City of Bellingham
Bicycle & Pedestrian Toolbox

City of Bellingham WASHINGTON

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ACKNOWLEDGMENTS

STAFF TEAM

Chris Comeau, FAICP-CTP, Transportation Planner, City of Bellingham Public Works Engineering

Chad Schulhauser, P.E., Assistant Director/ City Engineer, City of Bellingham Public Works Engineering

Holly Pederson, ADA Coordinator, City of Bellingham Public Works Facilities

Steve Haugen, Traffic Operations Supervisor, City of Bellingham Public Works Operations

PREPARED BY

Michael Hintze, AICP, Toole Design Group

Quinn Kelly, Toole Design Group

Tyler Wong, PE, Toole Design Group

TOOLE DESIGN

0.1 TABLE OF CONTENTS

0.2 INTRODUCTION

This Bicycle and Pedestrian Toolbox provides **guidance on the application and design of infrastructure to improve safety, comfort, and accessibility for people walking, bicycling, and rolling in the City of Bellingham**. It supplements the guidance provided in the Bellingham Pedestrian and Bicycle Master Plans.

Providing high quality multimodal transportation facilities helps to address transportation equity in the city by expanding transportation options. Walking and cycling provide a mobility option for people who cannot drive a motor vehicle, people who do not have the financial resources to own and maintain a motor vehicle, and people who choose not to drive. They also expand the catchment areas served by bus stops, making transit a more viable option for more people, which supports the goals established in Whatcom Transportation Authority's WTA 2040 Long Range Transit Plan. The development of walking and bicycling facilities also supports the City's transportation mode shift and greenhouse gas reduction goals, adopted in the Bellingham Comprehensive Plan and Climate Protection Action Plan, by making walking and bicycling a more attractive travel option for a greater number of trips. Finally, the Toolbox includes substantial guidance on improving the accessibility of transportation facilities for people with disabilities, supporting the goals of the City's 2021 Mobility for All ADA Transition Plan.

The Toolbox presents a menu of potential treatments that may be used to support the City's multimodal transportation goals. It is not intended to be an exhaustive resource for technical information on when and how to make use of the treatments included. In addition to high level guidance and considerations for each treatment, the Toolbox includes references to other guidance documents from FHWA, NACTO, AASHTO, and other local and state agencies where more information can be found for that treatment. **Existing City of Bellingham standards were integrated and should be the first source of information** when considering any of the included treatments. **Design guidelines are flexible and should be applied using professional judgment.**

The Toolbox is organized into three sections: **Pedestrian Facilities, Bicycle Facilities, and Intersections & Crossings**. The Pedestrian Facilities addresses linear facilities for people walking and rolling. The Bikeways section includes updated guidance on the design of Separated Bicycle Lanes and Bike Boulevards to help identify solutions to upgrade the City's bicycle network to accommodate people of all ages and abilities. The Intersections & Crossings section includes a wide variety treatments to reduce and eliminate conflicts between different road users where facilities intersect, including updated guidance on uncontrolled crossings.

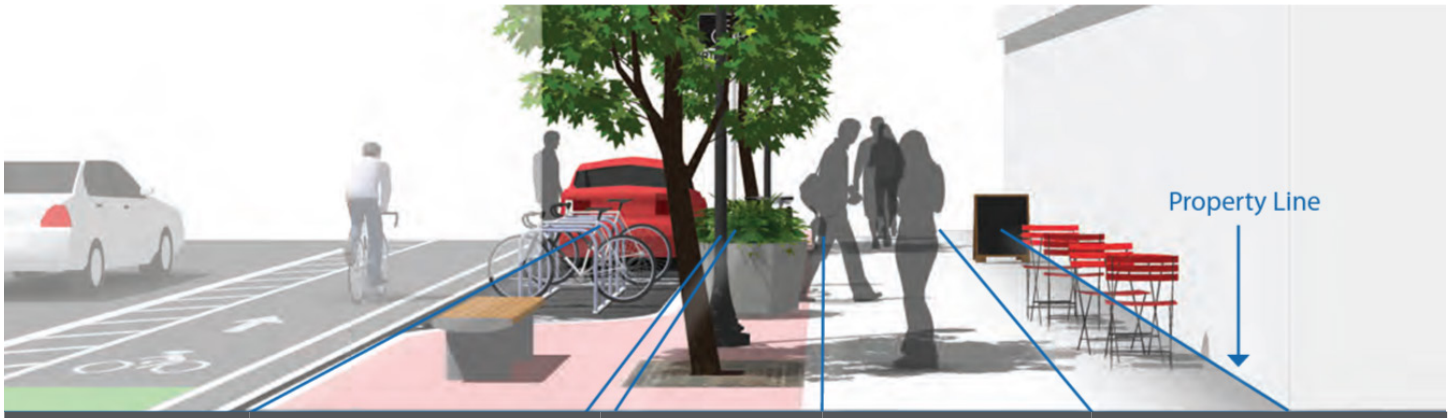
Pedestrians crossing W Chestnut St at Bay St

1 PEDESTRIAN FACILITIES

The provision of facilities to accommodate pedestrians along and crossing roads is essential for the safe movement of people walking or rolling. This section provides guidance on the selection and design of pedestrian facilities relevant to Bellingham streets.

Pedestrian crossing Commercial St at Flora St

1.1 SIDEWALK



Street Classification	Parking Lane / Enhancement Zone		Furnishing Zone	Pedestrian Access Route (PAR)	Frontage Zone	Total
Local Streets	Varies	.5 ft Curb	0 - 5 ft	5 ft	N/A	5.5 - 10.5 ft
Commercial Areas	Varies		4 - 6 ft	5 - 12 ft	2.5 - 10 ft	12 - 28.5 ft
Arterials & Collectors	Varies		2 - 6 ft	5 - 8 ft	2.5 - 5 ft	10 - 19.5 ft

GUIDANCE

» **Accessibility.** Standards for sidewalks are outlined by the Americans with Disabilities Act (ADA) and the Proposed Public Right-of-Way Accessibility Guidelines (PROWAG) currently in development by the Access Board. Though PROWAG is not fully approved or enforceable at the time of this writing, standards and recommendations laid out are best practices and should be followed where possible.

» **Design.** In addition to minimum design standards (see Municipal Code Chapter 13.04), additional elements should be included where possible to provide a more comfortable and accessible sidewalk. Widening sidewalks in areas with constrained right-of-way may require parking removal or reconfiguration. Sidewalk features are organized into distinct zones, and the table above provides preferred widths for each sidewalk zone according to street type:

- **Parking Lane/Enhancement Zone**. A flexible space to further buffer the sidewalk from moving traffic. Curb extensions and bike corrals may occupy this space.
- **Furnishing Zone**. Buffers pedestrians from the adjacent roadway and provides space for street trees, signal poles, signs, and other street furniture.
- **Pedestrian Accessible Route**. Free of permanent and temporary objects. Municipal Code also refers to this area as the "movement zone." In areas where pedestrian volumes are higher a greater width should be used.
- **Frontage Zone**. Provides pedestrians a comfortable "shy" distance from the building fronts. Can be used for window shopping, sign placement, planters, or chairs. Must provide a detectable edge to accommodate cane users who use the side of buildings to navigate.

» **Urban Villages.** Refer to subarea plans for sidewalk widths and standards in urban villages (Municipal Code Ch. 20.37).

CONSIDERATIONS

» **Connectivity**. Building a connected network of sidewalks is important to provide safe and accessible routes for pedestrians. Sidewalks should be planned and built with the understanding of how they will terminate and connect to other existing links to avoid gaps or abrupt ends.

» **Drainage**. When building a new sidewalk, drainage flow paths can be disrupted. It is important that drainage is designed and accounted for in the design of new sidewalks, especially at ramps to prevent ponding and sediment build up in the pedestrian path of travel.

» **Driveway Conflicts**. Where sidewalks cross driveways, flares and ramps should be kept out of the accessible route to avoids constant elevation changes where driveway frequency is high. Refer to Driveways section of the WSDOT Field Guide for Accessible Public Right of Way.

REFERENCES

NACTO Urban Street Design Guide (2013)
WSDOT Field Guide for Accessible Public Right of Way (2012)
Public Right-of-Way Accessibility Guidelines (PROWAG) (2023)
Bellingham Commercial Right-of-Way User Permits Guide (2021)

1.2 SHARED USE PATH

Shared use paths are designed for bicyclists, pedestrians, and other non-motorized users and are preferred by more cautious cyclists due to their complete separation from vehicular traffic. Shared use paths provide a network of off-road transportation routes for bicyclists and other users that extends and complements the on-road bicycle network. Shared use paths are most commonly designed for two-way travel, and the guidance herein assumes a two-way facility. Shared use path design is similar to roadway design, following many of the same core design precepts but on a different scale and with typically lower design speeds.

Shared use path along Kellogg Rd

GUIDANCE

» **Width and Separation.** The appropriate paved width for a shared use path depends on the context, volume, and mix of users. Widths typically range from 10 to 14 ft. Paths wider than 10 ft allow people traveling single file to pass someone coming from the opposite direction. Paths wider than 11ft allow for people to travel side-by-side and be passed by someone coming from the opposite direction. Separation of bicyclists and pedestrians may need to be considered on shared use paths, when higher volumes of children, seniors, or individuals with disabilities are likely to be present, or where faster bicycle speed is anticipated to serve longer distance bicycle travel. For more information, see the FHWA Shared-Use Path Level of Service Calculator.

» **Pinch Points.** Minimum path widths should only be used for short distances to accommodate physical constraints, such as an environmental feature, bridge abutment or pier, utility structure, property fence, building structure, or limited public right-of-way where a wider path is not practical or where negative environmental impacts associated with a preferred path width cannot be mitigated. Path users should be notified of upcoming narrowed width via advanced signage where user volumes are likely to result in conflict.

» **Enhancing and Reducing Crossings.** For shared use paths on independent alignments, crossings occur at mid-block roadway locations and are often unsignalized. When necessary, enhanced crossing treatments like Rectangular Rapid Flashing Beacons, Pedestrian Hybrid Beacons (Multi-lane streets only), Crossing Islands, or Raised Crossings, should be considered to provide additional awareness of the trail crossing. Reducing road crossings can increase safety and reduce travel times, and shared use paths can be grade-separated from crossings (e.g., highways, rail lines) with their own structure or incorporated into highway bridges or tunnels. In cases where path user volumes are high, assignment of right of way that favors the shared use path should be considered.

CONSIDERATIONS

» **Surface.** Shared use paths should be stable, firm and slip resistant and be accessible to and usable by individuals with disabilities. All-weather concrete, asphalt pavement, or permeable pavement surfaces are generally preferred over surfaces of crushed aggregate, sand, clay, or stabilized earth. On shared use paths, loads should be substantially less than on roadways. However, to prevent pavement damage, shared use paths should be designed to sustain wheel loads of occasional emergency, patrol, maintenance, and other motor vehicles that are expected to use or cross the path. Pavement and subsoil should also be designed to resist root heaving when located near trees.

Recreational Trails

In addition to paved, transportation-oriented shared use paths, Bellingham also has a robust network of recreational trails which are managed by the Parks and Recreation Department. These trails are used by people walking and biking for transportation, but are primarily designed for recreation. They have different standards for design and maintenance.

1.2 SHARED USE PATH (CONT.)

» **Pavement Markings.** A consistent approach to striping along shared use paths provides guidance to trail users and can increase awareness of conflicts. Signs may also be used to remind bicyclists to pass on the left and to give an audible warning prior to passing slower users.

» **Clearances.** A graded shoulder with a 5 ft preferable (2 ft minimum) width, with a maximum cross-slope of 1V:6H should be provided on both sides of all shared use paths. The shoulder should be clear of all lateral obstructions such as bushes, large rocks, bridge piers, abutments, and poles. Where continuous "smooth" features, such as bicycle railings or fences, are introduced, a lesser clearance (1 ft minimum) is acceptable. In constrained conditions, clearances to lateral obstructions may be eliminated to maximize the paved width of the shared use path and a white edge line may be beneficial to identify the hazard. The MUTCD requires a minimum 2-ft clearance to post-mounted signs or other traffic control devices located adjacent to the shared use path. Physical barriers or railings are recommended where the path edge is less than 5 ft from the top of a slope equal or steeper than:

- Slopes 1V:3H, with a drop of 6 ft or greater
- Slopes 1V:3H, adjacent to a parallel body of water or other substantial obstacle
- Slopes 1V:2H, with a drop of 4 ft or greater
- Slopes 1V:1H, with a drop of 1 ft or greater

» **Grades and Drainage.** The minimum recommended pavement longitudinal grade of 0.5 percent and cross slope of 1 percent with an even surface usually provides adequate drainage and prevents ponding and ice formation. Shared use path grades must be accessible to and usable by pedestrians with disabilities. While final standards have not been adopted, the U.S. Access Board's Supplemental Notice of Proposed Rulemaking (SNPRM) on shared use paths provides the best available information on accessibility. On unpaved paths, particular attention is required to drainage to avoid erosion and ponding. Shared use paths with cross slope in the direction of the existing terrain will typically provide sheet flow of surface runoff and avoid the need to channelize flow. However, where a path is constructed on the side of a slope that has considerable runoff or other conditions that result in relatively high runoff, a ditch should be placed on the uphill side to intercept the slope's drainage.

» **Lighting.** Pedestrian-scale lighting on shared use paths can improve visibility, increase feelings of personal security, and reduce crashes. Lighting should be considered on regionally significant paths and paths that serve a transportation purpose. Where lighting isn't warranted all night, a study of usage can determine scheduled hours to provide it. These conditions should be made known to path users with a sign at path entrances. At a minimum, lighting should be provided at roadway crossings and on key segments to address safety concerns if night use is expected.

» **Restricting Motor Vehicles.** Unauthorized use of shared use paths by motor vehicles can degrade pavement quality and conflict with trail users (most electric bicycles are not considered motor vehicles). The NO MOTOR VEHICLES (R5-3) sign can be used to reinforce the rules. Additionally, shared use path points of entry can be designed so their appearance clearly indicates it is not for vehicle access and makes intentional access difficult. A preferred method is a conspicuous center island that splits the entry way into two sections no more than 6 ft wide separated by low landscaping and delineated with solid line pavement markings to guide the path user around the split. The center island should be designed to allow emergency and maintenance vehicles to enter the shared use path by straddling the island. Bollards are only recommended as a last resort when there is a documented history of unauthorized intrusion by motor vehicles with no other alternative design. If used, bollards should be marked with retroreflective material or with appropriate object markers, as described in the MUTCD.

REFERENCES

WSDOT Design Manual Chapter 1515 Shared Use Paths (2022)
ODOT Multimodal Design Guide (2022)
AASHTO Guide for the Development of Bicycle Facilities (2012)
FHWA Shared-Use Path Level of Service Calculator (2006)
Manual on Uniform Traffic Control Devices (MUTCD) (2012)

1.3 SIDEPATH

Side paths are a closely related sub-category of shared use paths. Unlike shared use paths, which are located within independent alignments that result in midblock road crossings, side paths run parallel to a roadway resulting in the path crossing at the intersection of two or more roadways. Crossing movements are usually controlled by the larger intersection control (e.g., signal, stop signs).

GUIDANCE

» **Design.** Sidepath design should follow shared use path design for features including striping and shoulder offsets. Sidepath section and materials may follow those used typically for sidewalks. Similarly drainage follows practices uses for sidewalks, and water is usually directed to flow to the gutter line and into street drainage systems.

» **Width.** Sidepath widths should generally follow the same guidelines as those for Shared Use Paths.

CONSIDERATIONS

» **Use.** Rather than a shared sidepath, separated or buffered bicycle lanes should also be provided as a preferred, more transportation-oriented bikeway whenever possible.

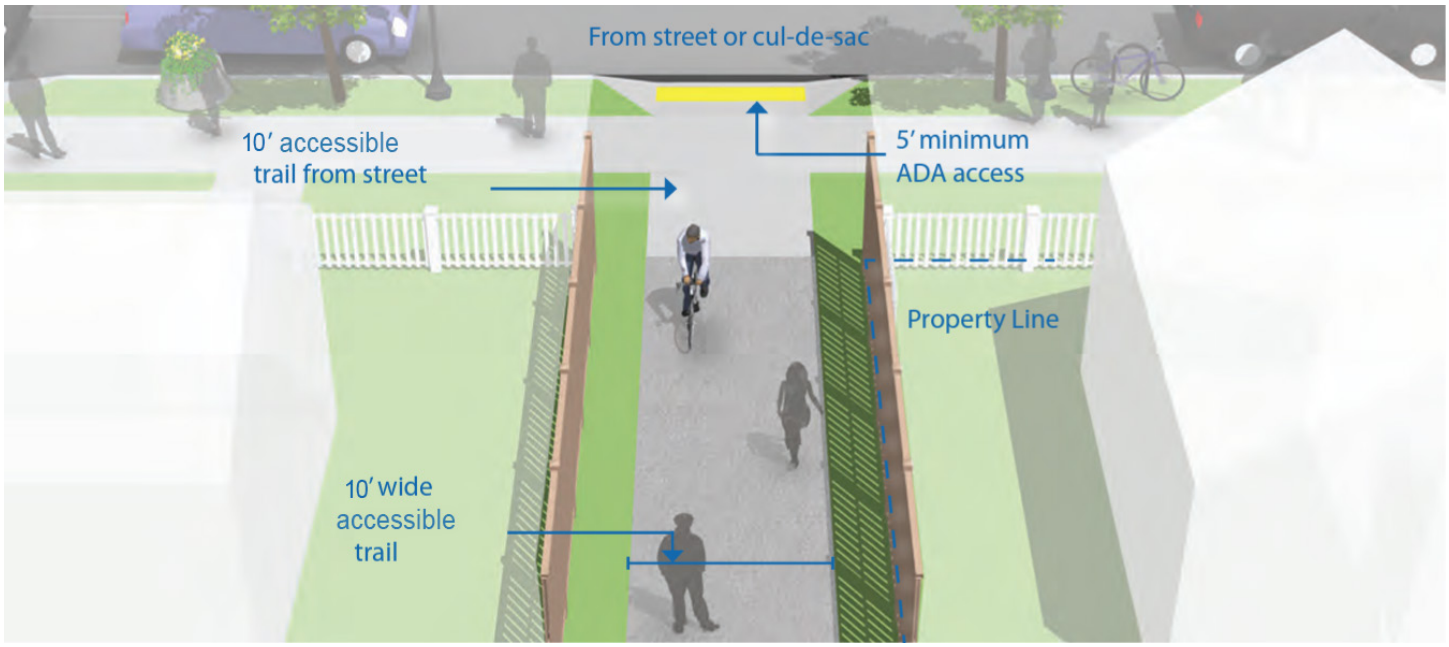
» **Intersections.** Two-way sidepaths introduce many challenges with managing turning conflicts, especially along two-way streets. The geometric and operational design of sidepaths at intersections closely follows best practices for separated bicycle lanes and protected intersections. When a sidepath continues through an intersection, and pedestrians and people on bikes continue to function in a mixed environment, all users should be directed to use marked crosswalks and follow pedestrian signals. At intersections with high pedestrian and bicycle volumes, or where on-street bike facilities connections are made, the sidepath can transition to separated bike lanes prior to the intersection and directional bike crossing markings and signals can be provided to reduce conflicts.

REFERENCES

WSDOT Design Manual Chapter 1515 Shared Use Paths (2022)
ODOT Multimodal Design Guide (2022)
AASHTO Guide for the Development of Bicycle Facilities (2012)
FHWA Shared-Use Path Level of Service Calculator (2006)
Manual on Uniform Traffic Control Devices (MUTCD) (2012)

1.4 LOCAL NEIGHBORHOOD ACCESSWAY

Neighborhood accessways provide direct pedestrian access in residential areas to commercial services, parks, trails, green spaces, and other recreational areas. They most often serve as small path connections to and from the larger trail network. Additionally, these smaller trails can be used to provide bicycle and pedestrian connections between dead-end streets, cul-de-sacs, and access to nearby destinations not provided by the street network.



GUIDANCE

» **Width and Access.** Neighborhood accessways should be at least 10 feet wide to accommodate emergency and maintenance vehicles. They should also meet ADA requirements and be considered suitable for multi-use. Trail widths should be designed to be less than 10 feet wide only when necessary to protect large mature native trees, wetlands or other ecologically sensitive areas.

» **Wayfinding.** Signage providing direction and wayfinding should be placed in conjunction with larger routing through neighborhoods for shared street networks or Bike Boulevards to direct people walking and biking through neighborhood accessways. Localized signage at the beginning of dead-end streets and cul-de-sacs with accessways for people walking and bicycling should supplement any NO OUTLET or DEAD END signs with the EXCEPT BIKES AND PEDS plaque to bring awareness of the connection. Additionally signage at the entrance to the neighborhood accessway can call attention to its location and where it connects.

CONSIDERATIONS

» **Ownership and Opportunities.** Neighborhood accessways should be located in public right of way or within an easement that allows for public access at all times. They should be designed into new subdivisions at every opportunity. For existing subdivisions, Neighborhood and homeowner association groups are encouraged to identify locations where such connections would be desirable.

» **Visibility and lighting.** Designing accessways so users can clearly see to the other end increases feelings of personal security, while also providing a safe entry and exit of the accessway onto local roadways. Additional lighting may be necessary since neighborhood accessways are often setback from typical street lighting placement. Where accessways are lined with tall hedges or privacy fences, lighting is increasingly important.

1.5 ALTERNATIVE WALKWAY

In some locations, a full raised sidewalk with curb and gutter cannot be built due to site constraints or costs, but street characteristics like accessibility, or vehicle speed or volume may warrant a separate space for pedestrians to travel. In these instances, alternative walkways can provide dedicated space for pedestrians, either by delineating exising street space or creating a parallel paved path. See Alternative Walkway Selection (1.6) for guidance on selecting a facility type. See Edge Treatment Materials Selection (1.7) for guidance on what type of barrier should be used, when applicable.

Alternative Walkway with wheel stops, Seattle, WA

Barrier separated walkway with parking stops and flex posts, Seattle, WA

Alternative Walkway with asphalt curb, Alderwood Ave

CONSIDERATIONS

» **Recognizability**. For walkways located within the existing roadway, signage, symbols, or surface treatments can be used to alert users that the space is intended for pedestrian use. Common tools include thermoplastic pedestrian symbols or wayfinding signage at the beginning of the walkway or thermoplastic or Methyl Methacrylate (MMA) paint along the entire length of the facility to differentiate it from the street surface.

» **ADA Accessibility**. Walkways intended for pedestrian use must provide a 6 ft minimum continuous clear width, a maximum grade consistent with the road grade, a maximum 2-percent cross slope, and a firm, stable, and slip-resistant surface. Detectable warning surfaces must also be used at intersections, and major driveways with comparable volumes to that of an intersection, to warn pedestrians at crossing locations on barrier-separated and buffer-separated walkways. Tactile warning surfaces should meet the requirements of Section R305 of PROWAG. They should be a minimum width of 24 inches in the direction of pedestrian travel and should extend the full width of the walkway.

» **Intersections and Crossings**. Like conventional sidewalks, intersections and crossings have additional factors to consider. Alternative walkways should be designed to provide a safe transition to crossings or adjacent facilities that are protected from turning vehicle traffic.

» **Maintenance**. Delineating pedestrian space separate from vehicle traffic may interfere with existing maintenance procedures, so it is important to create a maintenance plan. Snow and debris (leaves, branches, etc.) removal are two common issues. Long term upkeep and replacement of the edge treatment must also be considered.

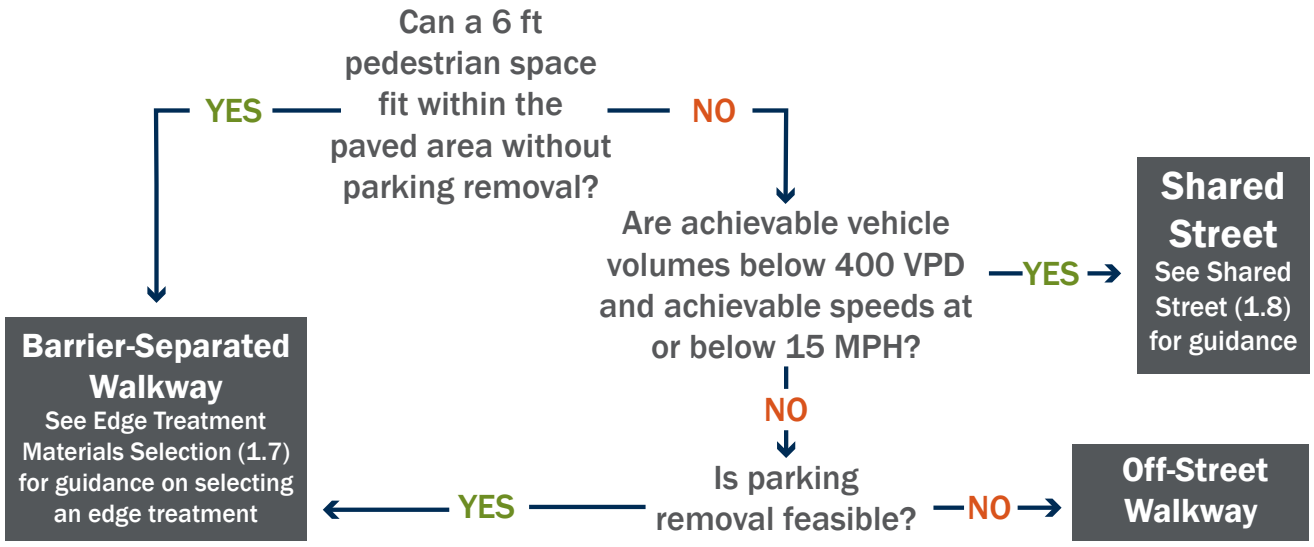
» **Drainage**. One benefit of alternative sidewalks is drainage patterns are usually maintained and no new drainage structures are required. It is important that drainage cuts are provided within the edge treatment to allow water from the road and alternative walkway to drain.

REFERENCES

Seattle Right-of-Way Improvement Manual (2017)
NACTO Urban Street Design Guide (2013)
Ohio DOT Multimodal Design Guide (2022)

1.6 ALTERNATIVE WALKWAY SELECTION

The decision tree below provides guidance on what type of pedestrian facility may be appropriate, or is needed, on a local access street. When deciding whether to implement an alternative walkway, roadway width is an important consideration. Based on the guidance provided for each walkway type, the minimum space required for a pedestrian-only facility (inclusive of minimum and maximum buffer/barrier spaces) can range from 6 ft to 8 ft, and shared bicycle and pedestrian facilities can be between 8 ft and 12 ft, depending on the edge treatment. See Alternative Walkway (1.5) for additional design considerations and Edge Treatment Materials Selection (1.7) for guidance on selecting a barrier type.



CONSIDERATIONS

» **Shared Use Facilities.** On streets with no bicycle facilities, some bicyclists are likely to use the separated walkway as a bicycle lane. As part of the walkway design, staff should collect pedestrian and bicycle counts, conduct field observations, and perform a bicycle network analysis to determine if additional width is needed to minimize conflicts between pedestrians and bicyclists. Shared-use facilities should be a minimum width of 8 ft, with a preferred width of 10 ft of clear space to accommodate bicyclists.

» **Barrier Separated and Off-Street Walkways.** For more guidance on Barrier-Separated Walkways and Off-Street Walkways, see Alternative Walkway (1.5).

ASSUMPTIONS

» "Achievable" vehicle volumes refers to predicted vehicles per day (VPD) after acceptable traffic diversion or traffic calming measures are in place on local access streets.

» This decision tree assumes that vehicular travel and parking lanes will be narrowed to the minimum allowable width. Local access streets should include a travelway that is at least 16 ft wide.

» Providing a walkway should be prioritized over the provision of on-street parking

» Widths for pedestrian space reflect constrained minimums on one side of the street only.

» This decision tree also assumes that there are not currently funded or planned sidewalks.

REFERENCES

FHWA PEDSAFE Pedestrian Safety Guide and Countermeasure Selection System (2013)

AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities (2021)

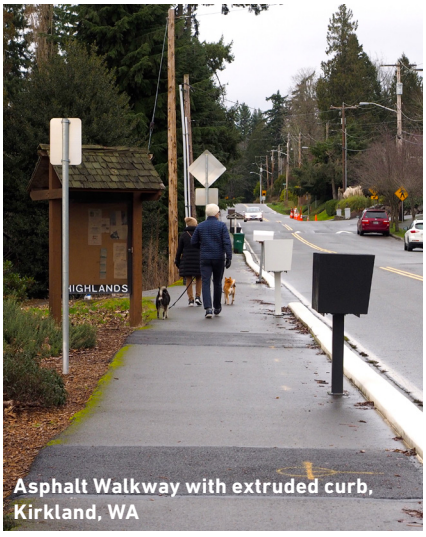
Pedestrian and Bicycle Information Center (PBIC) SRTS Guide: Sidewalks (2015)

1.7 EDGE TREATMENT MATERIALS SELECTION

Delineation is important to separate dedicated pedestrian and bicycle space from the roadway. Treatments should be tactile and continuous where possible to provide an edge for visually impaired pedestrians to follow. Treatments that do not provide a detectable edge will require additional measures (i.e. detectable directional strips) for accessibility. The type of material used for physical separation is an important consideration when implementing barrier-separated bikeways or walkways. Vertical elements can vary relative to cost, durability, protection level, and required width, which are compared in the table below. More durable materials, such as concrete curbing, are recommended at intersections and corners. Delineator posts should be used in conjunction with concrete curbing to decrease the likelihood that they will be hit by vehicles. When less durable materials such as delineator posts and rubber curbing are used, it is important to plan for more regular maintenance. The table below compares the relative cost, durability, level of protection, and minimum required width for different edge treatments.

	FLEX POSTS	PARKING STOPS + FLEX POSTS	RIGID BOLLARDS	PLANTERS / LAND-SCAPING	EXTRUDED ASPHALT CURB	CAST IN PLACE CURB	PRECAST BARRIER CURB
Installation Cost	$-$$	$$-$$$	$$ - $$$$	$$ - $$$$	$$$	$$$$	$$$$
On-going Maintenance Needs	High	Medium	Medium	High	Low	Low	Low
Level of Protection	Low	Fair	Good	Good	Great	Great	Great
Minimum Width	1.5 ft	1.5 ft	2 ft	3 ft	8 in	8 in	8 in

Alternative Walkway with wooden curb and detectable warning surface, Chevy Chase, MD


Asphalt Walkway with extruded curb, Kirkland, WA


Painted walkway adjacent to bike lane with detectable directional strip, Seattle, WA

REFERENCES

NACTO Urban Street Design Guide (2013)

1.8 SHARED STREET

Conditions on certain streets may not warrant designated spaces for each user and pedestrians, bicyclists, and motor vehicles may all share the same street space. Shared streets use various design elements to blur the boundary between pedestrian and motor vehicle space. The design should create conditions where pedestrians and bicyclists can walk or ride on the street and cross at any location, as opposed to at designated locations. This encourages cautious behavior on the part of all users, which in turn reinforces slower speeds and comfortable walking and bicycling conditions. Design features may be similar to Bike Boulevards, and many of the elements can be used interchangeably between them with the same characteristics of a low-volume, slow-speed space where all users sharing the road.

Shared street with chicanes, Seattle, WA

GUIDANCE

» **Managing Volumes and Speeds**. Motorist design speeds should not exceed 15 mph and volumes should not exceed 400 vehicles per day. For streets that do not meet this criteria but are intended to serve as shared streets, significant traffic calming and diversion may be required to adjust motorist speed and/or volume to meet these criteria.

» **Coherence and Predictability**. Design details should communicate clearly that the shared street is a multimodal environment where pedestrians are given priority. On shared streets, the lack of predictability of all users heightens awareness, thereby creating lower vehicle speeds and reducing conflicts. Centerlines should be removed if present.

REFERENCES

FHWA Accessible Shared Streets (2017)
ODOT Multimodal Design Guide (2022)
FHWA Achieving Multimodal Networks (2016)

CONSIDERATIONS

» **Gateways**. Intersection features like Curb Extensions (3.4), Raised Crossings (3.5), Median Refuge Islands (3.3), traffic circles, parking daylighting markings, and signage can be used to alert motorist that they are entering a shared street. Where lower speed limits are authorized, a Speed Limit sign (R2-1) should be located at the beginning of the shared street and on each block where the reduced speed limit applies to ensure motorists are aware of the reduced limit.

» **Mid-Block Traffic Calming.** Treatments such as pinch points, chicanes, speed humps, and speed cushions can be used to reduce design speeds and discourage cut-through traffic to achieve desired vehicular speeds and volumes.

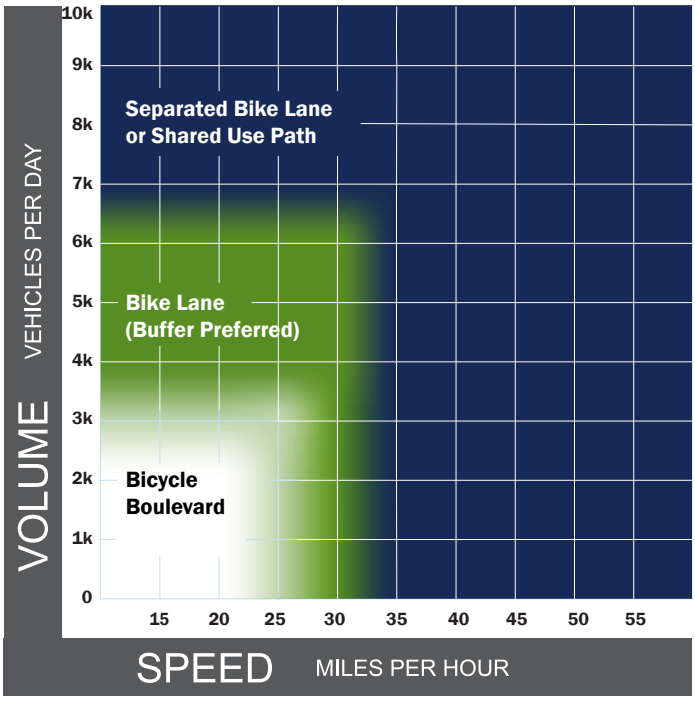
» **Accessibility.** Shared streets, which remove barriers between drivers and pedestrians, can result in an ambiguous and potentially difficult experience for pedestrians with vision disabilities. Detectable edges and detectable changes in surface texture can help mitigate these issus (see FHWA Accessible Shared Streets for guidance).

2 BIKEWAYS

Bikeways should provide a safe and comfortable experience that supports and encourages diverse users. This section provides guidance on the selection and design of bikeways for different contexts and roadway characteristics. Bellingham uses the term "bikeways" to refer to the entire spectrum of facility types that comprise the bicycle network.

Cyclists on N State St at E Holly St

2.1 BIKEWAY SELECTION



Notes

1 *Chart assumes operating speeds are similar to posted speeds. If they differ, use operating speed rather than posted speed.*

GUIDANCE

» **Bikeway Selection**. The selection of a preferred bikeway requires a balance of data analysis and engineering judgment working within relevant constraints for the project. Proximity to motor vehicle traffic is a significant source of stress and discomfort for bicyclists. As mentioned, crash and severe injury risks sharply rise for vulnerable users when motor vehicle speeds exceed 25 mph. Further, as motorized traffic volumes increase above 6,000 vehicles/day, it becomes increasingly difficult and uncomfortable for motorists and bicyclists to share roadway space. For example, on a roadway with 10,000 vehicles/day, a bicyclist traveling at 10 mph will be passed approximately every four seconds by a motor vehicle during the peak hour. While there are no physical barriers in place separating people biking from motor vehicles on Bike Boulevards, the very low instances of vehicles passing makes these streets high-comfort facilities as well. The chart above identifies bicycle facilities that improve the operating environment for people who are interested in but concerned about bicycling in Bellingham at different roadway operating speeds and traffic volumes.

» **Design Users.** People who bike are influenced by how comfortable they are using the street. The provision of low-stress, connected bikeways often improves a user's safety and accommodates biking for a broader range of people. As such, designing for the widest range of users will best accommodate the majority of users. To design a multimodal transportation system that works for all people, the design process must account for basic factors such as destination demand, safety, and comfort, as well as human factors such as a person's physical abilities, experience, and their ability to perceive and react to potential conflicts.

» **Conditions for Increasing Separation.** There are a variety of other considerations that may indicate the need for greater separation between bicyclists and motor vehicles (such as additional buffer width, additional vertical buffer elements, or other measures). These include:

- Unusually high motor vehicle peak hour volumes
- Traffic vehicle mix (higher percentages of trucks and buses)
- High parking turnover and curbside activity
- Vulnerable populations (i.e. children and seniors)
- Network connectivity gaps (i.e. on-street connections between two shared use paths)
- High bicyclist volumes

2.2 BIKE BOULEVARD

Bike boulevards are residential local access streets that are designed to optimize bicycle travel through neighborhoods and connect to bikeways on arterial streets. Bellingham's residential streets typically have low volume motor vehicle traffic (less than 2,000 vehicles per day), and the vehicles present are typically making local trips and are traveling at slow speeds (20-25 mph). Where necessary to maintain slower vehicle speeds, Bike boulevards typically include traffic calming features and may include green infrastructure to manage stormwater.

Texas St Bike Boulevard

Treatment	Volume Management	Speed Management
Horizontal Deflection		
Curb Extension	—	○
One-Lane Pinch Points	◒	◒
Chicanes	○	◒
Neighborhood Traffic Circles	—	◒
Median Islands	—	◒
Horizontal Deflection		
Speed Humps/Cushions	◒	●
Raised Crossing	◒	●
Traffic Diverters		
Signs and Markings	○	—
Diagonal Diverter	●	◒
Major Street Refuge Island	●	—
Forced Turn	●	◒

Potential effectiveness

● High ○ Low

◒ Medium — None

GUIDANCE

» **Thresholds.** To minimize conflicts and the frequency of motorists passing bicyclists, bicycle boulevards should meet the following guidelines for volumes and operating speeds:

	Peak Hourly Traffic Volume (vehicles/hr)	Average Daily Traffic Volume (ADT)	Operating Speed (mph)
Preferred	150	1,000	15
Acceptable	300	2,000	20
Maximum	450	3,000	25

» **Wayfinding**. Along Bike Boulevards, pavement markings and wayfinding signs help give a visual identity to the corridor and differentiate from other nearby streets. They also provide route information including time and distance to destinations. See Bicycle Wayfinding (2.10) for guidance.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)

NACTO Urban Bikeway Design Guide (2014)

Manual on Uniform Traffic Control Devices (MUTCD) (2012)

Fundamentals of Bicycle Boulevard Planning & Design (2009)

Bellingham Bicycle Wayfinding Plan (2016)

CONSIDERATIONS

» **Users.** When Bike Boulevards meet the preferred thresholds for volume and operating speed, they are generally attractive to bicyclists of all ages and abilities.

» **Stop Controls.** For Bike Boulevards to serve as efficient routes for longer distance travel, they should minimize the need for bicyclists to stop at crossings of local streets while being careful not to encourage vehicle short cutting.

» **Crossings.** To reduce the likelihood of risky crossing behaviors, arterial street crossings should consider enhancements and safety improvements. Safe and comfortable crossings can be achieved by naturally occurring gaps, by installing active warning or geometric designs which induce motorist yielding, or by installing traffic control signals that require motorist to stop.

» **Offset Intersections**, where bicyclists may need to make turns or travel a brief distance along an arterial street, require special consideration and treatments to provide a continuous, comfortable path for bicyclists.

2.3 MARKED BICYCLE LANE

Marked bicycle lanes are a portion of an arterial street designated for use by bicyclists. Bellingham marked bicycle lanes are typically 5' wide with a 4" to 8" stripe at the outer edge of the vehicle lane with bicycle symbol markings placed at regular intervals. Marked bicycle 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. See also Bicycle Climbing Lanes (2.4). Marked bicycle lanes comprise about 40% of Bellingham's bicycle network.

Marked Bicycle Lane on Northwest Ave

GUIDANCE

» **Width.** The minimum width of marked bicycle lanes adjacent to a curb or parking is 5 ft, with a more desirable width of 6 ft. The minimum combined width of a parking lane and marked bicycle lane on an arterial street is 14 ft.

» **Placement.** On one-way streets, bike lanes should typically be on the right-hand side of the roadway. A bike lane may be placed on the left side if there are a significant number of left-turning bicyclists or if a left-side bike lane would decrease conflicts with bus stops, heavy right-turn movements, deliveries, or on-street parking. Additional signage and street markings must be provided with bikeways on the left-side of a one-way street so that vehicle drivers are prompted to look for people on bike before making left-turns.

CONSIDERATIONS

» **Use.** Minimum arterial street standard; typically installed at time of new construction or by reallocating existing street space on lower speed (25-35 mph) streets.

» **Contra-Flow Lanes.** Marked bike lanes are used on one-way or two-way arterial streets. Contra-flow bicycle lanes may be used to allow two-way bicycle travel on streets designated for one-way travel for motorists to improve bicycle network connectivity. Additional signage and street markings must be provided with contra-flow bikeways on one-way streets so that vehicle drivers are prompted to look for people on bikes traveling in the opposite direction at intersections and driveways before making turns. This adds significant cost to construction.

» **Users.** In some contexts (higher speed; more traffic), marked bicycle lanes are a relatively high stress facility for many bicyclists and are not attractive to people who are "interested in but concerned about" bicycling.

» **Curb Management.** Vehicles stopping, idling, and parking in dedicated bike lanes is problematic in areas of high parking demand and deliveries. Locations with high demand may include metered or two-hour on-street parking zones, commercial districts, Urban Villages, and locations with high ride-hailing demand. Providing Separated Bike Lanes (2.6) can help alleviate conflicts.

» **Regulation.** Bicyclists are not required to remain in a bicycle lane and may leave the bicycle lane as necessary to make turns, pass other bicyclists, or to properly position themselves for other necessary movements.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)

NACTO Urban Bikeway Design Guide (2014)

Manual on Uniform Traffic Control Devices (MUTCD) (2012)

2.4 BICYCLE CLIMBING LANE

Roadway topography can be a major factor in the ease of riding along a bikeway as well as the speed differential between moving bicycles and vehicles on slopes. Preferred bicycle routes cannot always avoid all elevation changes due to limits in the street network and some arterial streets do not have adequate physical space between curbs to install marked bicycle lanes on each side. Where hills are present, but adequate width is not available, a bicycle climbing lane improves comfort and safety for people riding uphill at a much slower speed than passing vehicles. A bicycle climbing lane, provided for the uphill direction of the bikeway, allows them to take their time without worrying about mixing or blocking traffic.

Climbing lane on Lincoln St in the Puget Neighborhood

GUIDANCE

» **Facility types**. Climbing lanes are typically used in combination with arterial shared lane markings for downhill bicycle traffic where there is not adequate space to provide a striped bicycle lane in both directions. The centerline may be offset from the center of the roadway. People on bicycles traveling downhill may reach speeds of 20-25 mph, similar to moving vehicle traffic in most places.

» **Tapers**. The beginning and end of the climbing lane should be striped to guide vehicles along the edge of the travel lane at the appropriate taper length based on the roadway speed limit per the MUTCD. At the crest of the hill, there may sometimes be locations where two climbing lanes terminate, and the tapering should either align with each other or adequate space should be provided between them to provide a smooth travel experience.

CONSIDERATIONS

» **Width**. Climbing lanes should be designed with the standard width of a bicycle lane. A wider lane should be provided to accommodate passing in locations with higher bicycle volumes. This allows people bicycling at a faster speed to pass safely and also accommodates people on e-bikes and shared mobility devices that may travel at higher speeds.

» **Topography**. Determining if a climbing lane is necessary depends on the speed of approaching bicycles, slope of the incline, and length of the hill. Climbing lanes should be provided where bicycle speeds are expected to slow significantly. When bicycles can maintain speeds, approach at a higher speed, or where inclines are gradual or short it may not be necessary to provide a climbing lane. Additionally, on roadways with rolling hills, providing intermittent climbing lanes may be less feasible.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)
NACTO Urban Bikeway Design Guide (2014)
Manual on Uniform Traffic Control Devices (MUTCD) (2012)

2.5 BUFFERED BICYCLE LANE

Increasing the lateral separation between bicyclists and motor vehicles provides a more comfortable environment for people riding bikes on arterial streets. Where space is available, bicycle lanes can be improved by marking horizontal buffers on the street surface between the designated bicycle lane and the adjacent vehicle travel lane and/or between the bicycle lane and vehicle parking lane. While the buffer is not part of the bicycle lane, it should be anticipated to be used by bicyclists if the surface is ridable and vertical elements are not placed within it. Where wider (7 ft – 8 ft) bike lanes are feasible, a buffer will help to reduce incidences of motorist attempting to use the bike lane as a travel lane or parking lane.

Buffered bike lane on York St

GUIDANCE

» **Buffer Width** varies depending on available space but should ideally be 3-5 ft if placed adjacent to a travel lane or 2-3 ft if placed adjacent to a parking lane.

» **Cross Hatching**. Diagonal or chevron cross hatch markings are recommended in locations where buffers exceed 2 ft in width. Where buffers are less than 2 ft wide, a double white line or a single wide white line may be used. Where buffers exceed 4 ft in width, chevron hatch markings are recommended. Cross hatching should be provided at a regular interval. A typical spacing is 20 ft with some locations reduced to as low as 5 ft based on engineering judgement. The maximum spacing should not exceed the equivalent of the speed limit of the roadway roadway (e.g., 35 mph posted speed equals a 35-foot maximum spacing between markings).

REFERENCES

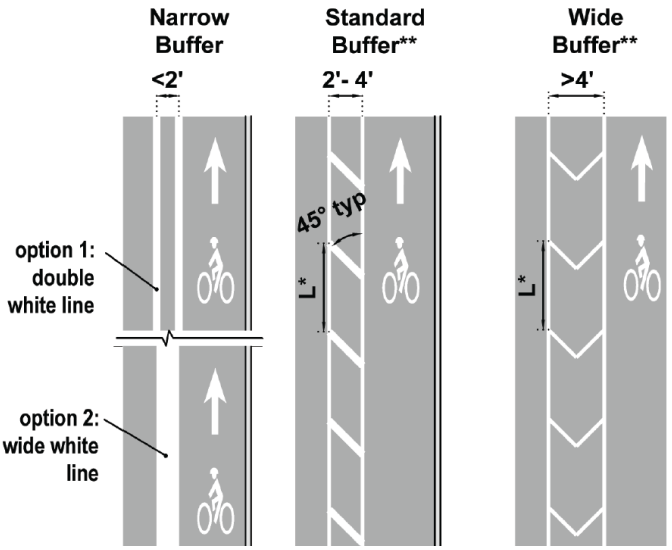
AASHTO Guide for the Development of Bicycle Facilities (2012)

NACTO Urban Bikeway Design Guide (2013)

CONSIDERATIONS

» **Parking Side or Vehicle Side**. Where parking is prohibited, the buffer should be placed between the bike lane and travel lane. Where parking is permitted, a buffer between both the bike lane and parking will increase the comfort and safety of bicyclists by reducing the potential for injury due to vehicle doors opening into the bicycle lane.

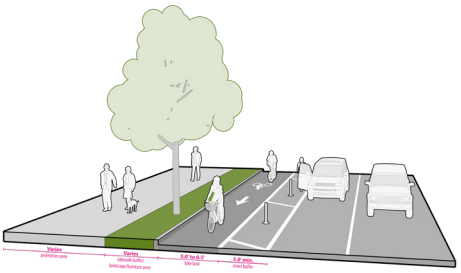
» **Vertical Elements / Separated Bike Lanes**. A buffered bike lane can be enhanced to create a Separated Bicycle Lane (2.6) by adding a vertical element to the buffer. Examples of vertical elements include flexible delineator posts, parking stops, planter boxes, or parked cars. See Edge Treatment Materials Selection (1.7). The placement of vertical elements within the street buffer should also consider the need for shy distance to the bikeway and to the travel lane. For retrofit projects (repurposing existing street space), most vertical elements are non-continuous, which facilitates positive drainage along the established roadway crown to existing catch basins. Designers should ensure the vertical separation is highly visible to approaching bicyclists and motorists.



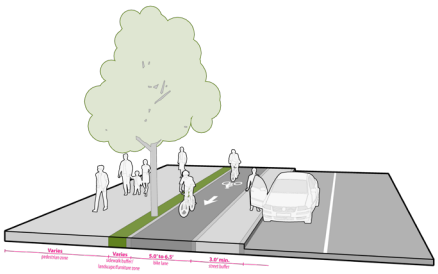
L = 20' (typical)
*Spacing may be reduced based on engineering judgment
**Wider buffers recommended for roadways with higher speeds and/or volumes

2.6 SEPARATED BICYCLE LANES

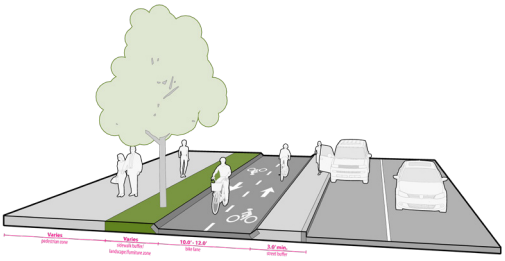
Separated bicycle lanes (also called "protected bike lanes") are a type of bikeway that provides an exclusive space for bicyclists along or within a roadway. They include two fundamental elements: 1. Separation from motor vehicles both a) horizontally, with a separated space for bicycling along the street and/or a change in elevation from the street surface, and b) vertically, separated by a vertical element and 2. Separation from pedestrians with a vertical element, a change in elevation, or a change of surface materials. They may be one-way or two way. The examples below illustrate several different configurations.



One-Way Street Level with Flexible Delineators



One-way Raised with Buffer



Two-Way Street Level with Raised Buffer

GUIDANCE

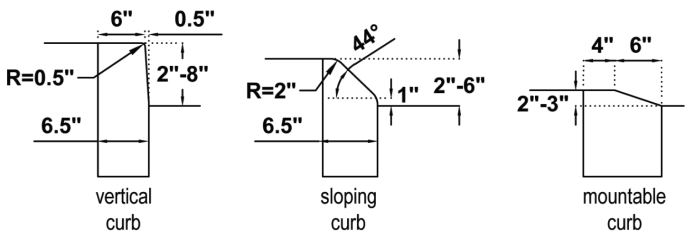
» **Width.** Separated bicycle lanes attract a wider spectrum of users, some of whom ride at slower speeds. They should ideally accommodate side-by-side bicycling and allow for safe passing. The elements used to separate the lane typically prevent bicyclists from pass each other by moving out of the separated lane. See the tables below for preferred and minimum widths based on edge type and bicycle volume.

Peak Hour Directional Bicyclist Volume	One-Way Separated Bicycle Lane Width (ft)		
	Between Vertical Curbs	Adjacent to One Vertical Curb	Between Sloped Curb or at Sidewalk Level
<150	6.5 - 8.5	6 - 8	5.5 - 7.5
>150	8.5 - 10	8 - 9.5	7.5 - 9
Practical Minimum	4.5	4	4
	Two-Way Separated Bicycle Lane Width (ft)		
<150	10-12	9.5-11.5	9-11
>150	12-16	11.5-15.5	11-15
Practical Minimum	8.5	8	7.5

» **Elevation.** Separated bicycle lanes may be located at various elevations, each with its own advantages and challenges:

- A street-level bike lane is preferred in a retrofit situation, where relocating the existing curbs may not be possible or cost-effective. The impacts to existing utilities, especially drainage infrastructure, is usually minimal.
- An intermediate-level bike lane may increase comfort and visibility and slow turning motorists at driveways. It minimizes pedestrian encroachment into the bicycle lane by maintaining some elevation difference between the bike lane and the sidewalk.
- A sidewalk-level bike lane provides separation from motor vehicles but may invite pedestrian encroachment. Sidewalk buffers provide important detectable delineation for pedestrians with vision impairments.

» **Curb Type.** Selecting the appropriate curb slope and height for separated bicycle lanes influences the width, crash risk, ability to enter or exit the facility, and the risk of motorist and pedestrian encroachment. Standard height vertical curbs (6-8 in) reduce the operating width of the separated bicycle lanes and present a crash risk from pedal strikes. Three curb configurations should be considered for separated bicycle lanes: sloping curbs, mountable curbs, or short vertical curbs (2-3 in) (see below). All are detectable by people who are blind or have low vision. Sloping curbs and mountable curbs provide easy access to the sidewalk for bicyclists who wish to dismount and exit the lane. Where short vertical curbs are used, an edge line immediately adjacent to the curb (within the bike lane) should be used to indicate to users that the curb is not traversable.



2.7 SEPARATED BICYCLE LANE (CONT.)

CONSIDERATIONS

» **Retrofit vs. Capital Projects**. In retrofit projects, the existing curb line is often maintained with the separated bicycle lane located at street-level. Available right-of-way widths limit the installation of on-street separated bike lanes. Retrofit projects typically rely on lower-cost surface mounted treatments and/or parked vehicles to serve as the vertical element separating the bicycle lane. Capital improvement projects provide opportunities to implement preferred bikeway configurations, elevations, and widths because adjustments to existing curblines, curb ramps, utilities, and other street elements can often be incorporated into the project scope.

» **Parking-Protected Bicycle Lanes**, installed between the curb and on-street vehicle parking, require a painted buffer between bike lane and parked car helps protect bicyclist from vehicle doors opening into bike lane. Parked cars can be a problematic separator due to width available for sweeping access, encroachment into the horizontal buffer separating the bike lanes from parked vehicles. Additional measures may be needed with parking protected bike lanes, such as specialized (narrow) street sweeping equipment, parking enforcement, towing, or vertical elements installed to prevent encroachment.

» **One-Way vs. Two-Way.** On two-way streets, one-way separated bike lanes are typically preferred over two-way separated bike lanes because bicycles traveling in the same direction as motorized travel are typically easier to integrate into the existing roadway operations, especially at intersections. In some situations, if right-of-way constraints or other site factors allow, providing a two-way separated bicycle lane on one side of a street may be appropriate. Care should be given to the design of intersections, driveways, and other conflict points, as people walking and driving may not anticipate bicyclists traveling in the counterflow direction, unless prompted to do so through intersection design, markings, and signage. Geometric treatments to slow turning motorists (e.g., raised crossings, hardened center lines), adequate sight distances, traffic control or warning signs, and high-visibility bicycle crossing markings should be used to alert motorists to the presence of counterflow bicyclists. Where appropriate, signal phasing should be used to eliminate conflicts between turning motorists and bicyclists traveling in the counterflow direction. Where the separated bicycle lane ends, counterflow bicyclists must be clearly directed back into the correct direction of travel. All of the above adds significant cost to providing two-way bike lanes on one side of a street.

Separated Sidewalk Level, Two-Way Bicycle Lane on Granary Ave

» **Sidewalk Delineation.** Separating people walking and bicycling enhances safety and comfort for both user groups. Providing a continuous detectable edge like a landscape bed with periodic breaks for parking access, a consistent buffer with street furniture or vertical elements, or a curbed edge allows pedestrians with vision disabilities to distinguish between the bike lane and the sidewalk. Guidance is evolving around best practices where the sidewalk is directly adjacent to a sidewalk level bike lane. A recent study sponsored by the City and County of San Francisco found a 12 in wide continuous raised trapezoid to be the preferred delineator by a majority of people with vision disabilities. Material type should also be chosen to distinguish between the two surfaces.

» **Drainage.** Adding continuous curbing or changing curb lines can affect drainage paths and new storm water inlets and catch basins may be needed. Typically for one-way street level separated bicycle lanes drainage is maintained at the curbline between the bicycle lane and sidewalk, and for sidewalk level bicycle lanes, drainage is directed to the curbline between the bicycle lane and roadway.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)
NACTO Urban Bikeway Design Guide (2014)
FHWA Separated Bike Lane Planning and Design Guide (2015)
MassDOT Separated Bike Lane Planning and Design Guide (2015)

2.8 ARTERIAL SHARED LANE MARKINGS

Bicycles may be operated on all roadways except where prohibited by law. Thus, shared lanes exist in all contexts including arterial streets and some highways. As vehicle volumes and speeds increase, designated bicycle lanes provide a minimum degree of separation by providing an exclusive lane for bicycle travel adjacent to motor vehicles. Arterial shared lanes are not a preferred treatment, but may be provided as an interim strategy to improve driver awareness of people bicycling on arterial streets where bicycle lanes or physical separation is deemed not feasible in the short term.

Arterial shared lane markings on 14th St in the South Hill Neighborhood

GUIDANCE

» **Markings.** Arterial shared lane markings (also referred to as "sharrows") indicate to motorists and bicyclists where bicyclists are expected to be bicycling, but are not considered a bikeway facility by themselves because they do not change the geometric or operational conditions of the roadway to improve comfort and safety for bicyclists. Arterial shared lane markings are typically placed in the right-most through travel lane. When parking is present, the placement should encourage bicyclist to avoid bicycling near parked vehicles. Markings should be spaced at intervals no greater than 250 ft thereafter. The first marking after an intersection or driveway should be placed no more than 50 ft downstream from an intersection and markings should be spaced at intervals no greater than 250 ft thereafter. Arterial shared lane markings should not be used on roadways that have a speed limit above 35 mph.

» **Signage.** The placement of bicycle warning or regulatory signage alerts motorists of the presence of bicycles on shared roadways. BICYCLES MAY USE FULL LANE (R4-11) sign may be used in situations where motorists stay behind bicyclists until an opportunity for safe passing.

CONSIDERATIONS

» **Design User/Facility Selection.** People who are interested in but concerned about bicylcing will likely not use arterial shared lanes unless traffic volumes are below 3,000 vehicles/day and operating speeds are at or below 25 mph, which excludes many arterial streets.

» **Wide Shared Lanes.** In the past, it was common practice to provide wide outside lanes under the assumptions that motorists in such a lane could pass a person riding a bicycle without encroaching into the adjacent lane. However, this configuration does not adequately provide safe passing distance and that motorists generally do not recognize that this additional space is intended for bicyclists. Wider travel lanes are associated with increases in motor vehicle speeds, which reduce comfort and safety for bicyclists. Wide curb lanes are therefore not recommended as a strategy to accommodate bicycling.

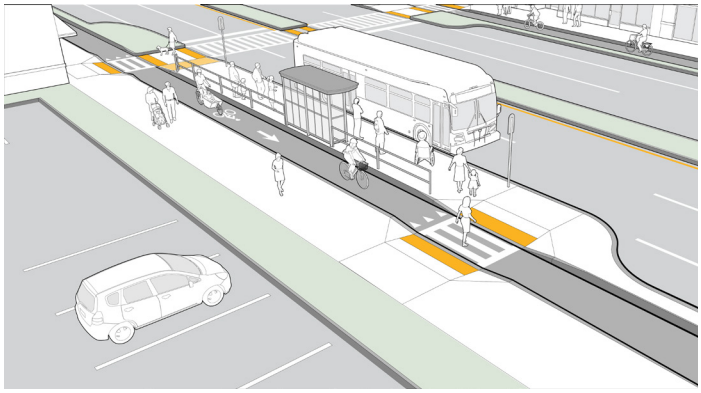
» **Alternatives.** When traffic volumes and speeds rise, the likelihood that a person riding a bicycle will feel comfortable sharing the lane with vehicles drops and bicycle lanes are preferred over shared lane wherever possible. This can be accomplished by reallocating travel lane space when outside lanes are 15 feet or more in width, narrowing all roadway lane widths, or by consolidating or removing parking in situations with low parking demand. Where providing dedicated street space is infeasible, alternative options to shared lanes like alternative parallel Bicycle Boulevards on local access streets or, if right-of-way, cost, and feasibility allow, widening the adjacent sidewalk to a side path width should be considered.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)

2.9 BICYCLE LANE AT TRANSIT STOP

The preferred location of bicycle lanes and transit stops are both adjacent to the curb line and sidewalk, creating conflicts when both are present. Providing clear and intuitive designs at bus stops can mitigate some of these conflicts or warn both transit operators and people bicycling of the conflict area. Floating bus stops are a configuration where bike lanes are routed behind transit stops. They eliminate conflicts between buses and bicyclists and are compatible with mid-block, near-side, and far-side transit stop locations. Transit passengers must cross the separated bike lane when entering and exiting the platform which requires that ADA accommodation be provided across the bike lane.



GUIDANCE

» **Pedestrian Design.** Guide transit users across the bike lane with an ADA-compliant pathway at clearly marked locations. Provide clear sight lines between pedestrians and bicyclists at crossing locations and clear direction to bicyclists when they are expected to yield to pedestrians.

» **Bus Stop Design.** All WTA bus stop and ADA requirements should be followed. In-lane transit stops should be considered to preserve space for the street buffer and separated bike lane, and to simplify bus re-entry into traffic.

» **Bicycle Lane Design.** Shelters and other vertical elements should be located to conform to shy distance needs for bicyclists. If necessary, narrow the bike lane along the transit stop to maintain an ADA-accessible sidewalk and transit stop in constrained areas. Bike lane can transition to sidewalk or intermediate level to minimize pedal strikes and maintain level pedestrian crossings. Include markings and signage that communicates yielding responsibilities and conflict points. Ths is particularly important for two-way bike lanes (or sidepaths) as there is an unexpected bicycle movement.

REFERENCES

NACTO Urban Street Design Guide (2013)

AASHTO Guide for Geometric Design of Transit Facilities on Highways and Streets (2014)

Alameda-Contra Costa Transit District (AC Transit) Multimodal Corridor Guidelines (2018)

CONSIDERATIONS

» **Bicycle Accommodations for Transit Users.** Transit stops can be good locations for secure bike parking. Bike parking increases the catchment area of transit stops, providing a longer range and faster first- and last-mile connection compared to walking. However, many people riding to bus stops will prefer to bring their bikes with them onto the bus if there is space on the bus-mounted bike rack.

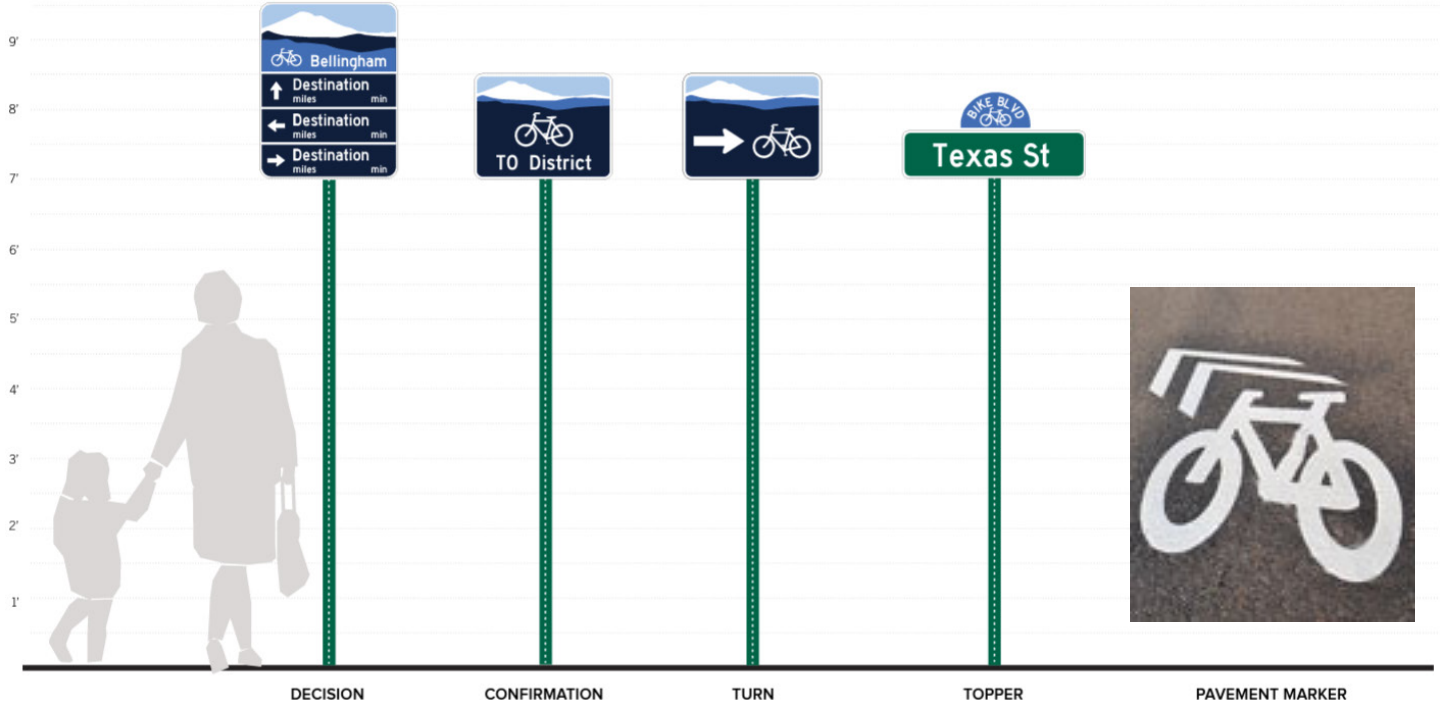
» **Detectability.** Providing clear delineation between pedestrian and bicycle space at floating bus stops is required to reduce conflicts and keep users in their intended zones and crossing locations. A standard or intermediate-height curb with a reveal greater than 2 inches can serve as a detectable edge between bicycle and pedestrian traffic, and the intermediate-level design can reduce the grading impacts needed to transition pedestrians from the sidewalk to the transit stop. When bicycle lanes are at sidewalk level, a detectable edge treatment should be provided at both sides of the bicycle lane to help pedestrians with a vision impairment find designated crossings.

Raised bicycle lane at a constrained bus stop, Seattle, WA

» **Constrained Locations.** Where a floating transit stop is not possible, the bicycle lane can be elevated up to the sidewalk level and run along the boarding area. Bicyclists can ride through the boarding area when no transit vehicles are present, but must yield the space to boarding and alighting passengers when a bus or streetcar stops. Markings and signage should be included to ensure that bicyclists yield to boarding and alighting transit passengers.

2.10 BICYCLE WAYFINDING SYSTEM

Bicycle wayfinding makes the city more legible and navigable for both local and visiting bicycle users. Wayfinding signage and markings are designed to be simple, intuitive, and predictable, providing information in a way that is easy to understand without requiring users to make frequent stops to reorient. Over time, wayfinding should be installed on all Bicycle Boulevards and regional bikeways and bicycle wayfinding signage should be included with all new transportation improvement projects. The 2016 Bellingham Bicycle Wayfinding Plan provides details and guidance on appropriate sign type and placement in various contexts.



SIGN TYPES

» **Decision Signs** clarify route options when more than one potential route is available. They display up to three destinations (see above), and distance in miles and time (based on 10 mph or 6 minute per mile travel speed). Decision signs should be placed in advance of decision-making points (turns) or intersections with other bikeways.

» **Confirmation Signs** are placed 50-100 ft after a turn movement or intersection to reassure cyclists that they are on the correct route, the signs include the system brand mark and route or pathway name.

» **Turn Signs** clarify a specific route at changes in direction when only one route option is available. They are placed at turns in advance of the turning action to provide cyclists advance notice of a change in direction.

GUIDANCE

» **Clearance.** The nearest sign edge should be a minimum of 2 feet from the edge of traveled way. The lowest edge of post-mounted signs should be seven feet. Protruding signs shall not reduce the clear width required for accessible routes.

» **Spacing.** Wayfinding signs for bicycles should be spaced a minimum of 50-75 feet apart. Sign clutter should be avoided. In general, regulatory and warning signs are a higher priority than wayfinding signs.

» **Greenway Trails.** For signs along the city's Greenway Trail Network, refer to sign standards identified in the Bellingham Parks & Recreation Department Design Standards for Park and Trail Development (2011).

» **Placement with City Center Wayfinding.** If there is an existing downtown wayfinding sign directing to a destination, a bicycle wayfinding sign should not repeat the same destination information.

REFERENCES

Bellingham Bicycle Wayfinding Plan (2016)
AASHTO Guide for the Development of Bicycle Facilities (2012)
Manual on Uniform Traffic Control Devices (MUTCD) (2012)

3 INTERSECTIONS & CROSSINGS

A safe and intuitive crossing requires the proper layout of design elements such as curb ramps, traffic control devices, intersection corner radii, and sight distance that accommodates all users. Pedestrian, bicycle, mobility device, and vehicular conditions factor into the design of intersections and crossings.

Mid-block pedestrian refuge island on Northwest Ave near Maplewood Ave

3.1 UNCONTROLLED CROSSING TREATMENT SELECTION

Uncontrolled pedestrian crossings occur where sidewalks or walkways intersect streets at a location without any traffic control (i.e. signal or STOP sign). Uncontrolled crossings are associated with higher rates of pedestrian crashes, often due to inadequate crossing facilities. Crash risk often increases with the number of vehicle lanes that need to be crossed. A "multiple threat" crash risk exists when a pedestrian in a crosswalk is obscured by a stopped vehicle and steps into the adjacent travel lane and risks being hit by a moving vehicle. The table below provides guidance on what treatments should be applied at uncontrolled crossings. See the FHWA Guide for Improving Safety at Uncontrolled Crossing Locations for additional guidance.

Street Configuration	Lanes crossed to reach a refuge	Multiple threat lanes per crossing	Roadway ADT and Posted Speed															
			1,500-9,000 vpd				9,000-12,000 vpd				12,000-15,000 vpd				> 15,000 vpd			
			≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph	≤ 30 mph	35 mph	40 mph	≥ 45 mph
2 lanes: One Way	2	1	A	B	C	E	A	B	C	E	B	B	C	E	B	C	C	E
2 lanes: Two way with no median	2	0	A	B	C	E	A	B	C	E	B	B	C	E	B	C	C	E
3 lanes: One Way	3	2	C	C	D	E	C	C	D	E	C	C	D	E	C	D	D	E
3 lanes: Raised Median	1 / 2	0 / 1	A	B	D	E	A	C	D	E	B	D	D	E	C	D	D	E
3 lanes: Striped Median	3	0 / 1	C	C	D	E	C	C	D	E	C	C	D	E	C	D	D	E
4 lanes: Two way with no median or center turn lane	4	2	B	D	D	E	C	D	D	E	D	D	D	E	D	D	D	E
5 lanes: Two way with raised median & turn lanes	2 / 3	2	B	D	D	E	D	D	D	E	D	D	D	E	D	D	D	E
5 lanes: Two way with striped center turn lane	5	2 / 3	D	D	D	E	D	D	D	E	D	D	D	E	D	D	D	E
5-6 lanes: Two way with access management barrier	2 - 6	2 / 4	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

TREATMENT DESCRIPTIONS

A. Install **marked crosswalk and signs**. Consider an **in-street pedestrian crossing sign**. If volumes are below 9,000 vpd, consider a **Raised Crossing** (3.5).

B. Install **marked crosswalk and signs**. Install **advance stop bars** at crossings on 3 lane (one-way streets) and at midblock crossings on 4 or 5 lane roadways. Use "State Law Stop for Pedestrians" signs in refuge islands. Consider geometric improvements such as **curb extensions** to increase visibility and reduce exposure. Consider a **RRFB (3.8)** or **PHB (3.7)**.

C. Install **marked crosswalk**, **signs**, and **geometric improvements** to increase pedestrian visibility and reduce exposure. Add **neckdowns** or **median refuge islands.** Consider a **RRFB (3.8)** or **PHB (3.7)**.

D. Install **marked crosswalk and signs**, **RRFB (3.8)**, and **geometric improvements** to increase pedestrian visibility and reduce exposure. Add **neckdowns** at the crossing if on-street parking is present. If pedestrian volumes are higher than 200 per hour and traffic volumes are higher than 2,000 vehicles per hour, consider a **PHB (3.7)** or **Pedestrian Traffic Signal**.

E. Do not install marked crosswalk. Determine if the speed limit can be effectively reduced to 40 mph AND a raised median can be installed. If so, utilize Scenario D criteria above. If not, consider **PHB (3.7)** or **Pedestrian Traffic Signal**.

F. Do not install marked crosswalk with 3 or more THROUGH lanes per direction or on a 5-lane crossing without a median refuge. Consider **a PHB (3.7)**, **pedestrian traffic signal**, or **grade-separated crossing**.

3.2 PEDESTRIAN CROSSING ELEMENTS

Crossings, whether mid-block or at an intersection, should provide safe and comfortable locations for people to cross the street. A crossing location should offer adequate gaps between vehicles and encourage motorist yielding or stopping to allow pedestrians to cross. Intersection designs should also minimize the speed differential between users at the points where travel movements intersect. Reducing speeds, particularly of motor vehicles, at conflict points may allow all users more time to react to avoid a crash and can reduce the severity of a potential injury if a crash does occur. Intersections with bicycle and pedestrian crossings should be designed to encourage slower-speed turning and weaving movements.

Crosswalk, curb ramp, and advanced stop line in Pedestrian Hybrid (HAWK) Signal on Lakeway Dr at Undine St

GUIDANCE

» **Marked Crosswalks.** A marked crosswalk signals to motorists that they must stop for a pedestrian waiting to cross and encourages pedestrians to cross at designated locations. Installing crosswalks alone will not necessarily make crossings safer, especially on multi-lane roadways. At signalized intersections, all crosswalks that connect to ADA-compliant ramps and sidewalks should be marked. For unsignalized intersections, see Uncontrolled Crossing Treatment Selection (3.1).

» **ADA Curb Ramps** allow all users to make the transition from the street to the sidewalk. A sidewalk without a curb ramp can be useless to someone in a wheelchair, forcing them back to a driveway and out into the street for access. The landing at the top of a ramp shall be at least 4 feet long and at least the same width as the ramp itself. The ramp shall slope no more than 1:50 (2.0%) in any direction. If the ramp lands on a dropped landing within the sidewalk or corner area where someone in a wheelchair may have to change direction, the landing must be a minimum of 5 feet long and at least as wide as the ramp, although a width of 5 feet is preferred. The edge of an ADA compliant curb ramp will be marked with a tactile warning device (also known as truncated domes) to alert people with visual impairments to changes in the pedestrian environment.

» **Advance Yield / Stop Lines and Signage.** Advance yield/stop lines and signage can be installed at locations where there are concerns about multiple threat crashes. They indicate to drivers the appropriate location to yield or stop so that they do not block the sight line between drivers in adjacent lanes and crossing pedestrians. Additionally, parking should be prohibited in between the yield or stop line and the crosswalk to increase visibility.

» **Sight Distance.** At intersections and driveways with permissive turning movements where bicyclists and motorists are traveling in the same direction, or where pedestrians cross concurrently, parking restrictions (and the resulting sight distances) are a key consideration. Additionally, when a separated bike lane or sidepath is located behind a parking lane, it is typically necessary to restrict parking and other vertical obstructions near a crossing to ensure adequate sight distances are provided. Often times these parking restrictions may coincide with those set for stop signs or crosswalks that already exist.

» **Minimizing Corner Radii.** One way to slow vehicles is to narrow the radius of corners. Both the actual and effective radius, which takes into account parking and other offsets from the curb, should be designed to be as tight as possible to slow vehicles. The radius may be as small as 3 ft where there are no turning movements, or 5 ft where there are turning movements and there is adequate street width and a larger effective curb radius created by parking or bike lanes. Where larger vehicles (i.e. freight or buses) are expected to turn regularly, a mountable truck apron can be provided to allow their turns while still discouraging smaller vehicles to cut the turn.

REFERENCES

FHWA STEP Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations (2018)

FHWA Achieving Multimodal Networks (2016)

AASHTO Guide for the Planning, Design, and Operation of Pedestrian Facilities (2021)

3.3 MEDIAN REFUGE ISLAND

Median refuge islands allow multi-stage crossings of wide streets. They can be located mid-block or at intersections, as roundabout splitter islands, or as "pork chop" islands where right-turn slip lanes are present. Islands allow pedestrians to focus on one direction of traffic at a time, which is particularly useful at locations where gaps in motor vehicle traffic are limited. Crossing islands are also effective at slowing left turns when located at intersections by reducing the effective turning radius.

Median Refuge Island on Lincoln St at 2nd St

GUIDANCE

» **Accessibility.** The refuge island must be accessible, including detectable warning surfaces. An at-grade passage is preferred over ramps and landings.

» **Dimensions.** The refuge area should be at least 6 ft wide to accommodate pedestrians. The island should be at least 20 ft long. A "nose" that extends past the crosswalk is recommended to protect people waiting on the crossing island and to slow turning drivers.

» **Signage and Markings.** On streets with speeds higher than 25 mph there should also be double centerline markings, reflectors, and "KEEP RIGHT" signage.

» **Plantings.** Vegetation and other aesthetic treatments may be incorporated, but must not obscure visibility. Planting strips must be 5 ft or greater in width to accommodate small to medium trees.

REFERENCES

NACTO Urban Street Design Guide (2013)
FHWA STEP Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations (2018)
ODOT Multimodal Design Guide (2023)
Manual on Uniform Traffic Control Devices (MUTCD) (2012)

CONSIDERATIONS

» **Use.** Refuge islands are appropriate at signalized or unsignalized crosswalks and are strongly recommended where a center turn lane is present or where physical width allows on arterial streets with posted speeds of 35 mph or greater, or traffic volumes exceed 15,000 vehicles per day.

» **Combining Treatments.** Refuge islands can be coupled with other traffic calming features, such as partial diverters and curb extensions at mid-block and intersection locations. However, many traffic calming features are used only on local access streets whereas refuge islands are typically used on arterials.

» **Signal Activation.** Where pedestrian signals are provided, they shall include Accessible Pedestrian Signals and pushbuttons complying with sections 4E.08 through 4E.13 of the MUTCD. At signals where Bike Boulevards cross arterial streets, push buttons should be mounted on poles at the curb so that bicyclists do not have to dismount from their bike to activate the signal. Ideally, a bicycle stand is also recommended at the curb to allow a bicyclist to be in the best riding position to cross the street quickly.

3.4 CURB EXTENSION

Curb extensions, also known as bulb-outs or bump-outs, are created by extending the sidewalk at intersections or mid-block. Curb extensions are intended to increase safety, calm traffic, and provide extra space along sidewalks for users and amenities. In addition to shortening crossing distances, curb extensions can be used to change the geometry of intersections resulting in smaller corner radii, better curb ramp placement, slower motor vehicles turns, and opportunities for green infrastructure. At signalized intersections, shorter crossing distances can result in less delay.

Curb extension with bioswale on E Magnolia St at N State St

GUIDANCE

» **Geometry.** For curb extensions immediately upstream or downstream of parallel parking, the curbline should be offset 6 ft. For curb extensions adjacent to diagonal parking, the curbline should be offset 13 ft. The minimum length of a curb extension is the width of the crosswalk, allowing the curvature of the curb extension to start after the crosswalk, which should deter parking. When curb extensions conflict with turning movements, reducing the width and/or length of the curb extension should be prioritized over elimination.

» **Drainage.** The installation of curb extensions affects drainage patterns and may require changes to grading or the location of catch basins.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)
NACTO Urban Street Design Guide (2013)
City of Los Angeles Supplemental Street Design Guide (2020)

CONSIDERATIONS

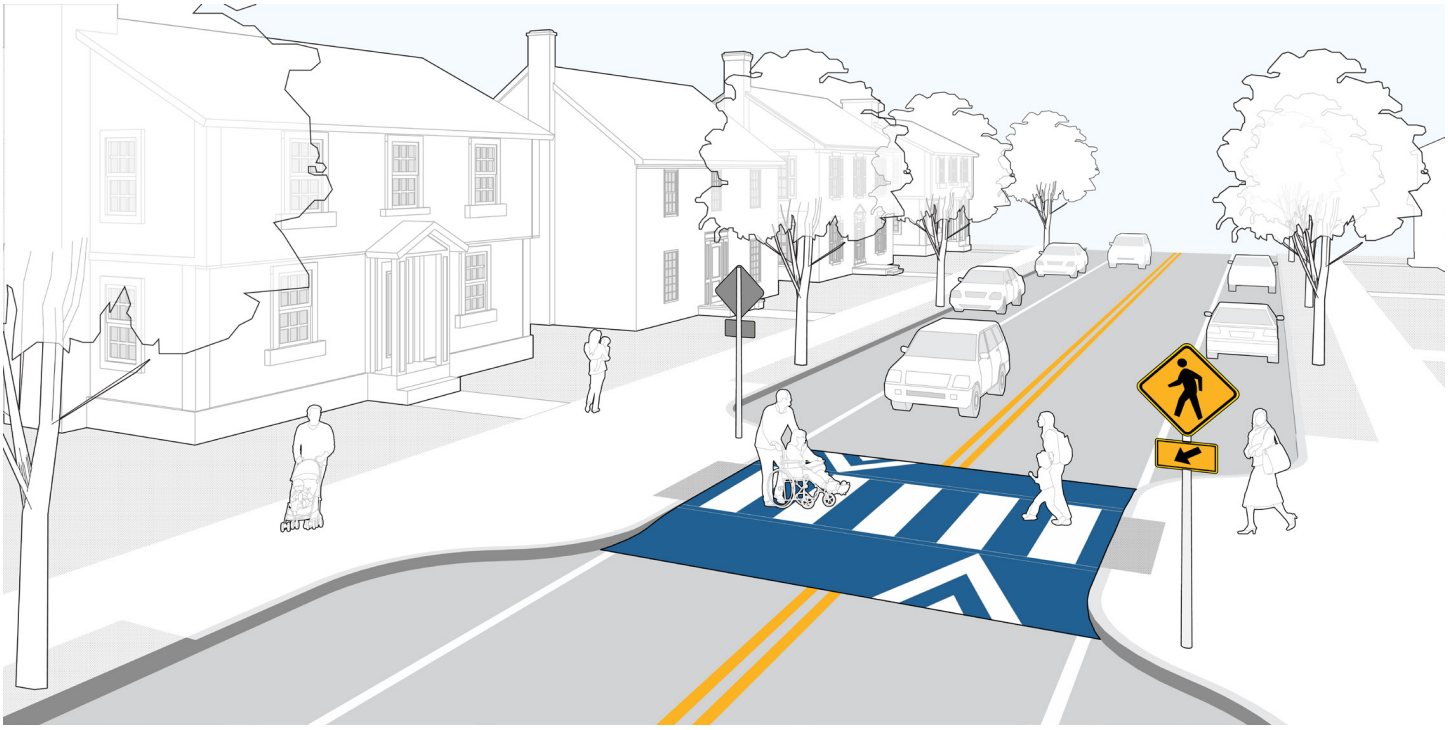
» **Use.** Curb extensions can be used at intersections and marked crosswalks. They are particularly valuable in locations with high volumes of pedestrian traffic, near schools, and at unsignalized pedestrian crossings. On arterial streets that serve as regional bicycle routes, the benefits of curb extensions for people walking and rolling must be weighed against the benefits of continuous bikeways so that the curb extension does not protrude into the bikeway.

» **Plantings.** If landscaping is included, plantings should not compromise the visibility of people walking and rolling in the crosswalk. Shrubs and ground plantings should be no higher than 1 ft 6 in. Planted curb extensions may be designed as a bioswale, a vegetated system for stormwater management.

» **Quick-build.** If warranted, low-cost, quick-build curb extensions can be constructed with paint and vertical elements like posts or planters. Vertical element spacing should not exceed 10' on center except at crosswalk entrances, which should be clear of vertical elements.

3.5 RAISED CROSSING

A raised crossing includes ramps on each vehicle approach to elevate the entire crosswalk, bicycle lane crossing, or shared use path crossing to the level of the sidewalk. It can slow turning or approaching traffic, help make crossings more accessible, and improve motorists' yielding behavior. Raised crossings can be considered where motorists are required to yield the right-of-way to the crossing user but should only be used in limited cases. Raised crossings may also be used mid-block or applied to an entire intersection.



GUIDANCE

» **Geometry.** Deviations from the raised crossing geometrics may dramatically reduce their effectiveness and safety. Raised crossing approaches that are too abrupt may cause rear-end crashes or cause bicyclists or motorcyclists to lose control. Conversely, a raised crossing that is too low (under 3 inches) may fail to reduce motorists' operating speeds.

» **Width.** A width of 12 ft for the flat portion of the crossing is preferred to cover a wide range of vehicle wheelbases, from passenger vehicles to freight trucks.

» **Drainage.** Similar to curb extensions, raised crossings may create a new low spot due to the existing cross slope and longitudinal slope of one, or both intersecting streets.

CONSIDERATIONS

» **Combining Treatments.** In order to maximize raised crossing benefits, they can be implemented in conjunction with a curb extension to decrease crossing distances and improve pedestrian visibility to motorists.

» **Accessibility.** Use detectable warning surfaces at curb edges to alert vision-impaired pedestrians that they are entering the roadway. On streets with steep grades, particular attention is required to the grade of the vehicle ramps.

» **Feasibility.** Like speed humps, raised crosswalks have a traffic slowing effect which may be unsuitable for emergency response routes, transit, and freight routes. Raised crossings on bus routes need to be discussed with WTA and should not exceed 3 inches in height due to the large wheelbase of buses (typically 20 - 25 ft).

REFERENCES

City of Los Angeles Supplemental Street Design Guide (2020)

Updated Guidelines for the Design and Application of Speed Humps (2007)

ODOT Multimodal Design Guide (2022)

Denver Complete Streets Design Guidelines (2020)

3.6 TRAFFIC SIGNALS

TIMING AND ACTIVATION

» Signal design should prioritize safety and minimize the time that pedestrians must wait. Traffic signals should include Lead Pedestrian Interval (LPI) phases (see below). Requiring pedestrians to wait for extended periods can encourage crossing against the signal. Pedestrians have an increased likelihood of risk-taking behavior (crossing against the signal) after waiting longer than 30 seconds for a WALK indication.

» All new pedestrian signal heads should contain a visual numerical countdown display provided with the DON'T WALK indication, as well as an audible countdown, informing pedestrians of the amount of time in seconds available to safely cross.

» In areas with higher pedestrian activity, such as near transit stations, main streets, and school zones, traffic signals should be placed on pedestrian recall to provide appropriate pedestrian walk indicators on every cycle.

» In order to provide adequate pedestrian crossing time, the MUTCD recommends traffic signal timing to assume a pedestrian walking speed of 4 ft per second but a speed of 3 ft per second may be assumed where many children, seniors, and people with disabilities are expected.

LEADING PEDESTRIAN INTERVALS

» The Leading Pedestrian Interval (LPI) initiates the pedestrian WALK indication three to seven seconds before motor vehicles traveling in the same direction are given the green indication. This signal timing technique allows pedestrians to enter the intersection prior to turning vehicles, increasing visibility between all modes, improving driver yielding rates to pedestrians, and reducing crashes.

» The LPI should be prioritized at intersections with high volumes of pedestrians and conflicting turning vehicles or at locations with a large population of people using mobility devices, elderly people, or school children.

» Where appropriate, a lagging protected left arrow for vehicles should be provided to accommodate the LPI.

REFERENCES

NACTO Urban Street Design Guide (2013)
Manual on Uniform Traffic Control Devices (MUTCD) (2012)
ODOT Multimodal Design Guide (2022)
SDOT Technical Memorandum on Accessible Pedestrian Signals (APS) and ADA Compliance (2017)

ACCESSIBLE PEDESTRIAN SIGNALS

» Accessible Pedestrian Signals (APS) are devices that communicate information about the traffic signal in non-visual formats to pedestrians with visual and/or hearing disabilities. APS may include audible tones, speech messages, detectable arrow indications and/or vibrating surfaces.

» For guidance on when APS should be installed, see the City's APS Policy (Appendix I of the ADA Transition Plan).

» Locator tones help pedestrians with visual impairments locate the pushbutton needed to actuate the WALK interval. Detectable arrows should be located on pushbuttons to point in the same direction as the crosswalk. At corners of signalized locations where two pushbuttons are present, they should be separated by at least 10 ft.

» For automatically-called pedestrian phases, pushbuttons can be used to activate accessible pedestrian signal features such as speech messages and beaconing.

3.7 PEDESTRIAN HYBRID BEACON

Pedestrian hybrid beacons (PHBs), also called a High-intensity Activated Crosswalk Beacon (HAWK), are a type of traffic control device that allows pedestrians and bicyclists to stop traffic to cross high-volume arterial streets. A hybrid beacon consists of a signal head with two red lenses over a single yellow lens on the major street, and a pedestrian signal head for the crosswalks. While this type of device is intended for pedestrians, it may also benefit bicyclists if designed for bicycle needs. When activated, the PHB provides signal indications to vehicle drivers that a person is walking, biking, or rolling in the crosswalk and that traversing the crosswalk is prohibited for vehicles (when the indication is steady red) or must be treated as a stop sign (when the light is flashing red).

GUIDANCE

» **Warrant Study.** There is flexibility in applying warrants to determine if a traffic signal or beacon is needed at a pedestrian crossing. Chapter 4F of the MUTCD contains provisions on how PHBs can be installed and used in conjunction with signs and pavement markings to warn and control traffic at locations where pedestrians enter or cross a street or highway. The MUTCD also identifies factors for agencies to consider in determining the use of PHBs, including pedestrian and traffic volumes, roadway speeds, and sight distance. A volume of 20 pedestrians or bicyclists an hour for major arterial crossings (volumes exceeding 2,000 vehicles/hour) is the recommended minimum for warranting a hybrid beacon. When completing an engineering study of the location, pedestrian volumes can be estimated if the absence of a signal limits crossing opportunities of potential users, especially the young, elderly, or persons with disabilities. Hybrid beacons may be installed without meeting traffic signal control warrants if roadway speeds and volumes are excessive for comfortable pedestrian crossings.

» **Visibility.** Parking should be prohibited for at least 100 feet in advance of and at least 20 feet beyond the marked crosswalk to provide adequate sight distance. Since they have similar lighting requirements to signals, installing a PHB may also trigger lighting upgrades.

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

REFERENCES

NACTO Urban Bikeway Design Guide (2013)
Manual on Uniform Traffic Control Devices (MUTCD) (2012)
FHWA STEP Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations (2018)
City of Bellingham: HAWK Crosswalk Signal

HAWK Signal with Pedestrian Refuge Island on Lincoln St at Lakeway Estates Senior Mobile Home Park

CONSIDERATIONS

» **Use.** Pedestrian hybrid beacons should be considered for arterial crossings in a bicycle network and for path crossings if other engineering measures are found inadequate to create safe crossings. Ideally, a bicycle stand is also recommended at the curb to allow a bicyclist to be in the best riding position to cross the street quickly. If installed within a signal system, signal engineers should evaluate the need for the hybrid signal to be coordinated with other signals. The MUTCD recommends, but does not require, that PHBs be located at least 100 feet from an intersection.

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

3.8 RECTANGULAR RAPID FLASHING BEACON

At some uncontrolled crossings, it can be difficult to achieve compliance with laws that require motorists to yield to pedestrians. Vehicle speeds and poor pedestrian visibility combine to create conditions in which very few drivers are compelled to yield. One type of traffic control device proven to be successful in improving yielding compliance at these locations is the Rectangular Rapid Flash Beacon (RRFB). RRFBs combine a pedestrian crossing sign with a bright flashing beacon that is activated when a pedestrian or bicyclist is present, either using push buttons or another form of actuation. Bellingham has installed many of these on arterial streets.

RRFB crossing in Kirkland, WA

GUIDANCE

» **Actuation and Timing.** RRFBs shall initiate operation based on pedestrian or bicyclist actuation and shall cease operation at a predetermined time after actuation or, with passive detection, after the pedestrian or bicyclist clears the crosswalk.

» **Push Buttons.** If intended for use by bicyclists, push button actuation should be provided, located so that bicyclists can activate the signal without dismounting. Push buttons should include a supplemental sign facing the bicyclist's approach to increase visibility. Ideally, a bicycle stand is also recommended at the curb to allow a bicyclist to be in the best riding position to cross the street quickly.

REFERENCES

NACTO Urban Street Design Guide (2013)

Manual on Uniform Traffic Control Devices (MUTCD) (2012)

FHWA STEP Guide for Improving Pedestrian Safety at Uncontrolled Crossing Locations (2018)

ODOT Multimodal Design Guide (2022)

CONSIDERATIONS

» **Use.** RRFBs can be used for pedestrian and bicycle crossings. The MUTCD recommends minimum volumes of 20 pedestrians or bicyclists an hour for major arterial crossings (volumes exceeding 2,000 vehicles/hour). RRFBs should be considered for arterial crossings in a bicycle network and for path crossings if other engineering measures are found inadequate to create safe crossings and a traffic signal is not feasible. For multilane streets or roads with posted speeds above 35 mph, a Pedestrian Hybrid Beacon (3.7) or traffic signal should be installed as opposed to a RRFB.

» **Estimating Demand.** Designers have the flexibility to estimate future demand in the absence of a signal if existing conditions limit vulnerable user crossing opportunities. In some cases, people may not be crossing a street in sufficient numbers to satisfy a warrant because there are not adequate gaps in traffic or they do not feel comfortable doing so–thus they avoid the crossing altogether.

3.9 BICYCLE SIGNAL

As bicycle lanes and intersection treatments become more widespread, the option to separate bicycle movements in time in addition to space allows for less conflicts with motor vehicles but requires new equipment like bicycle specific signal heads, detection and actuation, and signage. Most bicycle signal equipment is compatible with traditional signal controllers, but extra phases may require upgrading signal controllers to achieve more capacity and signalizing options.

Dedicated Bicycle Signal on Granary Ave at Roeder Ave with Push Button Actuation and a Bicycle Stand

GUIDANCE

» **Bicycle Signals.** A bicyclist traveling in a shared lane is controlled by the vehicular signal head. Where it is necessary or desirable to control a bicycle separately from a motor vehicle, a bicycle may be controlled by a pedestrian signal head, a traffic signal head designated for bicycle use or a bicycle signal face. Each of these three options are described below. The layout of traffic signals is a key factor in the safe operation of bikeways. The MUTCD establishes requirements for the size, arrangement, number, visibility, and positioning of vehicle traffic signals at an intersection. Along a corridor, it is recommended that traffic signal indications for bicyclists are consistent and as uniform as possible.

» **Bicycle Signal Faces (Interim Approval).** A bicycle signal is a signal head with bicycle symbols on the lenses. Bicycle signal faces currently have Interim Approval for situations where there are no conflicting motor vehicle movements with the signalized bicycle movement. The Interim Approval also prohibits bicycle signal faces at pedestrian hybrid beacons. Situations where bicyclists follow pedestrian signals or where a standard traffic signal head is designated for bicycle use are not restricted by the provisions of the bicycle signal face's Interim Approval. The use of bicycle signal faces is desirable at locations where bicyclists cannot see vehicle signal faces or where bicyclists have a separate directional movement, phase, or interval. It may also be beneficial at locations where designers want to maximize the time a bicyclist may legally enter a crosswalk.

» **Pedestrian Signal Heads.** Bicyclists operating on shared use paths and on sidewalks unless specifically prohibited must follow the indications of pedestrian signal heads where they are crossing in crosswalks unless a traffic signal face or bicycle signal face is intended for bicyclists. Additionally, bikes may be directed to follow pedestrian signal heads when operating in a separated bike lane within the roadway and vehicle signal faces are not visible or when provided a separate directional movement, phase, or interval from motor vehicle movements. The BIKES USE PED SIGNAL sign (MUTCD R9-5) should be mounted adjacent to the pedestrian signal heads to inform bicyclists they are not to follow the adjacent motor vehicle signals. Care should be taken to ensure the pedestrian indication is visible to bicyclists. Where bicyclists are directed to follow a pedestrian signal, they are only legally allowed to enter the crosswalk during the "WALK" indication. Research has found low bicyclist compliance rates at locations where bicyclists are directed to follow pedestrian signals and most bicyclists continue to enter crosswalks on the flashing "don't walk" indication because it is timed for a pedestrian who moves much more slowly than a bicyclist. Caution should be exercised when using pedestrian signals to provide guidance to bicyclists at locations with long crossings or unique signal timing phases.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)
NACTO Urban Bikeway Design Guide (2014)
Manual on Uniform Traffic Control Devices (MUTCD) (2012)

3.10 BICYCLE DETECTION AT SIGNALS

Active warning devices, pedestrian hybrid beacons, and traffic signals should passively detect bicycles or provide bicycle specific pushbuttons; otherwise, a bicyclist will have to dismount to use a pedestrian pushbutton, wait for a vehicle on same movement to arrive, cross on the red indication, or cross without the warning device activated. If detection is used on an intersection approach where bicyclists are expected, it should be designed to sense bicycles whether they are mixed with vehicle traffic or in their own lane. Various technologies are available for passively detecting bicycles, including inductive loops, microwave, video, and magnetometers. Detection at shared-use path crossings should consider whether it is desirable to detect bicyclists and pedestrians using passive detection and should consider how to distinguish between directions of travel at these locations. There are a variety of techniques that can be used to detect bicyclists at locations with active warning devices, pedestrian hybrid beacons, or traffic signals. Detection should be monitored to evaluate effectiveness and field calibrated as needed to ensure the detection systems are working as intended.

Bicycle Pushbutton with stand and dedicated waiting area (Seattle, WA)

GUIDANCE

» **Signs and Markings for Detection.** Where detection is provided, the use of a bicycle detector pavement marking can guide bicyclists to wait within the optimum zone or position to be detected. Bicycle stencils exist at all traffic signals in Bellingham indicating the best spot for a metal bicycle frame to be detected by the traffic signal sensor, but carbon framed bicycles are unlikely to be detected. There is a link on the City web site to a video showing "How to trigger a traffic signal on a bike." To further increase awareness of the detection zone, the marking may be accompanied by a bicycle signal actuation sign (R10-22).

» **Detection Confirmation Lights.** A detection confirmation light indicates to the user that the detector has been activated, potentially improving compliance with the traffic signal. The use of Detector Confirmation Indications require a Request to Experiment from FHWA.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)
NACTO Urban Bikeway Design Guide (2014)
Manual on Uniform Traffic Control Devices (MUTCD) (2012)

DETECTION & ACTUATION OPTIONS

» **Bicycle Signal Recall.** In urban contexts with frequent bicycle traffic and fixed-time signal operations, no bicycle detection is required and signal operations should assume a bicycle is present in every phase.

» **Bicycle and Pedestrian Pushbuttons** should not be used as primary detectors on roadways where bicyclists are operating away from a curb edge. Pushbuttons should allow bicyclists to actuate them without dismounting while satisfying lateral offset requirements from the AASHTO Roadside Design Guide. Alternatively, bike ramps should be provided so that a bicyclist can access a sidewalk or separated bike lane to actuate the pushbutton. Bicycle pushbuttons should include a supplemental sign (e.g. R10-24) explaining their purpose and use. Pushbuttons may also be used where it is desirable for a bicyclist to be detected but not a motorist (e.g., a Bike Boulevard crossing an arterial with a pedestrian hybrid beacon). Where pushbuttons are not intended for the use of pedestrians, they do not have to meet accessibility guidelines or MUTCD requirements for placement.

» **Inductive Loop Detection** is the most common type of vehicle detection and can be adjusted to detect bicycles with proper calibration and sensitivity settings.

» **Video Detection Systems** process an image stream from a video camera located on a mast arm or pole aimed at the intersection approach. They may have problems detecting bicycles due to poor street lighting. This can be mitigated to some extent by ensuring that the detection zone is well lit with street lighting. Thermal cameras may also be used.

» **Microwave (Radar) Detection Systems** analyze the reflections from a radar transmitter/receiver installed either on a signal mast arm or on a pole at the intersection.

3.11 BICYCLE SIGNAL PHASING STRATEGIES

When evaluating signal phasing options, it is important that, in addition to intersection efficiency, designers consider potential conflicts between motorists and bicyclists, the potential severity of a crash should one occur with a bicyclist, and changes to delay and impacts to compliance for all users. Designers should consider both the operational and safety impacts of signal phasing changes at an intersection. Designers should be aware that a phasing scenario may necessitate a separate motor vehicle turn lane and an additional phase which may increase delay for some users, including bicyclists.

SIGNALIZATION OPTIONS

» **Separating Bicycle and Turning Vehicle Movements** can eliminate or manage conflicts and improve safety at an intersection. This potential for conflict is evaluated using the volume of turning motor vehicles crossing the bikeway. The table below provides peak hourly volume thresholds for turning motor vehicle traffic crossing a bikeway to determine when a protected or partially protected bicycle phase should be considered based on a review of existing research and guidance.

Hourly Volume Thresholds for Separate Turn Phases *

	Left Turn Crossing One Oncoming Lane	Left Turn Crossing Two Oncoming Lanes
One-Way Separated Bike Lane	≥ 100 ≥ 150*	≥ 50 ≥ 150*
Two-Way Separated Bike Lane or Sidepath	≥ 50 ≥ 100*	ANY ≥ 100*

* The volumes included are rough guidelines. Engineering judgement is required and protected phasing may be warranted in consideration of other factors such as fast turn speeds, dual turn lanes, heavy truck turn volumes, steep approach grades, or low bike volumes.

» **Concurrent Protected Bicycle Phase.** The bicycle phase runs concurrently with parallel through vehicle phases, but conflicting vehicle turns across the bikeway are restricted. Right- and left-turn movements across the bikeway operate under a protected only phase. In this phasing scheme, a bicycle needs to be controlled by a signal face that is separate from the vehicle signal. Right (or left) turns on red must be prohibited during the protected bicycle phase. The extension of turn lane storage lengths to accommodate queues, reduction of split times for other phases or an increase in signal cycle length may be necessary. This phasing scheme can be effective for bikeways along roadways with high through movement volumes and low turning volumes.

» **Leading Bicycle Interval.** Leading Bike Intervals or LBIs provide between 3 and 8 seconds for bikes to get a head start in advance of the green indication for turning motor vehicles. A leading bicycle interval allows a bicyclist to enter the conflict area prior to a turning motorist, improving visibility. In some cases, a leading bicycle interval may allow bicyclists to clear the conflict point before motor vehicles enter. A parallel leading pedestrian interval should also be considered where there is a parallel pedestrian crossing. In this phasing scheme, a bicycle needs to be controlled by a signal face that is separate from the vehicle signal. Right (or left) turns on red must be prohibited during the leading bicycle interval. Because it only requires a few seconds, a leading bicycle interval has only a minor impact on vehicle operations and generally does not require an increased signal cycle length. The use of a red arrow followed by a flashing yellow arrow (FYA) should be considered for left- and right-turn movements across a bikeway with a leading interval.

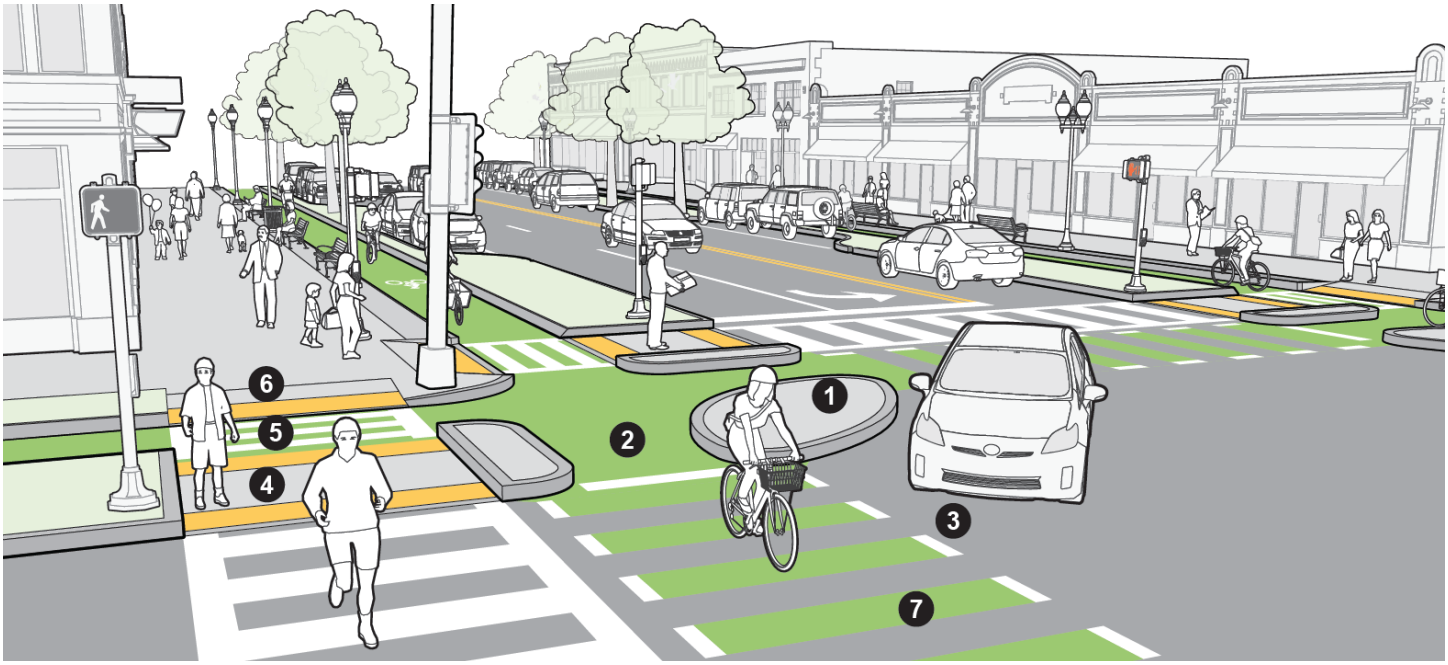
» **Green Wave.** Another strategy in signal timing is coordinating signals to provide a "green wave", such that bicycles will receive a green indication and not be required to stop. Several cities including Portland, OR and San Francisco, CA have implemented "green waves" for bicycles.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)
NACTO Urban Bikeway Design Guide (2014)
Manual on Uniform Traffic Control Devices (MUTCD) (2012)

3.12 PROTECTED INTERSECTION

Protected intersections include a suite of design characteristics that provide enhanced separation and encourage slower motor vehicle speeds. Well-designed protected intersections are intuitive and comfortable, provide clear right of way assignment, promote predictability of movement, and allow eye contact between motorists, bicyclists, and pedestrians. They also clearly define pedestrian and bicyclist operating spaces within the intersection and minimize potential conflicts between users.



GUIDANCE

1. **Corner Island.** A floating curbed segment placed between the through bicycle lane and the right turning vehicle path, creating space for a forward bicycle queuing area and for vehicles to wait while yielding to crossing bicyclists and pedestrians. They also reduce the speeds of turning motorists and through bicyclists. In retrofit projects, corner islands may be constructed with rubber speed bumps and/or flexibile delineators.
2. **Forward Queuing Area.** Provides a waiting area that is fully within the view of motorists who are waiting at the vehicle stop bar, improving bicyclist visibility. Enables bicyclists to enter the intersection prior to turning motorists at the beginning of the green signal and establish the right of way. The bicycle queuing area should be at least 6 ft long to accommodate a typical bicycle length.
3. **Motorist Yield Zone.** A space for turning motorists to yield to bicyclists and pedestrians. Improves motorist view of approaching bicyclists by reducing the need for motorists to scan behind them. Creates space for a motorist to yield to bicyclists and pedestrians without blocking traffic and provides more time for all users to react to each other.
4. **Pedestrian Refuge Median.** A space for pedestrians to wait between the street and the separated bike lane. It should be a minimum width of 6 ft and should include detectable warning surfaces. A pedestrian refuge median enables pedestrians to negotiate potential bicycle and motor vehicle conflicts separately, shortens the pedestrian crossing distance of the road, reduces the likelihood that pedestrians will block the bike lane while waiting to cross the road, and provides more pedestrian visibility to motor vehicles approaching the intersection.
5. Pedestrian crossing of the separated bike lane
6. Pedestrian curb ramp
7. Bicycle crossing of travel lanes

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)

NACTO Urban Bikeway Design Guide (2014)

MassDOT Separated Bike Lane Planning and Design Guide (2015)

3.14 BICYCLE CROSSING MARKINGS

Communicating the right-of-way priority at intersection requires providing bicyclists, pedestrians, and motorists with cues that both clearly establish which user(s) have the right of way and consistently communicate expected yielding behavior. Bike crossing markings are desirable to delineate a preferred path for people bicycling through the intersection, especially crossings of wide or complex intersections, improve the legibility of the bike crossing to roadway users, and encourage motorist yielding behavior where motorists must merge or turn across the path of a bicyclist.

Intersection Type	Condition	Separated Bicycle Lane	Conventional/ Buffered Bike Lane	Bicycle Boluevard
Signalized	Major Street Crossing or History of Bicycle Collisions			*
	Minor Street Crossing			No Markings
Unsignalized	Major Street Crossing or History of Bicycle Collisions			*
	All Other Conditions			No Markings
Driveway	Major Driveway			No Markings
	Minor Driveway			No Markings

*Additional treatment, such as BikeHAWK or RRFB may be needed; Crossing markings along a Bicycle Boulevard require short sections of receiving bicycle lanes

Bike HAWK crossing on Lakeway Dr on the Grant Street Bike Boulevard, including green crossing markings, short sections of green receiving bike lanes, a refuge island, and a diverter

GUIDANCE & CONSIDERATIONS

» **Options.** The table above summarizes the preferred pavement markings based on the intersection and bikeway type. Where a bikeway crosses an intersection separate from a crosswalk, bikeway lane markings may be extended through the intersection to delineate the bicycle crossing and raise awareness of the presence of bicyclists.

» **Use.** In addition to the applications from the table above, green dashed crossing markings are also used to highlight a transition zone between bikes and vehicles, such as a right turn lane.

» **Maintenance.** Where possible bicycle crossing markings should be placed outside the wheel path of vehicles to improve their longevity. Highly durable materials should be used to avoid premature fading where vehicle wheel paths are expected to pass over markings.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)

NACTO Urban Bikeway Design Guide (2014)

MassDOT Separated Bike Lane Planning and Design Guide (2015)

3.15 TWO-STAGE QUEUE BOX

Weaving across travel lanes and merging with motor vehicle traffic to reach the left side of the street is a challenging and uncomfortable maneuver for most people. The two-stage bicycle queue box allows bicyclists to traverse the intersection within the bike lane, stop within the queue box, reorient themselves to the cross street, and wait for the signal for the cross street to proceed, eliminating the need to merge across travel lanes. The two-stage queue box designates an area for bicyclists to wait for traffic to clear before proceeding in a different direction of travel. It may be used for left or right turns.

Two-stage queue box at the intersection of Champion St and State St

GUIDANCE

» **Placement.** A two-stage queue box must be located outside of the path of through and turning traffic, adjacent to the direct path of bicyclist travel, and downstream of the crosswalk and stop line. The queue box should be placed in a logical location that aligns with the receiving bicycle facility, where bicyclists have space to reorient and are safety out of the way of through traffic. A NO TURN ON RED (R10-11) sign must be installed where a two-stage turn queuing box is not located outside the path of right-turning traffic to prevent motorists from entering the bicycle queuing area.

» **Design.** Markings for a two-stage queue box must include a bicycle symbol oriented in the direction in which the bicyclists enter the box, must include an arrow showing the direction of the turn, and may include green-colored pavement or pavement markings to enhance the conspicuousness of the box. Two-stage bicycle turn box dimensions will vary based on the street operating conditions and available street space. The queuing area should be a minimum of 6.5 ft deep measured in the longitudinal direction of bicycles sitting in the box. The box must be outlined with solid white lines.

CONSIDERATIONS

» **Use.** A two-stage queue box may be used at signalized intersections per FHWA Interim Approval IA-20. Experimental approval from FHWA is required to use this pavement marking at unsignalized intersections. Queue boxes are most useful on high-volume and multi-lane roads to eliminate bicyclist merging across motor vehicle traffic.

» **Detection.** Passive detection of bicycles in the two-stage bicycle turn box must be provided if detection is required to actuate a traffic signal.

» **Maintenance.** Ensuring periodic refreshing of markings will ensure that the turn box stays conspicuous and visible to bicyclists intended to use the box as well as motorists who should be aware of it. Highly durable materials should be used where for markings to avoid premature fading where vehicle wheel paths are expected to pass over markings.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)

NACTO Urban Bikeway Design Guide (2014)

MassDOT Separated Bike Lane Planning and Design Guide (2015)

3.16 BICYCLE BOX

A bicycle box (or "bike box") is a designated area on the approach to a signalized intersection consisting of paint and bicycle symbols. Bike boxes should be considered to mitigate conflicts between through bicyclists and right-turning motorists and to reduce conflicts between motorists and bicyclists at the beginning of the green signal phase.

Bike box on XX at XX

GUIDANCE

» **Dimensions.** Bike boxes should be a minimum of 10 ft deep. The bike box should connect directly to the approaching bike lane. At least 50 ft of bike lane should be provided on the approach to a bike box so bicyclists will not need to ride between lanes to enter the box. The approaching bike lane, and the bike box, may be colored green.

» **Multiple Lanes.** Bike boxes should generally not be installed across more than one *through* travel lane. Where a bike box is provided across multiple lanes of an approach (e.g., one through lane and a left turn lane), countdown pedestrian signals should be provided for the crosswalk across the approach where the bike box is located to inform bicyclists whether there is adequate time remaining to cross to an adjacent lane before the onset of the green signal phase for that approach.

REFERENCES

AASHTO Guide for the Development of Bicycle Facilities (2012)
NACTO Urban Bikeway Design Guide (2014)
City of Bellingham: Bike Boxes and Beyond

CONSIDERATIONS

» **Use.** They are limited to signalized intersections and should not be used in other locations. Bike boxes may be used with an authorized request for interim approval per FHWA Interim Approval IA-18.

» **Benefits.** Bike boxes improve motorist visibility of bicyclists at intersections by placing the bicycle in front of stopped motorists, reducing conflicts which may occur at the onset of the signal turning green.

» **Left turns.** In limited situations, bike boxes may be used to facilitate left turns for bicycles when there is an unusually heavy left turn volume, such as near the entrance to a popular shared use path. Research has shown that bicyclists' use of bike boxes to make left turns is limited in practice. The preferred treatment for left-hand turns is the two-stage bicycle turn box.

» **Turning vehicle crashes.** At intersections where a high number of collisions occur between through bicyclists and turning vehicles, alternative treatments should be considered such as a protected intersection.

3.17 ROUNDABOUT ACCOMMODATIONS

Roundabouts are a popular design solution for intersections because they reduce delay for motorists and increase capacity through an intersection compared with a stop-controlled intersection, while also reducing travel speeds and the number of conflict points. While some bicyclists may be comfortable traversing a roundabout in a shared lane environment, many will not feel comfortable navigating roundabouts with vehicular traffic, especially multilane roundabouts. Facilities should be provided for both bicycles and pedestrians outside of the circulating vehicle space as well as crossings on approaches.

Roundabout with bicycle lane transitioning to a shared path (Olympia, WA)

GUIDANCE

» **Allowable Bicycle Facilities in a Roundabout.** Bike lanes cannot be located within the circulatory roadway of a roundabout per the MUTCD. For comfort and safety reasons, roundabouts may be designed to facilitate bicycle travel outside of the circular roadway on a separated bike lane or shared use path. Although on-street bike lanes are to be terminated in advance of roundabouts, some bicyclists may choose to ride through the circulatory roadway as a vehicle rather than using a separated bikeway. Shared lane markings may be used within the circulatory roadway of the roundabout to indicate the preferred bicyclist position in the center of the lane.

» **Pedestrian and Bicycle Crossings.** Where pedestrians and bicycles cross the roadways, yield control for motorists should be provided in advance of the crossing location for both vehicles entering and exiting the roundabout. Channelizing islands or detectable surface materials to maintain separation between bicyclists and pedestrians throughout the crossings should be provided where separate facilities are provided on the approach to the crossing. BICYCLE/PEDESTRIAN WARNING signs (W11-15) should be provided at the bicycle and pedestrian crossings and YIELD HERE TO (or STOP HERE FOR) BICYCLES AND PEDESTRIANS (R1-5 alt. A), supplemented with yield lines (or stop bars) may be considered at crossings at roundabout exits to reinforce motorist yielding. Separated bike lanes at roundabouts operate based on the principle of mutual yielding. Additional signs or pavement markings may be appropriate to reinforce the bicyclist's and motorist's responsibility to yield (or stop) for pedestrians.

» **Accessibility at Multi-Lane Roundabout Crossings.** Higher volume multi-lane roundabouts may require additional visual and audible cues to accommodate pedestrians with disabilities. PROWAG recommends including accessible pedestrian signals (APS) to meet the accessibility needs.

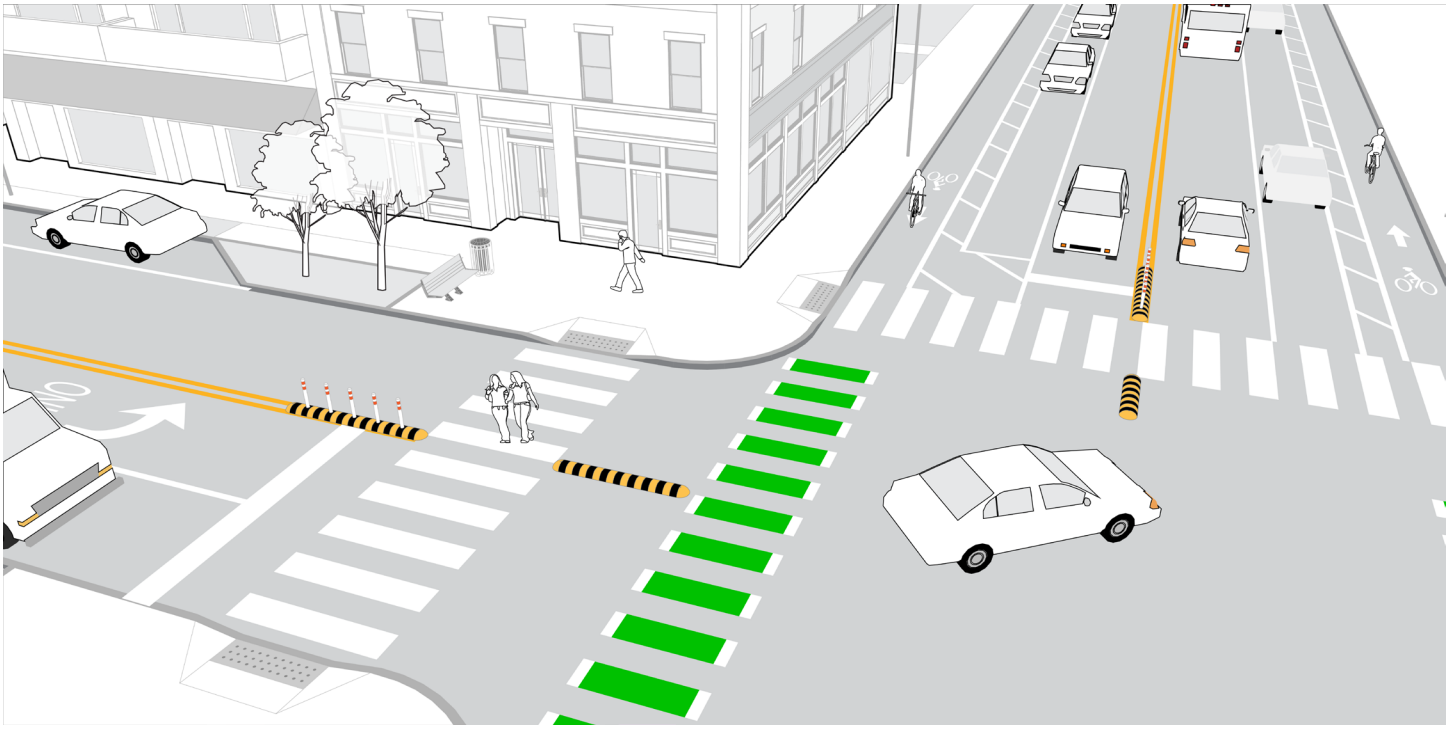
» **Protected Roundabouts.** The determination to use either a separated bike lane or shared use path is determined primarily by the anticipated volume of bicyclists and pedestrians. Accommodations should be provided for on-street bicyclists to move from the roadway to an adjacent separated bikeway or shared use path before reaching a roundabout. This transition should be located a minimum of 100 ft from the roundabout. If the elevation of the separated bikeway differs from the on-road facility, a bicycle ramp must be provided to transition between these facility types. The separated bicycle lane or shared use paths should be continuous around the circulating roadway. Shared use paths should accommodate both bicycle and pedestrians with a minimum path width of 10 ft and widened curb ramps that match the shared use path width at crosswalks.

REFERENCES

ODOT Multimodal Design Guide (2022)
AASHTO Guide for the Development of Bicycle Facilities (2012)
Caltrans Pedestrian Safety Countermeasures Toolbox (2019)
NCHRP: Crossing Solutions at Roundabouts and Channelized Turn Lanes for Pedestrians with Vision Disabilities (2015)

3.18 HARDENED CENTERLINE

Where intersections are large, drivers may cut the corner of their left turn path through the crosswalk, which allows them to increase their speed while simultaneously exposing more people walking and bicycling to conflicts. To mitigate corner cutting and slow turning motor vehicles, reduce the pedestrian exposure area, and improve sight lines between the motorist and people crossing, a median or hardened centerline can be used. A hardened centerline channelizes and slows the speeds of left turning motorists as they prepare to cross the path of pedestrians and bicyclists. These treatments have been found to reduce left turn speeds of motorists by reducing the effective turning radius of this maneuver.



GUIDANCE

» **Design.** Hardened centerlines are comprised of a painted centerline supplemented by flexible delineators, mountable curb, rubber curb, concrete curb, IN-STREET PEDESTRIAN CROSSING signs (R1-6), or a combination of these treatments. The design of a hardened centerline will depend on the intersection geometry and vehicle turning radius of both the design and control vehicles expected to turn in the intersection. Mountable curbs are used where larger vehicles (control vehicles) need room to turn but passenger vehicles (design vehicle) can maneuver around them. No vertical elements should be within the crosswalk.

CONSIDERATIONS

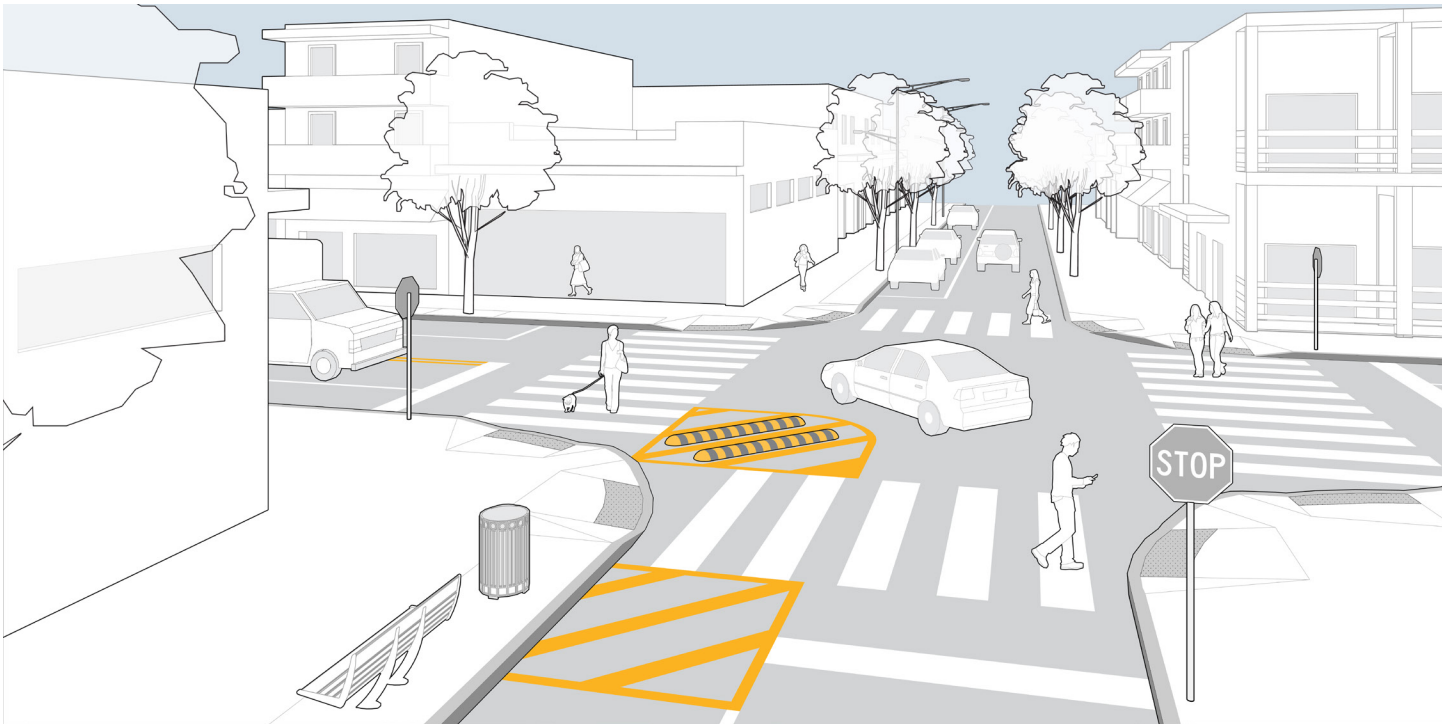
» **Placement.** Hardened centerlines should be considered where higher-speed left turns occur concurrent with pedestrian and/or bicyclist movements, as they have been found to reduce the speed of left turning motorists by reducing the effective turning radius. Hardened centerlines can be appropriate on both the departure roadway and the receiving roadway to channelize turning vehicles to take the tightest turns.

REFERENCES

ODOT Multimodal Design Guide (2022)
NACTO Don't Give Up at the Intersection (2019)
Caltrans Pedestrian Safety Countermeasures Toolbox (2019)
Denver Complete Streets Design Guidelines (2020)

3.19 TURN WEDGE

A turn wedge, or a slow turn wedge, is a tool that lowers the effective radius of a turn by extending the edge line of the roadway into the intersection and keep vehicles turning in a straight alignment longer before allowing them to turn their vehicle. The turn wedge discourages drivers of smaller vehices from cutting turns without restricting larger vehicle turning movements and decreases the potential conflict area between turning vehicles and crossing pedestrians.



GUIDANCE

» **Design.** The turn wedge treatment consists of marking a daylighted no parking zone prior to the nearside crosswalk as well as a marked slow turn wedge in the intersection, but outside of the intersecting travel lane. Rubber speed bumps should be included to deter smaller vehicles from cutting through while allowing larger vehicles to still make the turn. Turn wedges should match striping edge colors where appropriate, yellow for left edges and white for right edges.

CONSIDERATIONS

» **Use.** Turn wedges may be used in a variety of contexts, but are most commonly used where a one-way road approaches an intersection with turning movements onto the intersecting street, especially left turn movements. The one-way approach means that vehicles can turn without worrying about oncoming traffic, which allows them to take a wider turn, starting at or before the nearside crosswalk. The turn wedge forces vehicles to square the turn and continue straight through the intersection before turning.

» **Use with Hardened Centerlines.** Turn wedges can be used in conjunction with hardened centerlines to provide a combined effect of aligning the turning vehicle on the approach and the receiving ends of the turn.

REFERENCES

NACTO Don't Give Up at the Intersection (2019)
Denver Complete Streets Design Guidelines (2020)