

APPENDIX A // TRAIL MAINTENANCE RESOURCES

INTRODUCTION

The cost of maintenance should be considered during trail planning and design. Greenways can be costly to design and install, and developing a maintenance plan will ensure the investment is not wasted. Proper maintenance is also essential to user safety and access.

During the greenway planning and design phases, a comprehensive list of maintenance costs and responsibilities should be estimated. These should then be accounted for with clear commitments of funds, person hours, or volunteer efforts to maintain the trail in the coming years. Consider the following potential costs¹ when developing your trail-maintenance strategy:

SURFACE MATERIALS

In general, the higher the initial installation cost of the surface, the less maintenance it will require over time.² Aggregate and mulch trails are very economical to construct but require regular resurfacing, as well as special attention after severe weather events. Asphalt surfaces require less frequent resurfacing (every 8-15 years), but can develop cracks from differential settlement or heaves from root growth. Concrete paths are the most expensive to build and require the least maintenance. The Federal Highway Administration (FHWA) has guidance on maintaining trail surfaces for safety and mobility.³

TRAIL CLEARING

Trails should be cleared regularly by dedicated staff or dependable volunteers. Fallen branches, rocks, and discarded litter are potential hazards and discourage greenway use. Leaves and mud on hard-surface trails can be slipping hazards. In cases of fallen trees or large logs on natural-surface trails, a section may be removed equal to the width of the trail. This permits free passage by walkers and cyclists and discourages use by unauthorized vehicles.⁴

VEGETATION MAINTENANCE

Management of vegetation surrounding the trail may also be performed by staff or volunteers. Management strategies will vary depending on the individual landscape. Grasses require mowing and other groundcover plants need regular trimming or

burning. Taller species should be trimmed to maintain visibility and safety. Trees should be pruned so they do not encroach on the walkway or obscure trail signage. Dying trees in the vicinity of the trail should be monitored and removed prior to falling. Active and preventative measures of vegetation maintenance include cultivating native species that will crowd out weeds and installing root barriers when the trail is constructed. Removal of poisonous plants and briars from natural-surface trails is especially important because users will walk around such obstructions causing erosion at trail edges.⁵

REPAIRS

Bridges, boardwalks, fences, guard rails, sign posts, retaining walls, and other structural greenway features must be regularly inspected for defects. Small repairs on such items are usually easy to accommodate. If neglected, defects in these features can pose safety hazards and require trails to be rerouted while repairs are completed. Maintenance for such items is less frequent than trail clearing or vegetation management.

AMENITY MAINTENANCE

When properly maintained, amenities help encourage greenway use. Amenities should be selected and planned based on what resources are available to keep them in working order. Public toilets and drinking fountains require almost daily attention. Waste and recycling bins must be emptied on a schedule consistent with the level of use of the greenway. Pet waste stations require periodic restocking and support preventative greenway maintenance by encouraging users to clean up after pets. Benches, lighting, and emergency call stations require less frequent maintenance, especially if durable fixtures are selected.

REFERENCES

1. Checklist of maintenance activities available in National Park Service's Handbook for Trail Design, Construction and Maintenance, Chapter 9. Accessed on 11/26/2013 at: www.nps.gov/noco/parkmgmt/ncttrailconstructionmanual1.htm
2. Trail surfaces overview from Rails-to-Trails Conservancy accessed on 11/26/2013 at: www.railstotrails.org/ourwork/trailbuilding/toolbox/informationsummaries/trail_surfaces.html
3. FHWA-SA-13-037, A Guide for Maintaining Pedestrian Facilities for Enhanced Safety, safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa13037/
4. National Park Service Handbook for Trail Design, Construction and Maintenance. (see 1).
5. From vegetation control article accessed on 11/26/2013 at: blueandwhitecrew.org/overseerinfo/vegetation.php

APPENDIX B // MILE MARKERS

MILE MARKER GUIDELINES

Mile markers are a popular form of wayfinding signage that provides guidance to trail users about how far they have traveled. Especially useful for runners, walkers, or cyclists who want to track their mileage, the markers can also assist maintenance crews in finding places in need of repair, and help guide emergency responders in case of an injury on the trail. Consider coordinating with local emergency responders so they know where the mile markers are located, as well as the trail access points for emergency vehicles.

Decisions to be made before beginning a mile marker project:

MARKER TYPE

Mile markers can be on signs on posts, or marked on the trail surface itself. Since post-mounted signs are located close to the trail, they must be mowed around by the trail maintenance crew. The posts can also prove easy targets for graffiti. Marking directly on the trail surface may wear faster and require more frequent replacement than signs. Consider the available maintenance resources on the trail in question before choosing the marker type.

- Markers on Wooden Posts: 6-inch by 6-inch wooden posts are a popular and inexpensive choice. Metal signs that are 5-inch x 10-inch fit posts this size and are easy to install.
- Markers on standard metal sign posts are typically hammered into the ground instead of digging holes and setting them in cement. You might be able to get advice and equipment from your local government's sign shop to help with installation. If you prefer to dig holes and use cement, follow the instructions for wooden posts above.
- Painting Markers on the Trail: Markers can be painted directly on hard-surface trails (asphalt or concrete). Be sure to choose a durable paint and use plastic or cardboard stencils for a neat installation.

WHAT TO INCLUDE ON THE MARKERS

A basic mile marker will just have the distance from the beginning of the trail. Other possible information includes the name or jurisdiction of the trail, emergency re-

sponder and maintenance phone numbers, and who sponsored the trail markers.

WHERE TO BEGIN AND END

Clearly define the beginning and end points before locating any markers. Where paths cross town, city, or county borders, work across jurisdictions to ensure everyone agrees to the same beginning and end points. Consider using signs or markers in different colors to denote different trails – this can be helpful in complicated situations where multiple trails or trail systems intersect. Finally, think about where future greenways are likely to go when choosing beginning and end points.

INTERVALS

Typical intervals to mark are $\frac{1}{4}$ and $\frac{1}{2}$ mile.

MAINTENANCE

Maintenance expense should be included when considering the overall cost to install mile markers. Staff or volunteers will be needed to regularly survey the markers for wear and damage. Resources will also be required to replace or repair damaged markers in a timely manner.

OTHER CONSIDERATIONS

- Call Before You Dig: Follow the Tennessee One Call process to make sure that you avoid underground utilities when digging holes for post-mounted signs. Keep in mind that once Tennessee One Call has marked utilities, those markings are only good for a limited time.
- Keep All Signs and Posts at Least 2 Feet From the Trail: The Manual on Uniform Traffic Control Devices (MUTCD) states: "Where used on a shared-use path, no portion of a sign or its support shall be placed less than 2 feet laterally from the near edge of the path, or less than 8 feet vertically over the entire width of the shared-use path."
- Measuring the Trail: The process of installing markers starts with the measuring and marking of the greenway. Use a measuring wheel for consistency and mark the mile-marker locations with spray chalk; don't put markers that are meant to be temporary on the trail with paint, as they will last for a long time.

APPENDIX C // PLANT PALETTE

GUIDING PRINCIPLES

Proper plant material selection and design decreases maintenance, provides year-round beauty, and promotes wildlife habitat along greenway corridors. Plantings should be carefully matched to the surrounding context to promote safety and visibility. Native plant species are encouraged as they are adapted to regional conditions, generally require less maintenance, and enhance the regional aesthetic. To avoid the widespread loss of vegetation within a greenway corridor due to disease or insect infestation, consider using a variety of native plant species instead of a single species. In urban areas, where vegetation may be sparse, tree canopy that is either preserved or created along trails provides a significant portion of urban forest and provides communities with multiple environmental and aesthetic benefits.

PLANT PALETTES

The following palettes provide a sample of appropriate plants for site conditions commonly found along East Tennessee trails.

ADDITIONAL REFERENCES

AASHTO Guide for the Development of Bicycle Facilities – refer to this document for information about planting heights and restrictions along roadways and near intersections.

Knoxville Street Tree Master Plan – refer to document this for tree species recommendations and tree placement and spacing guidelines:
archive.knoxmpc.org/plans/treeplan/index.htm

Landscaping with Native Plants: East Tennessee – refer to this PDF to learn about the benefits of native plants and for information on native plant species selection for various sites: www.se-eppc.org/pubs/east.pdf

TVA Riparian Restoration – refer to this website for information regarding planting along watersides: tva.com/river/landandshore/stabilization/index.htm

PLANTS FOR FULL-SUN OPEN SPACES

These low-maintenance species range from 12 to 48 inches in height. They thrive in full sun and are suitable for use in large open areas that will not be mown. Native plant meadows provide habitat for many bird and insect species.



Pictured: *Asclepias tuberosa*, Butterfly weed; *Echinacea purpurea*, Purple coneflower; *Rudbeckia fulgida*, Black-eyed Susan; *Schizachyrium scoparium*, Little blue stem

Not pictured: *Andropogon gerardii*, Big blue stem; *Andropogon ternarius*, Split beard bluestem; *Andropogon virginicus*, Broomsedge; *Chasmanthium latifolium*, River oats; *Eupatorium dubium*, Joe-Pye weed; *Liatris spicata*, Dense blazing star; *Panicum virgatum*, Switchgrass; *Solidago rugosa*, Rough stemmed goldenrod; *Sorghastrum nutans*, Indian grass

LOW PLANTS FOR MEDIANS AND PLANTING STRIPS

These hardy, low-growing species make an attractive addition to medians and planting strips between roads and trails.



Pictured: *Hypericum frondosum*, Golden St. John's Wort; *Muhlenbergia capillaris*, Pink muhly grass; *Rhus aromatica* 'Gro Low,' Gro Low Fragrant sumac; *Schizachyrium scoparium*, Little blue stem

Not pictured: *Asclepias tuberosa*, Butterfly weed; *Echinacea purpurea*, Purple coneflower; *Rudbeckia fulgida*, Black-eyed Susan

PLANTS FOR PART-SUN TO SHADE TRAIL SIDES

These species range in height from 12 to 72 inches and are good choices for the maintenance area along a forested segment of trail. Plant material closest to the trail should be of shorter height to promote visibility.



Pictured: *Callicarpa americana*, American beautyberry; *Carex pensylvanica*, Pennsylvania sedge; *Phlox divaricata*, Wild blue phlox; *Osmunda cinnamomea*, Cinnamon fern

Not pictured: *Calycanthus floridus*, Sweetshrub; *Chasmanthium latifolium*, River oats; *Euonymus americanus*, Hearts-a-bustin; *Heuchera americana*, Alumroot; *Hydrangea quercifolia*, Oak-leaf hydrangea; *Polygonatum biflorum*, Solomon's seal; *Polystichum acrostichoides*, Christmas fern; *Viburnum acerifolium*, Mapleleaf viburnum

PLANTS FOR WET HABITATS

These species are for use in and around wet areas such as depressions and swales, wetlands, and stream banks.



Pictured: *Aster novae-angliae*, New England Aster; *Hibiscus moscheutos*, Swamp mallow; *Lobelia cardinalis*, Cardinal Flower; *Monarda media*, Purple Bergamot

Not pictured: *Asclepias incarnata*, Swamp Milkweed; *Cephalanthus occidentalis*, Buttonbush; *Eupatorium purpureum*, Joe-Pye Weed; *Iris versicolor*, Northern Blue Flag; *Lobelia siphilitica*, Great Blue Lobelia; *Vernonia altissima*, Tall ironweed

LARGE SHADE TREES

These tree species are appropriate for use along roadways* and open space trails where shade is desired.



Pictured: **Betula nigra*, River birch; **Liriodendron tulipifera*, Tulip poplar; **Platanus occidentalis*, Sycamore; **Quercus phellos*, Willow oak

Not pictured: *Fagus grandifolia*, American beech; *Ilex opaca*, American holly; *Juniperus virginiana*, Eastern red cedar; *Liquidambar styraciflua*, Sweetgum; *Magnolia grandiflora*, Southern magnolia; *Magnolia virginiana*, Sweet bay magnolia; *Nyssa sylvatica*, Blackgum; *Pinus strobus*, White pine

TREES FOR UNDER UTILITY LINES

These tree species have mature heights less than 30 feet making them appropriate choices for planting under utility lines.



Pictured: *Crataegus viridis*, Winter King hawthorn; *Oxydendrum arboreum*, Sourwood; *Amelanchier arborea*, Serviceberry; *Hamamelis virginiana*, Witchhazel

Not pictured: *Acer buergerianum*, Trident maple; *Asimina triloba*, Pawpaw; *Cercis canadensis*, Eastern redbud; *Cornus florida*, Flowering dogwood; *Cotinus obovatus*, American smoketree; *Halesia carolina*, Carolina silverbell

APPENDIX D // SIDEPATH CHECKLIST

This checklist has been developed by the Knoxville Regional Transportation Planning Organization, based on Chicagoland Bicycle Federation's Tech Sheet.

Its goal is to demonstrate to bikeway planners and designers that no one type of bikeway can meet the needs of every bicyclist. Bicyclists have a wide range of skill levels and needs. When working to develop a safe, cost-effective and convenient bike system, these three principles can help benefit the greatest number of bicyclists:

- Include bicycle and pedestrian facilities in all road projects. Improvements are easier and cheaper when done simultaneously with other changes.
- Target available resources to overcome the most significant barriers for the broadest possible range of bicyclists.
- Maintain as many travel and routing options as possible, allowing people to ride where they feel most comfortable, as long as they follow the rules.

SIDEPATH BASICS

A sidepath is a shared-use facility for bicyclists and pedestrians that runs parallel to a roadway. Many people think that sidepaths are a good idea because they provide separation between bicyclists and motorized traffic. However, studies have shown that bicycling on sidepaths is more dangerous than riding on the roadway. The risk of injuries on sidepaths compared to roadways has been calculated as 40%, 80%, and 260% higher.

The operational problems with this type of facility are noted in the 2012 AASHTO Guide for the Development of Bicycle Facilities.

The AASHTO guide says that shared-use paths operate best when they offer opportunities not provided by the road network and have continuous separation from traffic (i.e., along a river or railroad corridor). The guide lists several operational problems that can occur with paths along roadways, among them:

- At intersections and driveways, motorists entering or crossing the roadway often will not notice bicyclists approaching from their right, as they do not expect wheeled traffic from this direction. Motorists turning from the roadway onto the cross street may likewise fail to notice bicyclists traveling the opposite direction from the norm.

- Bicyclists traveling on sidepaths are apt to cross intersections and driveways at unexpected speeds (i.e., at speeds that are significantly faster than pedestrian speeds). This may increase the likelihood of crashes, especially where sight distance is limited.
- Attempts to require bicyclists to yield or stop at each cross-street or driveway are inappropriate and are typically not effective.
- Where the sidepath ends, bicyclists traveling in the direction opposed to roadway traffic may continue on the wrong side of the roadway. Similarly, bicyclists approaching a path may travel on the wrong side of the roadway to access the path. Wrong-way travel by bicyclists is a common factor in bicycle-automobile crashes.
- Some bicyclists will use the roadway instead of the sidepath because of the operational issues described above. Bicyclists using the roadway may be harassed by motorists who believe bicyclists should use the sidepath. In addition, there are some states that prohibit bicyclists from using the adjacent roadway when a sidepath is present.
- Bicyclists on the sidepath, even those going in the same direction, are not within the normal scanning area of drivers turning right or left from the adjacent roadway into a side road or driveway.

The AASHTO guide recommends that if such a facility is built, there should be wide separation between the roadway and the path to demonstrate to bicyclists and motorists that the path functions as an independent facility.

Note that sidepath facilities should never preclude bicyclist use of the parallel roadway. Experienced bicyclists or bicyclists trying to reach a destination on the opposite side of the roadway will continue to use the roadway, following the rules of the road.

SIDEPATH CHECKLIST

Before proceeding with plans for a sidepath, there is a need to assess whether such a facility is warranted, what other design options are available and which design will best serve the intended users.

To assist with this process, consider the factors presented in this checklist, consult the recommended references and use site-specific engineering judgment to develop a design that works best for bicyclists, pedestrians and motorists.

CHECKLIST FOR SIDEPATH FACILITIES

- Does the combination of roadway traffic volumes, speeds and curb lane widths create poor conditions for bicycling?
- Is it impossible to create wider outside lanes or slow traffic to improve bicycling on the road?
- Are a majority of destinations located on the same side of the roadway as the proposed path?
- Will the path cross few driveways and/or street intersections?
- Is there at least 18 feet of right-of-way width available?
- Can changes be made to signal timing and turning movements to allow bicyclists adequate crossing time across intersections without causing traffic congestion?
- Can the areas around all driveways and intersections be cleared of visual obstructions?
- Can bicyclists safely transition to other bikeways where the sidepath begins and ends?

If you answered NO to two or more of the above questions, it is advisable to reassess the feasibility of constructing a sidepath.

Here's a little more information on each of the items in the checklist above:

1. CAN BICYCLISTS SAFELY USE THE ROADWAY?

Bicyclists are considered vehicles and have the same rights and responsibilities as other drivers. However, a bicyclist's comfort level and perceived safety when using a roadway are influenced by several factors: traffic volumes, traffic speeds, and curb lane width/presence of a shoulder or bike lane.

Neighborhood streets and minor collector roads are usually compatible for bicycling because of low traffic volumes and/or low speeds. Sidepaths are usually not needed along such streets, and investments to improve bicycling would be better used in areas of greater need.

Bicycle Level of Service (LOS) analysis can be done to determine the bicycle LOS on a corridor. If the road scores poorly, then some type of improvement is needed.

2. CAN THE ROADWAY BE IMPROVED?

Explore whether it may be more desirable or cost effective to accommodate bicycles on the roadway with other vehicles than to construct a separate path.

AASHTO has established guidelines for three basic types of on-road improvements:

- Wide outside lane: where the right lane is a minimum of 14 feet wide, excluding curb and gutter
- Bicycle lanes: signed and striped lane for bicycle use, minimum of 4 feet wide, excluding curb and gutter
- Paved shoulders: 4 feet minimum

Modifying roadway cross-sections by shifting lane striping, reconfiguring center turn lanes, moving on-street parking and/or adding extra pavement width can provide space for on-street bicycle accommodations. Lowering speeds through design can also make a roadway more compatible for bicycling.

If on-street accommodations effectively meet bicyclists' needs within the corridor, you may find that a sidepath is not needed.

3. ACCESS TO DESTINATIONS

Bicyclists have both mobility and access needs. When destinations are located on the opposite side of the road from a sidepath, bicyclists must often double back, hop curbs and cross mid-block, or ride in the street against traffic in order to get where they want to go. Such practices should be discouraged because unexpected bicycle movements are major causes of bicycle/motor vehicle crashes.

By comparison, bicyclists riding in the street have the ability to predictably merge lanes and complete turning movements just as other vehicles do. Therefore, planners and engineers need to assess the adjacent land uses to determine whether a sidepath adequately accommodates bicycle access needs.

4. CONFLICTS AT INTERSECTIONS

Studies show that bicyclists who ride on sidewalks or sidepaths incur a greater risk of being involved in a collision with a motor vehicle than those who ride on the roadway. Intersections are especially hazardous for wrong-way riders. (see Figure 1)

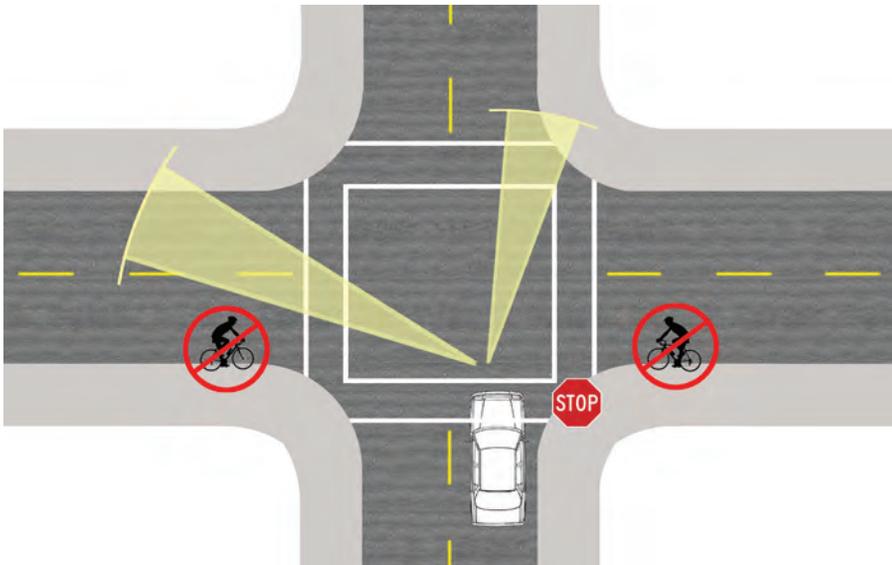


Figure 1: The yellow areas in this illustration show where a driver who's about to make a turn is looking. A bicyclist riding on a sidepath from the left is outside of where the driver is looking and may not be seen. A bicyclist riding from the right (against traffic) is completely unexpected for a motorist. A bicyclist riding on the street with traffic is more easily spotted.

The more often a bike path crosses a driveway or street intersection, the more risk exposures for users of the facility. Commercial strips with multiple driveways and a lot of turn movements are particularly dangerous corridors for sidepaths. Planners must use engineering judgment to determine if a sidepath is feasible based on the number and type of intersections.

SIDEPATH CROSSING RISK

How many points per mile does the proposed path score?

TYPE OF CROSSING	# OF POINTS	TYPE OF CROSSING	# OF POINTS
RESIDENTIAL DRIVEWAY	1	LOW RISK: USE SPECIAL CARE	1 – 8 pts
COMMERCIAL DRIVEWAY	2	MODERATE RISK: PURSUE ALTERNATIVES	9 – 16 pts
MINOR STREET (<1000 ADT)	2	HIGH RISK: NOT RECOMMENDED	> 16 pts
MAJOR STREET (>1000 ADT*)	4		

* crossing of a street with >10,000 ADT without a signal automatically moves the proposed path into the high risk category.

The above chart can be used as a guide. In this chart, scoring is based upon a threshold of 12 residential driveways or six minor streets per mile. Beyond this, a cyclist would face more than one driveway every 30 seconds or one street every minute, at which point the safety and utility of the sidepath diminishes dramatically.

5. RIGHT-OF-WAY CONSIDERATIONS

A final physical constraint that may limit the ability to construct a sidepath within a roadway corridor is the amount of space available. According to AASHTO guidelines, a sidepath should be horizontally separated from the roadway to demonstrate to bicyclists and motorists that the path functions as a separate facility. When this is not possible, bikeways located less than 5 feet from the roadway should be protected by a suitable physical barrier of no less than 42 inches high.

To facilitate safe two-way bicycle travel and allow for shared-use with pedestrians and others, paths should be a minimum of 10 feet wide and have an additional 3 feet of clearance to lateral obstructions such as signs, fences, trees, and buildings. This demands a total sidepath right-of-way width of no less than 18 feet.

Full details of bike path design and right-of-way requirements are presented in the AASHTO Guide referenced above.

6. ADEQUATE SIGNAL TIMING

Modifying signal phases may be required to provide safe bicycle access where a path crosses a signalized intersection. Conflicts may be especially prevalent at crossings where the path is controlled by a “walk/don’t walk” signal phase with the parallel roadway. The sidepath user may be given a false sense of security by a “walk” signal while turning motorists from the parallel roadway simultaneously have a green light. Right turns on red present another hazard, as do large turning radii that encourage fast turning traffic.

Another important conflict to resolve is created by a left-turning motorist whose attention is focused on gaps in approaching traffic. Upon finding a gap, the motorist often accelerates through the turn and is then faced with an unexpected path crossing.

Design solutions to these problems include use of appropriate warning signs, all red signal phases (a “green” for just the pathway), right-on-red prohibitions, and signal cycles that allow adequate time for bicyclists and pedestrians to cross.

7. SIGHT TRIANGLES AND CROSSING PLACEMENT

Safety at intersections will be improved if bicyclists are able to see approaching cars, and motorists are able to see bicyclists and pedestrians on the path. This is best accomplished by providing an area free from visual obstructions at each corner of all driveway and street intersections. The minimum size of the sight triangle may be determined by the AASHTO stop control intersection recommendation of 20 feet back from the edge of a travelway. No signs, structures, parked cars or vegetation that blocks views should be permitted in this area. Parallel arterials and rural areas with high travel speeds will require larger sight triangles based upon drivers’ stopping distances as per AASHTO guidelines.

More information on intersection design is available in the AASHTO Guide as well as Florida DOT’s Trail Intersection Design Handbook.

8. THE END OF THE PATH

How bicyclists enter and the sidepath must be considered. The design of the transition must encourage bicyclists to approach and leave the path traveling on the correct side of the roadway, riding with the traffic flow. Wrong-way bicycle riding is a major cause of bicycle/motor vehicle crashes and should always be discouraged. Safe transitions to another path, an on-road facility or bicycle-compatible street route require appropriate signing, curb cuts and merge areas.

REFERENCES

American Association of State Highway and Transportation Officials

Florida Department of Transportation’s Trail Intersection Design Handbook:
atfiles.org/files/pdf/trailintersect.pdf

Moritz, William E. 1998. Adult Bicyclists in the United States—Characteristics and Riding Experience. Transportation Research Board. 77th Annual Meeting; Aultman-Hall, Lisa and M. Georgina Kaltenecker. 1998

APPENDIX E // KNOXVILLE REGIONAL TPO GUIDELINES FOR SIGNING & MARKING GREENWAY TRAILS

OVERVIEW

Adequate signing and marking are essential on shared-use paths, especially to alert trail users to potential conflicts and to convey regulatory messages to bicyclists, pedestrian and motorists at roadway intersections.

Both advanced crossing and crossing warning signs are needed on roadways to provide appropriate warning to motorists of the upcoming path intersection. In addition, signage for path users, such as to indicate directions, destinations, distances and names of crossing streets, is helpful for navigating trails. Signs with maps of the entire path route and indicating important destinations should be placed at major trailheads and other key points. The most recent Manual on Uniform Traffic Control Devices (MUTCD) provides minimum traffic control measures that should be applied. Warning signs, directional signs and other devices along the path should also meet the MUTCD guidelines.

Traffic control at path-roadway crossings should be treated so that the intersection looks and functions like a regular road intersection. Path crossings can occur as signalized or unsignalized intersections, depending on the particular attributes of the location. Warrants for signals and beacons are discussed in the MUTCD and could be used as guidance for path crossings as bicycles are considered vehicles. The speed and volume of motor vehicles along the crossing corridor are also an important factor in this analysis.

At unsignalized locations, adequate sight distance should be provided along the roadway approaches to the path and the path approaches to the roadway. In most cases, advanced warning signs should be provided on the road, indicating that a path is crossing the roadway. The path crossing of the street should be marked as a crosswalk since it carries a mix of non-motorized users. Due to the potential conflicts at these junctions, careful design is of paramount importance to the safety of path users and motorists. Each roadway/path intersection is unique and will require sound engineering judgment on the part of the designer as to the appropriate solution. The 2012 AASHTO Guide for the Development of Bicycle Facilities provides examples and guidelines for various intersection treatments.

Refer to MUTCD Figure and Table 9B-1 for size and sign placement recommendations for shared-use paths.

SIGN LOCATION TYPES

The following describes the sign location types and the recommended signage and markings for each.

AT MAJOR TRAILHEADS (THESE ARE GREENWAY ENTRANCES WITH PARKING)

- Big G (Figure 1)
- Entering map (Figure 2)
- Connections map showing how this greenway connects to other greenways, if relevant (Figure 3)
- “No Motor Vehicles” sign (R5-3), if needed
- Courtesy/user behavior sign if desired
- Bollards, if needed (see “Bollards” on Page 5)

ON ROADWAY NEXT TO MAJOR TRAILHEAD PARKING AREA (ORIENTED FOR MOTORISTS)

- Greenway symbol sign—the Big G (Figure 1)
- Greenway identifier (Figure 4)

AT MINOR TRAILHEADS (WALKING AND BICYCLING ACCESS ONLY)

- Big G (Figure 1)
- Greenway identifier (Figure 4)
- Directional/destination signage (Figure 5); if the destination is very close (within ¼ mile), the sign does not need to indicate distance

AT JUNCTIONS WITH OTHER TRAILS OR SPLITS IN THE TRAIL

- Directional/destination signage (Figure 5); if the destination is very close (within ¼ mile), the sign does not need to indicate distance

AT ROAD CROSSINGS, ON THE GREENWAY

- “No Motor Vehicles” sign (R5-3)
- Yield signs, if sight distance is adequate
- Stop signs, if sight distance is limited

- Directional/destination signage for nearby schools, libraries, shopping malls, bus stops and parks.
- Street name sign for greenway users
- Bollards (see “Bollards” section)

AT ROAD CROSSINGS, ON ROADWAY

- Crossing warning signs W11-15 and W16-7P, with supplemental plaque W16-9P or W16-2aP for advanced warning
- Marked crosswalk
- Stop or yield line pavement marking, set back from crosswalk (see MUTCD for guidance on distance)

DEPENDING ON ROAD TYPE AND LEVEL OF GREENWAY USE:

- Consider raised crosswalk
- Consider center line striping on greenway on intersection approach
- On multi-lane roads, consider median refuge island, signals, beacons and other strategies – refer to the MUTCD.
- On roads with posted speed higher than 40 mph, or roads with 4 or more lanes and ADT over 12,000, a marked crosswalk alone is not sufficient. See MUTCD for additional treatments, or another resource. NCHRP report 562 is a good one.

AT DRIVEWAY CROSSINGS, ESPECIALLY ON GREENWAYS PARALLEL TO ROADWAYS

- At high-volume/commercial driveways, yield signs for greenway traffic, warning sign for driveway traffic (W11-15, W16-7P), and a marked crosswalk.
- For lower-volume driveways, consider signage for greenway users if the driveway is near a curve or is otherwise not obvious, or to warn of a series of driveways.

AT RAILROAD CROSSINGS

- Railroad crossing sign (R15-1) and advance sign (W10-1 for RR crossings ahead, W10-2, W10-3, or W10-4 for RR crossings following a turn)

GREENWAY SIGN EXAMPLES:

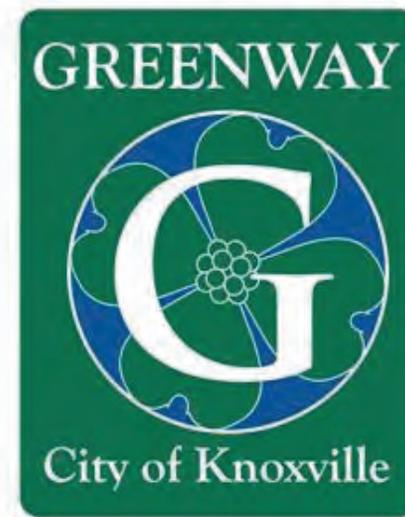


Figure 1: Big G sign

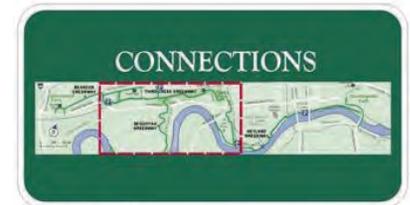


Figure 3: Connections map



Figure 4: Greenway identifier

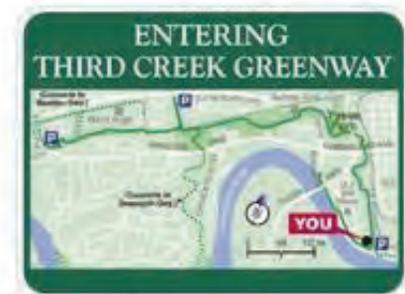


Figure 2: Entering map

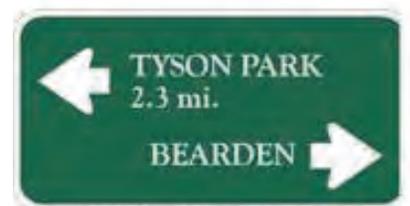


Figure 5: Directional/destination sign

OTHER SIGNS AND MARKINGS MAY BE USED WHERE NEEDED FOR SPECIFIC SITUATIONS.

Warning users of potential hazards:

“Slippery when wet” (W8-10 and W8-10p)

“Path Narrows” (W5-4a)

“Bump” or “Dip” (W8-1,2)

and others as described in the MUTCD

The R9-6 (“Bicyclists yield to peds”) or R9-7 (“Peds keep right, bikes keep left”) signs could be used where user conflicts are occurring. Also consider centerline striping in those areas.

If a greenway must be closed for construction, signage should be used to show where the detour is. There should be an advance notice closure sign, a detour sign with an arrow, and a detour map sign.

TERMINI SIGNAGE

Path/greenway termini at roadways should be designed under the assumption that bicyclists and pedestrians may want to exit the greenway to the roadway and access the greenway from the roadway. Each terminus is different and should be analyzed to see what the appropriate treatment is for that intersection. The following are general guidelines to use:

- Analyze how greenways users (bicyclists, pedestrians, skaters) and motorists are behaving at the location. Is there a difference between desired and actual behavior?
- Provide sidewalks along the intersecting road, and design them knowing that some bicyclists will use them.
- Include positive guidance such as signs, pavement markings, and channelization to induce bicyclists to ride on the right side of the road once they have left the greenway.
- Provide educational materials for greenway users (such as courtesy signs listing proper behavior).

BOLLARDS

Where needed, use bollards to keep unauthorized motor vehicles from entering a greenway. But recognize that bollards can be a hazard themselves, especially to bicyclists. In light of that potential hazard, consider these guidelines:

- Use bollards only where there is a demonstrated need: either a history of unauthorized drivers accessing the greenway, or a specific reason to believe that it will occur.
- Maximize the visibility of bollards by locating them properly and using reflective material on and around them.

FIGURE 6: TYPICAL BOLLARD LAYOUT

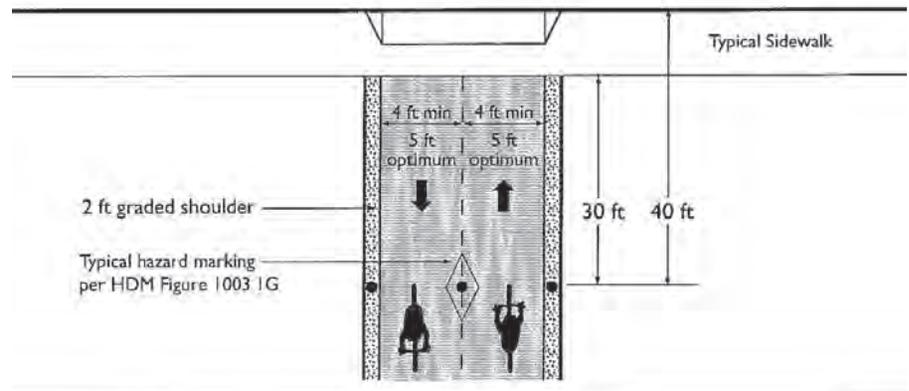


Illustration source: Contra Costa County Trail Design Guidelines

As Figure 6 illustrates, it's best to set bollards back from the trail entrance. This gives bicyclists more time to see the bollard after they enter the trail. Use reflective paint or tape on the bollard itself and in markings around the bollard to make it more visible in low-light conditions.

FIGURE 7: AN ALTERNATIVE TO BOLLARDS

An alternative to bollards where there is adequate right-of-way is to divide the trail into two short one-way segments at the intersection approach

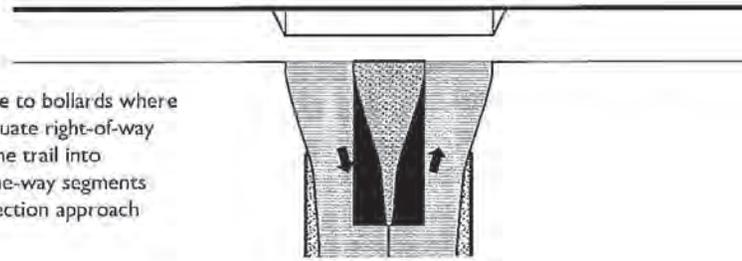


Illustration source: Contra Costa County Trail Design Guidelines

As an alternative to bollards, consider constructing or reconstructing trail entrances so that the path separates into two one-way paths, as in Figure 7. This design will help reduce conflicts between greenway users and keep unauthorized motor vehicles off the path.

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IMAGE CREDITS

Unless otherwise noted, images in this publication are from the collections of the authors, or others listed in the acknowledgments.

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