CHAPTER 7 OUTLINE:

CHAPTER 7: BICYCLE FACILITY STANDARDS

DESIGN PRINCIPLES

This chapter provides guidelines to both public and private entities for the future development of various types of bicycle facilities in the City of Raleigh. The guidelines noted herein are based on the best practices in use throughout the United States, as well as accepted national standards for bicycle and greenway facilities.

The guidelines should be used with the understanding that design adjustments will be necessary in certain situations in order to achieve the best results. Facility installation and improvements should be evaluated on a case-by-case basis, in consultation with local or state bicycle coordinators, and/or a qualified engineer and landscape architect. Should national standards be revised in the future and result in discrepancies with this chapter, the national standards should prevail for all design decisions.

On facilities maintained by NCDOT, the State's design guidelines will apply. The City of Raleigh has the potential to exceed minimum guidelines where conditions warrant (within its jurisdiction).

According to the City of Raleigh Planning Department website, (http://www.raleigh-nc.org/Strategic_Planning/Streetscape_Plans.html) Streetscape Plans are a key element of the urban development process. The City describes these plans as follows:

> "Streetscape Plans or Streetscape and Parking Plans are required to be adopted as part of a Pedestrian Business Overlay zoning classification. See Section 10-2055 of the City of Raleigh Planning and Development Regulations. Streetscape Plans include standards for improvements to street right-of-ways, vehicular areas and building facades that reinforce the unique character and pedestrian orientation of an area. Streetscape standards may address unifying design features for sidewalks, paving, curbing, street trees, building facades, setbacks, vehicular parking areas, building heights, bicycle parking, signage, awnings, street furniture, overhead utilities, streetlights, and other elements of a streetscape. In addition to the aforementioned standards, Streetscape and Parking Plans also address the provision of adequate vehicular and bicycle parking for a Pedestrian Business Overlay District."

Streetscape Plans have been developed for the following areas:

Cameron Village Streetscape and Parking Plan
Glenlake Office Park Streetscape and Parking Plan
Glenwood South Streetscape and Parking Plan
Oakwood Mordecai Business District Streetscape Plan
Peace Streetscape and Parking Plan
Promenade at Crabtree Streetscape and Parking Plan
Southeast Raleigh Streetscape Master Plan
Stanhope Center Streetscape and Parking Plan
University Village Streetscape Plan on Hillsborough Street

In reviewing these streetscape plans, they appear to be highly focused on the pedestrian realm. Bicycle parking is provided as a streetscape element, but most street cross sections only show 11' to 14' shared curb lanes. Bike lanes, bicycle boulevards and other on-street bike lanes could be integrated into these streetscape concepts and cross sections. On-street bikeways will help the City connect greenways with the pedestrian-oriented Streetscape Plans. This will allow people to travel by bicycle to all destinations safely.

The following are key design principles for these guidelines:

1. All streets in Raleigh (except for limited access highways) are legal for the use of bicyclists. Therefore, most streets are bicycle facilities and will be designed, built (or retrofitted) and maintained accordingly. 'Complete Streets' is a term used for streets that are designed and operated to enable safe access for all users. On such streets, pedestrians, bicyclists, motorists and bus riders of all ages and abilities are able to safely move along and across the roadway environment. The Complete Streets concept is recommended for the design and maintenance of all City of Raleigh Streets. See *Chapter 5: Programs and Policies* for additional information.

2. Raleigh will have both a complete network of on-street bicycling facilities and a complete network of greenway trails. These two systems will be interconnected to make it possible for all destinations in Raleigh to be accessible by bicycle.

3. Bicyclists have a range of skill levels, from Type "C"*/beginners* (especially children and seniors), to Type "B"*/intermediate* (occasional commuters and recreational cyclists), to Type "A"*/experienced* (regular commuters and recreational cyclists, including any adults comfortable sharing the road with motor vehicles). These groups are not always exclusive- some elite-level athletes still like to ride on shared-use paths with their families, and some recreational bicyclists will sometimes use their bicycles for utilitarian travel.

4. Bicycle facility design should take into account the needs of all levels. At a minimum, facilities will be designed for the use of Type "A" cyclists, with a goal of providing for Type "B" cyclists to the greatest extent possible. In areas where specific needs have been identified (for example, near schools) the needs of appropriate types of bicyclists will be accommodated.

5. Design guidelines are intended to be flexible and can be applied with professional judgment by designers. Specific national and state guidelines are identified in this document, as well as design treatments that may exceed these guidelines. Some new treatments may require formal applications to NCDOT and FHWA for approval as experimental uses.

Additional Design Considerations and Resources

Facility design is a broad topic that covers many issues. Additional design considerations include the Americans with Disabilities Act, sustainable design, Context Sensitive Solutions, and many other topics that are covered in greater detail within the resources listed on the following page.

Americans with Disabilities Act: requires that portions of Raleigh's greenways be accessible to persons with varying motor skills and abilities. Perhaps the best way to comprehend the importance of ADA is to understand that most of us, at some time in our life, will experience a temporary disability that affects the way in which we make use of outdoor resources. ADA benefits all Americans by making the outdoor environment more accessible.

Sustainable Design :The use of recycled materials and products is recommended in the construction of bicycle and trail facilities whenever feasible. Recycled materials offer design versatility, often have a long life span, and require less long-term maintenance than similar products constructed from natural materials. Recycled plastic lumber and or concrete can be used for the construction of posts and poles, and recycled aluminum can be used for signs. Whenever possible, local materials should be used for construction.

Context Sensitive Solutions: A collaboration between the Congress for New Urbanism and the Institute of Transportation Engineers produced the report *Context Sensitive Solutions in Designing Major Urban Thoroughfares for Walkable Communities: An ITE Proposed Recommended Practice*. It advances the successful use of what are often called context sensitive solutions (CSS) in the planning and design of major urban thoroughfares. It provides guidance and demonstrates for practitioners how CSS concepts and principles may be applied in roadway improvement projects that are consistent with their physical settings. Although the main focus is on walkability, the majority of concepts and principles outlined are also highly applicable for the design of bicycle-friendly communities. The design and construction of all streets in the City of Raleigh should follow CSS concepts whenever possible. Go to www.ite.org/css for more information.

Resources: Information in this chapter is not a substitute for professional, site-specific design and engineering work. For more in-depth information and design development standards, the following publications should be consulted:

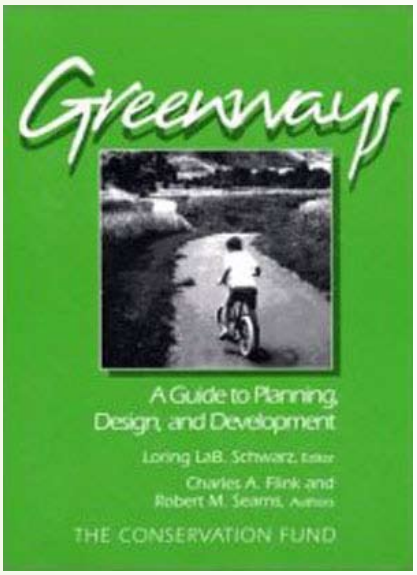
Bicycle Facility Selection: A Comparison of Approaches
Michael King, for the Pedestrian and Bicycle Information Center Highway Safety Research Center, 2002
http://www.bicyclinginfo.org/pdf/bikeguide.pdf

Bicycle Parking Design Guidelines
http://www.bicyclinginfo.org/pdf/bikepark.pdf

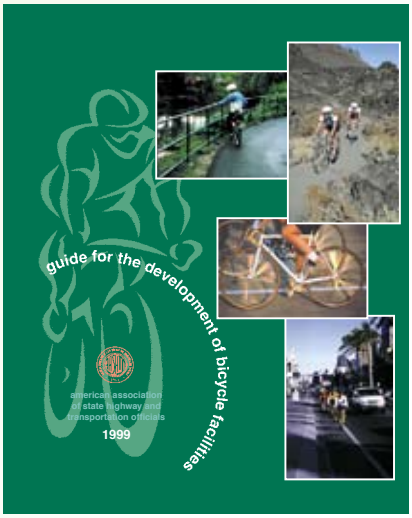
Bike Lane Design Guide
City of Chicago
http://www.bicyclinginfo.org/pdf/bike_lane.pdf

Engineer Bicycle Facilities
Bicycle and Pedestrian Information Center, 2008
http://www.bicyclinginfo.org/engineering/

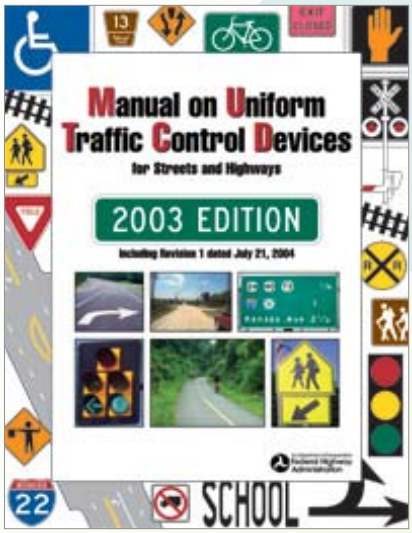
Greenways: A Guide to Planning, Design and Development
Island Press, 1993. Authors: Charles A. Flink and Robert Searns



*Guide for the Development of Bicycle Facilities**
American Association of State Highway Transportation Officials , 1999
http://www.transportation.org



**Once available, the City of Raleigh should use the updated AASHTO Bicycling Guide scheduled for release in 2009.*

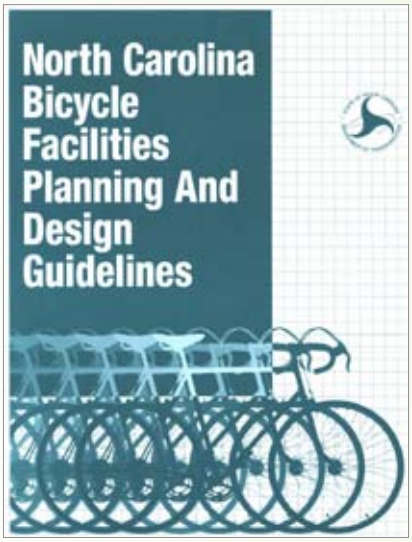


Manual on Uniform Traffic Control Devices (MUTCD)
U. S. Department of Transportation, Washington, DC, 2003
http://mutcd.fhwa.dot.gov

North Carolina Bicycle Facilities Planning and Design Guidelines
NCDOT Office of Bicycle and Pedestrian Transportation, Raleigh, NC, 1994
http://www.ncdot.org/transit/bicycle/projects/resources/projects_facilitydesign.html

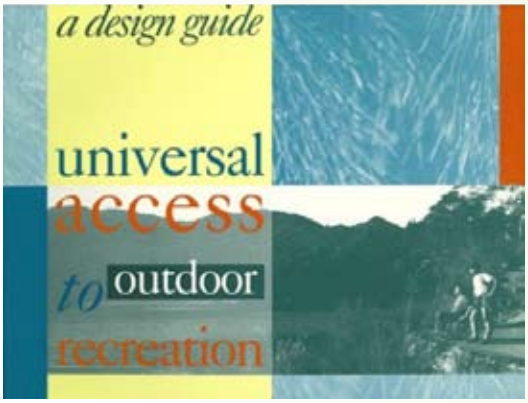
Policy on Geometric Design of Streets and Highways
American Association of State Highway Transportation Officials , 2001
http://transportation.org

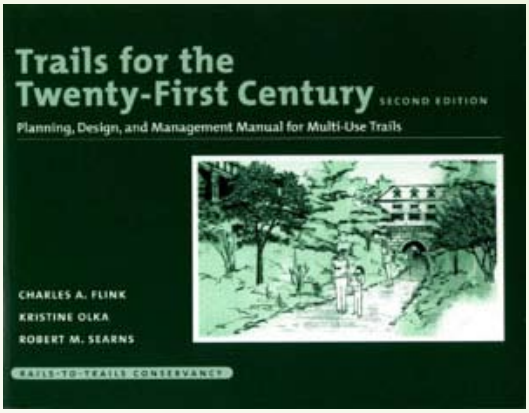
Raleigh Capital Area Greenway Map
http://www.raleighnc.gov/portal/server.pt/gateway/PTARGS_0_2_109824_0_0_18/Capital_Area_Greenway_Map.pdf



Trails for the Twenty-First Century
Island Press, 2nd ed. 2001. Authors: Charles A. Flink, Robert Searns, Kristine Olka

Universal Access to Outdoor Recreation: A Design Guide
PLAE, Inc., Berkeley, CA, 1993.





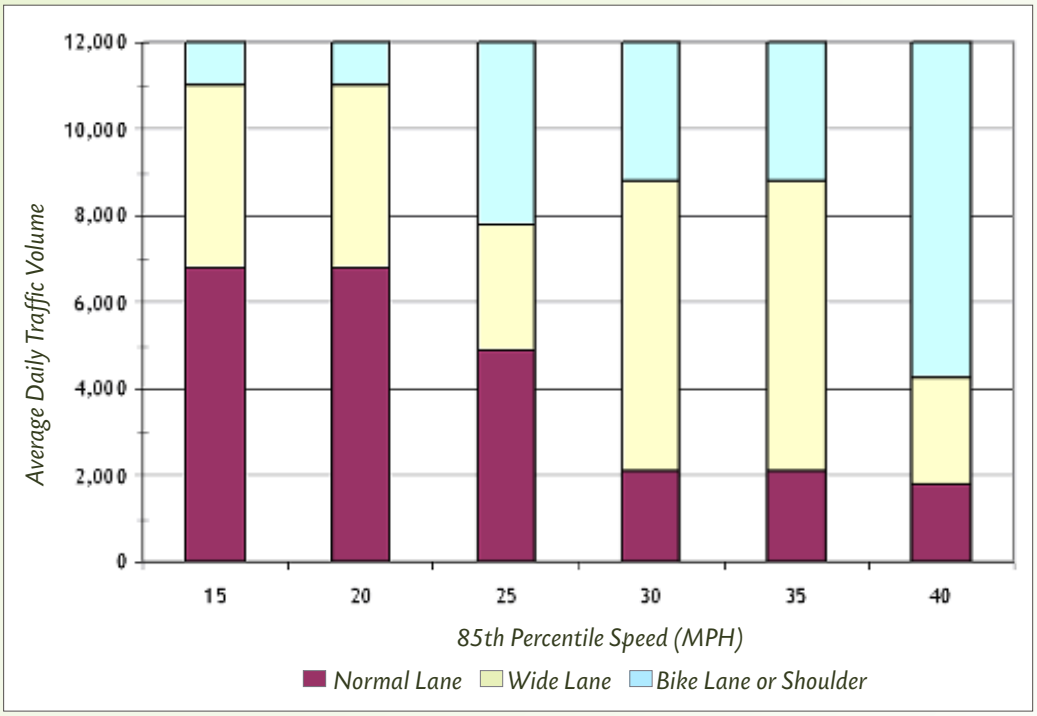
ON-ROAD BICYCLE FACILITIES

A complete street in Amsterdam includes wide sidewalks with landscaping and bicycle parking, bicycle lanes, transit lanes and vehicle lanes.

Bicycle facility design is often included within a larger design philosophy called "Complete Streets." The concept of a complete street is based on the principle that all streets should include basic amenities that consider and include features that facilitate the use of all forms of transportation, not just motor vehicles. If planned thoughtfully, non-vehicular amenities can serve more than one mode of transportation. For example, landscaped median strips can separate and buffer automobile traffic from pedestrians and cyclists and can create a zone with furnishings for both.

A wide variety of on-road bicycle facilities have been developed to meet different transportations needs in different roadway situations. The appropriate bicycle facility for any particular roadway, whether new or existing, should be dictated primarily by vehicle volume and speed of the roadway. Figure 7.2 below provides a matrix for evaluating bicycle facilities. The speed of the travel lane is shown along the x-axis and total traffic volumes per day are shown along the y-axis. The different colors represent the type of bikeway facility prescribed given the volume and speed of the travel lane.

North American Speed-Volume Chart



Source: M. King: Bicycle Facility Selection: A Comparison of Approaches

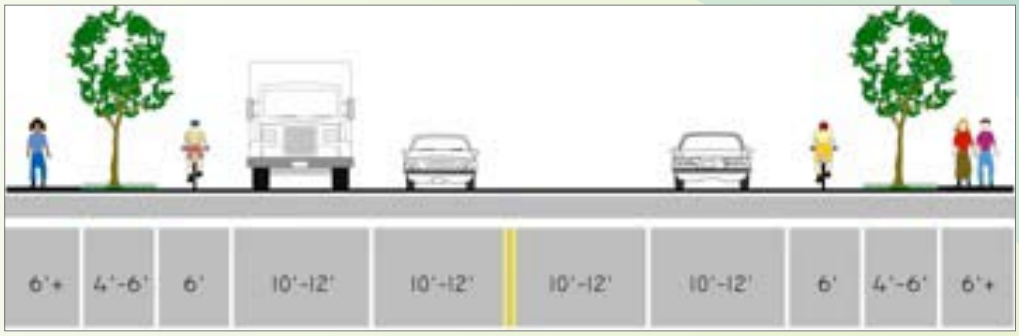
The following diagrams show how these recommendations could translate into roadway/facility configurations:

Multi-Lane Roadways

On roadways with 3,000 or more vehicles a day, bicycle lanes should be used to improve bicyclist safety and comfort. A buffer or curb must separate the shared use path or sidewalk from the roadway for pedestrian safety. The width of the bicycle lane, buffer, and sidewalk or path should appropriately reflect the volume and speed of the vehicles using the roadway. Figure 7.3 illustrates typical bicycle accommodation in urbanized areas. The minimum bike facility width is 4 ft on open shoulders and 5 ft from the face of a curb, guardrail, or parked cars, while 6 ft the preferred width in urbanized areas.[1]

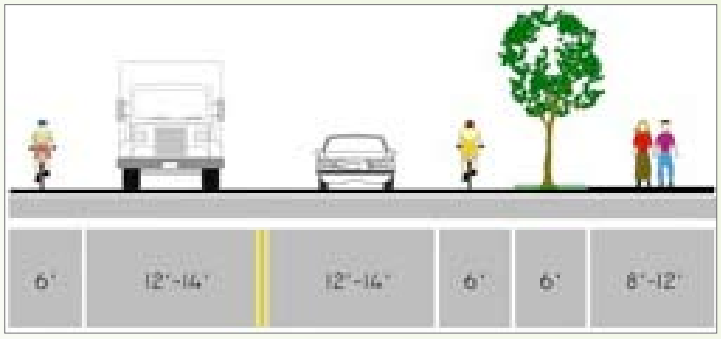
Note 1: MUTCD offers that roadways with 4,000 vpd or greater should have pavement marking (rather than 3,000, as stated at right). However, the MUTCD is primarily concerned with motor vehicles. The research cited in the document indicates that bicyclists safety and comfort are improved at lower thresholds - especially when encouraging less experienced cyclists to use on-street facilities, hence the use of 3,000 vpd as the threshold for this Plan.

Note 2: For information related to the adequacy of 10-foot lanes in a restriping scenario, see Chapter 4, pages 4-6 to 4-8 .



Option 1: Bicycle Lane on a Multi-lane Roadway

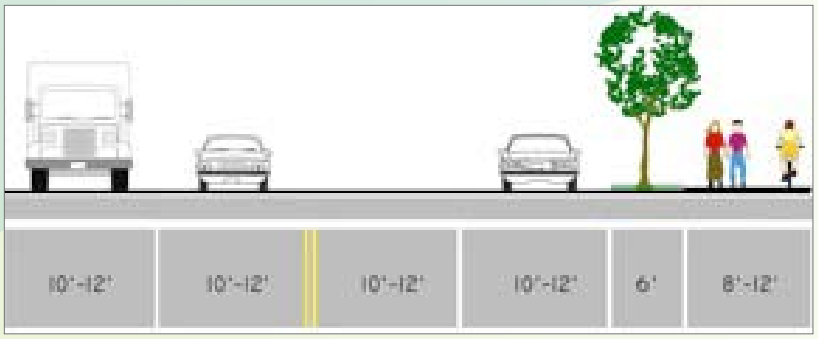
Some arterials and major collectors can accommodate a shared use path on one side of the roadway and on-street bicycle lanes for more experienced bicyclists (Figure 7.4). The shared use path provides a comfortable walking space for pedestrians and enables children and recreational bicyclists to ride without the discomfort of riding in a busy street. This configuration works best along roadways with limited driveway crossings and with services primarily located on one side of the roadway, or along a riverfront or other natural feature.



Option 2: Shared Use Path with Bike Lanes on a Multi-lane Roadway

1 AASHTO and MUTCD

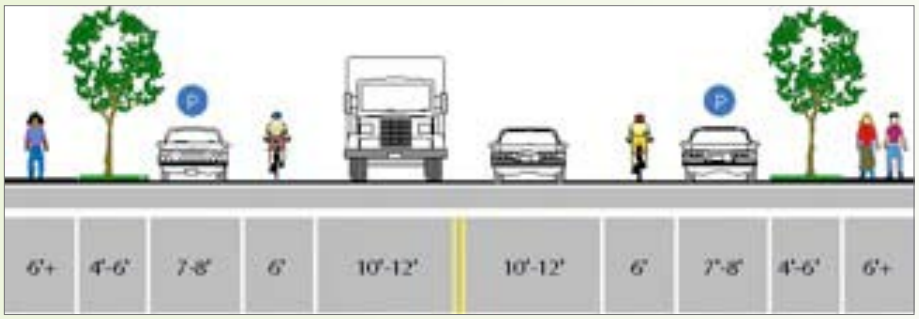
Sometimes a shared use path can provide accommodation on high-volume, high-speed roadways (Figure 7.5). This type of trail works best in corridors where there are limited driveway/intersection crossings and more desirable destinations along one side of the roadway, or where no roadway space is available to provide bike lanes, yet the road travels past a number of desirable locations. The trail should be at least 10' wide (preferable 12-15') with a 6' or greater vegetated buffer where possible.



Option 3: (Shared Use Path) on a Multi-lane Roadway

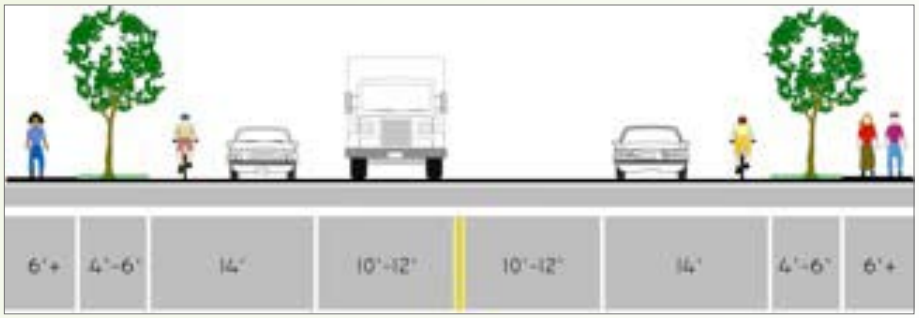
Two Lane Roadways

On moderate volume roadways, such as minor collectors, on-street parking is often permitted. Where on-street parking is permitted, and a bike lane is provided, the bike lane must be between parking and the travel lane (Figure 7.6).



Option 1: Bike Lane with On-Street Parking on a Two Lane Roadway

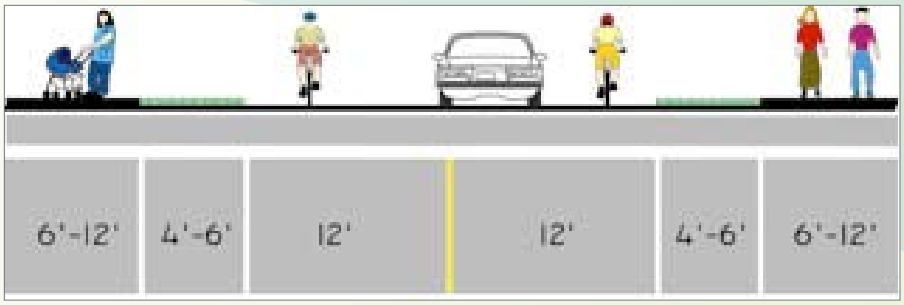
If no bicycle lane is striped, the outside travel lane in either direction may be widened to provide enough roadway space so that bicyclists and motor vehicles can share the roadway without putting either in danger (Figure 7.7).



Option 2: Wide Outside Lane on a Two Lane Roadway

Neighborhood Streets

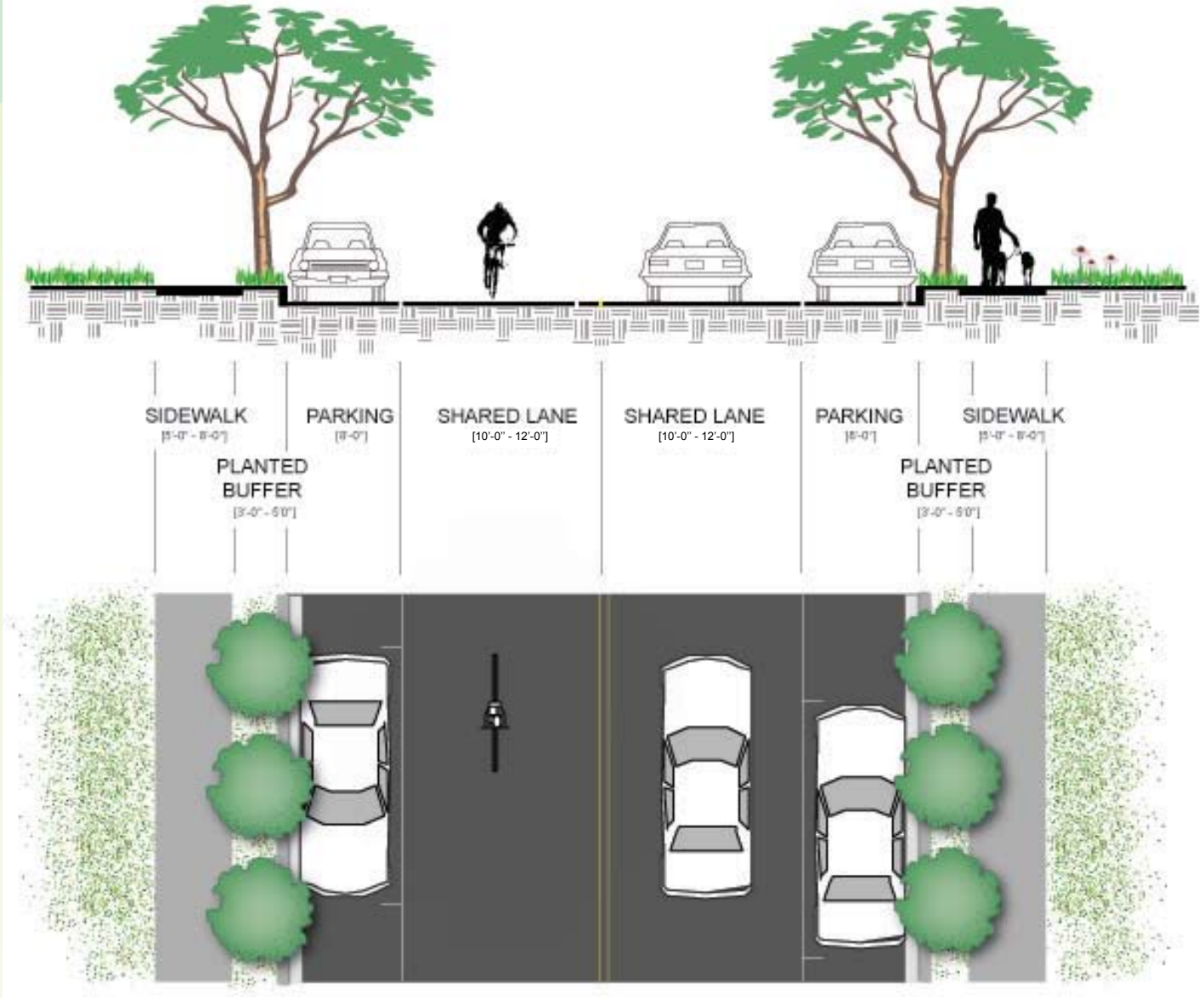
On a low volume, low speed roadway (e.g., a residential or neighborhood street); many bicyclists can safely share the road with vehicles. Pedestrians should be separated from the roadway with a buffer or, if there is insufficient space for a buffer, a curb. The width of the sidewalk or trail should depend on the traffic volume and speeds of the adjacent roadway (Figure 7.8).



Neighborhood Streets

Signed/Shared Roadway

• May either be a low volume (less than 3000 cars per day) roadway with traffic calming and signage to create a safe shared use environment, *OR* a higher volume roadway with wide (14') outside lanes.



Shared Lane Marking

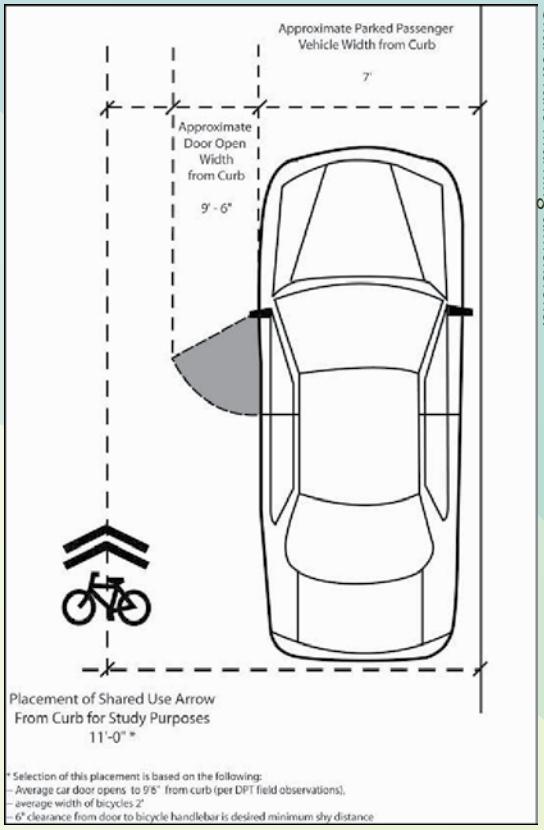
A bicycle shared lane marking (or 'sharrow') can serve a number of purposes, such as making motorists aware of bicycles potentially traveling in their lane, showing bicyclists the appropriate direction of travel, and, with proper placement, reminding bicyclists to bike further from parked cars to prevent "dooring" collisions. The shared lane marking stencil is used:

- Where lanes are too narrow for striping bike lanes
- Where the speed limit does not exceed 35 MPH
- With or without on-street parking

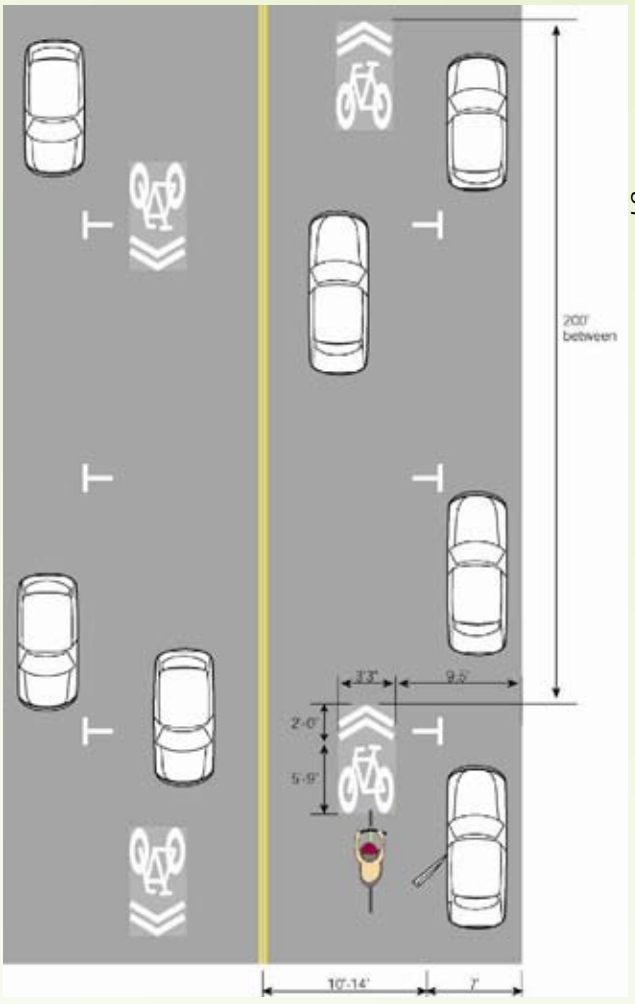
Cities such as Denver, San Francisco, Portland, Los Angeles, and Gainesville have effectively used this treatment for several years. In North Carolina, cities such as Chapel Hill and Carrboro have also begun using the shared lane marking (as well as college campuses, such as NC State in Raleigh). As of this writing, the sharrow treatment is being considered in the 2009/2010 update of the MUTCD.

A number of shared lane markings are recommended in this Plan, especially in the Downtown area where there is on-street parking and little room for bicycle lanes. Shared lane markings should also be considered for use on suburban roadway segments that connect bicycle lanes on either side, but do not have width for bicycle lanes.

It is recommended that shared lane markings be approached incrementally as a new facility treatment. Precedent studies and guidelines should also be examined, such as the City of Missoula's (MT) guidelines on the application of sharrows that was developed in 2007-2008.



Shared lane marking dimensions.



Shared lane marking placement.

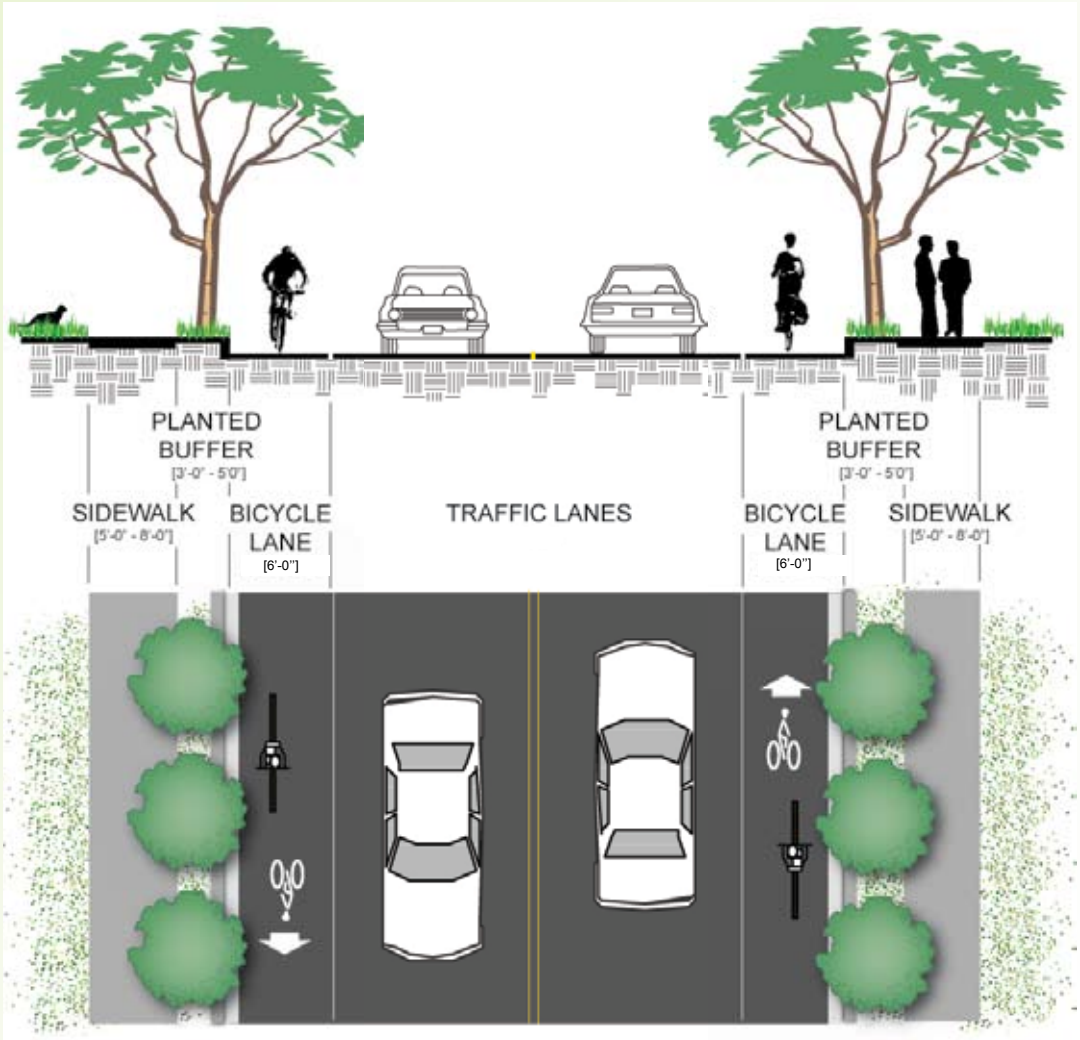
Shared lane markings installed on lanes that are too narrow for striping designated bike lanes.

Bicycle Lane

A bicycle lane is a portion of the roadway that has been designated by striping, signing, and pavement markings for the preferential and exclusive use of bicyclists. Bicycle lanes are always located on both sides of the road (except one way streets), and carry bicyclists in the same direction as adjacent motor vehicle traffic. The minimum width for a bicycle lane is four feet; five- and six-foot bike lanes are typical for collector and arterial roads (greater width is needed for bicycle lanes where traffic volume and speed are higher).

NCDOT recommends a bike lane width of:

- 6' from the curb face when a gutter pan is present (or 4' from the edge of the gutter pan)
- 4' from the curb face when no gutter pan is present
- Should be used on roadways with 3,000 or more ADT
- Not suitable where there are a high number of commercial driveways
- Suitable for 2-lane facilities and 4-lane divided facilities



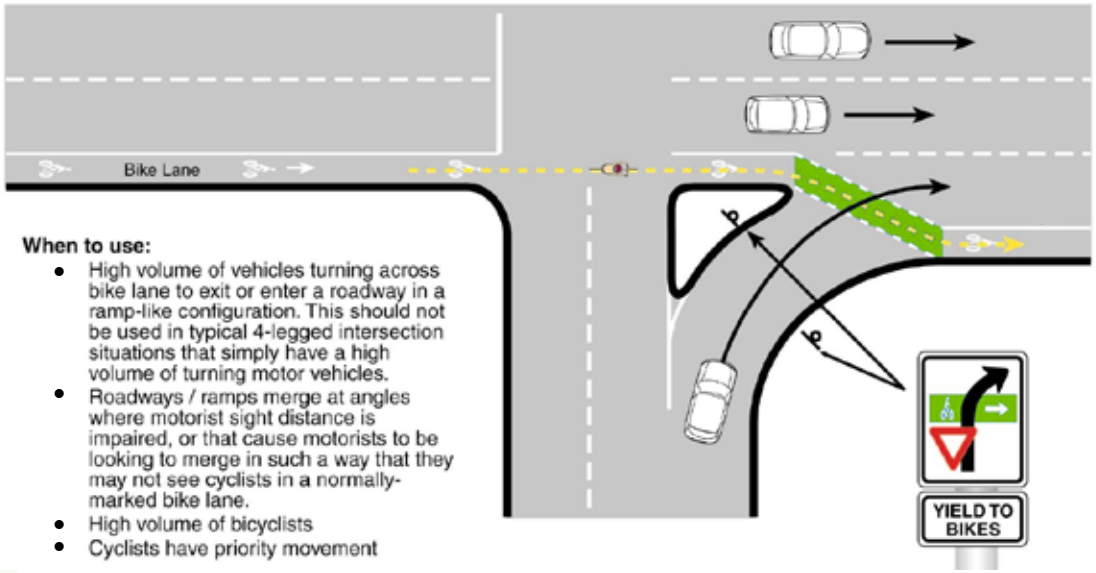
Colored Bike Lanes

In addition to markings presented in the MUTCD, the following experimental pavement markings may be considered. European countries have used colored pavement in bike lanes that tend to have a higher likelihood for vehicle conflicts. Examples of such locations are freeway on- and off-ramps and where a motorist may cross a bike lane to move into a right turn pocket. In the United States, the City of Portland and New York City have colored bike lanes and supportive signing with favorable results. Studies after implementation showed more motorists slowing or stopping at colored lanes and more motorists using their turn signals near colored lanes. Green is the recommended color (some cities that have used blue are changing to green, since blue is associated with handicapped facilities).

This colored bike lane in Portland is used to warn motorists approaching the on-ramp that bicyclists have a through lane.

Colored bicycle lane use in Denmark

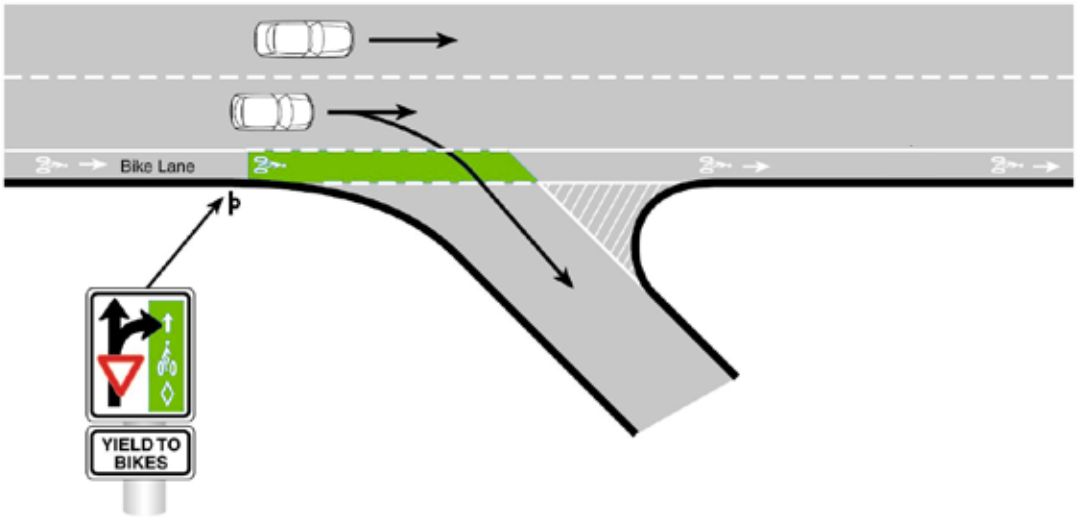
Entrance Ramp Zone



When to use:

- High volume of vehicles turning across bike lane to exit or enter a roadway in a ramp-like configuration. This should not be used in typical 4-legged intersection situations that simply have a high volume of turning motor vehicles.
- Roadways / ramps merge at angles where motorist sight distance is impaired, or that cause motorists to be looking to merge in such a way that they may not see cyclists in a normally-marked bike lane.
- High volume of bicyclists
- Cyclists have priority movement

Exit Ramp Zone

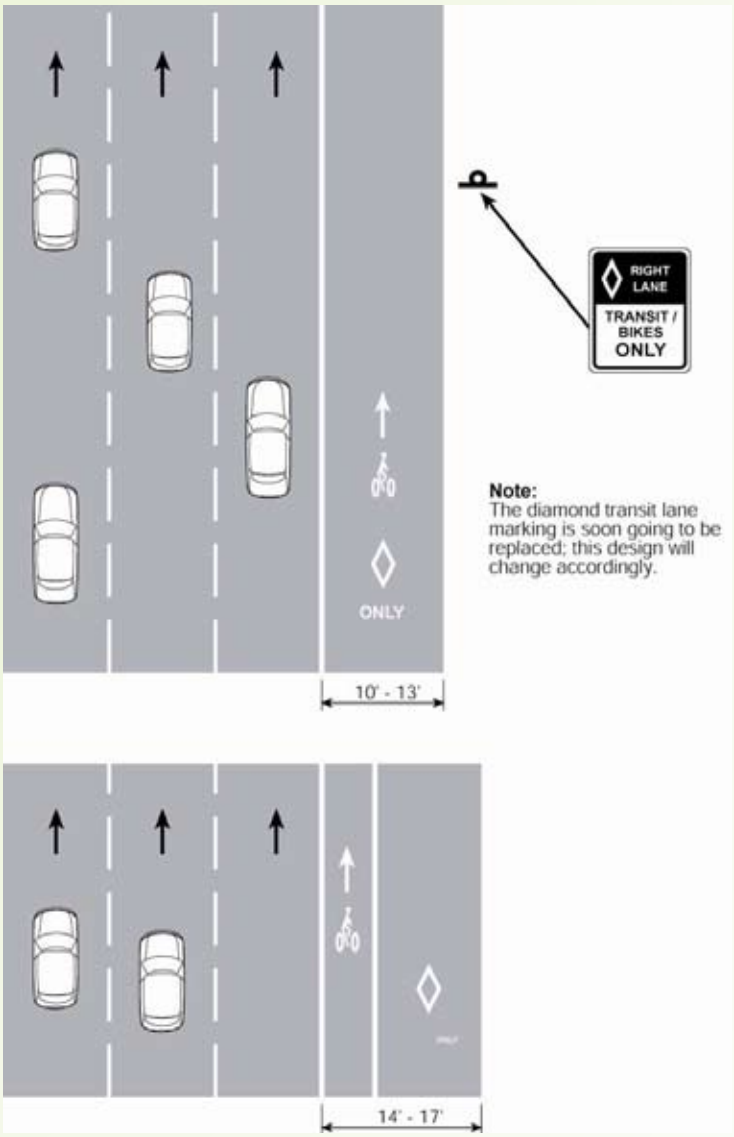


Shared Bus/Taxi/Bicycle Lane

Many cities have created multi-use lanes that accomodate bicycles and transit vehicles within the street. This innovative bikeway treatment is utilized in Phoenix, AZ; Philadelphia, PA; and Toronto, Canada.

Potential applications include:

- On auto-congested streets with moderate or long bus headways
- Moderate bus headways during peak hour
- Areas with limited alternative routes



Bicycle Lane + Parking

- On moderate volume roadways, such as minor collectors, where on-street parking is permitted and a bike lane is provided, the bike lane must be between parking and the travel lane.
- Appropriate space must be allocated to allow passing cyclists room to avoid open car doors.
- For lanes with combined vehicle parking and bike use (as shown below, in the photo at left), NCDOT recommends a minimum width of 12' to 13' and AASHTO recommends 11' to 13'.

Contra-flow Bicycle Lane

The contra-flow bicycle lane provides a striped lane going against the flow of automobile travel. The lanes should be separated by a double yellow line.

Potential applications:

- Provide direct access to key destination
- Improve safety
- Infrequent driveways on bike lane side
- Bicyclists can safely and conveniently re-enter traffic at either end
- Sufficient width to provide bike lane
- No parking on side of street with bike lane
- Existing high bicycle usage of street
- Less than three blocks in length
- No other reasonable route for bicyclists

Contra-flow bicycle lanes utilized in Scotland (top) and Burlington, VT (below)

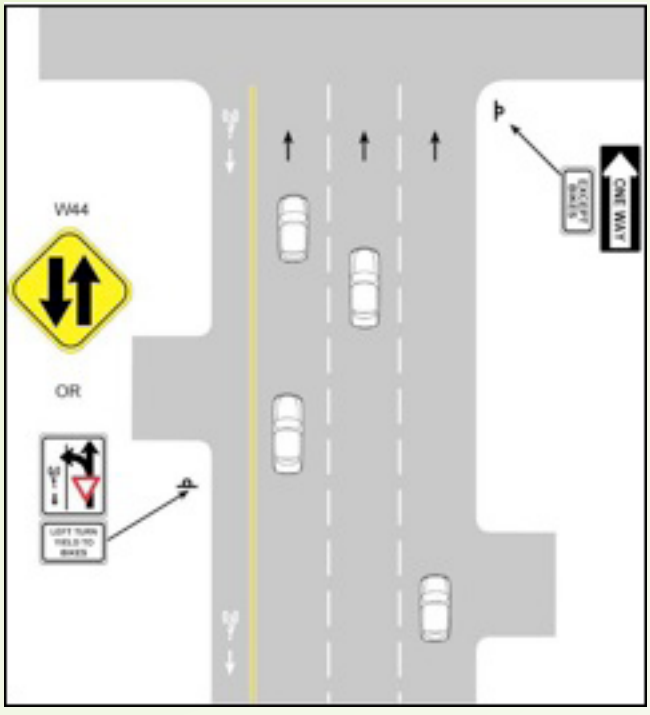
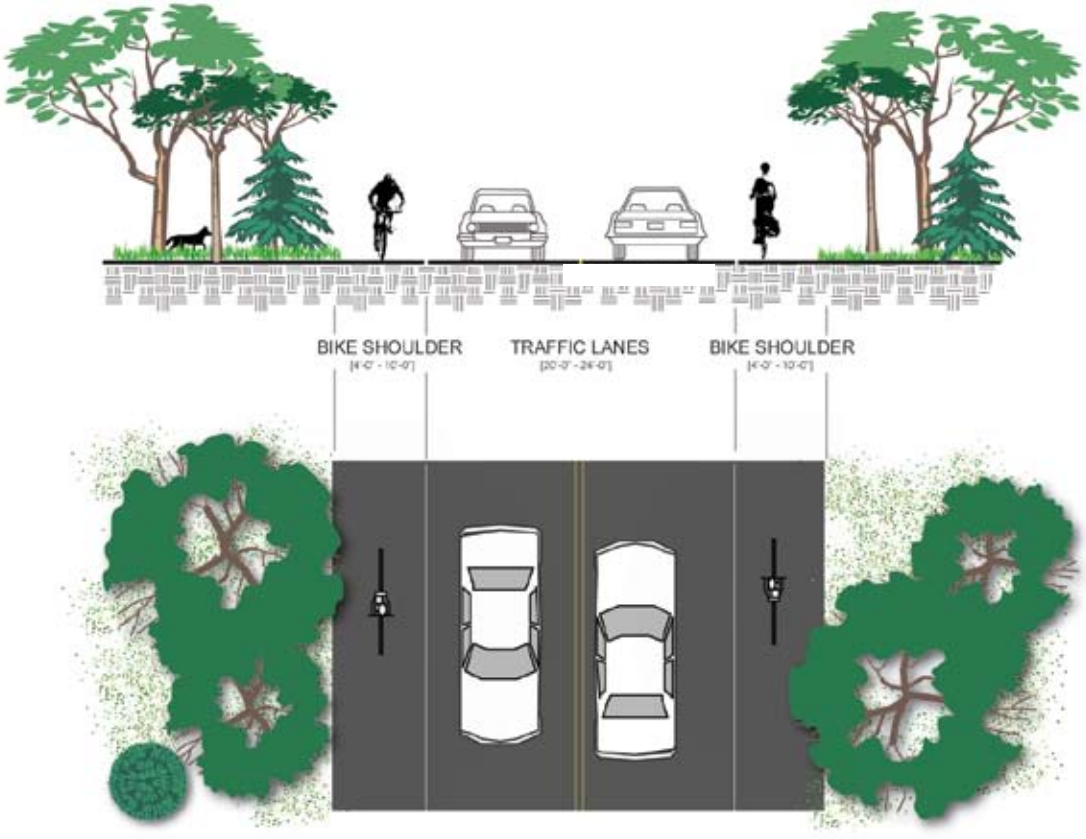


Fig. 7.15. Plan view of contra-flow bicycle lane

Paved Shoulder

Paved shoulders are the part of a roadway which is contiguous and on the same level as the regularly traveled portion of the roadway. There is no minimum width for paved shoulders, however a width of at least four feet is preferred. Ideally, paved shoulders should be include in the construction of new roadways and/or the upgrade of existing roadways, especially where there is a need to more safely accommodate bicycles.

- Most often used in rural environments, although not confined to any particular setting
- Should be delineated by a solid white line, and provided on both sides of the road
- Should be contiguous and on the same level as the regularly traveled portion of the roadway
- 4' minimum width; however for speeds higher than 40 MPH with high ADT, a shoulder width of more than 4' is recommended.
- Rumble strips should be avoided, but if used, then a width of more than 4' is needed.
- Paved shoulders should not be so wide as to be confused with a full automobile travel lane



Sidepath

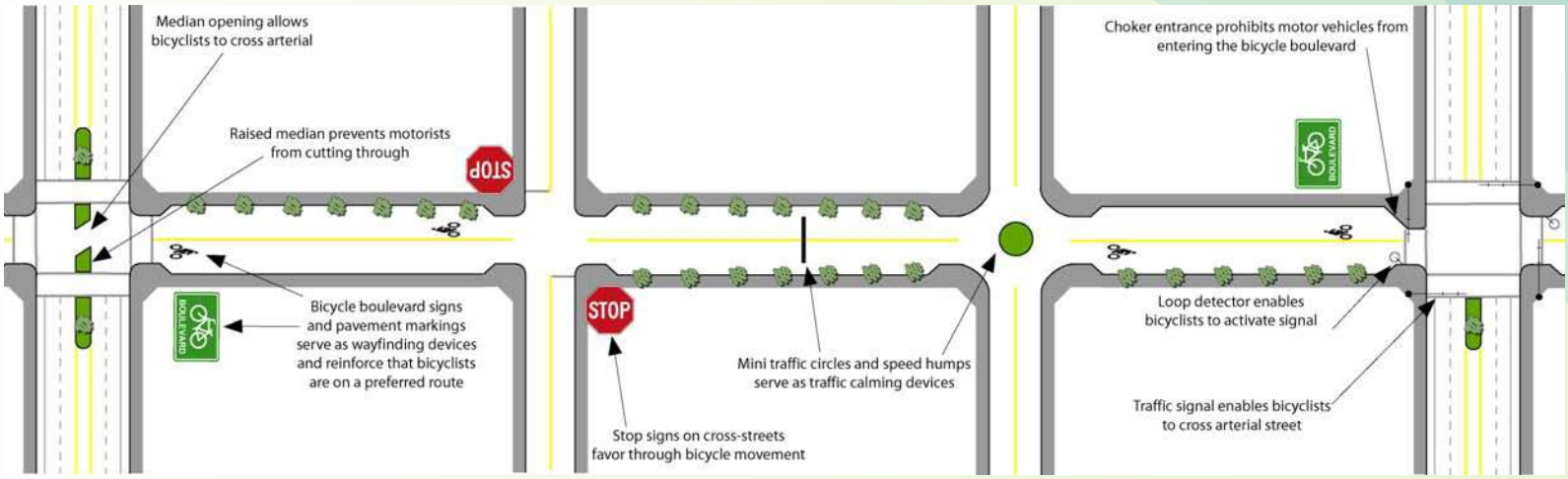
Multi-use paths located within the roadway corridor right-of-way, or adjacent to roads, are called 'Sidepaths'. Sidepaths are most appropriate in corridors with few driveways and intersections. Bicycle routes where side paths are recommended should also have adequate on-road bicycle facilities (such as paved shoulders or bicycle lanes), so that all types of users are accommodated.

- This type of facility works best in corridors where there are limited driveway/intersection crossings and more desirable destinations along one side of the roadway, or where no roadway space is available to provide bike lanes.
- A !0' minimum width is necessary on sidepaths for bicyclists to pass one another safely (12' for areas expecting high use)
- A 3-5' (preferably 6') vegetated buffer between the sidepath and the roadway should be provided where possible.
- Well-designed transitions from sidepaths to on-road facilities will direct bicyclists to the correct side of the roadway (see pages 7-28 and 7-29 for information on trail-roadway intersections)

Bicycle Boulevards

To further identify preferred routes for bicyclists, the operation of lower volume roadways may be modified to function as a through street for bicycles while maintaining local access for automobiles. Traffic calming devices reduce traffic speeds and through trips while limiting conflicts between motorists and bicyclists, as well as give priority to through bicycle movement.

Bike boulevards are often located on roadways that parallel a major roadway.



A bicycle boulevard.

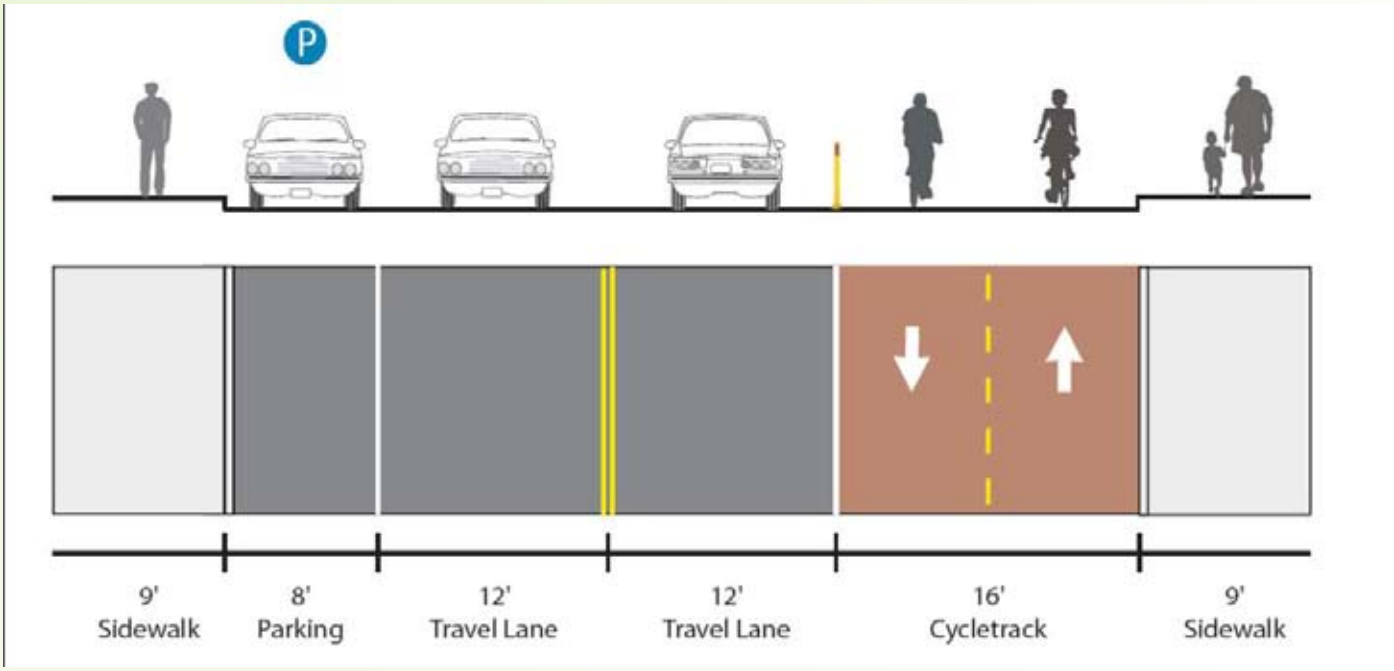
Bike boulevard route signs and/or pavement markings can be used to direct bicyclists.

Cycle Tracks

Cycle tracks are a hybrid type of bicycle facility that combines the experience of a separated path with the on-street infrastructure of a conventional bike lane. This type of facility is widely used in European cities and was recently introduced on 9th Ave. in New York City. The cycle track can provide for either one- or two-way traffic depending on the road conditions. This facility is generally used under certain conditions, such as along a waterfront, as part of an urban "road diet," and in limited locations where cross traffic and turning movement can be controlled.

The cycle track concept has been used to form a core urban bikeway loop in Montreal. Crossings at roadways include pedestrian priority markings and bicyclist actuated signals..

A small section of cycle track was provided by Arlington County, Virginia, as a connector to Gateway Park in Rosslyn.



Cycle track on a road with 66-foot right-of-way section.

Bicycle Access on Transit

Integrating bicycle facilities with transit modes allows bicyclists to greatly expand the area accessible. Below are examples of commuter trains and bus services with customized facilities allowing for simple and secure storage of bicycles without hindering or impeding other passengers. The City of Raleigh should continue to accommodate bikes on all buses, and should support similar options when light-rail or similar transit options become available.

1. Have your bike ready to load—always approach the bus from the curbside. Remove water bottles or other loose items.

2. Make eye contact with the driver to alert him/her to your presence.

3.If the rack is empty, lift the metal handle and pull the folded bike rack down flat.

4. Load the bike in the space nearest the bus.

If another bike is on the rack, load your bike in the open position. You are responsible for loading and securing your bike on the rack. Drivers are not allowed to load or unload bicycles.

5. Lift the support arm and hook it over the front tire.

Make sure the support arm clamps the tire and not the fender or frame. Your bike now is securely fastened in the rack.

6. Hop on and pay your fare.

7. When you reach your stop, tell the driver before you exit the bus that you'll be removing your bike.

Raise the support arm, lower it into place and lift your bike off the rack.

Fold up the rack if it is empty, and step onto the sidewalk with your bike.

NEVER cross in front of the bus—wait until the bus has left the stop.

If the rack is full, please wait for the next bus.

Instructions on how to load a bicycle onto a bus equipped with a bicycle rack, developed for a bicycle user map by Fremont, CA

BICYCLE-FRIENDLY INTERSECTIONS

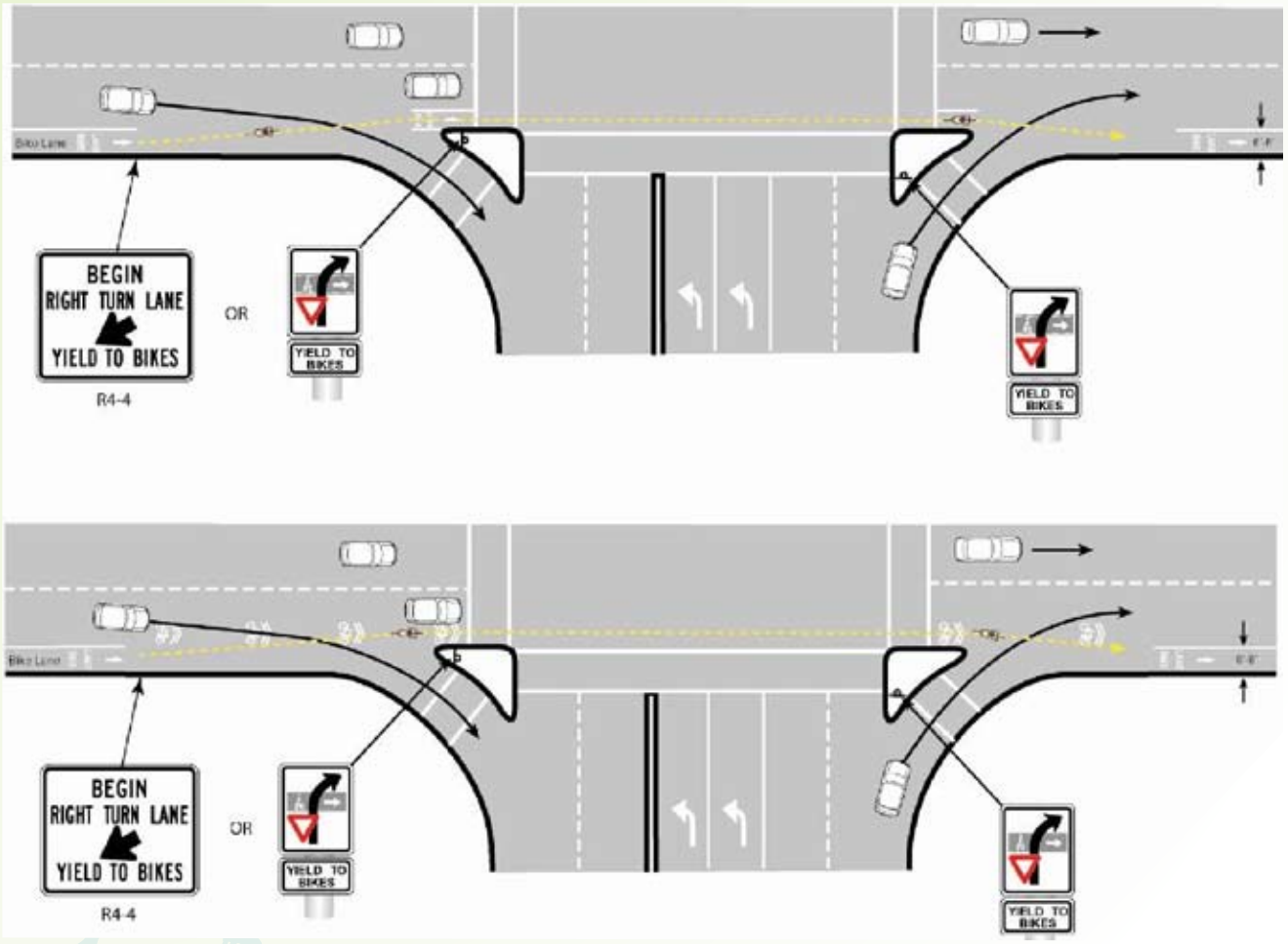
Intersections represent one of the primary collision points for bicyclists, with many factors involved:

- Larger intersections are more difficult for bicyclists to cross.
- On-coming vehicles from multiple directions and increased turning movements make it more difficult for motorists to notice non-motorized travelers.
- Most intersections do not provide a designated place for bicyclists.
- Bike lanes and pavement markings often end before intersections, causing confusion for bicyclists.
- Loop and other traffic signal detectors, such as video, often do not detect bicycles.
- Bicyclists making a left turn must either cross travel lanes to a left-turn lane, or dismount and cross as a pedestrian.
- Bicyclists traveling straight may have difficulty maneuvering from the far right lane, across a right turn lane, to a through lane of travel.

Solutions to these problems include bicycle-friendly intersection treatments. (Note: the following diagrams are from Caltrans, thus there is a discrepancy with what is recommended in this Plan regarding bike lane widths.)

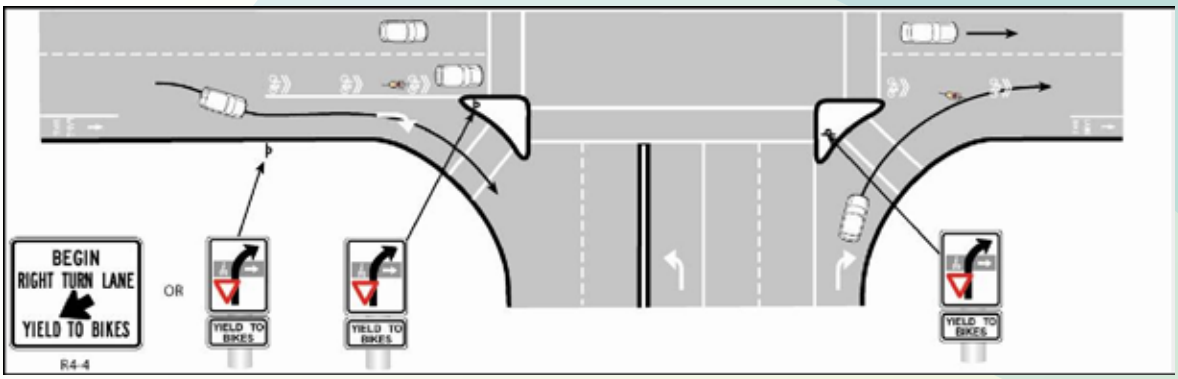
- Bike Lane Through 'Right Turn Island' Intersections
- Shared Travel Lane Through 'Right Turn Island' Intersection
- Bicycle Lane Adjacent to a 'Right Turn Only' Lane

Bike Lane Through 'Right Turn Island' Intersections (Caltrans)

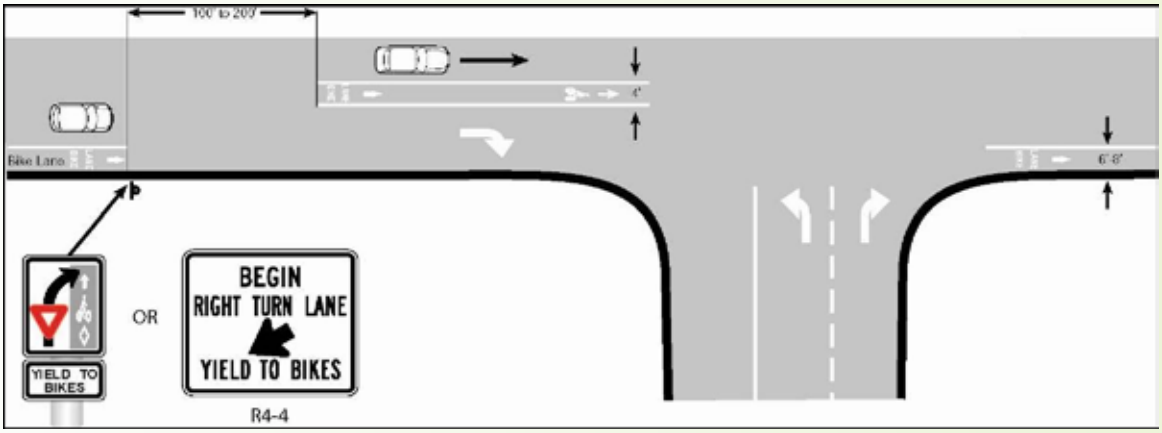


Shared Travel Lane Through 'Right Turn Island' Intersection

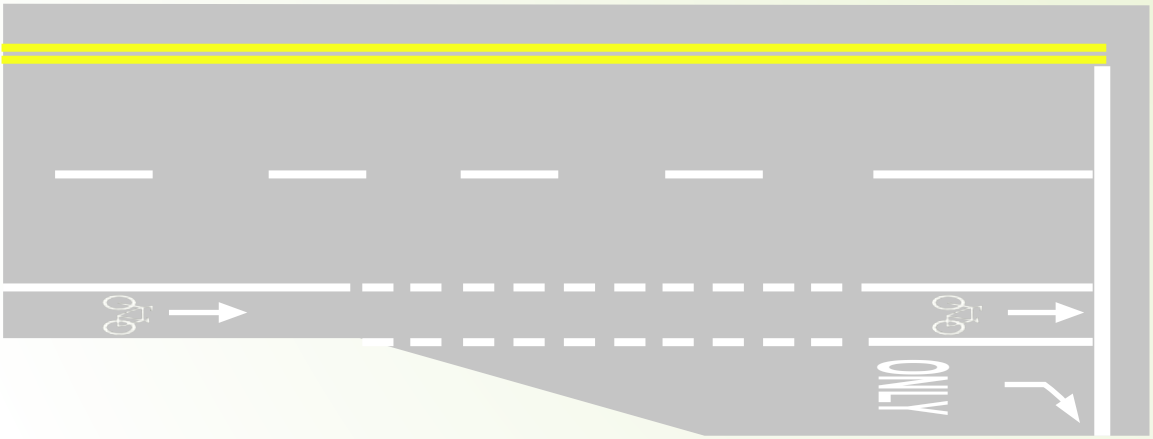
(with exclusive right turn lanes) (Caltrans)



Bicycle Lane Adjacent to a 'Right Turn Only' Lane *(Caltrans)*

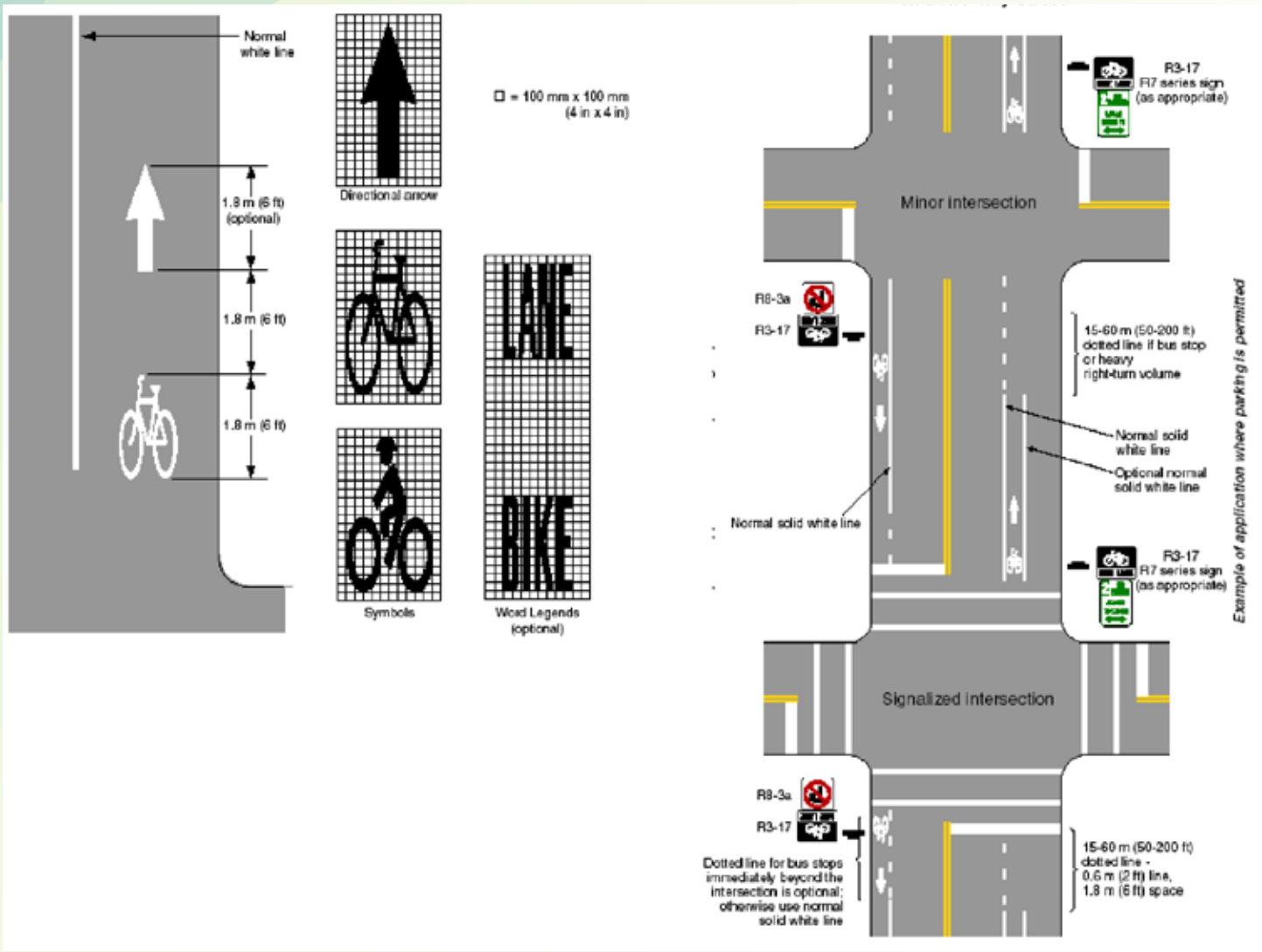


Bicycle Lane Adjacent to a 'Right Turn Only' Lane



Typical Pavement Markings and Intersection Configuration for Bike Lanes

The Manual on Uniform Traffic Control Devices (MUTCD) provides guidance for lane delineation, intersection treatments, and general application of pavement wording and symbols for on-road bicycle facilities and off-road paths (http://mutcd.fhwa.dot.gov/pdfs/millennium/12.18.00/9.pdf).

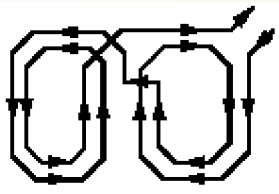


MUTCD examples of optional word and symbol pavement markings for bicycle lanes.

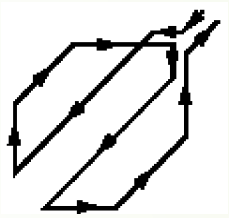
Bicycle-Activated Detector Loop

Changing how intersections operate can help make them more "friendly" to bicyclists. Improved traffic signal timing for bicyclists, bicycle-activated loop detectors, and camera detection make it easier and safer for cyclists to cross intersections. Bicycle-activated loop detectors are installed within the roadway to allow the weight of a bicycle to trigger a change in the traffic signal. This allows the cyclist to stay within the lane of travel and avoid maneuvering to the side of the road to trigger a push button, which ultimately provides extra green time before the light turns yellow to make it through the light. Current and future loops that are sensitive enough to detect bicycles should have pavement markings to instruct cyclists on how to trip them. These common loop detector types are recommended:

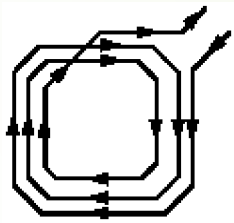
Use pavement marking to aid bicyclists in locating loop detectors at intersections.



Quadruple Loop
(Recommended for bike lanes)
- Detects most strongly in center
- Sharp cut-off sensitivity

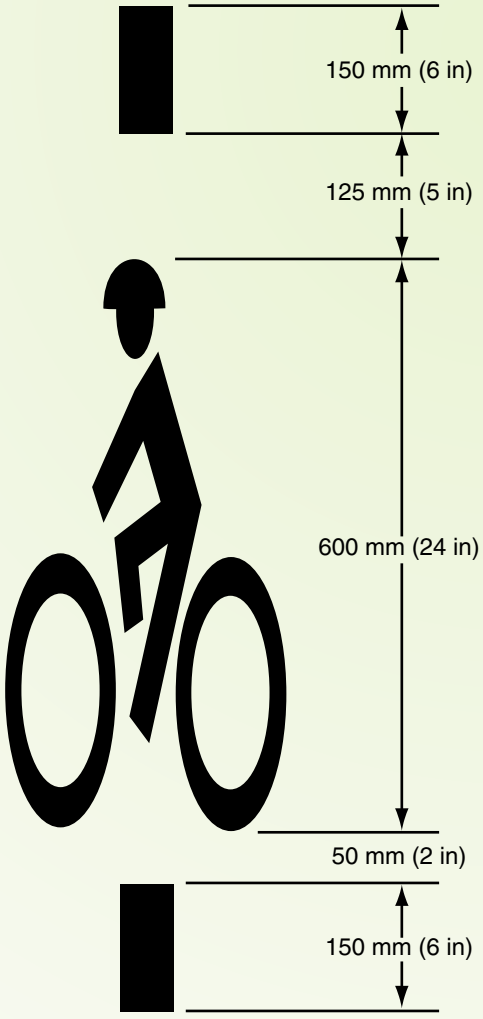


Diagonal Quadruple Loop
(Recommended for shared lanes)
- Sensitive over whole area
- Sharp cut-off sensitivity

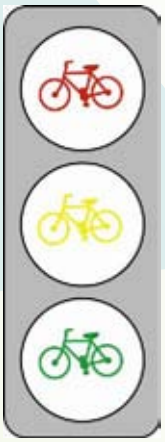


Standard Loop
(Recommended for advanced detection)
- Detects most strongly over wires
- Gradual cut-off

(See: Implementing Bicycle Improvements at the Local Level, FHWA, 1998, p. 70)



Bicycle Specific Traffic Control Signals



A bicycle signal is an electrically-powered traffic control device that may only be used in combination with an existing traffic signal. Bicycle signals direct bicyclists to take specific actions and may be used to address an identified safety or operational problem involving bicycles. A separate signal phase for bicycle movement will be used. Alternative means of handling conflicts between bicycles and motor vehicles shall be considered first. When bicycle traffic is controlled, green, yellow or red bicycle symbols are used to direct bicycle movement at a signalized intersection. Bicycle signals shall only be used at locations that meet MUTCD warrants. A bicycle signal may be considered for use only when the volume and collision, or volume and geometric warrants have been met:

1. Volume. When W = B x V and W > 50,000 and B >50.

Where:
W is the volume warrant.
B is the number of bicycles at the peak hour entering the intersection.
V is the number of vehicles at the peak hour entering the intersection.
B and V shall use the same peak hour.

2. Collision. When 2 or more bicycle/vehicle collisions of types susceptible to correction by a bicycle signal have occurred over a 12-month period and the responsible public works official determines that a bicycle signal will reduce the number of collisions.

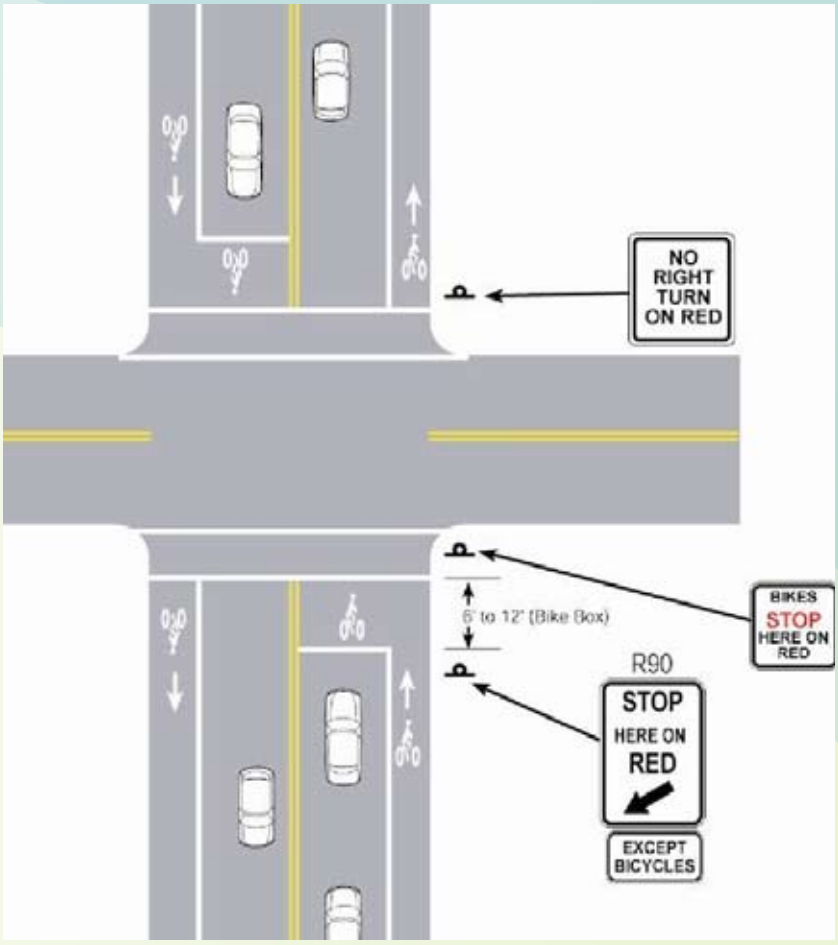
3. Geometric.
(a) Where a separate bicycle/multi use path intersects a roadway.
(b) At other locations to facilitate a bicycle movement that is not permitted for a motor vehicle.

See: MUTCD 2003 and MUTCD 2003 California Supplement (May 20, 2004), Sections 4C.103 and 4D.104 - www/dot.ca.gov/hq/traffopps/signtech/mutcdsupp/

Bicycle traffic signal used to bring bicycles leaving the UC Davis campus back into the road network.

Bike Box / Advance Stop Line

A bike box is a relatively simple innovation to improve turning movements for bicyclists without requiring cyclists to merge into traffic to reach the turn lane or use crosswalks as a pedestrian. The bike box is formed by pulling the stop line for vehicles back from the intersection, and adding a stop line for bicyclists immediately behind the crosswalk. When a traffic signal is red, bicyclists can move into this "box" ahead of the cars to make themselves more visible, or to move into a more comfortable position to make a turn. Bike boxes have been used in Cambridge, MA; Eugene, OR; and European cities.



Plan view of a bike box.

Potential Applications:

- At intersections with a high volume of bicycles and motor vehicles
- Where there are frequent turning conflict and/or intersections with a high percentage of turning movements by both bicyclists and motorists
- At intersections with no right turn on red (RTOR)
- At intersections with high bicycle crash rates
- On roads with bicycle lanes
- Can be combined with a bicycle signal (optional)

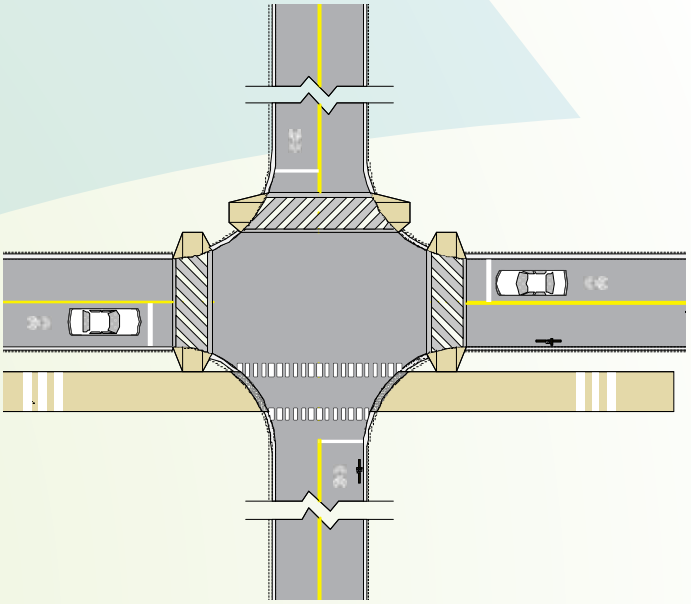
Considerations:

- Bike boxes are not currently included in the MUTCD but there are provisions for jurisdictions to request permission to experiment with innovative treatments (and thus with successful application, future inclusion of bike boxes in the MUTCD could occur).
- If a signal turns green as a cyclist is approaching an intersection, they should not use the bike box.
- Motorists will need to be educated to not encroach into the bike box.

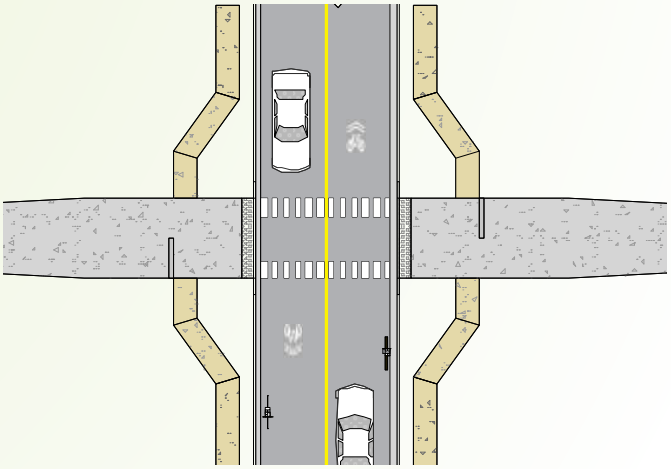
Above and below: Bike boxes filled in with color to emphasize allocation of space to bicycle traffic.

Trail-Roadway Intersections

- Site the crossing area at a logical and visible location; the crossing should be a safe enough distance from neighboring intersections to not interfere (or be interfered) with traffic flow; crossing at a roadway with flat topography is desirable to increase motorist visibility of the path crossing; the crossing should occur as close to perpendicular (90 degrees) to the roadway as possible.
- Warn motorists of the upcoming trail crossing and trail users of the upcoming intersections; motorists and trail users can be warned with signage (including trail stop signs), changes in pavement texture, flashing beacons, raised crossings, striping, etc.
- Maintain visibility between trail users and motorists by clearing or trimming any vegetation that obstructs the view between them.
- Intersection approaches should be made at relatively flat grades so that cyclists are not riding down hill into intersections.
- If the intersection is more than 75 feet from curb to curb, it is preferable to provide a center median refuge area; a refuge is needed in conditions exhibiting high volumes/speeds and where the primary user group crossing the roadway requires additional time, such as school children and the elderly.
- If possible, it may be desirable to bring the path crossing up to a nearby signalized crossing in situations with high speeds/ADT and design and/or physical constraints.
- In 4-Way Intersection Crossing with Shared Use Path (diagram at right) – This is also a depiction of a "sidepath" intersecting a roadway. Trail users would navigate this crossing like a common pedestrian.

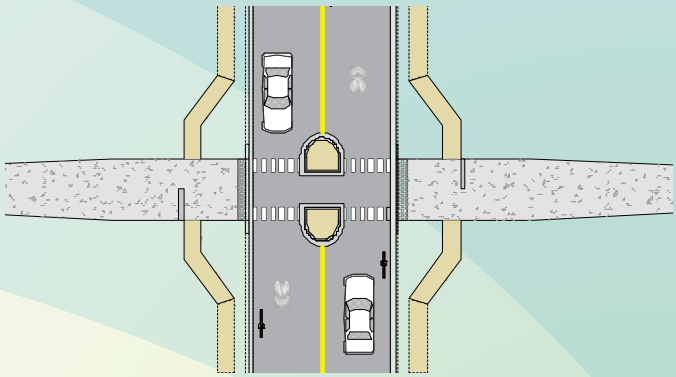


4-Way Intersection Crossing
Shared Use Path

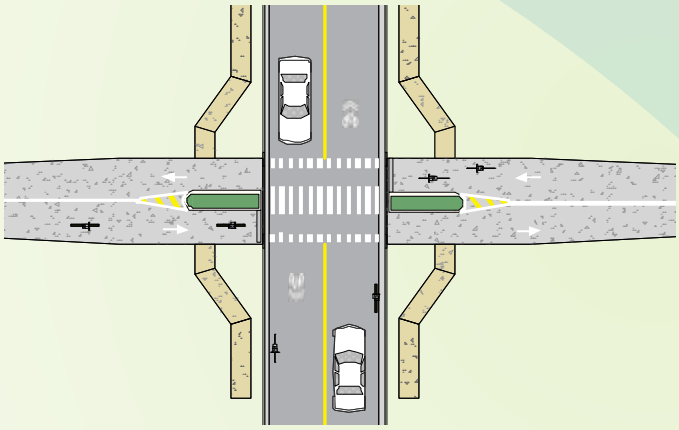


Mid-block Intersection
Shared Use Path with Sidewalks

Trail-Roadway Intersections (Continued)



Median Refuge
Shared Use Path with Sidewalks



Mid-block Crossing
Shared Use Path with Sidewalks and Medians

Trail-Roadway Intersections (Signalized)

• Signalized crossings may be necessary on trails with significant usage when intersecting with demanding roadways, but MUTCD warrants must be met for the installation of a signalized crossing. Consult the MUTCD or NCDOT Division of Bicycle and Pedestrian Transportation for signal, sign and light placement.

• FHWA issued an interim approval for the optional use of rectangular rapid flashing beacons (RRFBs, shown at left) as warning beacons supplementing pedestrian crossing or school crossing warning signs at crossings across uncontrolled approaches. An analysis by the Center for Education and Research in Safety found them to have much higher levels of effectiveness in making drivers yield at crosswalks than the standard over-head and side-mount round flashing beacons.

Trail Underpass

- Typically utilize existing overhead roadway bridges adjacent to steams or culverts under the roadway that are large enough to accommodate trail users
- Vertical clearance of the underpass should be at least 10'; NCDOT only requires 8' minimum vertical clearance.
- Width of the underpass should be at least 12'
- Proper drainage must be established to avoid pooling of stormwater.
- Lighting is recommended for safety.

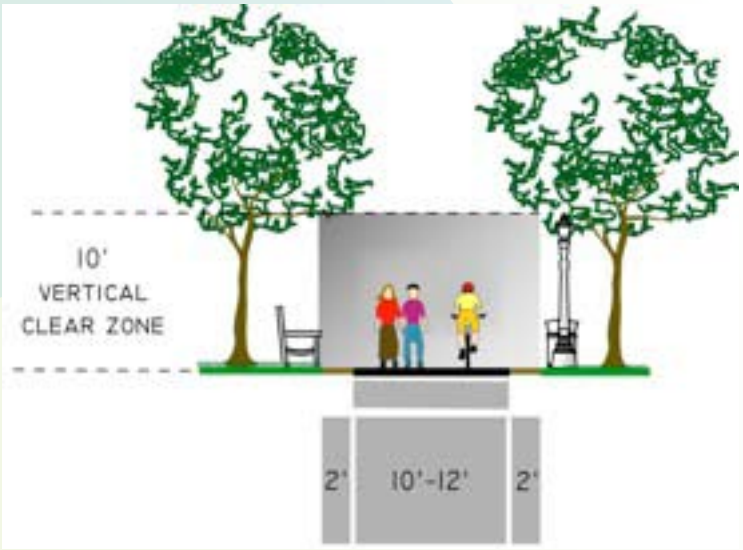
Trail Overpass

- Safety should be the primary consideration in bridge/overpass design.
- Specific design and construction specifications will vary for each bridge and can be determined only after all site-specific criteria are known.
- Always consult a structural engineer before completing bridge design plans, before making alterations or additions to an existing bridge, and prior to installing a new bridge.
- A 'signature' bridge should be considered in areas of high visibility, such as over major roadways. While often more expensive, a more artistic overpass will draw more attention to the trail system in general, and could serve as a regional landmark.
- For shared-use facilities, a minimum width of 14' is recommended.
- Trail overpasses are prohibitively expensive and should only be placed in areas of substantial need.

SHARED USED PATHS, GREENWAYS, AND TRAILS

Multi-Use Paths

Multi-use paths are completely separated from motorized vehicular traffic and are constructed in their own corridor, often within an open-space area. Multi-use paths include bicycle paths, rail-trails or other facilities built for bicycle and pedestrian traffic. In the City of Raleigh, the term 'greenway' is used only for those multi-use paths and sidepaths that are indicated on the Capital Area Greenway map.



Typical multi-use path design

Local Trail Accessway

Accessways provide direct connections for trail users to schools, parks, community centers, retail areas, neighborhoods, and other trails. They are intended to be short, direct connections to reduce unnecessary out-of-direction travel for bicyclists and pedestrians. Accessways in parks, greenways, or other natural resource areas may have a 5' wide gravel path with wooden, brick or concrete edgings. "Neighborhood Entrance Trails" (page 7-33) represent a type of local trail accessway.

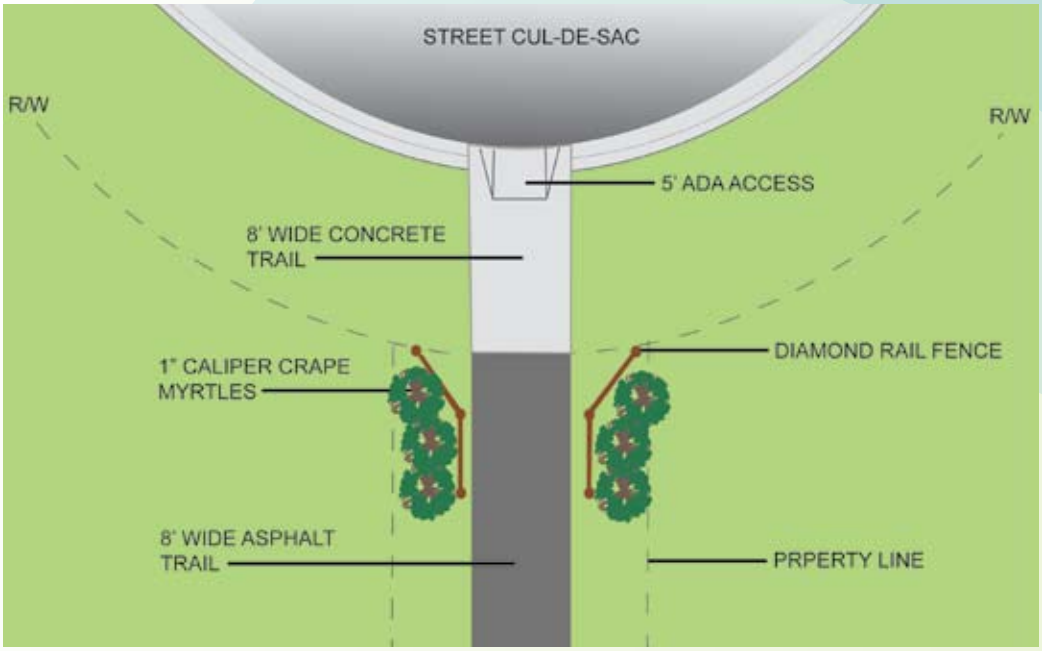
Bicycle and Pedestrian Accessway

Innovative Accessways

There are also other innovative ways to provide direct access, particularly in topographically constrained areas (e.g., on steep hills, over waterways, etc.) Stairs, alleyways, bridges, and elevators can provide quick and direct connections throughout the city and can be designed so they are safe, inviting, and accessible to most trail users. For example, stairways can have wheel gutters so that bicyclists can easily roll their bicycles up and down the incline and boardwalks can provide access through sensitive wet areas and across small waterways.

Bicycle wheel gutters on stairs and boardwalk bridge

Neighborhood Entrance Trail



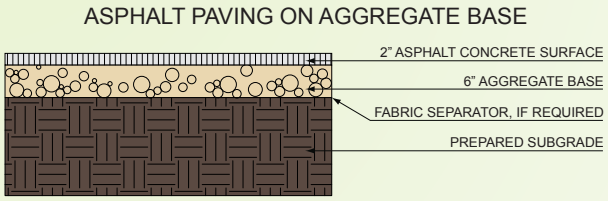
Neighborhood entrance trail diagram.

Neighborhood trails provide access for most, if not all, trail users within neighborhoods, parks, greenspaces, and other recreational areas. They are similar to regional trails in that they typically have their own right-of-way and serve only non-motorized users. These trails should be at least at least 8' wide if bicycle use is anticipated. All efforts should be made so that at least one ADA accessible trail is available and serves the most desirable parts of the area (i.e., picnic areas, viewpoints, playground equipment, etc.). Neighborhood and homeowner association groups are encouraged to identify potential areas for neighborhood entrance trails. For new developments, neighborhood entrance trails should be created upon development. The following "Neighborhood Entrance Trail' guidelines are adapted from Mecklenburg County, NC. In any instance that an access trail is developed in a residential area to link to a greenway, the trail should remain open to the public and, the following standards shall be applied:

- Trail pavement shall be at least 8' wide to accommodate emergency and maintenance vehicles, meet ADA requirements and be considered suitable for multi-use.
- Trail widths should be designed to be less than 8' wide only when necessary to protect large mature native trees over 18" in caliper, wetlands or other ecologically sensitive areas.
- Access trails should meander whenever possible.
- All landscape materials shall be installed during the appropriate planting season for the particular species.
- Other ornamental landscape shall be included at the street frontage of the access trail based upon input from the residents of the cul-de-sac. If the access is not in a cul-de-sac, the adjacent property owners and property owners directly across from the access trail will be invited to provide landscape design input.
- Two sections of diamond rail fencing shall be included on each side of the trail near the street frontage. Diamond rail will not be included if the respective neighborhood deeds and covenants do not permit it.

Paved Multi-use Trail (10' wide typ.)

- Typically composed of asphalt or concrete, paved multi-use trails should be designed to withstand the loading requirements of occasional maintenance and emergency vehicles.
- In areas prone to frequent flooding, it is recommended that concrete be used for its excellent durability.
- As a flexible pavement, asphalt should be considered when installing a paved multi-use trail on slopes.
- A concern for the use of asphalt is the deterioration of trail edges. Installation of geotextile fabric beneath a layer of aggregate base course (ABC) can help to maintain the edge of the trail. It is also important to provide a 2 foot wide graded shoulder to prevent edges from crumbling.
- Most often, concrete is used for intensive urban applications. It is the strongest surface type and has the lowest maintenance requirement if it is installed properly.
- Centerline stripes should be considered for trails that generate substantial amounts of traffic. Centerline stripes are particularly useful along curving sections of trail.
- Trail landscaping and maintenance should enhance conditions for wildlife by planting only native species in the trail corridor, removing invasive species when possible, and avoiding harmful pesticides and herbicides. The overall shape of protected natural landscapes along trail corridors also influences wildlife: single, large, contiguous natural areas are more beneficial to wildlife than the same acreage split into smaller segments.



SIGNAGE

A comprehensive system of signage ensures that information is provided regarding the safe and appropriate use of all facilities, both on-road and on greenways. The bicycle network should be signed seamlessly with other alternative transportation routes, such as bicycle routes from neighboring jurisdictions, trails, historic and/or cultural walking tours, and wherever possible, local transit systems.

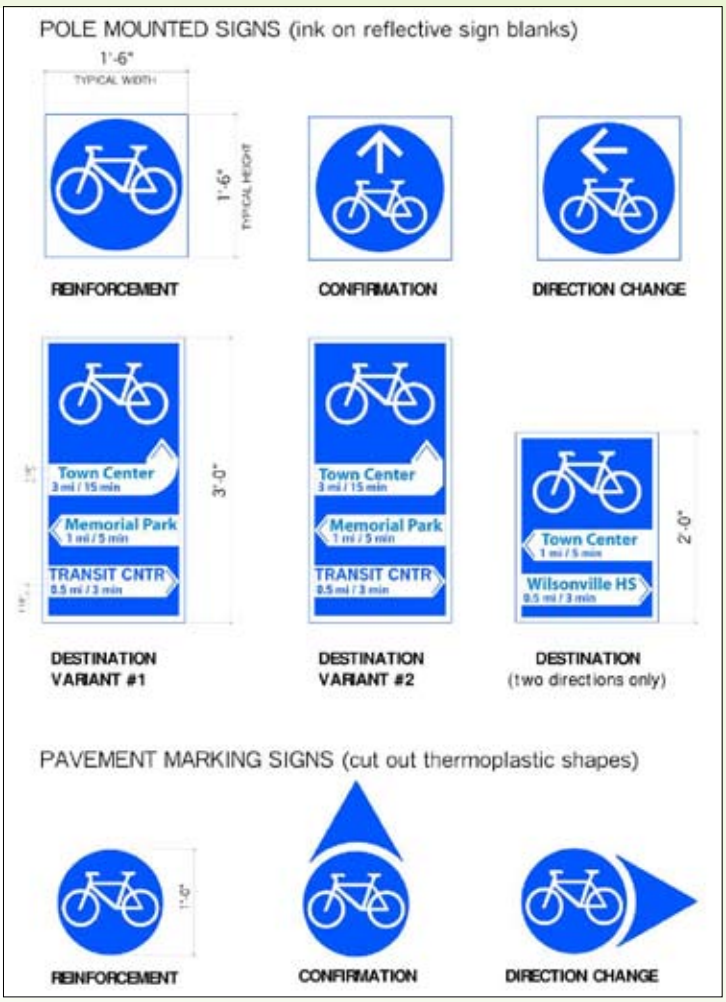
Signage includes post- or pole-mounted signs and pavement striping. Signage is further divided into information signs, directional/wayfinding signs, regulatory signs and warning signs. Trail signage should conform to the (2001) Manual on Uniform Traffic Control Devices and the American Association of State Highway Transportation Official Guide for the Development of Bicycle Facilities. Bicycle signage should also be coordinated with local colleges and universities.

Directional Signs

Implementing a well-planned and attractive system of signing can greatly enhance bikeway facilities by signaling their presence and location to both motorists and existing or potential bicycle users. Effective signage can encourage more bicycling by leading people to bikeways, and by creating a safe and efficient transportation option for local residents and visitors.

The signage examples at right show a number of different signs and markings, both on poles and on the roadway, that the City of Portland has adopted for their new bicycle signage program. The signs have been approved by the Oregon DOT, and will be installed around Portland in the near future. Wayfinding signs such as these improve the clarity of travel direction while illustrating that destinations are only a short ride away. The signs shown are provided only as a point of reference for the purposes of these guidelines and are not being adopted by Raleigh.

Some national examples of high-quality wayfinding include those in Centre City Philadelphia (left), the City of Greenville, SC (below/left), and Grand Forks Greeway, ND (below).



Innovative On-Road Facilities Signage used in Portland

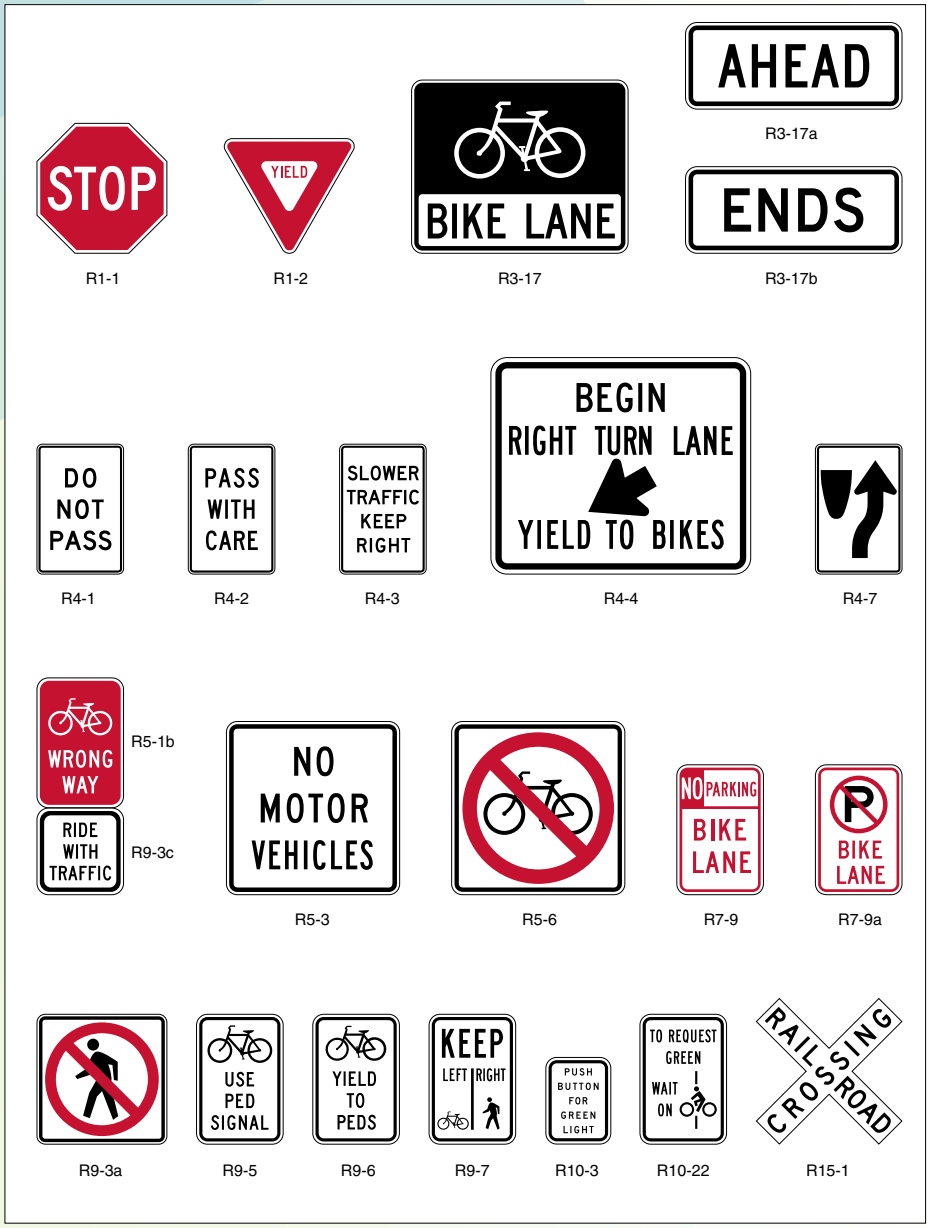
Regulatory/Warning Signs

Regulatory and warning bicycle signage should conform to the Manual on Uniform Traffic Control Devices (MUTCD). The signs to the right are examples of regulatory signs for bicycle (their labels are sign reference numbers for the MUTCD).

Special Purpose Signage

The "Share the Road" sign (below), is designed to advise motorists that bicyclists are allowed to share and have the right to cycle on narrow roadways with motor vehicles. For more on the "Share the Road Initiative" go to: http://ncdot.org/transit/bicycle/safety/programs_initiatives/share.html

Innovative signage is often developed to increase bicycle awareness and improve visibility (such as 'Bikes Allowed Use of Full Lane', bottom right). Special purpose signs to be installed on public roadways in North Carolina must be approved by NCDOT's Traffic Control Devices Committee and/or the City of Raleigh. New designs can be utilized on an experimental basis with NCDOT approval.



Share the Road signs remind motorists that bicyclists have the right to ride on the roadway

The "Bikes Allowed Use of Full Lane" sign is currently used on an experimental basis in several cities.

ANCILLARY FACILITY STANDARDS

Bicycle Parking

As more bikeways are constructed and bicycle usage grows, the need for bike parking will climb. Long-term bicycle parking at transit stations and work sites, as well as short-term parking at shopping centers and similar sites, can support bicycling. Bicyclists have a significant need for secure long-term parking because bicycles parked for longer periods are more exposed to weather and theft, although adequate long-term parking rarely meets demand. These bicycle parking standards should also be shared with NC State and Shaw Universities and Meredith, St. Augustine's and Peace Colleges.

When choosing bike racks, there are a number of things to keep in mind:

- The rack element (part of the rack that supports the bike) should keep the bike upright by supporting the frame in two places allowing one or both wheels to be secured.
- Install racks so there is enough room between adjacent parked bicycles. If it becomes too difficult for a bicyclist to easily lock their bicycle, they may park it elsewhere and the bicycle capacity is lowered. A row of inverted "U" racks should be installed with 15" minimum between racks.
- Empty racks should not pose a tripping hazard for visually impaired pedestrians. Position racks out of the walkway's clear zone.
- When possible, racks should be in a covered area protected from the elements. Long-term parking should always be protected.

The table below provides basic guidelines on ideal locations for parking at several key activity centers as well as an optimum number of parking spaces.

Table 7.1: Recommended Guidelines for Bicycle Parking Locations and Quantities

Use Category	Specific Use	Required Long-term Parking Spaces	Required Short-term Parking Spaces
Residential	Boarding houses	2, or 1 per ten sleeping rooms	None
	Hotels, motels	2, or 1 per 50 employees	None
Commercial / Industrial	Retail sales, service operations *	2, or 1 per 50,000 square feet of gross floor area	2, or 1 per 25,000 square feet of gross floor area
	Office buildings **	2, or 1 per 50,000 square feet of gross floor area	2, or 1 per 50,000 square feet of gross floor area
	Museums, libraries	2, or 1 per 50 employees	4, or 1 per 25,000 square feet of gross floor area
	Movie theaters	2, or 1 per 50 employees	4, or 1 per 50 seats
	Restaurants, ice cream shops, coffee shops	2, or 1 per 50 employees	4, or 1 per 50 seats
	Recreation centers	2, or 1 per 50 employees	4, or 1 per 25,000 square feet of gross floor area
	Major event entertainment (e.g., stadiums, arenas)	2, or 1 per 50 employees	8, or 1 per 500 seats
	Manufacturing	2, or 1 per 50 employees	None
	Warehousing	2, or 1 per 50 employees	None
Institutional	Medical centers	2, or 1 per 50 employees	2, or 1 per 25,000 square feet of gross floor area
	Transit park and ride lots	1 per 50 daily boardings	None

* Retail businesses below 3,000 square feet of gross floor area are exempt from bicycle parking requirements
** Office buildings below 10,000 square feet of gross floor area are exempt from bicycle parking requirements

The rack element should:

- Support the bicycle upright by its frame in two places
- Prevent the wheel of the bicycle from tipping over
- Enable the frame and one or both wheels to be secured
- Support bicycles without a diamond-shaped frame with a horizontal top tube (e.g. a mixte frame)
- Allow front-in parking: a U-lock should be able to lock the front wheel and the down tube of an upright bicycle
- Allow back-in parking: a U-lock should be able to lock the rear wheel and seat tube of the bicycle

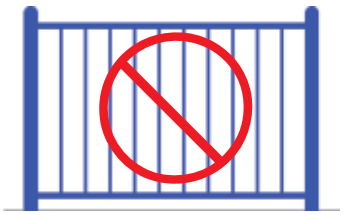
Comb, toast, school-yard, and other wheel-bending racks that provide no support for the bicycle frame are NOT recommended.

The rack element should resist being cut or detached using common hand tools, especially those that can be concealed in a backpack. Such tools include bolt cutters, pipe cutters, wrenches, and pry bars.

INVERTED "U"
One rack element supports two bikes.

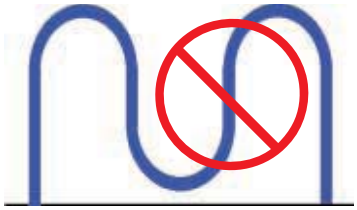
"A"
One rack element supports two bikes.

POST AND LOOP
One rack element supports two bikes.

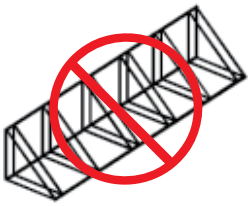


COMB
One rack element is a vertical segment of the rack.

Not recommended



WAVE
One rack element is a vertical segment of the rack.
(see additional discussion on page 3)



TOAST
One rack element holds one wheel of a bike.

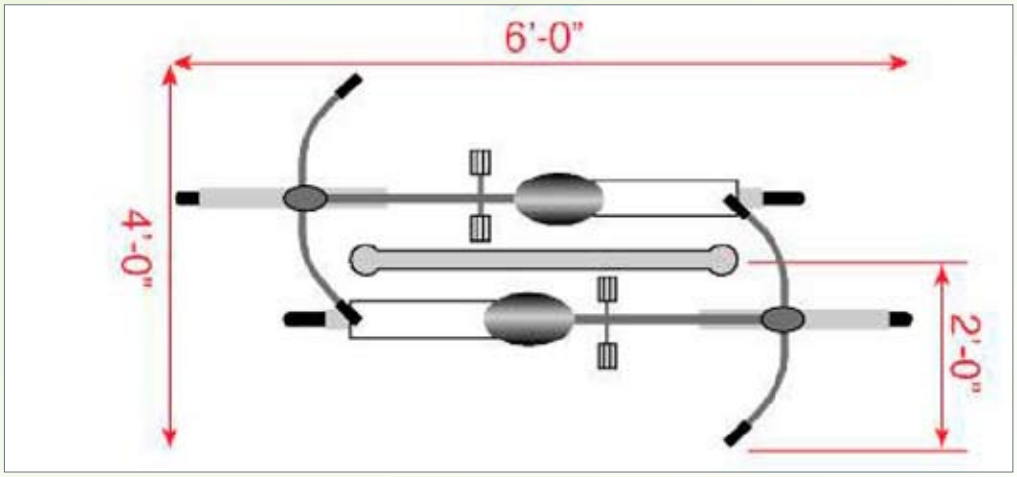
Recommended guidelines for bicycle parking from the Association of Pedestrian and Bicycle Professionals, 2002, www.apbp.org.

Bicycle racks that incorporate advertising can be sponsored by local merchants.

Provision of shelter from rain greatly increases usefulness of this bicycle parking facility during inclement weather.

A single inverted "U" rack can accommodate two bicycles.

Recommended guidelines for bicycle parking spacing dimensions.



Example of a bicycle rack in Durham, NC, serving as a piece of utilitarian public art.

Below: An example of replacing on-street vehicular parking with bicycle parking (in Portland, OR).

Bicycle lockers are a crucial component of the bicycle system. They offer safe and secure storage at transit centers and destinations. Parking rates are reasonable at about 3-5 cents per hour (www.bikelink.org).

Bike lockers should be constructed of opaque materials and be clearly labelled as bicycle parking. Rental management can be either under contract or provided as a service by transit operators or other agencies. *(photos from www.cyclesafe.com/LockerPhotos.tab.aspx).*

Bicycle Parking and the Public vs. Private Right-of-Way

Bicycle parking can be located either in the public right of way or on private property, depending on the adjacent land uses and streetscape. For example, an office park may provide short-term bicycle parking racks near building entrances, and may also provide secure indoor parking for employees. For on street bike parking, the following text is from the Portland, OR city policy.

Example On-Street Bicycle Parking Requirements:

- *Sidewalk racks at capacity on a recurring basis:*
- *City staff and applicant jointly determine time of day and day of week for highest bicycle use. This assessment must be independent of any special event that may inflate the average daily use.*
- *City staff visits site to assess bicycle use, based on the formula listed below, and whether or not it can be met by normal sidewalk rack installations. Due to seasonal variations and weather dependence, determination of bicycle use may need to be delayed pending suitable conditions to assess actual needs.*
- *Formula used to determine supply and demand for the areas:*
  1. *Bicycles parked within 50 feet of proposed site multiplied by 1.5*
  2. *Bicycles parked more than 50 feet, but less than 150 feet, of proposed site multiplied by 1.0*
  3. *Bicycles parked more than 150 feet, but less than 200 feet, of proposed site multiplied by 0.5*
- *City staff inventories parked bicycles and available bicycle racks within 200 feet of the site, measured using marked and unmarked crosswalks, including street crossing distances. City staff also will assess the possibilities for additional sidewalk racks.*
- *If sidewalk bicycle parking cannot be installed to meet 80 percent of inventoried, parked bicycles, then a bicycle corral is warranted. City staff will determine this.*
- *At a minimum there must be 100 percent agreement with adjacent property owners, established through petition.*
- *A Maintenance Agreement must be signed by the requestors and the City and kept on file with the City.*
- *If the business owner that originally requested the bicycle parking closes, sells or transfers ownership the new owner must give written approval of the bicycle parking to the City within 30 days of taking ownership.*

(Source: City of Portland, OR, Administrative Rule for On-Street Bicycle Parking, Draft 12/17/2008)

Bicycle Facilities at Transit Stops

Integrating bicycle facilities with transit modes allows bicyclists to greatly expand their range of travel or "trip chain". Integration of facilities with transit modes allows cyclists to use their bicycles on one or both ends of their daily commute, allowing greater flexibility.

- Although the current buses that serve Raleigh are equipped with bicycle racks, the bus *stops* should incorporate bicycle racks, and local-area bicycle maps.

- Improve overall design of current and future bus and light-rail stops by providing amenities such as bicycle racks, bicycle lockers, water fountains, bicycle air compressors, local bicycle maps, transit maps, bikes-on-buses, and other amenities.

Right and below: bike racks, air compressor (for bicycle tires), maps, and water fountains should be included at bus stops and light-rail stops to encourage multi-modal transportation.

Bicycle Stations and Repair Stands

Bicycle repair stands and bicycle stations are fixtures in highly successful bicycle-friendly communities. Popular locations include farmer's markets or public areas that are centers for activity, easily accessible by foot or bicycle. Local bike shops and local events in Raleigh could provide similar services. The presence of smaller scale operations that primarily provide maintenance and repair functions within semi-permanent structures like the tent and tarp shown below allow for a lower cost operation, thereby passing on savings to the customer in terms of lower repair and maintenance costs.

A bicycle stand in Copenhagen, Denmark.

In North Carolina communities (Durham and Carborro, for example), local, volunteer-run bicycle non-profit organizations offer maintenance training and space for local residents to work on their bikes. The City of Durham, for example, granted funding to their local bicycle co-op for their provision of this important bicycle support facility.

A bicycle maintenance stand at a farmers' market in Durham, NC.

Attended Bike Parking

Attended bike parking is analogous to a coat check – your bike is securely stored in a supervised location. An organization called The Bikestation Coalition is promoting enhanced attended parking at transit stations.

The Bikestation concept is now in use in Palo Alto, Berkeley and San Francisco and Seattle. Bikestations offer secured valet bicycle parking near transit centers. What makes Bikestations distinctive are the other amenities that may be offered at the location – bicycle repair, cafes, showers and changing facilities, bicycle rentals, licensing, etc. Bikestations become a virtual one-stop-shop for bicycle commuters.

Attended bicycle parking can be offered at some special events. For example, the Marin County Bicycle Coalition sponsors valet parking at many festivals in the county, the Sonoma County Bicycle Coalition sponsors valley parking at the downtown Santa Rosa Farmer's Market, and secured bicycle parking is offered at Pac Bell Park in San Francisco.

A bicycle station with attended parking in Long Beach, CA.

Bike Sharing Programs

Many cities including Washington, DC, Montreal and Louisville are implementing innovative bike-sharing programs using a variety of revenue generating and fee-for service programs. Copenhagen, Denmark, pioneered the concept of providing a fleet of bicycles for free public use throughout the urban center. Paris has made this concept popular with the development of the city-wide Velib system of credit-card operated bike rentals. The Danish free bikes are subsidized by advertising sales on the bicycles, and they require a coin or credit card deposit for use. The bicycles are single speed, durable and suitable only for short trips. Their design makes them less likely to be stolen. They can be picked up and dropped off at a variety of destinations – making them an easy choice for in-town travel by residents and visitors. A variety of similar programs utilize recycled bicycles or bicycles painted in a common color for free public use.

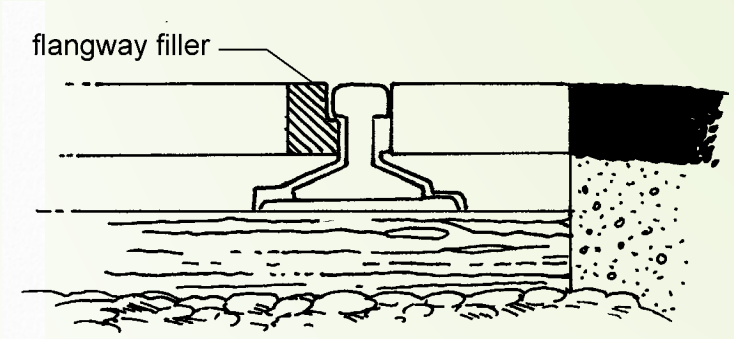
Lousiville's "Freewheelin" bike sharing system is supported by Humana Healthcare. The City is working with public private partnerships to provided a fleet of shared bicycles.

Bicycle Facilities at Railroad Crossings

Railroad crossings are particularly hazardous to those who rely on wheeled devices for mobility (railroad crossings have flangeway gaps that allow passage of the wheels of the train, but also have the potential to catch wheelchair casters and bicycle tires). In addition, rails or ties that are not embedded in the travel surface create a tripping hazard. Recommendations:

- Make the Crossing Level: Raise approaches to the tracks and the area between the tracks to the level of the top of the rail.
- Bikes Should Cross RR at Right Angle
- When bikeways or roadways cross railroad tracks at grade, the roadway should ideally be at a right angle to the rails. When the angle of the roadway to the rails is increasingly severe, the approach recommended by Caltrans (Highway Design Manual, Section 1003.6) and AASHTO (Guide for the Development of Bicycle Facilities, 1999, p.60) is to widen the approach roadway shoulder or bicycle facility, allowing bicycles to cross the tracks at a right angle without veering into the path of passing motor vehicle traffic.
- Use Multiple Forms of Warning: Provide railroad crossing information in multiple formats, including signs, flashing lights, and audible sounds.
- Clear Debris Regularly: Perform regular maintenance to clear debris from shoulder areas at railroad crossings.
- Fill Flangeway with Rubberized Material or Concrete Slab: Normal use of rail facilities causes buckling of paved-and-timbered rail crossings. Pavement buckling can be reduced or eliminated by filling the flangeway with rubberized material, concrete slab, or other treatments. A beneficial effect of this is a decrease in long-term maintenance costs.

Installing a rubber surface rather than asphalt around railroad flangeways reduces changes in level and other maintenance problems.

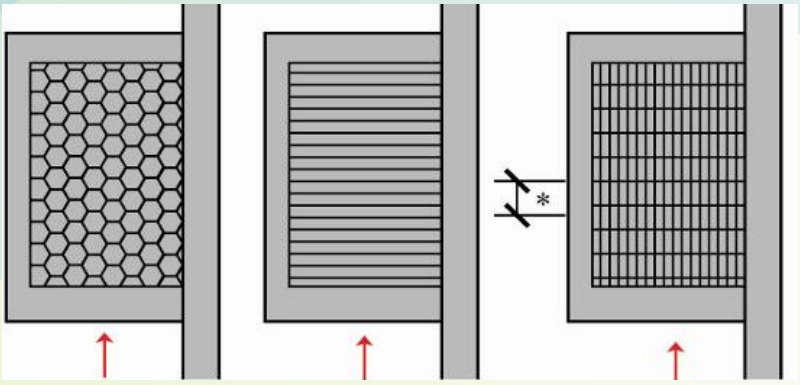


The "flangeway filler" eliminates the gap in the path of travel for pedestrians crossing railroad tracks. The filler, consisting of a rubber insert, will deflect downward withe the weight of a train and does not affect railway function.

Bicycle Friendly Drainage Grates

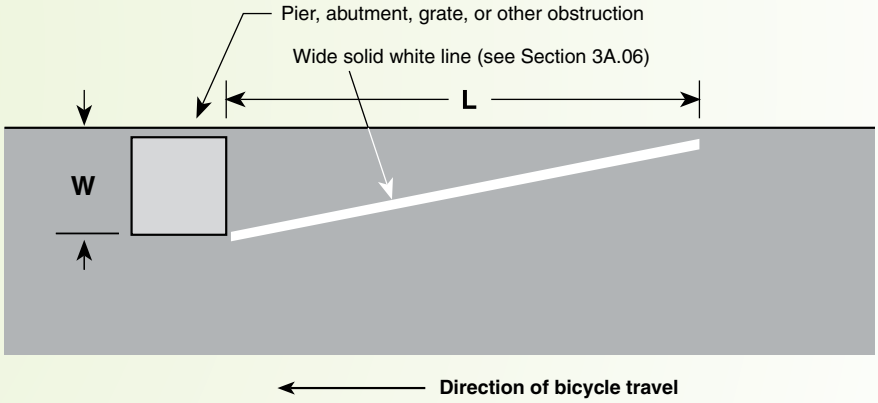
Drainage grates usually occupy portions of roadways, such as bicycle lanes, where bicycles frequently travel. Often drainage grates are poorly maintained or are of a design that can damage a bicycle wheel or in severe circumstances, cause a bicyclist to crash. Improper drainage grates create an unfriendly obstacle a cyclist must navigate around, often forcing entrance into a motor vehicle lane in severe cases. Bicycle friendly drainage grates should be installed in all new roadway projects and problem grates should be identified and replaced.

Right: Bicycle Friendly Drainage Grate Designs



**max 150 mm (6'') spacing*

Right: MUTCD example of obstruction pavement marking; if dangerous drainage grates (or other obstructions) are not to be fixed in the short term, then this pavement marking should direct cyclists away from the obstruction.



Dangerous Drainage Grate Condition; this example is dangerous due to the grate running parallel to the roadway, creating a trap for bicycle tires.

Dangerous Drainage Grate Condition; this example is dangerous due to the surrounding paving condition (when the road was resurfaced the drainage grate remained at the same height).

Bicycle-Friendly Drainage Grate

BICYCLE FACILITY MAINTENANCE STANDARDS

Shared-Use bike path maintenance costs are based on $18,000 per mile (East Bay Regional Parks District estimate) which includes cleaning, resurfacing and re-striping the asphalt path, repairs to crossings, cleaning drainage systems, trash removal, and landscaping. Underbrush and weed abatement should be performed once in the late spring and again in mid-summer.

In addition, these same maintenance treatments should be performed on Bike Lanes. These facilities should be prioritized to include an accelerated maintenance plan that is already a part of on-going street maintenance. A maintenance task list is provided in Table 7.2 below.

A City of Raleigh staff member should be designated as the main contact for the maintenance of pedestrian and bicycle facilities in the roadway right-of-way. This staff member should coordinate with the appropriate departments to set up a free maintenance hotline and conduct maintenance activities in the field. Funding for an ongoing maintenance program should be included in the City's operating budget. The City of Raleigh should make immediate repairs to any on-road bicycle facilities that are damaged or have hazardous conditions.

On page 7-46, two bicycle facility maintenance case studies are provided from communities that have been very successful in routine maintenance: Portland OR, and Jackson WY. These are provided as model standards for the City of Raleigh to work towards.

Table 7.2 Bicycle Facility Maintenance Checklist and Schedule.

Maintenance Task	Frequency
Inspections	Seasonal – at both beginning and end of summer
Signage replacement	1-3 years
Site furnishings; replace damaged components	As needed
Fencing repair	Inspect monthly for holes and damage, repair immediately
Pavement markings replacement	1-3 years
Pavement sweeping/blowing	As needed; before high use season
Pavement sealing; pothole repair	5-15 years
Lighting repair	Annually
Introduced tree and shrub plantings, trimming	1-3 years
Shrub/tree irrigation for introduced planting areas	Weekly during summer months until plants are established
Shoulder plant trimming (weeds, trees, branches)	Twice a year; middle of growing season
Major damage response (fallen trees, washouts, flooding)	Schedule based on priorities
Culvert inspection	Before rainy season; after major storms
Maintaining culvert inlets	Inspect before onset of wet season
Waterbar maintenance (earthen trails)	Annually
Trash disposal	Weekly during high use; twice monthly during low use
Litter pick-up	Weekly during high use; twice monthly during low use
Graffiti removal	Weekly; as needed

Bicycle Facility Maintenance Case Studies

(Source: The League of American Bicyclists)

Case Study 1: Portland, OR

Most bikeways within the City of Portland are the responsibility of the Portland Office of Transportation (PDOT). Other responsible jurisdictions include the Oregon Department of Transportation (ODOT), and Multnomah County. All roadway facilities receive regular routine maintenance (sweeping, vegetation trimming, pothole repair, etc) on a regular cycle (daily to quarterly, depending on the roadway). More pertinent to bikeway maintenance is a long-established system within the City of Portland that allows cyclists to inform the responsible jurisdiction when maintenance is needed immediately, typically for sweeping glass/gravel, filling potholes, or trimming encroaching vegetation. Portland's practice is to respond to bikeway maintenance requests as immediately as possible, as noted below. Cyclists noting a repair need can contact the city in one of several different ways: 1) through an on-line "facility maintenance request form" on the city's web site, 2) through the bicycle "hot line" (823-CYCL), 3) through a 24-hour maintenance number, 4) through a pothole repair number (823-BUMP). The first two options are routed directly to PDOT bicycle staff who forward the request to the appropriate response team. Sweeping requests on bikeways generally result in service within 12 hours; pothole requests typically result in filled potholes within 24 hours; vegetation trimming requests generally result in trimmed vegetation within 1-7 days, depending on the extent of required trimming. Requests coming to the City of Portland that are the responsibility of another jurisdiction are immediately forwarded to the appropriate contact at those jurisdictions and are typically addressed within several days. Information about how to contact the city about such maintenance requests is widely distributed. Such contact information is included on Portland's most widely distributed free bike maps, included in information outreach to more than 50,000 residents a year, distributed on "bicycle contact" refrigerator magnets, and included in "bicycle maintenance/contact information" cards that are also widely distributed through the city's outreach programs.

Case Study 2: Jackson, WY

The Town of Jackson Public Works and Teton County Road and Levee Departments sweep the on-street bike lanes and street shoulders once every two weeks or as needed from May until mid-October. Annual routine maintenance includes re-painting pavement markings, checking signage and repairing asphalt pavement as necessary during spring and summertime. Jackson Hole Community Pathways has a full resealing program for its pathway system, just completing approximately 6 miles of resealing in 2008. High level maintenance is provided on the 33 mile pathway system. Friends of Pathways provides volunteer assistance in spot sweeping pathway intersections, sign maintenance, painting, and other routine maintenance. Volunteers use specially equipped Bob bike trailers to carry tools. FOP also conducts on-going advocacy campaigns to encourage Jackson Hole Agencies all continue to complete high quality maintenance as promised in management plans.