewalk buffers are eliminated.
- Ensure a detectable edge is provided for people with vision disabilities.
- May increase maintenance needs to remove debris from roadway run-off 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 run-off.
- Provide intuitive and simplified transitions to existing bike lanes and shared travel lanes (see pages 24-26).

If flexposts are used as the vertical separation element, they must be located and spaced in a manner that prevents motor vehicle encroachment. Closer spacing at intersections, high-turnover parking and/or drop-off areas may be appropriate.

REFERENCES

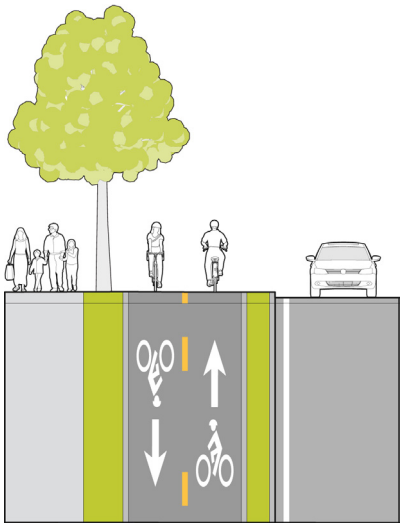
NACTO. Urban Bikeway Design Guide. 2nd Edition.

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

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

SEPARATED BIKE LANES: TWO-WAY AT SIDEWALK LEVEL

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



TYPICAL APPLICATION

- Roadway is greater than 4 lanes in width.
- Both sides of two-way street where destinations exist on both sides and where crossing spacing is infrequent.
- Right side of one-way streets.

GUIDANCE

- A constrained bike lane width of 8 feet may be used for short distances immediately adjacent to transit stops or accessible parking spaces to navigate around them. This constrained bike lane may only occur for the length of the transit stop or accessible parking space(s).
- A significant visual contrast between the sidewalk and bike lane is required when the sidewalk buffer is eliminated.
- For additional information on separated bike lane width, see page 34.
- To determine priorities in constrained corridors, see page 35.

CONSIDERATIONS

Sidewalk level bike lanes:

- May encourage pedestrian and bicyclist encroachment unless discouraged with a continuous sidewalk buffer.
- Maximize usable bike lane width by allowing temporary bicycle use of street or sidewalk buffer.
- Requires no transition for raised bicycle crossings at driveways, alleys or streets.
- Allows use of bike lane as a level landing area for bus stops in constrained corridors with narrow street buffers.
- May reduce maintenance needs by preventing debris build-up from roadway run-off.
- 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.
- Require special attention to transition the contra-flow bicyclist into existing bike lanes and shared travel lanes.

REFERENCES

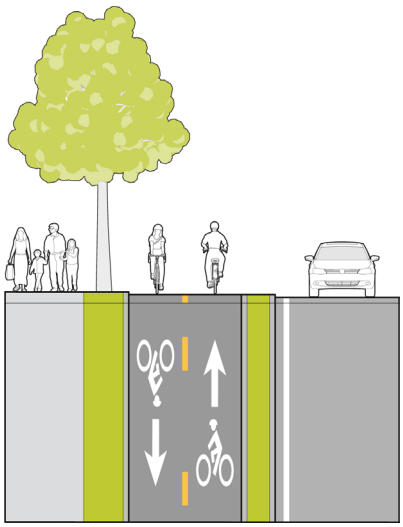
NACTO. Urban Bikeway Design Guide. 2nd Edition.

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

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

SEPARATED BIKE LANES: TWO-WAY AT INTERMEDIATE LEVEL

This treatment provides an exclusive, bidirectional operating space for bicyclists between the street and sidewalk that is physically separated from motor vehicles and pedestrians by vertical and horizontal elements at an elevation below the sidewalk, but above the street.



TYPICAL APPLICATION

- Roadway is greater than 4 lanes in width.
- Both sides of two-way street where destinations exist on both sides and crossing spacing is infrequent.
- Right side of one-way streets.

GUIDANCE

- A minimum curb reveal of 2-3 inches below sidewalk level is required to provide a detectable edge for visually impaired pedestrians. Three inches is the county standard.
- The recommended minimum width is 10 feet, which allows for passing.
- A constrained bike lane width of 8 feet may be used for short distances immediately adjacent to transit stops or accessible parking spaces to navigate around them. This constrained bike lane may only occur for the length of the transit stop or accessible parking space(s).
- For additional information on separated bike lane width, see page 34.
- To determine priorities in constrained corridors, see page 35.

CONSIDERATIONS

Intermediate level bike lanes:

- Create a separation between bicyclists and pedestrians where sidewalk buffers are eliminated.
- Ensure a detectable edge is provided for people with vision disabilities.
- May reduce maintenance needs by preventing debris build-up from roadway run-off.
- May complicate snow plowing operations.
- May require careful consideration of drainage design and in some cases may require catch basins to manage bike lane run-off.
- Require special attention to transition the contra-flow bicyclist into existing bike lanes and shared travel lanes.

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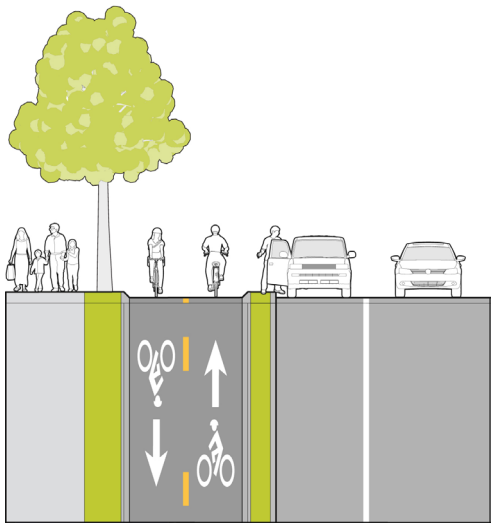
SEPARATED BIKE LANES: TWO-WAY AT STREET LEVEL

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



TYPICAL APPLICATION

- Roadway is greater than 4 lanes in width.
- Both sides of two-way street where destinations exist on both sides and where crossing spacing is infrequent.
- Right side of one-way streets.

GUIDANCE

- The recommended minimum width is 10 feet, which allows for passing.
- A constrained bike lane width of 8 feet may be used for short distances immediately adjacent to transit stops or accessible parking spaces to navigate around them. This constrained bike lane may only occur for the length of the transit stop or accessible parking space(s).
- For additional information on separated bike lane width, see page 34.
- To determine priorities in constrained corridors, see page 35.

CONSIDERATIONS

Street level bike lanes:

- Create a separation between bicyclists and pedestrians where sidewalk buffers are eliminated.
- Ensure a detectable edge is provided for people with vision disabilities.
- May increase maintenance needs to remove debris from roadway run-off 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 run-off.
- Require special attention to transition the contra-flow bicyclist into existing bike lanes and shared travel lanes.

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

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

NEIGHBORHOOD GREENWAY TREATMENTS

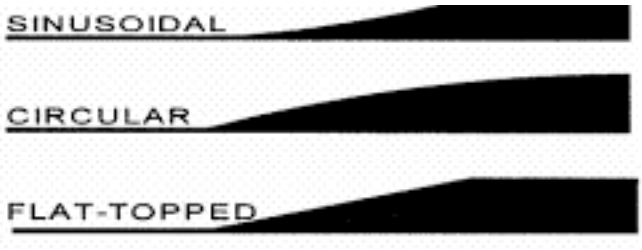
TRAFFIC CALMING VIA RAISED PAVEMENT

Vertical traffic calming forces motorists to drive at slower speeds. These treatments lower the speed differential between bicyclists and cars, increasing bicyclist comfort. They are typically used where 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

TYPICAL APPLICATION

Vertical traffic calming is not necessary on all neighborhood greenways. It should be considered where a street meets the criteria identified by the Montgomery County Department of Transportation for traffic calming.

GUIDANCE

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

CONSIDERATIONS

- Speed humps and raised crosswalks affect bicyclist comfort. The approach profile should preferably be flat-topped, but sinusoidal and circular profiles are acceptable.
- Where traffic calming must not slow an emergency vehicle, speed cushions or raised crosswalks should be considered. Speed cushions provide gaps spaced for an emergency vehicle's wheelbase to pass through without slowing. These gaps also provide a space for bicyclists to pass through unabated.
- Consider using raised crosswalks at intersections to slow traffic turning onto the neighborhood greenway from a major street.

REFERENCES

IPBI, Alta Planning + Design, Portland State University. Bicycle Boulevard Planning and Design Guidebook. 2009.

NACTO. Urban Bikeway Design Guide. 2nd Edition.

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

TRAFFIC CALMING VIA STREET NARROWING

Horizontal traffic calming reduces speeds by narrowing lanes, creating 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 requiring motorists to yield to oncoming traffic.

Chicane

Neckdown

Curb extension

Neighborhood traffic circle

TYPICAL APPLICATION

Street segments or intersections where street width contributes to higher motor vehicle speeds. Especially where:

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

GUIDANCE

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

CONSIDERATIONS

- 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 increasing motorist speeds.
- Costs for infrastructure will range depending on 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.

REFERENCES

IPBI, Alta Planning + Design, Portland State University. Bicycle Boulevard Planning and Design Guidebook. 2009.

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

TYPICAL APPLICATION

- Diversion can be used to reduce motor vehicle traffic on neighborhood greenways to desired volumes:
  - Preferred: 1,000 - 1,500 vehicles per day.
  - Acceptable: up to 3,000 vehicles per day.

GUIDANCE

- Diversion treatments 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.

CONSIDERATIONS

- Diversion is most applicable in areas with a grid of streets to disperse traffic and may not be appropriate in some areas of Montgomery County.
- Diversion shifts 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.
- Where motor vehicle volumes are already within the desired range, diverson may be considered to maintain desired volumes.
- 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.

REFERENCES

IPBI, Alta Planning + Design, Portland State University. Bicycle Boulevard Planning and Design Guidebook. 2009.

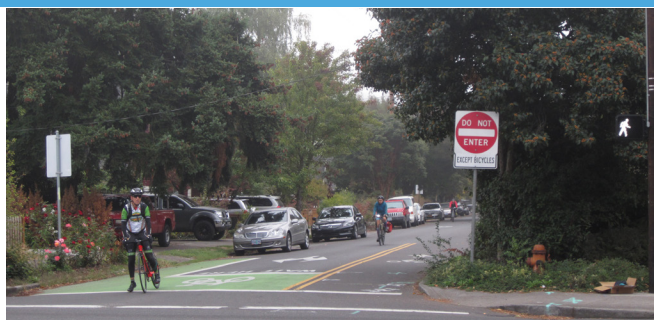
NACTO. Urban Bikeway Design Guide. 2nd Edition.

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

CROSSING TREATMENTS

While the street segments of a neighborhood greenway may be generally comfortable for bicyclists without significant improvement, major street crossings must be addressed to provide safe, convenient and comfortable travel along the entire route. Treatments provide waiting space for bicyclists, control cross traffic or ease bicyclist use by removing traffic control for travel along the neighborhood greenway route.

Off-set intersection bicyclist left turn median diverter



Bicycle box with lead-in bike lane

HAWK beacon

Offset crossing left turn box with lead-in bike lane

TYPICAL APPLICATION

Intersections along a neighborhood greenway route may need treatment in the following situations:

- Unsignalized crossings of arterial or collector streets with high traffic volumes and speeds.
- Offset intersections where the greenway route makes two turns in short succession.
- Two-way stop-controlled intersections where the traffic calming benefit of the stop control is not needed for motor vehicle traffic.

GUIDANCE

Medians should be a minimum of 6 feet in width, although 8 feet is desirable to allow adequate space for a person to wait with bicycle.

CONSIDERATIONS

- Adjustments to traffic control such as a high-intensity activated crosswalK (HAWK) beacon or stop sign adjustments may necessitate a traffic study. HAWK signals are not currently approved for use in Maryland.
- Median islands may be constructed to require right-in/right-out turns by motor vehicles while still allowing left turns by bicyclists at off-set intersections.
- Numerous treatments exist to accommodate offset intersection crossings and the full range of design treatments should be considered in these situations. These treatments include left turn queue boxes, two-way center left turn lanes, median left turn pockets and short sidepath segments.

REFERENCES

IPBI, Alta Planning + Design, Portland State University. Bicycle Boulevard Planning and Design Guidebook. 2009.

NACTO. Urban Bikeway Design Guide. 2nd Edition.

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