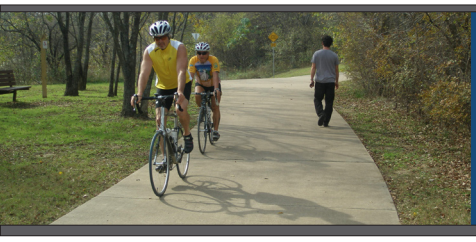


7. DESIGN GUIDELINES

Chapter Contents

7.1 Introduction

7.2 References & Resources

7.3 Design Principles

7.4 Pedestrian Network

7.5 Bicycle Network

7.6 Multi-Use Facilities

7.7 Pedestrian and Bicycle Signage

7.8 Bicycle Parking and Storage

7.9 Traffic Calming

7.10 Bikeway and Walkway Maintenance

7.1 INTRODUCTION

Walking and biking are becoming popular alternative modes of transportation for residents to navigate in and around the City. A key goal for the City of Arlington is to provide design guidelines for future development so as to facilitate a safe environment for bicyclists and pedestrians of all ages and abilities. These design guidelines are based on national standards and best practices for this region and around the country.

How to Use this Guide

A full list of design guidelines is outlined in this chapter. The intent of this chapter is to follow the example set forth in the national design standards as defined by the American Association of State Highway Transportation Officials (AASHTO), the Americans with Disabilities Act (ADA), the Federal Highway Administration (FHWA), the Manual on Uniform Traffic Control Devices (MUTCD), and the Texas Department of Transportation (TxDOT). The City of Arlington intends for these recommended guidelines to be used in designing a complete, safe, attractive, and functional off-road and on-street environment in the City for both pedestrians and bicyclists. In some cases, design adjustments may be necessary in order to achieve the best result. Any design adjustments need to be evaluated by a qualified engineer, landscape architect, or state bicycle coordinator. If national standards are revised in the future and result in discrepancies with this chapter, the latest national and state standards should prevail for all design decisions.

How this Guide was Created

This chapter was created as part of the Hike and Bike System Master Plan. Additional information from other reports and studies were used to develop the different criteria of each type of recommendation. This guide incorporates comments and input from the City of Arlington.

7.2 REFERENCES & RESOURCES

The following is a list of national and state references/resources utilized to develop the design guidelines for the City of Arlington's Hike and Bike System Master Plan. Many of these documents are available online and provide a wealth of information and resources to the public.

Federal Guidelines:

AASHTO Guide
Guide for the Development of Bicycle Facilities, 1999
American Association of State Highway and Transportation Officials, Washington, DC.
www.transportation.org

AASHTO Green Book
Policy on Geometric Design of Streets and Highways, 2001; American Association of State Highway and Transportation Officials,
Washington, DC.
www.transportation.org

Bicycle Lanes Versus Wide Curb Lanes: Operational and Safety Findings and Countermeasure Recommendations; U.S. Department of Transportation Federal Highway Administration
www.fhwa.dot.gov/publications/research/safety/pedbike/99035/99035.pdf

Designing Sidewalks and Trails for Access
Part I of II: Review of Existing Guidelines and Practices
U.S. Department of Transportation Federal Highway Administration
www.fhwa.dot.gov/environment/sidewalks/index.htm

Designing Sidewalks and Trails for Access
Part II of II: Best Practices Design Guide
U.S. Department of Transportation Federal Highway Administration
www.fhwa.dot.gov/environment/sidewalks/index.htm

MUTCD
Manual on Uniform Traffic Control Devices, 2009
Federal Highway Administration, Washington, DC.
mutcd.fhwa.dot.gov

ITE Manual
Designing Walkable Urban Thoroughfares: A Context Sensitive Approach
http://www.cnu.org/streets

State and City Guidelines:

PBIC / APBP
Bicycle Facility Selection: A Comparison of Approaches; Michael King, for the Pedestrian and Bicycle Information Center
Highway Safety Research Center, University of North Carolina - Chapel Hill; August 2002
www.bicyclinginfo.org/pdf/bikeguide.pdf

Bike Lane Design Guide (City of Chicago)
www.bicyclinginfo.org/pdf/bike_lane.pdf

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

Oregon Bicycle and Pedestrian Plan
www.oregon.gov/ODOT/HWY/BIKEPED/planproc.shtml

Texas Manual on Uniform Traffic Control Devices (MUTCD)
www.txdot.gov/txdot_library/publications/tmutds.htm

Local Guidelines:

City of Arlington, Texas Design Criteria Manual
www.arlingtontx.gov/publicworks/pdf/design_criteria_manual.pdf

City of Arlington, Thoroughfare Development Plan
www.arlingtontx.gov/planning/Transportation.html

North Central Texas Council of Governments
www.nctcog.org

7.3 DESIGN PRINICIPLES

These recommended Hike and Bike Design Principles have been tailored to meet the specific development needs of the City of Arlington's pedestrian and bicycle system. They are based on creating a livable community where bicycling and walking will be incorporated into existing and proposed transportation projects to achieve the overriding goal of improvement, safety, convenience, and comfort.

Because streets are a critically important part of a livable and healthy community and the growing demand for multimodal streets, this document adheres to the "Complete Streets Principle" that roadways shall be planned, designed, and developed to enable safe, attractive, and comfortable access and travel for all users which includes walking, biking, and public transit, to co-exist with automobiles. The Complete Street Act is currently being debated in Congress and should it be approved, it will require that "all federally funded transportation projects, (with certain exceptions), must accommodate the safety and convenience of all users in accordance with certain Complete Street Principles. This will ensure that the safety and convenience of all users of a transportation system, including pedestrian, bicyclist, public transit users, and motorists are accommodated in all phases of project planning and development.

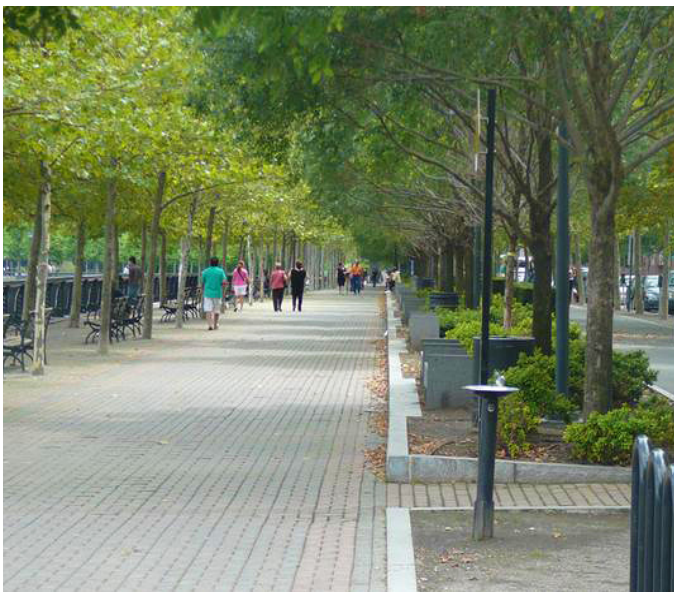
This document is also based on the principle of designing hike and bike projects that are aesthetically pleasing and sensitive to the environment and community within which they are located. This type of design process is often described as context sensitive design. Hike and bike improvements must incorporate the important and often competing values of a variety of stakeholders that live, work, and play in the City. Successful solutions that address safety, mobility, and the communities overall interest shall prevail.

The following are key principles for these design guidelines:

- The City of Arlington has both off-road trails and on-street pedestrian and bicyclist facilities. These two systems will be interconnected to make it possible for many destinations in the City to be accessible for pedestrians and bicyclists.
- The law gives bicyclists the same rights and responsibilities as automobile drivers. In Arlington, all roads except for limited access highways are legal for bicycle usage.
- Bicyclists typically have a wide range of skill levels from expert to novice. These skill levels are commonly designated as Type A, B, and C. A Type A bicyclist is an experienced adult who is capable of riding in motorized traffic in a shared road situation. A Type B bicyclist has less experience and is most comfortable riding in a sepa-

rated bike facility such as a bike lane. A Type C bicyclist is a recreational bicyclist who is most comfortable on a low-volume residential road or off-road trail (often a child or senior adult). These groups are not always exclusive and are often mixed on a shared-use path. It is critical to ensure that safety and convenience of all users of a transportation system are accommodated in all project planning and development projects. At a minimum, the facilities will be designed for Type B bicyclist use, with the overall goal to meet the needs of Type C bicyclists to the greatest extent possible. In areas where specific needs have been identified (i.e., near schools), the needs of appropriate types of bicyclists will be accommodated.

- Design guidelines provide a recommended direction and are not a substitute for a more thorough evaluation by a qualified engineer or landscape architect during the design and construction process.



7.4 PEDESTRIAN NETWORK

Planned sidewalk and crossing improvements must meet AASHTO, MUTCD, TxDOT, and City of Arlington Design Criteria Manual (latest edition) standards.

A. Sidewalk Standards

The sidewalk corridor is typically the portion of the pedestrian system from the edge of the roadway to the edge of the right-of-way or property line. Successful sidewalks include minimal obstacles; moderate grades and slopes; rest areas outside of the pathways; minimal changes in level areas; firm, stable, and slip resistant surfaces; and adequate lighting (Figure 7.4.1).

The City of Arlington has made the commitment to create sidewalks that are safe and to ensure connectivity through the community. In pursuing that effort, the City has developed a design system that divides the sidewalk corridor into three zones. The system is used to determine the width of the sidewalk improvements for each land-use and roadway classification. The three zones within the sidewalk corridor are referred to as the frontage, the sidewalk zone, and the pedestrian buffer (Figure 7.4.2).

The frontage zone separates pedestrians from building fronts by providing distance between the property line and the sidewalk. If the sidewalk is adjacent to open spaces, such as residential areas, or parks, the frontage zone can be eliminated. Typically the frontage zone is used in urban areas. It should be free of obstacles and protruding objects. Sidewalks in urban situations against buildings need additional width and vertical clearance to allow for building awnings and signage (Figure 7.4.3).

Figure 7.4.1. Wide sidewalk allows for high pedestrian use and street amenities.

The sidewalk zone is the paved walking area. Wider sidewalks provide more comfort and space for users and are preferred in high pedestrian use areas, such as in urban/commercial/mixed-use locations. The width of a sidewalk zone is one of the most significant factors in determining the type of pedestrian experience. In urban areas, the sidewalks can be paved from the back of the curb to property lines. In other areas, the paved portion of the sidewalk may be setback from the street leaving space for a pedestrian buffer/furnishing zone.

The City of Arlington standard sidewalks range from a minimum of 4-feet to 7-feet wide, not including curb and other obstructions. Refer to

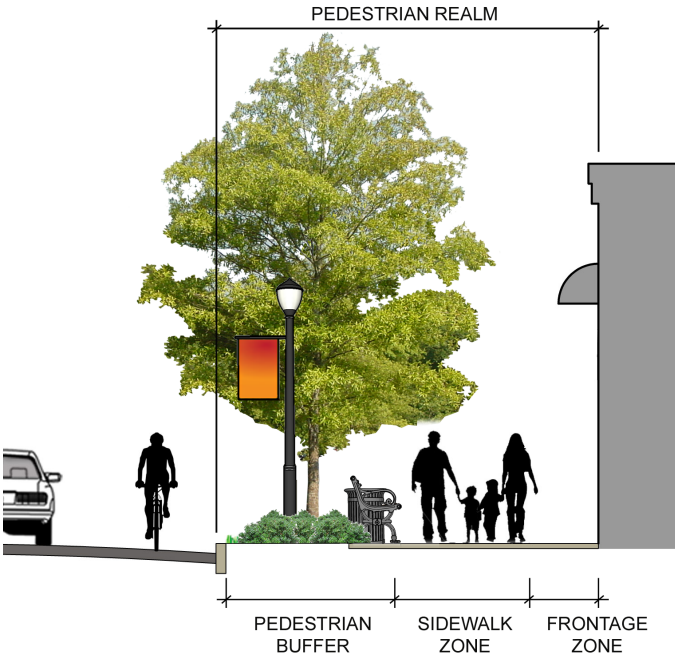


Figure 7.4.2. Sidewalk corridor zones.

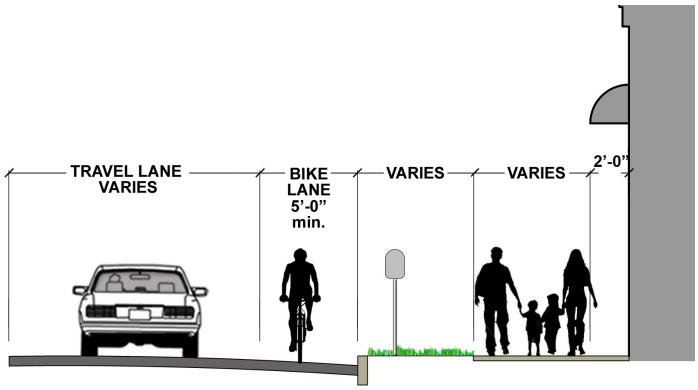


Figure 7.4.3. Frontage zone.

the Thoroughfare Development Plan for minimum sidewalk width requirments for various street types. A six-foot-wide sidewalk width is desirable if right-of-way and other site conditions allow. This width allows two pedestrians, including handicapped users, to comfortably walk side by side, or to pass each other. It can also provide enough space for two pedestrians to pass a third pedestrian without leaving the sidewalk. Sidewalks should be clear of obstructions such as sign posts, utility and signal poles, mailboxes, parking meters, fire hydrants, trees, and other street furniture (Figure 7.4.4).

The pedestrian buffer/furnishing zone, often referred to as a planting strip, provides a physical separation between pedestrians and vehicular travel lanes. This improves safety, helps decrease road noise, prevents splashing onto sidewalk users, and creates a more positive pedestrian experience. The pedestrian buffer/furnishing zone provides a place for street trees and landscaping, sign posts, utility and signal poles, mailboxes, parking meters, fire hydrants, and other site furnishings to be located. Streets designed with a pedestrian buffer or a furnishing zone should be landscaped with low maintenance plantings. Trees, street furniture, and other objects should not obscure or impair motorist and pedestrian visibility (Figures 7.4.5).

When cars are parked perpendicular or diagonally to sidewalks, a minimum of a four-foot parking lot buffer with wheel stops shall be provided to prevent car overhang and narrowing usable sidewalk width (Figures 7.4.6). When feasible it is the City of Arlington's goal to provide a complete street section (Figures 7.4.7).

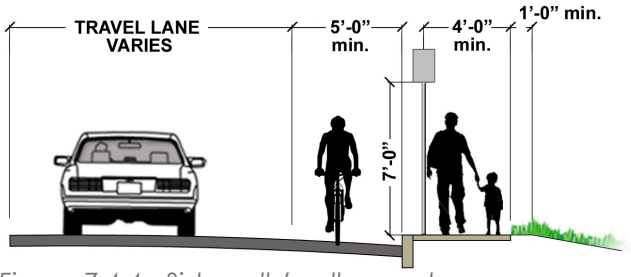


Figure 7.4.4. Sidewalk/walkway clearances.

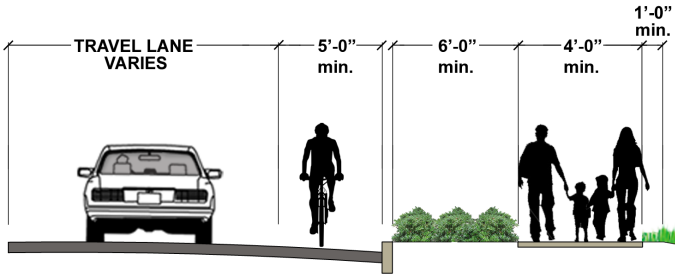


Figure 7.4.5. Sidewalk with pedestrian buffer zone.

Figure 7.4.6. Sidewalk with landscape buffer at parking lot.

Figure 7.4.7. Typical complete street section.

Design Criteria:

- Refer to Thoroughfare Development Plan for the minimum sidewalk/pedestrian realm standards.
- All new construction of sidewalks shall meet ADA accessibility requirements.
- Frontage zone dimensions vary from 0-3 feet depending on the street and land-use classification.
- A minimum 4-foot parking lot buffer shall be provided when cars are parked perpendicular or diagonally to sidewalks.
- Pedestrian buffer/furnishing zone width ranges from 6 to 8 feet, depending on the street and land-use classification.
- Sidewalks are typically required on all streets, and shall be located on each side of the street within the existing right-of-way. Sidewalks are not required on local rural streets or cul-de-sac streets, or otherwise as determined by the City of Arlington.
- Should permanent obstructions occur in the sidewalk path, a minimum of 3 feet of clearance shall be provided. All obstructions that can be relocated should be located outside of the sidewalk zone.
- A minimum of 7 feet is required for vertical clearance on sidewalks.
- Objects mounted on a pole or to a wall shall not protrude more than 4 inches into the sidewalk throughway zone.
- Sidewalk surfaces shall be smooth concrete or paved surfaces.
- The standard width for sidewalks on bridges is 7 feet. Sidewalks on bridges next to high-speed travel lanes require a vehicle barrier at the curb line. Bridge pedestrian rails must be ADA compliant (Figure 7.4.8).
- The maximum slope of a sidewalk is 5 percent.
- Handrails are to be provided if slopes in excess of 5 percent are encountered.
- The maximum grade of 12:1 (8.33 percent) is acceptable for a rise of no more than 2.5 feet. A level landing area at least 5 feet long and 5 feet wide at 2 percent grade shall be provided at each end (Figure 7.4.9).
- Changes in level surface from .25 to .5 inches shall be beveled. Changes greater than .5 inches shall be removed or a ramp with a maximum grade of 8.3 percent shall be installed.
- Gaps and grate openings should not allow passage of a .5 inch sphere or the long dimension of the opening should be perpendicular or diagonal to the dominant direction of travel.
- The maximum cross-slope for a walkway is 2 percent.

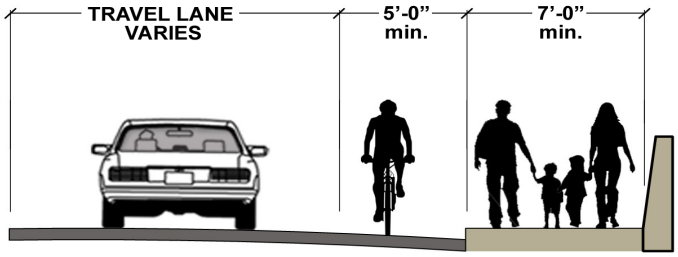


Figure 7.4.8. Sidewalk on bridge.

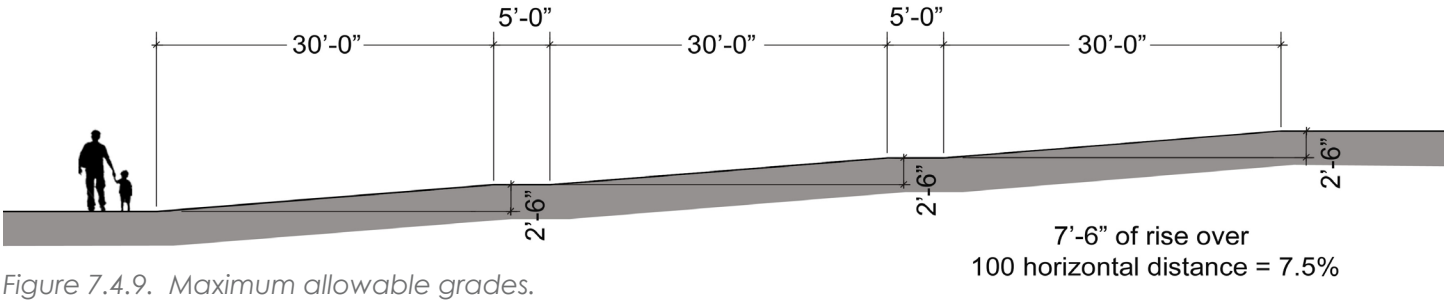


Figure 7.4.9. Maximum allowable grades.

- When on-street parking is provided, a minimum furnishing zone of 5 feet shall be required. This allows car doors to open and people to exit from the vehicle without blocking the sidewalk.
- At driveways, curb cuts, and road approaches, a 4-foot minimum sidewalk area must be maintained at 2 percent cross slope. Additional right-of-way may be secured to maintain minimum sidewalk widths and maximum slopes when crossing driveways or curb cuts.
- Passing space on sidewalks at intervals of no more than 200 feet should be provided. The passing areas shall be a minimum of 5 feet by 5 feet.
- Sidewalks that are narrow or in steep terrain areas should provide rest and passing areas outside of the pedestrian zone.
- In steep terrain areas, wider sidewalks are recommended to allow wheelchair and handicap users to travel in a zigzag motion to reduce the grade they must travel.
- Pedestrian signage indicating the upcoming grade is recommended in steep terrain areas.
- It is recommended that with new construction, the elevation of the buildings be coordinated with the elevation of the road to provide ADA access.
- If on street parking is permitted, periodic curb ramps along planting strips should be provided to facilitate pedestrian access onto the sidewalk.
- It is recommended that the larger the sidewalk width, the larger the width of the planter or furnishing zone that should be provided.
- When transit stops are provided, larger furnishing zones are recommended. Transit requirements vary, but should be coordinated with and connected to an accessible path of travel.
- Should new building construction occur that requires wider sidewalks to accommodate the increase in pedestrian traffic, it is recommended that the property owner donate the property to the City and be responsible for construction that meets the sidewalk standards.
- On narrow right-of-way areas, if additional right-of-way cannot be obtained, a corridor traffic study is recommended to determine if street widths can be reduced in order to create a wider path of travel for the pedestrians.
- Street tree plantings should be considered to provide a visual buffer between pedestrian and automobile traffic, improve the aesthetic appearance of the street, and provide shade or shelter in warm and windy regions. Tree and root protection devices should be used to minimize sidewalk and paving maintenance issues. The proper tree should be chosen based on the tree and site characteristics. Refer to TxDOT and City requirements for tree selection and setback requirements
- To reduce cost and to minimize inconvenience to users, sidewalks should be incorporated during the initial planning stage of a transportation project.

7.4.1 Pedestrian Intersection Crossings

A. Marked Crosswalks

Marked crosswalks designate pedestrian and/or bicycle rights to cross a street at intersections and at mid-blocks. Texas State law defines and summarizes guidelines as it relates to crosswalks and the pedestrian right-of-way. The law defines "a marked crosswalk as a pedestrian crossing that is designated by surface markings and an unmarked crosswalk as an extension of a sidewalk across intersecting roadways." The State of Texas law recognizes both marked and unmarked crosswalks and makes no legal distinction between the two in assigning pedestrian right-of-way (Figure 7.41.1).

A mid-block crossing is a pedestrian crossing that is not located at a roadway intersection. If a mid-block crossing is not designated by marked crosswalks, pedestrians must yield the right-of-way to motorists (Figure 7.41.2).

An uncontrolled location is a roadway intersection or other mid-block crossing that is not controlled by either a traffic signal or a stop sign. Uncontrolled locations can be the most difficult and challenging places to provide safe pedestrian crossings.

When determining appropriate pedestrian crossings, it is found that quantitative criteria-based warrants, along with qualitative criteria and practical guidelines, should be studied to address unique problems in the community.

When providing a pedestrian crossing, proper signage should be considered in addition to marked crosswalks to improve safety and visibility. For example, at mid-block crossings, fluorescent green pedestrian crossing signage with lighted signs should be installed at crosswalks to ensure safe pedestrian crossing (Figure 7.41.4).

It is recommended that marked crosswalks should be 10 feet wide or the width of the approaching sidewalk, if it is greater. Textured crossings, using non-slip bricks or pavers, help raise a driver's awareness through increased noise and vibration. Marked crosswalks combined with curb extensions, illumination, and

Figure 7.41.1. Example of marked crosswalk.

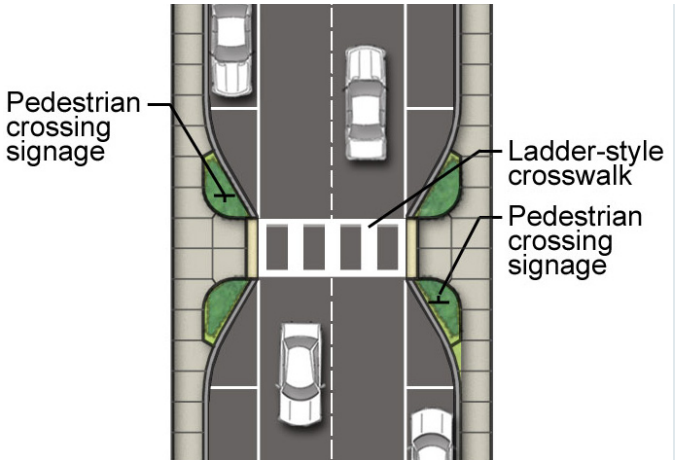


Figure 7.41.2. Typical mid-block crosswalk.

signage can improve the visibility of pedestrian crossings. Crosswalks send the message to motorists that they are entering a pedestrian area. A traffic study should be used to determine if a marked crosswalk will enhance pedestrian safety. This is usually in locations that are likely to receive high use, based on adjacent land uses.

Design Criteria:

- The design must meet and follow the City of Arlington Design Criteria Manual, Chapter 6 and MUTCD standards and information on pedestrian crossing signage and crosswalk markings.
- Use thermoplastic markings that are highly reflective for crosswalks.
- Crosswalks shall have a minimum 10-foot width.
- Appropriate push buttons and walk signals should be placed at signalized intersections indicating when pedestrians may cross.
- Adequate street lighting shall be provided at crosswalks.

- Mid-block crosswalks can be considered in a controlled environment with speeds less than 35 mph, after a traffic study has been provided and the City Engineer has approved them.
- For quantitative guidance on marked crosswalks at uncontrolled locations, see the 2005 FHWA Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations Final Report and Recommended Guidelines (www.fhwa.dot.gov/publications/research/safety/04100/04.cfm#toc110157073).
- Provide high-intensity activated crosswalk (HAWK) system when providing mid-block crossings (Figure 7.41.4). HAWK signals are applied to intersections or mid-block crossings with low vehicular volumes where bicyclists and/or pedestrians have difficulty obtaining adequate gaps in major street traffic to safely cross the street. These signal faces will rest in an off condition until a bicyclist and/or pedestrian activates a control sequence. After flashing yellow and/or steady yellow change intervals, the red lenses will first display steady red, followed by a simultaneous flashing red display. The bicyclist or pedestrian then follows standard crossing signals with a countdown crossing signal and "do not cross" signal.

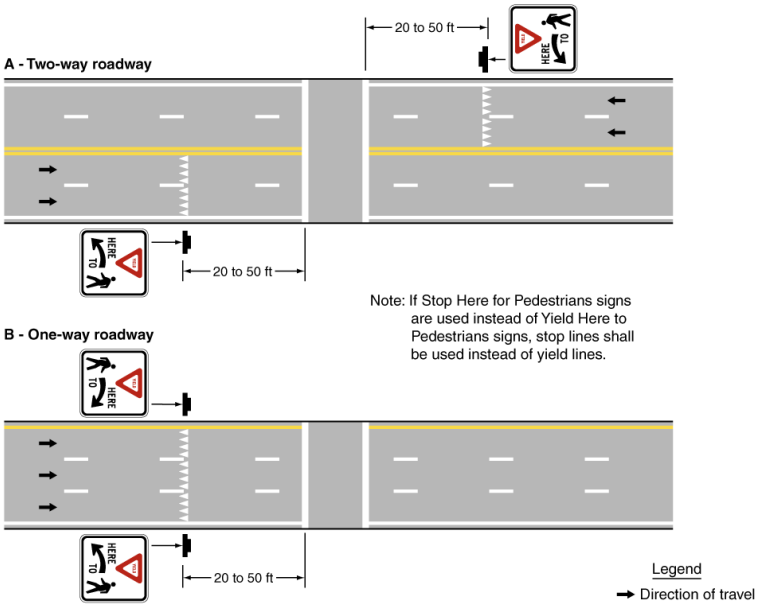


Figure 7.41.3. Typical signage placement for mid-block crosswalks.

- Crosswalks should be used where substantial pedestrian and vehicular conflicts exist and not used indiscriminately.
- Crosswalks should be used at appropriate points of pedestrian concentration or where pedestrians could not otherwise recognize the proper place to cross (e.g. loading islands, mid-block pedestrian crossing).
- Crosswalks may be provided to concentrate or channelize multiple pedestrian crossings to a single location.
- Crosswalks should be utilized at approved school crossings on recommended safe school routes.
- Advance warning signs for motorists should be installed for mid-block crossings.
- Continental or ladder style high-visibility marked crosswalks are preferred.
- If possible, the crossing distance should be minimized by using curb extensions.
- Median refuge islands should be considered, especially for high-volume and/or multi-lane roadways.
- Signal timing patterns should be adjusted to minimize pedestrian conflicts with right or left turning vehicles.
- Visibility should be enhanced for motorists to recognize pedestrians and yield the right-of-way.
- On-street parking should be removed or minimized in the immediate proximity of an intersection. These locations provide an ideal location for a curb extension.

Figure 7.41.4. Typical signage placement for mid-block crosswalks.

- Pedestrian activated (or passive detection) flashers should be considered in addition to overhead signage.
- Motorist speeds should be reduced and controlled at crosswalks locations.
- Crosswalks should not be installed at locations which could present an increased safety risk to pedestrians, such as locations with poor sight distance, complex or confusing designs, substantial volumes of heavy truck traffic, or other dangers without first providing adequate design features and/or traffic control devices.

B. Advanced Stop Bars

Located at all signalized intersections and at multi-way stops, advanced stop bars are used to provide warning for automobiles that a pedestrian zone is approaching. Advanced stop bars are located on roadway pavement in advance of the crosswalk to prevent automobiles from encroaching on the pedestrian zone.

Design Criteria:

- Advanced stop bars should be placed 4 feet in advance of any marked crosswalks.
- The advanced stop bar should be a 24 inch wide white line across the length of the travel lane(s).
- See Arlington Design Criteria Manual for additional information regarding advance stop bar design requirements.

C. Curb Extensions

Curb extensions are often used as traffic calming devices in high pedestrian areas. Typically installed at curb radii, these are also known as bulbouts or neck downs and they reduce distance for pedestrians to cross streets. This improves pedestrian safety and slows turning vehicle movement. Curb extensions can be used on one side of a one-way street radius and at mid-block crossings where pedestrian traffic is high, such as in downtowns or on main streets. Curb extensions should be considered at all intersections where on-street parking is allowed. Curb extensions improve visibility of pedestrians by motorists. This visibility can be further improved with lighting and signage.

Design Criteria:

- Refer to the Thoroughfare Development Plan for minimum travel lane width.
- Maintain appropriate travel lane widths. Refer to the City of Arlington's Thoroughfare Development Plan.
- Provide ADA accessibility ramps at crosswalk locations.
- Follow MUTCD standards for signage and traffic markings for advance warning of curb extensions.
- Maintain pedestrian and vehicle visibility and sign distance.
- Line up sidewalks, curb cuts, and crosswalks at intersections.
- Average daily traffic (ADT) on the affected street should be between 800 and 3,500 .
- Street must be at least 750 feet long and must have existing curbs and an asphalt width of 22 feet.
- The speed limit may not be greater than 25 mph.
- Adequate provisions for emergency vehicles must be provided.
- The curb extension is best applied on local and minor collector streets.
- The curb extension is best used in conjunction with features such as textured or highly visible crosswalks, raised intersections, median refuge islands, or on-street parking.
- Curb extensions may require additional drainage provisions.
- Bollards or other landscape improvements can be used with curb extensions to provide pedestrian safety and visual enhancements.

D. Curb Ramps

Curb ramps are important devices at intersections because they facilitate crossing for wheelchair users, people pushing strollers, bicyclists, and others. Curb ramps provide transition areas from street to sidewalk where a raised curb is located (Figure 7.41.5).

Design Criteria:

- The curb ramp must meet American with Disabilities Act (ADA) standards.
- The minimum width for exterior ramps is 5 feet.
- A minimum of 4 feet (5 feet preferred) should be provided at the top of the ramp for turning or bypassing the ramp.
- Ramp and approaches shall be clear of obstacles, such as fire hydrants, poles, and inlets.
- A level landing area should be provided at both ends of the curb ramp to provide a resting zone for users.
- The low end of the ramp or curb cut should meet the grade of the street with a smooth transition.
- Curb ramps shall be provided at channelization islands in an intersection and median refuge island, unless the full cut through openings are provided at grade with the street.
- Curb ramp surfaces should be textured to meet ADA standards and to prevent slippage (Figure 7.41.6).
- Provide detectable warning pavement or pavers (truncated dome) at the bottom of the ramp.
- Good drainage at intersection corners is important so that standing water does not accumulate within the crossing area.
- Storm drainage inlets should be placed on the uphill side of the crosswalks and outside the crosswalk area.

Figure 7.41.5. The curb ramps below are aligned with the marked crosswalk and are ideally perpendicular to the roadway

Figure 7.41.6. The curb ramp with detectable warning strip at intersection.

E. Islands and Refuges

Pedestrian refuge islands are typically raised islands located along the centerline of a street. They are typically constructed at wide intersections with several travel lanes and turn lanes. Refuge islands allow pedestrians to cross fewer lanes at one time and should be wide enough to hold several pedestrians at once (Figures 7.41.7 and 7.41.8).

Design Criteria:

- Refuge islands should be a minimum of t least 6 feet wide (preferably 8 feet).
- An area should be provided for accessible pedestrian push-buttons.
- Vehicular and pedestrian visibility should be maintained if landscape enhancements are provided in the refuge area.
- On narrow islands (6 feet wide) bollards should be installed for added protection for waiting pedestrians.
- For narrow refuge islands, at-grade cuts are needed for wheelchair access.
- For wider islands, curb ramps with level landings are needed.
- Refuge islands are best applied on wide streets (four or more lanes) with moderate

to high traffic volumes.

- Refuge islands should be considered at locations where slower pedestrians are commonplace, or where it is difficult to cross more than one direction of traffic during one pedestrian crossing phase.
- Refuge islands should be considered to help reduce vehicle speeds or to make pedestrian crossings more visible to motorists.
- Refuge islands should be considered as a location for landscaping and visual enhancements.

Figure 7.41.7. Median refuge island with pedestrian signage at intersection.

Figure 7.41.8. Refuge island with pedestrian activated signalization at intersection.

F. Pedestrian Signals

There are a variety of possible traffic signal enhancement opportunities that can greatly improve the safety and flow of pedestrian traffic. A pedestrian activated signal may be warranted where the expected number of people needing to cross a roadway at a particular location is significant. Pedestrian signals are often combined with other traffic calming devices to ensure pedestrian safety is maintained when crossing a street. The preferred location for pedestrian signals are at intersections where pedestrian crossings are common. Sight-distance must be adequate to ensure that motorists will see the light in time to stop. Warning signs should be installed at warranted locations (Figure 7.41.9).

Design Criteria:

- Signals must meet City of Arlington standards.
- Adequate and proper signage, markings, clear zone, and lighting are required to allow motorists time to see the pedestrian signal.
- Countdown signals are required for all new signal installations. If existing countdown signals already exist, they must meet the provisions established (in 2003) by MUTCD, indicating that by 2013, any hardware that does not meet the standards will need to be replaced. With the adoption of special provisions in the 2009 MUTCD, any new countdowns installed from now forward must meet not only hardware requirements, but the new requirement that any new replacement pedestrian signals being installed must include countdowns unless the pedestrian change interval (flashing upraised hand) is 7 seconds or less (Figure 7.41.9).
- Proper signal timing intervals and timing needs should be adapted to the given situation.
- Large pedestrian signals should be utilized on larger roads to ensure readability.
- Pedestrian signal push buttons should be well signed and visible.

Figure 7.41.9. Examples of typical pedestrian crossing signal and countdown signal.

- Pedestrian signal push buttons should clearly indicate which crossing direction they control (Figure 7.41.10).
- Pedestrian signal push buttons should be reachable from a flat surface, at a maximum height of 3.5 feet.
- Walk intervals shall be provided during every traffic light cycle, especially in high pedestrian traffic areas.
- Where high-volume motorist turning movements conflict with pedestrians, an exclusive pedestrian interval is a preferred solution.
- A potential alternative to the exclusive pedestrian crossing is the leading pedestrian interval, which works in conjunction with the concurrent signal timing system and provides an advance signal notice to pedestrians.
- In addition to appropriate symbols, pedestrian signalization can be accompanied by an audible pulse or other messages to make crossings safe for all pedestrians.

Figure 7.41.10 Push-button activator for intersection crossing.

G. Underpass/Overpass

Pedestrian underpasses and overpasses provide the opportunity to design and construct a continuous hike and bike network.

Underpasses provide the opportunity to pass beneath existing bridges and though culverts to avoid slopes, railroad, and/or roadway conflicts (Figure 7.41.11).

Overpasses provide the opportunity for safe passage over streams, rivers, wetlands, slopes, railroads, and/or roadways. They can also provide a unique vantage point from which to view the surrounding environment. Both structures can be costly to design and implement

Refer to Section 7.53, Bicycle Intersection Crossing Facilities for Design Criteria and Other Design Considerations for the design of Pedestrian Underpasses/Overpasses.

Figure 7.41.11. Example of multi-use underpass.

H. Pedestrian Railroad Crossings

Refer to Section 7.53 Bicycle Intersection Crossings for Design Criteria and Other Design Considerations for the design of Pedestrian Railroad Crossings (Figure 7.41.12).

Figure 7.41.12. Center Street sidewalk in downtown Arlington shows how pedestrian signage is used at railroad crossing.

7.4.2 Transit Stop Treatment

Transit stops serve as the interface between points of the sidewalk/trail system, street networks, and transit routes. Treatment at transit stops is important to ensure pedestrian safety and to encourage continued use of the transit facility. An improved pedestrian system connecting to transit stops will make using the transit system safer and more enjoyable. The treatment should include comfortable site furnishings, including shelters, benches, waste receptacles, bike racks, lighting, landscaping, adequate buffering from the road, and wider pavement surfaces.

Transit facilities function best when they are designed to meet the demands of the peak user levels. In high use areas, transit stops require significantly wider sidewalk areas to accommodate users, transit shelters, clear zone areas, bike racks and storage, and waiting areas (Figure 7.42.1).

Appropriately located turnouts will enhance user safety while minimizing delay to traffic. For a transit pullout along a street, exiting and boarding passengers should not conflict with the needs of pedestrians and bicyclists moving through the area (Figure 7.42.2).

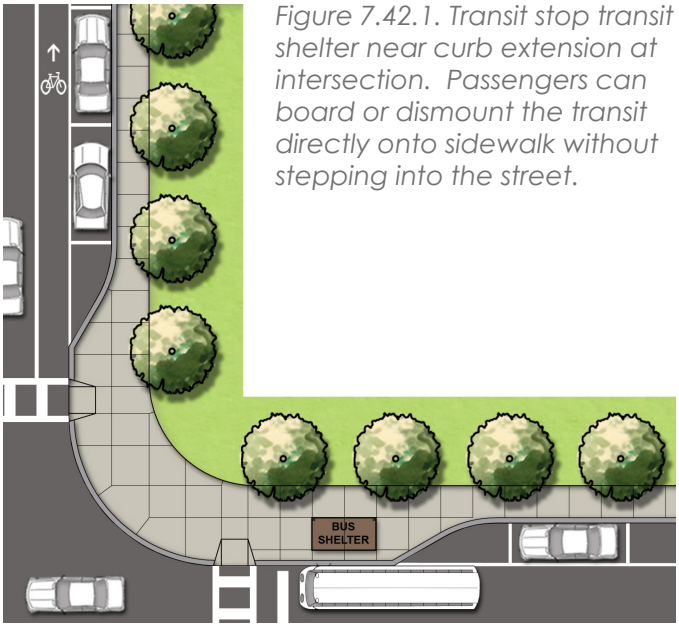


Figure 7.42.1. Transit stop transit shelter near curb extension at intersection. Passengers can board or dismount the transit directly onto sidewalk without stepping into the street.

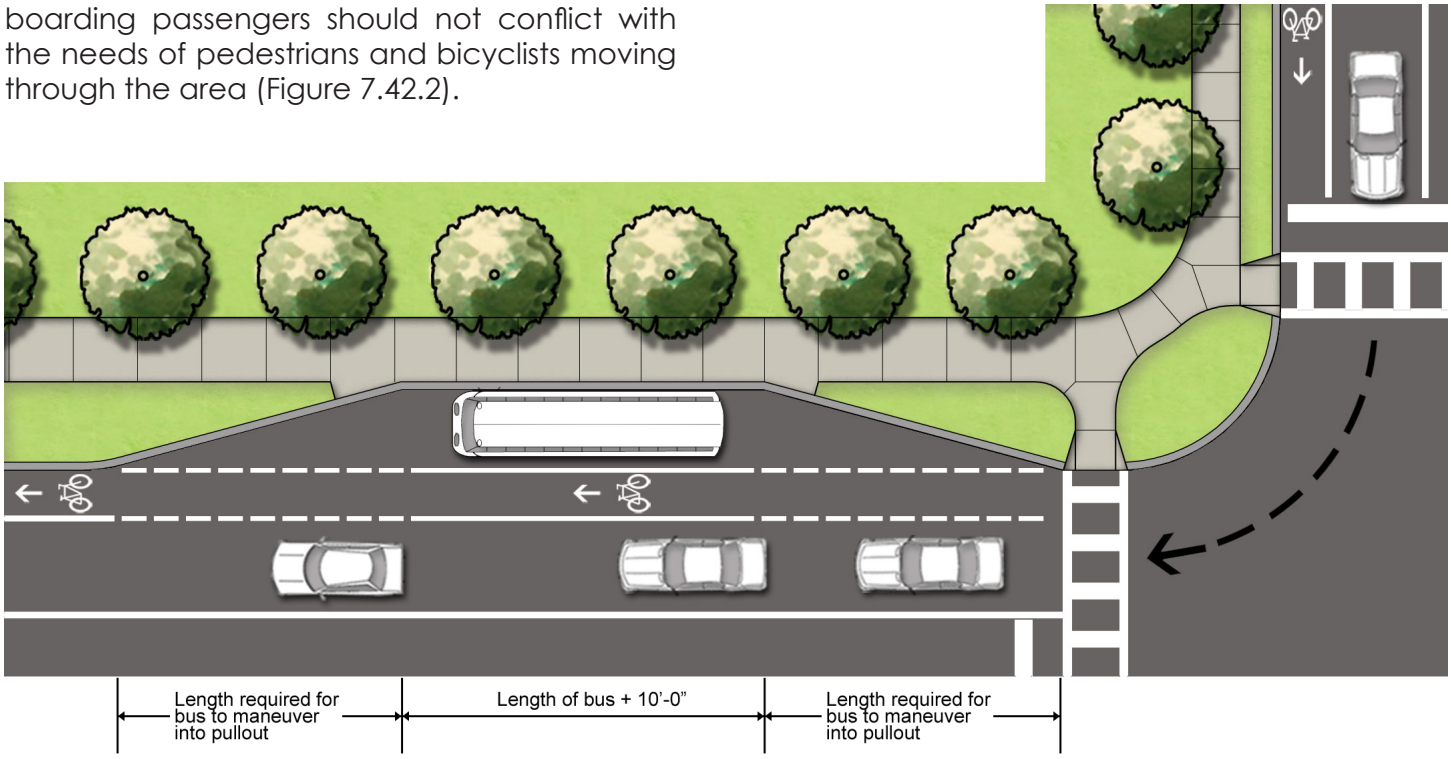


Figure 7.42.2. Transit stop transit lane pullout treatment at intersection does not interrupt the bike lane or travel lanes while transit vehicle is loading/unloading.

Design Criteria:

- The transit stop treatment should meet ADA accessibility requirements.
- Where transit stops warrant a pullout location due to high traffic conditions, a minimum of 8-foot-wide sidewalk pavement, the length of a regular transit vehicle, shall be provided.
- In addition to the sidewalk width, provide a landing pad or additional pavement area for loading and unloading for transit passengers. Landing area is 10 feet by 5 feet minimum.
- A minimum 4-foot clear zone should be provided so transit vehicle doors can open fully.
- Non-slip pavement surface should be provided for all loading and unloading areas.
- Benches, shelters, waste receptacles, and lighting should be provided at each stop.
- Benches shall not be located closer than 5 feet to the curb where speed limits are 35 mph or less, 10 feet from the curb where speed limits are greater than 35 mph, and 10 feet where there is no curb.
- Refer to zoning and development codes for shelter placement. If no standards apply, shelter placement shall meet the minimum standards established for benches. Shelter location should not adversely impact vehicular sight visibility and/or adjacent residence or business use.
- Transit stops shall be signed.
- Route and schedule information should be provided along with a location map.
- Transit stop design shall avoid conflicts with bike lanes.
- Curb extensions or bulbouts should be considered to allow passengers to board and exit transit vehicle without conflict with the sidewalk pedestrian flow.
- Varying curb heights should be avoided.
- Stops located after (far side of intersection) or near intersections should be examined closely so that transit, traffic operations, and pedestrian conflicts are avoided.
- Transit operators need to be able to safely re-enter traffic. Sight distance and location site amenities are critical in transit stop design.
- At large transit facilities, bicycle racks, public telephones, and drinking fountains should be provided. At larger stops, storage facilities may also be warranted.
- Coordinate with the City of Arlington on the required site furnishing for each transit location.
- At high capacity centers, avoid drastic level changes. If stairs or elevators are provided, make sure they are wide enough to allow faster passengers to pass.

7.4.3 Pedestrian Lighting

Adequate pedestrian lighting is often a deterrent for any vandalism activity and provides safety for night-time hours. Lighting can also make pedestrians more visible when crossing a roadway and should be provided in addition to vehicular lighting. The light fixtures should be vandal-proof with the overall system requiring minimum maintenance (Figures 7.43.1 and 7.43.2).

Design Criteria:

- Lighting should be a minimum 4 feet from curb and 100 watt high pressure sodium light fixtures/LED.
- Light standards should be installed at all four corners of an intersection.
- Photometric studies must be conducted to ensure that the proposed lighting meets safety/visibility requirements.
- Poles shall be steel telescoping or decorative poles.
- Refer to the Arlington Design Criteria Manual for additional lighting information.
- Light standards should be provided between the back of curb and front edge of the walkway in the street furnishing zone.
- Light standards should be provided that are aesthetically appropriate for the overall architectural design style of the area that they are located within.
- Glare onto adjacent residential and private property should be avoided. Use full or partial cut-off lighting fixtures to minimize light pollution and address "dark skies" goals.
- Dual- level lighting systems should be considered to reduce intensity and power usage in later night to morning hours.
- Accent lighting should be provided and up-lighting on architectural and landscape features should be used to add interest and focal points.
- Electrical service for seasonal events and event lighting should be provided.

Figure 7.43.1. Pedestrian and street level lighting in downtown urban situation.

Figure 7.43.2. Pedestrian and street level lighting at commercial/office area.

7.5 BICYCLE NETWORK

Bicycle projects must be planned and constructed according to AASHTO, MUTCD, TxDOT, and City of Arlington Design Manual standards.

7.5.1 On-Road Bicycle System

A. Paved Shoulders

Paved shoulders are the area adjacent to the nearest travel lane and are at the same elevation as the street. Often used to accommodate disabled vehicles, paved shoulders allow bicyclists to use the roadway in a safe environment. Unless the minimum width for bike lanes and standards are met, paved shoulders should not be marked or designated as bikeways (Figures 7.51.1 through 7.51.3).

Shoulder widths can vary depending on the classification of the roadway (rural arterial, collector, local route, etc.), the design speed, and volume of traffic. Refer to City of Arlington and TxDOT for minimum shoulder width standards.

Design Criteria:

- Paved shoulders should be at least 4 feet wide to accommodate bike travel.
- Paved shoulders should be 5 feet wide from face fixed objects including guardrails, curbs, or barriers.
- Paved shoulders should be increased to 6-foot in roadways when there is a high percentages of truck, transit, recreational vehicles, obstructions, when vehicle speeds exceed 40 mph, or on steep grades in excess of 8 percent.
- Rumbled strips or raised pavement is not recommended unless there is a minimum clear path of 1 foot from the rumble strip to the traveled way.
- See AASHTO and Policy on Geometric Design of Highways and Streets (Green Book), for additional guidance.
- Many existing gravel shoulders have sufficient width and base to support bikeways.
- When providing additional pavement surface to existing roadways, the thickness of pavement and base material will depend on local conditions, engineering evaluation, and the specification provided by the City of Arlington Design Criteria Manual.
- It is best to widen shoulders in conjunction with pavement overlay to add structural strength to bike lane and provide a smooth, seamless joint. Cost can also be less due to larger quantities of paving materials that will be purchased and the benefit of minimized traffic disruption.

Figure 7.51.1 Paved shoulder at Bowman Springs Street bridge over I-20.

Figure 7.51.2. Paved shoulder at Mansfield Webb Road and Ballweg Road.

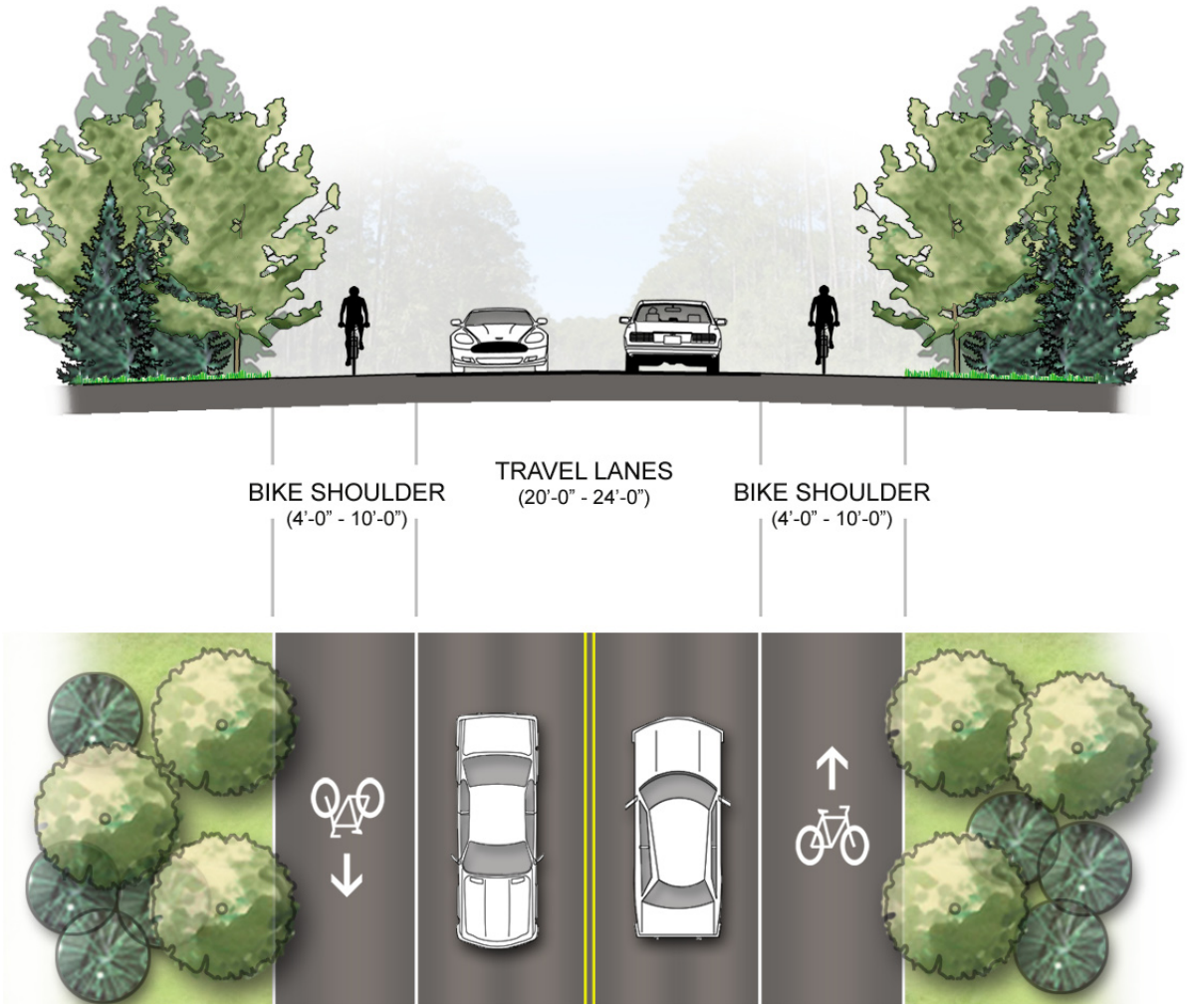


Figure 7.51.3. Typical section of paved shoulder facility.

B. Wide Outside Lane

For streets that do not have shoulders, a wide outside lane is preferred to safely accommodate bicyclists on a travel lane. In some instances, making travel lanes and left-turn lanes narrower to provide wide curb lanes that accommodate bicyclists may be considered, but should be supported by traffic and engineering studies (Figure 7.51.4).

Design Criteria:

- The minimum width for a wide outside lane is 14 feet for shared use from edge of gutter pan to edge of lane stripe.
- 16-foot lanes are desirable when drainage grates, raised reflectors, or on-street parking effectively reduces the usable width.
- Refer to MUTCD and ASSHTO standards for

Figure 7.51.4. Wide two lane road above provides ample space for a bicyclist to be separated from traffic.

"Share The Road" signage and pavement markings.

- See AASHTO and Policy on Geometric Design of Highways and Streets (Green Book), for additional guidance.
- When widths greater than 14 feet extend continuously along a stretch of roadway, they often encourage the undesirable operation of two motor vehicles in one lane. Consider striping bike lanes and shoulders when pavement widths are greater than 14 feet.

C. Signed, Marked Bike Route

A signed, marked bike route is a bicycle facility that allows both bicyclists and motorists to use the same travel lane along a street.

Bike routes are designated by signs and markings as a preferred route for bicycle use and are typically recommended on lower-volume residential streets and minor collector roads with low traffic volumes and a speed limit of less than 35 miles per hour. They are often used where there is no room for a designated bike lane or on-street parking is necessary.

The shared lane pavement marking is used to 1) show bicyclists where in the the roadway lane they should ride, particularly in locations with on-street parallel parking to ensure safe bicycle travel outside parked vehicle door zones; 2) identify the proper direction of travel for bicyclists; and 3) create awareness for motorists that the travel lane is a shared use lane. (Figures 7.51.5 through 7.51.7).

Design Criteria:

- Provide a smooth roadway surface. Adjust utility covers, install bicycle-safe grates, and fill potholes as needed.
- Refer to MUTCD and AASHTO Standards for bike route and share the road signage.
- Refer to MUTCD and AASHTO Standards for share the road pavement markings.
- A shared lane marking shall include white paint markings indicating that the roadway

Figure 7.51.5. Example of shared lane markings

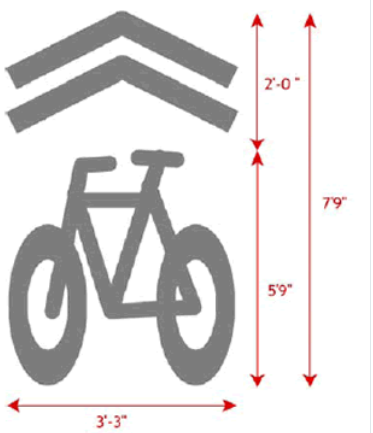


Figure 7.51.6. Shared Lane Stencil Dimensionss

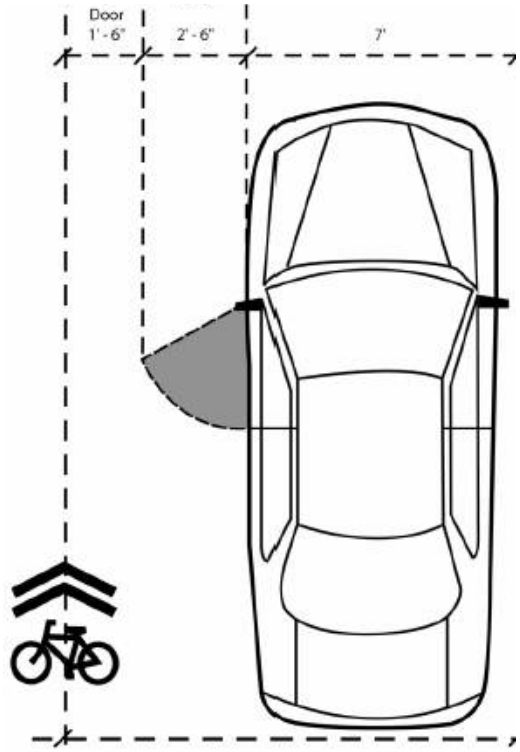


Figure 7.51.7. Shared lane dimensions for on-street parking.

Figure 7.51.8. Example of a signed shared roadway.

is shared by both bicyclists and motorists.

- When a bike route is provided adjacent to parallel parking, the appropriate "share the road" signage is required to inform motorists that the travel lane is shared among vehicles and bicyclists and the minimum combined lane width shall be 14'-0" (Figure 7.51.8).
- Arrows should be spaced approximately 200 feet on center, with the first arrow on each block or roadway segment placed no further than 100 feet from the nearest intersection.
- When a shared lane is greater than 16'-0" wide, a bike lane shall be striped to avoid undesirable operation of two motor vehicles in one lane.
- The signed shared roadway should direct bicyclists to other bicycle facilities.
- Signage should direct bicyclists to particular destinations such as parks, schools, or commercial districts.
- Where possible, the shoulder improvements and wider curb lanes can increase the comfort level of bicyclists using a shared lane facility.

Figure 7.51.9. Examples of Bike Route Signage

D. Bike Lanes

Bike lanes are portions of a roadway that have been designated by striping, signing, and pavement markings for the preferential or exclusive use of bicyclists. A bike lane is a one-way facility that carries bicycle traffic in the same direction as adjacent motorized traffic. Bike lanes should always be provided on both sides of a two-way street and should be located between on-street parking and travel lanes.

Bike lanes are typically provided on urban arterials and minor and major collector streets. Bike lanes may also be provided on rural roadways near urban areas, where there is a high potential of bicycle users. Bike lanes are not typically recommended on rural highways with greater than 45 mph post speeds.

Design Criteria:

- A bike lane requires a white pavement marking.
- The lane should be defined by a 6- to 8-inch-wide white line separating the bike lane from the motor vehicle travel lane.
- The lane should be defined by a 4-inch-wide white line separating the bike lane from parking spaces.
- The minimum width of a bike lane is 5 feet from center of stripe to face of curb or edge of pavement. 6'-0" bike lane widths are recommended for high use and high speed areas.
- Where on-street parking is permitted the bike lane should be a minimum of 6 feet wide. If traffic or parking volume is substantial or turn over is high, an additional 1 to 2 feet of bike lane width is desirable.
- Motorists are prohibited from using bike lanes.
- Where space is limited or a roadway has a steep grade, a bike lane may be used on the uphill portion and a sharrow may be used for the downhill portion of the roadway.
- Refer to City of Arlington's Design Criteria Manual, AASHTO, and MUTCD signage, pavement marking, and striping standards.

Figure 7.51.10.Example of clearly defined bicycle lane.

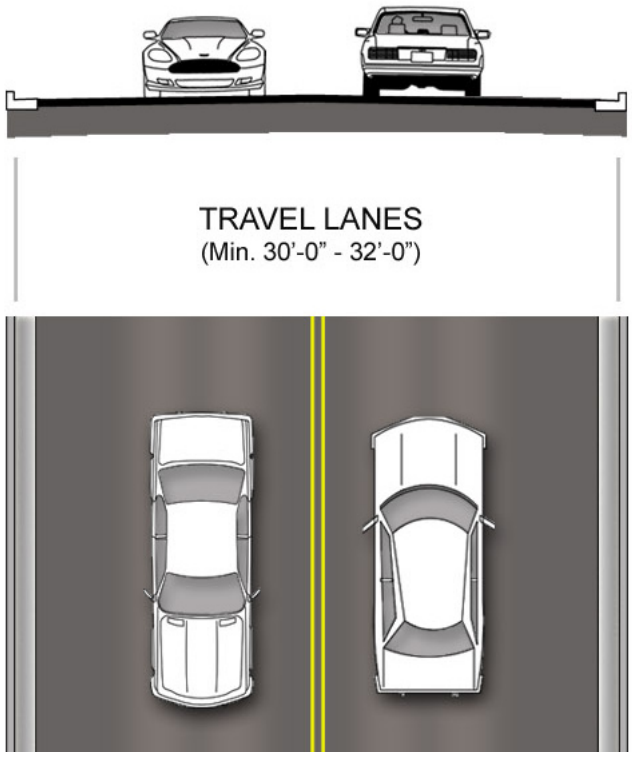
Figure 7.51.11. Example of a roadway where bike lanes are recommended and sufficient apace for striping a lane is available.

Figure 7.51.12. Example of bike lane and right turn lane.

- R3-17 Bike Lane sign should be used for bike lane signage. Refer to MUTCD standards for bike lane signage placement and pavement marking placement.
- Refer to the Thoroughfare Development Plan for minimum bike lane width requirements.
- Bike lanes should never be placed between the parking lane and curb.
- Adjust drain inlets and utility covers that extend into bike lane.

E. Bike Lane (Stripe Implementation Method)

Bike lane striping allows for an existing, designated, wide outside lane to be used exclusively for bicyclists. In an existing wide travel lane, narrowing the travel lane by striping for a bike lane is used to accommodate bicyclists. This is a low cost solution that only involves adding striping and pavement markings (Figure 7.51.14).



Existing two lane street plan and section (before)

Figure 7.51.13. Example of bike lane signage

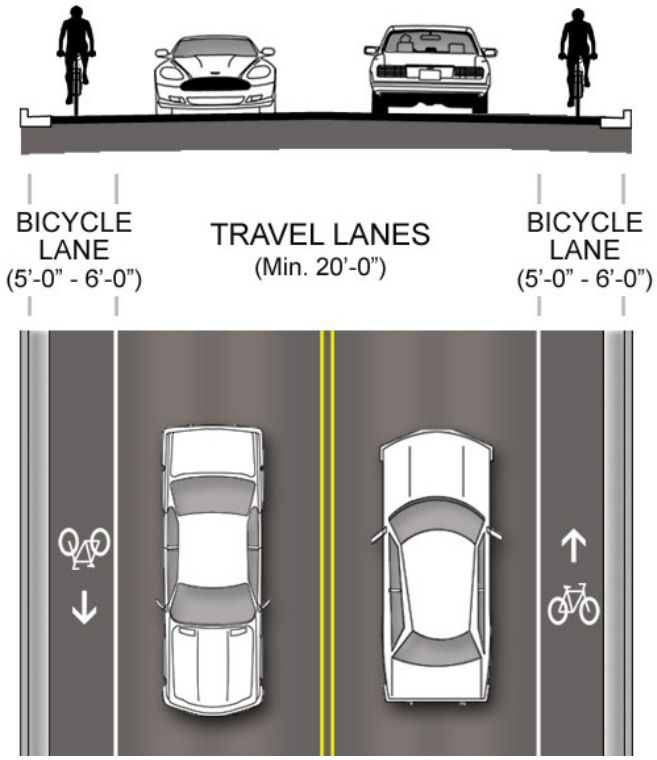


Figure 7.51.15. Two lane with bike striping plan and section (after)

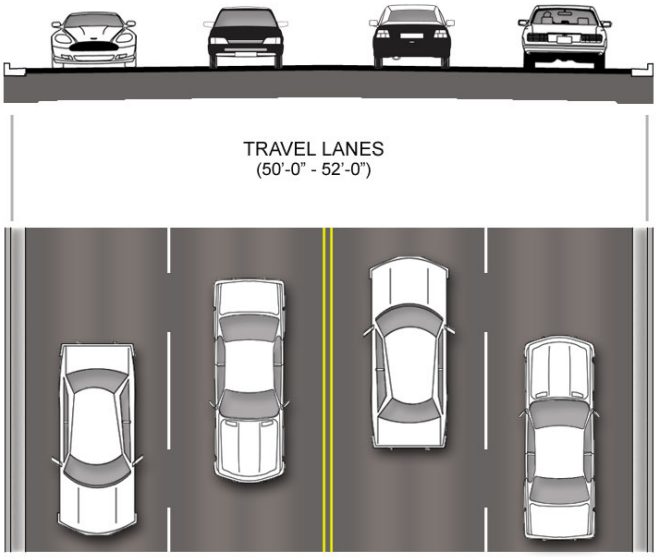
Figure 7.51.14. Example of roadway where pavement striping could be added to create bike lanes.

F. Bike Lane (Travel Lane Conversion Implementation Method)

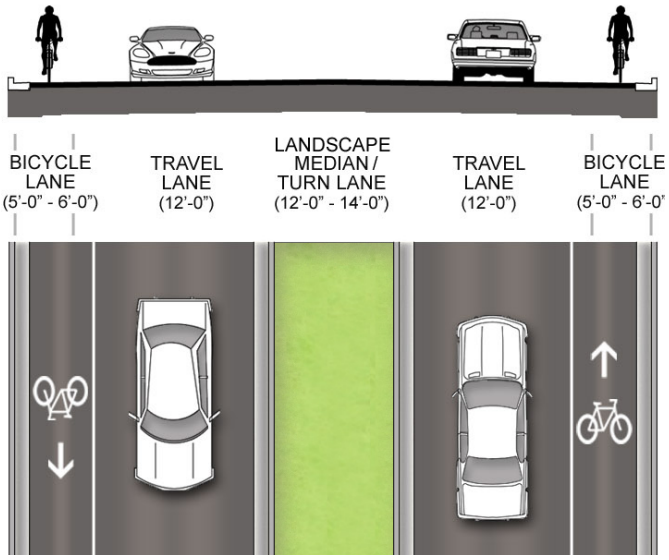
The travel lane conversion method involves a reduction in the number of travel lanes. Where future traffic volumes are expected to be low, a travel lane conversion is also recommended in this plan for four-lane divided roadways to convert to two lane divided roadways with bike lanes. Travel lane conversions can also include the reduction of four lanes to three lanes with center lane as turn lane to accommodate bike lanes (Figure 7.51.16 through 7.51.19).

Design Criteria:

- A traffic study is required to determine the feasibility of reducing the number of travel lanes.
- Examine the possibility of reducing the width of travel lanes or restripe if lanes cannot be eliminated.
- Refer to the City of Arlington Thoroughfare Development Plan and the Design Criteria

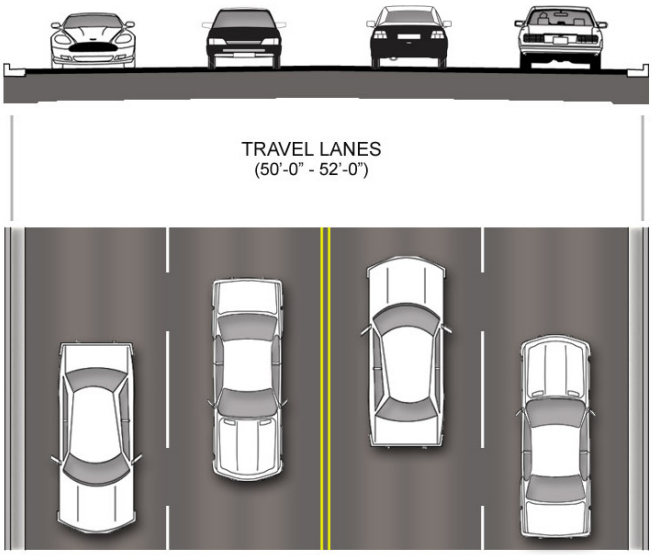


Existing Four Lane Street Plan and Section (before)

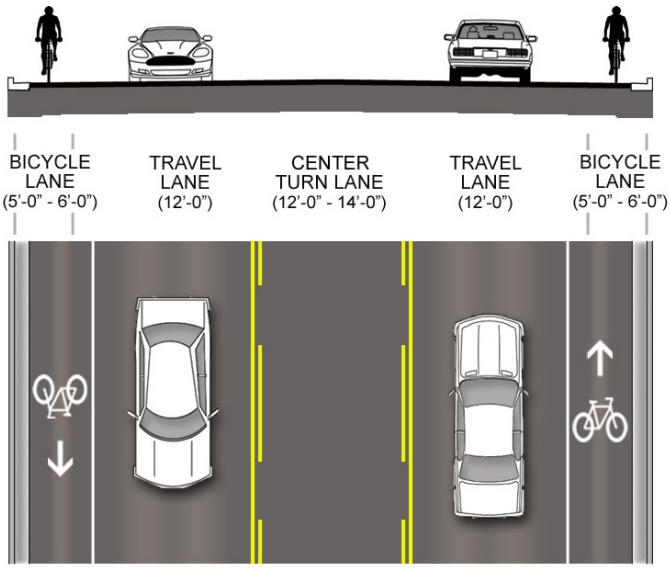


Existing Four Lane Street Plan and Section (after)

Figure 7.51.16. Bike lane road diet and restripe (four lanes to two lanes with median and bike lanes.



Existing Four Lane Street Plan and Section (before)



Existing Four Lane Street Plan and Section (after)

Figure 7.51.17 Two travel lanes, center turn lane, and bike lanes plan and section (after).

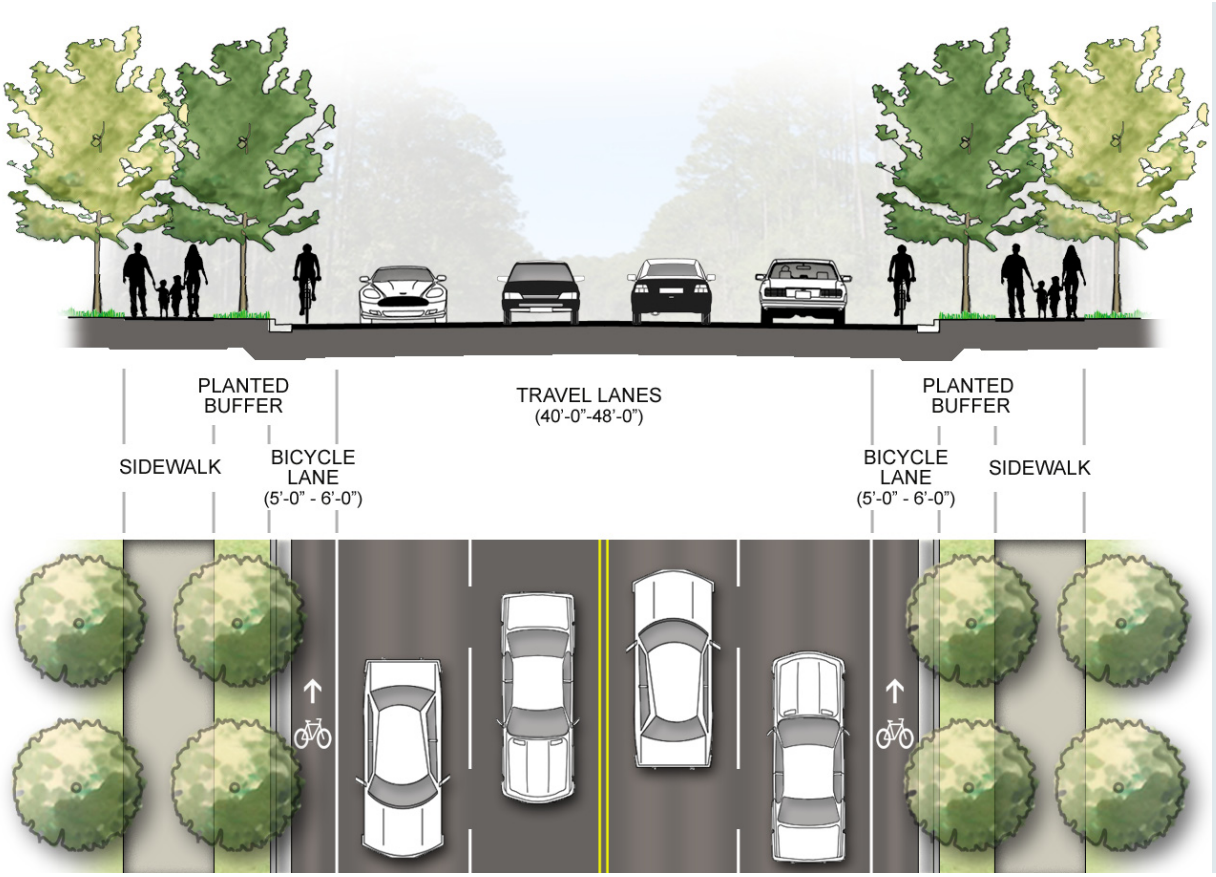


Figure 7.51.18. Four lane typical plan and section with bike lane.

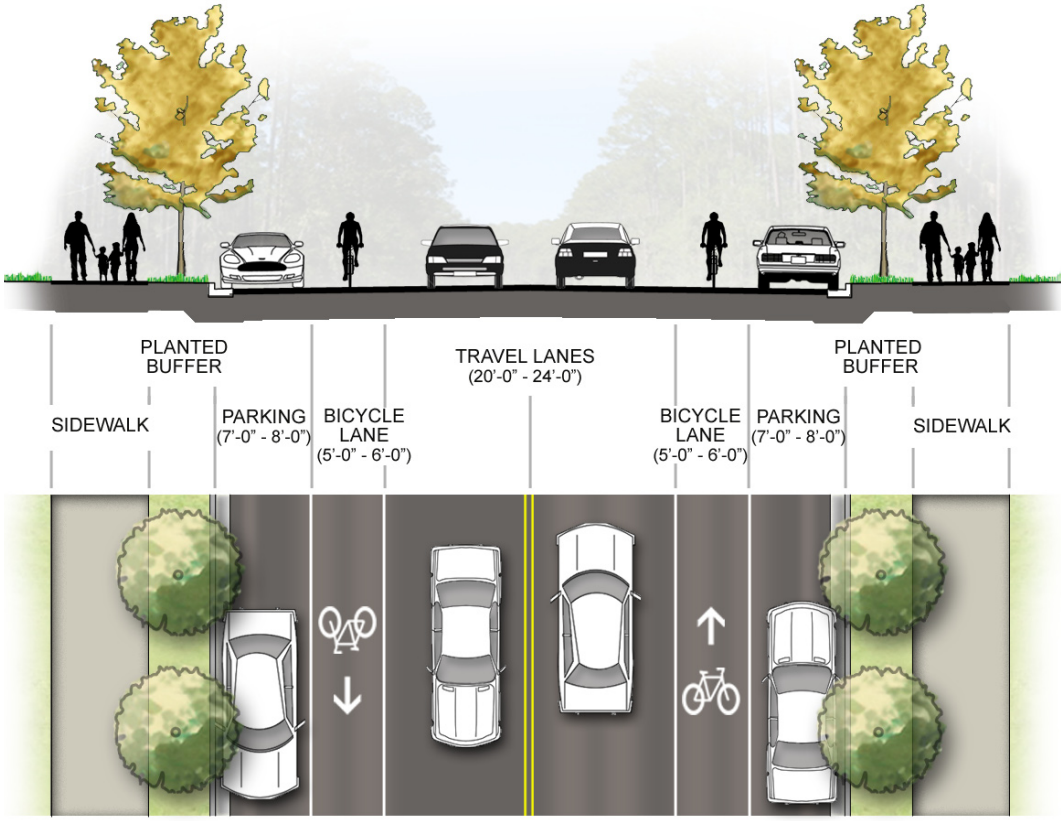


Figure 7.51.19. Two lane typical plan and section with bike lane & on street parking.

Manual to determine minimum lane width requirements.

- If the number of lanes or the lane width cannot be reduced and on-street parking exists, reexamine the need for on-street parking to accommodate bike lanes.
- Should angled parking exist, reconsider changing to parallel parking to accommodate bike lanes.

G. Bike Lane (Restripe Implementation Method)

A restripe of the roadway to incorporate bike lanes involves a reduction in the width, but not number of travel lanes (Figure 7.51.20).

Design Criteria:

- Depending on the roadway classification, narrow existing travel lanes to accommodate bicycle lanes.
- Bike lanes are a minimum of 5'-0".
- Provide pavement marking and signing on shoulders of bike lanes.
- On large traffic volume roads that have four or more lanes on streets that have a speed limit of 45 MPH or more, an off road / multi-use facility adjacent to the roadway should be utilized.
- With travel lane width reduction, reduced speeds are required.
- Consult with traffic engineer to determine if lane width reductions are feasible.
- Refer to AASHTO and the City of Arlington guidelines to determine if travel lane width is feasible without significantly affecting the safety operation of the roadway and surrounding roadways.

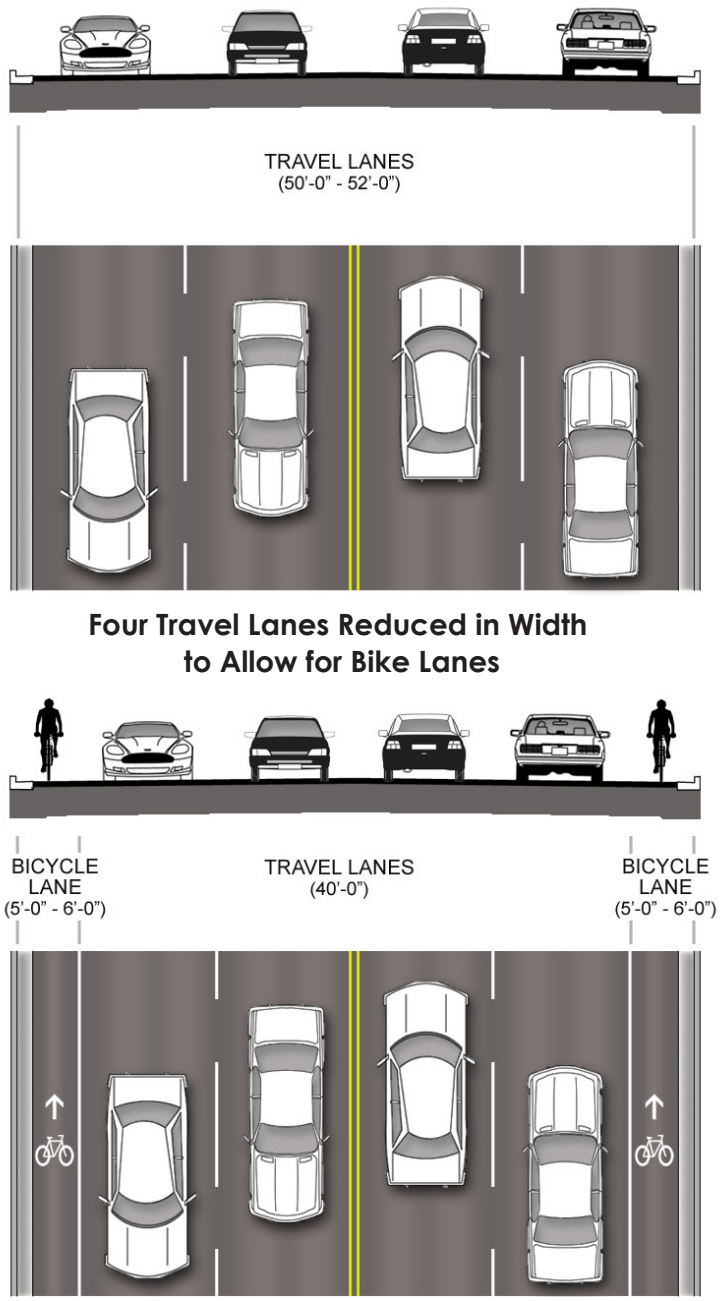


Figure 7.51.20. Bike lane restripe (narrowing travel lanes to add bike lanes)

H. Raised Bike Lanes

Raised bike lanes provide a psychological and physical separation between the bicyclists and the motorists using the street. They require a mountable curb to allow bicyclists to enter or leave the bike lane as needed for turning or passing. The mountable curb acts as a prevention for motorists entering the bike lane and provides a clear and strong, visible right-hand edge to the vehicle travel lanes. The raised bike lanes also experience less wear and tear than bike lanes at the same level as travel lanes. The raised bike lane should apply to limited urban environments. Raised bike lanes construction costs are mitigated by reduced long-term maintenance costs (Figures 7.51.21 to 7.51.23).

Design Criteria:

- Provide a mountable concrete curb or a 4:1 concrete slope left edge to the raised bike lane. The concrete edge shall be beveled at a maximum of 4:1 with a transition width of 1'-0" (3-inch rise in a 1-foot run).
- Raised bike lanes can be constructed of either concrete or asphalt.
- Minimum width of the raised bike lane is 6-foot.
- Drop the raised bike lane at intersections and handicapped ramps to meet ADA requirements.
- Provide signing and markings to comply with MUTCD and AASHTO standards.
- Provide 6-inch white lane markings to denote edge of raised bike lane.
- Provide color pavement markings at intersections to identify beginning and ending of raised bike lanes.
- Special attention needs to be provided to storm drainage measures.

Figure 7.51.21. Example of storm drainage with raised bike lane.

Figure 7.51.22. Example of transition between bike lane and raised bike lane along four lane street.

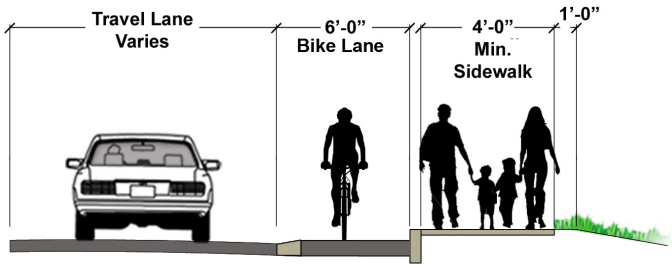


Figure 7.51.23. Section of raised bike lane.

I. Bike Boulevard

A bike boulevard is a shared roadway which has been optimized for bicycle traffic. It is designed to give priority to bicyclists and encourage regular use of bicycles by both the experienced and the novice, including children. They allow experienced bicyclists to enjoy lower traffic without significant increases in trip time, while less experienced bicyclists can use them as a "training ground" to help them move to other shared roadway (Figure 7.51.24).

Design Criteria:

- Access to private property, emergency services access, and impact on traffic patterns needs to be addressed prior to implementation.
- Bike boulevards should be considered when motor vehicle volumes are less than 3,000 – 4,000 vehicles per day; 1,500 vehicle trips per day are preferred.
- Vehicle speed should be 25 mph or less. The ideal speed is 15 - 20 mph. In general, a speed differential between motorists and cyclists of no more than 15 mph is desirable.
- Provide bike boulevard signage and pavement markings to serve as wayfinding devices and reinforce that bicyclists are on the preferred route.
- Install traffic calming devices such as chokers and bulbouts at corners to limit motor vehicles from entering bicycle boulevard and encroach traffic calming.
- Remove parking at intersections to ensure adequate sight distance.
- Provide large pavement markings (30" L x 60" w) at each intersection location to indicate and reinforce the message to motorists they are on a street prioritized for cyclists.
- Refer to MUTCD and AASHTO devices for pavement signing and markings, intersection treatment, and general application of pavement wording and symbols for on-road bicycle facilities.
- Install stop signs or signals on intersecting streets so bicyclists can ride free with few interruptions.
- Refer to Figure 7.51.26 for an appropriate mix of design elements for a bicycle boulevard development along a particular corridor.
- Refer to http://www.ibpi.usp.pdx.edu/media/BicycleBoulevardGuidebook.pdf
- Provide protection on bike boulevards where high volume arterials cross with signals or medians refuge improvements.
- Failure to provide arterial crossing improvements can result in unsafe conditions for bicyclists.
- If bike boulevards are improperly implemented, they can cause traffic diversions and congestion on other streets.

Figure 7.51.24. Example of bike boulevard

Bicycle Boulevard Lane Configuration

Bicycle boulevard alignments are selected primarily based on connectivity that can be provided to key destinations, the operational characteristics of the roadway corridor, or what may be achieved with their introduction (Figure 7.51.25).

Mix and match design elements to (Figure 7.51.25):

- Reduce or maintain low motor vehicle volumes.
- Reduce or maintain low motor vehicle speeds.
- Create a logical, direct, and continuous route.
- Create access to desired destinations.
- Create comfortable and safe intersection crossings.
- Reduce bicyclist delay.

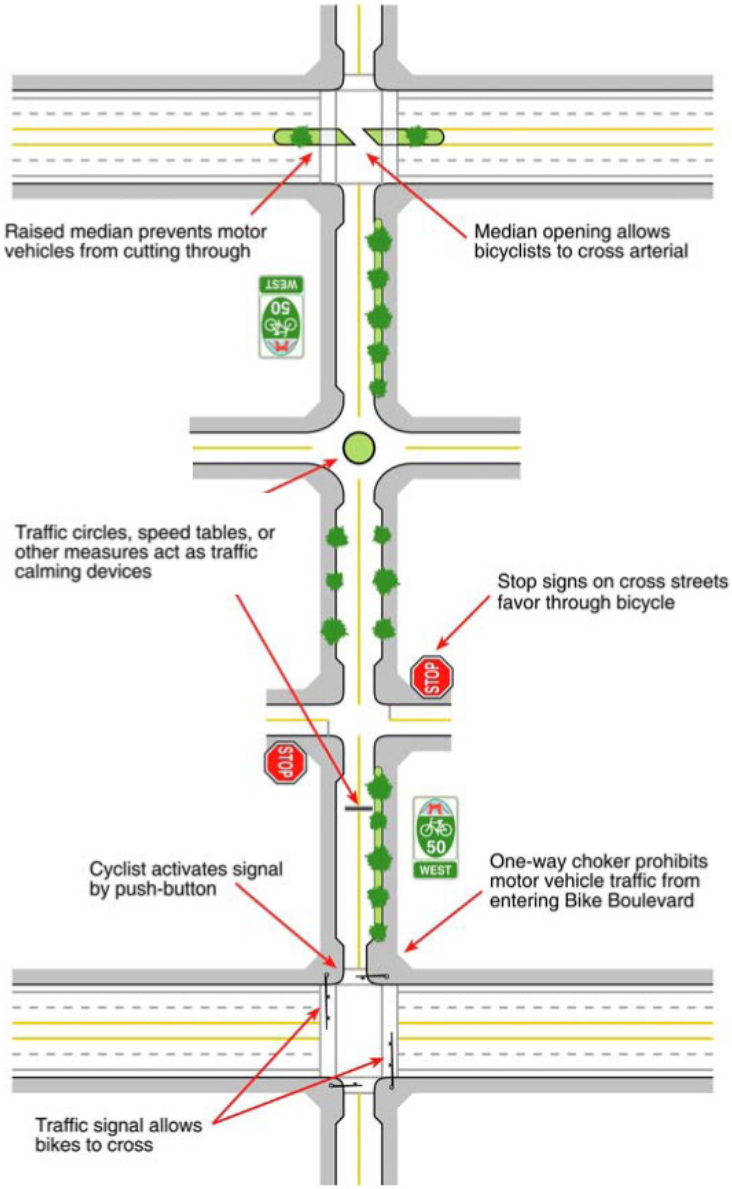


Figure 7.51.25. Typical bicycle boulevard lane configuration.

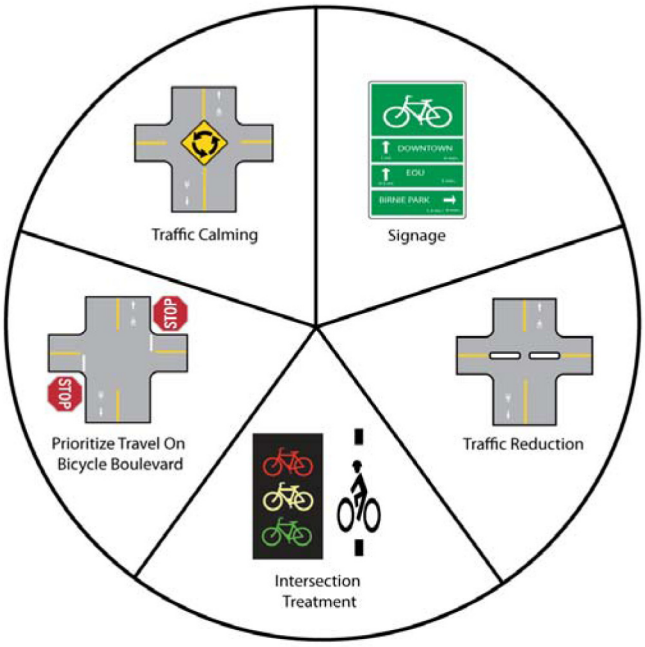


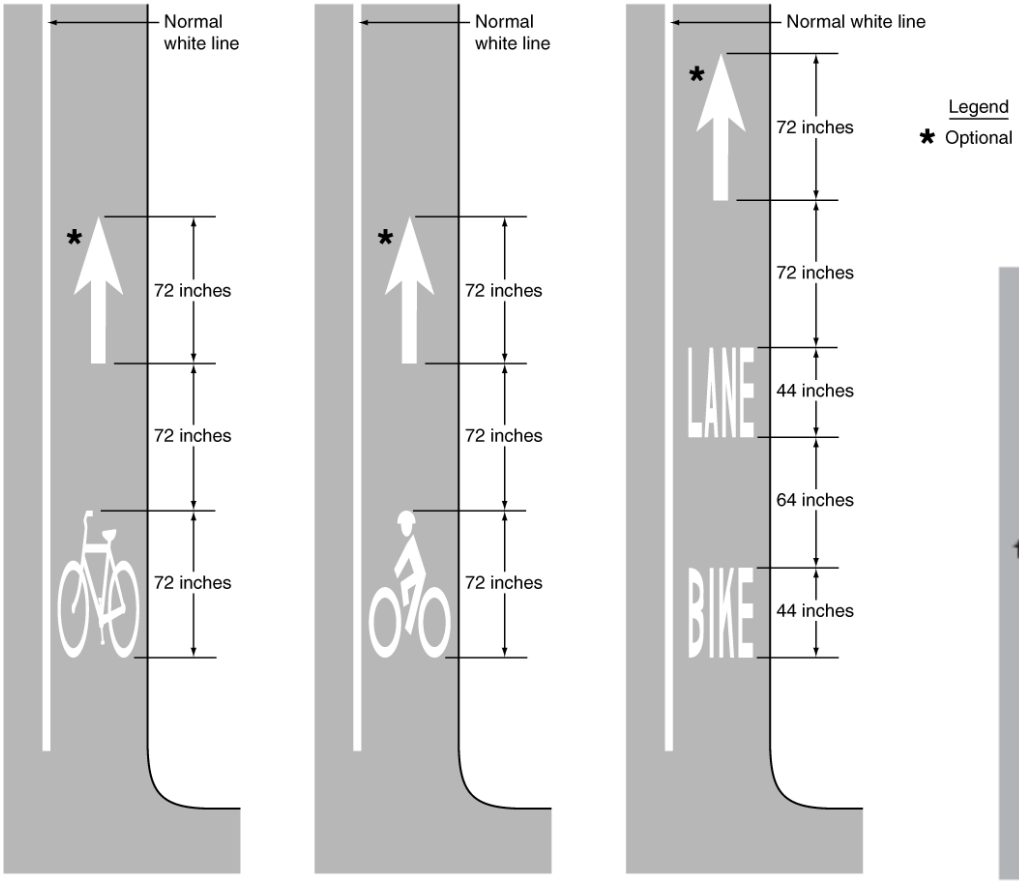
Figure 7.51.26. Design elements for bicycle boulevard.

J. Pavement Markings

The MUTCD provides guidance for lane delineations, intersection treatment, and general application of pavement wording and symbols for on-road bicycle facilities and off-road multi-use pathways. Refer to http://mutcd.fhwa.dot.gov/pdfs/millennium/12.18.00/9.pdf in addition to the standards presented in MUTCD. The following pavement markings may be considered (Figure 7.51.28).

Figure 7.51.27. Example of bike lane marking

Figure 7.51.29. Example of shared lane marking



A - Bike Symbol B - Helmeted Bicyclist Symbol C - Word Legends

Figure 7.51.28.Examples of pavement markings.

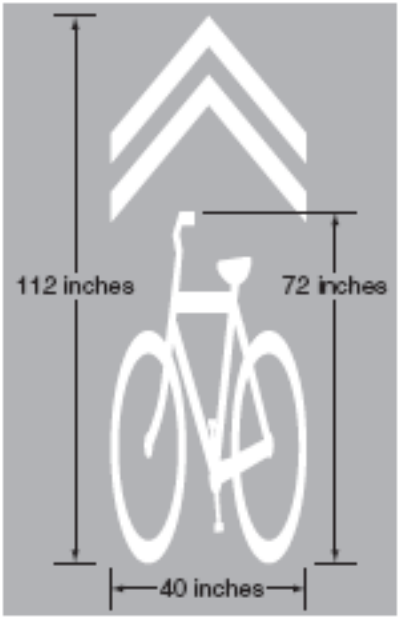


Figure 7.51.30.Shared Lane Marking

K. Bicycle Friendly Drainage Grates

Drainage grates are often located in the bike lane and can present a safety concern for bicyclists if the grates are improperly installed, clogged, or if the openings are too large. With proper planning during the design and street construction, these problems can be eliminated and a safe bicycle environment can be achieved (Figures 7.51.31 through 7.51.33).

Design Criteria:

- Bicycle-friendly drainage grates should be installed in all new roadway projects and problem grates should be identified and replaced in existing roadways where bicycle facilities are proposed.
- Drainage grates should be flush with adjacent pavement.
- Curb opening inlets should be considered in new street construction to minimize potential obstructions.
- Grates should be replaced with bicycle-safe, hydraulically efficient versions.

Figure 7.51.31. Bicycle friendly drainage grate.

Figure 7.51.32. Dangerous drainage grate conditions

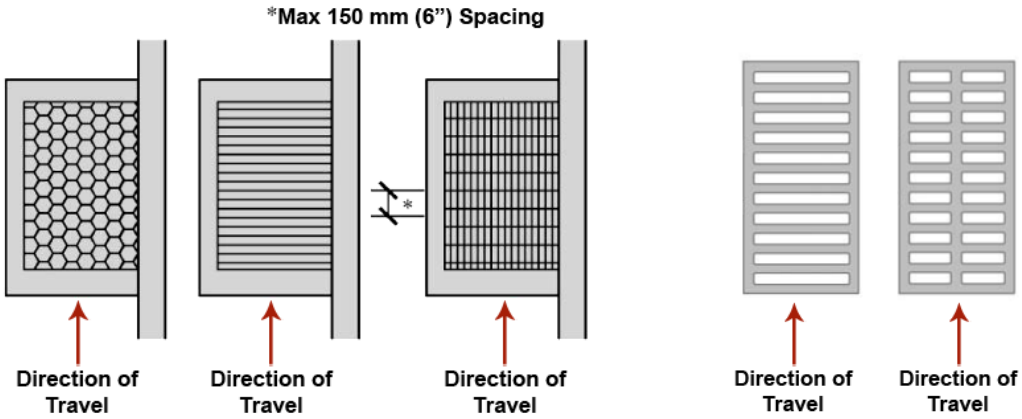


Figure 7.51.33. Bicycle friendly drainage grate designs.

7.5.2 Bicycle Intersection Crossing Facilities

The design of bike lanes at intersections is complicated by the need to accommodate numerous turning movements by both motor vehicles and bicyclists, often with limited available space. Intersections represent one of the primary conflict areas between motorists and bicyclists. Generally, the larger the intersection, the more difficult it is to cross safely.

The recommended designs are based on the assumption that motorists making right turns should make their turn from as close to the right-hand curb as practical; bicyclists going straight ahead shall be to the left of right turning traffic; and bicyclists turning left should turn from a left turn lane or as close to the centerline of the left side lane as practical. Proper pavement markings and signalization can help prevent future motorist and bicyclist accidents (Figure 7.52.1).

Figures 7.52.2 through 7.52.10 are typical occurrences. Refer to AASHTO Design Guidelines for further design requirements and guidance.

A. Bike lane at an uncontrolled intersection:

- Bike lane stripes typically are not extended through a pedestrian crosswalk or any street intersection (with the exception of dashed lines, which is optional through some intersections).

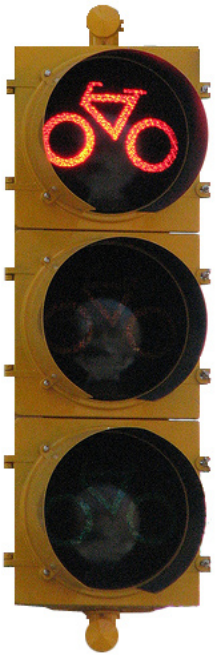


Figure 7.52.1. Bicycle traffic signal can be used in combination with other traffic signals.

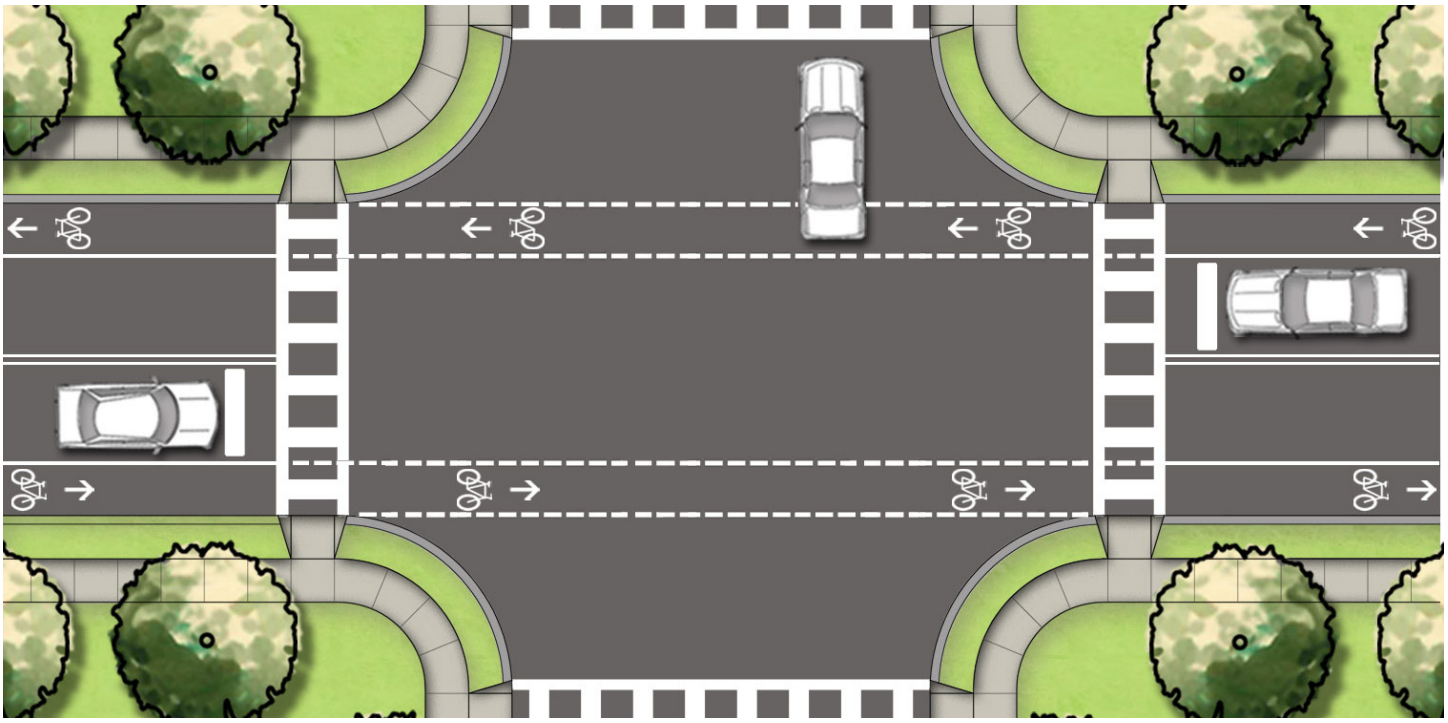


Figure 7.52.2. Example of bike lane markings at an uncontrolled intersection.

B. Bike lane at a controlled intersection:

- A bike lane stripe should end at the stop line or crosswalk with right turning traffic (Figure 7.52.3).
- Bike lanes should not be striped through controlled intersections, except with complex intersections where dash lines are acceptable (optional) (Figure 7.52.8).

C. Bike lane at intersection with right turn lane:

- Bicyclists going straight ahead shall be positioned to the left of right turning traffic, and bicycle lanes should not be marked on streets with multiple right turn lanes.
- Refer to Figure 7.52.3 from the AASHTO Guide for the Development of Bicycle Facilities, 3rd Edition for bike lane design, approaching right-turn only lane alternatives.
- Refer to Figure 7.52.3 to 7.52.9 for typical bike lane signing and marking associated with right turn lane movements.

D. Bike lane at intersection with left turn lane:

- When bike lanes are marked for left turn movements, the bike lane stripe should be to the right of left turning vehicles. (See Figure 7.52.8).

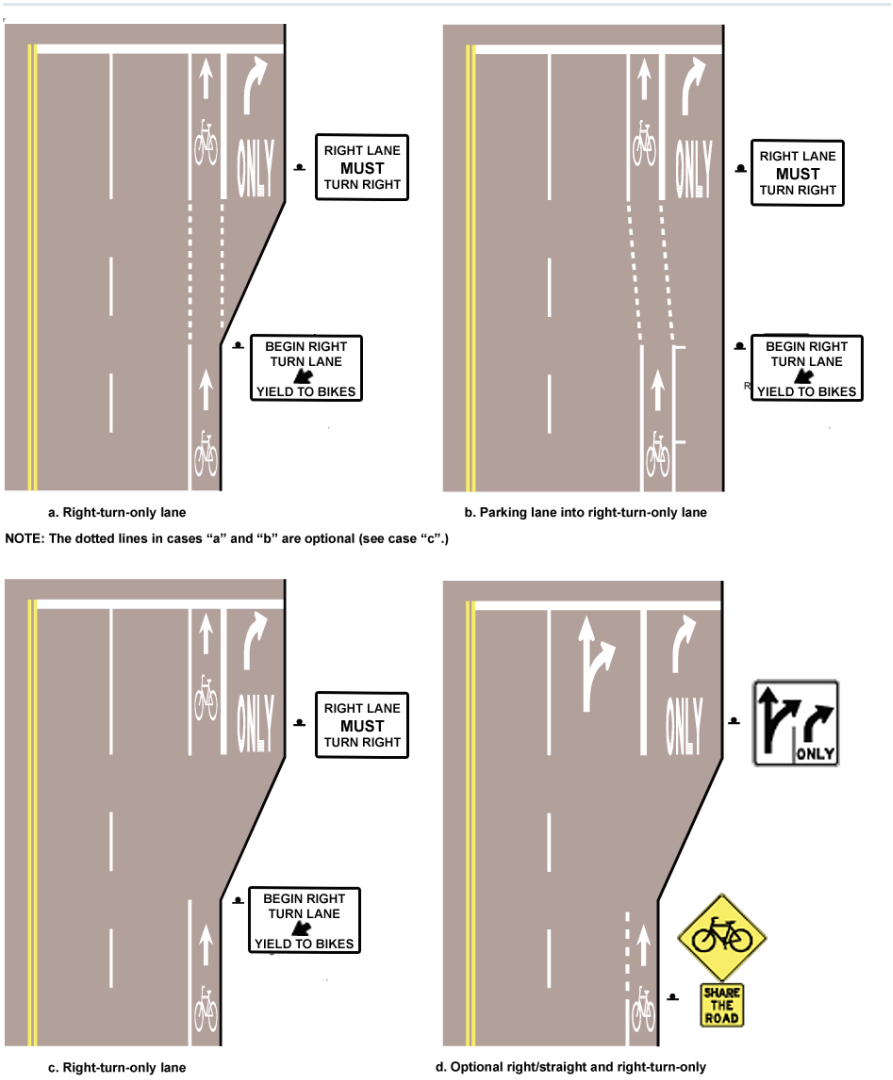


Figure 7.52.3. Bike lanes approaching right turn only lanes.

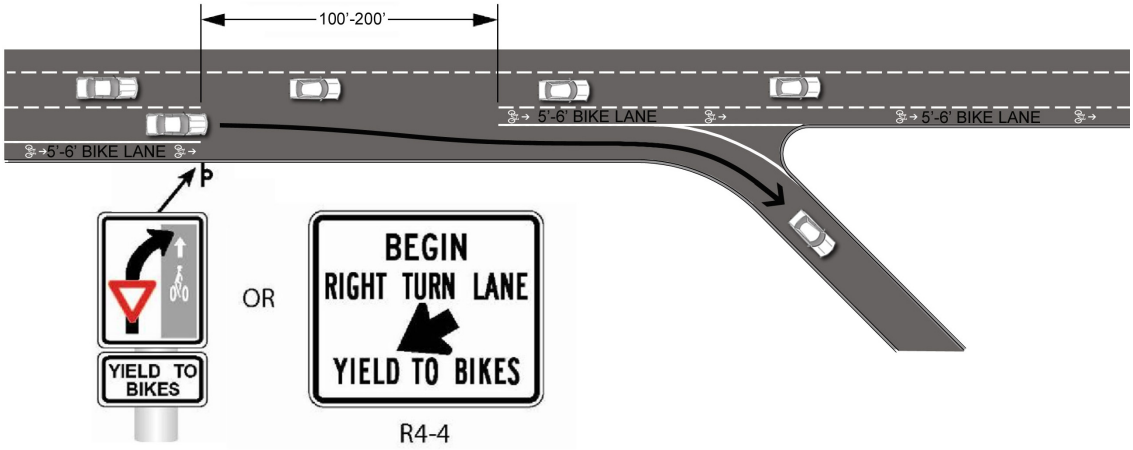


Figure 7.52.4. Typical signing and marking plan for a bicycle lane through a freeway ramp.

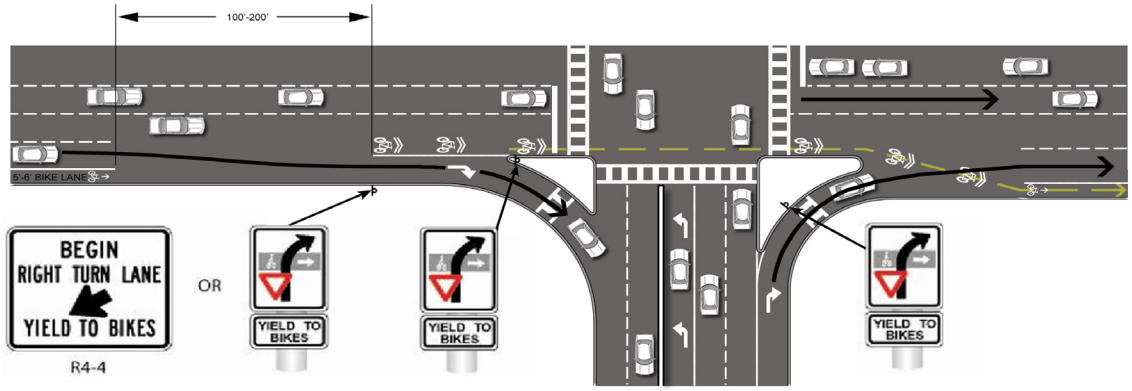


Figure 7.52.5. Typical signing and marking plan for a shared travel lane through a right-turn island intersection with exclusive right-turn movement.

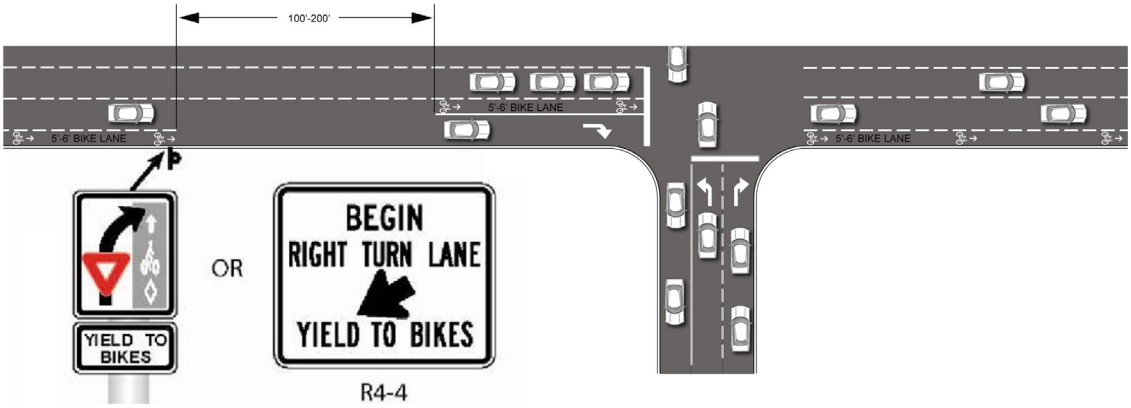


Figure 7.52.6. Typical signing and marking plan for a bicycle lane adjacent to right-turn only lane.

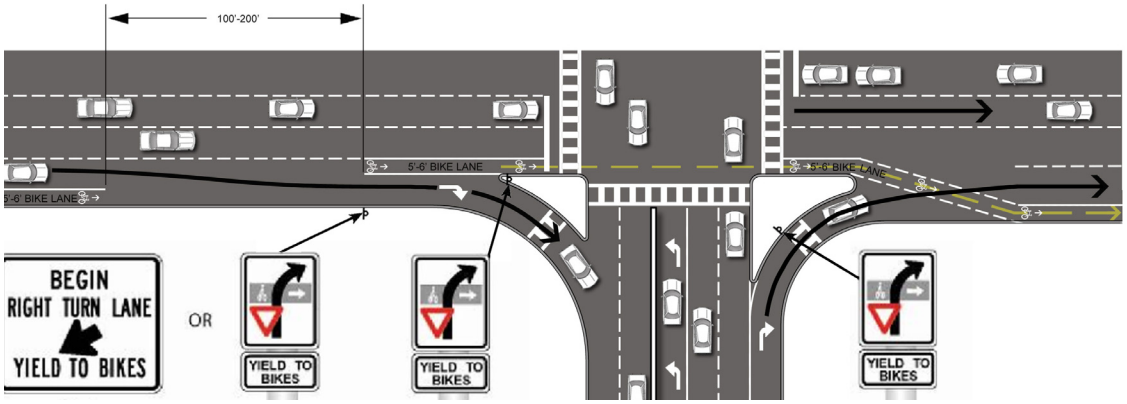


Figure 7.52.7. Typical signing and marking plan for a bicycle lane through a right-turn island intersection with free right-turn lane.

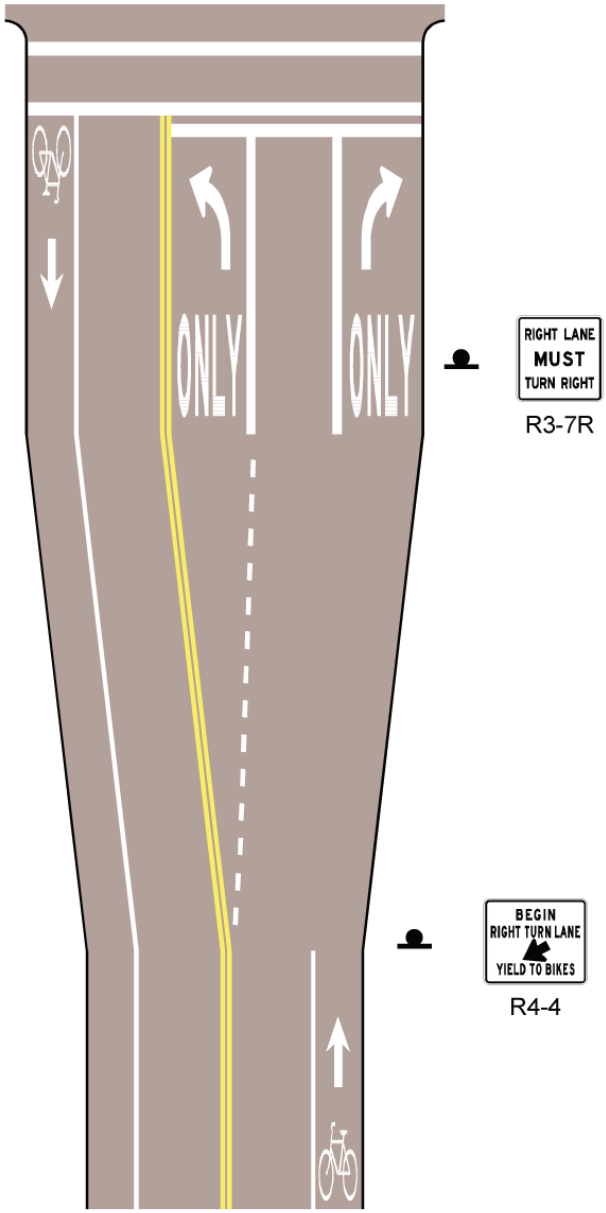


Figure 7.52.9. Typical bike lane approaching an intersection with two directions of travel and throat widening.

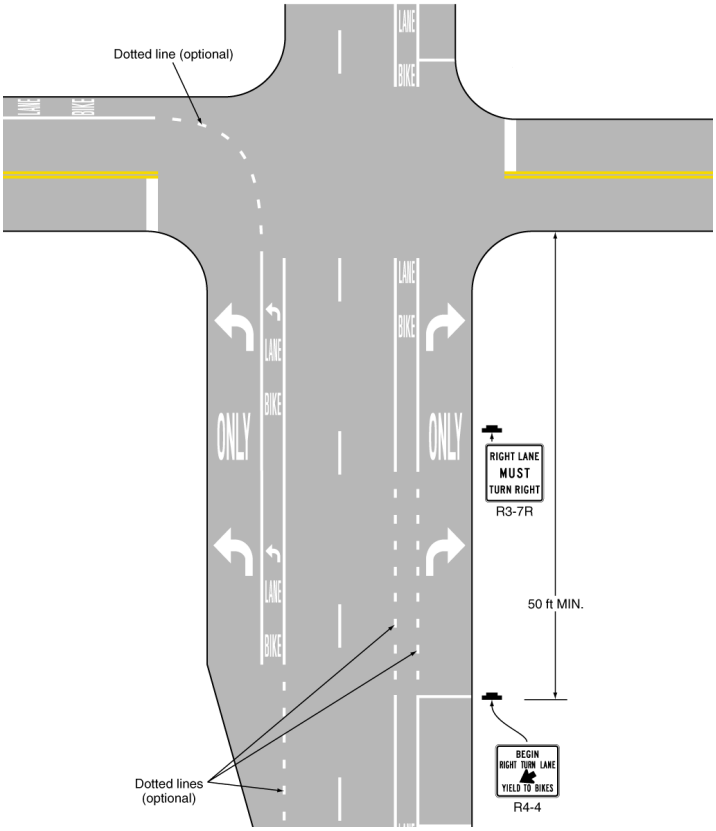


Figure 7.52.8. Examples of intersection signing and pavement markings for one-way travel direction and designated bicycle lane with left, heavy turn volumes.

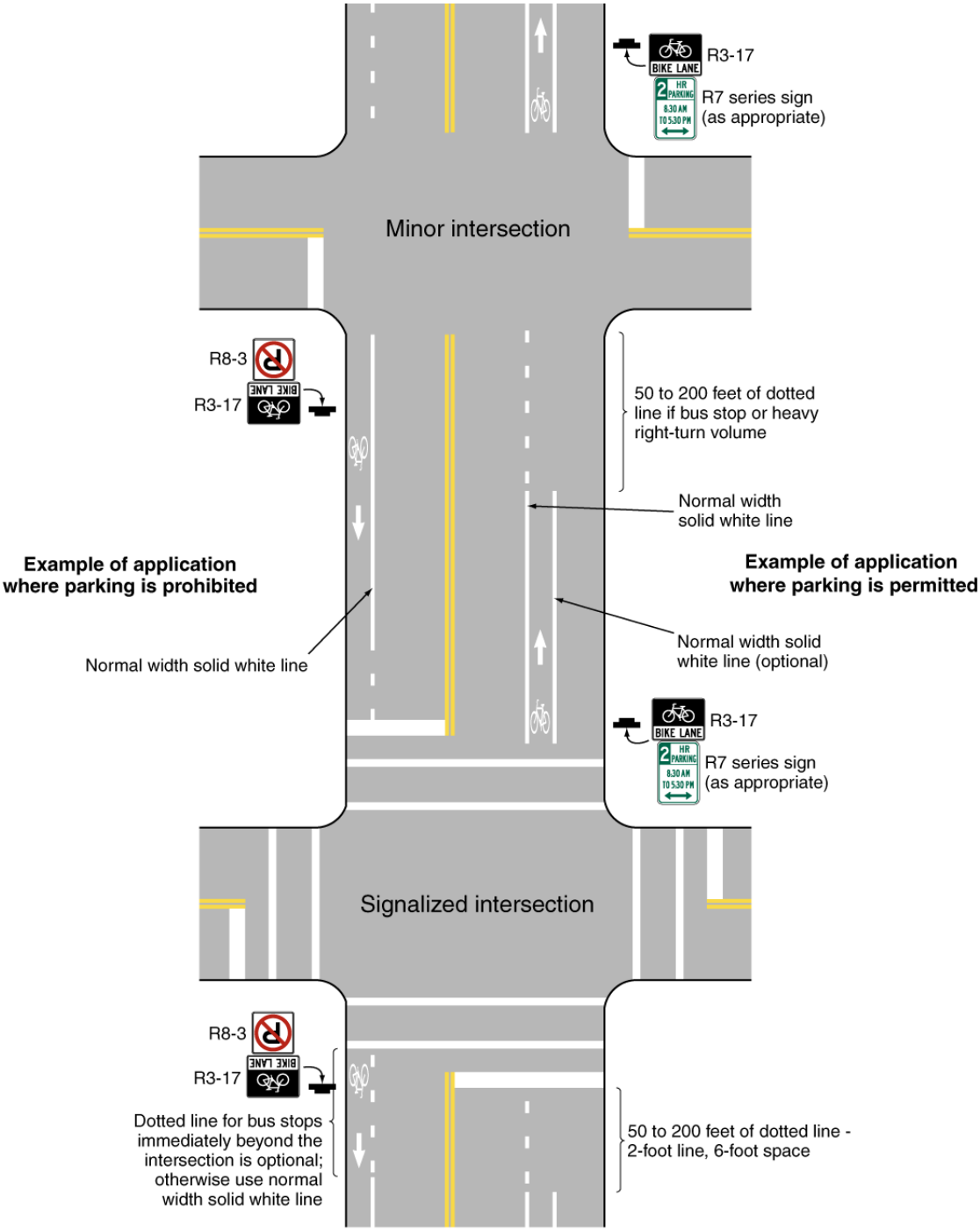


Figure 7.52.10. Example of typical signing and pavement markings for bicycle lanes on a two-way street.

E. Bike lane at modern roundabout: According to the AASHTO Guide for the Development of Bicycle Facilities, a bike lane should be discontinued a minimum of 35 feet to a maximum of 65 feet prior to a traffic circle or roundabout. Bike lane markings are not to be marked on the circular roadway (Figures 7.52.11 and 7.52.12).

Design Criteria:

- Allow bikes to flow with traffic without marked bike lane or allow bike onto pedestrian area for a short distance.
- Provide signing and pavement markings in accordance with MUTCD and AASHTO standards.

Figure 7.52.11. Aerial view of roundabout with multi-use path crossing.

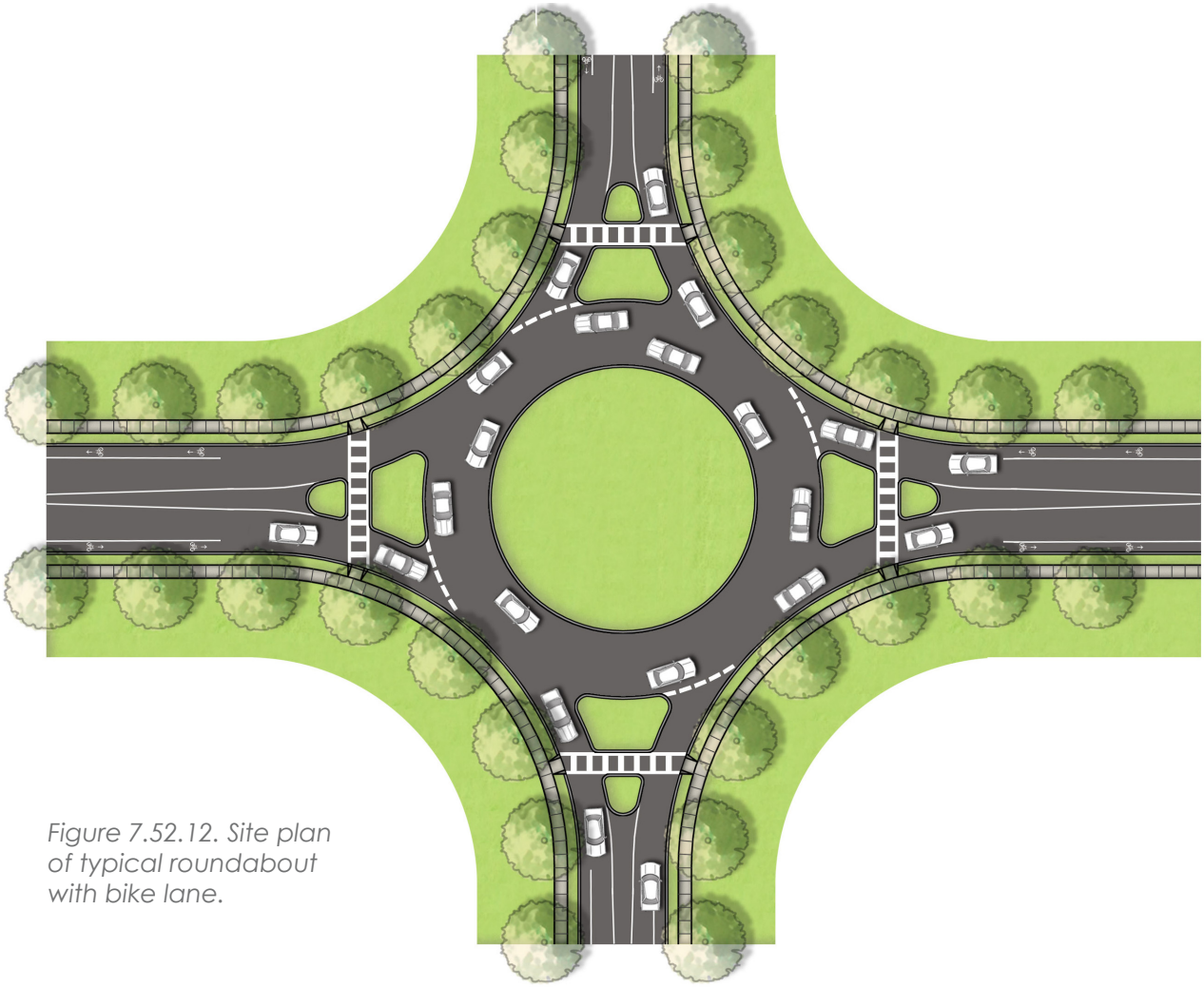


Figure 7.52.12. Site plan of typical roundabout with bike lane.

F. Bike lane at high speed interchange:

Design Criteria:

- Delineate a bike lane through the entire interchange area across the turning roadway intersections (Figure 7.52.13).
- If bicyclists are allowed to merge or maneuver, it would be recommended to discontinue the pavement markings through the crossing area (Figure 7.52.14).
- See page 63 of the AASHTO Guide for the Development of Bicycle Facilities, for additional information regarding pavement marking and signage with bike lanes intersecting high speed interchanges.

Figure 7.52.13. Bicycle crossing at interchange ramp.

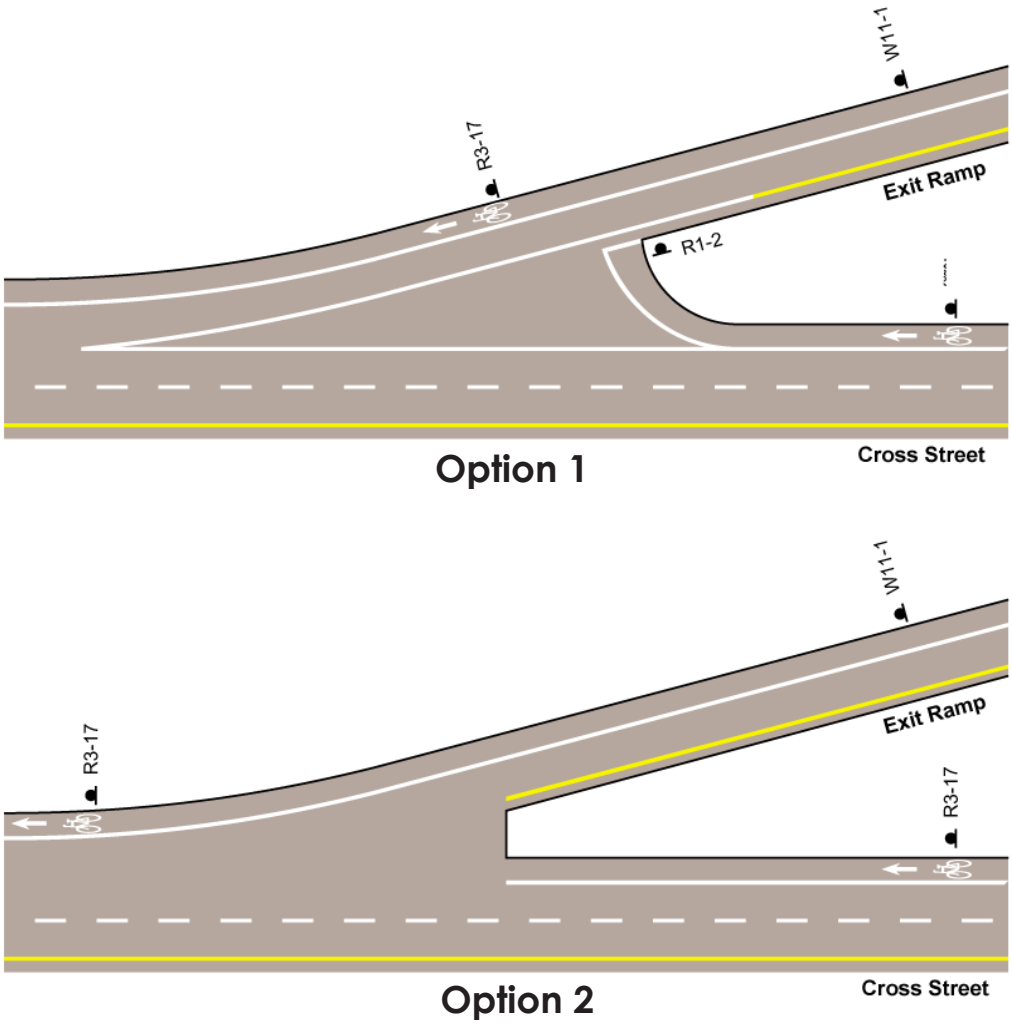


Figure 7.52.14. Bicycle crossing at interchange ramp

G. Bicycle-Activated Detector Loops

Intersections with high traffic volumes and/or high-speed motor vehicles are often very difficult for bicyclists to safely cross. Placing bike activation on these streets gives bicyclists preference on demand without causing undue delay to motorists. On main street intersections, the activation can prolong the green phase and extend the time needed for bicyclists to clear the intersection.

Design Criteria:

- Detector loops should be installed within the roadway to detect bicycles with metal rims.
- Detector loops should be installed at busy signalized intersections to allow safe crossing of bicyclists.
- Provide detector loops that do not require a push button to activate the system.
- Provide pavement markings to instruct cyclists on how to trip detector loops (Figures 7.52.15 through 7.52.18).

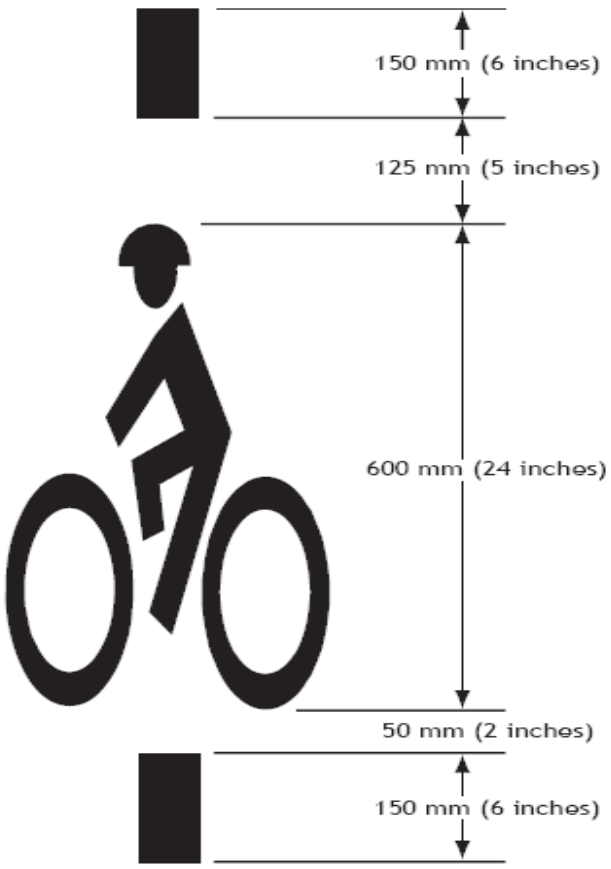
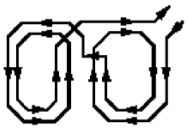


Figure 7.52.17 Pavement marking used to help bicyclists locate loop detectors at intersections.

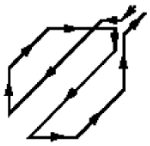
Figure 7.52.15. Pavement marking used to help bicyclists locate loop detectors at intersections.

Figure 7.52.16. Loop detector signage can guide bicyclists on how to use detector loop.

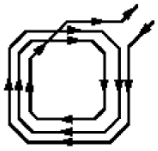
Quadruple Loop
- Detects most strongly in center
- Sharp cut-off sensitivity
- Used in bike lanes



Diagonal Quadruple Loop
- Sensitive over whole area
- Sharp cut-off sensitivity
- Used in shared lanes



Standard Loop
- Detects most strongly over wires
- Gradual cut-off
- Used for advanced detection



From: *Implementing Bicycle Improvements at the Local Level*, FHWA, 1998, p. 70.

Figure 7.52.18. Recommended detector loop patterns sensitive enough to detect bicycles.

H. Bike Box/Advance Stop Line

At busy intersections, bicyclists often have difficulty crossing streets. Installing a bike box/advance stop line allows bicyclists to get to the front of traffic and proceed first when the traffic signal changes to green. The bike box allows bicyclists to be more visible to motorists and eliminates conflicts with right turn movement traffic. Bike boxes have been used effectively in Cambridge, MA; Eugene, OR; Vancouver, BC; and in European countries.

Design Criteria:

- Bike boxes are located at intersections between pedestrian crosswalks and stop lines.
- Bike boxes are located at a right angle extension to a bike lane at the head of an intersection and allow increased motorist and bicyclist visibility.
- The "box" should have a contrasting pavement color and/or be clearly marked. Preferred color is blue or green (Figure 7.52. 19).
- Bike boxes can range from 6 feet to 12 feet in depth. The preferred depth is 12 feet.
- Design the bike box wide enough to encompass the entire outer lane and the adjacent bike lane if present.
- Right vehicle turns on red are prohibited (except bikes).
- Do not allow the bike box to encroach or extend into the crosswalk.
- Provide signage and pavement marking per Figure 7.52.20.
- Bike boxes are effective for use in high volumes of traffic and with high turning movements.
- Bike boxes are not currently included in MUTCD standards.
- Bike boxes can be combined with bicycle signal.
- Bike boxes at intersections with high volumes of right turns may not be compatible.

Figure 7.52.19 . Example of bike boxes filled in color to designate space for bicyclists. Painting or colored additives applied to the pavement are preferred over thermoplastic striping to reduce slick surface.

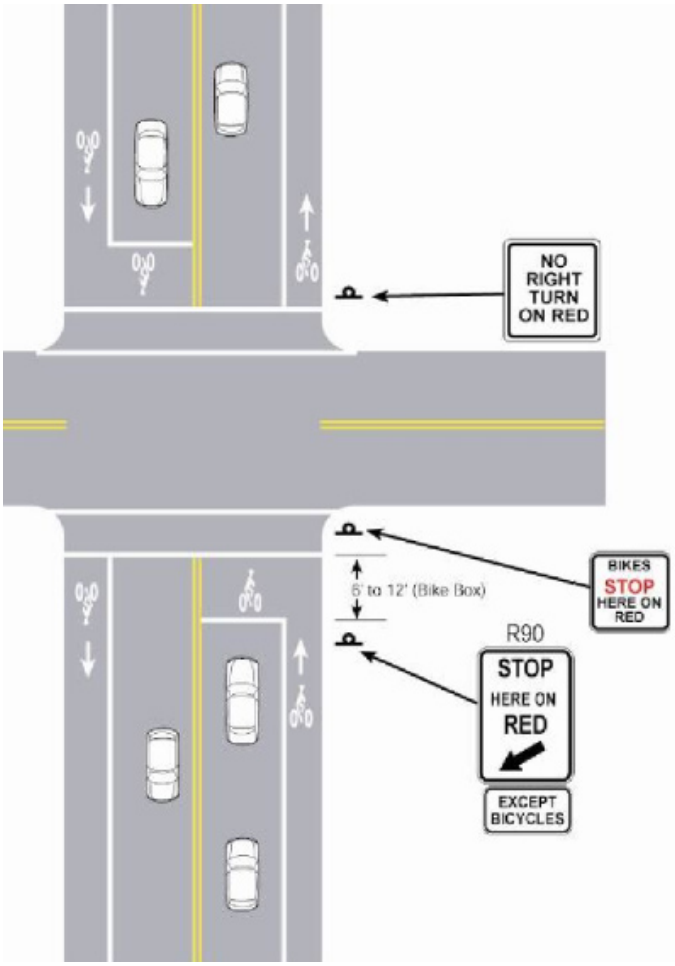


Figure 7.52.20. Plan view of bicycle box configuration

I. Advanced Stop Bars

Typically installed at busy intersections, advance stop bars allow for safe movement of bicyclists through an intersection. They are normally located several feet ahead of the motor vehicle stop bar to allow visibility by motorists. The advance stop bar also allows bicyclists to cross the street at a faster pace when the traffic signal changes to green (Figure 7.52.21).

Figure 7.52.21. Example of advanced stop bars.

Design Criteria:

- The advanced stop bar should be placed 4 feet in advance of any marked crosswalks.
- The stop bar should be painted white and is 24 inches wide.
- The stop bar should be located at signalized intersections and at multi-way stops.
- See Arlington Design Manual Criteria and MUTCD for additional information regarding Advance Stop Bar requirement.

J. Bicycle Facilities at Railroad Crossings

Railroad crossings are often hazardous to wheeled devises such as bicyclists and wheelchairs. Railroad crossings have flangeway gaps that allow passage of the train, but also have the potential to catch bicycle and wheelchair tires. In addition to the fixed rails and ties, other loose material can often create tripping hazards.

Where possible, bicycle crossings at railroads should be minimized and the crossing location should have a direct and clear view of oncoming trains and bicyclists. Warning signs and pavement markings must be installed in accordance with MUTCD standards.

Design Criteria:

- Filler should be made of compressible material to enhance bike operation and prevent pedestrian hazards (Figure 7.52.22).
- At the crossing of the train tracks, install a rubber surface that will not buckle, expand, or contract around railroad flangeways to reduce changes in grade and maintenance problems (Figure 7.52.23).

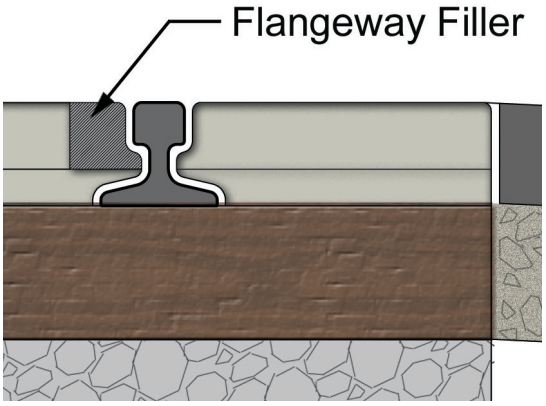


Figure 7.52.22. The flangeway filler eliminates the gap between the rail and pavement surface. It helps to provide a safe path of travel for pedestrians and bicyclists crossing the railroad tracks. The filler consists of a rubber insert that deflects downward with the weight of a train and does not affect railway function.

- The most desirable crossing is perpendicular (or as close to 90 degrees as possible) to the rails to minimize the potential for a bicyclist's front wheel becoming trapped in the flangeway (Figures 7.53.24).
- Pedestrian railroad crossings should have a clear view of an on-coming train several hundred feet away to give advance warning to users (Figure 7.53.25).
- If the crossing angle is less than 45 degrees, additional paved area on the outside lane, shoulder, or bike lane shall be provided to improve the angle of approach and allow bicyclist to cross as close to 90 degrees as possible (Figures 7.52.26 through 7.52.28).
- The rail elevation and bike path approach should be the same. Raise or lower the approach to the track to be level with the top of the rail and create a flat surface area to cross railroad tracks (Figure 7.52.29).
- Warning signage and pavement markings should be installed in accordance with MUTCD standards, providing railroad crossing information in multiple formats, including signs, flashing lights, and audible sounds. The MUTCD requires railroad crossing signs whenever railroad tracks intersect the street.
- The material and pavement should be free from gravel or any loose material that could potentially become a hazard or cause accidental tripping or crashing.
- Detectable warnings should be installed, similar to a transit platform, when crossing the railroad.
- Regular maintenance shall be conducted to ensure that a clear view of trains is achieved and the pavement is free from cracks and debris.
- Channelization of pedestrians at designated crossings should be considered.

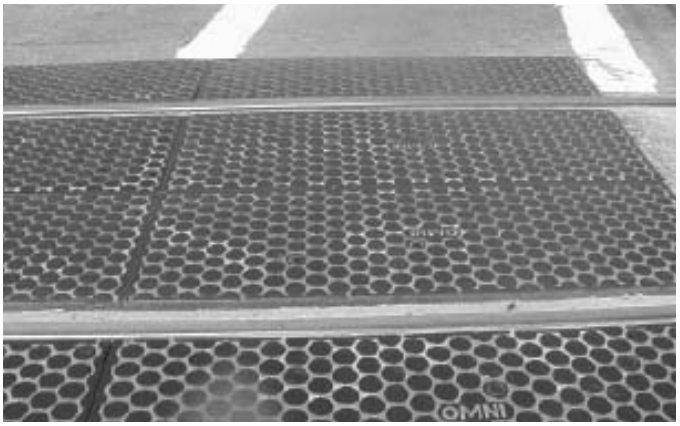


Figure 7.52.23. Example of a rubber surface around the railroad flangeways helps provide a safe level crossing surface and prevents other maintenance problems.

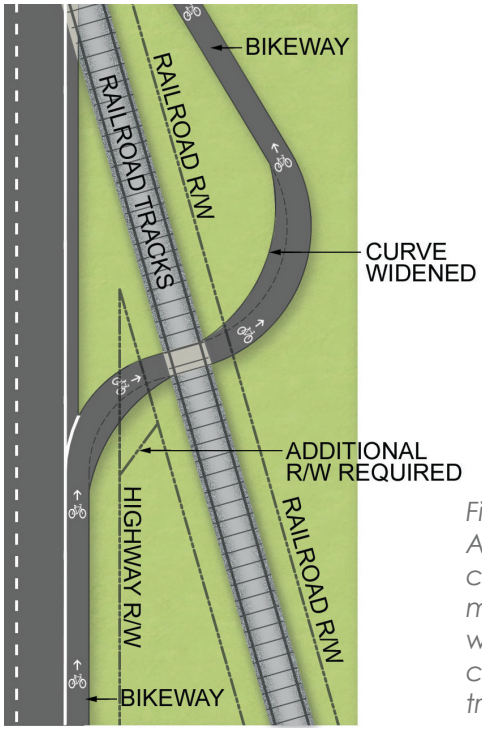


Figure 7.52.24. A 90 degree crossing is the most desirable when bikeways cross railroad tracks.

Figure 7.52.25. Provide clear visibility at railroad crossing.

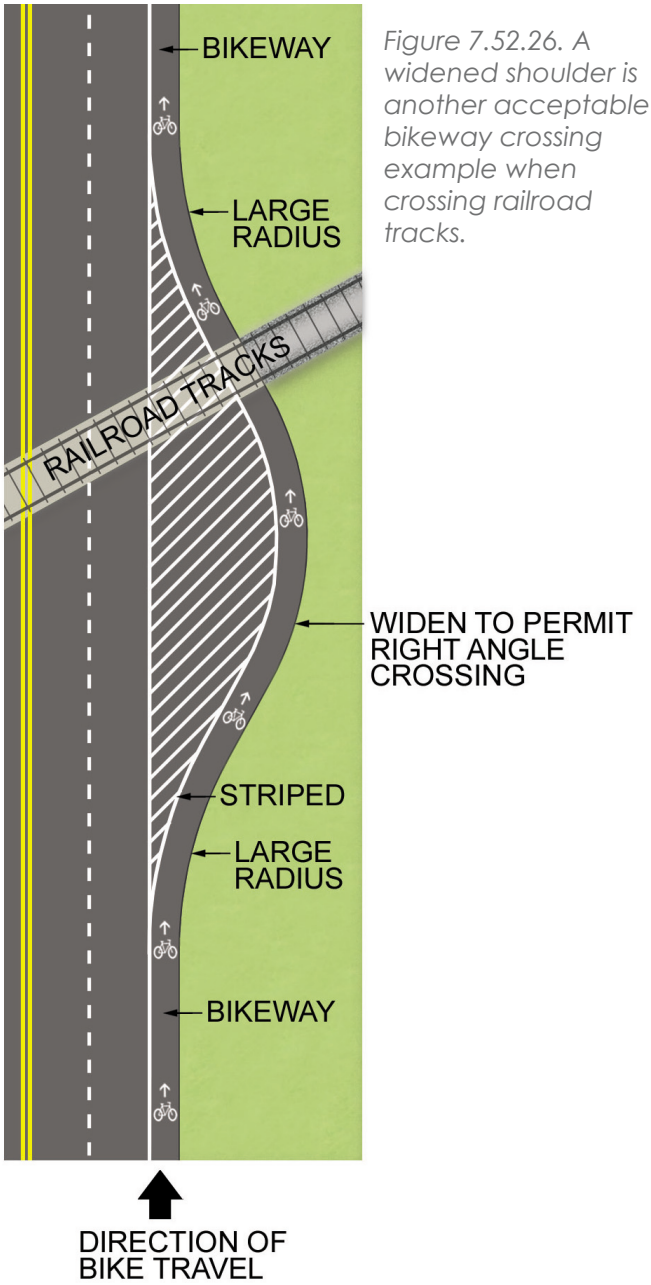


Figure 7.52.26. A widened shoulder is another acceptable bikeway crossing example when crossing railroad tracks.

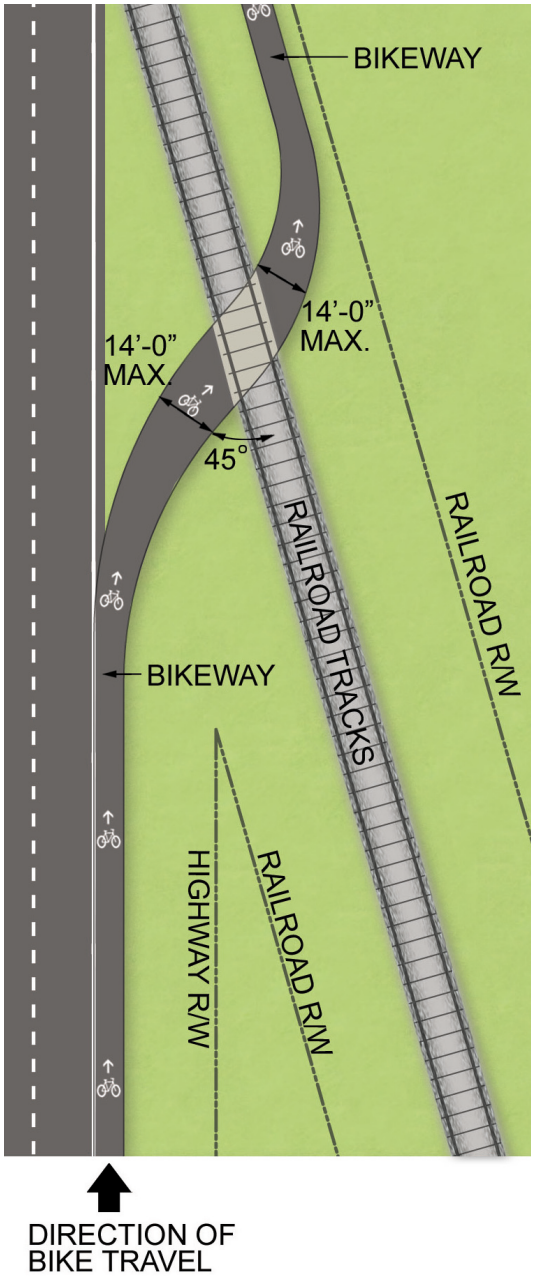


Figure 7.52.27. A 45 degree bikeway crossing is acceptable when crossing railroad tracks.

Figure 7.52.28 . Avoid crossing railroad tracks at less than 45 degree angle.

Figure 7.52.29. Raise the path approach to the track level to create a flat surface to cross the rail road track.

K. Bicycle Refuge Islands

Refuge islands should be used when high volumes of roadway traffic and/or speeds create unacceptable conditions for path users or when roadway widths are excessive, given the available crossing time. Refuge islands are used by a number of people who cross a intersection more slowly such as elderly, school children, and people with disabilities.

Refuge areas should be large enough to accommodate large groups of pedestrians and bicyclists. Adequate space should be provided so that bicyclists do not feel threatened by passing motorists while waiting to finish the intersection crossing. (Figure 7.52.30) Refer to pedestrian facilities section for more information regarding median refuge islands.

Design Criteria:

- Minimum width of median refuge island for bicyclists is 8 feet.
- Provide pavement striping and signage in accordance to City of Arlington Design Criteria Manual, AASHTO, and MUTCD design standards.
- Refer to 8.13 Appendix, City of Arlington's Design Criteria Manual for design specification for creating refuge areas.
- Provide low-level landscape material in medians to maintain motorists and bicyclists sight visibility.
- Provide adequate roadway lighting.

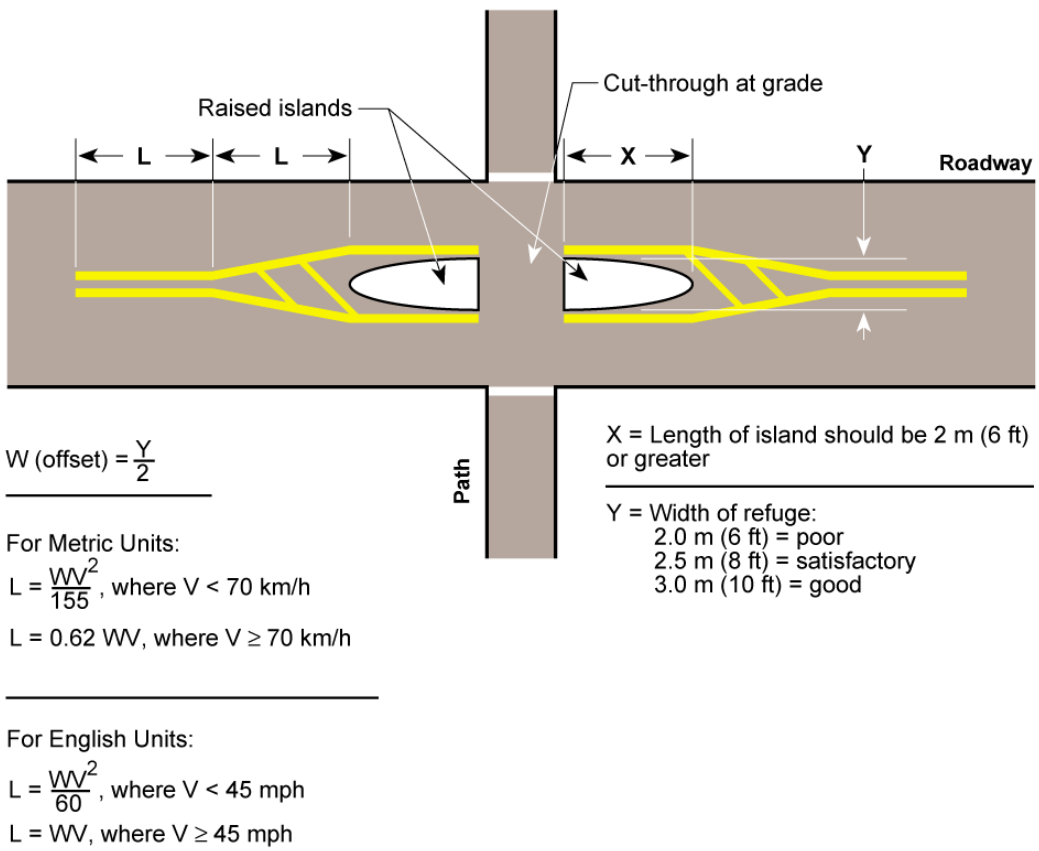


Figure 7.52.30. Typical detail for refuge island and pavement markings.

L. Underpass

An underpass is a passage way for a pedestrian or bicyclist that is typically below a bridge, roadway, or railroad. Underpasses can provide a safe connection between two land uses that are separated by a physical barrier. Roadways can provide a physical barrier due to high traffic volumes. Topographic conditions, safety, and other physical barriers can also warrant the construction of underpasses to help ensure pedestrian access and connections to occur.

As with underpasses or bridges, ADA–compliant ramps and/or stairs are used to effect the elevation change. It is found that pedestrians and bicyclists use grade separated crossings more often if the elevation change can be minimized or worked into the normal path of pedestrian and bicyclist movements. Underpasses can be more expensive than other bicycle and pedestrian solutions to install, but because they can be designed with less grade changes than overpasses, they are often preferable (Figure 7.52.31).

Design Criteria:

- The minimum vertical clearance of an underpass is 10 feet. Special consideration shall be provided to maintain adequate clearance and a maximum grade of 5 percent for the approaching parkway. (Figure 7.52.32).
- The minimum width is 12 feet.
- The underpass shall be wide enough to accommodate emergency vehicles.
- The underpass shall include adequate lighting for safety.
- The slope of ramps must be comply with ADA Guidelines and be accessible by all ages and abilities.
- When underpasses are used, approach grades shall slope away from the underpass to prevent flooding and provide positive drainage away from the underpass. Additional drainage measures may be required.
- Adequate sight distance should be provided in underpasses, preferably with open ends of the tunnel in clear view at all times.
- When designing an underpass, the aesthetic appearance of the facility shall be considered so that the structure fits within the surrounding context.
- Underpass materials can be either concrete or galvanized metal sheeting. Concrete is the preferred material.
- Pedestrian and bicycle access to roadway surfaces above underpass should be provided.
- When designing a tunnel, provide soil exploration to determine if a tunnel is feasible to construct.
- Tunnels should be designed to let more natural light in and provide a wide opening to be more inviting to pedestrians.

Figure 7.52.31. A tunnel for multi-use trail underpass.

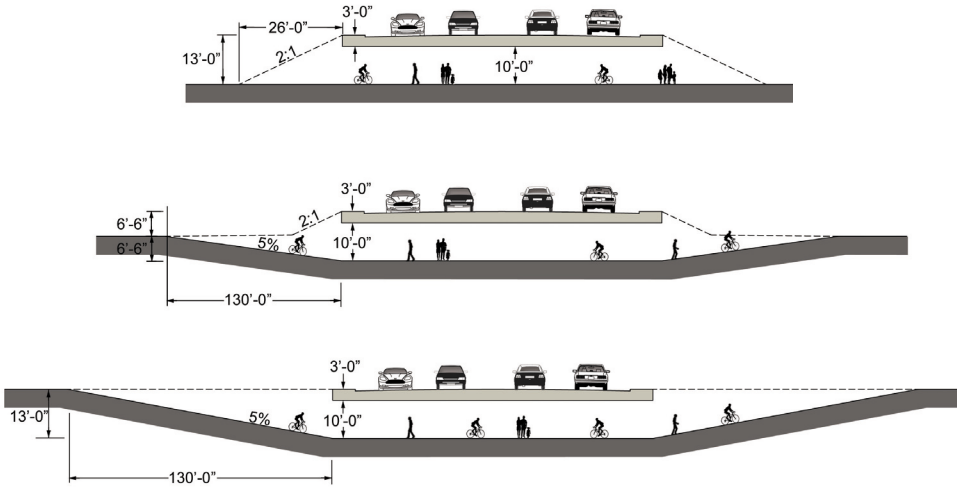


Figure 7.52.32. Typical underpass/undercrossing configurations.

M. Overpass

Overpasses are an important part of pedestrian and bikeway design and may be necessary to provide continuity for shared and multi-use paths. Barriers to bicycling often include freeways, complex interchanges, existing busy roads, waterways, or railroads. Overpasses and bridges should be easily accessible and convenient for pedestrian and bicycle access. Consideration should be given to cost, constructability, maintenance, aesthetics, safety, and physical constraints when designing or providing an overpass. The type of structure typically depends on the span length.

Design Criteria:

- The overpass must meet bridge structural design standards and shall be designed to accommodate pedestrian, bicyclist, maintenance, and emergency vehicle loading.
- Bridges built over roadways, railroads, and waterways must maintain a minimum clearance under the structure. When designing a bridge structure, consult local, state, and federal design requirements for required clearance heights.
- Bridges built over waterways must not negatively impact the 100 year flood elevations. Consult engineering guidelines for clearance requirements when crossing over 100 year flood zone.
- Enclose overpasses with fencing and/or with safety railings to protect users.
- Railing fences or barriers on both sides of the path on a structure shall be a minimum of 42 inches high.
- On new bridge or overpass structures, the minimum clear width should be the same as the approach paved surface, plus a minimum of 2-foot-wide clear areas on each side. The clear areas provide the opportunity to avoid conflicts among bicyclists and railings, handrails, and other bicyclists who may have stopped on the bridge.
- The slope approach should grade away from the overpass to provide positive drainage away from the structure. The maximum slope approaching the overpass shall be 5 percent (Figure 7.52.34).
- Geotechnical evaluations of existing soil conditions and recommendations for bridge abutments are required.
- When designing an overpass, the aesthetic appearance of the facility shall be considered so that it fits within the surrounding context.

Figure 7.52.33. Examples of multi-use trail overpasses.

- Overpass materials can be constructed of concrete, steel, wood, or a combination of these materials.
- Overpasses can often be designed as a community landmark or gateway element.
- Grade separated crossings are more commonly used and look more aesthetically pleasing if elevation changes can be minimized or worked into the normal path of pedestrian movements.
- Screens are often used as a necessary buffer between vehicle traffic and the bicycle overcrossing.
- On all bridge decks, special care should be taken to ensure that bicycle–safe expansion joints are used and that decking materials that become slippery when wet are avoided.
- Lighting should be considered in urban conditions and should be provided, where street lighting is not provided.

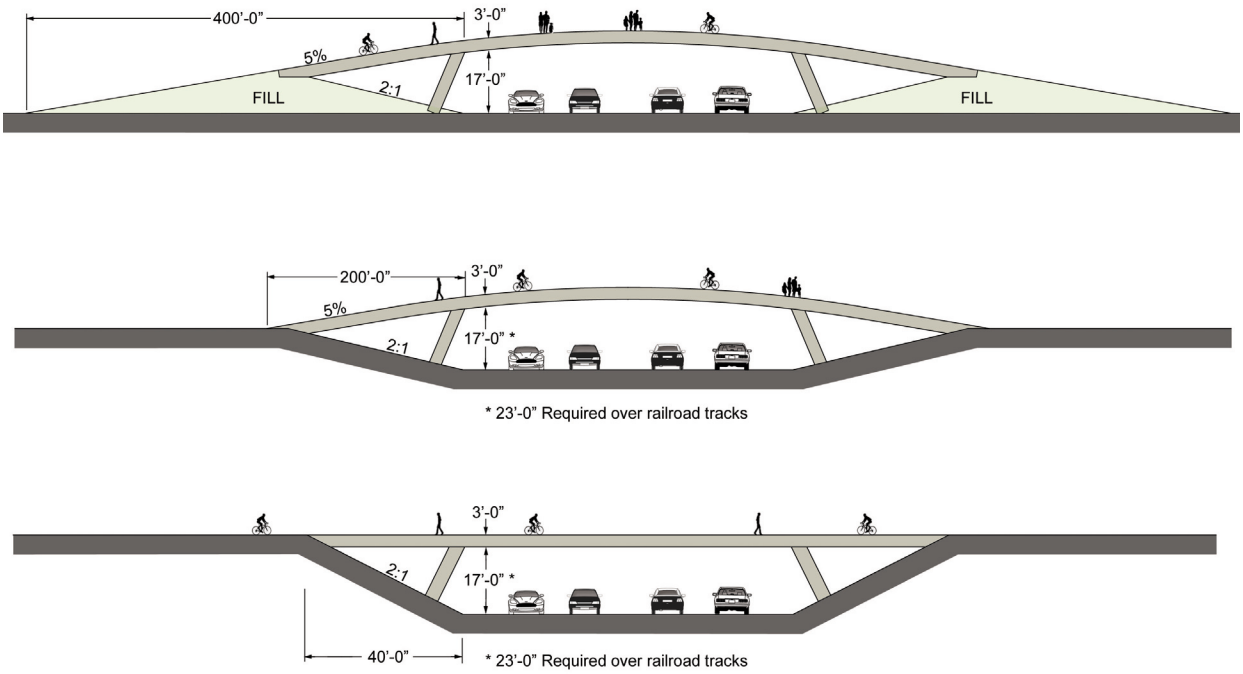


Figure 7.52.34. Typical overpass/overcrossing configurations.

7.6 MULTI-USE FACILITIES

There are three types of multi-use trails; sidepaths, paved trails and unpaved trails. A sidepath is a multi-use facility that runs adjacent to a roadway. A trail is typically located within a linear greenway corridor which may be natural (rivers, streams) or manmade (abandoned rail line or utility corridors). Multi-use sidepaths and trails are designed to accommodate a variety of users including bicyclists, walkers, hikers, joggers, skaters, horseback riders, and those confined to wheelchairs.

Multi-use sidepaths and trails are are an important recreational amenity for communities. They provide connections to neighborhoods, schools, parks, and other community landmarks. Sidepaths and paved multi-use trails are generally located in or near urbanized areas. Unpaved multi–use trails are generally located in rural areas and also provide access to environmentally sensitive areas.

This section also includes design guidelines related to trail heads which are typically located at the terminus of a trail corridor and at a place where large concentrations of trail users are expected, such as major parks, schools, commercial areas and/or neighborhoods. Also refer to the City of Arlington Design Criteria Manual, Chapter 4, Section 4.7, Protection and Restoration of Linear Park Land when designing multi-use trails.

Figure 7.61.1. Example of a multi-use, multi-directional sidepath.

7.6.1 Multi-Use Sidepaths

Where space is limited to accommodate a separate bike lane and a sidewalk, a multi-use sidepath may be the best alternative to facilitate the safe movement of all users. To prevent conflicts with motorists, a multi-use sidepath is best located where corridors have fewer driveways and intersections, and is located within the right-of-way. It is also advantageous if the multi-use sidepath is part of a bicycle route system with other bicycle facilities, such as paved shoulders and/or marked bike lanes (Figures 7.61.1 and 7.61.2).

Design Criteria:

- A two directional sidepath should have a minimum width of 10 feet with at least 2 feet graded shoulder area at both sides of path.
- In high use areas, provide a minimum 12-foot sidepath.
- A sidepath should have a minimum vertical clearance of 7 feet.
- A planted buffer of 3 to 5 feet (5 feet preferably) between edge of path and back of curb or edge of street shall be provided.
- The sidepath should be paved asphaltic concrete or a concrete.
- Provide removal bollards at intersection or roads and multi-use side paths. Multi-use side paths often need some form of physical barrier at intersections to prevent unauthorized motor vehicles from using the facilities. Provisions can be made for a lockable, removable (or reclining) barrier post to permit entrance by authorized vehicles.
- When crossing a road, side paths shall cross at 90 degree angle (Figure 7.61.3).
- At intersections, side paths shall provide connections to existing sidewalks (Figure 7.61.4).
- When side paths cross an intersecting road, vehicular motorists are required to stop before the side path intersection (Figure 7.61.6).
- Post or bollards should be setback beyond the clear zone on the crossing roadway or be a breakaway design. The post should be permanently reflectorized for nighttime

visibility and painted a bright color for improved daytime visibility. When more than one post is provided, a minimum of 5-foot spacing is desirable between posts (Figures 7.61.5 and 7.61.6).

- Provide signing and marking for multi-use paths in accordance with AASHTO and MUTCD design standards.
- Well designed transitions from sidepaths to on-road facilities will direct bicyclists to the correct side of the roadway.
- Coordination with utility provider will be necessary if multi-use sidepath is located within the utility corridor.

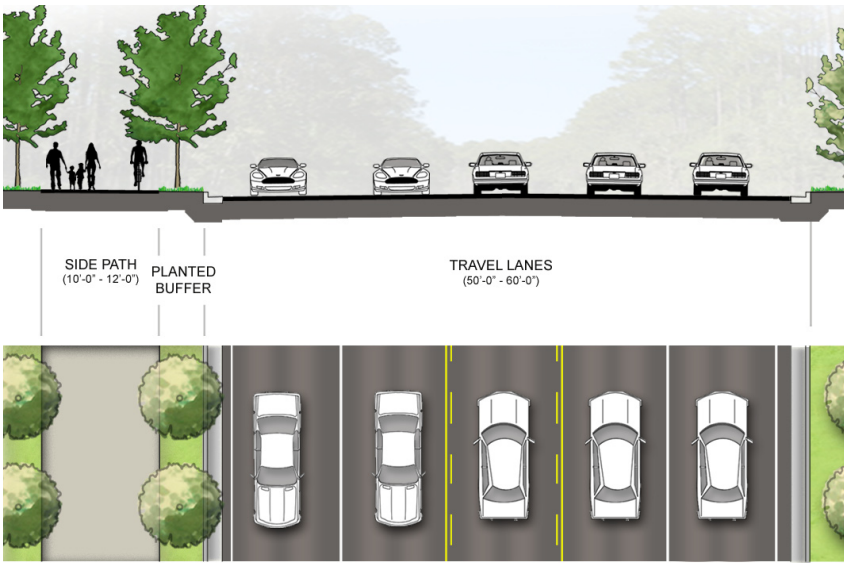


Figure 7.61.2. Four travel lanes with center turn lane typical plan and section with multi-use side path.

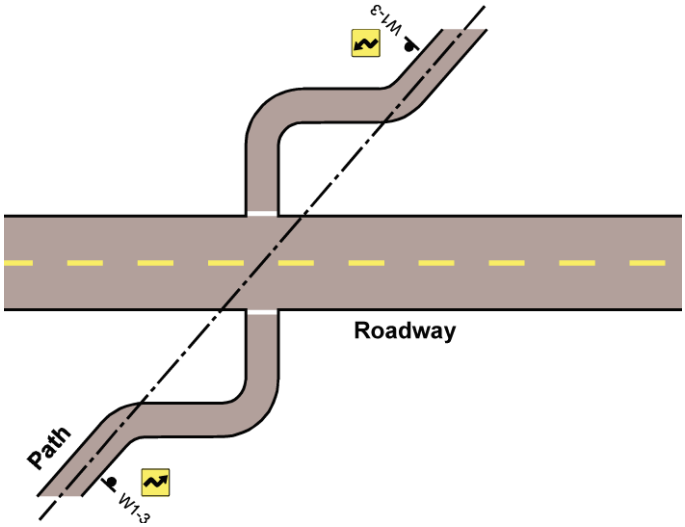


Figure 7.61.3. Typical redesign of a side path crossing road at 90 degree angle to provide better visibility at intersection.

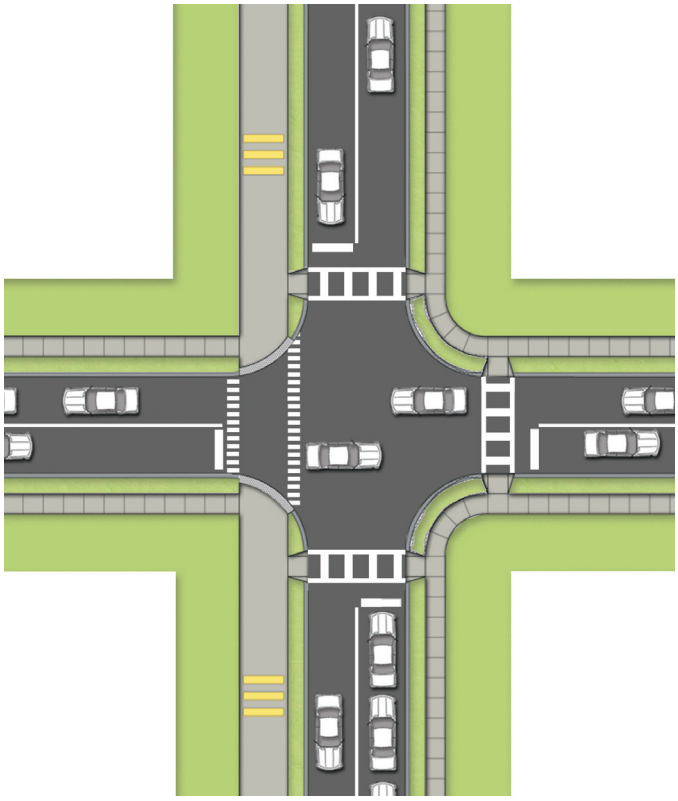


Figure 7.61.4. Typical detail of four-way intersection crossing with side path and sidewalks.

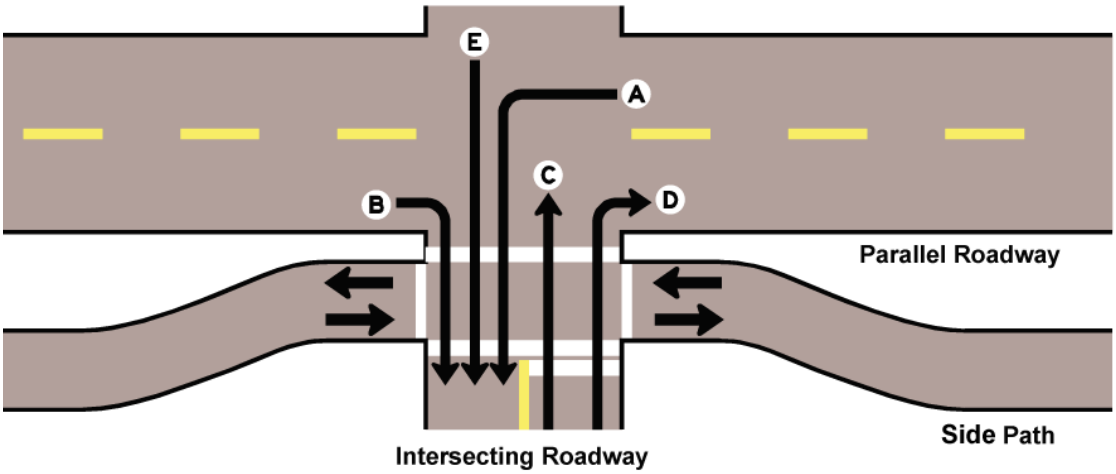
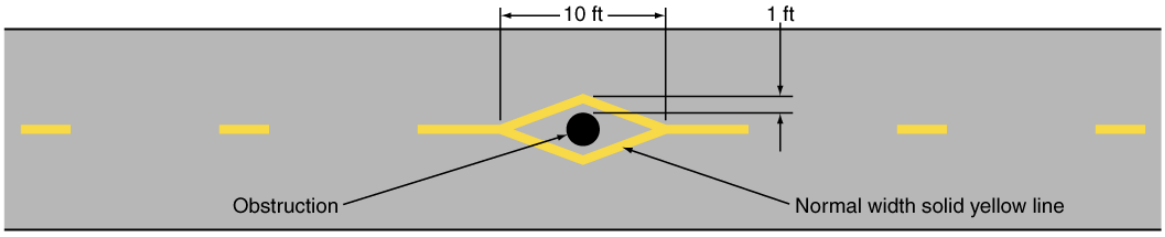


Figure 7.61.5. Typical Example of sidepath at roadway intersection. Vehicular motorists are required to stop before sidepath intersection. A-E indicates traffic direction through intersection.

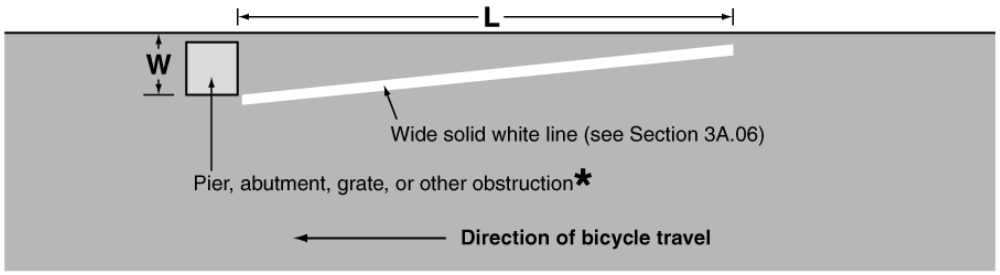
Figure 7.61.6. Example of bollard spacing.

Figure 7.61.7. A multi-use side path at controlled intersection.

Figure 7.52.8. Obstruction and required pavement markings.



A - Obstruction within the path



B - Obstruction at edge of path or roadway

L = WS, where W is the offset in feet and S is bicycle approach speed in mph

* Provide an additional foot of offset for a raised obstruction and use the formula L = (W+1) S for the taper length

7.6.2 Paved Multi-Use Trails

For corridors with heavy bicyclist and pedestrian use, paved multi-use trails are desirable over unpaved since they minimize accidental tripping and provide better traction for all users. If these trails are connected to an urban environment, street, or other major landmarks, it is preferred that they are paved to provide better long term use and limit future maintenance concerns.

Design Criteria:

- The minimum width for a one-way paved facility is 6 feet. The clearing and grubbing area is approximately 12 feet wide and the selective thinning area is approximately 20 feet (Figure 7.62.1).
- The minimum width for a two-way paved facility is 10 feet. The clearing and grubbing area is approximately 18 feet and the selective thinning area is 30 feet (Figure 7.62.2).
- Selective thinning is meant to provide visibility along the trail or pathway corridor. Mature trees that do not create a site distance hazard should be maintained. Additional selective clearing may be required to provide adequate sight lines and safety for the trail users.
- On trails with heavy pedestrian and bicyclist use, a 12-14 foot wide multi-use trail facility is required. The clearing and grubbing area should be an additional 4 feet each side of the pathway plus additional 5 feet each side of the path for selective thinning area (Figure 7.62.3).
- Multi-use trails must conform to ADA and MUTCD standards.
- The recommended surface for paved facilities shall be concrete or asphalt and should be designed to withstand the loading requirements of emergency and maintenance vehicles. Refer to the City of Arlington Design Criteria Manual for pavement standards (Figure 7.62.4).
- Location maps, directional, mileage, and navigation, and regulatory signage ("rules

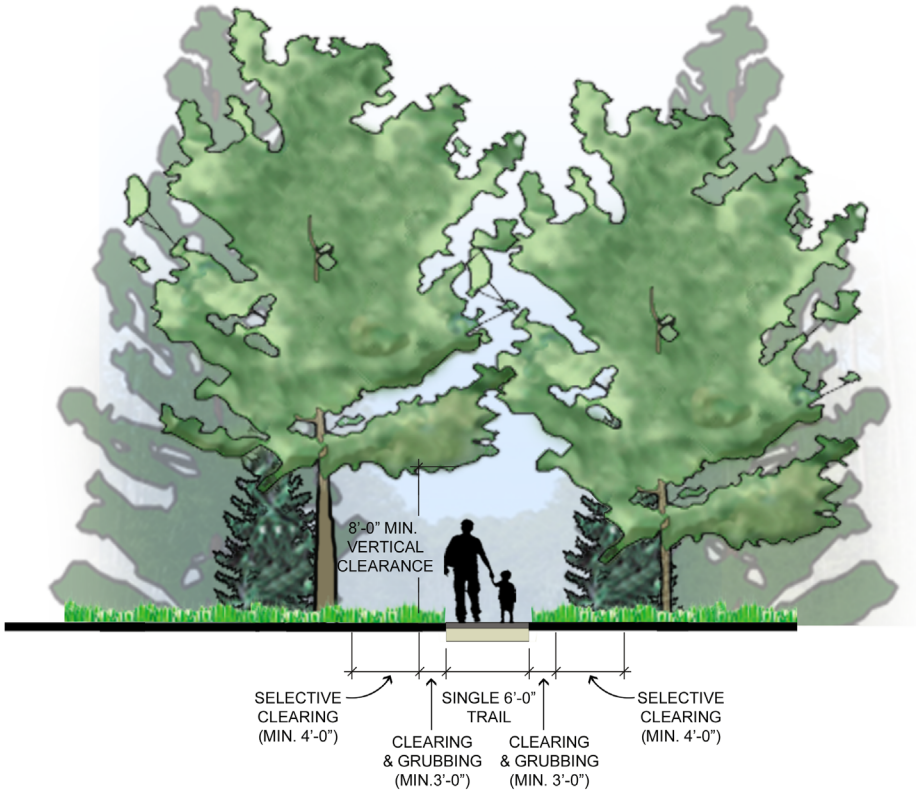


Figure 7.62.1. Typical one-way, paved 6-foot wide trail.

of the trail") shall be posted.

- In flood prone areas, multi-purpose trails should be constructed of concrete.
- When constructing multi-use trails on steep slopes, walls may be required. Wall materials shall withstand periodic flooding. (Figure 7.62.5).
- Centerline stripes should be provided for paths that generate substantial amounts of traffic.
- Side slopes shall be a maximum of 1:6 adjacent to both sides of the trail. When the bottom of the slope is unsafe, a dense shrubbery, chain link fence, or other physical barrier may be required.
- The minimum vertical clearance is 10 feet. Greater clearance for maintenance and emergency vehicles may be required.
- Trails need to be well drained with a 2 percent cross slope.
- Environmental and wetland impacts should be minimized.
- Cautionary signs should be provided for steep slopes, blind curves, and other potential hazards.
- When the separation between the edge of the road and trail is less than 5 feet, a suitable barrier should be provided. The barrier shall be a minimum of 42 inches in height. When barriers are used, they shall not impair sight distance at intersection or along a roadway.
- Potential conflicts between user groups must be considered and addressed during the development phase of the trail.
- Refer to AASHTO design standards for design speed, horizontal alignment, grade, sight distance requirements and other related design requirements.
- Slopes greater than 5 percent are considered undesirable. When slopes exceed 5 percent on a heavy use multi-purpose trail, increase the width to 14 feet. Provide signage that alerts bicyclist of maximum percent grade.
- Refer to local, state, and federal stream

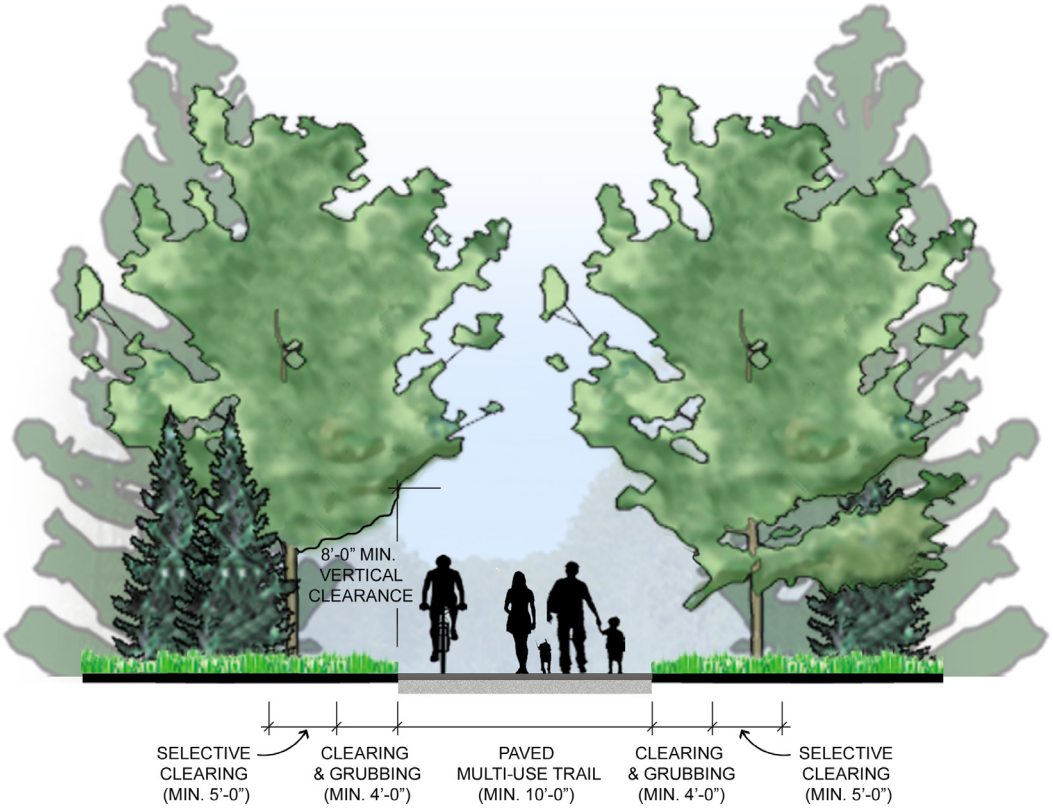


Figure 7.62.2. Typical two-way, paved 10-foot wide multi-use trail.

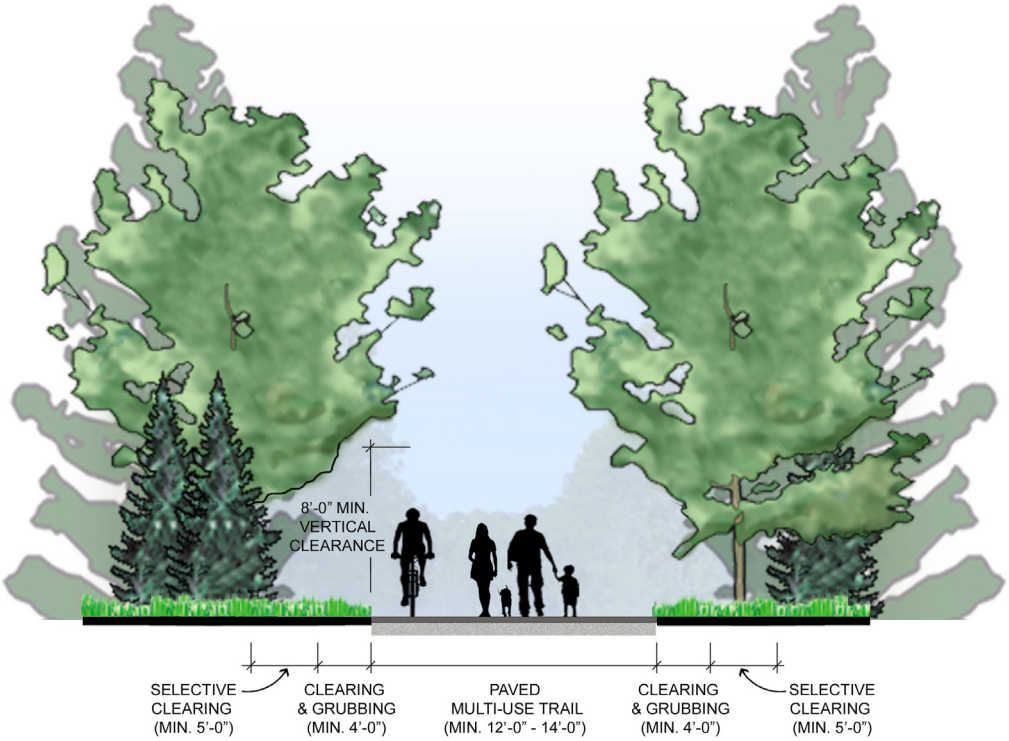


Figure 7.62.3. Typical section for heavy traffic areas for two-way paved 12 to 14-foot wide multi-use trail.

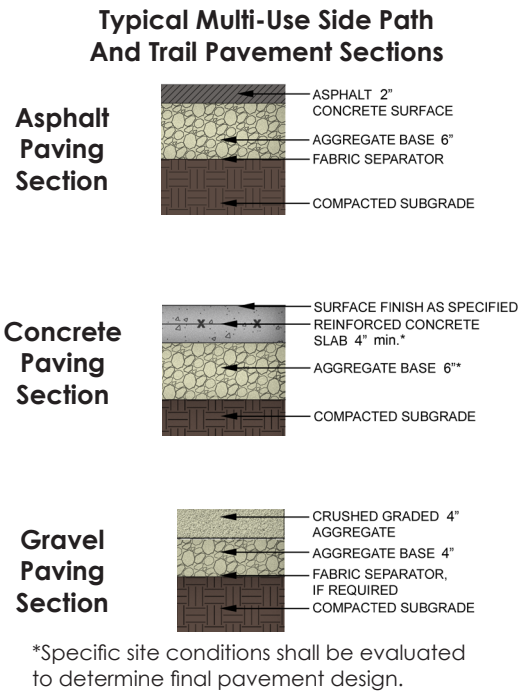


Figure 7.62.4. Typical path and trail sections.

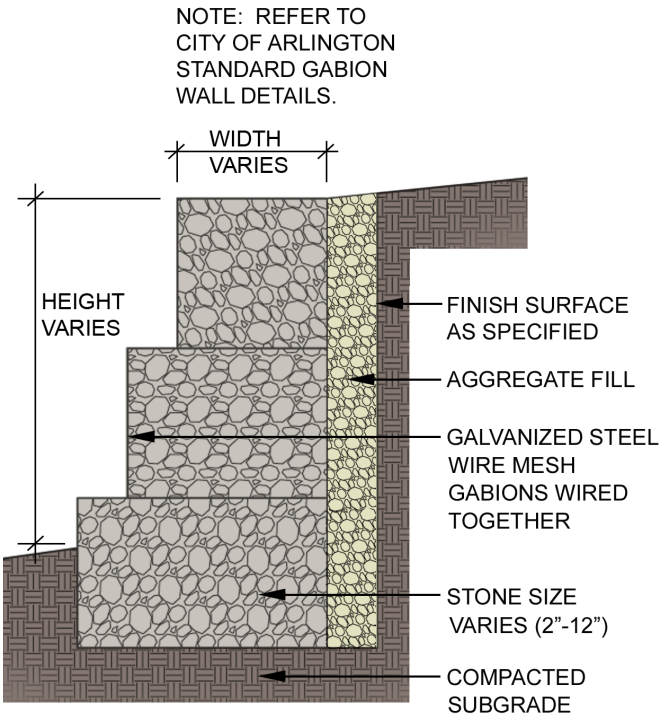


Figure 7.62.5. Gabion Wall with Stepped Face.

buffer set-back requirements when designing multi-purpose paths and trails adjacent to wetlands, creeks, and waterways.

- Provide native landscaping to enhance wildlife and protect natural landscape along trail corridors in areas to be revegetated. Avoid using harmful pesticides and planting invasive plant material.
- When designing a paved trail or path seek a soil engineer evaluation and a geotechnical report of existing site soil conditions to determine final recommendations of trail pavement design.
- Provide a 10-foot shoulder minimum adjacent to waterways, ditches, and steep slopes.
- Elevated structures should be provided when slopes or environmental conditions warrant.
- Provide rest and pull off areas on steep slopes.
- Provide secondary access to canoeing, kayaking and tubing when adjacent to navigable waterways.
- Along with the multi-purpose paths and trails provide the opportunity for designated picnic and seating areas.

Concrete vs. Asphalt Comparison.

Initially, asphalt is cheaper than concrete, but over a life cycle, concrete is considered to have better value. Concrete has a longer service life of roughly 40 years while asphalt's life span is roughly 10-20 years. Concrete does not require as much maintenance (sealing for example) as asphalt requires over a life span. The climate of Texas can cause asphalt to become soft in the hot sun and therefore susceptible to ruts. Installation costs for concrete and asphalt surface projects are not significantly different. Varying reports suggest a life span savings of around 20% with the use of concrete. Refer to Chapter 4 of the City of Arlington's Design Criteria Manual for paving requirements for public and private streets.

Floodway Trails

Floodway trails are typically located within the floodway, where an undisturbed vegetative buffer is located between the stream and trail. Refer to City of Arlington and State Requirements regarding stream buffer setbacks. Floodway trails should be designed to handle periodic flooding. Hard paved concrete or asphalt surfaces are required depending on the frequency of the flooding and expected velocity of flow. The installation of site furnishings should be considered and studied to not obstruct the creek flow during storm events and be selected to withstand periodic flooding. Floodway trails should follow the design criteria outlined under the multi-use trail section. Refer to local, state, and federal requirements regarding stream buffer setbacks (Figure 7.62.6).

Floodplain Trails

Floodplain trails are typically outside the floodway and within the floodplain, where a large undisturbed vegetative buffer is located between the stream and trail. Refer to local, state, and federal requirements regarding stream buffer setbacks. Floodplain trails should be designed to withstand occasional flooding, during large storm events. Hard paved concrete or asphalt surfaces are required depending on the frequency of the flooding and expected velocity of flow. Permeable paving treatments may be considered in environmentally-sensitive areas. Floodplain trails should follow the design criteria outlined under the multi-use trail section and in accordance with the City of Arlington's Design Criteria Manual standards, State, and Federal requirements regarding stream buffer setbacks.

Creekside Trails

Creekside trails are typically located directly adjacent to the stream channel. They are typically located in urban areas, where there are right-of-way constraints. Hard paved concrete surfaces are required to withstand high-velocity stream flooding. Retaining walls or other structural devices may be required to construct and protect trail from erosion and flood damage. The installation of site furnishings should be considered and studied to not obstruct the

creek flow during storm events and be selected to withstand periodic flooding. Creekside trails should follow the design criteria outlined under the multi-use trail section and in accordance with local, state, and federal stream buffer set-back requirements (Figure 7.62.7).

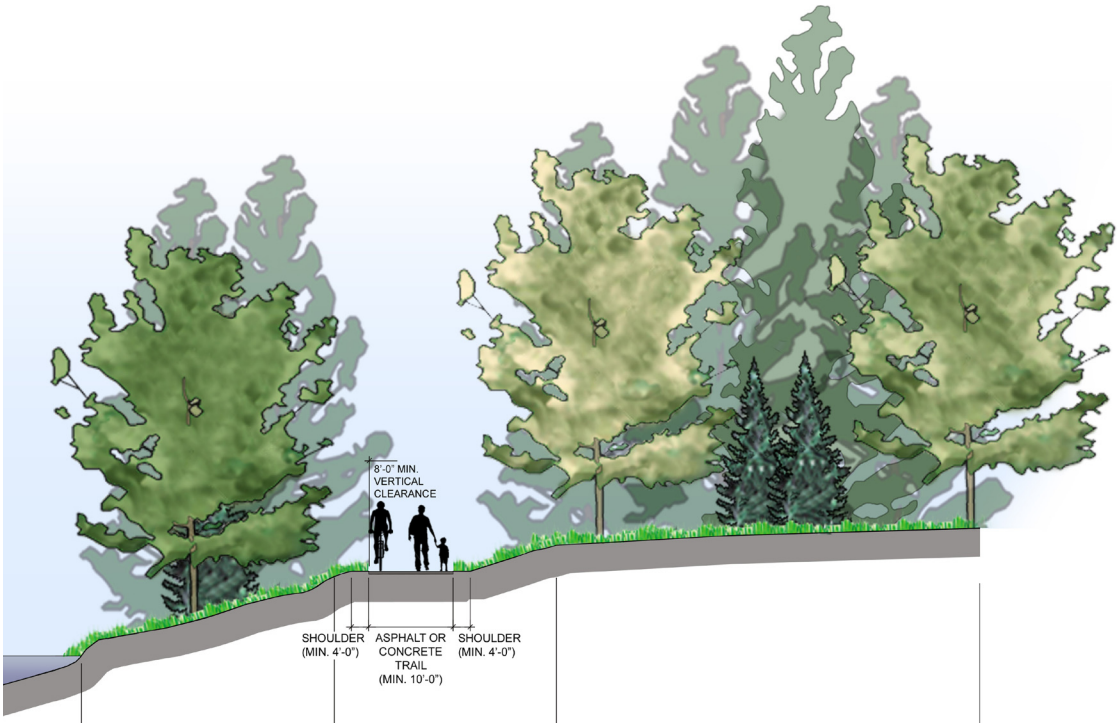


Figure 7.61.6. Typical floodway trail.

Figure 7.61.8. Typical creekside trail.

Secondary Community Trail Access

Secondary community trail access provides bicycle and pedestrian accessways and connectivity to schools, parks, neighborhoods, community centers, retail/entertainment centers and other trail systems. Accessways are intended to reduce unnecessary out-of-way travel for bicyclists and pedestrians. (Refer to Figures 7.62.9 and 7.62.10)

Design Criteria:

- Trail pavement should be a minimum of 8 foot wide to accommodate emergency and maintenance vehicles.
- Trail surface needs to meet ADA requirements and be suitable for multi-use purposes.
- Minimize impact to mature vegetation.
- Landscape to be indigenous to the area.
- Where trail is located to adjacent properties provide a minimum of a 6 foot high privacy fence and landscape screening.
- For paving standards refer to the City of Arlington Design Criteria Manual and the multi-use trail paving recommendations.

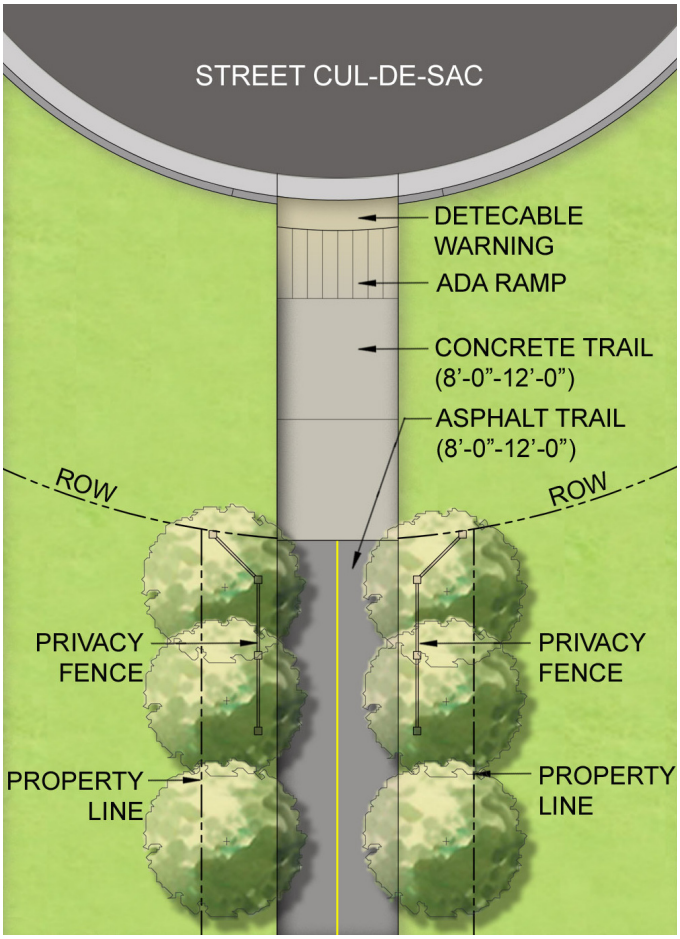


Figure 7.62.9. Secondary Community Trail Access.

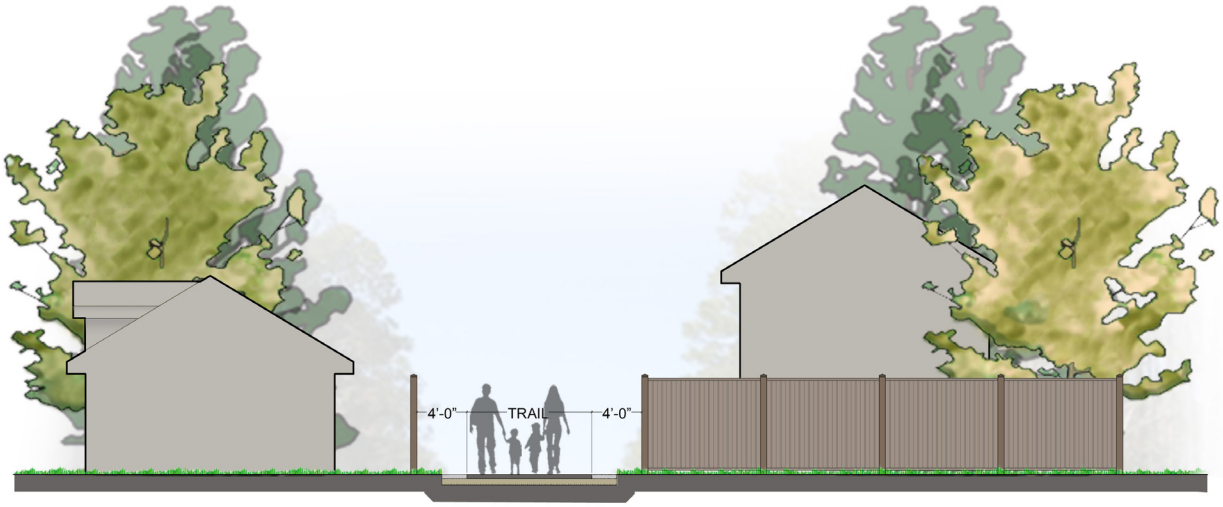


Figure 7.62.10. Secondary Community Trail Access.

7.6.3 Unpaved Multi-Use Trails

In corridors of low trail user volumes, multi-use trails may be unpaved. Unpaved trails may not be safe for all users. While the construction cost may be lower, they tend to have a higher maintenance cost and shorter life-cycle. While bicycle speeds are lower, unpaved trails are not recommended for novice users, for multiple age groups or for motorized equipment (Figure 7.63.1).

Design Criteria:

- A one-way unpaved facility is to be a minimum of 6 feet wide. The clearing and grubbing area is approximately 12 feet wide and the selective thinning area is approximately 20 feet (Figure 7.63.2).
- A two-way unpaved facility is to be a minimum of 10 feet wide. The clearing and grubbing area is approximately 18 feet and the selective thinning area is 30 feet (Figure 7.63.3).
- Selective thinning is meant to increase visibility along the trail or pathway corridor. Mature trees that do not create a visibility hazard should be maintained.
- The recommended pavement surface is crushed aggregate, sand, clay, wood chips, or stabilized earth.
- Provide a 3-foot-wide graded shoulder minimum on 6-foot-wide paths and 5-foot-wide graded shoulders on 10-foot-wide paths.
- Side slopes to be a maximum of 1:6 adjacent to both sides of trail. When the bottom of the slope is unsafe, dense shrubbery, chain link fence, or other physical barrier may be needed.

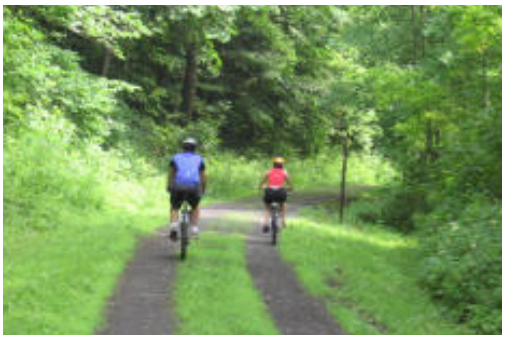


Figure 7.63.1. Example of unpaved multi-use trail. Unpaved trails usually are gravel, mulch, or natural surface.

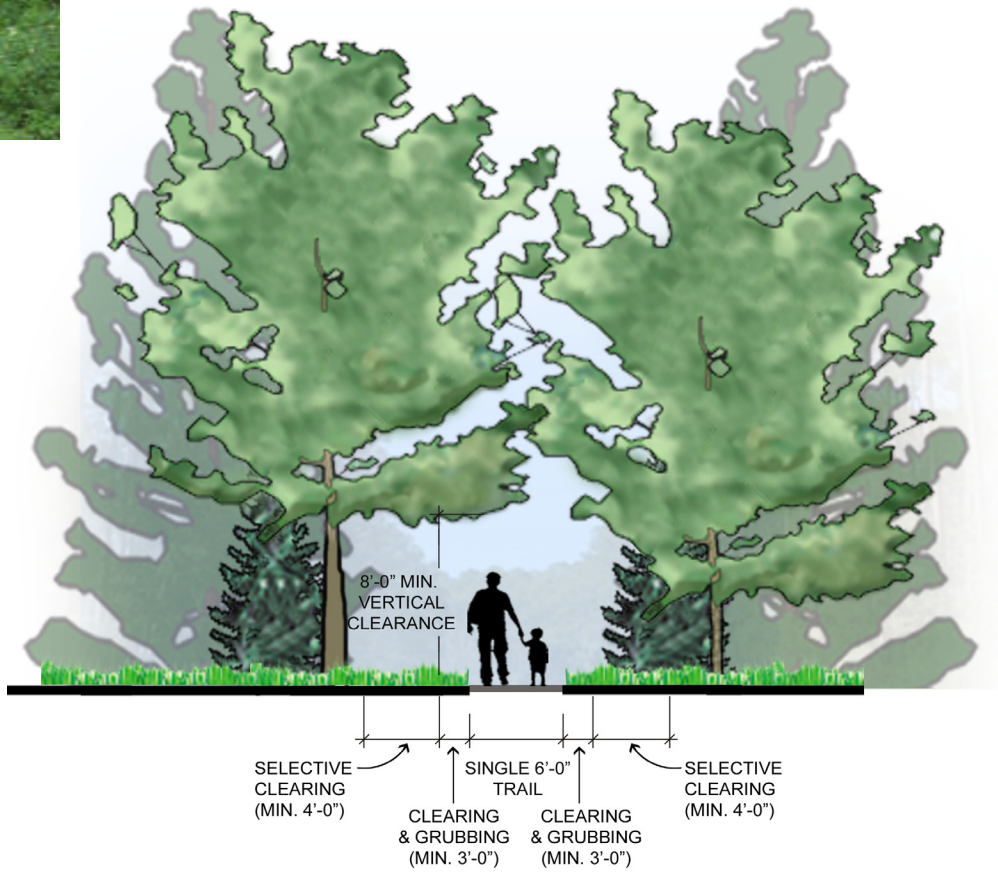


Figure 7.63.2. One-way unpaved 6-foot multi-use trail.

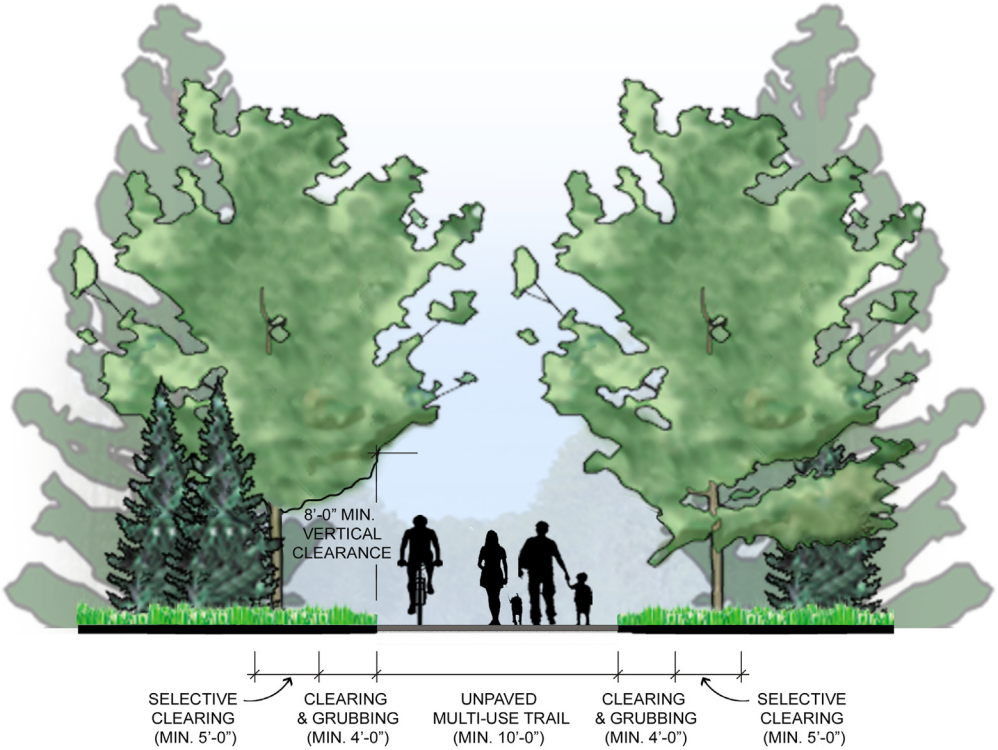


Figure 7.63.3. Unpaved multi-use trail.

- A minimum of 10 foot shoulder is required adjacent to waterways, ditches, and steep slopes. If a minimum 10-foot shoulder distance cannot be provided, a minimum 42" high railing should be installed.
- The minimum vertical clearance is 8 feet with greater clearance for maintenance and emergency vehicles.
- Unpaved areas to be well drained.
- Erosion control measures to be put in place prior to construction.
- Cautionary signs should be provided for steep slopes, blind curves, and other potential hazards.
- Grades steeper than 3 percent are not practical for shared or multi-purpose trails with crushed stone or other unpaved surfaces, due to handling and drainage erosion concerns.
- Location maps, directional, mileage, navigation, and regulatory signage ("rules of the trail") shall be posted.
- Mature native vegetation to be maintained if possible.
- Secondary footpaths and hiking trails to be a minimum of 2'-6" and a maximum 5'-0" in width.
- Provide elevated and boardwalk structures when slopes or environmental conditions warrant.
- Provide rest and pull off areas on steep slopes.
- Provide interpretive signage.
- In addition to unpaved multi-use trails, provide footpaths or hiking trails designated to accommodate pedestrians on foot; not intended for cyclist or wheeled users.
- Provide footpaths or low impact trails to access environmentally sensitive areas.

A. Boardwalks and Bridges

Boardwalks are used to connect trails over environmentally sensitive areas. Boardwalks are typically made of wood timbers, recycled composite plastic, or narrow liner concrete slab. If properly constructed, boardwalks minimize impacts to sensitive areas and can be a good alternative where extensive grading is required (Figure 7.63.4).

Design Criteria:

- Boardwalks to conform to ADA and City of Arlington's Design Criteria Manual standards.
- Railings are required when boardwalks exceeds 30 inches in heightabove the ground surface.
- Boardwalks to meet bridge structural design standards and be designed with pedestrian loading. Where maintenance and emergency vehicles may be expected to cross a boardwalk, the design should accommodate them.
- Identify floodway and floodplain elevations to determine the height at which the decking can be constructed. Verify with local government authorities prior to construction.
- Refer to bicycle and pedestrian bridge section for railing height standards (Figure 7.63.5).
- Environmental and wetland impacts should be minimized when boardwalks are used.
- Use wood products that are environmentally sensitive and nontoxic to the environment.
- Auger piers are preferred for greater support and durability over wood post foundations.
- Interpretive signage should be provided.
- Materials used to construct boardwalk should be contextually appropriate.
- Lighting may be provided at trailheads.

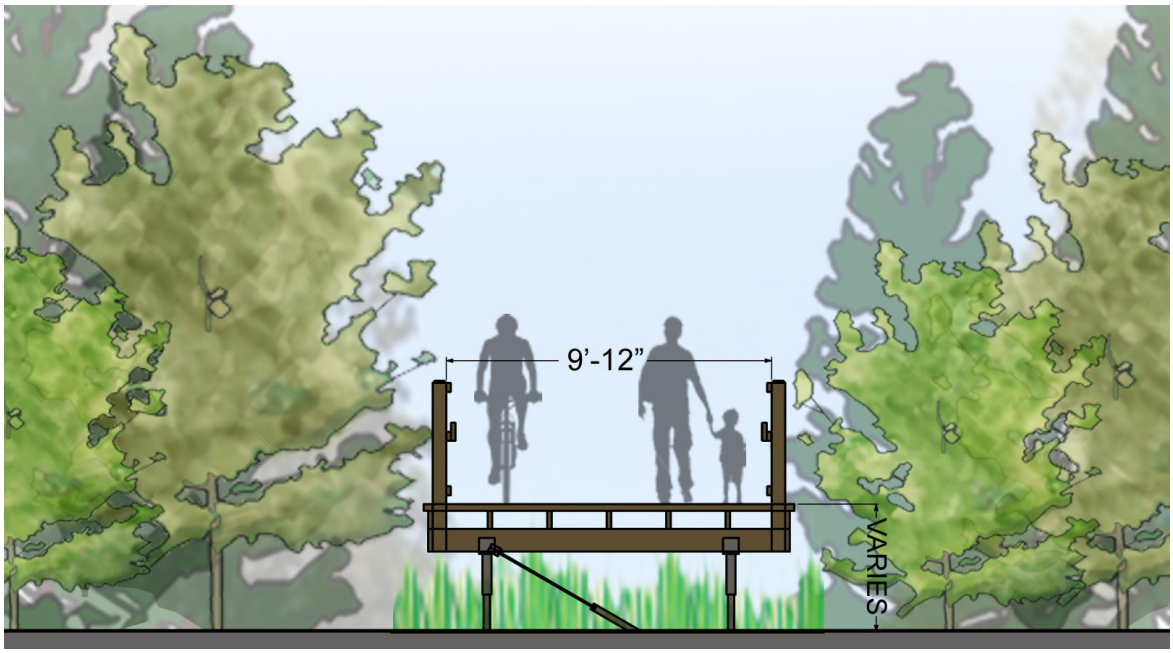


Figure 7.63.4. Multi-use trail boardwalk section.

B. Pedestrian and Bicycle Bridges

In environmentally sensitive areas where boardwalks may not be possible, such as over a wide stream, river, or roadway, building pedestrian and bicycle bridges may be the best option to continue access. Bridges may be more expensive than boardwalks, but greatly minimize impacts to the adjacent areas. Existing abandoned railroad bridges could be reused if the structural integrity is approved by an engineer.

Design Criteria:

- The bridges must conform to ADA, AASHTO, local, and state regulatory standards.
- Refer to AASHTO for information about load bearing capacity of bridges.
- Railings on bridges and boardwalks used by pedestrians to be a minimum of 42 inches high.
- Railings on bridges and boardwalks where bicyclists are present to be a minimum of 54 inches in height. The higher railing height is due to a bicyclists higher point of gravity. (Refer to figure 7.63.5 and 7.63.6)
- On new structures, the minimum clear width should be the same as the approach paved surface, plus a minimum of 2 feet wide on each side. The clear areas provide the opportunity to avoid conflicts between bicyclists, railings, handrails, and other bicyclists who may have stopped on the bridge.
- Prior to design of pedestrian and bicycle bridge crossing, define the floodway and floodplain elevations. This data will determine the minimum height at which the bridge decking can be constructed. The proposed bridge installation shall be verified with local government authorities prior to construction.
- Consider using prefabricated pedestrian bridges.
- Materials utilized to construct bridges should be contextually appropriate.
- Provide lighting as needed and where street lighting is not present.

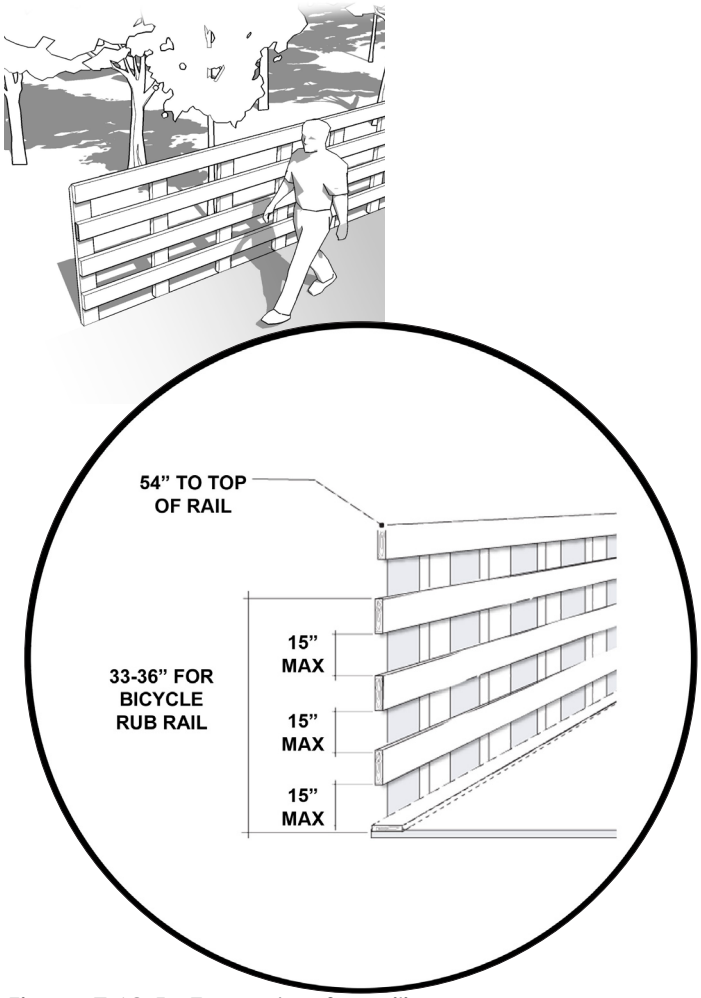


Figure 7.63.5. Example of a railing.

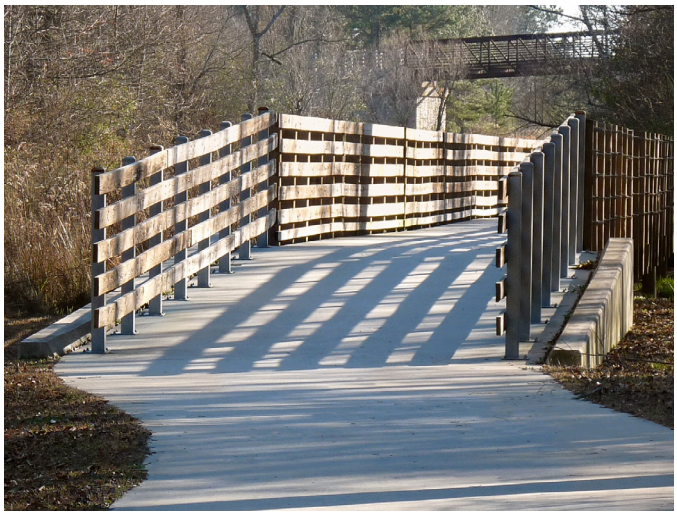


Figure 7.63.6. Example of boardwalk and bridge railing for bicyclists and pedestrians.

Figure 7.63.7. Pedestrian and bicycle bridge.

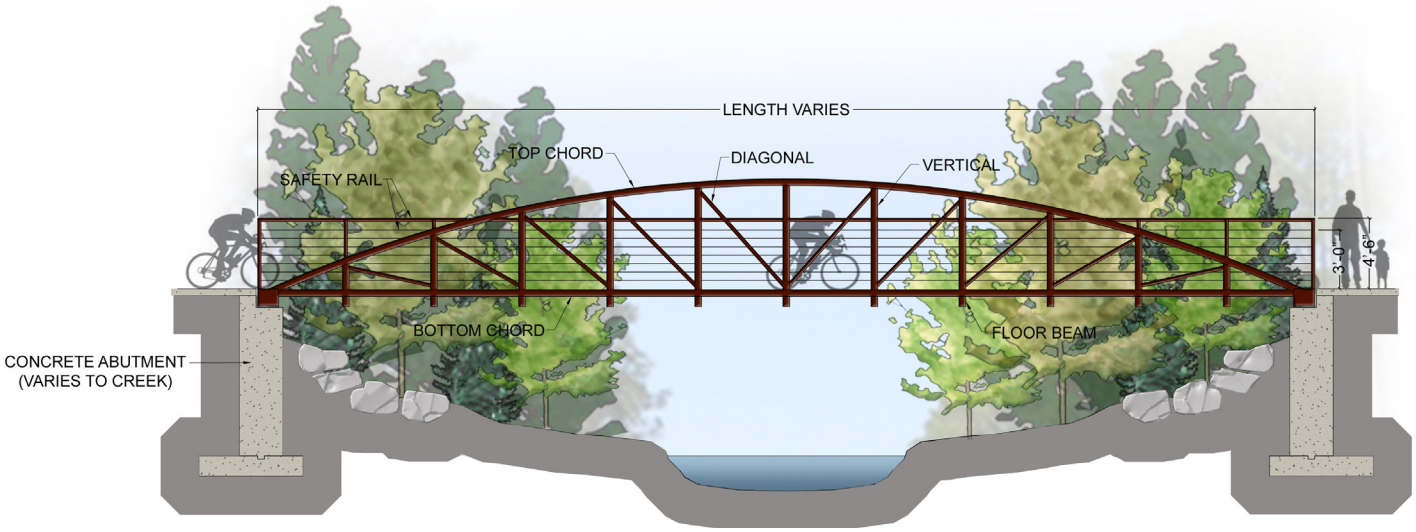


Figure 7.63.8. A section of a pedestrian and bicycle bridge.

7.6.4 Trailheads And Support Facilities

There are different sizes of trailhead facilities. Minor trailheads are smaller and simpler in character and offer pedestrians and bicycle entrances in parks and residential communities. Major trailheads should be located near commercial developments and transportation nodes, making them highly accessible to the overall community (Figures 7.64.1 and 7.64.2).

Design Criteria for Minor Trailheads

- Adequate Parking
- Drinking Fountains
- Benches
- Bicycle Racks
- Trash Receptacles
- Information Kiosk
- Signage, including location maps, directional, mileage, emergency, and navigational information.

Design Criteria for Major Trailheads

- Adequate Parking
- Drinking Fountains
- Benches
- Bicycle Racks
- Trash Receptacles
- Information Kiosk
- Signage includes information in minor trailhead facilities plus points of interest and education.
- Restrooms
- Shelters
- Picnic Areas
- Bicycle Rental & Storage Facilities
- Air Compressors
- Emergency Phone Services

Figure 7.64.1. Example of trailhead

Figure 7.64.2. Example of trailhead.

There is a wide variety of site furnishings available to choose from in terms of style and materials. Material selection should be based on desired design theme, location that it is used, cost, and durability.

Bench Design Criteria:

- Benches should have back rest.
- Benches are 18"-20" above ground.
- Benches are 48" to 96" in length.
- All benches are constructed of either recyclable materials, finished wood (mahogany or similar material), powder-coated steel, or cast iron (Figure 7.63.2).

Trash Receptacle Design Criteria:

- Trash receptacles should be constructed of a suitable material to withstand the harsh elements of the outside environment; including weather and wildlife.
- Tops or lids should be able to be secure.
- Trash receptacles should be a minimum of 32 gallon, with a side door opening, large bearing stainless steel hinge pins.
- Provide latch and padlocks on all door openings.
- Trash receptacles should be constructed of either recyclable materials, finished wood (mahogany or similar material), powder-coated steel, or cast iron.
- Trash receptacles to be placed at trailhead locations and periodically (plus or minus half a mile) along trail to combat littering and preserve a clean environment for all users (Figure 7.64.3).

Picnic Table Design Criteria:

- Picnic tables should be constructed of either recyclable materials or finished wood (mahogany, redwood, or similar material).
- Picnic tables should be either square or rectangle. Square tables to be 4'x4' and the rectangle tables to be 4'x8'.
- Picnic tables should be ADA accessible.
- Picnic tables should have 4-inch square structural steel center post (Figure 7.64.4).

Figure 7.64.3. Examples of benches and trash receptacles.

Figure 7.64.4. Example of picnic table.

7.7 PEDESTRIAN & BICYCLE SIGNAGE

Signage includes visual graphics that display specific information to an audience. A unified system of signs improves the movement of motorists, bicyclists, and pedestrians, and minimizes conflicts for all users. These include identification, directional, informational, and regulatory signs. A comprehensive system of signage ensures that information is provided regarding the safe and appropriate use of all facilities. Implementing a well planned and attractive signage system can greatly enhance a hike and bikesystem by signaling their presence and location to both motorist and existing or potential users.

A. Pedestrian and Bicycle Wayfinding Signage

Pedestrian and bicycle signage is often part of an overall wayfinding signage system. Signage should have a clear message, be easy to read, with simple colors and be standard in dimension to minimize maintenance and cost. A wayfinding signage system for on-and off-street bicycle route network should include directional, educational, and interpretive points of interest (Figures 7.7.1 and 7.7.2).

Figure 7.7.1. Example of signage.

Design Criteria:

- Signage should be post or pole mounted or integrated within a kiosk or information booth.
- Maintain minimum clearance heights and setbacks when locating signs along pedestrian and bicycle facilities.
- Signage should conform to MUTCD and AASHTO Guide for Development of Bicycle Facilities.
- Add city name, logo, and name of pathway to bicycle signage to make distinctive and unique to the City of Arlington.

Figure 7.7.2. Example of kiosk.

B. Special Purpose and Directional Signage

The purpose of signage can be to identify routes for motorists, pedestrians, and bicyclists; provide destination and distance information; and warn users about changes in conditions. An efficient and effective directional signage system can enhance and provide for a safer experience for pedestrians and bicyclists (Figure 7.7.3).

Design Criteria:

- Signs should be pole- or post-mounted.
- Signs should conform to City of Arlington, MUTCD, and AASHTO design standards.
- Provide special purpose and directional signs on a bike route map, allowing for better hike and bike planning to occur.
- Provide uniform color and City of Arlington logo on special purpose and directional signage.

* A fluorescent yellow-green background color may be used for this sign or plaque. The background color of the plaque should match the color of the warning sign that it supplements.

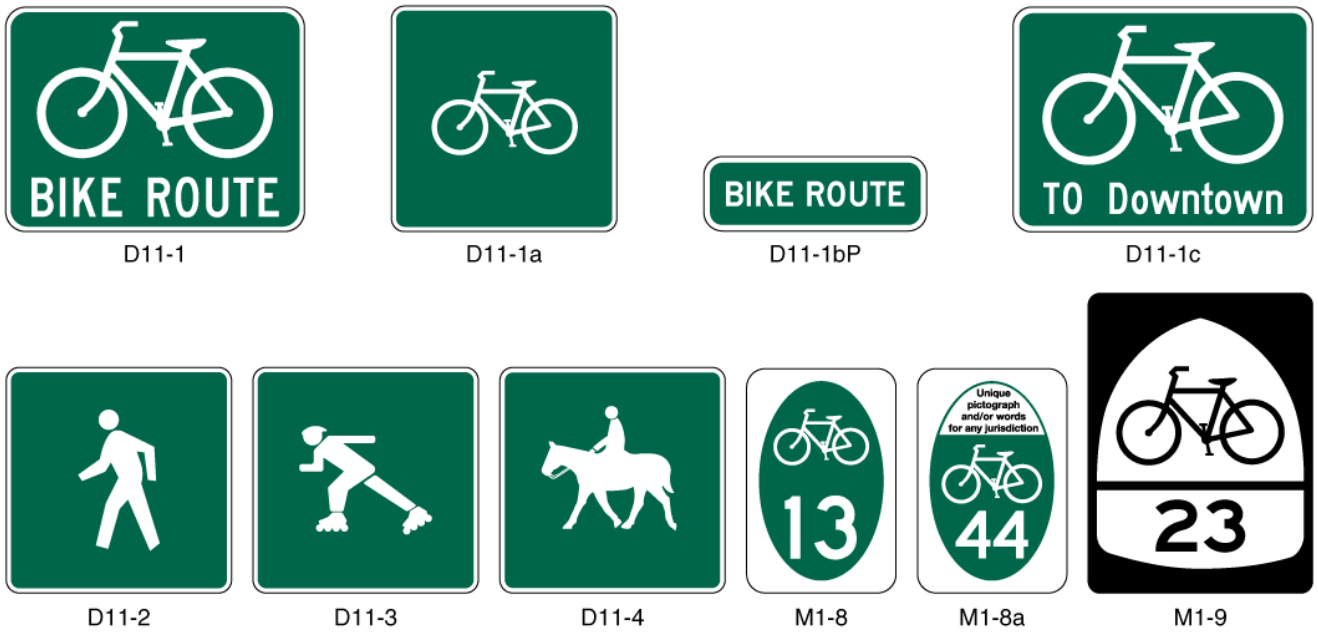


Figure 7.7.3. Examples of special purpose and direction signage.

C. Regulatory or Warning Signs

These signs are often standard in dimensions and have specific information. Installed adjacent to the street, these signs contain information such as speed limit and parking rules. Regulatory signs are used to inform roadway users of a legal requirement. Warning signs are used to inform roadway users of unexpected or unusual conditions (Figures 7.7.4 through 7.7.9).

Design Criteria:

- The signage should conform to City of Arlington MUTCD, and AASHTO, design standards.
- Signs should be pole or post mounted.

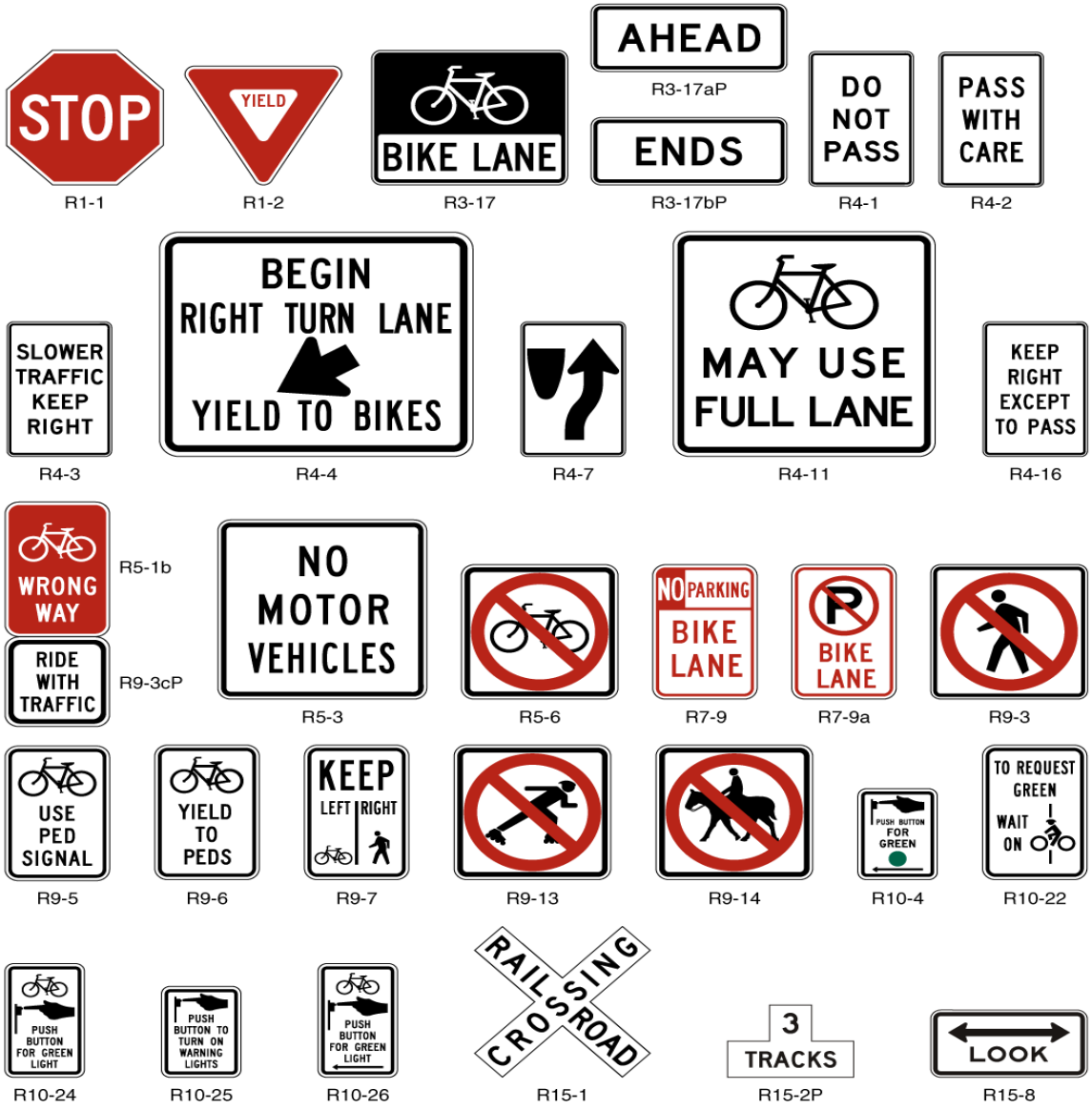


Figure 7.7.4. Examples of regulatory signage.

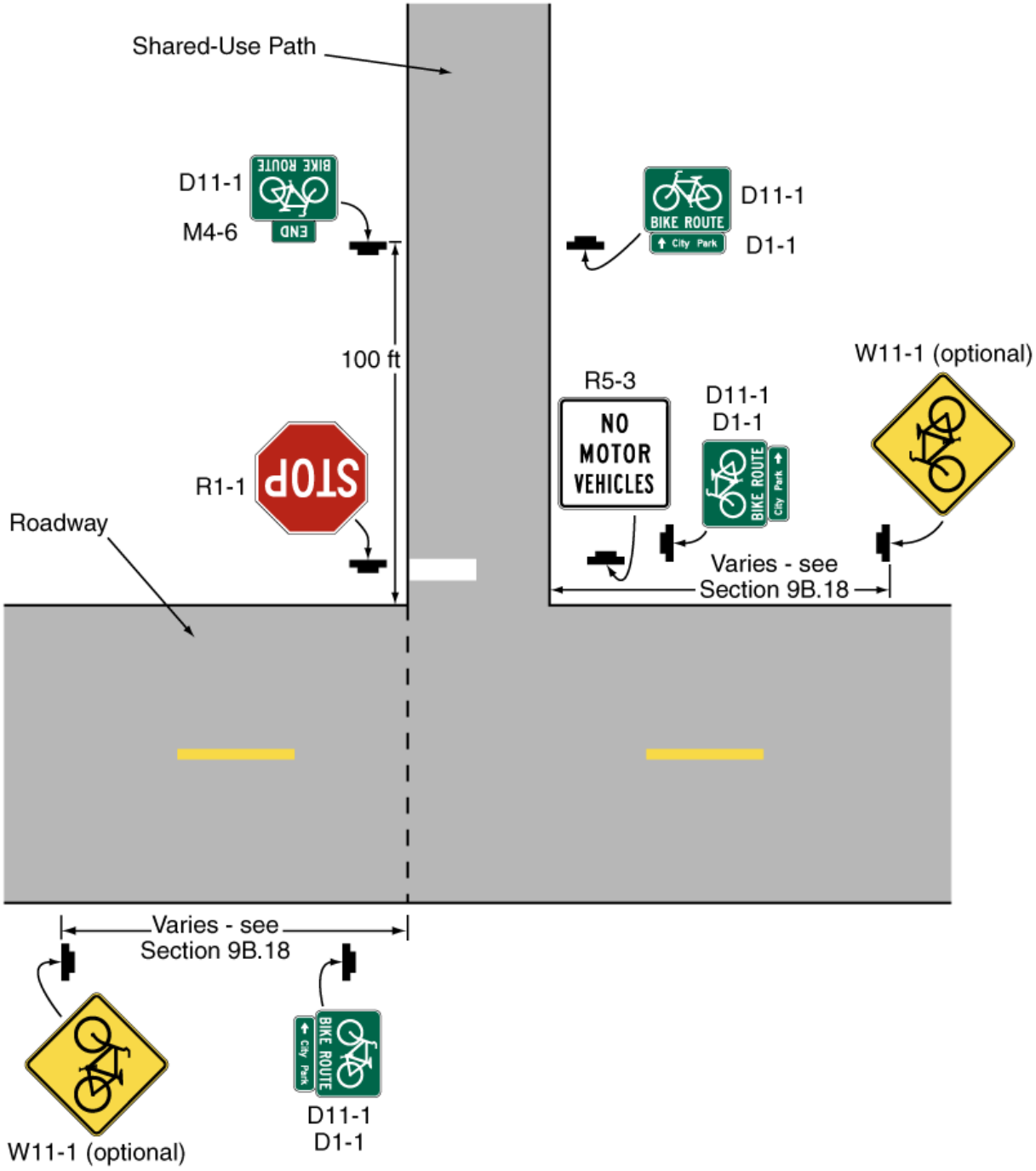


Figure 7.7.5. Example of signing for the beginning and end of a designated bicycle route on a shared-use path.

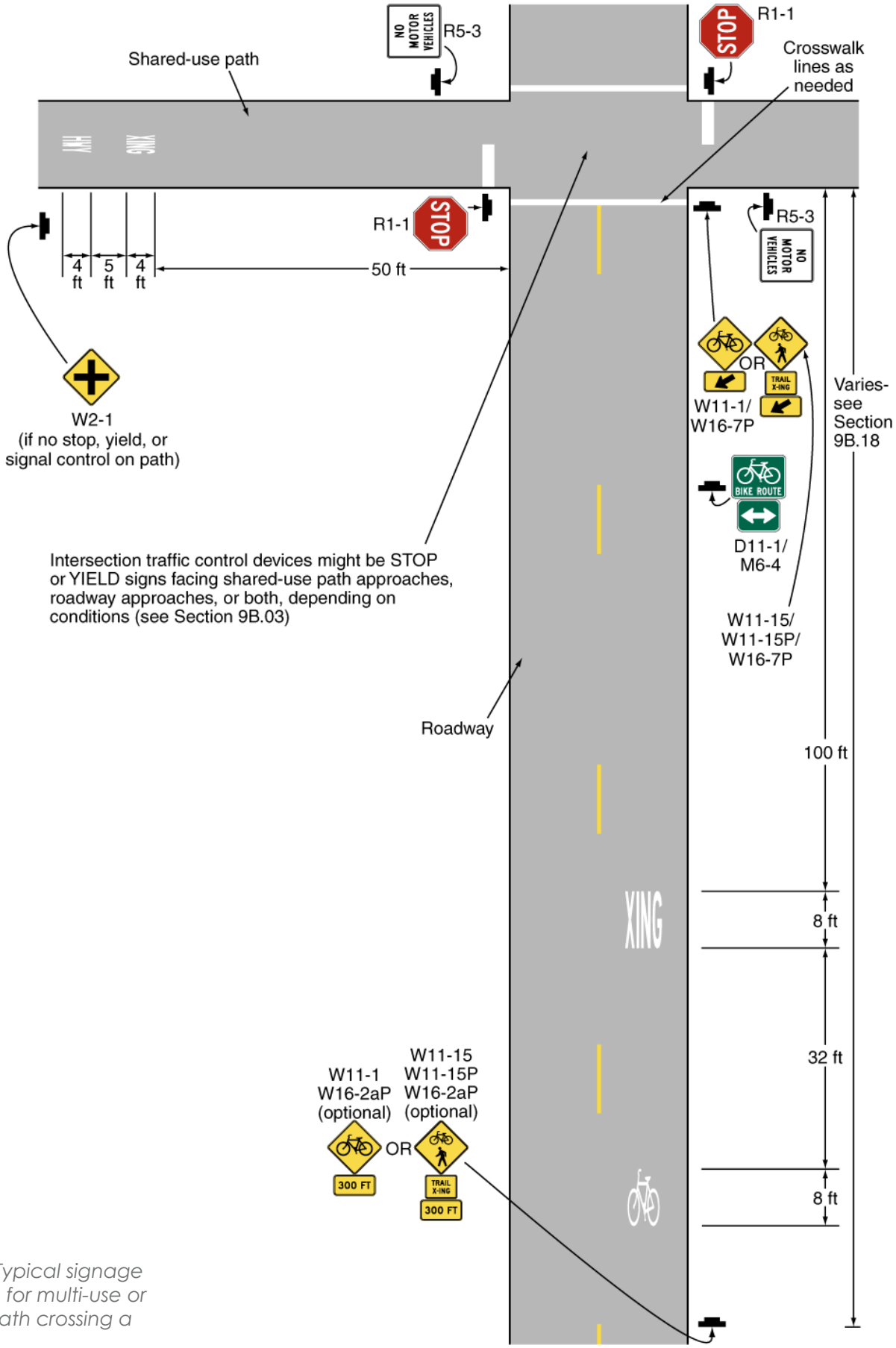


Figure 7.7.6. Typical signage requirements for multi-use or shared use path crossing a roadway.

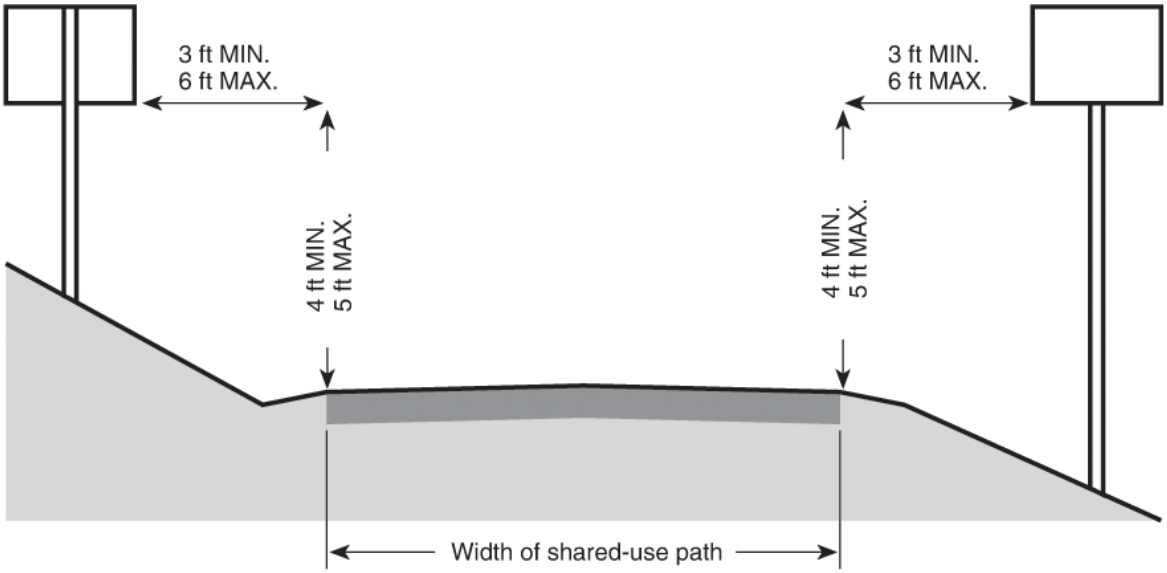


Figure 7.7.7. Typical setback for signage along shared use path.

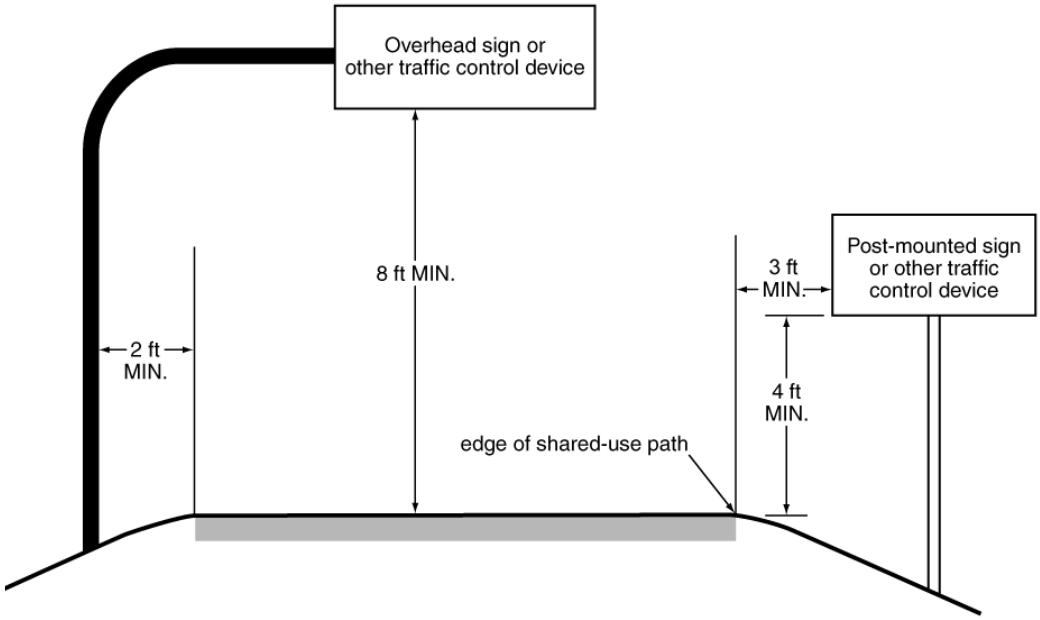


Figure 7.7.8. Sign placement on multi-use or shared-use paths.

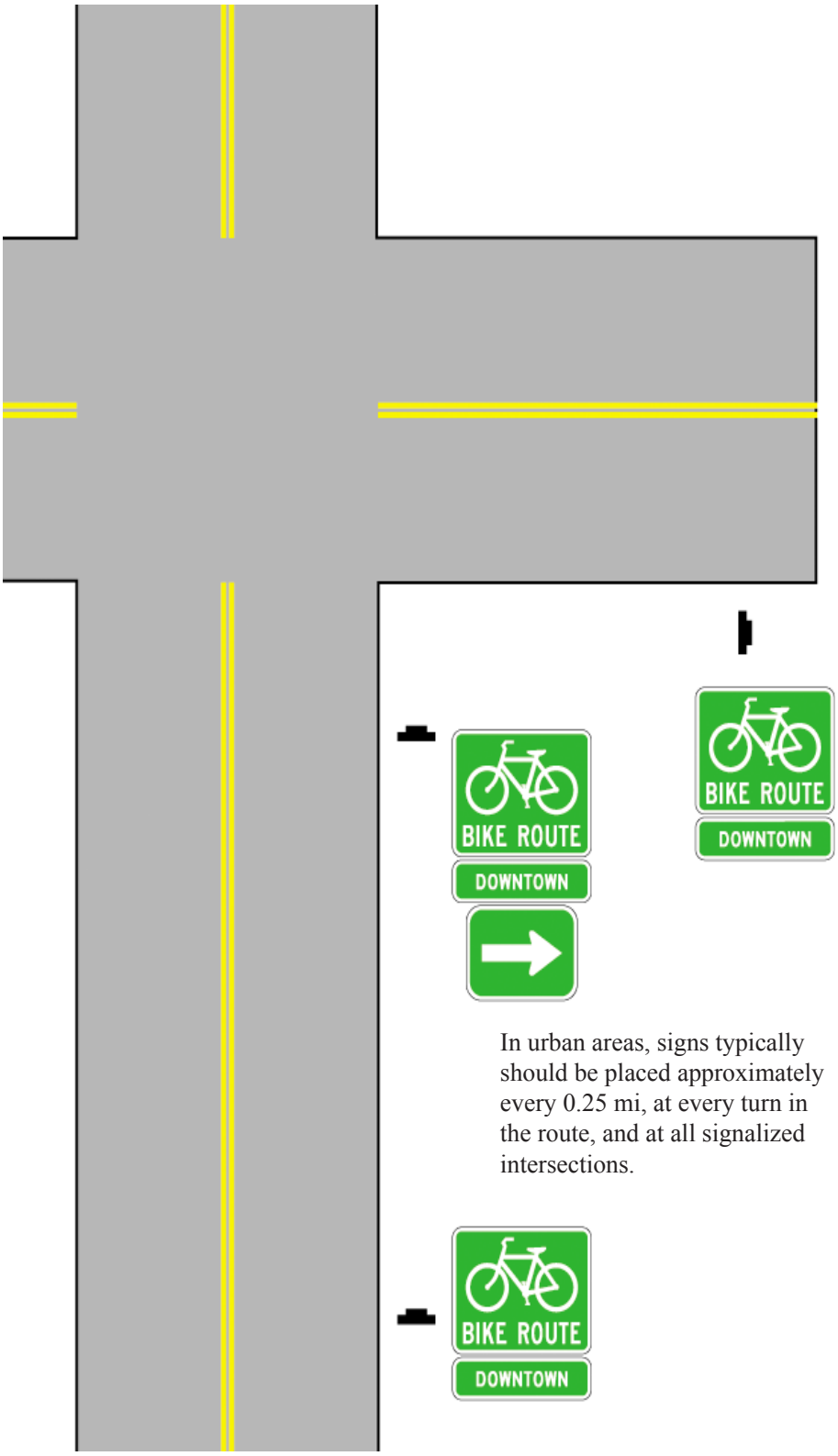


Figure 7.7.9. Example of Typical Sign Placement at the intersection of multi-use trail.

7.8 BICYCLE PARKING & STORAGE

To encourage and facilitate bicycling in Arlington, bicycle parking and storage should be provided at specific points along bicycle routes. Bicycle parking, such as bike racks, should be available for short-term or daily-use. For long-term use (more than 24 hours) bicycle storage is recommended. Bicycle parking and storage should be easily accessible.

A. Bicycle Racks and Standards

Bicycle racks provide a secure place for short and long-term parking of bicycles. They are best located at the entrance of a park, trail head, or other public places, but should be clear of the throughway zone in a sidewalk (Figures 7.8.1 to 7.8.5).

Figure 7.8.1. Example of a functional decorative bike rack.

Design Criteria:

- Provide long-term parking for bicycle to be protected from the weather and secured from potential theft.
- Provide bike racks that secure at least the frame and one of the tires and allow adequate spacing between racks so bikes are easy to maneuver.
- Locate bike racks so they do not obstruct pedestrian or wheelchair movement.
- Locate bike racks in well-lighted and highly visible areas in order to minimize theft and vandalism.
- Avoid installing bicycle racks inside designated loading/unloading, passenger, and pedestrian zones.
- For schools, retail, public buildings, and commercial uses; half of the bicycle parking spaces shall be provided as long-term parking.
- Bicycle racks should be at the same grade as the sidewalk or at a location that can be reached by an accessible route.
- Bicycle racks should be within 50 feet of the main entrance to a building as measured along the most direct pedestrian access route, for a building with more than one main entrance, bicycle racks should be placed at each main entrance.
- If bicycle parking is more than 50 feet from a main entrance, it should be in a central location preferably along a pedestrian route.
- When a bike is parked at a rack there should be no less than 2 feet from the curb and 36 inches from any permanent object to allow for adequate maneuvering space for the bicyclist and for motorists accessing parked vehicles.
- Maintain a 5 feet minimum access aisle or sidewalk adjacent to bike racks.
- There should be at least 2 feet of clearance beside each parked bicycle when installing multiple racks.
- Prevent the wheel of the bicycle from tipping over.
- Support bicycles without a diamond-shaped frame with a horizontal top tube.
- 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.
- Refer to Figure 7.8.5 for guidelines for bicycle parking locations and quantities of facilities.

- Refer to the Association of Pedestrian and Bicycle Professionals (APBP) Guide on Bicycle Parking for more information.
- Comb, toast, 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.

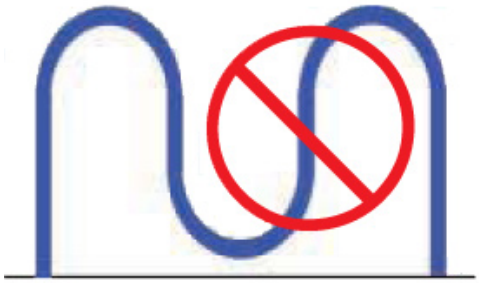
POST AND LOOP

One rack element supports two bikes.

COMB

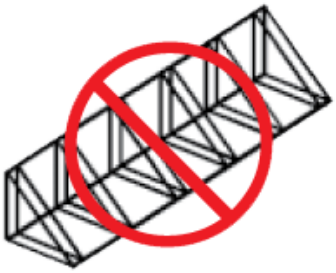
One rack element is a vertical segment of the rack.

NOT RECOMMENDED



WAVE

One rack element is a vertical segment of the rack.



TOAST

One rack element holds one wheel of a bike.

Figure 7.8.2. Recommended guidelines for bicycle parking from the Association of Pedestrian and Bicycle Professionals, 2002, (www.apbp.org).

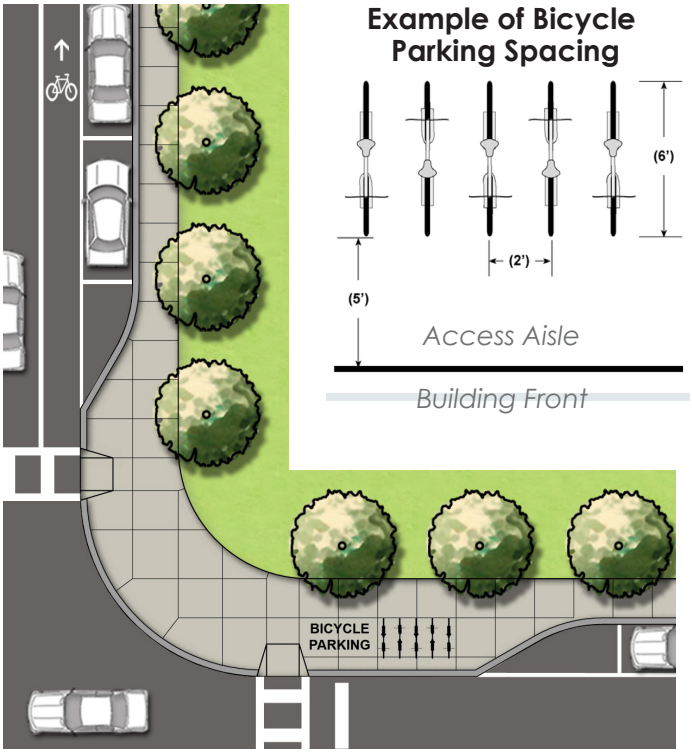


Figure 7.8.3. Example of bicycle parking near urban intersection.

Figure 7.8.4 Example of a well designed bicycle parking area using the single inverted "U" bike rack that can accommodate two bicycles per bike rack.

Land Use or Location	Physical Location	Bicycle Capacity
City Park	Adjacent to restrooms, picnic areas, fields, and other attractions	8 bicycles per acre
City Schools	Near office entrance with good visibility	8 bicycles per 40 students
Public Facilities (City hall, libraries, community centers)	Near main entrance with good visibility	8 bicycles per location
Commercial, retail and industrial developments over 10,000 gross square feet	Near main entrance with good visibility	1 bicycle per 15 employees or 8 bicycles per 10,000 gross square feet
Shopping Centers over 10,000 gross square feet	Near main entrance with good visibility	8 bicycles per 10,000 gross square feet
Commercial Districts	Near main entrnace with good visibility; not to obstruct auto or pedestrian movement	2 bicycles every 200 feet
Transit Stations	Near platform or security guard	1 bicycle per 30 parking spaces

Figure 7.8.5. Recommended guidelines for bicycle parking locations and quantities.

B. Bicycle Stations

Bicycle stations offer secure bicycle parking and other services to bicyclists. These services may include bicycle rentals and repair, bike accessories, showers, restrooms, lockers, and 24-hour secure bike parking. In addition, food and beverages are sometimes served at these stations (Figure 7.8.6).

Design Criteria:

- Parking should be provided for loading and unloading of bikes when bicycle stations are provided.
- Bicycle racks should be provided.
- Benches for seating should be provided.
- Provide drinking fountains and air compressors.
- Restroom facilities should be provided.
- Lighting should be provided.
- Secured storage and covered parking for bikes should be provided.
- Provide appropriate signage addressing bicycle maintenance and storage.
- Fee membership should be required.

Figure 7.8.6. Examples of bicycle stations/lockers. Bicycle lockers offer safe and secure storage at popular destinations. Parking rates are reasonably priced at about 3-5 cents an hour. (www.bikelink.org)

C. Bike Sharing Programs

Bike sharing programs, typically run by municipal governments or community groups, allow people to shift easily from other forms of transportation to bicycle and back again. This promotes bicycle sharing as an easily accessible alternative to motorized travel and enables residents to become healthier through exercise. Bike sharing programs have been operating successfully in Portland, OR; Madison, WI; Washington, DC; and in European countries (Figure 7.8.7).

Bicycles should be made available for shared use by individuals who do not own bicycles. The sharing program should provide for use of a bicycle for short trips inside a "bike zone," thereby reducing traffic congestion, noise, and air pollution. Bike share programs typically require a small deposit to prevent theft.

Design Criteria:

- Fleets should be distinctive, and clearly branded.
- Bikes should come with full fenders, chain guards, and bike locks.
- Global positioning systems (GPS) unit and/or other tracking mechanism should be mounted.
- Provide rack or kiosk for collecting bikes using a credit card or smart card.
- Provide instructions on where and how to return bicycles.
- Provide information on pricing and contact information to report damage.
- Provide a computerized system to check bicycles in and out.
- Provide maps of nearby stations and recommended bike routes.
- Determine direct capital cost (bikes and terminals) operating cost, (administrative, maintenance, power), associated capital cost (construction of system, sidewalk improvements) and the associated operating cost (maintenance) prior to making a commitment to develop a bike share program.
- Develop a public private partnership in operation of bike share program.

Figure 7.8.7. Examples of bicycle sharing programs.

7.9 TRAFFIC CALMING

Developing traffic calming devices throughout the transportation network will help to increase area-wide safety and traffic management. Well-designed traffic calming devices can effectively reduce traffic speeds and volumes, while maintaining local access to neighborhoods. A few of the benefits of traffic calming for bicycling and walking, especially along local streets, include:

- Reduced traffic speed allows bicyclists and pedestrians to safely share the road.
- Treatments, such as improved crossings, enhance the pedestrian environment.
- Traffic calming allows all ages and abilities to use the streets either for walking or biking.

A. Traffic Circles and Roundabouts

- Traffic circles and roundabouts allow bicyclists to maneuver through the intersection in a safe manner. They also slow motor vehicles to a desired speed (Figures 7.9.1 through 7.9.4).
- They may reduce points of conflict between pedestrians and motor vehicles.

Design Criteria:

- Terminate bike lanes before roundabout entrances to allow bicyclists to merge with motor vehicles or allow bicyclists to enter sidewalk.
- Provide adequate radius, offset distance, circle diameter, opening width, and turning for vehicular speeds.
- Provide a refuge to allow safe crossing of travel lanes.
- Maintain and avoid blocking motorist and pedestrian sight lines with landscape enhancements in the roundabouts.
- Provide landscape, lighting, and signage improvements in center of traffic circle or roundabouts.
- Provide mountable curbs at the perimeter of the traffic circle to allow large vehicles, including emergency vehicles, to drive over the edge of the circle, if needed.

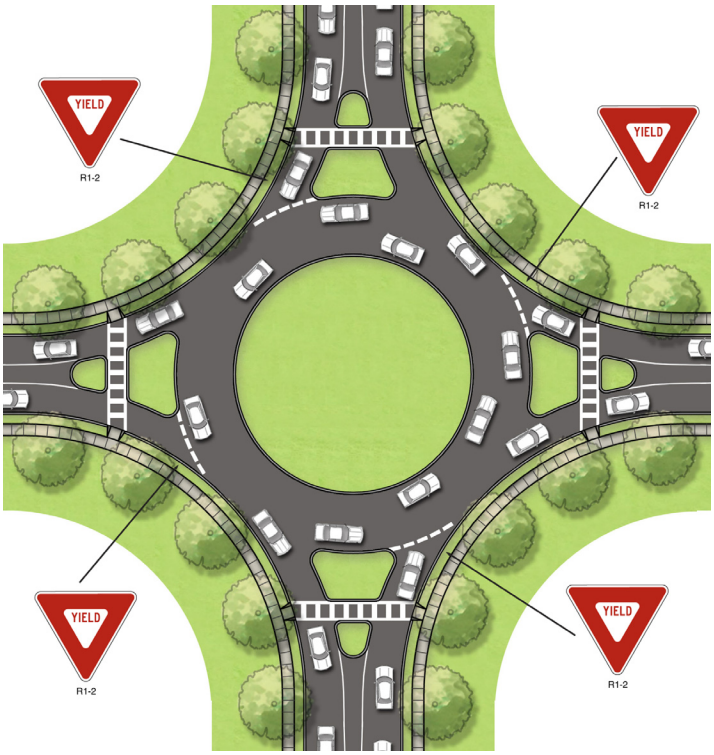
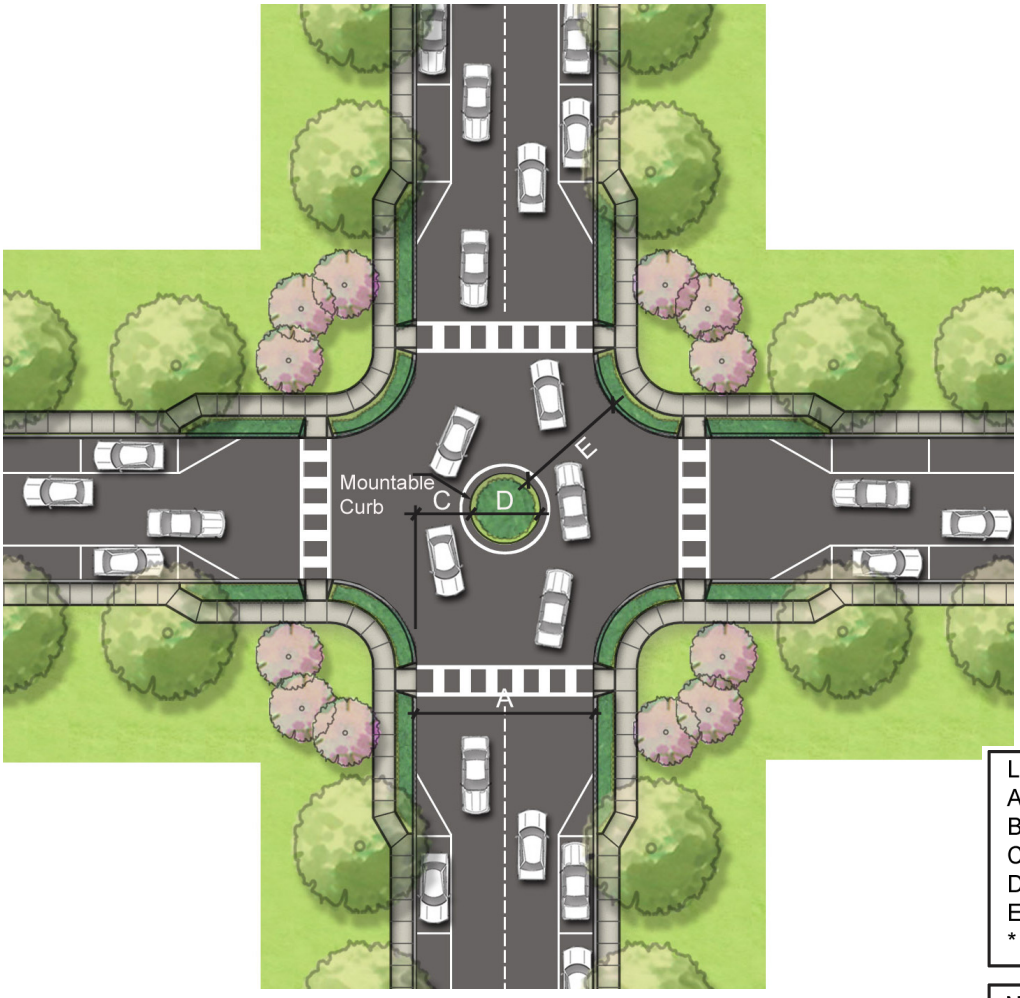


Figure 7.9.1 Example of a roundabout.

Figure 7.9.2 The roundabout at Road to Six Flags and Nolan Ryan Expressway is a pedestrian and bicycle friendly traffic calming device.

Figure 7.9.3. Examples of traffic circles and mini-circle traffic calming devices.

Site Plan of Mini-Circle Traffic Calming Device



Legend
A - Street Width - 32 feet min.
B - Cross street width (varies) 32 feet min.
C - Travel width (10'*)
D - Circle diameter (12' min.)
E - Opening width (18' min.)
* where A<B

Note: To provide for emergency vehicles, traversable low profile landscaping should be used.

Figure 7.9.4. Examples of traffic circle added to existing roadway.

B. Narrow Streets and Travel Lanes

Wide travel lanes often encourage a higher speed of travel, which is unsafe for all users, especially bicyclists and pedestrians. Narrowed streets are either physically narrower or create a perception that they are narrower as a method of calming traffic. Reduced street widths in residential, suburban, and commercial areas are more commonly allowed by local jurisdictions. Narrow streets not only provide the benefits of traffic calming, but also help to create a more attractive and pedestrian friendly character along the street. When the driver's vision is narrowed, the automatic response is to slow down. An effective method to reduce traffic speed is reducing travel lane width and adding on-street parking when roadway width allows. This alternative would allow drivers to adjust to the available lane width and street conditions, while reducing construction and maintenance costs (Figure 7.9.5).

Design Criteria:

- Where appropriate, reduce travel lanes to a minimum of 10 feet to reduce speeds.
- Provide street trees in planting strip along streets to create the perception of narrow lanes.
- Traffic study should be conducted prior to narrowing lane width to ensure safety and traffic management can be addressed.
- Refer to the City of Arlington Thoroughfare Development Plan for the required dimensions of roadways.
- Select and provide appropriate shade trees to survive harsh roadway and environmental conditions.
- Select street trees that can be limbed up to avoid pedestrians and motorist impacts.
- Locate and plant trees back from travel lane to avoid impacting motorists.
- Evaluate drainage and utility cost prior to narrowing of the road or the relocation of curb and gutter.

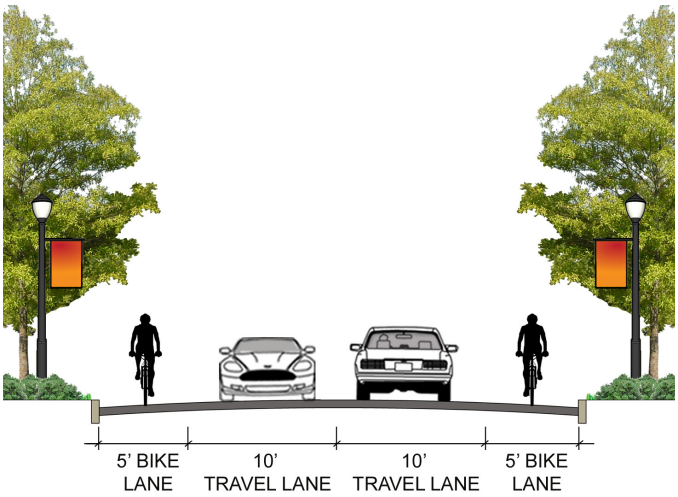


Figure 7.9.5. Examples of narrow streets and travel lanes.

C. Speed Humps/Speed Tables

Speed humps are used to reduce traffic speed by having a gradual mountable slope which would present a minimal discomfort for slower traffic, but would be uncomfortable for drivers at higher speeds. Speed humps are generally installed on local streets with high pedestrian and bicycle traffic, such as adjacent to schools and Main Streets. Bicyclists can ride over speed humps safely (Figures 7.9.6)

Speed tables are similar to raised crosswalks but are used for reducing vehicular speeds only. A raised speed table can be constructed similarly to raised crosswalks but will not include signing and marking for pedestrian crossings (Figures 7.9.7).

Design Criteria:

- Speeds humps are located on streets that have more than 300 and less than 3,000 trips a day.
- Reduce speed between speed humps to 15-20 mph.
- Install street signage indicating speed hump approach a minimum of 100 feet in advance.
- Install speed humps 300 to 400 feet apart on a road.
- Speed humps to be 200 to 300 feet from intersections.
- Add speed limit of 15 mph over speed hump.
- Install pavement marking, including indicating speed hump ahead, white striping and white reflectors.
- Refer to Figures 7.9.8 and 7.9.9 for typical speed hump detail and plan.
- Maintain minimum travel lane requirements per City of Arlington Design Criteria Manual and the Thoroughfare Development Plan.
- A speed table is a reverse curve with a level area in the middle and then another reverse curve. The level area in the middle is approximately the width of a motor vehicle wheel base.
- Refer to Figure 7.9.10 and 7.9.11 for a typical raised speed table detail and plan.
- Evaluate storm drainage design and driveway locations prior to installation of speed humps.

Figure 7.9.6. Perspective sketch of speed hump.

Figure 7.9.7 . Perspective sketch of speed table.

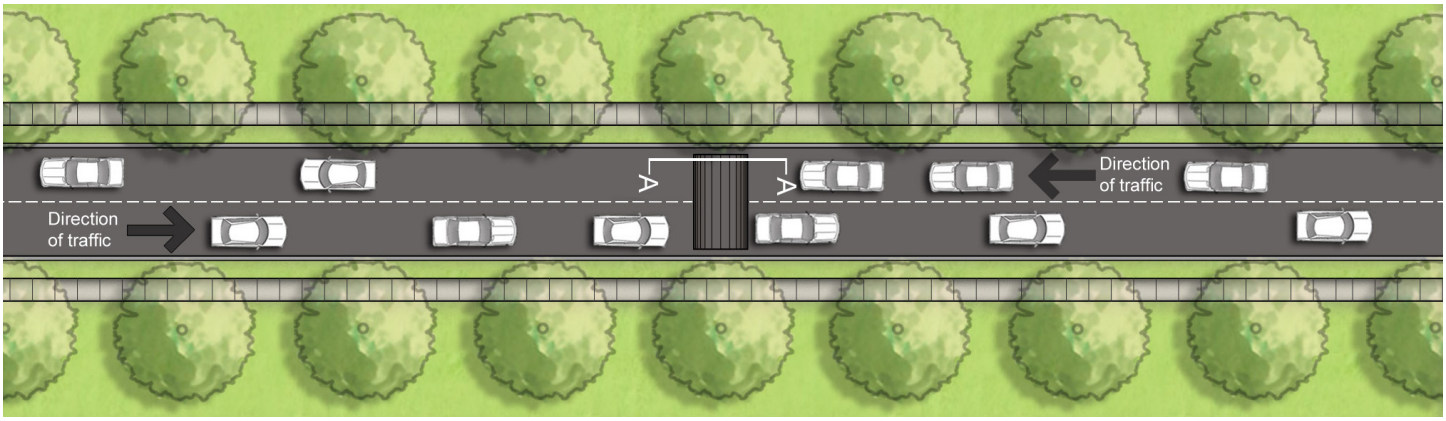


Figure 7.9.8. Site Plan of Speed Hump. Refer to City of Arlington's speed hump/bump policy.

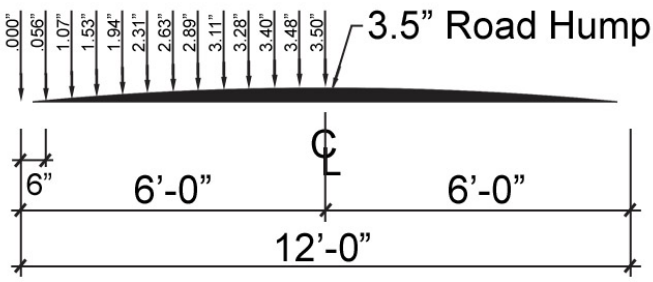


Figure 7.9.9. Speed Hump Section A-A

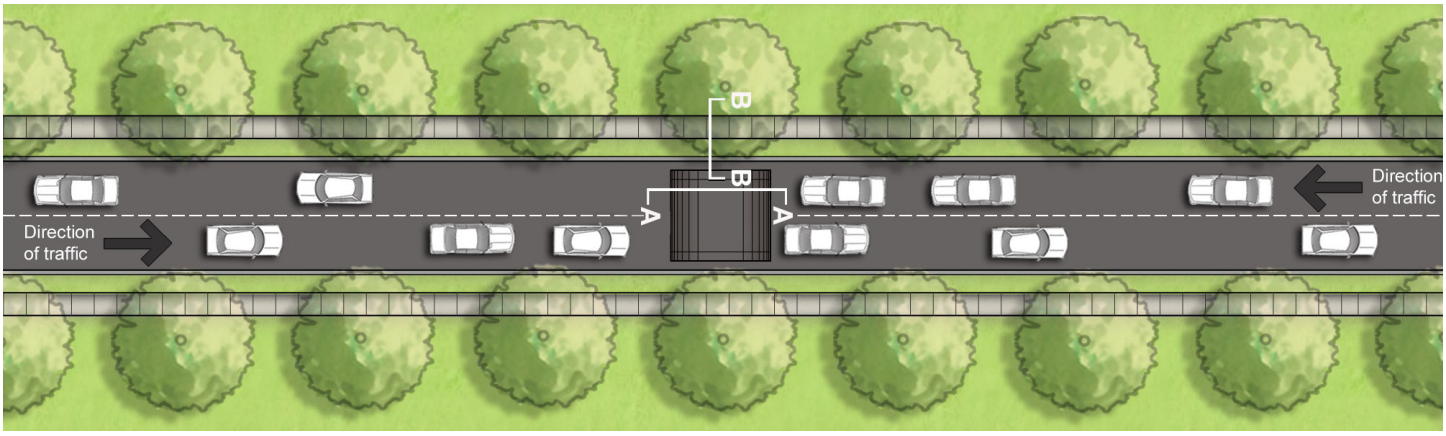


Figure 7.9.10. Site plan of raised speed table used as a traffic calming device.

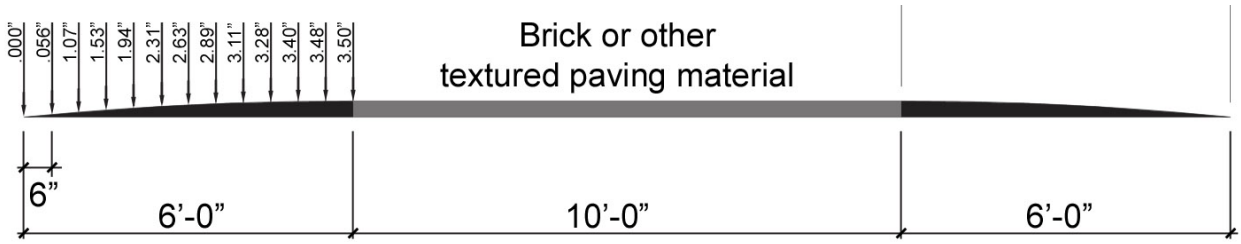


Figure 7.9.11. Example of raised crosswalk or speed table (Section A-A).

D. Chokers

Chokers, also commonly known as bulb outs, curb extensions, or neck downs, are typically installed at curb radii. By adding chokers to curb radii, they reduce distance for pedestrians to cross streets. By reducing the distance to cross a street, pedestrian safety and vehicle movement improves (Figure 7.9.12 and 7.9.13).

Chokers can be used on one side of a one-way street radius and at mid-block crossings where pedestrian traffic is high, such as in downtowns or Main Streets. They can be used at intersections to create a one-way entry or exit point for that specific street alignment.

Chokers are best used where on-street parking is dominant. When chokers are used in conjunction with landscape treatments they can enhance the street and buffer adjacent parking. Chokers help to identify mid-block crossing locations for motorists. They can be used at intersections with high volumes of traffic and significant numbers of crossings, or on minor access roads and local residential streets where there is insufficient time to cross the street.

Design Criteria:

- Maintain pedestrians' and motorists' visibility.
- Provide appropriate traffic signage and traffic signals at intersections and mid-block crossings.
- Provide lighting (street-level or pedestrian-level) and marked crosswalks to enhance pedestrian visibility for mid-block crossings.
- Provide adequate radius for intersections and vehicular turning movement.
- Provide median and refuge islands when the length of the crossing exceeds 33 feet or with three or more travel lanes.
- Evaluate storm drainage and utility locations prior to design and installation of chokers, curb extensions, or bulb outs.
- Provide low growing landscape and plant material in islands.

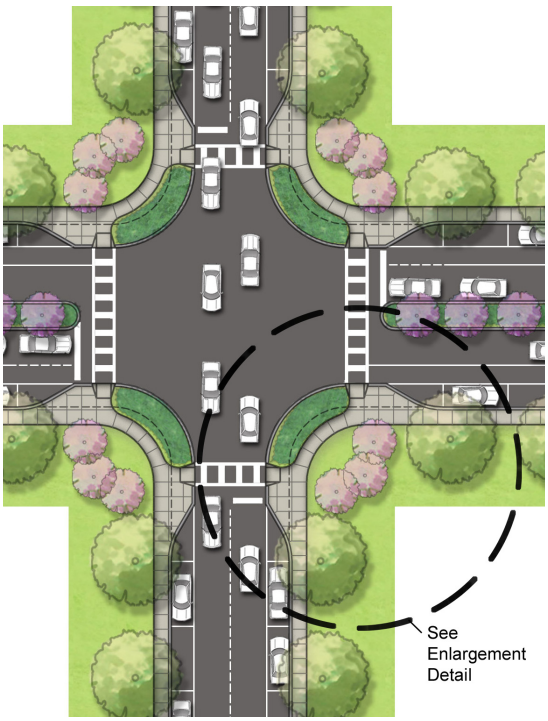


Figure 7.9.12. Site plan of choker traffic calming device.

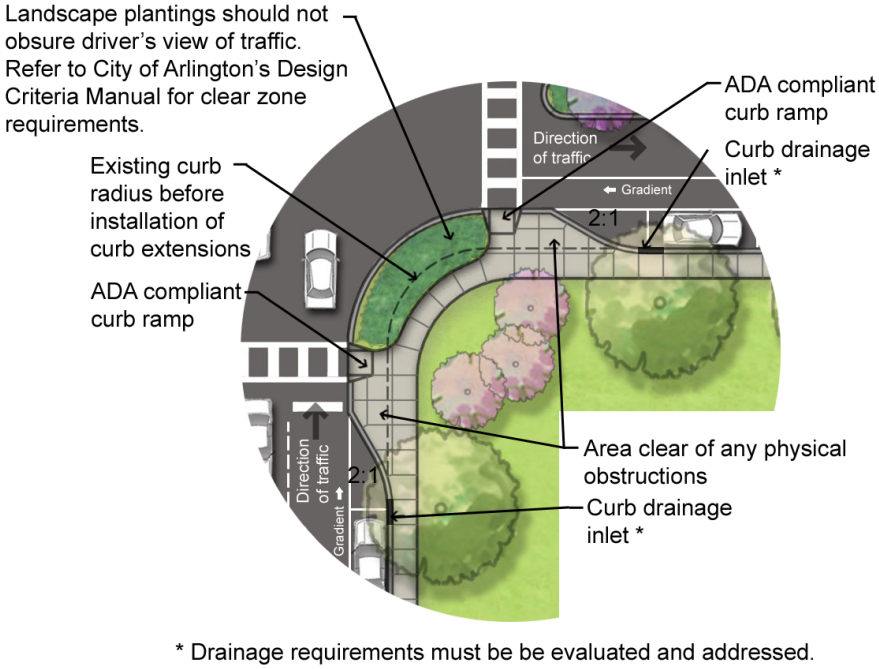


Figure 7.9.13. Choker enlargement detail.

E. Raised Crosswalks

Raised crosswalks are applicable for busy streets with multiple lanes. They are similar to speed tables and typically wider than a speed humps. Raised crosswalks are appropriate at some intersections, mid-block crossings, and drop-off and pick-up zones for high pedestrian traffic generators, such as schools, parks, libraries, and airports. Raised crosswalks are typically marked with high visibility pavement markings, signage, lights, and may be surfaced with special pavement material. Raised crosswalks can directly reduce motorist speeds and increase the occurrence of motorists yielding to crossing pedestrians. Marked crosswalks on both sides of a street allow for better visibility of crossing pedestrian zones by motorists (Figures 7.9.14 and 7.9.15).

Design Criteria:

- Surface should be smooth and a different paving and color than the road to enhance pedestrian safety and visibility.
- Pavers or pavement sections shall meet local, state, and federal load-bearing standards.
- To ensure crosswalk visibility, crosswalks must be marked with reflective lines; high visibility markings are best.
- Proper signage and pavement marking are required in advance of raised crosswalks.
- Refer to the City of Arlington Design Criteria Manual for Crosswalk Standards.
- Evaluate storm drainage and utility locations prior to design and installation of raised median or crosswalks.
- Paving materials are important to the function and look of a street, both in the road and on the sidewalk. Occasionally, paving materials in and of themselves act as a traffic-calming device (e.g., when the street is paved in brick or cobblestone). These materials are however noisy and unfriendly to bicyclists, pedestrians, or wheelchairs. In particular, cobblestone should not be used in the expected bicycle path, although they may be used as aesthetic elements in a streetscape design. Smooth travel surfaces are best for all pedestrians.
- Utilize a concrete paver or natural stone paver with sufficient load-bearing strength.

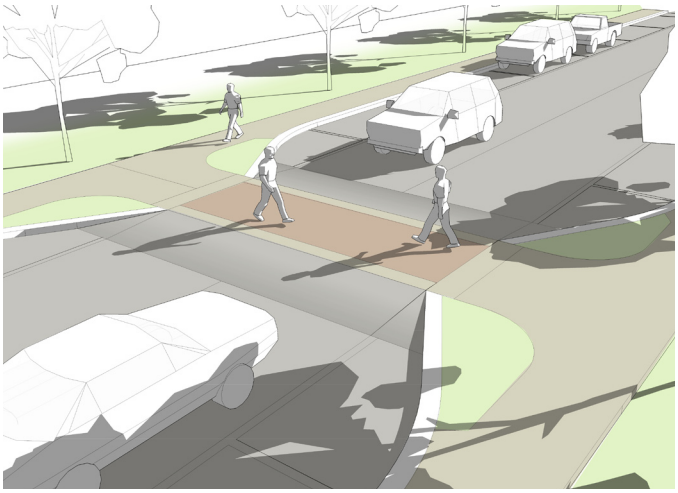


Figure 7.9.14. Perspective sketch of raised median/ crosswalk.

Figure 7.9.15. Example of raised crosswalks.,

F. Colored Bike Lanes

Colored bike lanes are an effective method to provide greater visibility and alert motorists of bicyclists on a busy road. Provide colored pavement for bike lanes where there is a higher probability of conflict. They are used to guide bicyclists through major vehicle/bicycle conflict points, especially at locations where the volume of conflicting vehicle traffic is high and where the vehicle/bicycle conflict area is long. Examples of such locations include freeway on and off ramps, where motorists move into a right turn pocket. In the United States, cities such as Portland and Seattle have experimented with colored bike lanes and supportive signage favorably (Figures 7.9.16 to 7.9.18).

Design Criteria:

- Provide colored concrete, colored seal coat, or colored dyes that can be incorporated in concrete and/or asphalt to provide colored pavement markings.
- For bike lanes use the color green; blue pavement markings are reserved for handicap uses.
- Colored bike lanes to be used at critical points of conflict between motorists and bicycle users.
- Colored bike lanes must be restored after construction with the same preconstruction color and treatment type.

Figure 7.9.17. Example of colored bike lanes.

- Painting or colored additives applied to the pavement material are preferred over thermoplastic striping to reduce slick surface.
- When possible, minimize points of bicyclist and vehicular conflict.
- Use color pavement markings sparingly so that when they are used they have a greater impact.

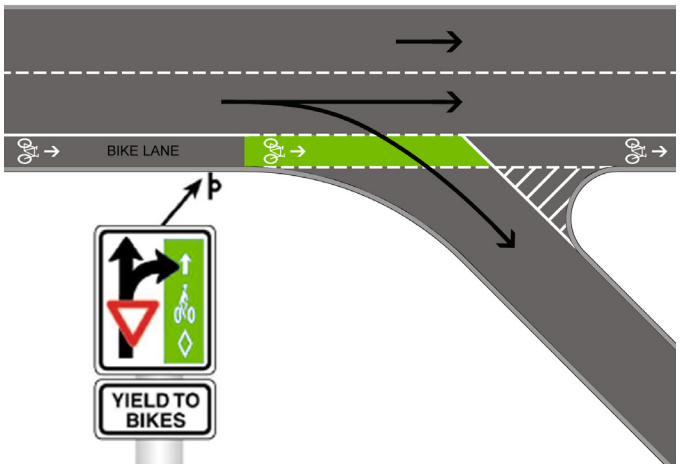


Figure 7.9.18 Colored bike lane at exit ramp/side street. (above)

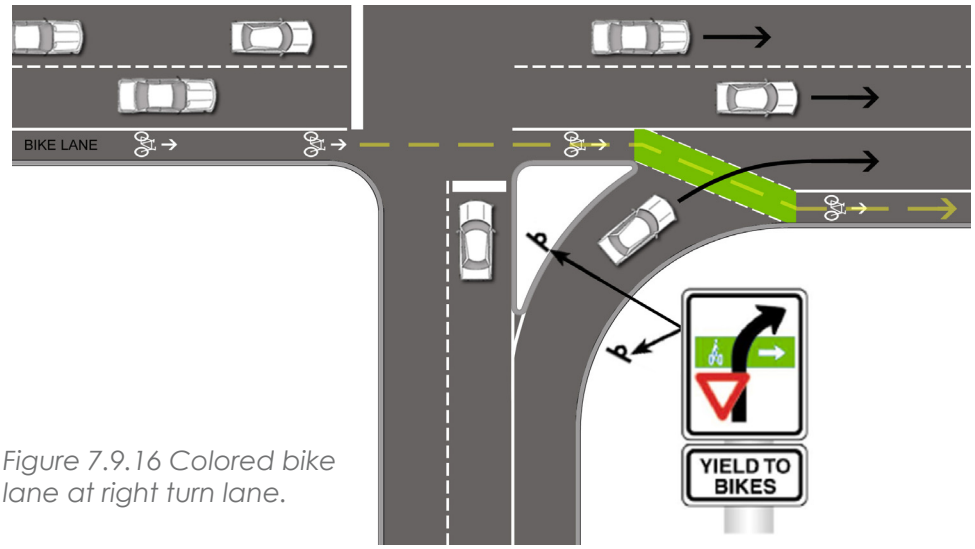


Figure 7.9.16 Colored bike lane at right turn lane.

G. Channelization

Channelization is often used to prevent cut-through traffic onto local streets or to control turning traffic in or out of a neighborhood. Channelization can also be used to reduce speed, create an opportunity for landscaping, control turning movement, direct/guide pedestrians, and to increase the safety of pedestrians and bicyclists. Channelization can be at street-level, provided there is a physical separation, or they can be elevated to create a separation from the roadway. The curb creates the separated space, as well as preventing passengers from opening doors into the cyclists' track and discouraging pedestrians from walking on the facility (Figures 7.9.19 to 7.9.21).

Design Criteria:

- Provide regulatory signage, pavement markings, landscaping, bollards, or raised islands to direct vehicular, bicyclist, and pedestrian traffic.
- Confirm proper warrants and public interest needs during the development of channelization recommendations.
- Signalization, pavement markings, and signage to comply with City of Arlington, MUTCD, AASHTO, and ADA standards.
- The major street must be wide enough to accommodate a 10-foot median.
- Provide treatment only along busy bicycle and pedestrian routes.

Figure 7.9.19. Example of channelization.

Figure 7.9.20. Example of channelization of intersection to prevent through movement.

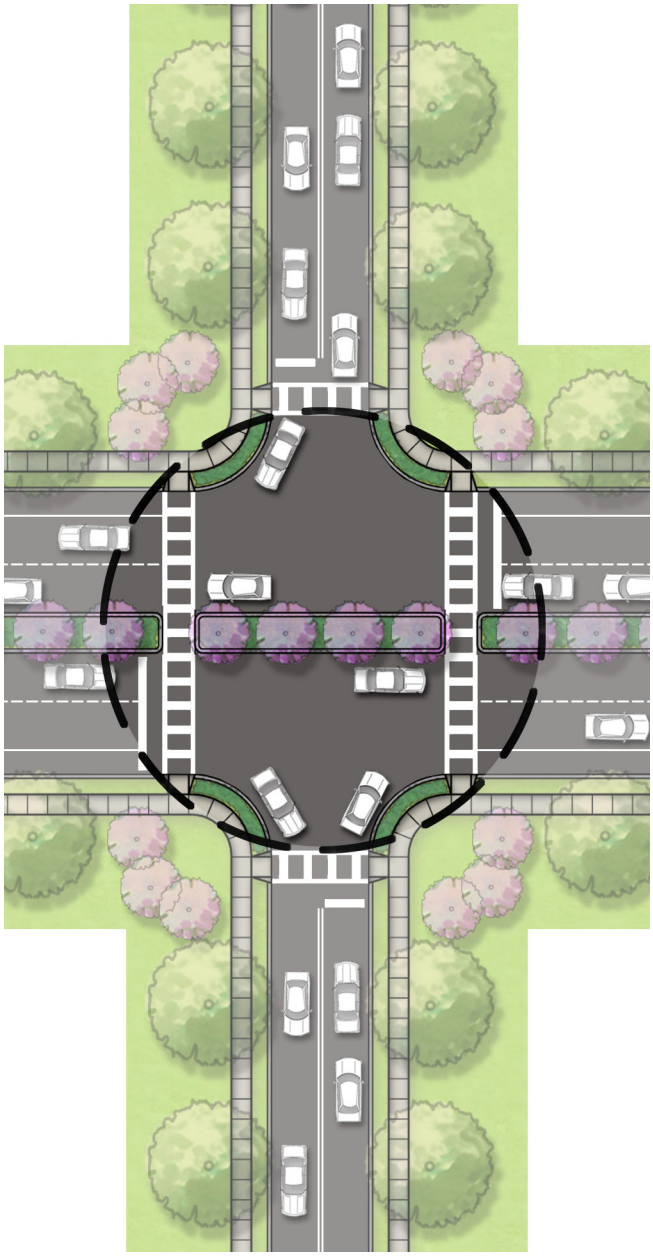


Figure 7.9.21. Site plan of channelization traffic calming device to prevent left turn movement.

H. Chicanes (Lane Diversion)

Another method to increase pedestrian and bicyclist safety is to employ chicanes or lane diversion along a street. Often this is done on local streets, but could be installed on major roads if engineering study results allow for this method to be installed. Shifting a travel lane has an effect on speeds, as long as the taper is not so gradual that motorists can maintain speeds. For traffic calming, the taper lengths should reflect the desired speed. Limits should be posted prior to the chicane. Chicanes create a horizontal diversion of traffic and can be gentler or more restrictive, depending on the design (Figures 7.9.22 through 7.9.27).

Design Criteria:

- Provide curb extension to alter direction of traffic movement, thus reducing speed.
- Reduce posted design speeds to accommodate chicanes.
- Shift traffic alternately from side to side of the street to create an S-shaped path of travel (Figure 7.9.22).
- Spacing of chicane segments depend on site considerations, driveway locations, grades of the road (Figure 7.9.23).
- Bicycles can use the same path as motor vehicles (Figure 7.9.26).
- When bicycles and motor vehicles use the same lane, properly sign lane as a shared path.
- Landscape plantings and islands should not obscure the driver's view of traffic.
- Refer to AASHTO and City of Arlington's Design Criteria Manual and Thoroughfare Development Plan for sight distance, centerline criteria, clear zones criteria, and minimum lane width standards.
- Shift on-street parking to opposite side of the street after the S-shaped path of travel (Figure 7.9.24).
- Build landscaped islands (islands can also effectively supplement the parking shift) (Figure 7.9.27).
- Refrain from installing chicanes on slopes greater than 5%.

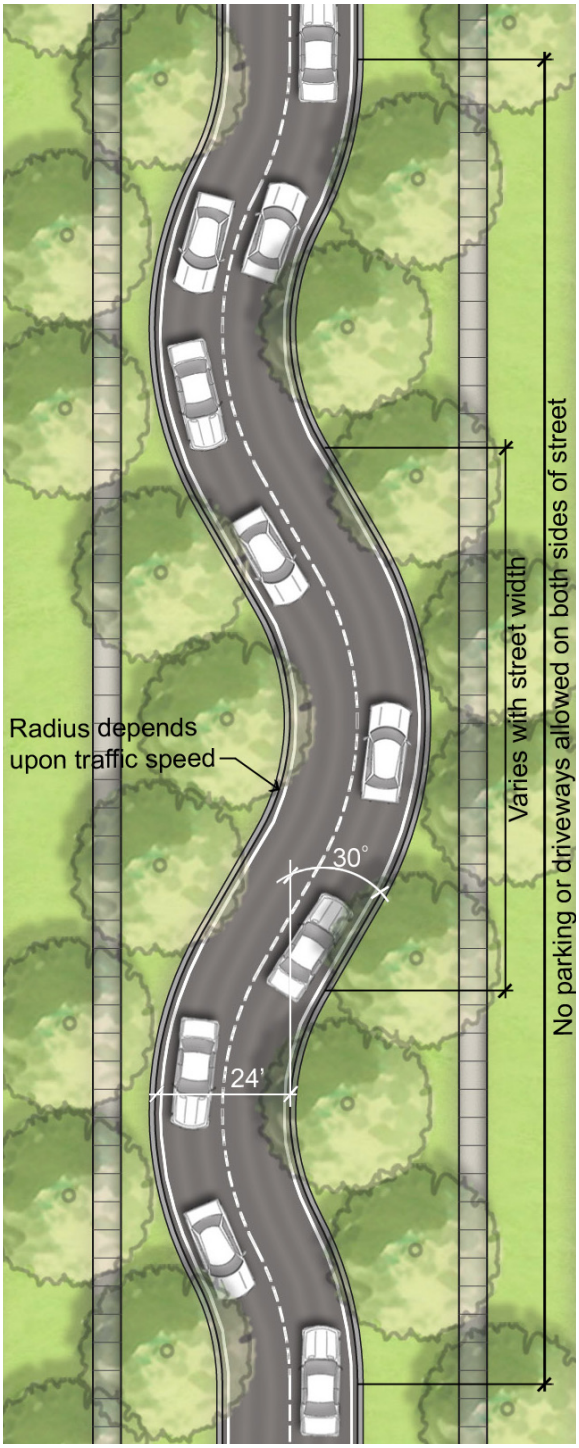


Figure 7.9.22. Site plan of chicane for new installations.

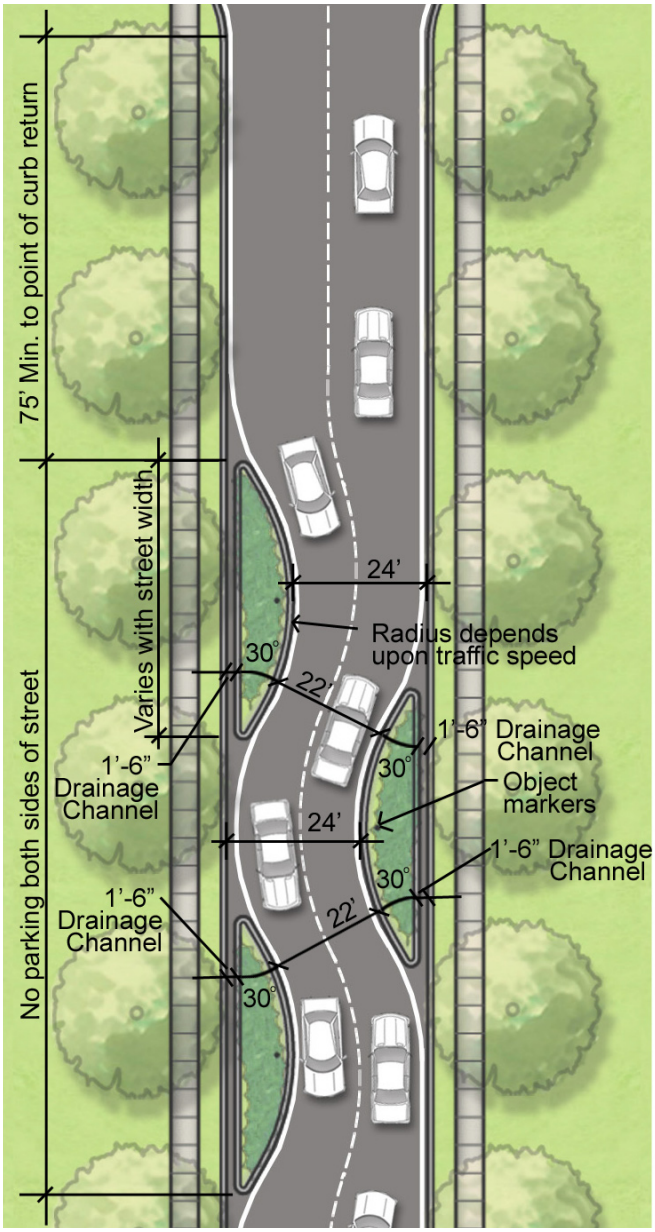


Figure 7.9.23. Site plan of chicane for retrofit installations.

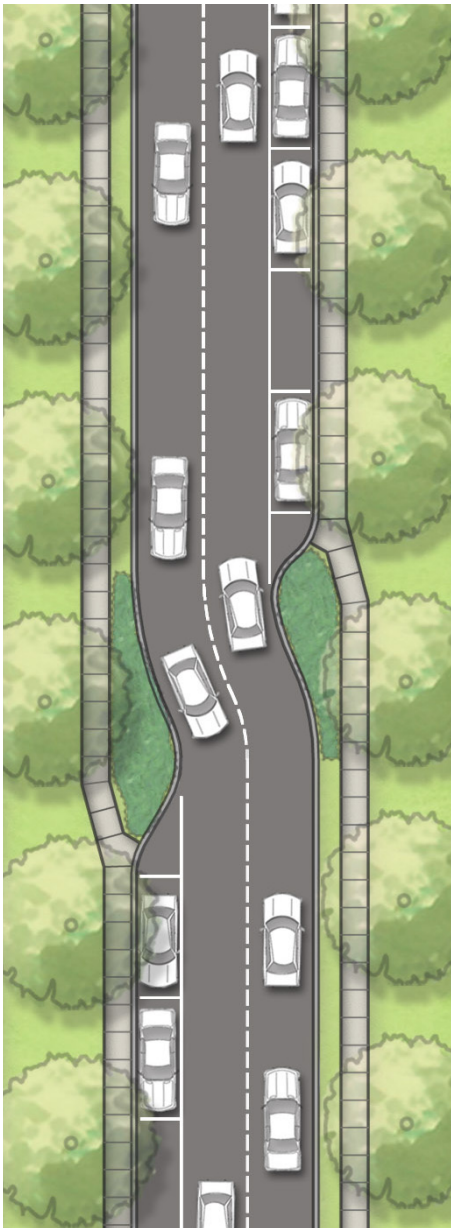


Figure 7.9.24. Site plan of chicane created through alternate parking.

Figure 7.9.25. Spacing of chicane segments depends on existing site conditions.

Figure 7.9.26. Bicyclist flow through the same path as motorists.

Figure 7.9.27. Built islands to help create parking opportunities.

I. On-Street Parking

On-street parking creates the perception of a narrow street, especially if parking occurs on both sides. On street parking also buffers pedestrians from vehicle traffic. Additional space should be provided for the nearest travel lane to the parking to prevent conflict with bicyclists and doors from parked vehicles (Figure 7.9.28).

Design Criteria:

- Refer to City Arlington Development Standards for angled and parallel parking design standards.
- Provide a minimum 4 foot wide door zone adjacent to the bike lane, if parallel parking is provided.
- Provide bulb extensions at intersection to allow visibility of pedestrians by motorists.
- Require adequate signage and lighting to increase visibility of pedestrians and bicyclists.
- Provide appropriate pavement signage and markings to identify use of bike lanes, door zone, and parallel parking.
- Provide adequate lane width for large vehicle turning movements.
- Landscape plantings should not obscure the driver's view of traffic. Refer to the City of Arlington's Design Criteria Manual for clear zone requirements.

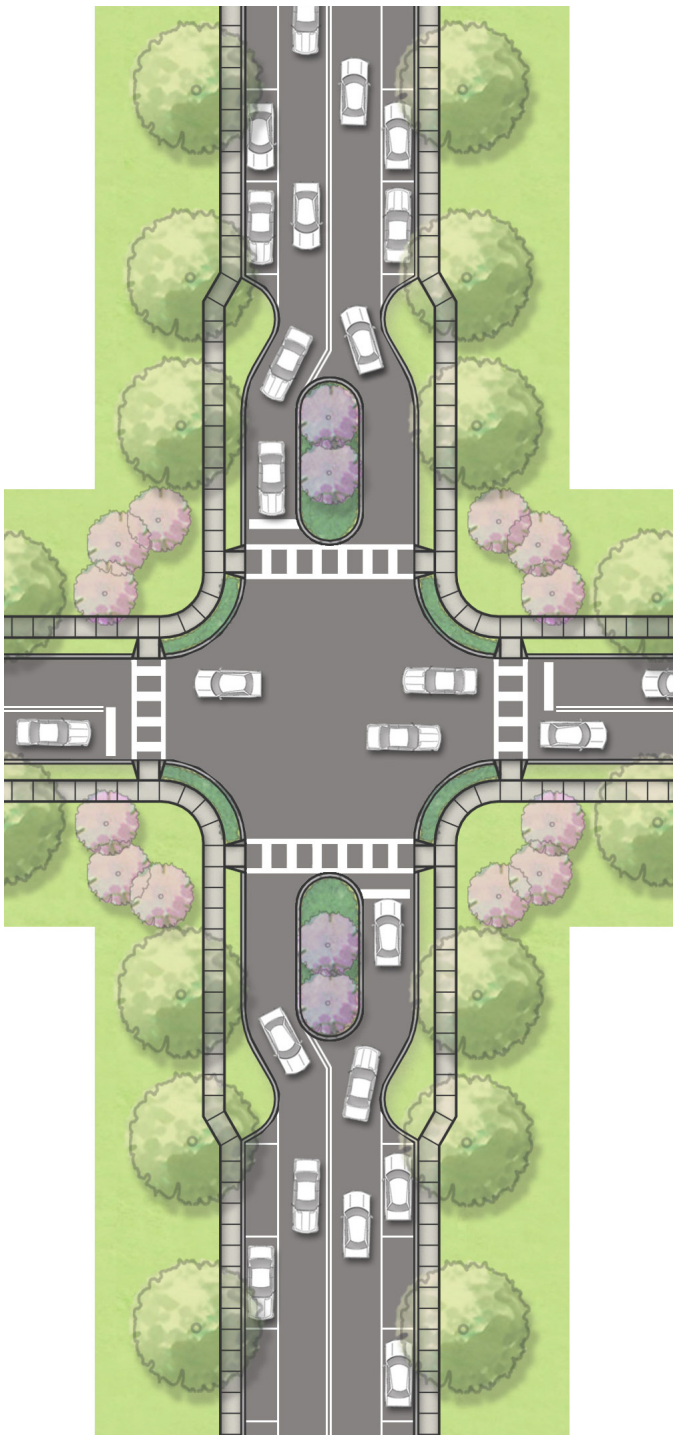


Figure 7.9.28. On-street parking slows down traffic.

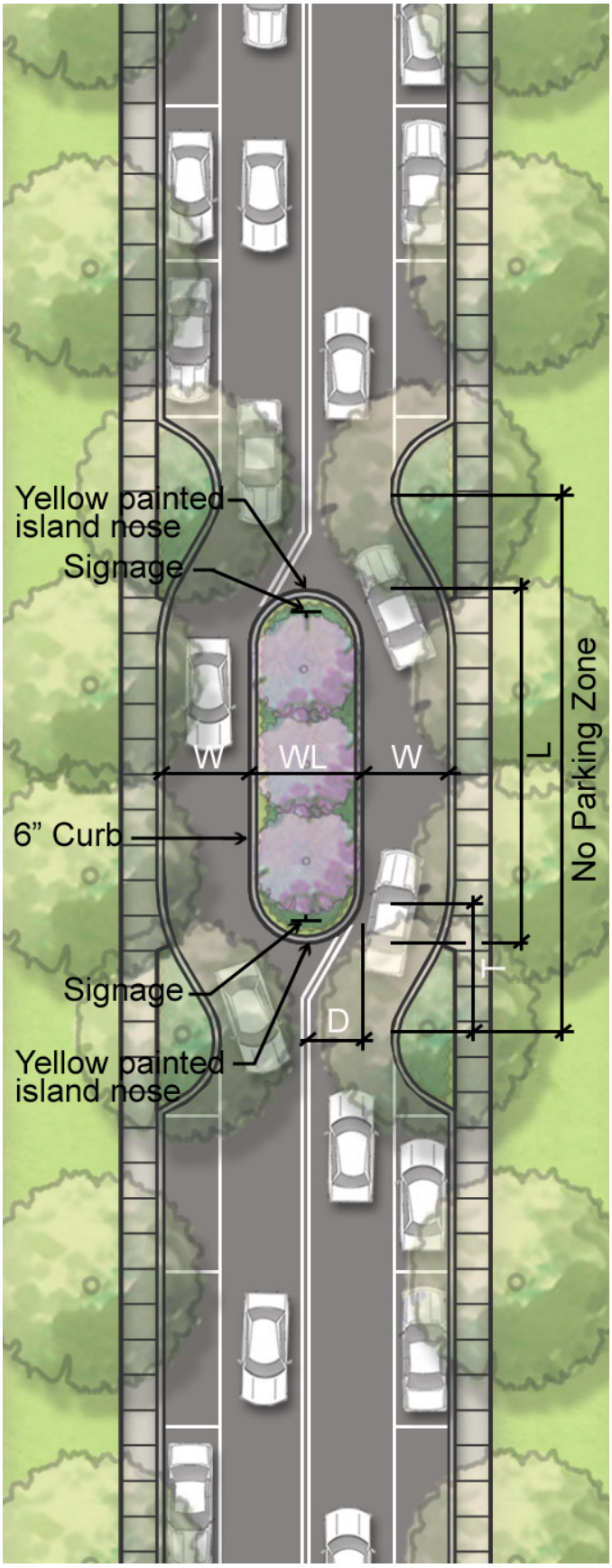


Figure 7.11.29. Site plan of mid block median slow down traffic calming device.

J. Median Slow Down

Center medians or islands that narrow a road are often landscaped to provide a visual and physical amenity. Center medians or islands are placed at entrances into neighborhoods or at a mid block crossing, combined with textured pavement and landscape improvements, to help slow down traffic and create a gateway for the neighborhood (Figures 7.9.29 and 7.9.30).

Figure 7.11.30. Example of mid block median slow down through neighborhood street.

Legend

W - Travel lane width = 14'-0"

WL - Width of slow point/median (varies depending on street width, 12' minimum)

L - Length of slow point, varies depending on parking and driveways

D - Horizontal deflection, 6' minimum

T - Transition, calculated as follows:
T = (D x S<2) / 120 - minimum
Where: D=deflection in feet
S = 85th percentile speed in mph

Note:
Median landscape planting should not obscure driver's view. Refer to City of Arlington's Design Criteria Manual for clear zone requirements.

Design Criteria:

- Reduce speed limits.
- Provide signing and markings in accordance with City of Arlington, AASHTO, and MUTCD standards.
- Refer to the City of Arlington's Thoroughfare Development Plan for minimum lane widths.
- Confirm drainage pattern and adjusts structures as needed.

K. Restricted Turn Only

Restricted turn only or half closures are barriers that block travel in one direction for a short distance on an otherwise two-way street. It may also limit two-way traffic to one directional traffic flow. Restrictive turn only improvements avoid extreme traffic volume problems and limited conflicts between motorist, pedestrian, and bicyclist, while maintaining local neighborhood access. A half closure integrates elements of a forced turn island by directing all vehicles to turn left or right and changes a street into a one way street with on-street parking (Figure 7.9.31).

Design Criteria:

- Reduce speed at intersections and along corridors.
- Provide proper signing and markings in accordance to the City of Arlington, AASHTO, and MUTCD design standards.
- Refer to the City of Arlington Thoroughfare Development Plan for minimum lane requirements.
- Provide traffic plan to determine if restricted movement may have effect in other nearby streets.

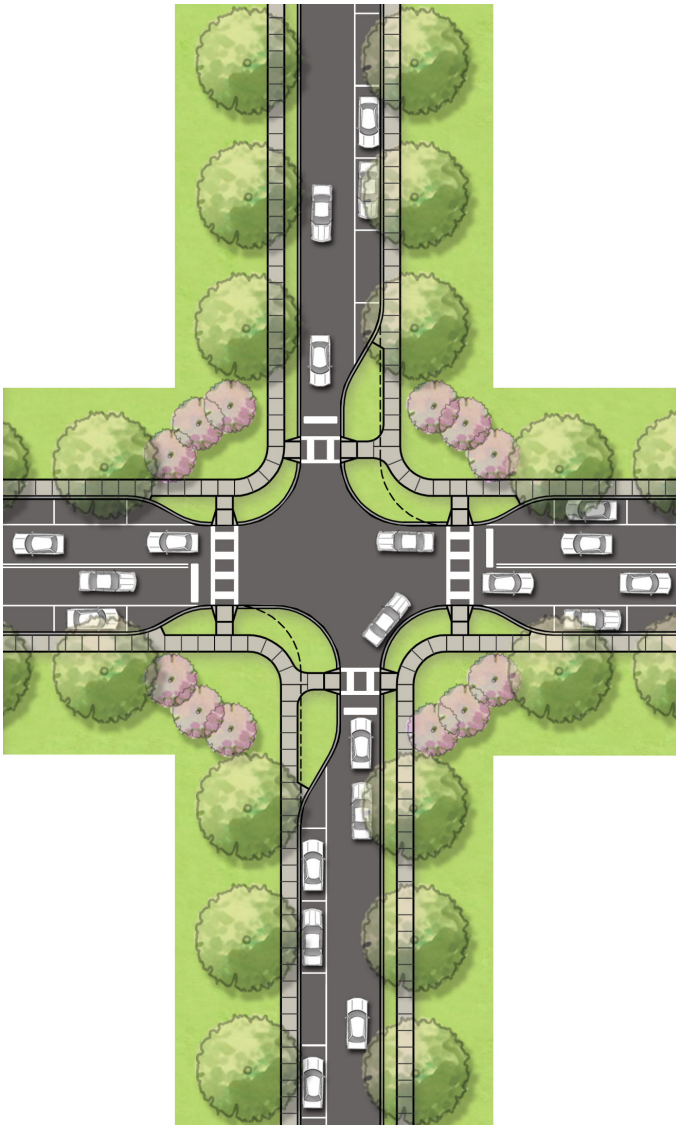


Figure 7.9.31. Site plan of restricted right turn only traffic calming device.

7.10 BIKEWAY & WALKWAY MAINTENANCE

The issues of proper maintenance and security should be addresses during the planning and design phases of the project as well as at the completion of the construction. Bikeways and walkways should be constructed only if adequate budgets for maintenance and security can be provided. Maintenance is essential to the safety of the trail user as well as extending the useful life of the project. Items for consideration include scheduling and documentation of inspections with regard to the condition of railings, bridges, trail surfaces, proper and adequate signage, removal of debris, and coordination with all agencies that maybe associated with trail maintenance. Maintenance is dependent upon a variety of development and use factors and therefore, each type of bikeway and walkway should have a maintenance program established for that specific type of improvement.

A maintenance program should plan, prioritize, schedule, and track maintenance work by:

1. Identifying specific maintenance goals and standards which will provide a consistent level of service.
2. Developing the necessary maintenance programs specific to the facility types.
3. Executing the maintenance programs by using the most efficient resources.
4. Conducting an ongoing evaluation the effectiveness of the maintenance program.
5. Developing cost data from which future budgets can be built.

Identify Project Areas

The first step in implementing a maintenance system plan is to determine the bikeway and walkway routes. An inventory of the physical features on or adjacent to the bikeways and walkways and the total mileage of each type of improvement should be prepared. The inventory should be updated when features are added, modified, replaced, or removed. An inventory is critical in preparing the maintenance budget and in determining the total dollar amount needed to fully maintain the bikeway and walkway system. By comparing the needed funds to available funds, a long range maintenance plan can be developed. If kept current, maintenance logs may be used to prepare documentation for contract packages, and will show the location of structures and other features which require maintenance.

Identify Maintenance Priorities

The assigning of maintenance level priorities to the hike and bike system is based on criteria such as amount of use, potential to affect resources, safety considerations, etc. Once maintenance priorities are established, they should be reviewed and updated annually. When assigning maintenance levels, give higher priority to bicycle and trail facilities where use is significant. Traffic counters to collect and record traffic volume data can be used to determine facilities that receive the most use. This data collection should proceed on a continuing basis to provide necessary information for planning, developing, monitoring, and confirming maintenance levels.

Identify Maintenance Activities

Determine what maintenance activities will be tracked and the necessary steps that are required. Activities may be tracked by a broad category such as by maintenance, which would lump all the specific work activities and specific costs for these activities (such as cleaning, rebuilding or replacing, etc.) under one broad activity. Specific activities may be tracked to aid in the preparation of contract estimates or to compare in-house costs to contract costs for certain activities. Condition surveys can also be performed in locations where higher maintenance needs are anticipated, such as areas that have significant traffic, steep grades, bad soils, drainage problems, etc. Special emphasis should be given to these types of locations.

Identify Maintenance Standards

Maintenance standards should be established to document work requirements to meet the acceptable physical standard, or the acceptable end product for a maintenance level, or for a particular activity. The maintenance standard is met when all the work activities listed on the standard are completed.

Identify Maintenance Program

A "maintenance program" is written to show the work that is required to bring the bike or trail to a standard level and will include the associated cost. The maintenance needs identified in the prescription should be prioritized and used in the development of the annual maintenance plan.

Developing Maintenance Plans

The following describes an optional method for preparation of a maintenance plan.

a. The person responsible for maintenance determines the following for each facility:

(1) A maintenance level,
(2) A base maintenance year, and
(3) A maintenance frequency based on the expected trail use.

After all information is collected, combine the individual plans to see if the annual maintenance plans for maintenance period relates to the expected annual funding, and to assure that the movement of personnel and equipment from one facility to another is reasonable. Adjust the plan as necessary; the resulting report will be the proposed maintenance plan.

b. An annual maintenance plan may be developed from the long range maintenance plan by generating a list of the bikeways and walkways to be maintained in any given year.

c. Prepare a maintenance work plan for the approaching season. Various formats for the maintenance plan may be developed. At a minimum, the plan must identify cost estimates, funding sources, and the party responsible for performing the work on the trails.

d. Use the annual maintenance plan to estimate costs for the required work and determine the funding needs for the next budget period.

Deferred Maintenance Plan

Develop a plan for the accomplishment of deferred maintenance. The plan should indicate the items of deferred maintenance, the estimated cost of the work, and the anticipated year of accomplishment. The plan should be balanced, so as to accomplish a percentage of the deferred maintenance annually.

Scheduling

Document the work that will be performed within the season. Documentation of work schedules is important (1) to ensure that high priority work is accomplished first, (2) to determine if all required work is being accomplished on time and (3) to provide a documented history of maintenance scheduling for future maintenance managers.

A. Maintenance to be performed on a regular basis:

1. Bikeway and walkway inspection

Inspections are integral to all bikeway and walkway maintenance operations. Inspections should occur on a regularly scheduled basis, the frequency of which will depend on the amount of use, location, age, and the type of construction. All inspections are to be documented.

2. Leaf and Debris removal

Keeping the bikeway and walkway surfaces clean is one of the most important aspects of facility maintenance. Mud and other sediment shall be removed along with fallen leaves and branches to ensure the safety of the users and increase the life expectancy of the facilities. Areas that require sweeping of the whole system shall be swept by machine. Bikeways or walkways that require only spot sweeping of bad areas will be cleaned with blowers. Some locations will require a combination of methods. Broken glass and small stones are not only unsafe for bicyclists or pedestrians, but the debris can also cause damage to tires and serious injury. Regular maintenance of bikeways and walkways shall be required on a set schedule to improve the safety of its users.

3. Trash removal

Trash removal from trail corridors is important from both a safety and an aesthetic viewpoint. Trash removal includes removing ground debris and emptying trash containers. Trash removal

will take place on a regularly scheduled basis, the frequency of which will depend on trail use and location.

4. Tree and brushing pruning

Tree and brush pruning will be performed for the safety of bikeway and walkway users. Pruning will be performed to established specifications on a scheduled and as needed basis.

- Maintain minimum vertical clearance along bikeways and sidewalks. Low vegetation can encroach on the bicyclist and pedestrian zones, and can be a nuisance and safety concern.
- Vegetation can obscure visibility of motorists at intersections.
- Vegetation can prevent road signage from being visible and reduces illumination of an area, especially at night.
- Tree roots can make uneven pavement surface. Prune and control tree roots to prevent uneven surfaces.
- Trim vegetation to prevent encroachment and to maintain a clear zone at intersections.

5. Mowing of vegetation

Bikeway and walkway maintenance personnel should mow vegetation along trail corridors on a determined schedule. Brush and grasses should not be allowed to grow to excessive heights along the edges of bikeways and walkways.

6. Scheduling maintenance tasks

Inspections and repair of bikeway and walkway related maintenance concerns will be regularly scheduled. Inspection and repair priorities should be dictated by use, location, and design. Scheduling maintenance tasks key towards the goal of consistently clean and safe trails.

B. Maintenance to be performed on an irregular or as needed basis:

1. Roadway Repairs and Maintenance

Roadway surfaces may be adequate for automobiles, but may often not be safe for bicycles and pedestrians. Poor pavement drainage, pavement failures, and debris are some examples of road hazards for bicyclists and pedestrians. Roadway pavement surfaces should be repaired, to maintain pedestrian and bicyclist safety. Pave street over the entire roadway surface to avoid any abrupt road edge (Figure 7.10.1).

2. Bikeway and Walkway Repair

Repair of asphalt or concrete on bikeways and walkways shall be closely tied to the inspection schedule. Prioritization of repairs is part of the process. The time between observation and repair of a trail will depend on whether the needed repair is deemed a hazard and to what degree the needed repair will affect the safety of the user. It also depends on whether the needed repair can be performed by the trails maintenance crew or if it is so extensive that it needs to be repaired by outside entities.

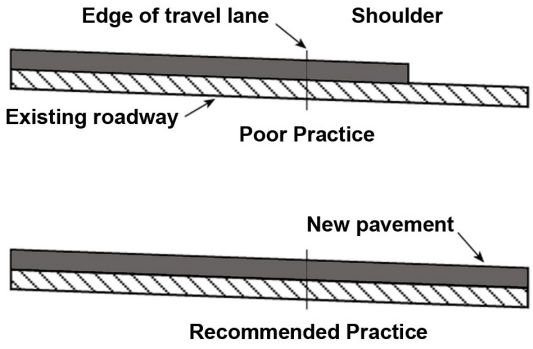


Figure 7.10.1. Example of on-road repaving at bike lane or shoulder.

3. Bikeway and Walkway Replacement

The decision to replace a bikeway or walkway and the type of replacement depends on many factors, such as the age of the facility and the money available for replacement. Replacement involves either completely overlaying an asphalt trail with a new asphalt surface, or replacement of an asphalt trail with a concrete trail. In general, replacing asphalt with concrete is desirable.

4. Bikeway and Walkway Signage and Markings

Bikeway and walkway signs fall into two categories: safety and information. Trail users should be informed where they are, where they are going, and how to use the facilities safely. Signs related to safety are most important and should be considered priority and shall be maintained. Informational signage can enhance the users' experience. Inspection of bikeway and walkway safety and information signs and other pavement markings is critical. Signage should be visible at all times for all users. Horizontal signs and pavement markings on the street should be visible and the appropriate color reflectivity should be used. Replace defective signs and pavement markings on an as needed basis.

5. Weed control

Weed control along Bikeways and walkways will be limited to areas in which certain weeds create a hazard to users. Environmentally safe weed removal methods should be used, especially along waterways.

6. Edging

Edging maintains bikeway and walkway widths, and improves drainage. Problem areas include trail edges where berms tend to build up and where uphill slopes erode onto the trails. Removal of this material will allow proper draining, allow the flowing action of the water to clean the trail, and limit standing water.

7. Drainage control

A culvert often becomes clogged with trash and debris and must be cleaned to prevent flooding and undercutting of pavement surfaces. In places where low spots on the bikeway or walkway catch water, the pavement surface should be raised or drains should be considered to carry away water. Drainage control can also be achieved through the proper edging of trails. If drainage is corrected near steep slopes, the possibility of erosion must be considered. Drainage structures shall be flush with pavement surfaces or adjusted as needed to prevent damage and harm to pedestrians and bicyclist and to maintain proper drainage.

8. Maintenance of water crossings

Water crossings can be bridges, boardwalks or open box culverts. Debris needs to be removed on an as needed basis from the structures to allow the free flow of water and to reduce the risk of flooding. These structures need to be inspected on a regular basis for erosion control and action taken accordingly to preserve or replace structures.

9. Revegetation

Areas adjacent to bikeways and walkways that have been disturbed for any reason should be revegetated to minimize future erosion concerns.

10. Habitat enhancement and control

Habitat enhancement is achieved by planting vegetation along trails, mainly trees and shrubs. This can improve the aesthetics of the trail, help prevent erosion, and provide for wildlife habitat. Habitat control involves mitigation of damage caused by wildlife. An example is the protection of trees along waterways from damage caused by beavers.

11. Coordination with other agencies

Maintenance of bikeways and walkways can often be located within more than one jurisdiction. A clear understanding of maintenance responsibilities needs to be established to avoid duplicating efforts or missing maintenance on the sections of the facilities.

12. Graffiti control

The key to graffiti control is prompt observation and removal. During scheduled trail inspections any graffiti should be noted and the graffiti removal crew promptly notified. Vandalism left unattended encourages more of the same activity and should be a high priority of maintenance.

13. Law enforcement

Law-enforcement effort is critical towards the goal of a safe bikeway and walkway system. Law enforcement agencies should be aware of the location of facilities, and the types and lev-

els of use they receive. Increased law enforcement awareness shall be addressed on an as needed basis.

14. Proper training of employees

Properly maintenance training for employees is essential to the efficient operation of the bikeway and walkway maintenance program. All employees should be thoroughly trained to understand and be aware of all of the abovementioned aspects of the bikeway and walkway maintenance. Safety, a good work ethic, and proper care of equipment and tools will always be the backbone of a good training program. Employees must also be aware of the need for positive public contact. Proper positive attitude towards public questions and concerns is important, as is the conveyance of this information to supervisors.

15. Record Keeping

Good record-keeping techniques are essential to an organized program. Accurate logs should be kept on items such as daily activities, hazards found, action taken, and maintenance needed and performed, etc. Records can also include surveys of the types and frequency of use of certain bikeway and walkway sections. This information can be used to prioritize facility management needs.

C. Operating During Construction

Bicyclists and pedestrians have greater exposure to the noise, dirt, and fumes in a construction zone due to their slower speed than motor vehicles. Temporary lane restrictions, detours, and other traffic control measures should be designed to accommodate these users. If these measures are not possible, access should be denied. Appropriate traffic control measures can provide safe and convenient passage for pedestrians and bicyclists during roadway construction (Figures 7.10.2 and 7.10.3).

- A passage should be created that allows pedestrians and bicyclists to proceed as close to their normal route as possible.
- Barricades and cones can be used to create a passageway, if a sidewalk is closed.
- Temporary passageways must be accessible by all ages and abilities.
- Keep crosswalks open at all intersections and temporary crosswalks must be painted.
- If temporary signal is required, pedestrian phases must be included.
- Bicyclists can share a lane with pedestrians for a short period of time if there is lack of additional passageway. For longer distances, a separate passageway for bicyclists must be maintained.
- Bicyclists should not be routed onto a sidewalk or unpaved shoulder.
- Passageways for bicyclists and pedestrians should be clear of debris.
- Placement of temporary signs should not obstruct movement of pedestrians and bicyclists.

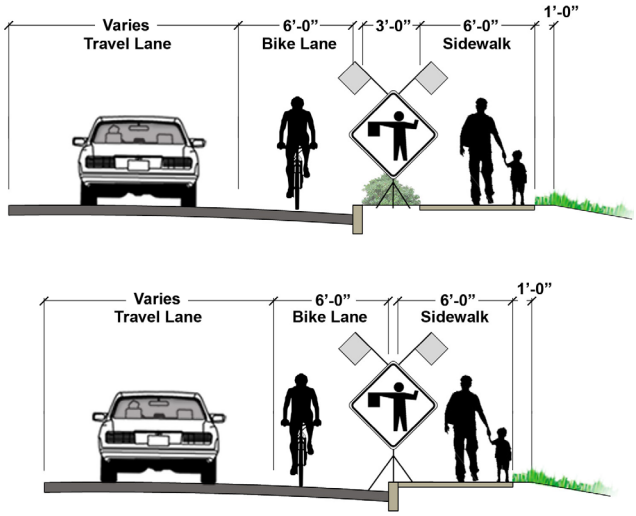


Figure 7.10.2. Section of construction sign placement

Figure 7.10.3. Provide the proper security measures during the construction process to ensure safe ingress and egress for businesses.