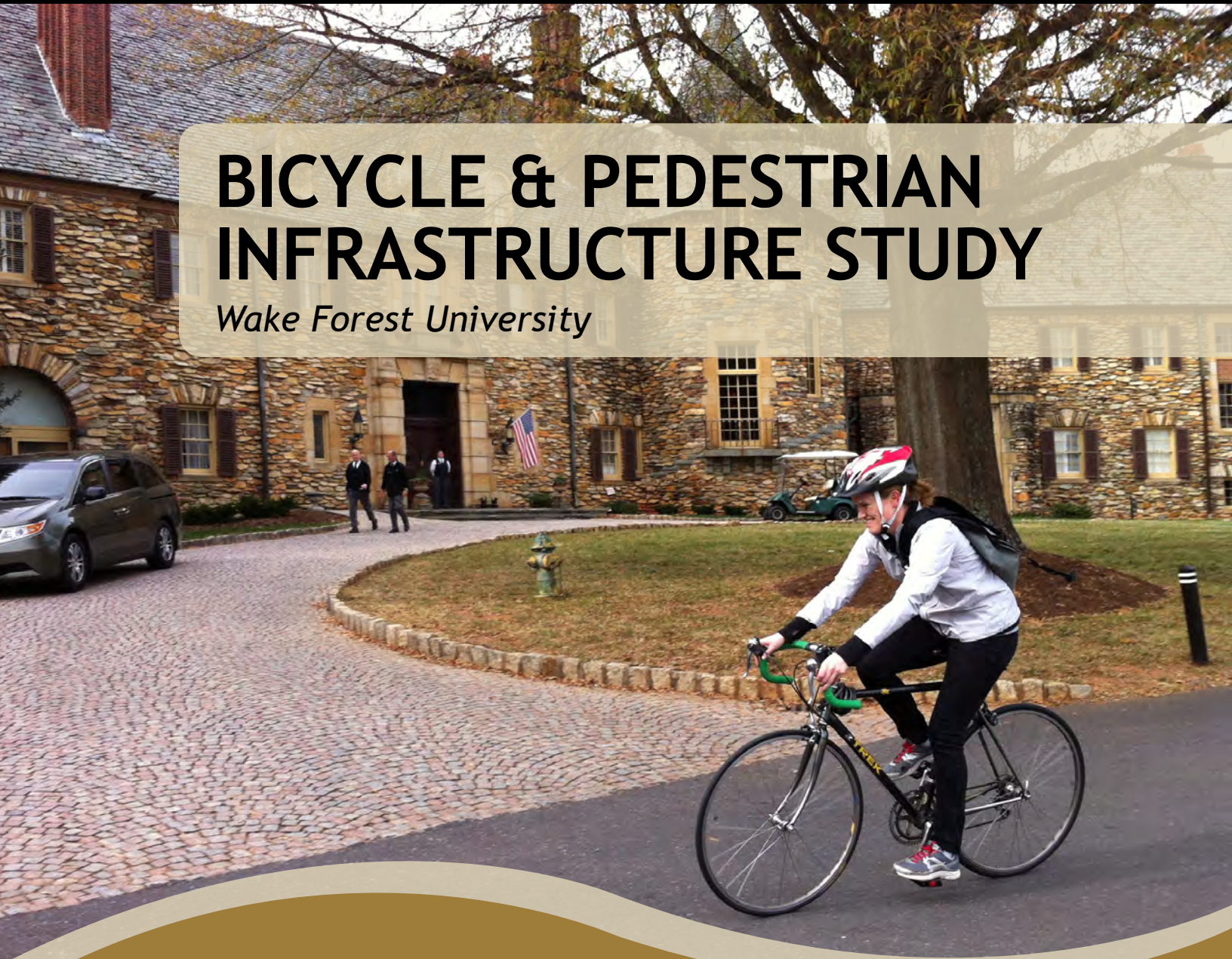




BICYCLE & PEDESTRIAN INFRASTRUCTURE STUDY

Wake Forest University



2015 | *Final Report*



WAKE FOREST
UNIVERSITY

Prepared for Wake Forest University (WFU)
Prepared by Alta Planning + Design





Acknowledgements

Thank you to the students, faculty, and administrative staff that participated in the development of this plan through meetings, interviews, and plan review.

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1 INTRODUCTION & CURRENT CONDITIONS

PROJECT OVERVIEW

This Bicycle and Pedestrian Infrastructure Study identifies current opportunities and constraints for walking and bicycling on the Reynolda Campus, and provides a prioritized set of recommendations for improvement. This project differs from a recent similar study (the *2014 Wake Forest University Area Bicycle, Pedestrian & Transit Study*), which focused on connections between the campus and the surrounding areas. Instead, this study is focused on campus itself, and aims to improve conditions for walking and bicycling campus-wide.



Clockwise from top left: Field review; tabling for student input; the Sustainability Interns Group.

Key Steps in the Planning Process:

OCTOBER 2014

Kick-Off Meeting with Project Stakeholders & Initial Field Review

NOVEMBER 2014

Student/Faculty/Admin Input through Meetings, Interviews, and Tabling

DECEMBER 2014

Develop Current Conditions Report of Key Opportunities & Constraints

JAN/FEB 2015

Develop Recommendations and Implementation Strategy into Draft Study

MAR/APR 2015

Develop Final Study based on Stakeholder Review

2015-

Begin Programming and Implementation



EXISTING PLANS, POLICIES, AND PROGRAMS

WAKE FOREST UNIVERSITY PLANS

2014 Wake Forest University Area Bicycle, Pedestrian & Transit Study

This project aims to improve active transportation and transit choices between the WFU campus and surrounding neighborhoods through infrastructure and policy changes. The plan was developed through a partnership between Wake Forest University (WFU), the Winston-Salem Department of Transportation (WSDOT), and the City-County Planning Board (CCPB) of Forsyth County and Winston-Salem. Key recommendations include making improvements for walking and bicycling along and across Polo Road, University Parkway, and between Reynolda Campus and the Athletic Campus.

2013 Wake Forest University Transportation Survey

This survey polled more than 2,000 students, faculty, and staff members on their transportation behavior. It found the following walk/bike rates for getting to campus:

- Undergraduates living off-campus: 3% walk/7% bike
- Graduates living off-campus: 3% walk/9% bike
- Faculty: 4% walk/4% bike
- Staff: 4% walk/4% bike

Key barriers for bicycling to campus were identified as weather and safety of routes to campus. Key barriers for walking included distance, convenience, and weather.

2011 Wake Forest University Parking Study

This study focused on campus parking needs and built on the findings of the 2009 *Master Plan*. The main findings were that parking demand exceeds practical capacity at peak times, and future growth will exacerbate these shortfalls. Transit was identified as a key to managing parking demand.

2011 Wake Forest University Signage Plan

This signage plan provides detailed specifications for the appearance and function of various wayfinding signage types to be used throughout campus. Wayfinding recommendations that are implemented from this 2015 Bicycle and Pedestrian Infrastructure Study should follow these signage guidelines. One suggested update to the signage guidelines could include the addition of bicycling information on the pedestrian-oriented signage and kiosk maps (showing the location of bicycle racks, bicycle repair stations, bicycle lanes, trails, etc.).

2009 Reynolda Campus Master Plan

This plan took a comprehensive look at a campus issues, ways to accommodate growth, and the future vision of the university. The transportation element was primarily inwardly focused on circulation and parking issues on campus. A few campus connection pieces were identified, including providing transit shuttle service to apartment complexes north of campus and improving pedestrian and bicycle connections, particularly between main campus and the athletics area. A campus master plan update is needed to reflect recent additions to campus, such as Farrell Hall, Dogwood Hall, and Magnolia Hall.



EXISTING WAKE FOREST UNIVERSITY PROGRAMS

Wake Forest University Cycling Club

The Cycling Club attempts to provide cyclists in the Wake Forest community with an organization through which it is possible to meet others with similar interests. Road bikers as well as mountain bikers are welcome to compete in National Collegiate Cycling Association events at other regional schools. Organized into different categories based on experience and sex, racers compete for conference championships as well as the opportunity to qualify for the National Collegiate Cycling Championships held in the spring. The Cycling Club is also interested in potential campus programs that encourage bicycling in general, such as having building space on campus dedicated to bicycle repair for club members and non-members alike.

Car Share

The University partners with Zipcar to have four car share vehicles parked on campus in easily accessible locations for Zipcar members to reserve by the hour or day. Members pay an annual fee and a rental fee of \$8.50 per hour, which covers all costs of vehicle ownership and operation (gas, insurance, maintenance, depreciation).

Rideshare

There are two rideshare programs which are available to university-affiliated individuals, Zimride and SharetheRideNC. Zimride facilitates sharing trips by making it easier to find people with similar trips to share a vehicle and split costs; this service focuses on longer trips (e.g., a trip out of state for a holiday break). SharetheRideNC is the state's ridematching program that helps interested carpoolers find people to share their trip. The University also incentivizes carpooling by offering desirable parking spaces to individuals who sign up for the carpool program.

Education, Encouragement, and Enforcement

The Office of Sustainability coordinates, encourages, and promotes various types of alternative transportation to campus, including the Zipcar and carpooling/ridesharing programs. The Office of Sustainability also coordinates programs and events to encourage biking and walking to campus like the Campus/Community Bike Ride.

EXISTING WAKE FOREST UNIVERSITY POLICIES

Parking Pricing

The University requires employees and students to register their vehicle to park on campus. Students are charged \$500 per year for on-campus spaces and between \$200 and \$300 for off-campus lots. University faculty and staff used to park for free, but recently begun paying for parking as well. Different lots are available to different groups depending on permit type.

Student Housing

Currently, students are required to live on campus during their freshman, sophomore, and junior years of study.

CITY OF WINSTON-SALEM AND NCDOT PLANS, PROGRAMS, AND POLICIES

For a review and summary of related plans, programs, and policies for the City of Winston-Salem and NCDOT, please refer to pages 2-3 to 2-6 of the *2014 Wake Forest University Area Bicycle, Pedestrian & Transit Study*. The plan can be accessed through this link - http://www.walkbikeridewfu.com/uploads/1/3/1/7/13179627/wfu_bikepedtransit_study_full_lowres.pdf.



OPPORTUNITIES & CONSTRAINTS

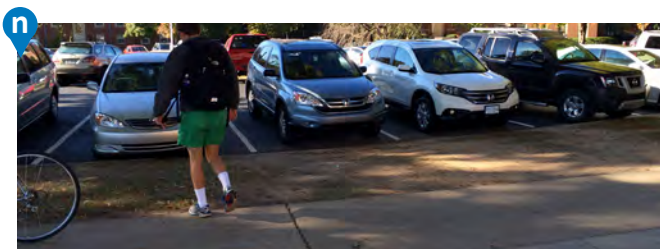
The following text and maps summarize the input collected from students, faculty, and administrative staff in late 2014. The maps also depict the existing bicycle and pedestrian infrastructure on campus, such as sidewalks, crosswalks, and bicycle racks. These maps, along with the identified opportunities and constraints, were used to inform the development of this study's recommendations for infrastructure improvements.

CONNECTIVITY & CIRCULATION

Most comments received for this study related to connectivity and circulation were located in the **northern end of campus near newer buildings**. Additionally, **stairways, parking lots, and access to interior plazas** were commonly mentioned as circulation constraints for pedestrians, bicyclists and wheel chair users. These issues are listed below in greater detail, grouped by the general area on campus (letters correspond to Map 1.1: Connectivity & Circulation).



This stairway connection between parking lot Q and Wake Forest Road is not ADA accessible and does not accommodate bicyclists.



Parking lot P, while heavily used by pedestrians does not provide a direct pathway accommodation.



This space between parking lot P and Winston Hall is an excellent trail connection opportunity between the northern terminus of the Reynolda Greenway and Gully Drive.

Near Polo Rd & Polo Hall:

- a** Wider path & ramp needed from Polo Hall to Polo Rd
- b** Consider adding ramps or bicycle-friendly staircases near southeast corner of Polo Hall
- c** There is an informal trail used by bicyclists to connect through southeast corner of the Polo Rd and Long Rd intersection; explore opportunities to improve this connection
- d** Consider new or improved gate locations and lighting where north campus connects to off-campus near Rosedale Circle and Polo Rd
- e** Lack of pedestrian connectivity between Carroll Weathers Dr and Magnolia/Dogwood Buildings

Near Parking Lot Q:

- f** Opportunity for short paved trail for bicycle travel between higher elevation of Magnolia & Dogwood buildings to lower elevation of Parking Lot Q (current stairway and ramp is not useful for bicycling)
- g** Lack of defined bicycle and pedestrian space moving southeast/northwest through Parking Lot Q
- h** Existing sidewalk through Parking Lot Q from Magnolia & Dogwood Halls to Wingate Rd is too narrow for bicycle use & the stairway to Wingate Rd has no ramp for bicycle access
- i** Pathway/bridge on northeast end of Parking Lot Q has a narrow choke point that is difficult for bicyclists and pedestrians to navigate simultaneously.

Near Allen Easley St:

- j** The route from Allen Easley St into the parking lot along Aaron Lane is inadequate for pedestrians; the sidewalk transitions into painted pavement, then disappears into the parking lot.
- k** There is no access for bicyclists from Aaron Ln to Wake Forest Rd. Elevation change presents challenges.
- l** There is potential for a new trail connection through the woods from Allen Easley St to Magnolia & Dogwood Hall; with topographic constraints

Near Farrell Hall:

- m** Pedestrians observed walking through north end of Poteat Field, from Farrell Hall to Parking Lot W1 - sidewalk lacking.
- n** Pedestrians observed walking from the south end of the new path in front of Farrell Hall, bisecting Parking Lot P straight to Huffman Hall/Hearn Plaza (currently lacking pedestrian connection through parking lot).



(Continued from previous page;
Letters correspond to points on map)

Near Hearn Plaza & Manchester Plaza:

- o Constraint for wheelchair users and bicycling due to inaccessible pathways and stairs at the following locations:
 - » Wingate Hall/Huffman Hall to Hearn Plaza
 - » Wingate Hall/Efrid Hall to Hearn Plaza
 - » Reynolda Hall/Davis Hall to Hearn Plaza
 - » Reynolda Hall/Kitchin Hall to Hearn Plaza
 - » Reynolda Hall/Calloway Center to Manchester Plaza
 - » Reynolda Hall/Benson Center to Manchester Plaza

Wingate Rd & Wake Forest Rd Intersection:

- p Although this intersection has high-visibility crosswalks in all directions, students mentioned it multiple times as problematic for pedestrians. It was reported that a roundabout was previously discussed as a solution.

Near Reynolda Greenway:

- q Better connectivity needed between the north end of Reynolda Greenway and Gulley Dr. There is potential for a new path around Parking Lot T.
- r There is a short, but heavily worn footpath between south end of Parking Lot S and Reynolda Trail that could be formalized.
- s The informal footpath from the Welcome Center to Reynolda Greenway could be formalized into a paved trail for greater accessibility.

Connectivity To & From Campus (See the 2014 study):

- t University Parkway was noted again during multiple input sessions as a problem area for connectivity.
- u Lack of connectivity noted from Betharbara Rd to campus and from Athletic Campus to main campus.
- v Pedestrians observed running across Polo Rd on a regular basis.
- w Many people voiced support for the proposed greenway trail from the main campus to the Athletic campus





AUTOMOBILE CONFLICTS & LIGHTING ISSUES

Aside from connectivity and circulation, two other topics emerged from stakeholder input that affect both walking and bicycling: Conflicts with automobile traffic and insufficient lighting.

Students and faculty noted several main areas of concern for automobile traffic:

- **Speed limits** are not posted regularly and do not seem to be consistently enforced.
- **Blind spots** for bicyclists and pedestrians on campus need to be addressed (for example, north of Wake Chapel).
- There are a variety of types of **speed bumps and crosswalks** that should be standardized to improve their visibility.

Students and faculty indicated that lighting improvements are needed for visibility at night, rather than from a personal safety/security standpoint. There is a need for legibility of signage in both daytime and nighttime, while also minimizing light pollution. Early morning and evening commuters require legible, lighted signs.

These issues are listed in greater detail on Map 1.2: Automobile Conflict & Lighting Issues (photos with letters correspond to notes on Map 1.2)



Wake Forest Road leading to the campus core is an area where speeding automobile traffic is observed.



Carroll Weathers Drive is another area where speeding automobile traffic is observed.



The crosswalk on the east side of the Wake Forest Road/Wingate Road intersection stretches for a considerable distance across the widened section of Wake Forest Road leading to the campus core. This leaves crossing pedestrians vulnerable to conflicts with motorists.



Allen Easley Street is narrow and uncomfortable for bicyclists.



A lack of nighttime lighting was cited as a concern along the Reynolda Greenway.

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(Letters correspond to points on map)

Automobile Conflicts:

- a** Cars reported as frequently speeding on Wake Forest Road, between University Drive and the campus core.
- b** Cars reported as frequently speeding on Carroll Weathers from Wake Forest Rd to Long Dr.
- c** Cars reported as not stopping or yielding for pedestrians at the intersection of Wingate Rd and Wake Forest Rd. This comment was made multiple times during input sessions.
- d** Bicycle & pedestrian travel through Parking Lot Q is difficult, especially the main travel way bisecting the lot from southeast to northwest. Cars also reported as frequently speeding through Parking Lot Q.
- e** Conflict area noted from Aaron Ln into Parking Lot Q.
- f** Allen Easley St is narrow for all road users; cars observed speeding.

Insufficient Lighting Reported:

- g** Along Polo Rd
- h** Along Wake Forest Rd (drivers cannot see pedestrians until they are in the road)
- i** Between Greene Hall & Calloway Center
- j** Between Collins and Reynolds Gym
- k** Area near Collins Hall and Parking Lots J & H
- l** Along Jasper Memory Lane, especially on the southern curve of the road approaching Gully Dr.
- m** The corner of Faculty Drive & Wingate Drive
- n** Along Faculty Drive (however, residents do not want light pollution)
- o** Reynolda Village/Garden
- p** Along the Reynolda Greenway





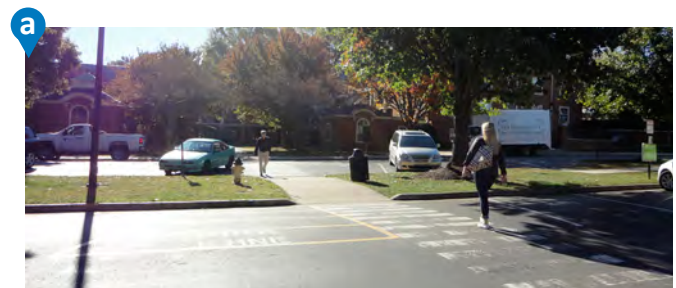
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BICYCLE-SPECIFIC ISSUES

There are no on-road facilities dedicated to bicycling at Wake Forest University. Aside from a few sections of multi-use trail (e.g., the Reynolda Greenway), **most bicycling on campus is done on-street, mixed with automobile traffic, or on sidewalk, mixed with pedestrians.** In most cases, the posted speeds on campus streets are low enough to accommodate both bicyclists and motorists without dedicated bicycle lanes. However, traffic speeds and volumes at certain times of the day prevent less experienced riders from bicycling comfortably.

Other general observations and comments received regarding bicycling include:

- **Bicycling to and from campus** is the main issue: once on campus many people lock up and walk.
- Aside from certain choke-points, many of the pathways on campus accommodate both bicyclists and pedestrians, so long as **bicyclists' speed and behavior** respects the needs of pedestrians.
- There is a **lack of curb ramps** in many areas of campus, causing bicyclists to divert routes unnecessarily, or causing them to hop curbs, potentially harming themselves or their bicycles. The north side of campus was noted as having a greater deficiency of curb ramps.



One-way loop in front of Poteat and Kitchin Halls.



Wide walkway in front of Farrell Hall that accommodates multiple user types.

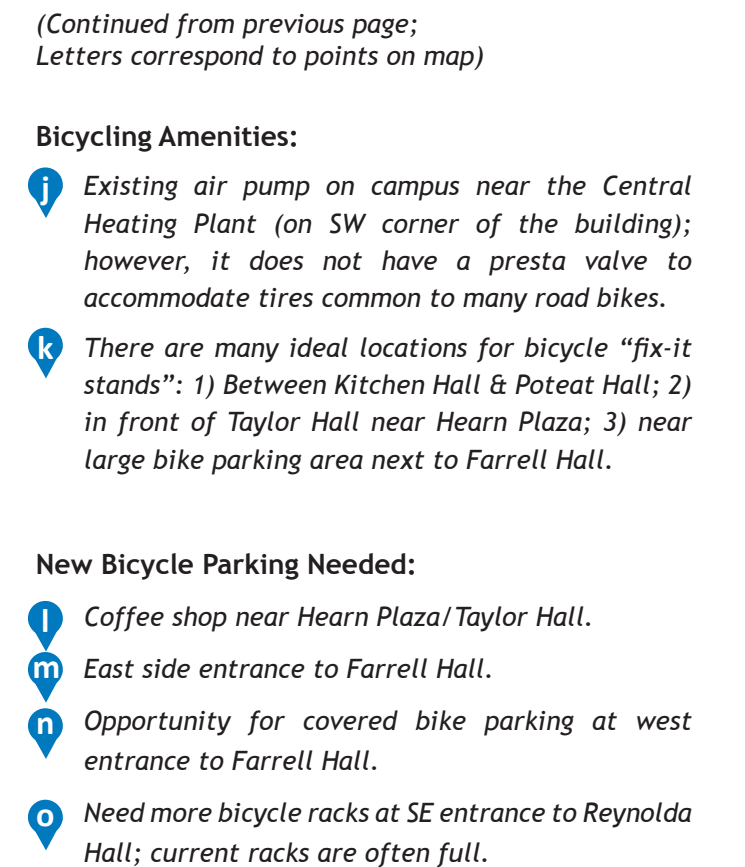
- A major barrier to bicycling on campus is going **north to south**, especially near the campus core – it's not clear how or where to connect through.
- Both bicyclists and motorists need to know the **rules of the road** and how to share the road safely.
- There is a **need for covered bicycle parking**, indoor bicycle parking, bicycle racks at more bus stops, and place on campus to repair bicycles.

These issues are listed in greater detail below and on Map 1.3: Bicycle-Specific Issues.

(Letters correspond to points on Map 1.3)

Conflict Areas for Bicycling:

- a** Motorists and bicyclists observed going the wrong way on small one-way loops on campus. Examples include in front of Martin Hall, Kitchen/Poteat Halls and Taylor/Davis Halls.
- b** Existing speed bumps are constraints for bicycling in some locations (for example, on Wake Forest Rd west of Davis Field and east of Allen Easley St); consider using ramps that have space for bicyclist to ride through.
- c** Allen Easley St is narrow for bicycling, especially with parked cars and other cars in travel lane.
- d** Part of the wide walkway in front of Farrell Hall could be formalized for bicycle use.
- e** There are blind spots for bicycling (for example, near Parking Lots A & P, and near Greene Hall)
- f** Expectations for bicycling and bicycling behavior could be better defined within the quad, and in the lower quad near the library.
- g** Ramps or bicycle-friendly staircases would facilitate bicycle travel near southeast corner of Polo Hall.
- h** Stairways from Parking Lot Q to Wingate Hall are barriers for bicycling; ramps or retrofitted bicycle-friendly staircases would improve conditions.





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PEDESTRIAN-SPECIFIC ISSUES

Wake Forest University's campus core has a **solid network of sidewalks, crosswalks, and interior walkways**. The largest barriers to pedestrians that were discussed during input sessions and observed included **automobile speeds, lighting issues, blind spots, and a lack of crosswalks and curb ramps** in some areas, especially outside the immediate campus core.

Accessibility for those with special mobility needs is another topic area that was discussed during this plan's input sessions. The WFU website has an online Accessibility Map that shows inaccessible paths, which are shown as red dots on Map 1.4. Other comments received on this topic included the need for truncated domes for detection of curb ramps by the blind, and the need for well-marked/high-visibility crosswalks for those with low-vision.

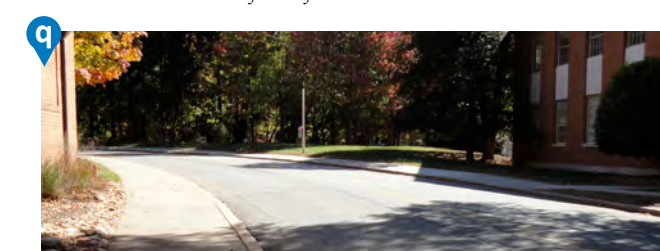
These issues are listed in greater detail below and on Map 1.4: Pedestrian-Specific Issues.



Overgrown trees cover the sidewalk at the Wingate Road/Jasper Memory Lane intersection and also block pedestrians from the view of motorists.



Curb ramps and a crosswalk are lacking between the Allen Easley Street sidewalk and the sidewalk in front of the Welcome Center.



Crossing improvements are needed on Gulley Drive between Winston and Salem Halls.

(Letters correspond to points on Map 1.4)

Conflict Areas for Walking:

- a** Crossing University Parkway (previous study).
- b** West side of Carroll Weathers Dr.
- c** Curve of Wake Forest Rd near Parking Lot P.
- d** Blind spot at curve of Wingate Rd near Scales Fine Art Center.
- e** Blind spot at curve of Wingate Rd near Greene Hall.

Signage:

- f** Need in-road pedestrian yield signs at crosswalks along northeast corner of Carroll Weathers Dr.
- g** Signage to Reynolda Trail could be improved.
- h** Need in-road pedestrian yield sign in Parking Lot Q between Starbucks and the trail/bridge.

Curb Ramp Issues:

- i** Missing curb ramp in front of Law School building at Wake Forest Rd.
- j** Missing curb ramp at intersection of Allen Easley St. and Wake Forest Rd.
- k** Large ramp needed between Manchester Plaza & Reynolda (expensive, longer term opportunity).
- l** The sidewalk around the South Hall parking lot has a curb cut that goes directly into a parking space.



(Continued from previous page;
Letters correspond to points on map)

Crosswalk Issues:

- m** Improved crossings needed in front of South Hall and Collins Hall on Jasper Memory Lane.
- n** Improved crossings needed at all legs of the Wake Forest Rd/Carroll Weathers Dr intersection - increased volumes are expected.
- o** Improved crossings needed along Polo Rd at Student Drive and between Student Drive and Long Dr.
- p** Improved crossings needed along Wake Forest Rd near Farrell Hall.
- q** Crosswalk needed along curve between Winston & Salem Halls.
- r** Crosswalks needed at intersection of Allen Easley St. and Wake Forest Rd.
- s** East end of Aaron Lane is not clearly identified in Q parking lot - possible crosswalk needed through parking area.

Sidewalk Issues:

- t** Sidewalk missing near Demon Deacons Radio Station building (east of Kentner Stadium).
- u** Sidewalk missing on north side of Wake Forest Rd, from Allen Easley St to Davis Field.
- v** There are new sidewalks being put in from Davis to Scales.





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2 RECOMMENDATIONS

RECOMMENDATIONS OVERVIEW

This chapter details the infrastructure improvements that are recommended to create a safe, accessible, and connected pedestrian and bicycle network on campus. A diverse mix of facilities are recommended to create this network, including sidewalks, crossing improvements, on-road bicycle facilities, and multi-use paths. Support facilities are also recommended, such as bicycle racks, bicycle repair stations, lighting, and ramps for accessibility.

METHODOLOGY FOR DEVELOPING RECOMMENDATIONS

Recommendations were developed based on information from many sources (see diagram at right). During the the first stage of planning, consultants collected input from WFU offices, services, groups, and students on the key opportunities and constraints for walking and bicycling on campus. This input was then compiled on maps and spreadsheets, and analyzed remotely using GIS and Google Streetview. Next, consultants conducted a field analysis to examine the opportunities and constraints first hand. The baseline results of this effort are summarized in chapter one, whereas the outcomes of this effort (the recommendations) are the focus of this chapter.

Key Inputs for Developing Recommendations:



CHAPTER ORGANIZATION

The first set of maps outline the overall recommendations by the following main categories, representing the comprehensive network of all recommended facilities:

- Map 2.1 Pedestrian Circulation Improvements
- Map 2.2 Bicycle Circulation Improvements
- Map 2.3 Multi-Use Trail Improvements

Priority recommendations are featured in the pages following these maps, including five high-impact *priority projects* that can be implemented at relatively low-cost, followed by five *priority investments*, that will have the greatest positive impact on walking and bicycling, but that are also more complex and more expensive to implement.

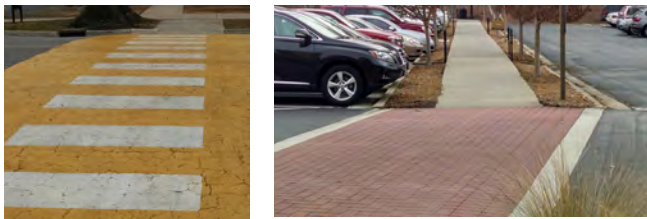


PEDESTRIAN CIRCULATION IMPROVEMENTS

While recommendations specific to bicyclists and multi-use facilities will also have a positive impact on pedestrian circulation, the following recommendations are most specific to pedestrians and include the following:

- Sidewalk Improvements
- Crossing Improvements
- Ramp Improvements

Each of these will improve pedestrian and ADA accessibility to, around, and within the campus core. Site-specific recommendations are detailed below and on Map 2.1: Pedestrian Circulation Improvements.



Crosswalks should clearly delineate a space for pedestrians and be highly visible. The yellow and white crosswalk connecting Scales and Taylor Hall (left) and the brick crosswalk in front of Dogwood Hall (right) provide excellent examples.



Ramps are needed on both sides of Wait Chapel to allow for wheelchair accessibility to Hearn Plaza (existing stairway on the west side pictured above).



A sidewalk along the western edge of Parking Lot Q would allow for people to walk safely to and from their cars, as well as to and from Allen Easley St. and points south.

RECOMMENDED IMPROVEMENTS

(Letters correspond to points on Map 2.1)

Sidewalk Improvements:

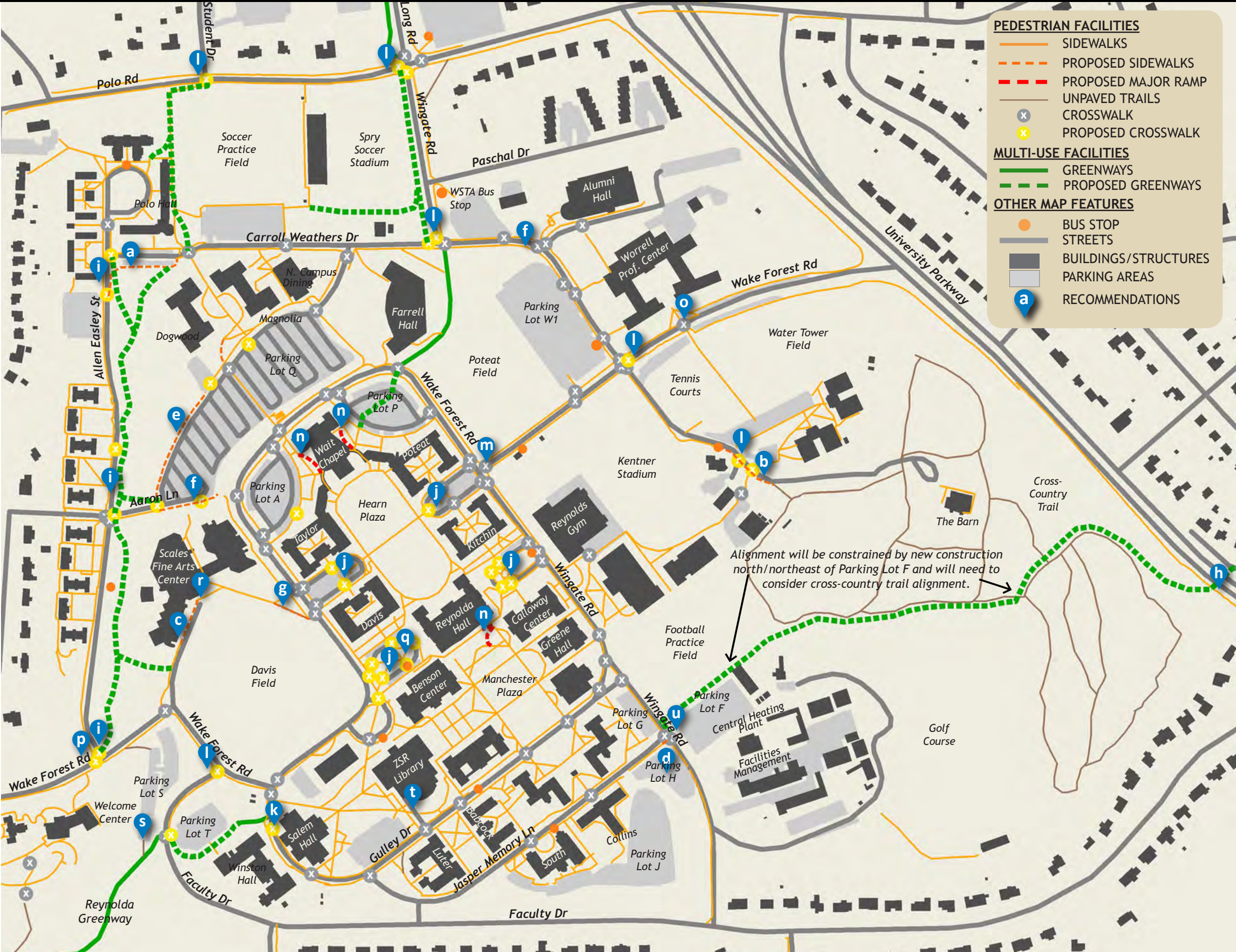
- a** New sidewalk connection from Allen Easley Street parking lot to north entrance of Dogwood Hall.
- b** New sidewalk connection near Demon Deacons Radio Station building (east of Kentner Stadium).
- c** New sidewalk or better defined pedestrian space on southeast side of Scales Fine Arts Center.
- d** New sidewalk link near the intersection of Jasper Memory Lane and Wingate Road.
- e** New sidewalk from Aaron Lane to existing and proposed sidewalk ramp in front of Dogwood Hall.
- f** New sidewalk along the south side of Parking Lot Q from existing Aaron Lane sidewalk to the stairs leading to Wake Forest Road.
- g** New sidewalk link on existing informal dirt path on north side of Davis Field.

Greenway Bridge:

- h** Greenway bridge crossing of University Parkway (recommended in the 2014 Wake Forest University Area Bicycle, Pedestrian & Transit Study).

Crosswalks:

- i** Allen Easley Street - several crosswalks will be needed in tandem with sidewalk and multi-use trail development, including a mid-block crossing north of Aaron Lane.
- j** Hearn Plaza area car loops - several crosswalks are currently needed where sidewalks traverse four automobile loops in the vicinity of Hearn Plaza.
- k** Winston & Salem Halls - high visibility crosswalk & speed table needed.
- l** Other crosswalks needed - several other crosswalks are needed for **existing** crossings such as at Wake Forest Road/Faculty Drive, Wake Forest Road/Carroll Weathers Drive, and Polo Road/Student Drive. **Future** crosswalks will be needed as sidewalks and greenways expand to the intersections at Polo Road/Wingate Road, Carroll Weathers Drive/Wingate Road, and near the Deamon Deacons radio station.



(Continued from previous page;
Letters correspond to points on map 2.1)

m Wake Forest Road and Wingate Road - This intersection is wide with high pedestrian and automobile activity. It currently has a high visibility crosswalk, but median refuge island is recommended on the northeast side of the intersection to enhance pedestrian comfort and safety.

Major Ramps:

- n** The connection between Manchester Plaza and Reynolda Hall can only be made by stairs. A new wheelchair-accessible ramp is recommended for this connection. The ramp would curve around the mangolia tree that is located on the northeast corner of Manchester Plaza, and would switchback to the center from behind the tree.
- n** The northern corners of Hearn Plaza are not wheelchair accessible from the parking lots on either side of Wait Chapel. New wheelchair-accessible ramps are recommended at these major gateways to Hearn Plaza.

Curb Ramps:

Curb ramps are recommended for all crossing and sidewalk/trail access locations, including these where they are currently missing:

- o** In front of Worrell Professional Center at Wake Forest Road.
- p** Intersection of Allen Easley Street and Wake Forest Road.
- q** Several curb ramps needed around loop west of Reynolda Hall.
- r** In front of Scales Fine Arts Center.
- s** Formalize short informal path between parking lot and the Reynolda Greenway with curb cut/ ramp.
- t** Crossing of driveway on south side of the library.
- u** East side of Jasper Memory Lane and Wingate Road intersection.





BICYCLE CIRCULATION IMPROVEMENTS

While recommendations specific to pedestrians and multi-use facilities will also have a positive impact on bicycle circulation, the following recommendations are most specific to bicycling and include the following:

- Cycle Tracks
- Bicycle Lanes
- Shared Lane Markings (Sharrows & Wayfinding)
- Bicycle Parking
- Bicycle Friendly Stairways
- Bicycle Repair Stands
- Bicycle Friendly Speed Bumps

Each of these are included in the Design Guidelines found in the Appendix.



Changing one side of one isle of parking from stalls to parallel would allow space for a two-way cycle track through parking lot Q to Wake Forest Road and Wait Chapel.



A bicycle-friendly stairway (with a wheel ramp) is needed at the parking lot Q/Wake Forest Road connection.



The entrance area on the west side of Farrell Hall would be a great place for covered bicycle parking as well as a bicycle repair stand (cover provided by the existing building).

The proposed greenway network, bicycle lanes, and shared lane markings are designed to improve bicycle circulation to and around the campus core. Distances within the campus core easily navigable by foot. By improving bicycle parking and installing bicycle-friendly stairways, ramps and repair stands, bicyclists arriving to the campus core will have enhanced opportunities to:

- Lock their bicycle and become pedestrians;
- Walk through the campus core with their bicycle;
- Slowly ride their bicycle through the campus core; and
- Have easy access to bicycle repair.

RECOMMENDED IMPROVEMENTS (Letters correspond to points on Map 2.2)

Cycle Track:

- a** *This proposed two-way cycle track will require changing one side of one isle of parking from 90 degree stalls to parallel parking—a net reduction of approximately 14 spaces (or, a fraction of a percent of all spaces provided at WFU). This would create an essential north-south bicycling link for campus, complementing the existing pedestrian walkways to the east and west.*

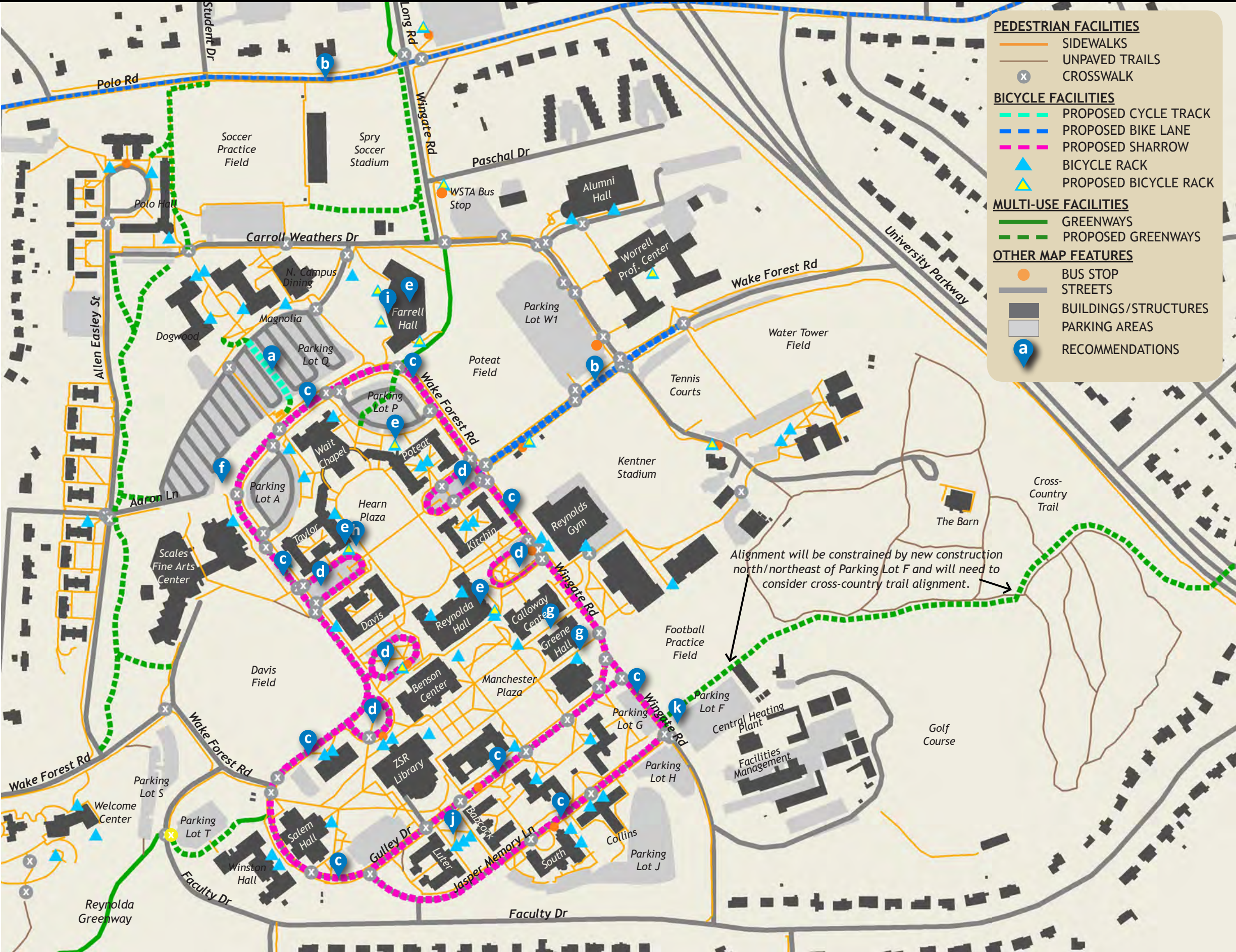
Bicycle Lanes:

- b** *Bicycle lanes are recommended on Polo Road for the length of its proximity to Wake Forest campus. Bicycle lanes are also recommended from the Wake Forest Road/Wingate Road intersection to the Worrell Professional Center (the existing roadway width is 30', allowing for 10' travel lanes and 5' bicycle lanes on each side).*

Shared Lane Markings (Sharrows):

- c** *Shared lane markings are recommended on the core campus roads of Wake Forest Road, Wingate Road, Gulley Drive, and Jasper Memory Lane.*
- d** *Sharrows are also recommended on the five small one-way loops near the campus core.*

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(Continued from previous page; Letters correspond to points on map 2.2)

Bicycle Parking:

e New bicycle racks are recommended underneath the cover of the west side of Farrell Hall, at the southeast entrance to Farrell Hall, the northeast corner of Poteat Hall, the coffee shop entrance at Hearn Plaza/Taylor Hall, and the southeast corner of Reynolda Hall (the existing rack is reportedly commonly full).

Bicycle Friendly Stairways:

- f** Stairway at the south end parking lot Q to Wake Forest Road.
- g** Both stairways flanking Greene Hall leading to Manchester Plaza.

Bicycle Repair Stations:

- h** In front of Taylor Hall near Hearn Plaza
- i** At west entrance to Farrell Hall
- j** At the large existing bicycle rack between the Luter and Babcock Halls.
- k** At the proposed greenway trailhead near Wingate Rd and Gulley Dr.

Bicycle Friendly Speed Bumps:

- Future speed bumps/tables should have spaces for bicyclists to pass without changing grade. This should also be considered during any improvements to existing speed bumps/tables.





MULTI-USE TRAIL IMPROVEMENTS

New multi-use trails are recommended to improve bicycle and pedestrian circulation to and from the campus core. These new trails would provide separation from motor vehicle traffic for people walking and bicycling. The main types of trail surfaces to be considered include:

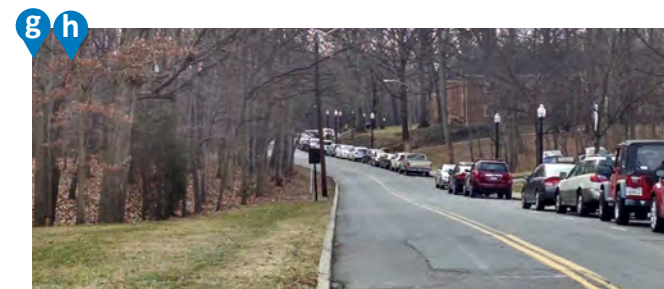
- Paved multi-use trails
- Unpaved multi-use trails
- Boardwalk

Each of these trail types are detailed in the Design Guidelines found in the Appendix.

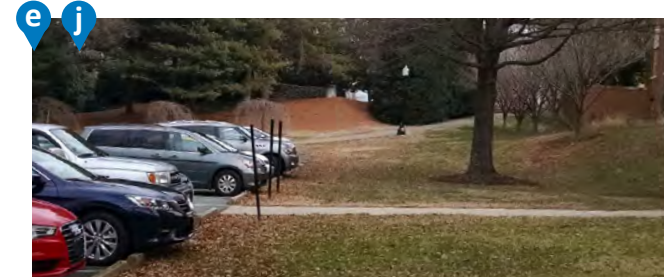
Recommendations for improved lighting and speed enforcement are also included in this section.



Widening this sidewalk and gate, along with a graded ramp would make this a key northern campus multi-use connection.



An excellent opportunity for a multi-use trail exists in the wooded area along the east side of Allen Easley Street.



Space between Winston Hall and the adjacent parking lot should be used for a multi-use trail connection to the Reynolda Greenway.

RECOMMENDED IMPROVEMENTS

(Letters correspond to points on Map 2.3)

Paved Multi-Use Trails:

- a** This sidewalk should be expanded to accommodate both walking and bicycling. Additionally, a ramp should be provided along with a bicycle-friendly gate at Polo Road. The existing sidewalk on the east side of Polo Hall should be reconstructed to a multi-use trail, connecting to the Allen Easley Street loop and Carroll Weathers Drive.
- b** Multi-use trail along the west side of Wingate Rd, linking existing greenways at Long Road and Farrell Hall.
- c** Multi-use trail along the south side of Spry Soccer Stadium, improving north campus circulation.
- d** Multi-use trail through parking lot P, providing a direct link between the Farrell Hall greenway and Hearn Plaza; a route that is already informally utilized.
- e** Extend the Reynolda Greenway in the ample space between Winston Hall and parking lot T. A short section of paved pathway already exists between the parking area and Gulley Dr.
- f** Previously proposed in the 2014 Wake Forest University Area Bicycle, Pedestrian, and Transit Study, this proposed multi-use trail would link to the athletic fields crossing University Parkway via a bicycle and pedestrian bridge.

Unpaved Trails and Boardwalk:

- g** A trail through the woods along Allen Easley Street would significantly enhance north-south bicycle and pedestrian connectivity on the west side of campus. Further analysis should be conducted to identify sustainable trail development options that may include a footpath, unpaved trail, paved trail, boardwalk, or some combination of surface types.
- h** This section near the Scales Fine Arts Center would likely require a combination of boardwalk and small trail bridges to accommodate the steeper grades and the proximity to the creek.



(Continued from previous page; Letters correspond to points on map 2.3)

Lighting Improvements:

Lighting improvements are recommended along Polo Road, between Greene Hall and the Calloway Center, between Collins Hall and Reynolds Gym along Wingate Road and Jasper Memory Lane, Wingate Road toward Faculty Drive, and along the Reynolda Greenway.

Speed Enforcement Locations:

Speed enforcement is recommended along Wake Forest Road between the Worrell Professional Center and the campus core, along Carroll Weathers Drive near Alumni Hall, along Allen Easley Street, and through parking lot Q.



Carroll Weathers Drive is an example of a location where speeding automobile traffic should be curtailed for pedestrian and bicycle safety. Even with speeds posted as low as 10 MPH, students and faculty reported this location as problematic.





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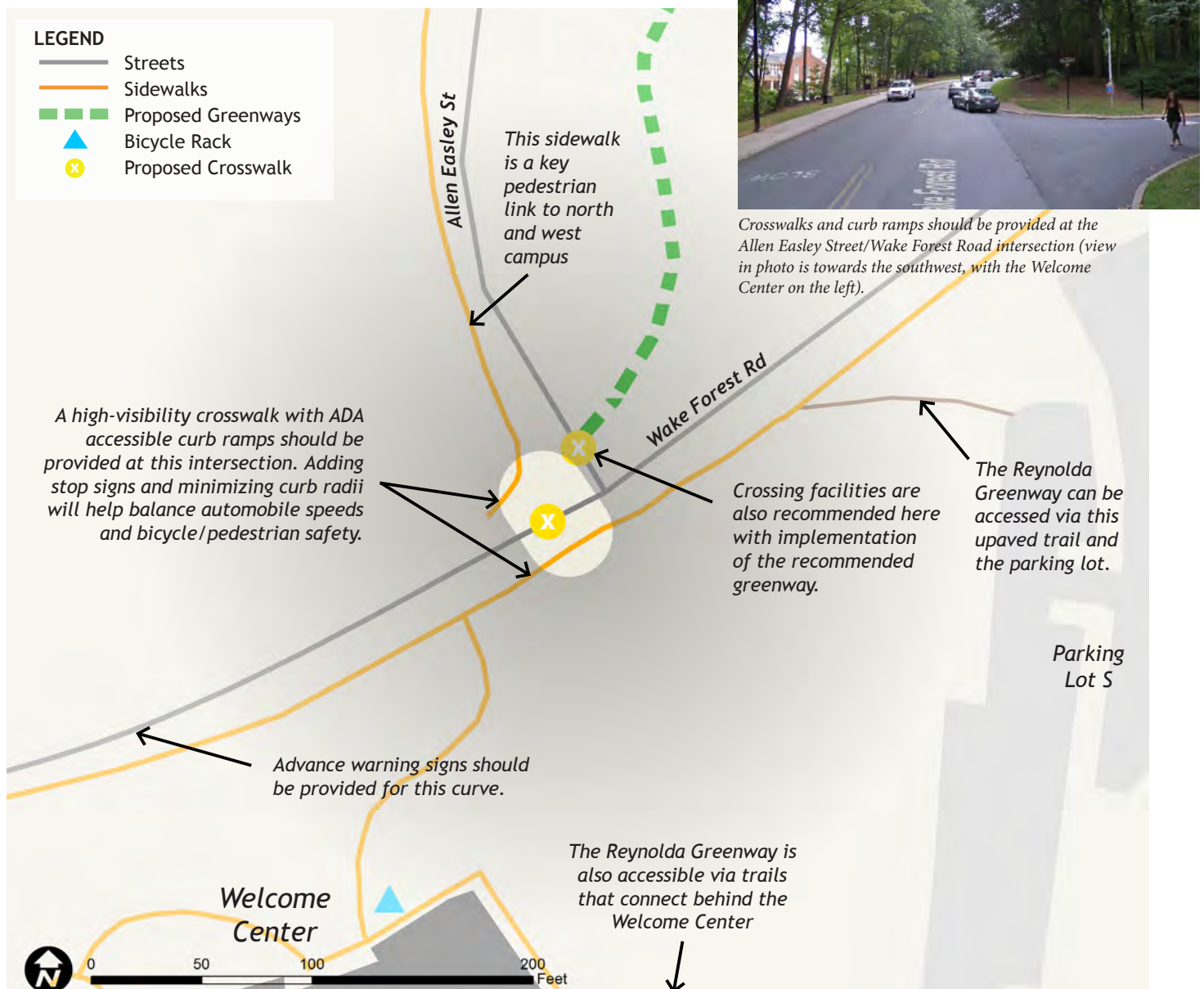


PRIORITY PROJECT #1: WELCOME CENTER INTERSECTION IMPROVEMENTS

This intersection serves as a key pedestrian link on the southwest side of campus, not only linking to the Welcome Center and the Allen Easley Street corridor, but also linking to the Reynolda Greenway (via the Welcome Center or Parking Lot S). Recommendations:

1. Convert the Allen Easley St and Wake Forest Rd intersection to a three-way stop.
2. Provide a high visibility crosswalk connecting the existing sidewalks on Allen Easley Street and Wake Forest Road, with ADA accessible curb ramps and advance warning signs.
3. Consider a curb radius reduction for both corners of the intersection to further balance automobile speed and pedestrian and bicycle safety, taking into account truck movements.
4. Provide additional crossing facilities in conjunction with the design and construction of the proposed greenway on the east side of Allen Easley St.

Planning-level Cost Estimate: \$6,677



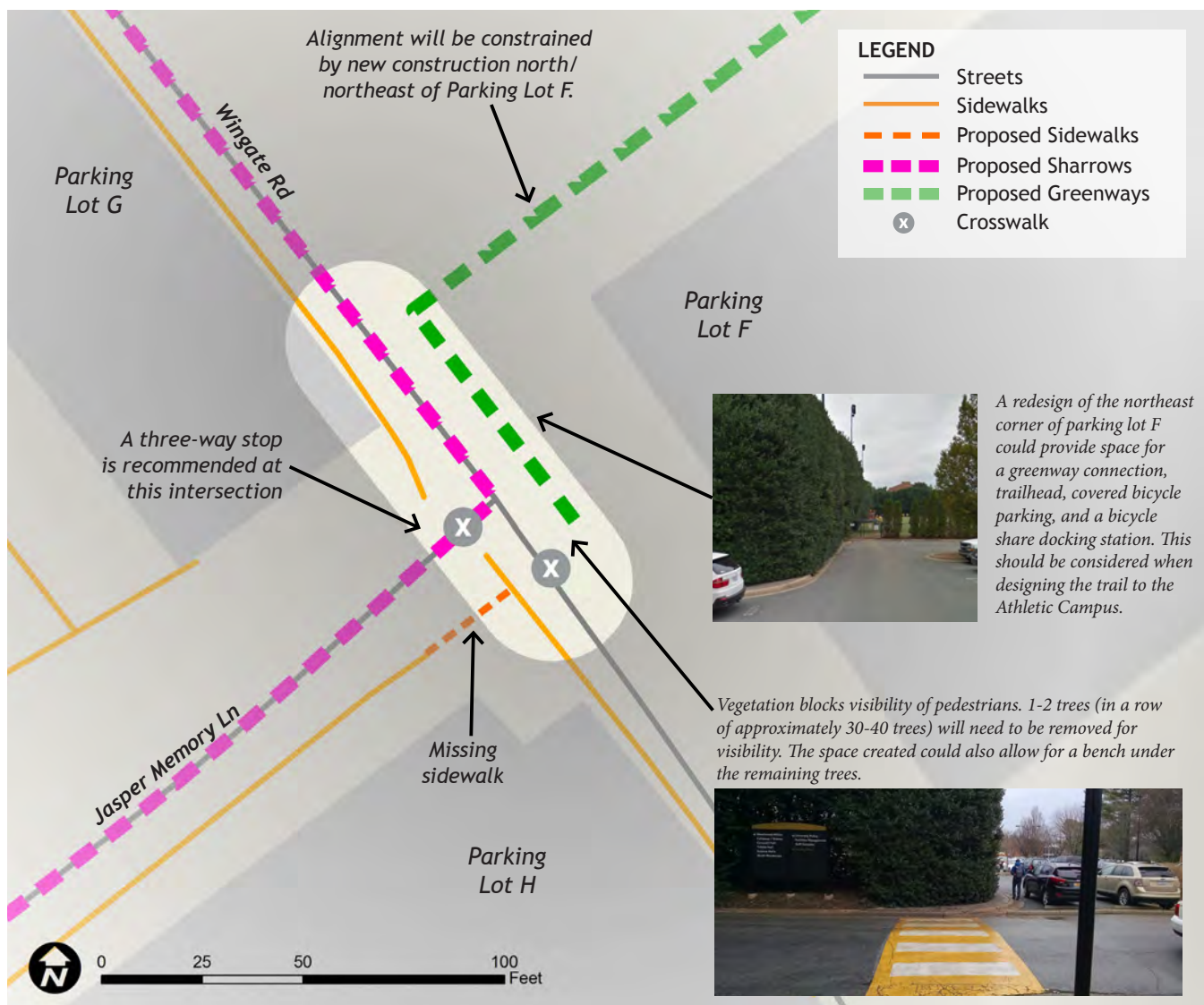


PRIORITY PROJECT #2: JASPER MEMORY LANE/WINGATE ROAD INTERSECTION IMPROVEMENTS

This intersection has high-visibility crosswalks and curb ramps, but it is still difficult for motorists and pedestrians to see one another due to vegetation covering the sidewalk on the east side of the intersection. Recommendations:

1. Complete missing section of sidewalk along Jasper Memory Ln, near the intersection.
2. Convert the Wingate Rd and Jasper Memory Lane intersection to a three-way stop.
3. Enhance visibility and create pedestrian space by removing the 1-2 trees that cover the sidewalk. Consider a bench and/or other street furniture under the remaining trees. This will also allow better access to the proposed greenway.
4. Redesign the western corner of Parking Lot F during the design and construction of the proposed greenway (which will eventually connect to the Athletic Campus). The proposed greenway trail should connect to this intersection through the western corner of the parking lot, which may require limiting automobile circulation in this part of the lot. Covered bicycle parking could also be provided here, and if WFU pursues a bicycle share system, this would be an ideal location for a bicycle share dock (in tandem with a dock at the eastern terminus at the Athletic Campus/Freshmen parking lot).

Planning-level Cost Estimate: \$2,448



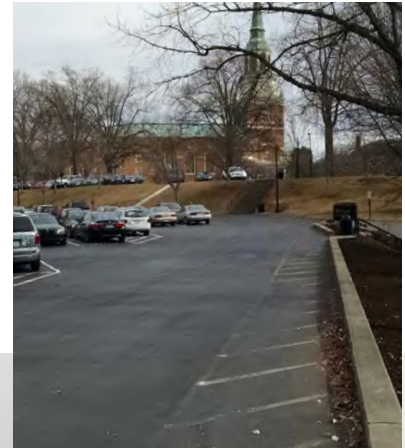


PRIORITY PROJECT #3: AARON LANE TO WAKE FOREST ROAD SIDEWALK/CROSSWALK (PARKING LOT Q)

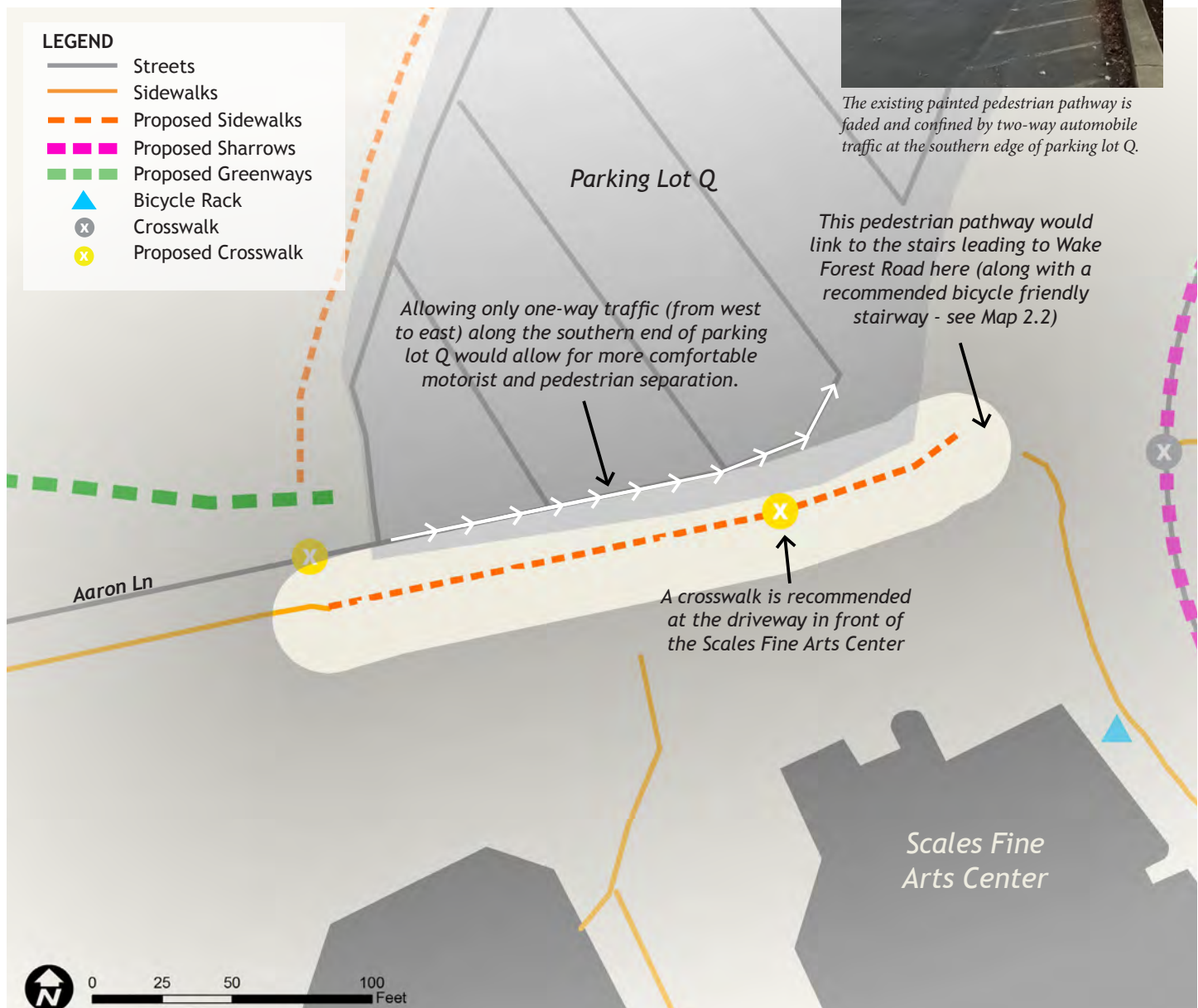
Aaron Lane provides a key connection between the campus core and the Welcome Center. The existing sidewalk stops at the intersection of Aaron Lane and parking lot Q, leaving pedestrians to walk through the southern part of parking lot Q to connect to the stairs leading to Wake Forest Road. Recommendations:

1. Designate a short section of parking lot Q as one-way for automobile traffic (west to east) (see below).
2. Use the space gained by the one-way conversion to create a pedestrian link with either a sidewalk or a painted pavement marking to indicate pedestrian space. If using pavement markings, also include a barrier on the north side of the walkway to separate pedestrians and motorists.

Planning-level Cost Estimate: \$10,728



The existing painted pedestrian pathway is faded and confined by two-way automobile traffic at the southern edge of parking lot Q.



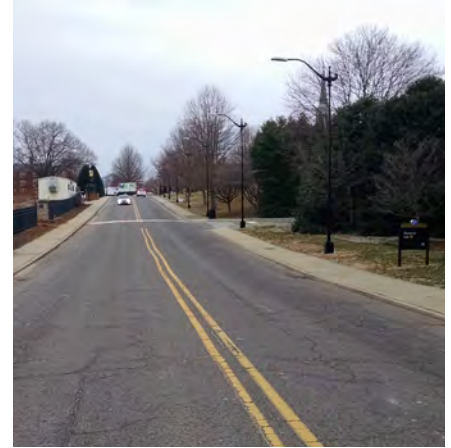


PRIORITY PROJECT #4: WAKE FOREST ROAD BIKE LANES

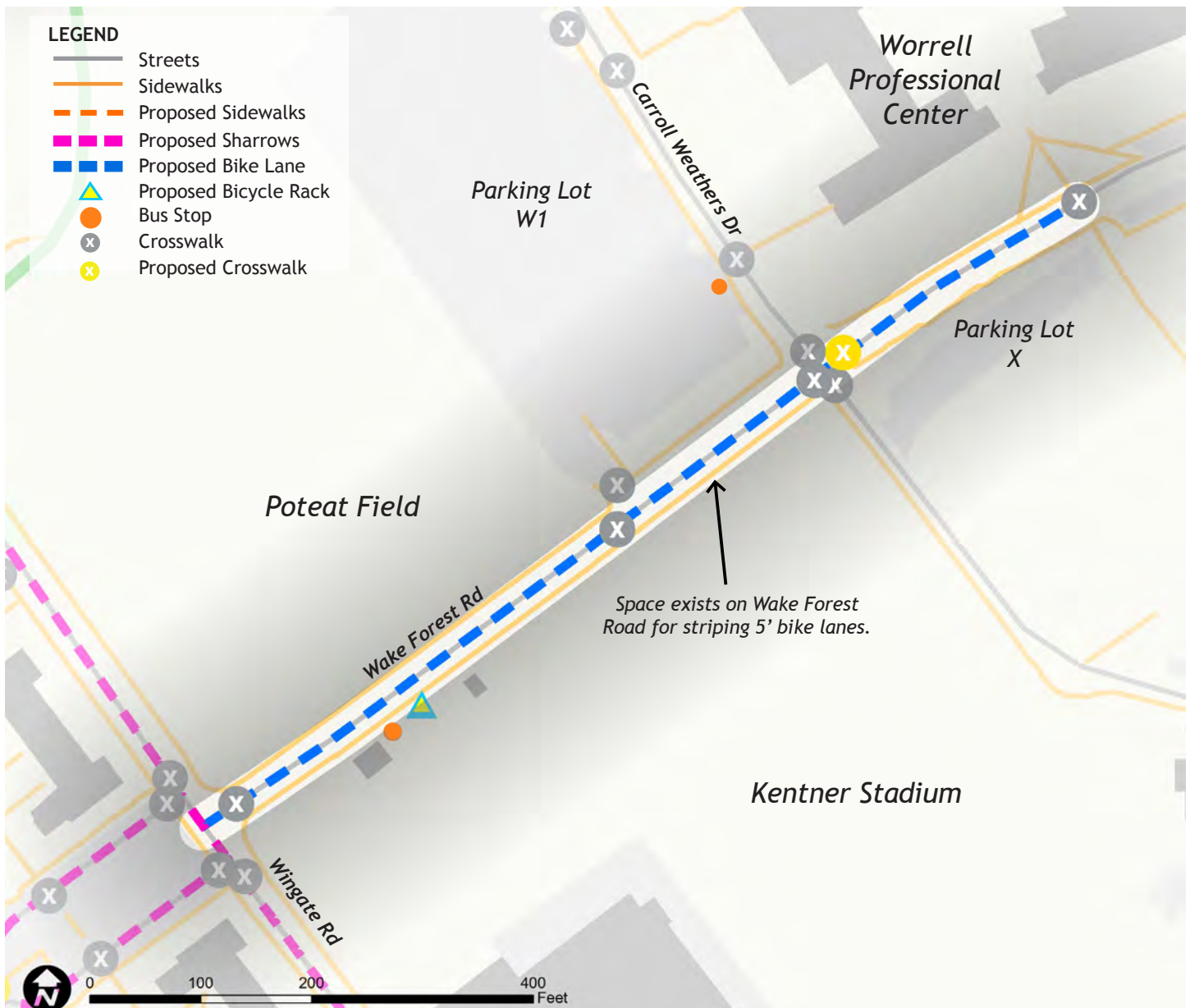
From the Wingate Road/Wake Forest Road intersection at the campus core to the front of the Worrell Professional Center, Wake Forest Road measures 30 feet in width. This allows for the striping of five foot bicycle lines on both sides of the road, allowing for 10 feet of roadway for each motorist lane. Narrowing of the motorist lanes will calm motorist traffic speeds and also provide a more comfortable pedestrian experience along the existing sidewalks that lack a buffer between the sidewalk and roadway. This recommendation will improve bicyclist circulation east of the campus core at relatively little cost. Recommendation:

1. Stripe bicycle lanes on Wake Forest Rd, from Wingate Rd to Worrell Hall.

Planning-level Cost Estimate: \$6,027



Wake Forest Road leading to the campus core has space for five foot bicycle lanes to be striped on both sides of the road.





PRIORITY PROJECT #5: REYNOLDA GREENWAY EXTENSION

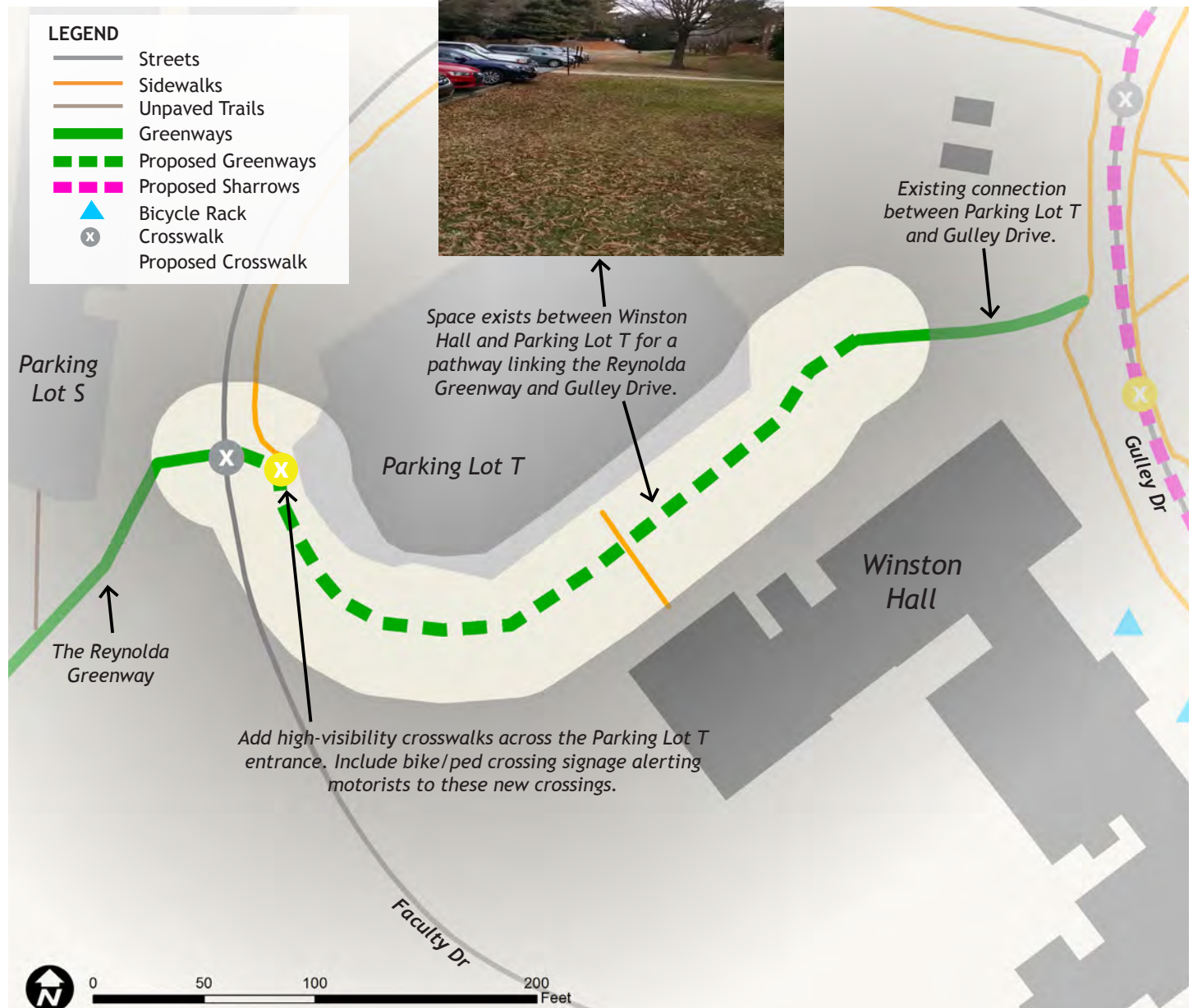
Ample space exists between Winston Hall and Parking Lot T for a greenway linking the existing Reynolda Greenway and pathway to Gulley Drive. This greenway link would enhance campus core connectivity to the Reynolda Greenway. Recommendation:

1. Construct greenway link between Winston Hall and Parking Lot T from the Reynolda Greenway to the existing pathway connecting Gulley Drive.

Planning-level Cost Estimate: \$40,416



Looking east from the Reynolda Greenway trail entrance toward Parking Lot T and Winston Hall.





PRIORITY PROJECT #6: BICYCLE REPAIR STATIONS

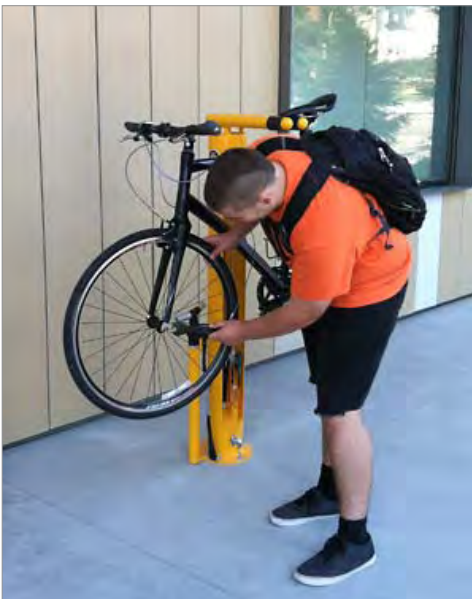
Bicycle repair stations have become a popular amenity in bicycle friendly communities and campuses because they provide bicyclists with access to tools on-the-go and encourage people to teach and learn bicycle maintenance in an informal setting. They can also help to reduce the number of abandoned or trashed bikes on campus; bikes are often abandoned by their owners when they have a minor mechanical issue that they do not have the tools or knowledge to fix. Public maintenance stands encourage people to learn bicycling skills from one another and send a message to students and visitors that bicycling is supported on campus. These fixtures require little upkeep or oversight, since the tools and stand are designed to be self-contained and theft-resistant.

Four locations are recommended for bicycle repair stations, based on student and stakeholder input and geographic distribution:

1. Near the large bicycle racks west of Farrell Hall
2. Near the coffee shop at Taylor Hall and Hearn Plaza
3. Near the large bicycle racks between Luter & Babcock Hall Plaza
4. Near Wingate Rd and Jasper Memory Lane, where the proposed greenway to the Athletic Campus would start

Typical components of bicycle repair stations include a bike pump, tool kit, and work stand. Please see the Design Guidelines Appendix for further detail on bicycle repair stations.

Planning-level Cost Estimate: \$6,062



Bicycle Repair Station examples.





PRIORITY INVESTMENT #1: DOGWOOD/MAGNOLIA CYCLE TRACK

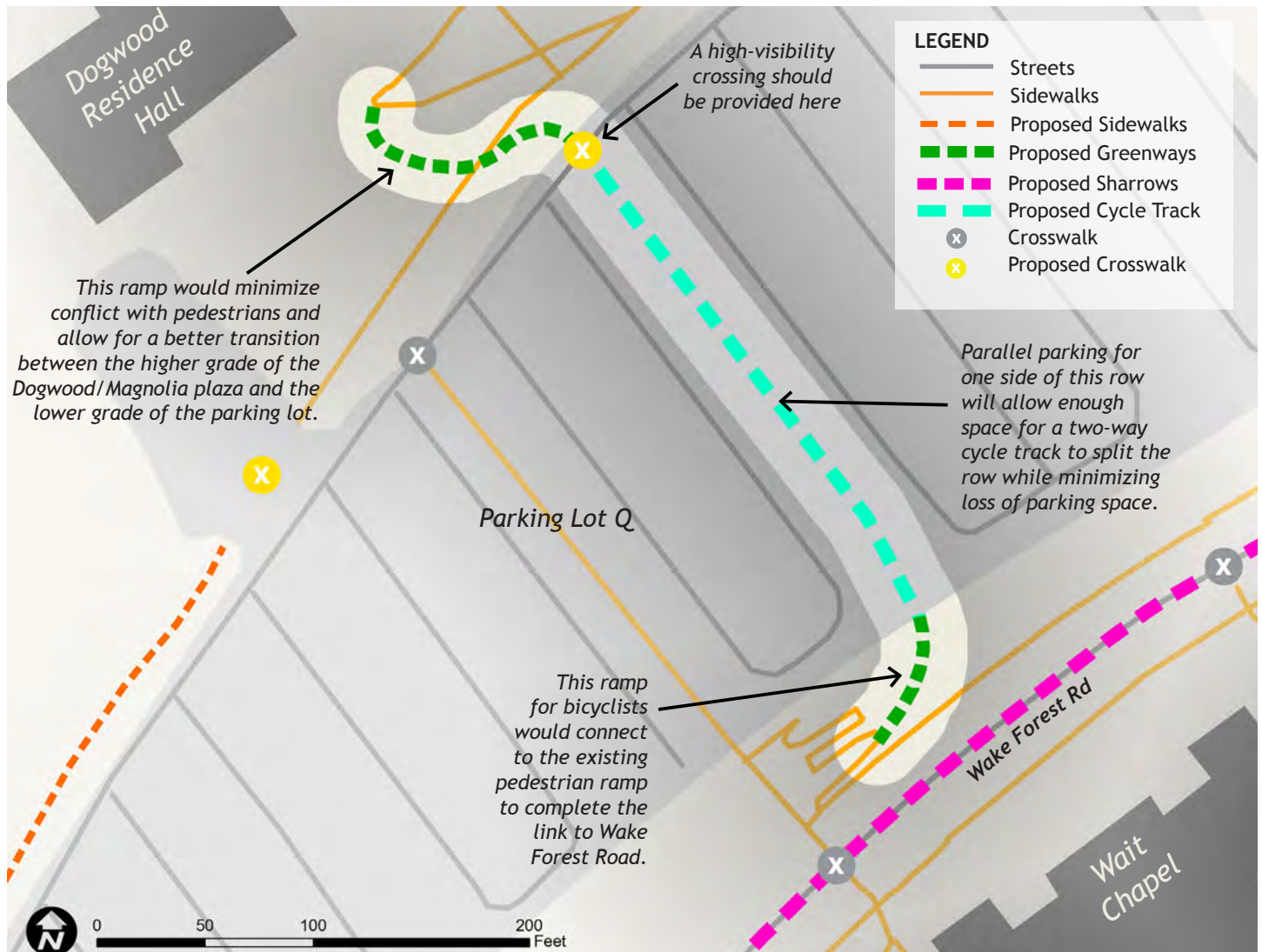
Parking lot Q is a conflict area for automobiles, pedestrians, and bicyclists due to its location between the campus core and north campus. Pedestrians are currently accommodated by a sidewalk on the northeast side of parking lot Q (connecting Wake Forest Road and the North Campus Dining Hall) and by another sidewalk bisecting parking lot Q from south of Dogwood Hall to Wake Forest Road. Recommendation:

1. Create a two-way cycle track with ramps at each end that would provide an essential north-south bicycling link for campus, complementing the existing pedestrian walkways on either side. This will require changing one side of one row of parking from 90 degree stalls to parallel parking—a net reduction of approximately 14 spaces (or 0.28 percent of all parking spaces provided at WFU). The cycle track would then split the row, with the parked cars serving as a buffer to moving automobile traffic. Careful design of this facility is required to ensure safety of all users.

Planning-level Cost Estimate: \$23,940



View from the Dogwood/Magnolia plaza. The proposed cycle track connecting to the campus core would require conversion to parallel parking on one side of the parking row to create space between the parked cars.





PRIORITY INVESTMENT #2: ALLEN EASLEY STREET GREENWAY

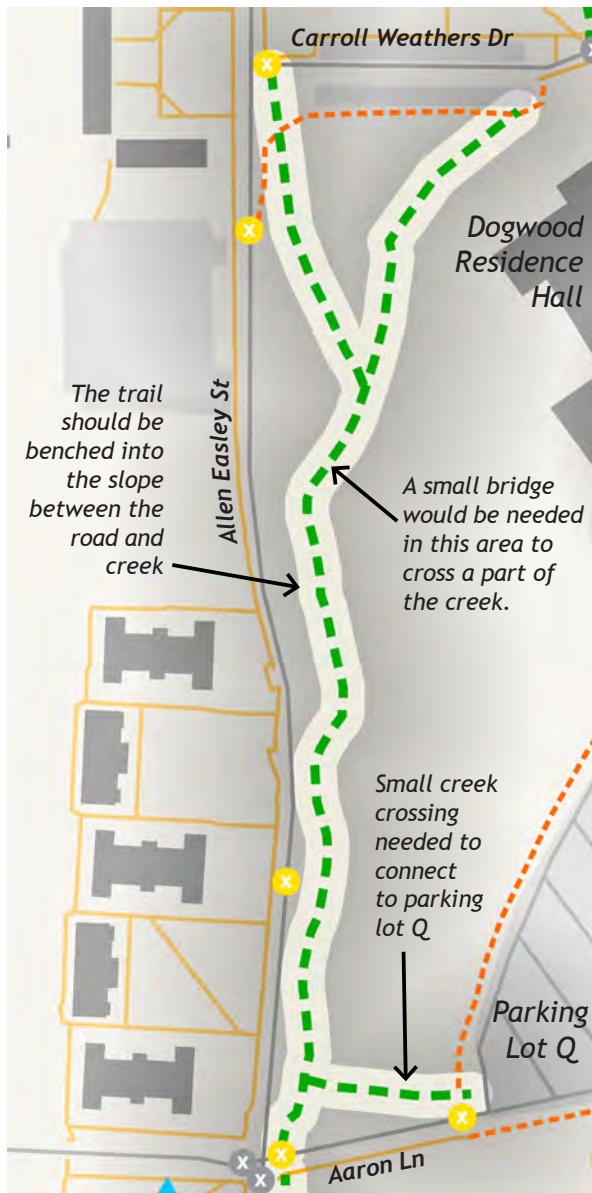
The proposed Allen Easley Street Greenway consists of a north-south multi-use trail on the east side of Allen Easley Street. This greenway would significantly enhance bicycle and pedestrian connectivity on the west side of campus. Further analysis should be conducted to identify sustainable trail development options that fit within county and state regulations for trails in floodplains with creek crossings. Recommendation:

1. Conduct a trail feasibility study that determines environmental permitting needs, proper trail surface types, and trail alignment (route shown below is conceptual only).

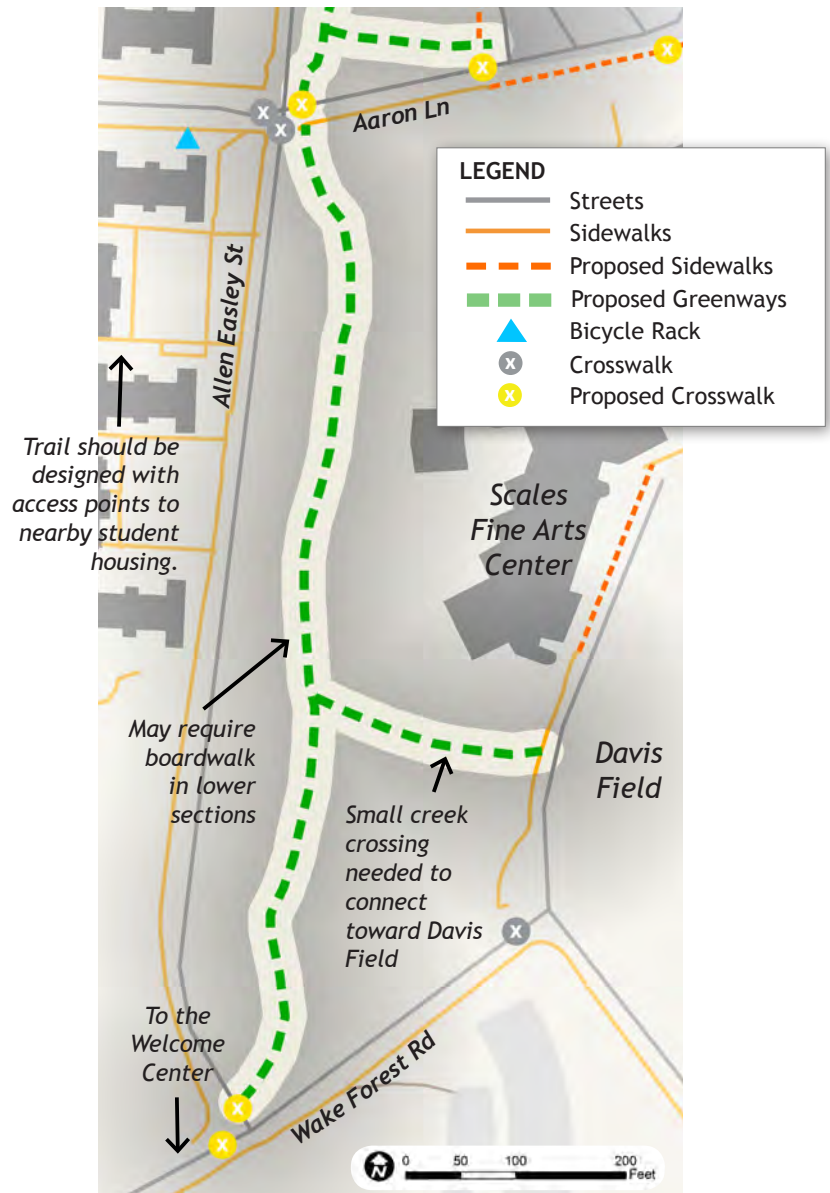
Planning-level Cost Estimate: \$60K-1.1M



NORTHERN SECTION



SOUTHERN SECTION





PRIORITY INVESTMENT #3: SPRY STADIUM SIDEPATH AND TRAIL

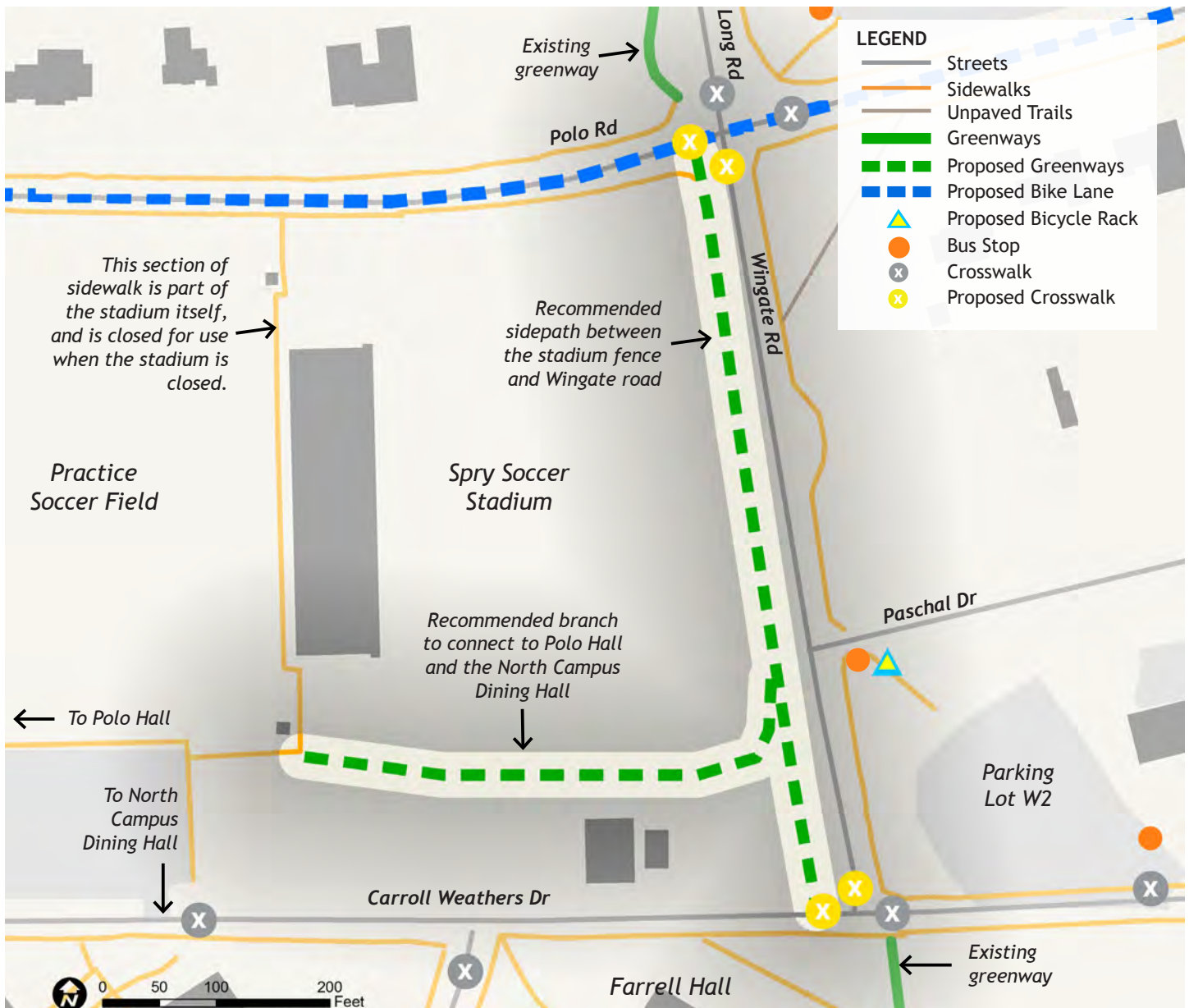
This proposed trail would complete the link between the greenway on the east side of Farrell Hall and the Long Road sidepath, significantly enhancing bicycle and pedestrian connectivity in north campus. Recommendation:

1. Create a sidepath along the west side of Wingate Rd, from Polor Rd to Carroll Weathers Dr.
2. Extend a branch of this trail west along the south side of Spry Stadium, connecting towards Polo Hall and the street crossings to Dogwood, Magnolia, and the North Campus Dining Halls.
3. Install high-visibility crosswalks at Polo Rd/Wingate Rd and at Carroll Weathers Dr at Wingate Rd.



There is ample space for a trail next to Spry Stadium along the west side of Wingate Road.

Planning-level Cost Estimate: \$149,098





PRIORITY INVESTMENT #4: REYNOLDA CAMPUS TO ATHLETIC CAMPUS GREENWAY

Previously proposed in the 2014 Wake Forest University Area Bicycle, Pedestrian, and Transit Study, this multi-use trail would link the core of the Reynolda Campus from Jasper Memory Lane to the Athletic Campus by crossing University Parkway via a bicycle and pedestrian bridge. Recommendation:

1. Create a multi-use trail from Wingate Rd to the sidewalk along University Pkwy (with intention to complete the connection to Athletic Campus in phases). Determine if the trail should be aligned with the cross-country trails, or separate from them (alignment below is conceptual).
2. Redesign the western corner of Parking Lot F to accommodate a trailhead, and, if feasible, a bicycle share docking station that would have a counterpart at the opposite end of the trail next to the freshmen parking lot.
3. Design the trail connection to University Parkway so that it can stand alone as a complete phase without the bicycle and pedestrian trail bridge, but also in a way that allows for its integration when that stage is feasible. Consider alternative trail crossings for university that can be provided if the bridge is not feasible.

Planning-level Cost Estimate: \$238,869

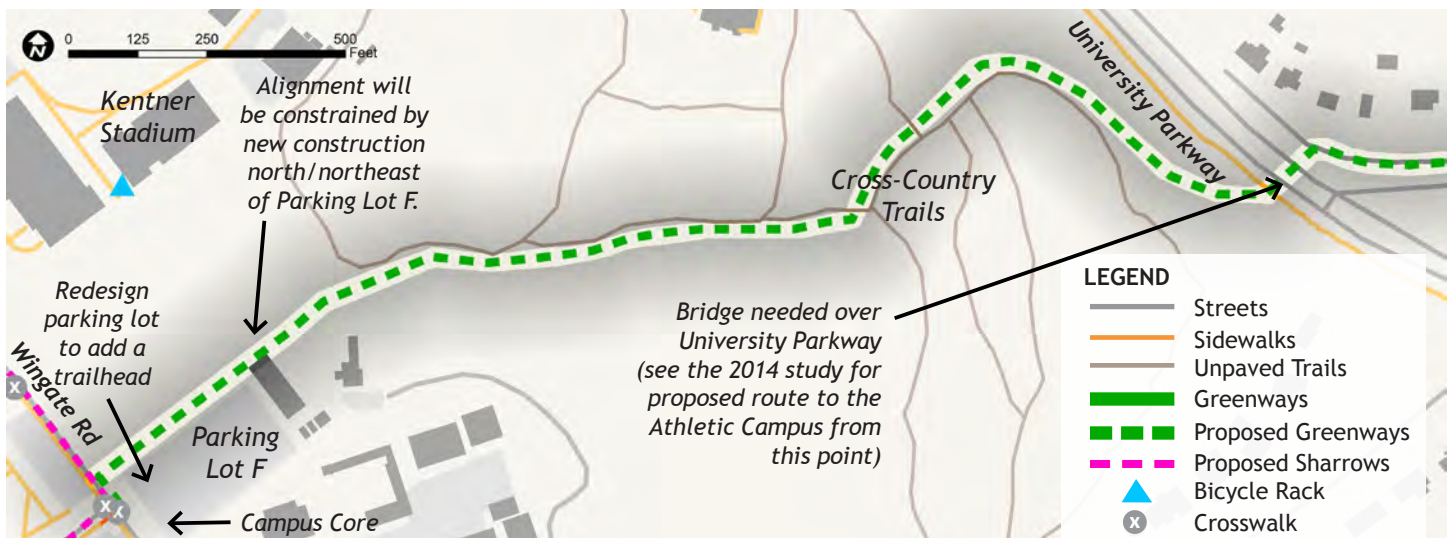


Photo sim of proposed bicycle and pedestrian bridge over University Parkway (from the 2014 Wake Forest University Area Bicycle, Pedestrian and Transit Study).

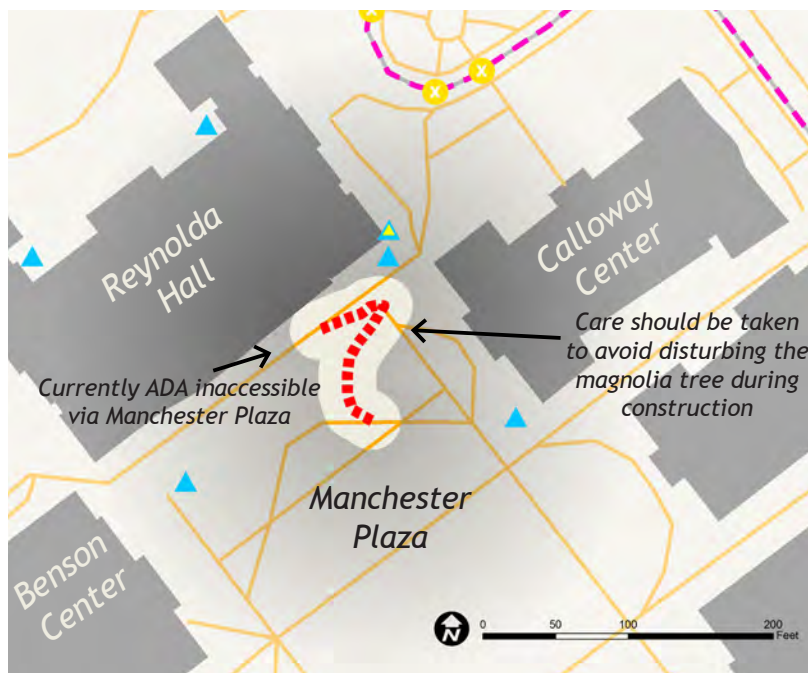


PRIORITY INVESTMENT #5: CAMPUS CORE MAJOR RAMPS

Three locations on the campus core would significantly enhance bicycle and pedestrian accessibility to the campus core if major ramps were installed. Recommended locations for major ramps include the following, all of which are currently inaccessible for people in wheelchairs:

- Manchester Plaza to Reynolda Hall
- Northeast and northwest corners of Hearn Plaza

Planning-level Cost Estimate: \$ TBD - further study needed



LEGEND

- Streets
- Sidewalks
- Proposed Major Ramp
- Proposed Sharrows
- Proposed Cycle Track
- Proposed Greenway
- Bicycle Rack
- Proposed Bicycle Rack
- Crosswalk
- Proposed Crosswalk



A ramp that switchbacks to Reynolda Hall from Manchester Plaza while avoiding the beautiful magnolia tree would provide improved bicycle and pedestrian accessibility.



A ramp along the southwest side of Wait Chapel would provide improved bicycle and pedestrian accessibility to the north-west corner of Hearn Plaza.



A ramp along the northeast side of Wait Chapel would provide improved bicycle and pedestrian accessibility to the north-east corner of Hearn Plaza.

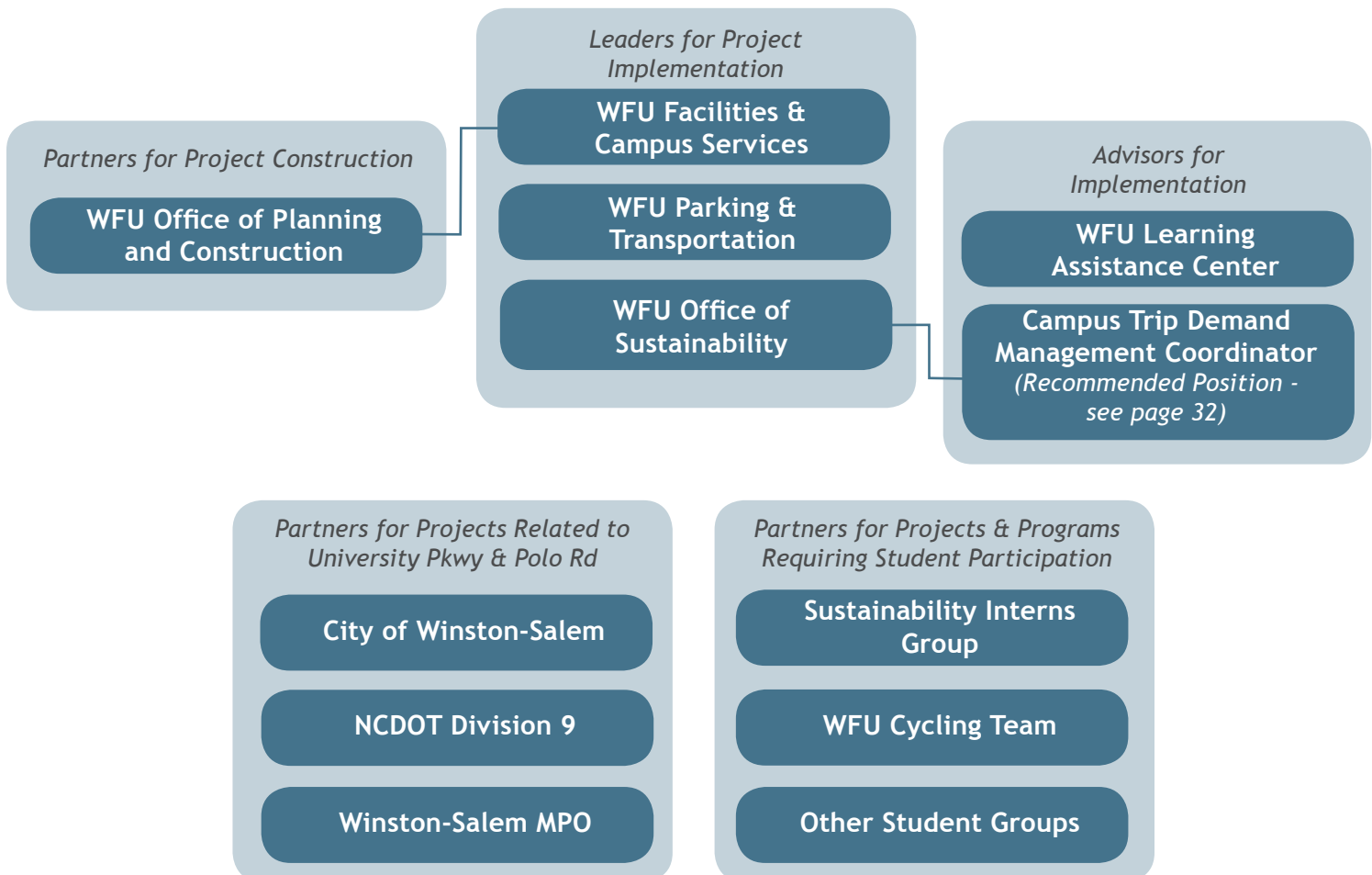


3 IMPLEMENTATION

IMPLEMENTATION FRAMEWORK

The implementation of this plan will require a concerted, collaborative effort of project partners. This chapter presents a detailed set of action steps to move the recommendations of this plan forward. Design guidelines and planning-level cost estimates are provided as an appendix to this study, and should be consulted during implementation.

Key Partners for Implementation





ACTION STEPS

ACTION STEP	LEAD AGENCY	SUPPORT AGENCIES	TIMELINE
POLICY ACTION STEPS			
Present this plan to the leadership of relevant WFU offices and departments.	WFU Office of Sustainability	Alta Planning + Design	First Year
Adopt this plan.	Wake Forest University	WFU Office of Sustainability	First Year
Continue the action steps from the 2014 WFU Area Bicycle, Pedestrian & Transit Study.		(See the 2014 Study)	
Fund and fulfill the Campus Trip Demand Management Program Coordinator position (outlined in the 2014 Study). Until fulfilled, temporarily distribute responsibilities of the position to a combination of existing staff.	Wake Forest University	WFU Office of Sustainability	First Year
Establish the Campus Bicycle & Pedestrian Advisory Committee (outlined in the 2014 Study). Identify and confirm individual members and begin meeting at least quarterly.	WFU Office of Sustainability	See potential stakeholders listed in the Implementation Framework diagram on the previous page	First Year
Determine available budget for bicycle and pedestrian infrastructure projects. Confirm amounts that are available immediately and those that are available in the near-term (2-5 years). For planning purposes, also estimate the availability of funding in the long-term (beyond 5 years).	Campus Bicycle & Pedestrian Advisory Committee	WFU Office of Planning and Construction	First Year
Confirm projects that can be implemented <i>immediately</i> , depending on budget. See priority projects #1-6, as well as the planning-level cost estimates. Priority projects are suggested to be completed first, but the Campus Bicycle & Pedestrian Advisory Committee should determine what is most appropriate given resources and opportunities available at the time.	Campus Bicycle & Pedestrian Advisory Committee	WFU Office of Planning and Construction	First Year
Confirm projects for the <i>near-term</i> , depending on budget. See notes in step above.	Campus Bicycle & Pedestrian Advisory Committee	WFU Office of Planning and Construction	First Year
Identify design work, permitting, and feasibility studies needed to make progress on <i>longer-term</i> priority investments (see steps below).	Campus Trip Demand Management Program Coordinator	Campus Bicycle & Pedestrian Advisory Committee, WFU Office of Planning and Construction	First Year
INFRASTRUCTURE ACTION STEPS			
Begin construction on short-term, low-cost priority infrastructure projects	WFU Office of Planning and Construction or Contractor	Campus Trip Demand Management Program Coordinator	0-2 years
Produce design documents for the Dogwood/Magnolia Cycle Track (<i>See Priority Investment #1</i>). Need preliminary design (including the ramps on each end) to determine an accurate projected cost for construction.	Internal WFU Engineer or Consultant	Campus Trip Demand Management Program Coordinator	1-3 years
Conduct a trail feasibility study for the Allen Easley Greenway (<i>See Priority Investment #2</i>). May require a survey, initial permitting review, and preliminary design to determine an accurate projected cost for construction.	Internal WFU Engineer or Consultant	Campus Trip Demand Management Program Coordinator	1-3 years



ACTION STEP	LEAD AGENCY	SUPPORT AGENCIES	TIMELINE
Produce design documents for the Spry Stadium Sidepath and Trail (<i>See Priority Investment #3</i>).	Internal WFU Engineer or Consultant	Campus Trip Demand Management Program Coordinator	1-3 years
Conduct a trail feasibility study for the Reynolda Campus to Athletic Campus Greenway (<i>See Priority Investment #4</i>). May require a survey, initial permitting review, and preliminary design to determine an accurate projected cost for construction. (<i>See Priority Investment #4</i>).	Internal WFU Engineer or Consultant	Campus Trip Demand Management Program Coordinator	1-3 years
Determine feasibility of major ramps, and project costs based on ramps constructed elsewhere on campus (<i>See Priority Investment #5</i>).	Internal WFU Engineer or Consultant	Campus Trip Demand Management Program Coordinator	1-3 years
Begin construction for longer-term priority investments	WFU Office of Planning and Construction or Contractor	Campus Trip Demand Management Program Coordinator	3 - 5 years

PROGRAM ACTION STEPS

Continue program action steps from the 2014 WFU Area Bicycle, Pedestrian & Transit Study

(See the 2014 Study)

Coordinate bicycle and pedestrian wayfinding with the 2010 Wake Forest University Signage Plan recommendations.

Campus Trip Demand Management Program Coordinator

Campus Bicycle & Pedestrian Advisory Committee

First Year

Dedicate a page on the university's website (along with illustrated guidance) regarding the rules/etiquette for bicycles and pedestrians sharing pathways. Establish a clear policy that says bicyclists should yield to pedestrians, and that they should dismount on pathways that are congested. Also include information for motorists and bicycles sharing roadways, which is established by state law and available through the NCDOT's website.

Campus Trip Demand Management Program Coordinator

WFU Web Administrator, Campus Bicycle & Pedestrian Advisory Committee

First Year

Enforce speed limits and yielding to pedestrians in crosswalks on campus, particularly along Wake Forest Rd and Carroll Weathers Dr. Consider using radar speed signs that alert motorists of their speed.

WFU Police

Campus Trip Demand Management Program Coordinator

First Year

Establish a 'Bicycle Kitchen' where students and faculty can repair and maintain their bicycles on campus. The facilities department may provide a building space where this could occur. Abandoned bicycles on campus racks could be donated to the program.

The WFU Cycling Team

WFU Facilities and Campus Services

First Year

Apply for Bicycle Friendly University Status.

Campus Trip Demand Management Program Coordinator

Campus Bicycle & Pedestrian Advisory Committee

1-2 years

Conduct regular pedestrian and bicyclist counts at same locations with automated counters and/or volunteers.

Campus Trip Demand Management Program Coordinator

City of Winston-Salem Transportation Planning Department; Volunteers

1-2 years

Incorporate recommendations from this Plan into any updates to the overall Reynolda Campus Master Plan.

WFU Office of Planning and Construction

WFU Office of Sustainability, WFU Parking & Transportation

Upon Update of Campus Master Plan





APPENDIX A: DESIGN GUIDELINES

OVERVIEW

The sections that follow serve as an inventory of bicycle and pedestrian design treatments and provides guidelines for their development. These treatments and design guidelines are important because they represent the tools for creating a safe, accessible community. The guidelines are not, however, a substitute for a more thorough evaluation by a landscape architect or engineer upon implementation of facility improvements. Some improvements may also require cooperation with the North Carolina Department of Transportation (NCDOT) for specific design solutions. The following standards and guidelines are referred to in this guide:

- The Federal Highway Administration's **Manual on Uniform Traffic Control Devices** (MUTCD) is the primary source for guidance on lane striping requirements, signal warrants, and recommended signage and pavement markings.
- American Association of State Highway and Transportation Officials (AASHTO) **Guide for the Development of Bicycle Facilities**, updated in June 2012 provides guidance on dimensions, use, and layout of specific bicycle facilities.
- The National Association of City Transportation Officials' (NACTO) 2012 **Urban Bikeway Design Guide** is the newest publication of nationally recognized bicycle-specific design standards, and offers guidance on the current state of the practice designs. Most NACTO treatments are compatible within AASHTO/MUTCD guidance, though some NACTO endorsed designs may not be permitted on state roads at this time.
- Offering similar guidance for pedestrian design, the 2004 AASHTO **Guide for the Planning, Design and Operation of Pedestrian Facilities** provides comprehensive guidance on planning and designing for people on foot.
- Meeting the requirements of the Americans with Disabilities Act (ADA) is an important part of any bicycle facility project. The United States Access Board's proposed Public Rights-of-Way Accessibility Guidelines (PROWAG) and the 2010 ADA Standards for Accessible Design (2010 Standards) contain standards and guidance for the construction of accessible facilities.

Should the national standards be revised in the future and result in discrepancies with this chapter, the national standards should prevail for all design decisions. A qualified engineer or landscape architect should be consulted for the most up to date and accurate cost estimates.

Nationally recognized bikeway standards such as NACTO, AASHTO, the MUTCD, along with guidance from the State of North Carolina have all informed the content of this appendix.



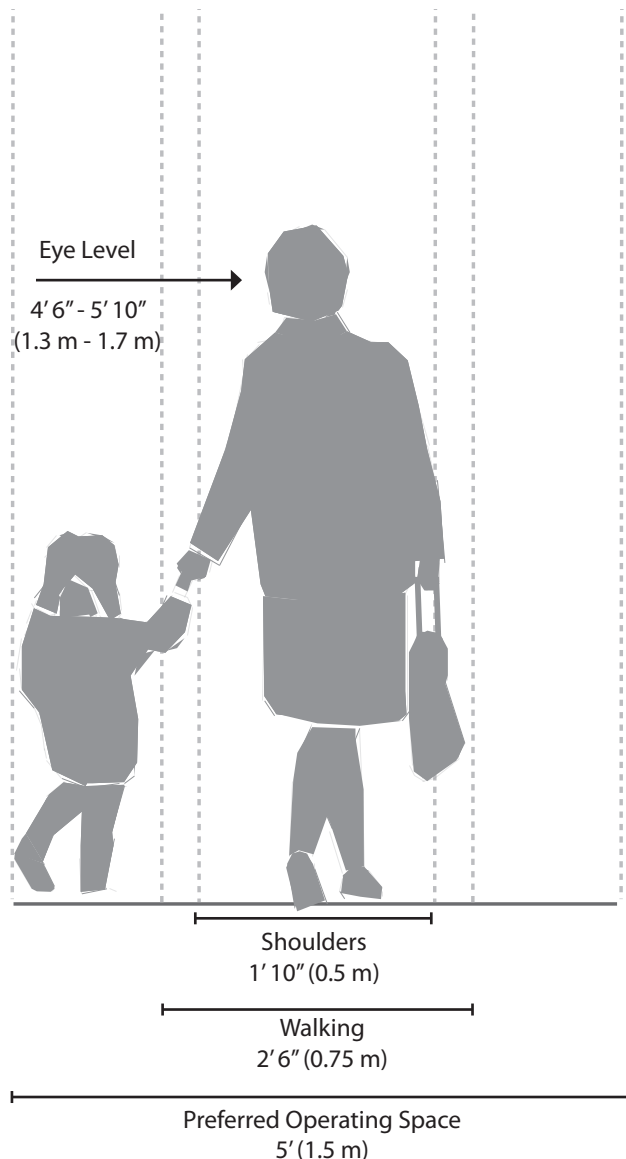
DESIGN NEEDS OF PEDESTRIANS

TYPES OF PEDESTRIANS

Pedestrians have a variety of characteristics and the transportation network should accommodate a variety of needs, abilities, and possible impairments. Age is one major factor that affects pedestrians' physical characteristics, walking speed, and environmental perception. Children have low eye height and walk at slower speeds than adults. They also perceive the environment differently at various stages of their cognitive development. Older adults walk more slowly and may require assistive devices for walking stability, sight, and hearing. The table below summarizes common pedestrian characteristics for various age groups.

The MUTCD recommends a normal walking speed of 3.5 feet per second when calculating the pedestrian clearance interval at traffic signals. The walking speed can drop to 3 feet per second for areas with older populations and persons with mobility impairments. While the type and degree of mobility impairment varies greatly across the population, the transportation system should accommodate these users to the greatest reasonable extent.

The table below summarizes common physical and cognitive impairments, how they affect personal mobility, and recommendations for improved pedestrian-friendly design.



Pedestrian Characteristics by Age

AGE	CHARACTERISTICS
0-4	Learning to walk Requires constant adult supervision Developing peripheral vision and depth perception
5-8	Increasing independence, but still requires supervision Poor depth perception
9-13	Susceptible to "dart out" intersection dash Poor judgment Sense of invulnerability
14-18	Improved awareness of traffic environment Poor judgment
19-40	Active, fully aware of traffic environment
41-65	Slowing of reflexes
65+	Difficulty crossing street Vision loss Difficulty hearing vehicles approaching from behind

Source: AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*, Exhibit 2-1. 2004.



Disabled Pedestrian Design Considerations

IMPAIRMENT	EFFECT ON MOBILITY	DESIGN SOLUTION
Wheelchair and Scooter Users	Difficulty propelling over uneven or soft surfaces.	Firm, stable surfaces and structures, including ramps or beveled edges.
	Cross-slopes cause wheelchairs to veer downhill.	Cross-slopes of less than two percent.
	Require wider path of travel.	Sufficient width and maneuvering space.
Walking Aid Users	Difficulty negotiating steep grades and cross slopes; decreased stability.	Smooth, non-slippery travel surface.
	Slower walking speed and reduced endurance; reduced ability to react.	Longer pedestrian signal cycles, shorter crossing distances, median refuges, and street furniture.
Hearing Impairment	Less able to detect oncoming hazards at locations with limited sight lines (e.g. driveways, angled intersections, channelized right turn lanes) and complex intersections.	Longer pedestrian signal cycles, clear sight distances, highly visible pedestrian signals and markings.
Vision Impairment	Limited perception of trail ahead and obstacles; reliance on memory; reliance on non-visual indicators (e.g. sound and texture).	Accessible text (larger print and raised text), accessible pedestrian signals (APS), guide strips and detectable warning surfaces, safety barriers, and lighting.
Cognitive Impairment	Varies greatly. Can affect ability to perceive, recognize, understand, interpret, and respond to information.	Signs with pictures, universal symbols, and colors, rather than text.



DESIGN NEEDS OF WHEELCHAIR USERS

As the American population ages, the number of people using mobility assistive devices (such as manual wheelchairs, powered wheelchairs) increases.

Manual wheelchairs are self-propelled devices. Users propel themselves using push rims attached to the rear wheels. Braking is done through resisting wheel movement with the hands or arm. Alternatively, a second individual can control the wheelchair using handles attached to the back of the chair.

Power wheelchairs use battery power to move the wheelchair. The size and weight of power wheelchairs limit their ability to negotiate obstacles without a ramp. Various control units are available that enable users to control the wheelchair movement, based on their ability (e.g., joystick control, breath controlled, etc).

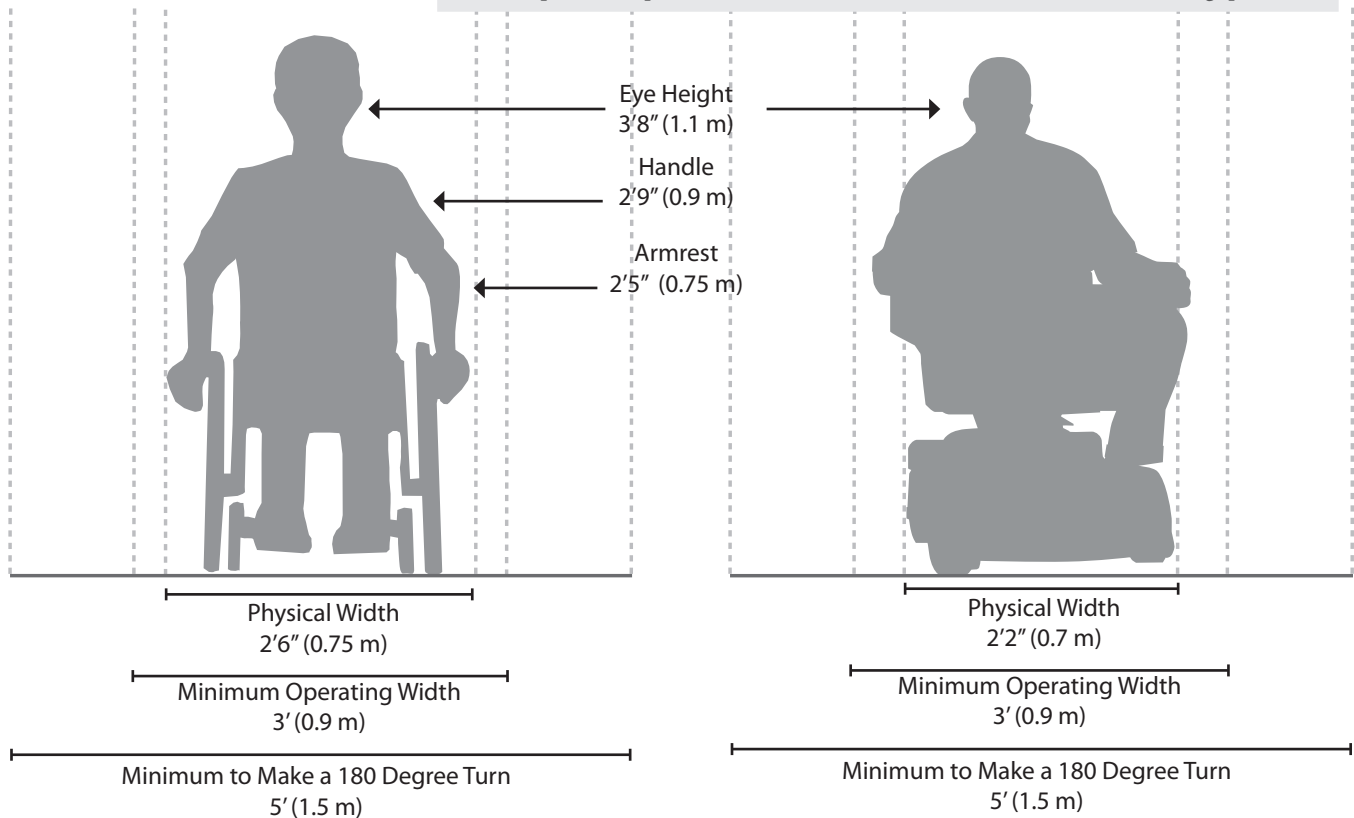
Maneuvering around a turn requires additional space for wheelchair devices. Providing adequate space for 180 degree turns at appropriate locations is an important element for accessible design.

Wheelchair User Typical Speed

USER	TYPICAL SPEED
Manual Wheelchair	3.6 mph
Power Wheelchair	6.8 mph

Wheelchair User Design Considerations

EFFECT ON MOBILITY	DESIGN SOLUTION
Difficulty propelling over uneven or soft surfaces.	Firm, stable surfaces and structures, including ramps or beveled edges.
Cross-slopes cause wheelchairs to veer downhill.	Cross-slopes of less than two percent.
Require wider path of travel.	Sufficient width and maneuvering space.



Source: FHWA. *Characteristics of Emerging Road and Trail Users and Their Safety*. 2004.
USDOJ. *2010 ADA Standards for Accessible Design*. 2010.



DESIGN NEEDS OF BICYCLISTS

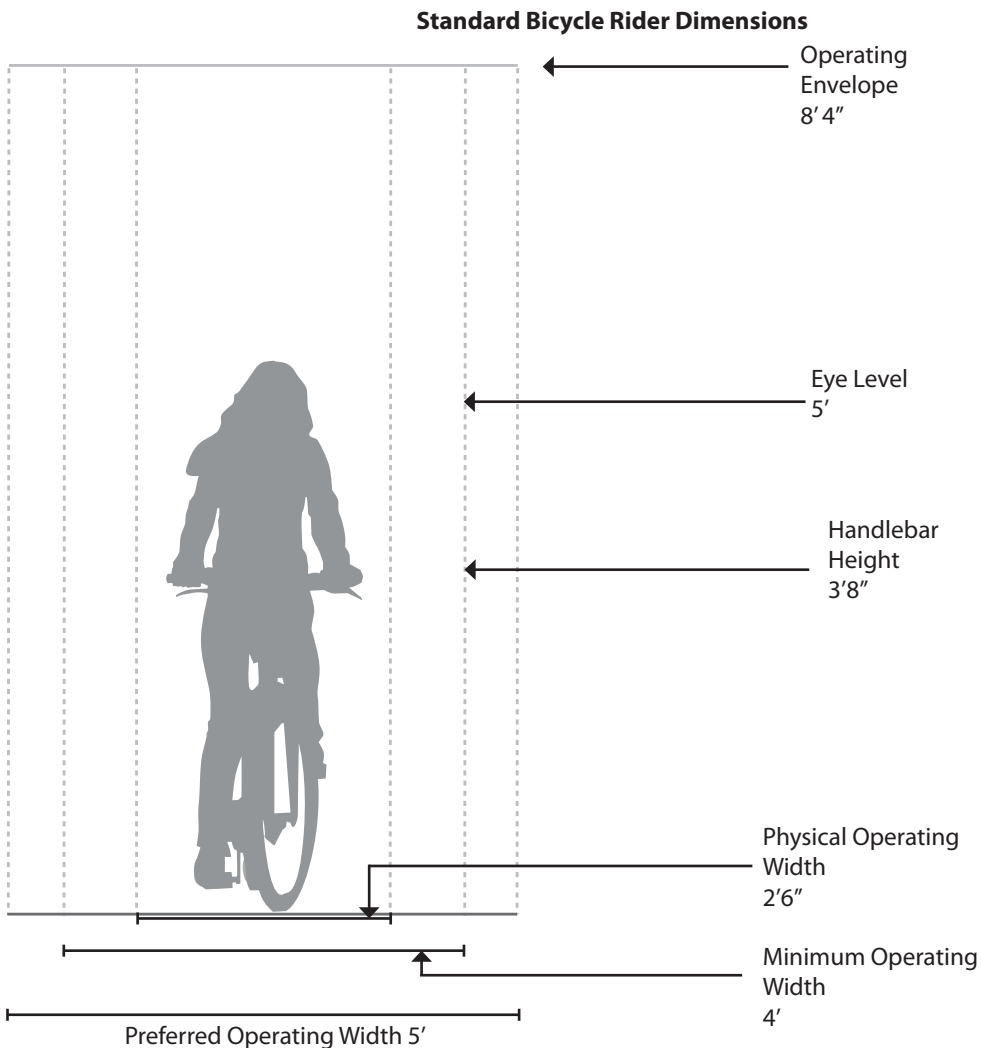
The purpose of this section is to provide the facility designer with an understanding of how bicyclists operate and how their bicycle influences that operation. Bicyclists, by nature, are much more affected by poor facility design, construction and maintenance practices than motor vehicle drivers. Bicyclists lack the protection from the elements and roadway hazards provided by an automobile's structure and safety features. By understanding the unique characteristics and needs of bicyclists, a facility designer can provide quality facilities and minimize user risk.

BICYCLE AS A DESIGN VEHICLE

Similar to motor vehicles, bicyclists and their bicycles exist in a variety of sizes and configurations. These variations occur in the types of vehicle (such as a conventional bicycle, a recumbent bicycle or a tricycle), and behavioral characteristics (such as the comfort level of the bicyclist). The design of a bikeway should consider reasonably expected bicycle types on the facility and utilize the appropriate dimensions.

The figure below illustrates the operating space and physical dimensions of a typical adult bicyclist, which are the basis for typical facility design. Bicyclists require clear space to operate within a facility. This is why the minimum operating width is greater than the physical dimensions of the bicyclist. Bicyclists prefer five feet or more operating width, although four feet may be minimally acceptable.

In addition to the design dimensions of a typical bicycle, there are many other commonly used pedal-driven cycles and accessories to consider when planning and designing bicycle facilities. The most common types include tandem bicycles, recumbent bicycles, and trailer accessories. The figure and table below summarize the typical dimensions for bicycle types.

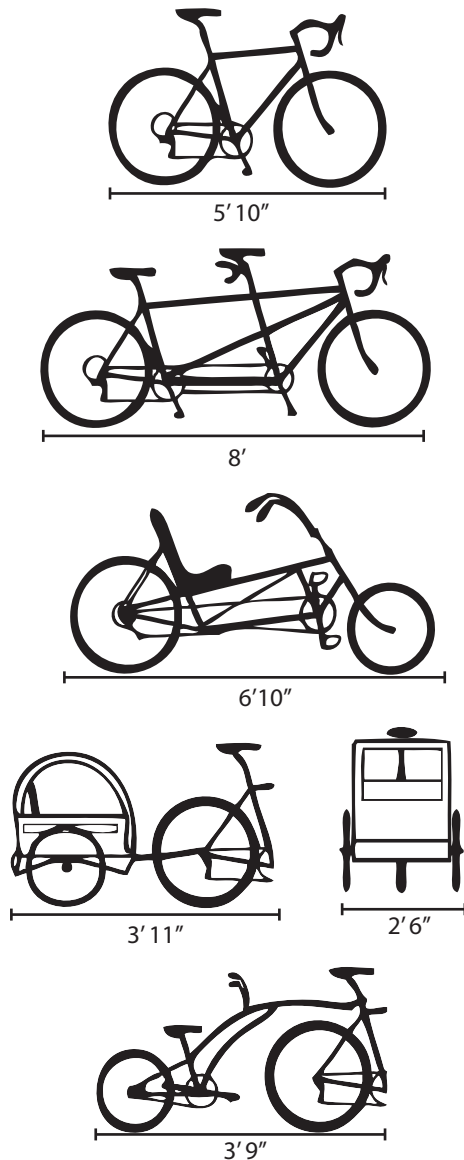


Source: AASHTO Guide for the Development of Bicycle Facilities, 4th Edition. 2012.



DESIGN SPEED EXPECTATIONS

The expected speed that different types of bicyclists can maintain under various conditions also influences the design of facilities such as shared use paved trails. The table to the right provides typical bicyclist speeds for a variety of conditions.



Bicycle as Design Vehicle - Typical Dimensions

Source: *AASHTO Guide for the Development of Bicycle Facilities*, 3rd Edition *AASHTO does not provide typical dimensions for tricycles.

Bicycle as Design Vehicle - Typical Dimensions

BICYCLE TYPE	FEATURE	TYPICAL DIMENSIONS
Upright Adult Bicyclist	Physical width	2 ft 6 in
	Operating width (Minimum)	4 ft
	Operating width (Preferred)	5 ft
	Physical length	5 ft 10 in
	Physical height of handlebars	3 ft 8 in
	Operating height	8 ft 4 in
	Eye height	5 ft
	Vertical clearance to obstructions (tunnel height, lighting, etc)	10 ft
	Approximate center of gravity	2 ft 9 in - 3 ft 4 in
Recumbent Bicyclist	Physical length	6 ft 10 in
	Eye height	3 ft 10 in
Tandem Bicyclist	Physical length	8 ft
Bicyclist with child trailer	Physical length	9 ft 9 in
	Physical width	2 ft 6 in

Bicycle as Design Vehicle - Design Speed Expectations

BICYCLE TYPE	FEATURE	TYPICAL SPEED
Upright Adult Bicyclist	Paved level surfacing	8-15 mph
	Downhill	20-30+ mph
	Uphill	5 - 12 mph
Recumbent	Paved level surfacing	11-18 mph

*Tandem bicycles and bicyclists with trailers have typical speeds equal to or less than upright adult bicyclists.

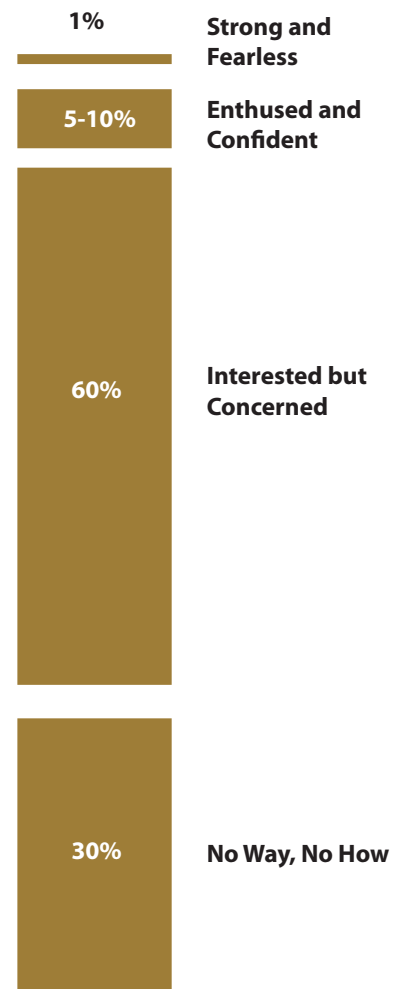


TYPES OF BICYCLISTS

It is important to consider bicyclists of all skill levels when creating a non-motorized plan or project. Bicyclist skill level greatly influences expected speeds and behavior, both in separated bikeways and on shared roadways. Bicycle infrastructure should accommodate as many user types as possible, with decisions for separate or parallel facilities based on providing a comfortable experience for the greatest number of people.

The bicycle planning and engineering professions currently use several systems to classify the population which can assist in understanding the characteristics and infrastructure preferences of different bicyclists. The current AASHTO Guide to the Development of Bicycle Facilities encourages designers to identify their rider type based on the trip purpose (Recreational vs Transportation) and on the level of comfort and skill of the rider (Causal vs Experienced). A more detailed framework for understanding of the US population's relationship to transportation focused bicycling is illustrated in the figure below. Developed by planners in Portland, OR¹ and supported by research², this classification provides the following alternative categories to address varying attitudes towards bicycling in the US:

- **Strong and Fearless** (approximately 1% of population)
 - Characterized by bicyclists that will typically ride anywhere regardless of roadway conditions or weather. These bicyclists can ride faster than other user types, prefer direct routes and will typically choose roadway connections -- even if shared with vehicles -- over separate bicycle facilities such as shared use paved trails.
- **Enthusied and Confident** (5-10% of population) - This user group encompasses bicyclists who are fairly comfortable riding on all types of bikeways but usually choose low traffic streets or shared use paved trails when available. These bicyclists may deviate from a more direct route in favor of a preferred facility type. This group includes all kinds of bicyclists such as commuters, recreationalists, racers and utilitarian bicyclists.
- **Interested but Concerned** (approximately 60% of population) – This user type comprises the bulk of the cycling population and represents bicyclists who typically only ride a bicycle on low traffic streets or multi-use trails under favorable weather conditions. These bicyclists perceive significant barriers to their increased use of cycling, specifically traffic and other safety issues. These people may become “Enthusied & Confident” with encouragement, education and experience.
- **No Way, No How** (approximately 30% of population) – Persons in this category are not bicyclists, and perceive severe safety issues with riding in traffic. Some people in this group may eventually become more regular cyclists with time and education. A significant portion of these people will not ride a bicycle under any circumstances.



Typical Distribution of Bicyclist Types

1 Roger Geller, City of Portland Bureau of Transportation. *Four Types of Cyclists*. <http://www.portlandonline.com/transportation/index.cfm?&a=237507>. 2009.

2 Dill, J., McNeil, N. *Four Types of Cyclists? Testing a Typology to Better Understand Bicycling Behavior and Potential*. 2012.



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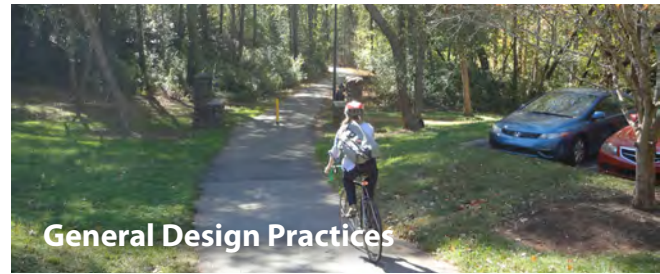


MULTI-USE TRAILS (GREENWAYS)

A multi-use trail (also known as a greenway) allows for two-way, off-street bicycle use and also may be used by pedestrians, skaters, wheelchair users, joggers and other non-motorized users. These facilities are frequently found in parks, along rivers, beaches, and in greenbelts or utility corridors where there are few conflicts with motorized vehicles. Trail facilities can also include amenities such as lighting, signage, and fencing (where appropriate).

Key features of shared use paved trails include:

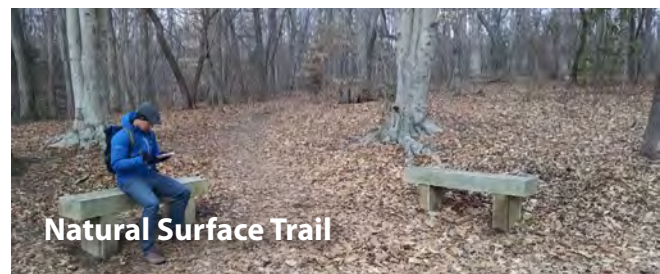
- Frequent access points from the local road network.
- Directional signs to direct users to and from the trail.
- A limited number of at-grade crossings with streets or driveways.
- Terminating the trail where it is easily accessible to and from the street system.
- Separate treads for pedestrians and bicyclists when heavy use is expected.



General Design Practices



Trails Along Roadways



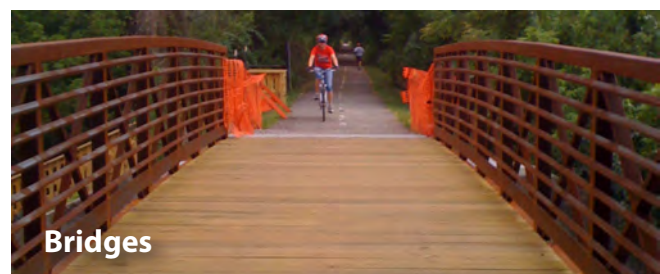
Natural Surface Trail



Boardwalks



Trail/Roadway Crossings



Bridges



GENERAL DESIGN PRACTICES

DESCRIPTION

Multi-use trails can provide a desirable facility, particularly for recreation, and users of all skill levels preferring separation from traffic. Bicycle trails should generally provide directional travel opportunities not provided by existing roadways.

GUIDANCE

Width

- 8 feet is the minimum allowed for a two-way bicycle trail and is only recommended for low traffic situations.
- 10 feet is recommended in most situations and will be adequate for moderate to heavy use.
- 12 feet is recommended for heavy use situations with high concentrations of multiple users. A separate track (5' minimum) can be provided for pedestrian use.

Lateral Clearance

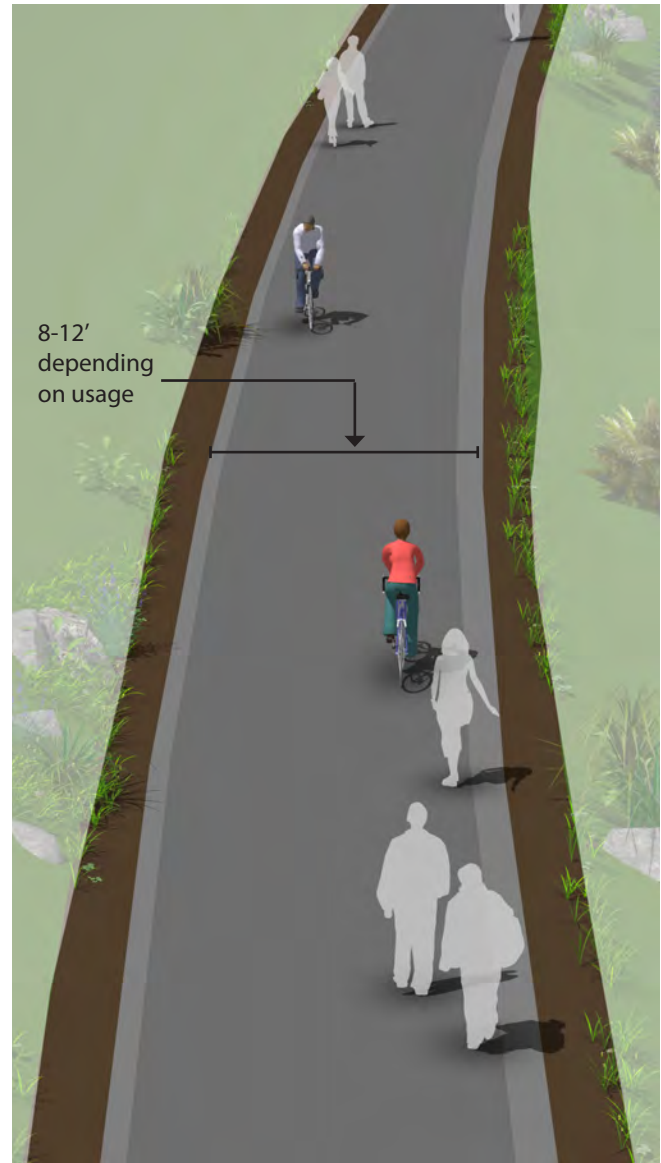
- A 2 foot or greater shoulder on both sides of the trail should be provided. An additional foot of lateral clearance (total of 3') is required by the MUTCD for the installation of signage or other furnishings.
- If bollards are used at intersections and access points, they should be colored brightly and/or supplemented with reflective materials to be visible at night.

Overhead Clearance

- Clearance to overhead obstructions should be 8 feet minimum, with 10 feet recommended.

Striping

- When striping is required, use a 4 inch dashed yellow centerline stripe with 4 inch solid white edge lines.
- Solid centerlines can be provided on tight or blind corners, and on the approaches to roadway crossings.



DISCUSSION

Terminate the trail where it is easily accessible to and from the street system, preferably at a controlled intersection or at the beginning of a dead-end street.

ADDITIONAL REFERENCES

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
FHWA. *Manual on Uniform Traffic Control Devices*. 2009.
Flink, C. *Greenways: A Guide To Planning Design And Development*. 1993.

MATERIALS AND MAINTENANCE

Asphalt is the most common surface for bicycle trails. The use of concrete for trails has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of trail users.



MULTI-USE TRAILS ALONG ROADWAYS

DESCRIPTION

Multi-use trails along roadways, also called Sidepaths, are a type of trail that run adjacent to a street.

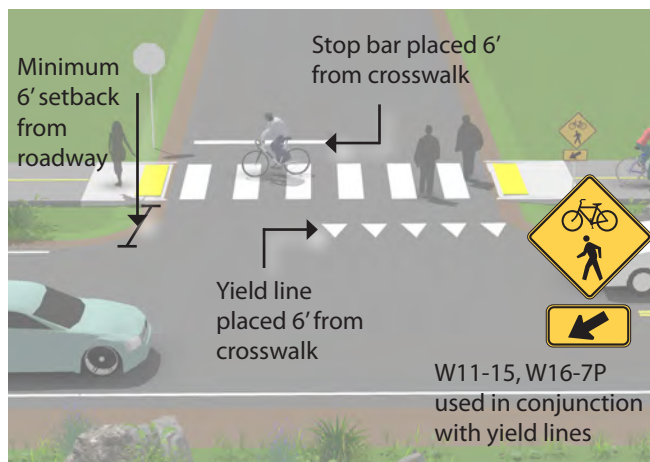
Because of operational concerns it is generally preferable to place trails within independent rights-of-way away from roadways. However, there are situations where existing roads provide the only corridors available.

Along roadways, these facilities create a situation where a portion of the bicycle traffic rides against the normal flow of motor vehicle traffic and can result in wrong-way riding where bicyclists enter or leave the trail.

The AASHTO Guide for the Development of Bicycle Facilities cautions practitioners of the use of two-way sidepaths on urban or suburban streets with many driveways and street crossings.

In general, there are two approaches to crossings: adjacent crossings and setback crossings, illustrated below.

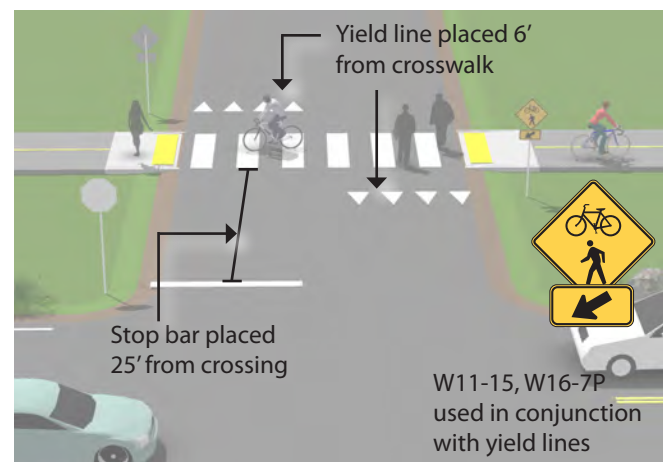
Adjacent Crossing - A separation of 6 feet emphasizes the conspicuity of riders at the approach to the crossing.



GUIDANCE

- Guidance for sidepaths should follow that for general design practices of multi-use trails.
- A high number of driveway crossings and intersections create potential conflicts with turning traffic. Consider alternatives to sidepaths on streets with a high frequency of intersections or heavily used driveways.
- Where a sidepath terminates special consideration should be given to transitions so as not to encourage unsafe wrong-way riding by bicyclists.
- Crossing design should emphasize visibility of users and clarity of expected yielding behavior. Crossings may be STOP or YIELD controlled depending on sight lines and bicycle motor vehicle volumes and speeds.

Setback Crossing - A set back of 25 feet separates the trail crossing from merging/turning movements that may be competing for a driver's attention.



DISCUSSION

The provision of a shared use paved trail adjacent to a road is not a substitute for the provision of on-road accommodation such as paved shoulders or bike lanes, but may be considered in some locations in addition to on-road bicycle facilities.

To reduce potential conflicts in some situations, it may be better to place one-way sidepaths on both sides of the street.

ADDITIONAL REFERENCES

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
NACTO. *Urban Bikeway Design Guide*. See entry on Raised Cycle Tracks. 2012.

MATERIALS AND MAINTENANCE

Asphalt is the most common surface for bicycle trails. The use of concrete for trails has proven to be more durable over the long term. Saw cut concrete joints rather than troweled improve the experience of trail users.



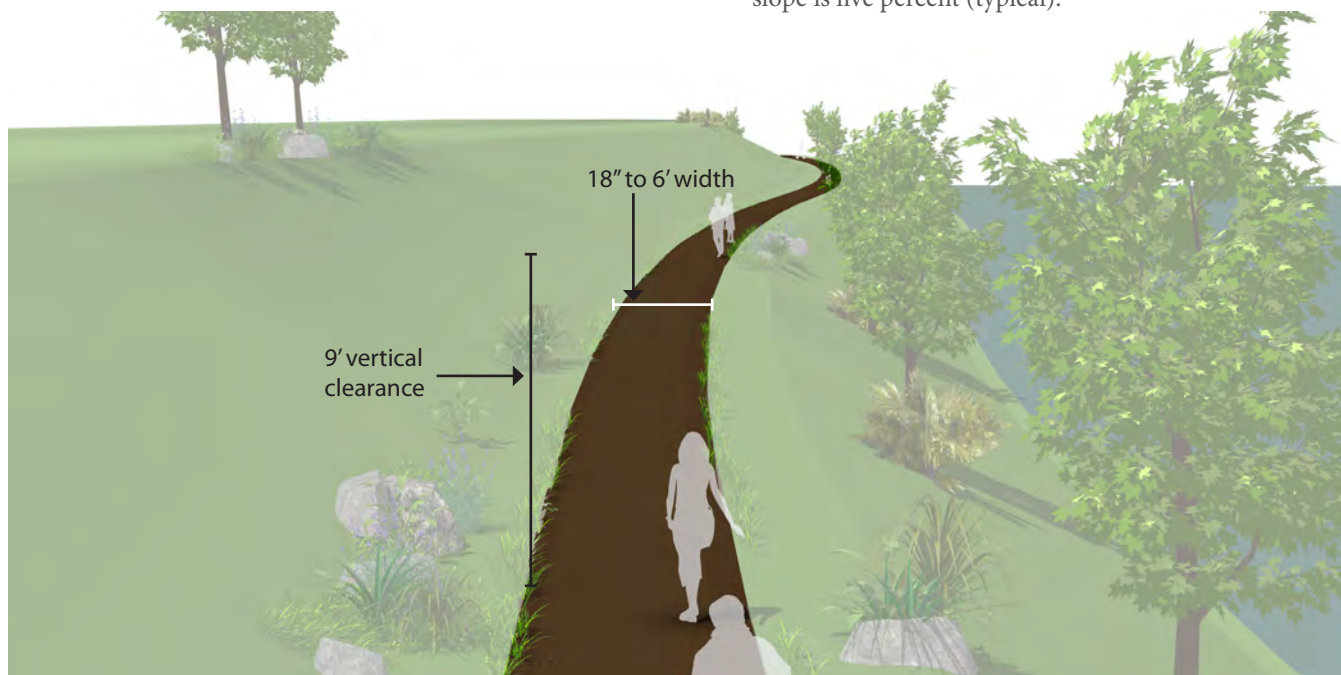
NATURAL SURFACE TRAIL

DESCRIPTION

Sometimes referred to as footpaths, hiking trails or single track trails, the soft surface shared use trail is used along corridors that are environmentally-sensitive but can support bare earth, wood chip, or boardwalk trails. Natural surface trails are a low-impact solution and found in areas with limited development or where a more primitive experience is desired.

GUIDANCE

- Trails can vary in width from 18 inches to 6 feet or greater; vertical clearance should be maintained at nine-feet above grade.
- Mountain bike trails are typically 18-24 inches wide and have compacted bare earth or leaf litter surfacing.
- Base preparation varies from machine-worked surfaces to those worn only by usage.
- Trail surface can be made of dirt, rock, soil, forest litter, or other native materials. Some trails use crushed stone (a.k.a. “crush and run”) that contains about 4% fines by weight, and compacts with use.
- Provide positive drainage for trail tread without extensive removal of existing vegetation; maximum slope is five percent (typical).



DISCUSSION

Trail erosion control measures include edging along the low side of the trail, steps and terraces to contain surface material, and water bars to direct surface water off the trail; use bedrock surface where possible to reduce erosion.

Due to their narrow width and ability to contour with the natural topography, single-track mountain bike trails typically require the least amount of disturbance and support features of all types of trails.

ADDITIONAL REFERENCES

IMBA. *Managing Mountain Biking*. 2007.
IMBA. *Trail Solutions*. 2004.
Flink, C. *Greenways: A Guide To Planning Design And Development*. 1993.

MATERIALS AND MAINTENANCE

Consider implications for accessibility when weighing options for surface treatments.



BOARDWALKS

DESCRIPTION

Boardwalks are typically required when crossing wetlands or other poorly drained areas. They are usually constructed of wooden planks or recycled material planks that form the top layer of the boardwalk. The recycled material has gained popularity in recent years since it lasts much longer than wood, especially in wet conditions. A number of low-impact support systems are also available that reduce the disturbance within wetland areas to the greatest extent possible.

GUIDANCE

- Boardwalk width should be a minimum of 10 feet when no rail is used. A 12 foot width is preferred in areas with average anticipated use and whenever rails are used.
- When the height of a boardwalk exceeds 30", railings are required.
- If access by vehicles is desired, boardwalks should be designed to structurally support the weight of a small truck or light-weight vehicle.

Wetland plants and natural ecological function to be undisturbed



DISCUSSION

In general, building in wetlands is subject to regulations and should be avoided.

The foundation normally consists of wooden posts or auger piers (screw anchors). Screw anchors provide greater support and last much longer.

ADDITIONAL REFERENCES

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
FHWA. *Wetland Trail Design and Construction*. 2007.

MATERIALS AND MAINTENANCE

Decking should be either non-toxic treated wood or recycled plastic. Cable rails are attractive and more visually transparent but may require maintenance to tighten the cables if the trail has snow storage requirements.



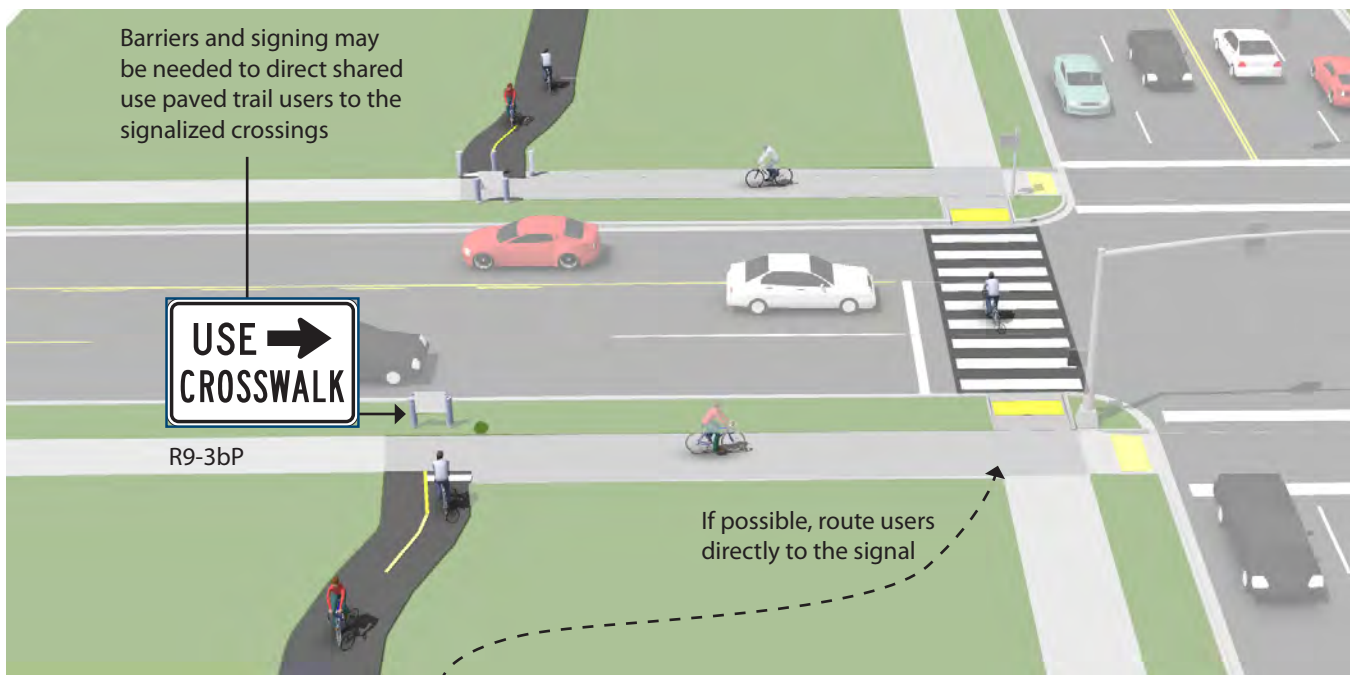
TRAIL/ROADWAY CROSSINGS: ROUTE USERS TO SIGNALIZED CROSSINGS

DESCRIPTION

Trail crossings within approximately 400 feet of an existing signalized intersection with pedestrian crosswalks are typically diverted to the signalized intersection to avoid traffic operation problems when located so close to an existing signal. For this restriction to be effective, barriers and signing may be needed to direct trail users to the signalized crossing. If no pedestrian crossing exists at the signal, modifications should be made.

GUIDANCE

Trail crossings should not be provided within approximately 400 feet of an existing signalized intersection. If possible, route trail directly to the signal.



DISCUSSION

In the US, the minimum distance a marked crossing can be from an existing signalized intersection varies from approximately 250 to 660 feet. Engineering judgement and the context of the location should be taken into account when choosing the appropriate allowable setback. Pedestrians are particularly sensitive to out of direction travel and jaywalking may become prevalent if the distance is too great.

ADDITIONAL REFERENCES

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*. 2004.

MATERIALS AND MAINTENANCE

If a sidewalk is used for crossing access, it should be kept clear of snow and debris and the surface should be level for wheeled users.



TRAIL/ROADWAY CROSSINGS: OVERCROSSINGS

DESCRIPTION

Bicycle/pedestrian overcrossings provide critical non-motorized system links by joining areas separated by barriers such as deep canyons, waterways or major transportation corridors. In most cases, these structures are built in response to user demand for safe crossings where they previously did not exist.

There are no minimum roadway characteristics for considering grade separation. Depending on the type of facility or the desired user group grade separation may be considered in many types of projects.

Overcrossings require a minimum of 17 feet of vertical clearance to the roadway below versus a minimum elevation differential of around 12 feet for an undercrossing. This results in potentially greater elevation differences and much longer ramps for bicycles and pedestrians to negotiate.

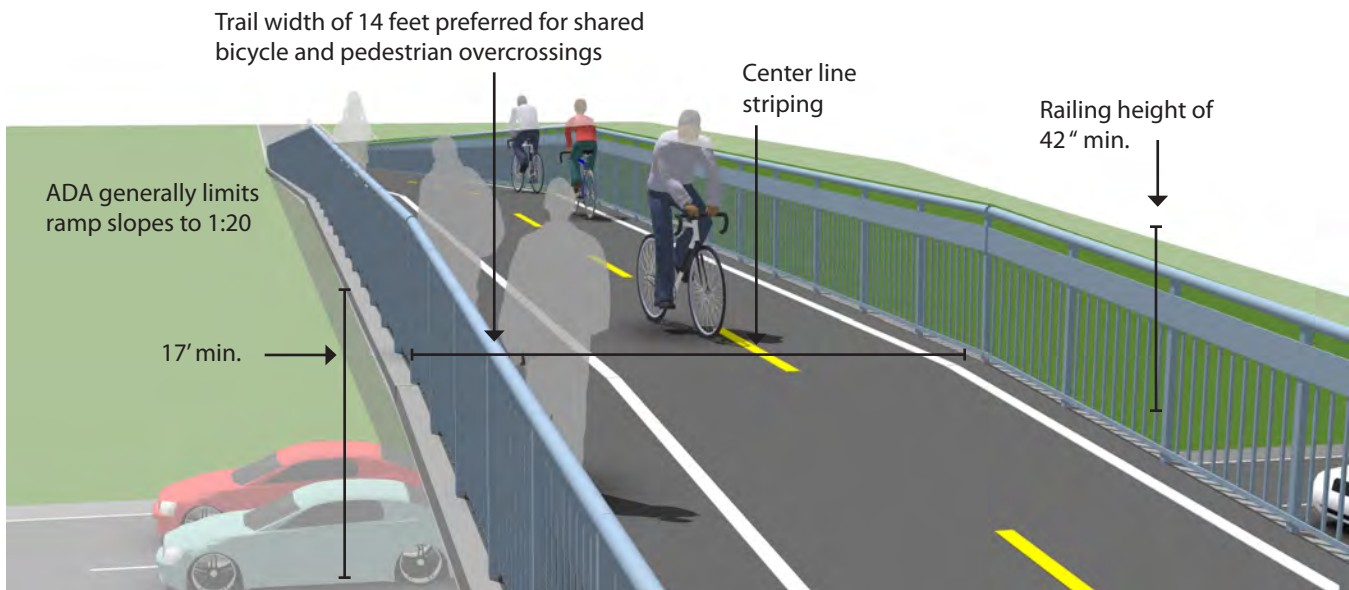
GUIDANCE

8 foot minimum width, 14 feet preferred. If overcrossing has any scenic vistas additional width should be provided to allow for stopping. A separate 5 foot pedestrian area may be provided for facilities with high bicycle and pedestrian use.

10 foot headroom on overcrossing; clearance below will vary depending on feature being crossed.

Roadway: 17 feet
Freeway: 18.5 feet
Heavy Rail Line: 23 feet

The overcrossing should have a centerline stripe even if the rest of the trail does not have one.



DISCUSSION

Overcrossings for bicycles and pedestrians typically fall under the Americans with Disabilities Act (ADA), which strictly limits ramp slopes to 5% (1:20) with landings at 400 foot intervals, or 8.33% (1:12) with landings every 30 feet.

Overcrossings pose potential concerns about visual impact and functional appeal, as well as space requirements necessary to meet ADA guidelines for slope.

ADDITIONAL REFERENCES

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*. 2004.

MATERIALS AND MAINTENANCE

Potential issues with vandalism.

Overcrossings can be more difficult to clear of snow than undercrossings.

BRIDGES

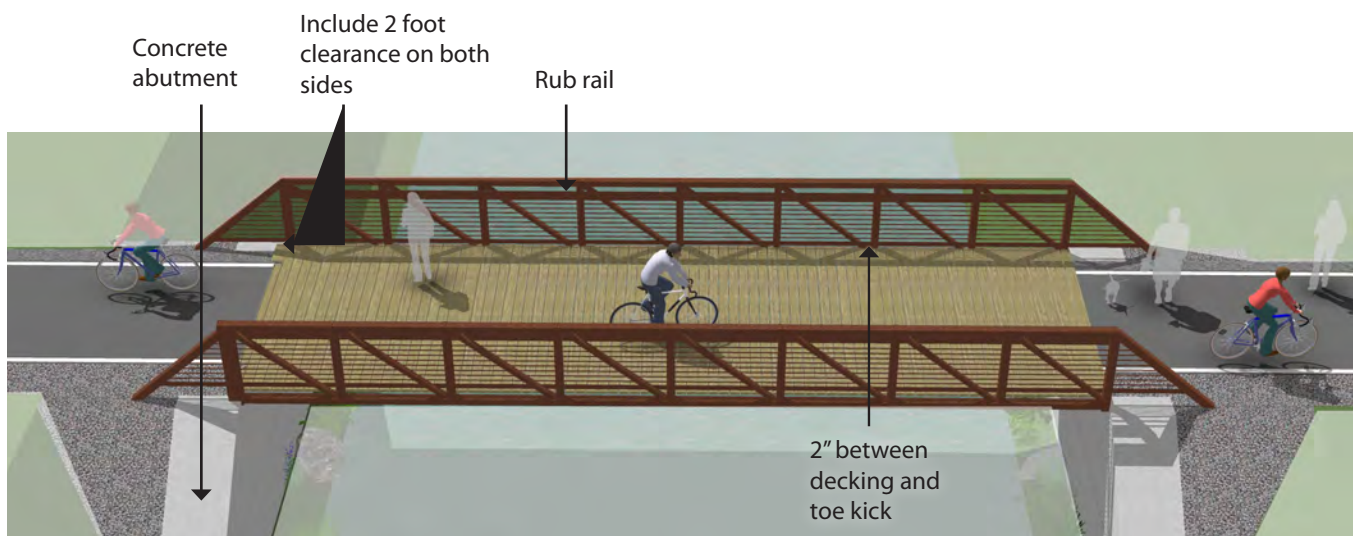
DESCRIPTION

Greenway trail bridges are most often used to provide user access over natural features such as streams and rivers, where a culvert is not an option or the span length exceeds 20 feet. The type and size of bridges can vary widely depending on the greenway trail and specific site requirements. Bridges often used for greenway trails include suspension bridges and prefabricated clear span bridges. When determining a bridge design for greenway trails, it is important to consider emergency and maintenance vehicle access.

Greenway trails that are poorly designed through water features can impact wetlands and streams, and become conduits for delivering sediments, nutrients, and pathogens to the watershed. Greenway trails that cross streams can exhibit bank and streambed erosion if not properly constructed.

GUIDANCE

- The clear span width of the bridge should include 2 feet of clearance on both ends of the bridge approach for the shoulder.
- Bridge deck grade should be flush with adjacent greenway trail tread elevation to provide a smooth transition.
- Railing heights on bridges should include a 42 inch minimum guard rail, and 48 inches where hazardous conditions exist.
- A minimum overhead clearance of 10 feet is desirable for emergency vehicle access. Maximum opening between railing posts is 4 inches.
- A greenway trail bridge should support 10 tons for 10 foot wide greenway trails, and 20 tons for wider than 10 feet for emergency vehicle access.
- Bridges along greenway trails that allow equestrian use should be designed for mounted unit loadings.
- When crossing small headwater streams, align the crossing as far upstream as possible in the narrowest section of stream channel to minimize impact.
- Greenway trail drainage features should be constructed to manage stormwater before the greenway trail crosses the watercourse.
- All abutment and foundation design should be completed and sealed by a professional structural engineer licensed in the State of North Carolina.
- All greenway trail bridges will require local building permits, stormwater and land disturbance permits, floodplain development permits, and FEMA approval. Length and height of the bridge cords are governed by the width of the floodway and impacts to the base flood elevation of streams.





PEDESTRIAN FACILITIES

Sidewalks are the most fundamental element of the walking network, as they provide an area for pedestrian travel that is separated from vehicle traffic. Sidewalks are typically constructed out of concrete and are separated from the roadway by a curb or gutter and sometimes a landscaped planting strip area. Sidewalks are an essential application on university campuses.

Attributes of well-designed sidewalks include the following:

Accessibility: A network of sidewalks should be accessible to all users.

Adequate width: Two people should be able to walk side-by-side and pass a third comfortably. Different walking speeds should be possible. In areas of intense pedestrian use, sidewalks should accommodate the high volume of walkers.

Safety: Design features of the sidewalk should allow pedestrians to have a sense of security and predictability. Sidewalk users should not feel they are at risk due to the presence of adjacent traffic.

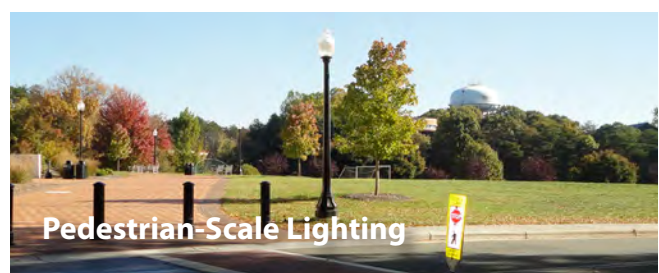
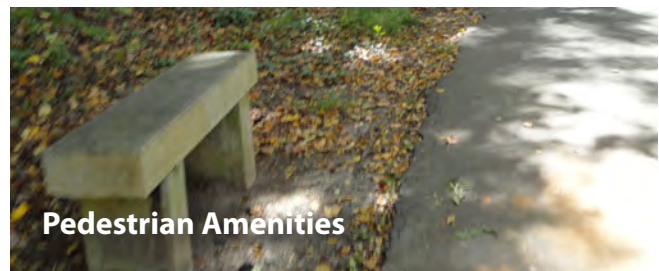
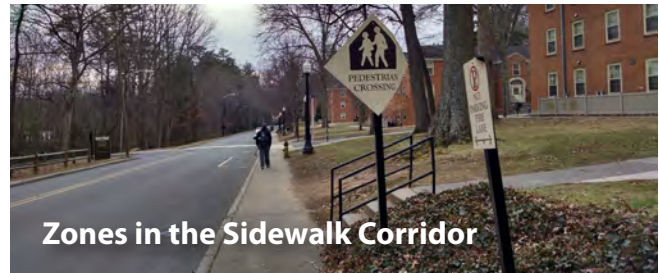
Continuity: Walking routes should be obvious and should not require pedestrians to travel out of their way unnecessarily.

Landscaping: Plantings and street trees should contribute to the overall psychological and visual comfort of sidewalk users, and be designed in a manner that contributes to the safety of people.

Drainage: Sidewalks should be well graded to minimize standing water.

Social space: There should be places for standing, visiting, and sitting. The sidewalk area should be a place where students, faculty, staff, and visitors can safely participate in campus public life.

Quality of place: Sidewalks should contribute to the character of campus.

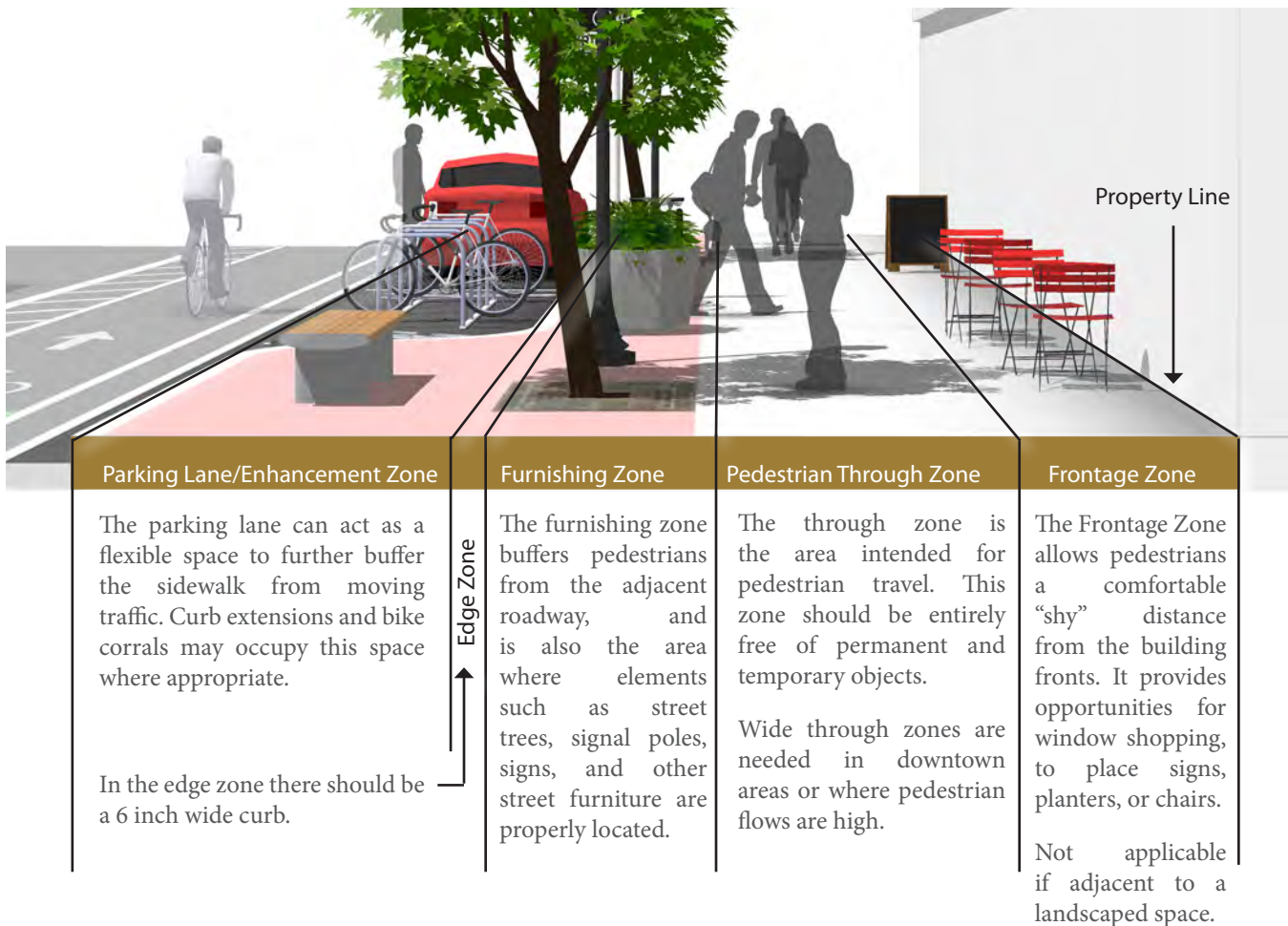




ZONES IN THE SIDEWALK CORRIDOR

DESCRIPTION

Sidewalks are the most fundamental element of the walking network, as they provide an area for pedestrian travel separated from vehicle traffic. A variety of considerations are important in sidewalk design. Providing adequate and accessible facilities can lead to increased numbers of people walking, improved safety, and the creation of social space.



DISCUSSION

Sidewalks should be more than areas to travel; they should provide places for people to interact. There should be places for standing, visiting, and sitting. Sidewalks should contribute to the character of campus, strengthen its identity, and be an area where students, faculty, staff, and visitors safely participate in campus life.

ADDITIONAL REFERENCES

USDOJ. *ADA Standards for Accessible Design*. 2010.
 United States Access Board. *Proposed Accessibility Guidelines for Pedestrian Facilities in the Public-Right-of-Way (PROWAG)*. 2011.
 AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*. 2004.
 NACTO. *Urban Street Design Guide*. 2013.

MATERIALS AND MAINTENANCE

Sidewalks are typically constructed out of concrete and are separated from the roadway by a curb or gutter and sometimes a landscaped space. Colored, patterned, or stamped concrete can add distinctive visual appeal.



SIDEWALK WIDTHS

DESCRIPTION

The width and design of sidewalks will vary depending on street context, functional classification, and pedestrian demand. Below are preferred widths of each sidewalk zone according to general street type. Standardizing sidewalk guidelines for different areas of the city, dependent on the above listed factors, ensures a minimum level of quality for all sidewalks.



STREET CLASSIFICATION	PARKING LANE/ ENHANCEMENT ZONE	FURNISHING ZONE	PEDESTRIAN THROUGH ZONE	FRONTAGE ZONE	TOTAL
Local Streets	Varies	2 - 5 feet	4 - 6 feet	N/A	6 - 11 feet
Commercial Areas	Varies	4 - 6 feet	6 - 12 feet	2.5 - 10 feet	11 - 28 feet
Arterials and Collectors	Varies	2 - 6 feet	4 - 8 feet	2.5 - 5 feet	8 - 19 feet

↑
Areas that have significant accumulations of snow during the winter may prefer a wider furnishing zone for snow storage.

↑
Six feet enables two pedestrians (including wheelchair users) to walk side-by-side, or to pass each other comfortably

DISCUSSION

It is important to provide adequate width along a sidewalk corridor. Two people should be able to walk side-by-side and pass a third comfortably. In areas of high demand, sidewalks should contain adequate width to accommodate the high volumes and different walking speeds of pedestrians. The Americans with Disabilities Act requires a 4 foot clear width in the pedestrian zone plus 5 foot passing areas every 200 feet.

ADDITIONAL REFERENCES

USDOJ. *ADA Standards for Accessible Design*. 2010.
United States Access Board. *Proposed Accessibility Guidelines for Pedestrian Facilities in the Public-Right-of-Way (PROWAG)*. 2011.
AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*. 2004.
NACTO. *Urban Street Design Guide*. 2013.

MATERIALS AND MAINTENANCE

Sidewalks are typically constructed out of concrete and are separated from the roadway by a curb or gutter and sometimes a landscaped boulevard. Surfaces must be firm, stable, and slip resistant. Colored, patterned, or stamped concrete can add distinctive visual appeal.



DRIVEWAYS AND SIDEWALK OBSTRUCTIONS

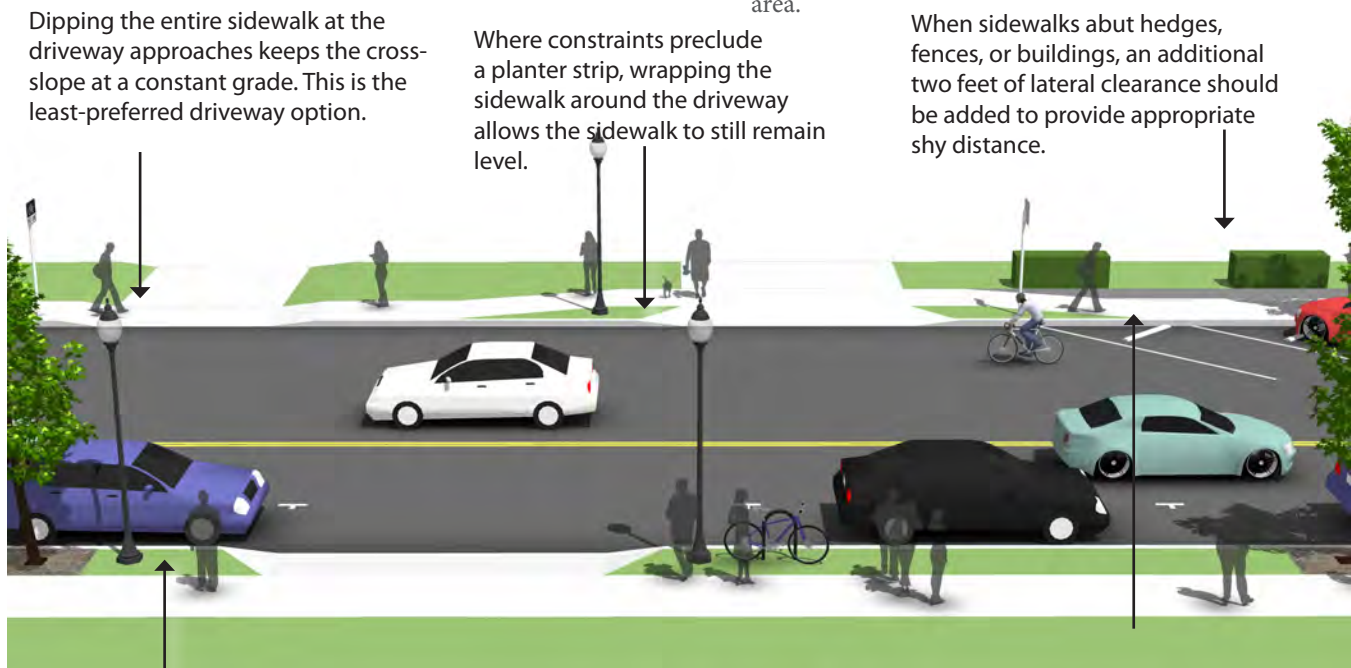
DESCRIPTION

Driveway crossings can present challenges and potential conflicts for pedestrians, especially if they are designed with the movement of the motor vehicle prioritized at the expense of pedestrian circulation.

Reducing the number of accesses reduces the need for special provisions. This strategy should be pursued first.

GUIDANCE

- To the extent possible the sidewalk should be flat and uninterrupted through driveways, so that the priority is always with the pedestrian flow. Vehicles may be required to drive up or down to cross over the sidewalk, but this reinforces to the motorist that they need to use caution and slow speeds when crossing the pedestrian zone.
- The use of a landscaped buffer area between the sidewalk and the street allows driveway slopes to occur within the landscape zone, and allows for a flat and level pedestrian through zone is always maintained through the driveway area.



Dipping the entire sidewalk at the driveway approaches keeps the cross-slope at a constant grade. This is the least-preferred driveway option.

Where constraints preclude a planter strip, wrapping the sidewalk around the driveway allows the sidewalk to still remain level.

When sidewalks abut hedges, fences, or buildings, an additional two feet of lateral clearance should be added to provide appropriate shy distance.

Planter strips allow sidewalks to remain level, with the driveway grade change occurring within the planter strip.

When sidewalks abut angled on-street parking, wheel stops should be used to prevent vehicles from overhanging in the sidewalk.

DISCUSSION

According to the United States Federal Highway Administration (FHWA): Well defined driveways clearly mark the area where motorists will be crossing the pedestrian's path. Non-defined vehicle access points with continuous access to parking create a long conflict area between pedestrians and motorists. This added area of ambiguity complicates the motorist's task of watching for pedestrians.

ADDITIONAL REFERENCES

United States Access Board. *Proposed Accessibility Guidelines for Pedestrian Facilities in the Public-Right-of-Way (PROWAG)*. 2011.
 AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*. 2004.
 U.S. Department of Transportation Federal Highway Administration. (2006). *How to Develop a Pedestrian Safety Action Plan*, p 56

MATERIALS AND MAINTENANCE

Sidewalks are typically constructed out of concrete and are separated from the roadway by a curb or gutter and sometimes a landscaped space. Surfaces must be firm, stable, and slip resistant.



PEDESTRIAN AMENITIES

STREET TREES

In addition to their aesthetic and environmental value, street trees can slow traffic and improve safety for pedestrians. Trees add visual interest to streets and narrow the street's visual corridor, which may cause drivers to slow down. It is important that trees do not block light or the vision triangle.

STREET FURNITURE

Providing benches at key rest areas and viewpoints encourages people of all ages to use the walkways by ensuring that they have a place to rest along the way. Benches should be 20" tall to accommodate elderly pedestrians comfortably. Benches can be simple (e.g., wood slats) or more ornate (e.g., stone, wrought iron, concrete). If alongside a parking zone, street furniture should be placed to minimize interference with passenger loading.

GREEN FEATURES

Green stormwater strategies may include bioretention swales, rain gardens, tree box filters, and pervious pavements (pervious concrete, asphalt and pavers).

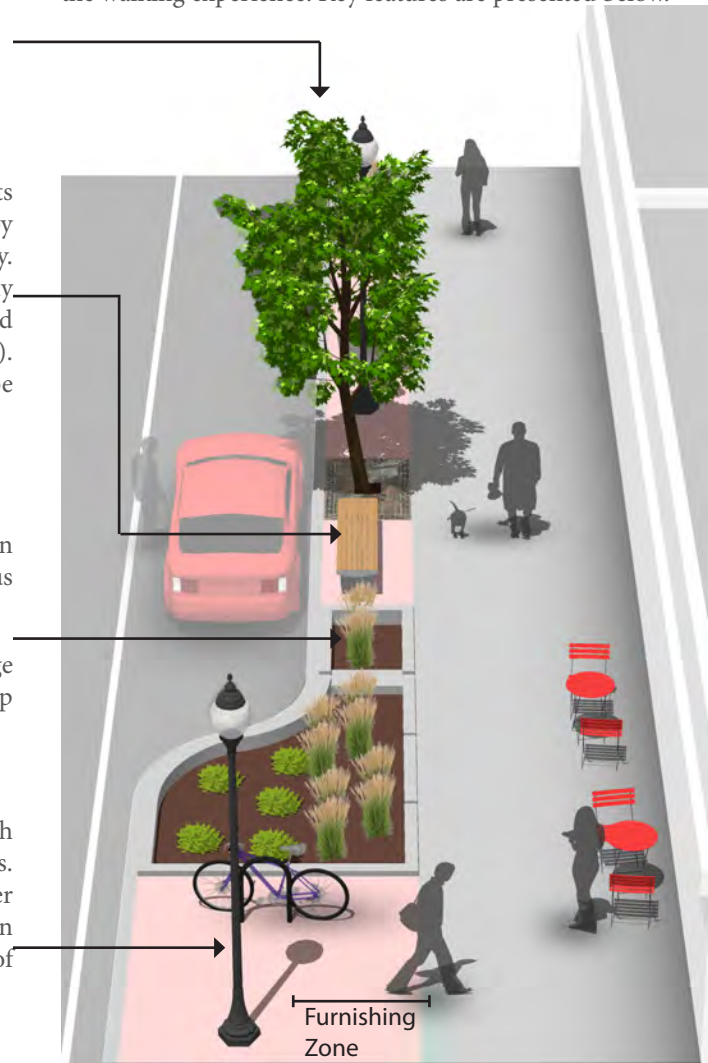
Bioswales are natural landscape elements that manage water runoff from a paved surface. Plants in the swale trap pollutants and silt from entering a river system.

LIGHTING

Pedestrian scale lighting improves visibility for both pedestrians and motorists - particularly at intersections. Pedestrian scale lighting can provide a vertical buffer between the sidewalk and the street, defining pedestrian areas. Pedestrian scale lighting should be used in areas of high pedestrian activity.

DESCRIPTION

A variety of streetscape elements can define the pedestrian realm, offer protection from moving vehicles, and enhance the walking experience. Key features are presented below.



DISCUSSION

Additional pedestrian amenities such as banners, public art, special paving, along with historical elements and cultural references, promote a sense of place. Public activities should be encouraged and commercial activities such as dining, vending and advertising may be permitted when they do not interfere with safety and accessibility.

Pedestrian amenities should be placed in the furnishing zone on a sidewalk corridor. See Zones in the Sidewalk Corridor for a discussion of the functional parts of a sidewalk. Signs, meters, tree wells should go between parking spaces.

ADDITIONAL REFERENCES

United States Access Board. *Proposed Accessibility Guidelines for Pedestrian Facilities in the Public-Right-of-Way (PROWAG)*. 2011.
NACTO. *Urban Street Design Guide*. 2013.

MATERIALS AND MAINTENANCE

Establishing and caring for your young street trees is essential to their health. Green features may require routine maintenance, including sediment and trash removal, and clearing curb openings and overflow drains.



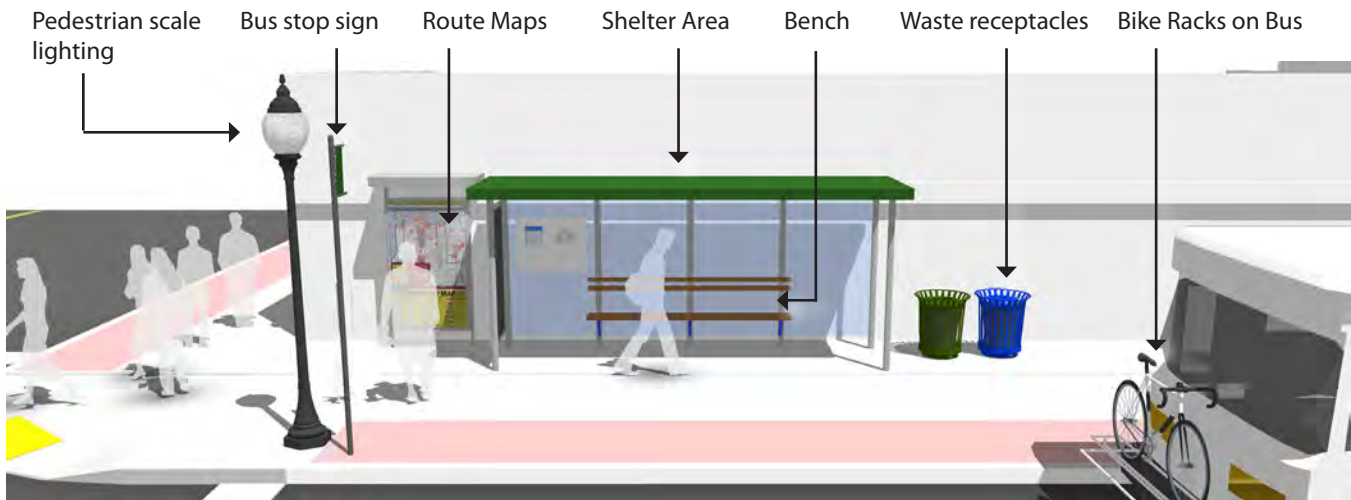
BUS STOP INFRASTRUCTURE

DESCRIPTION

A variety of streetscape elements can define the pedestrian realm, offer protection from moving vehicles, and enhance the walking experience. Key features are presented below.

GUIDANCE

- **Signs** at bus stops are an important element of good transit service. Signs serve as a source of information to patrons and operators regarding the location of the bus stop and are excellent marketing tools to promote transit use.
- **Benches** provide comfort and convenience at bus stops and are usually installed on the basis of existing or projected ridership figures. A bench may be installed by itself or as part of a shelter.
- **Lighting** is important for safety and security of transit patrons. A brightly lit bus stop makes it easier for the bus driver to observe waiting passengers and allows motorists to see pedestrians moving to and from the bus stop.
- **Shelters** provide protection from the elements and seating while for patrons waiting for rides. An attractive, well designed shelter can also be a positive addition to a streetscape that contributes to a sense of place. It also provides an excellent opportunity to improve the visibility of the transit service and to provide maps and other informational signage to help people use the service.
- **Waste receptacles** can be provided at higher use transit stops to reduce unwanted items being brought on the transit vehicle.
- **Marked Crossings** should help pedestrians safely navigate to bus stops and the surrounding destinations.
- **Bicycle Accommodations** are important to encourage multimodal trip making. Consider bicycle racks on busses, and bike parking at transit stations.



DISCUSSION

Signs and/or pavement markings identifying a bus stop and restricting parking are the bare minimum bus stop infrastructure. Ideally traffic regulations should be established prohibit parking, standing, or stopping at bus stops. An allowance for passenger vehicles to stop to load or unload passengers in the bus stops may be included.

ADDITIONAL REFERENCES

FHWA. (2006). *Federal Highway Administration University Course on Bicycle and Pedestrian Transportation. Lesson 18: Bicycle and Pedestrian Connections to Transit*

MATERIALS AND MAINTENANCE

Features should be maintained to ensure proper lighting, comfort and security.



PEDESTRIAN SCALE LIGHTING

DESCRIPTION

Pedestrian scale lighting improves visibility for both pedestrians and motorists - particularly at intersections and in areas of high pedestrian activity.

Pedestrian scale lighting is characterized by short light poles (around 15 feet high), close spacing, low levels of illumination (except at crossings), and the use of LED lamps to produce good color rendition, long service life and high energy efficiency.

Solar powered lights are available where utility collection is difficult.



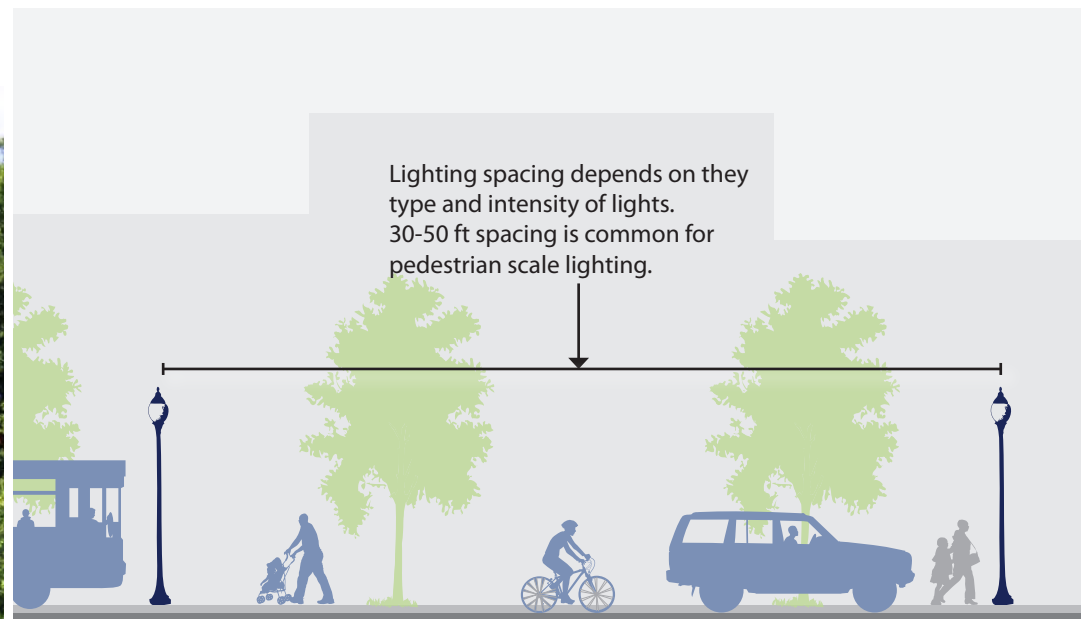
GUIDANCE

Locate lighting at the following locations:

- Pedestrian oriented areas
- Street crossings (intersection and mid block)
- Entrances and exits of bridges
- Areas near churches, schools, and community centers with nighttime pedestrian activity.

Placement details and dimensions:

- Spacing should be provided minimum illumination levels while limiting excess light pollution
- Luminaries should direct light downward
- Lighting poles should be placed in the furniture zone of the sidewalk and not interfere with pedestrian travel.



DISCUSSION

Both street and pedestrian lighting levels should be considered for the same street corridor, especially in areas with tree canopy. "Dark Sky" lighting should be considered within residential districts.

ADDITIONAL REFERENCES

Illuminating Engineering Society of North America. *American National Standard Practice for Roadway Lighting*. 2005.
 AASHTO. *Guide for the Development of Bicycle Facilities*. 2012
 FHWA. *Safety Effects of Marked Versus Unmarked Crosswalks at Uncontrolled Locations*. 2005.

MATERIALS AND MAINTENANCE

Low-cost light emitting diodes (LED) offer a wide range of light levels and can reduce long term utility costs.



GLOWING PATHWAYS

DESCRIPTION AND GUIDANCE

Glowing pathways are an innovative lighting technique requiring no power source (other than the sun) recently employed outside of Eindhoven, Netherlands (the Van Gogh-Roosegaarde Cycle Avenue). They are illuminated by thousands of twinkling stones that feature glow-in-the-dark technology and solar-powered LED lights.

These can be a sustainable solution to lighting and pathway needs as the bicycle and pedestrian network develops in and around campus.

Further information can be found at: <https://www.studioroosegaarde.net/project/smart-highway/photo/#van-gogh-path>



Photos of the Van Gogh-Roosegaarde Cycle Avenue from Studio Roosegaarde





PEDESTRIANS AT INTERSECTIONS

Attributes of pedestrian-friendly intersection design include:

Clear Space: Corners should be clear of obstructions. They should also have enough room for curb ramps, for transit stops where appropriate, and for street conversations where pedestrians might congregate.

Visibility: It is critical that pedestrians on the corner have a good view of vehicle travel lanes and that motorists in the travel lanes can easily see waiting pedestrians.

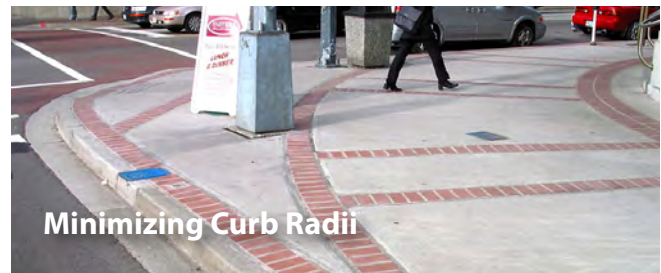
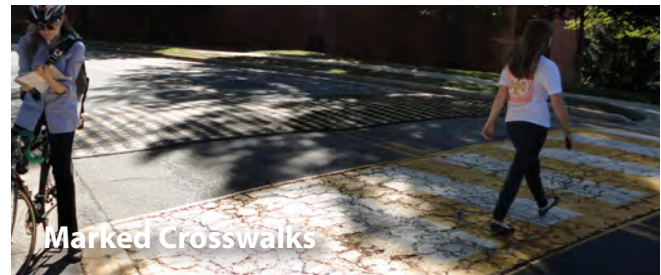
Legibility: Symbols, markings, and signs used at corners should clearly indicate what actions the pedestrian should take.

Accessibility: All corner features, such as curb ramps, landings, call buttons, signs, symbols, markings, and textures, should meet accessibility standards and follow universal design principles.

Separation from Traffic: Corner design and construction should be effective in discouraging turning vehicles from driving over the pedestrian area. Crossing distances should be minimized.

Lighting: Adequate lighting is an important aspect of visibility, legibility, and accessibility.

These attributes will vary with context but should be considered in all design processes.



MARKED CROSSWALKS

DESCRIPTION

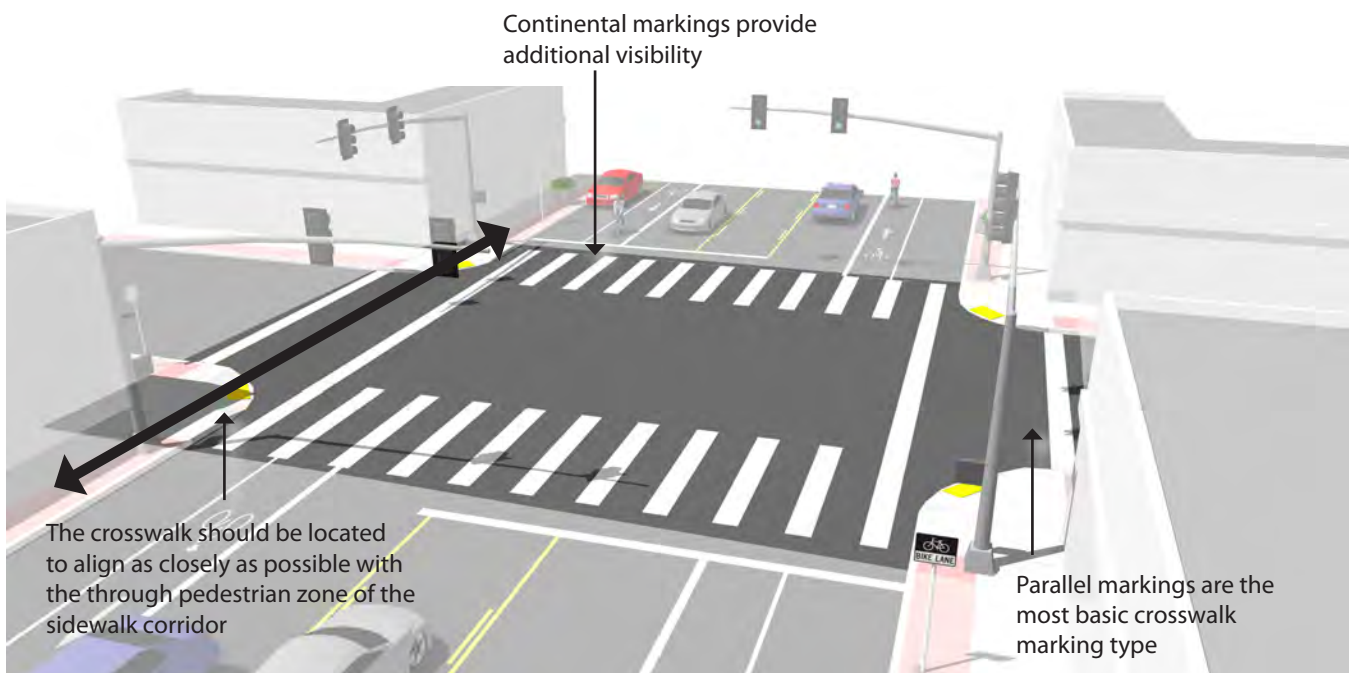
A marked crosswalk signals to motorists that they must stop for pedestrians and encourages pedestrians to cross at designated locations. Installing crosswalks alone will not necessarily make crossings safer especially on multi-lane roadways.

At mid-block locations, crosswalks can be marked where there is a demand for crossing and there are no nearby marked crosswalks.

GUIDANCE

At signalized intersections, all crosswalks should be marked. At un-signalized intersections, crosswalks may be marked under the following conditions:

- At a complex intersection, to orient pedestrians in finding their way across.
- At an offset intersection, to show pedestrians the shortest route across traffic with the least exposure to vehicular traffic and traffic conflicts.
- At an intersection with visibility constraints, to position pedestrians where they can best be seen by oncoming traffic.
- At an intersection within a school zone on a walking route.



DISCUSSION

Continental crosswalk markings should be used at crossings with high pedestrian use or where vulnerable pedestrians are expected, including: school crossings, across arterial streets for pedestrian-only signals, at mid-block crosswalks, and at intersections where there is expected high pedestrian use and the crossing is not controlled by signals or stop signs.

See intersection signalization for a discussion of enhancing pedestrian crossings.

ADDITIONAL REFERENCES

FHWA. *Manual on Uniform Traffic Control Devices*. (3B.18). 2009.
AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*. 2004.
FHWA. *Safety Effects of Marked vs. Unmarked Crosswalks at Uncontrolled Locations*. 2005.
FHWA. *Crosswalk Marking Field Visibility Study*. 2010.
NACTO. *Urban Street Design Guide*. 2013.

MATERIALS AND MAINTENANCE

Because the effectiveness of marked crossings depends entirely on their visibility, maintaining marked crossings should be a high priority. Thermoplastic markings offer increased durability than conventional paint.



MEDIAN REFUGE ISLANDS

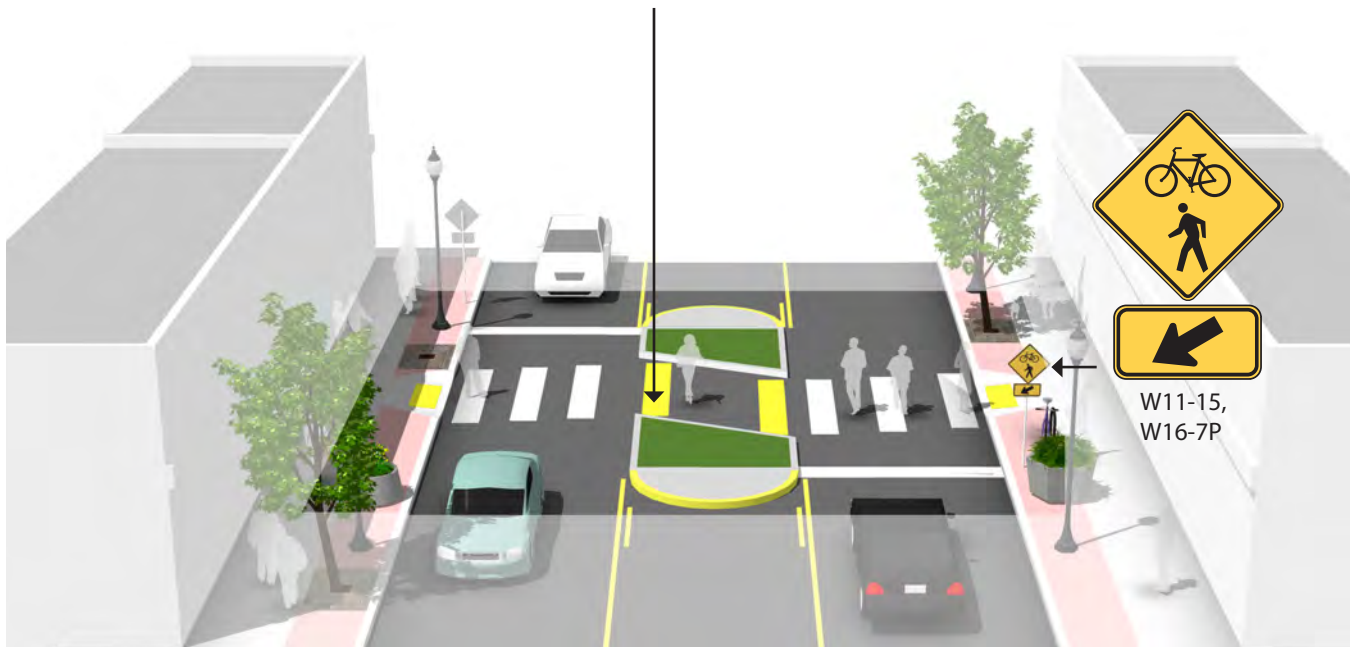
DESCRIPTION

Median refuge islands are located at the mid-point of a marked crossing and help improve pedestrian safety by allowing pedestrians to cross one direction of traffic at a time. Refuge islands minimize pedestrian exposure by shortening crossing distance and increasing the number of available gaps for crossing.

GUIDANCE

- Can be applied on any roadway with a left turn center lane or median that is at least 6' wide.
- Appropriate at signalized or unsignalized crosswalks
- The refuge island must be accessible, preferably with an at-grade passage through the island rather than ramps and landings.
- The island should be at least 6' wide between travel lanes (to accommodate bikes with trailers and wheelchair users) and at least 20' long.
- On streets with speeds higher than 25 mph there should also be double centerline marking, reflectors, and "KEEP RIGHT" signage.

Cut through median islands are preferred over curb ramps, to better accommodate bicyclists.



DISCUSSION

If a refuge island is landscaped, the landscaping should not compromise the visibility of pedestrians crossing in the crosswalk. Shrubs and ground plantings should be no higher than 1 ft 6 in.

On multi-lane roadways, consider configuration with active warning beacons for improved yielding compliance.

ADDITIONAL REFERENCES

FHWA. *Manual on Uniform Traffic Control Devices*. 2009.
 AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*. 2004.
 NACTO. *Urban Bikeway Design Guide*. 2012.
 NACTO. *Urban Street Design Guide*. 2013.

MATERIALS AND MAINTENANCE

Refuge islands may collect road debris and may require somewhat frequent maintenance. Refuge islands should be visible to snow plow crews and should be kept free of snow berms that block access.



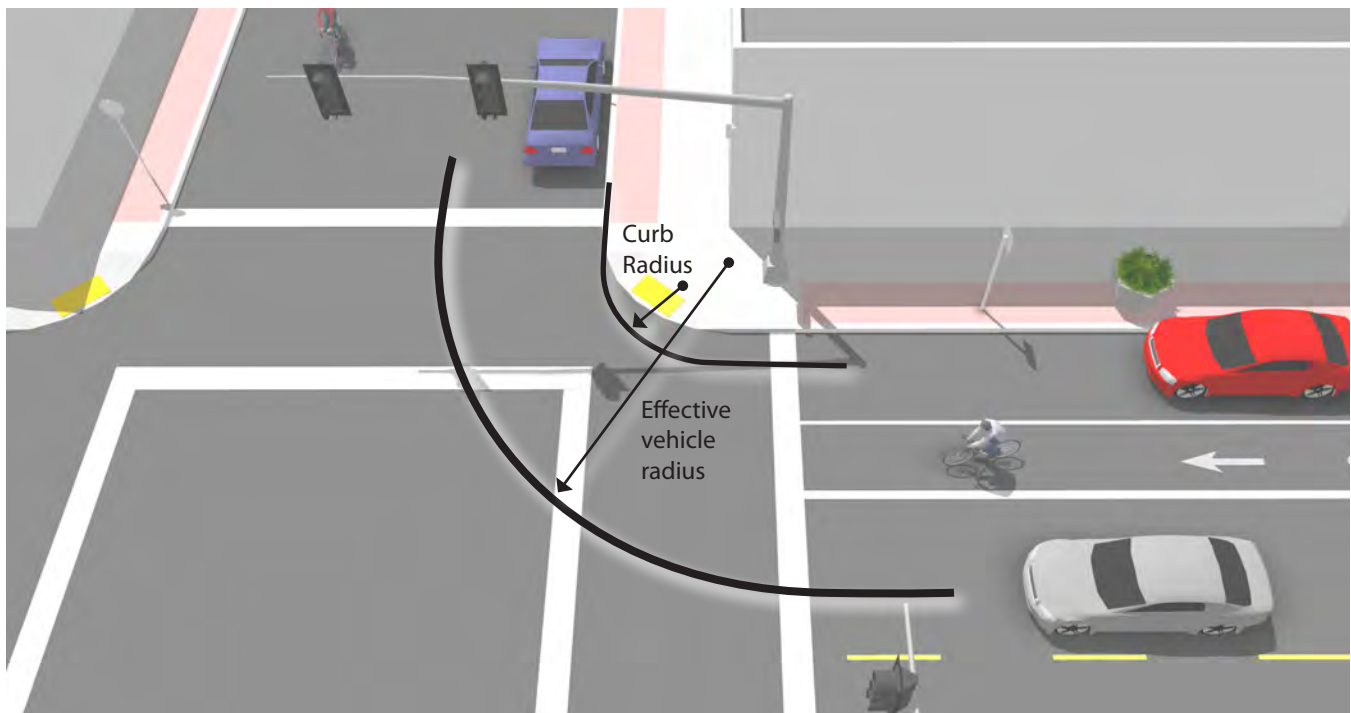
MINIMIZING CURB RADII

DESCRIPTION

The size of a curb's radius can have a significant impact on pedestrian comfort and safety. A smaller curb radius provides more pedestrian area at the corner, allows more flexibility in the placement of curb ramps, results in a shorter crossing distance and requires vehicles to slow more on the intersection approach. During the design phase, the chosen radius should be the smallest possible for the circumstances.

GUIDANCE

The radius may be as small as 3 ft where there are no turning movements, or 5 ft where there are turning movements, adequate street width, and a larger effective curb radius created by parking or bike lanes.



DISCUSSION

Several factors govern the choice of curb radius in any given location. These include the desired pedestrian area of the corner, traffic turning movements, street classifications, design vehicle turning radius, intersection geometry, and whether there is parking or a bike lane (or both) between the travel lane and the curb.

ADDITIONAL REFERENCES

AASHTO. *Guide for the Planning, Design, and Operation of Pedestrian Facilities*. 2004.
AASHTO. *A Policy on Geometric Design of Highways and Streets*. 2004.
NACTO. *Urban Street Design Guide*. 2013.

MATERIALS AND MAINTENANCE

Improperly designed curb radii at corners may be subject to damage by large trucks.



ADA COMPLIANT CURB RAMPS

DESCRIPTION

Curb ramps are the design elements that allow all users to make the transition from the street to the sidewalk. There are a number of factors to be considered in the design and placement of curb ramps at corners. Properly designed curb ramps ensure that the sidewalk is accessible from the roadway. A sidewalk without a curb ramp can be useless to someone in a wheelchair, forcing them back to a driveway and out into the street for access.

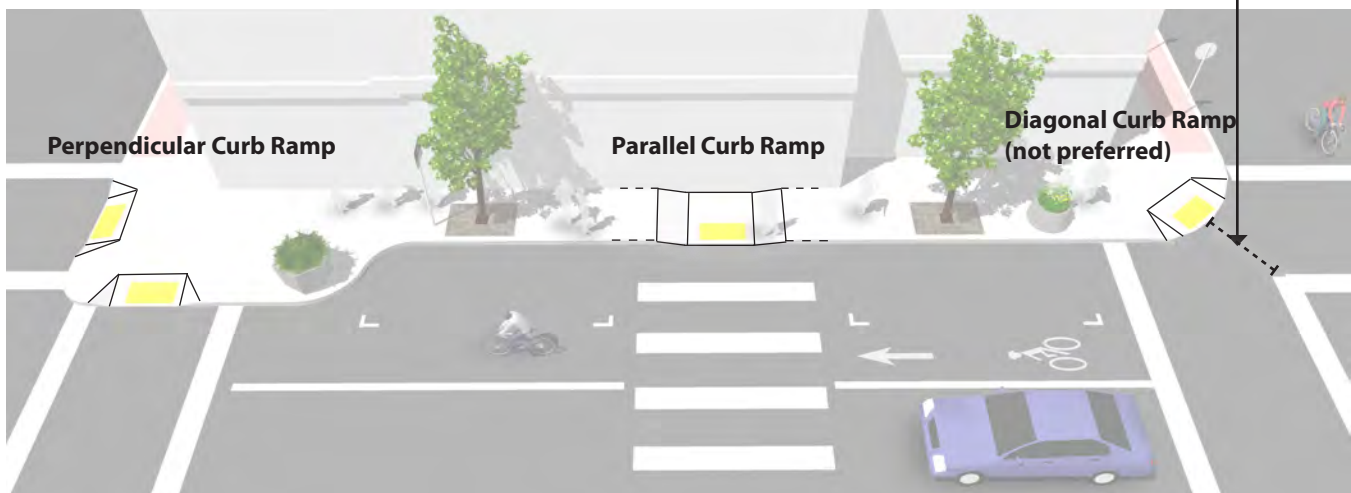
Although diagonal curb ramps might save money, they create potential safety and mobility problems for pedestrians, including reduced maneuverability and increased interaction with turning vehicles, particularly in areas with high traffic volumes. Diagonal curb ramp configurations are the least preferred of all options.

Curb ramps shall be located so that they do not project into vehicular traffic lanes, parking spaces, or parking access aisles. Three configurations are illustrated below.

GUIDANCE

- The landing at the top of a ramp shall be at least 4 feet long and at least the same width as the ramp itself.
- The ramp shall slope no more than 1:12, with a maximum cross slope of 2.0%.
- If the ramp runs directly into a crosswalk, the landing at the bottom will be in the roadway.
- If the ramp lands on a dropped landing within the sidewalk or corner area where someone in a wheelchair may have to change direction, the landing must be a minimum of 5'-0" long and at least as wide as the ramp, although a width of 5'-0" is preferred.

Diagonal ramps shall include a clear space of at least 48" within the crosswalk for user maneuverability



Crosswalk spacing not to scale. For illustration purposes only.

DISCUSSION

The edge of an ADA compliant curb ramp may be marked with a tactile warning device (also known as truncated domes) to alert people with visual impairments to changes in the pedestrian environment. Contrast between the raised tactile device and the surrounding infrastructure is important so that the change is readily evident. These devices are most effective when adjacent to smooth pavement so the difference is easily detected. The devices should provide color contrast so partially sighted people can see them.

ADDITIONAL REFERENCES

United States Access Board. *Accessibility Guidelines for Buildings and Facilities*. 2002.
 United States Access Board. *Proposed Accessibility Guidelines for Pedestrian Facilities in the Public-Right-of-Way (PROWAG)*. 2011.
 USDOJ. *ADA Standards for Accessible Design*. 2010.

MATERIALS AND MAINTENANCE

It is critical that the interface between a curb ramp and the street be maintained adequately. Asphalt street sections can develop potholes at the foot of the ramp, which can catch the front wheels of a wheelchair.



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BICYCLE FACILITIES

SHARED ROADWAY

On shared roadways, bicyclists and motor vehicles use the same roadway space. Sharing may include side-by-side operation, or single lane in-line operation depending on the configuration.

These facilities are typically used on roads with low speeds and traffic volumes, however they can be used on higher volume roads with wide outside lanes or shoulders. A motor vehicle driver will usually have to cross over into the adjacent travel lane to pass a bicyclist, unless a wide outside lane or shoulder is provided.

Shared roadways employ a large variety of treatments from simple signage and shared lane markings to more complex treatments including directional signage and traffic calming devices to reduce vehicle speeds or volumes.

SEPARATED BIKEWAYS

Designated exclusively for bicycle travel, separated bikeways are segregated from vehicle travel lanes by striping, and can include pavement stencils and other treatments. Separated bikeways are most appropriate on arterial and collector streets where higher traffic volumes and speeds warrant greater separation.

Separated bikeways can increase safety and promote proper riding by:

- Defining road space for bicyclists and motorists, reducing the possibility that motorists will stray into the bicyclists' path.
- Discouraging bicyclists from riding on the sidewalk.
- Reducing the incidence of wrong way riding.
- Reminding motorists that bicyclists have a right to the road.



Marked Shared Roadway



Bicycle Lanes



Buffered Bike Lanes



Cycle Tracks



MARKED SHARED ROADWAY

DESCRIPTION

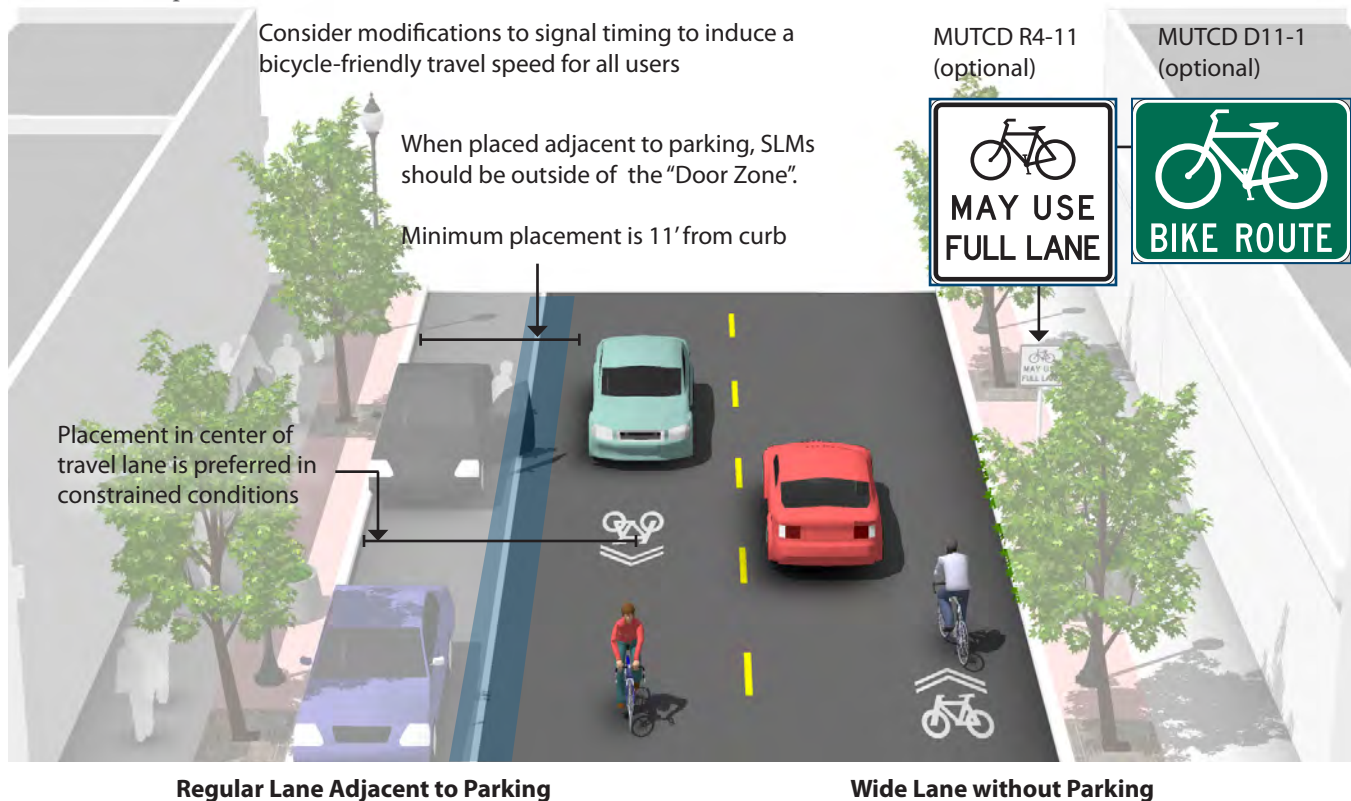
A marked shared roadway is a general purpose travel lane marked with shared lane markings (SLM) used to encourage bicycle travel and proper positioning within the lane.

In constrained conditions, the SLMs are placed in the middle of the lane to discourage unsafe passing by motor vehicles. On a wide outside lane, the SLMs can be used to promote bicycle travel to the right of motor vehicles.

In all conditions, SLMs should be placed outside of the door zone of parked cars.

GUIDANCE

- May be used on streets with a speed limit of 35 mph or under. Lower than 30 mph speed limit preferred.
- In constrained conditions, preferred placement is in the center of the travel lane to minimize wear and promote single file travel.
- Minimum placement of SLM marking centerline is 11 feet from edge of curb where on-street parking is present, 4 feet from edge of curb with no parking. If parking lane is wider than 7.5 feet, the SLM should be moved further out accordingly.



DISCUSSION

If collector or arterial, this should not be a substitute for dedicated bicycle facilities if space is available.

Bike Lanes should be considered on roadways with outside travel lanes wider than 15 feet, or where other lane narrowing or removal strategies may provide adequate road space. SLMs shall not be used on shoulders, in designated bike lanes, or to designate bicycle detection at signalized intersections. (MUTCD 9C.07)

ADDITIONAL REFERENCES

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
 FHWA. *Manual on Uniform Traffic Control Devices*. 2009.
 NACTO. *Urban Bikeway Design Guide*. 2012.

MATERIALS AND MAINTENANCE

Placing SLMs between vehicle tire tracks will increase the life of the markings and minimize the long-term cost of the treatment.



BICYCLE LANE

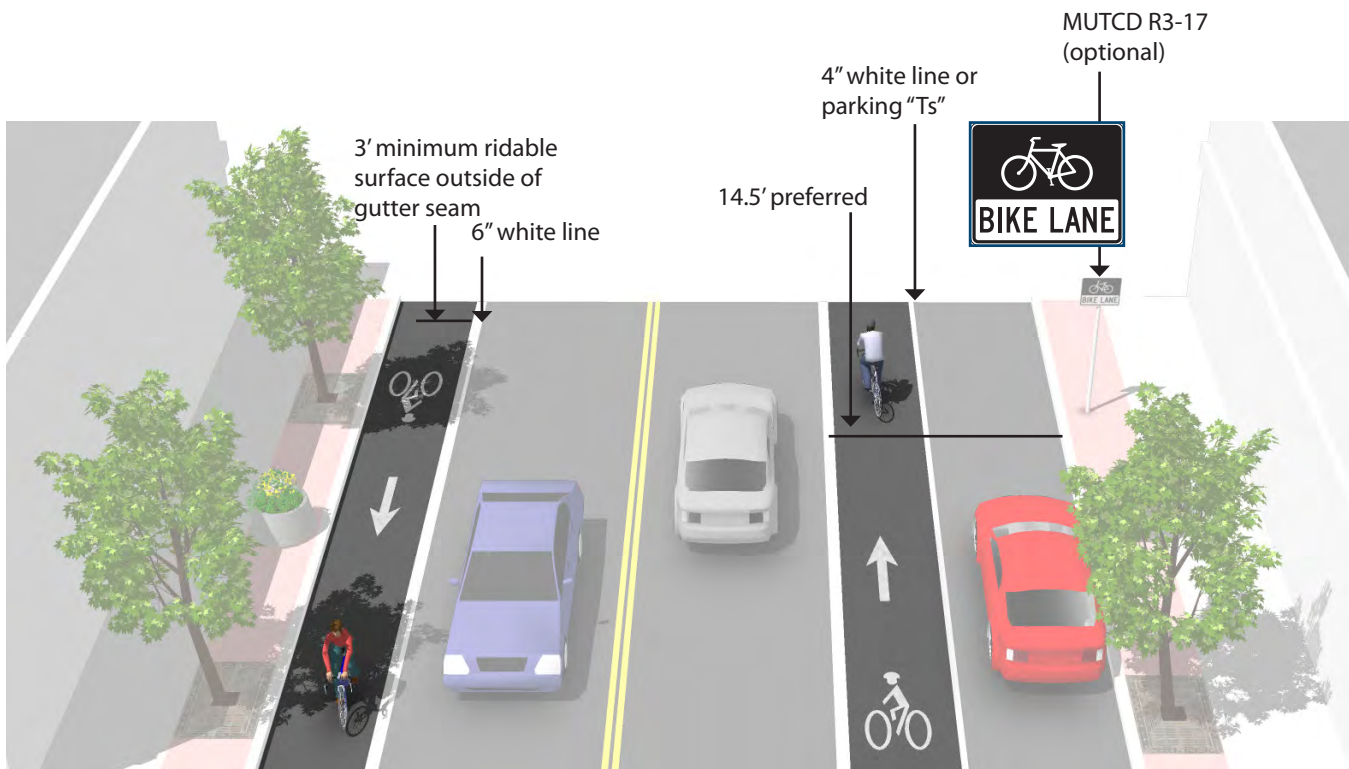
DESCRIPTION

Bike lanes designate an exclusive space for bicyclists through the use of pavement markings and signage. The bike lane is located adjacent to motor vehicle travel lanes and is used in the same direction as motor vehicle traffic. Bike lanes are typically on the right side of the street, between the adjacent travel lane and curb, road edge or parking lane.

Many bicyclists, particularly less experienced riders, are more comfortable riding on a busy street if it has a striped and signed bikeway than if they are expected to share a lane with vehicles.

GUIDANCE

- 4 foot minimum when no curb and gutter is present.
- 5 foot minimum when adjacent to curb and gutter or 3 feet more than the gutter pan width if the gutter pan is wider than 2 feet.
- 14.5 foot preferred from curb face to edge of bike lane. (12 foot minimum).
- 7 foot maximum width for use adjacent to arterials with high travel speeds. Greater widths may encourage motor vehicle use of bike lane.



DISCUSSION

Wider bicycle lanes are desirable in certain situations such as on higher speed arterials (45 mph+) where use of a wider bicycle lane would increase separation between passing vehicles and bicyclists. Appropriate signing and stenciling is important with wide bicycle lanes to ensure motorists do not mistake the lane for a vehicle lane or parking lane. Consider buffered bike lanes when further separation is desired.

ADDITIONAL REFERENCES

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
 FHWA. *Manual on Uniform Traffic Control Devices*. 2009.
 NACTO. *Urban Bikeway Design Guide*. 2012.

MATERIALS AND MAINTENANCE

Paint can wear more quickly in high traffic areas or in winter climates. Bicycle lanes should be cleared of snow through routine snow removal operations.

CYCLE TRACKS

DESCRIPTION

A cycle track is an exclusive bike facility that combines the user experience of a separated trail with the on-street infrastructure of a conventional bike lane. A cycle track is physically separated from motor traffic and distinct from the sidewalk. Cycle tracks have different forms but all share common elements—they provide space that is intended to be exclusively or primarily used by bicycles, and are separated from motor vehicle travel lanes, parking lanes, and sidewalks.

Raised cycle tracks may be at the level of the adjacent sidewalk or set at an intermediate level between the roadway and sidewalk to separate the cycle track from the pedestrian area.

GUIDANCE

Cycle tracks should ideally be placed along streets with long blocks and few driveways or mid-block access points for motor vehicles.

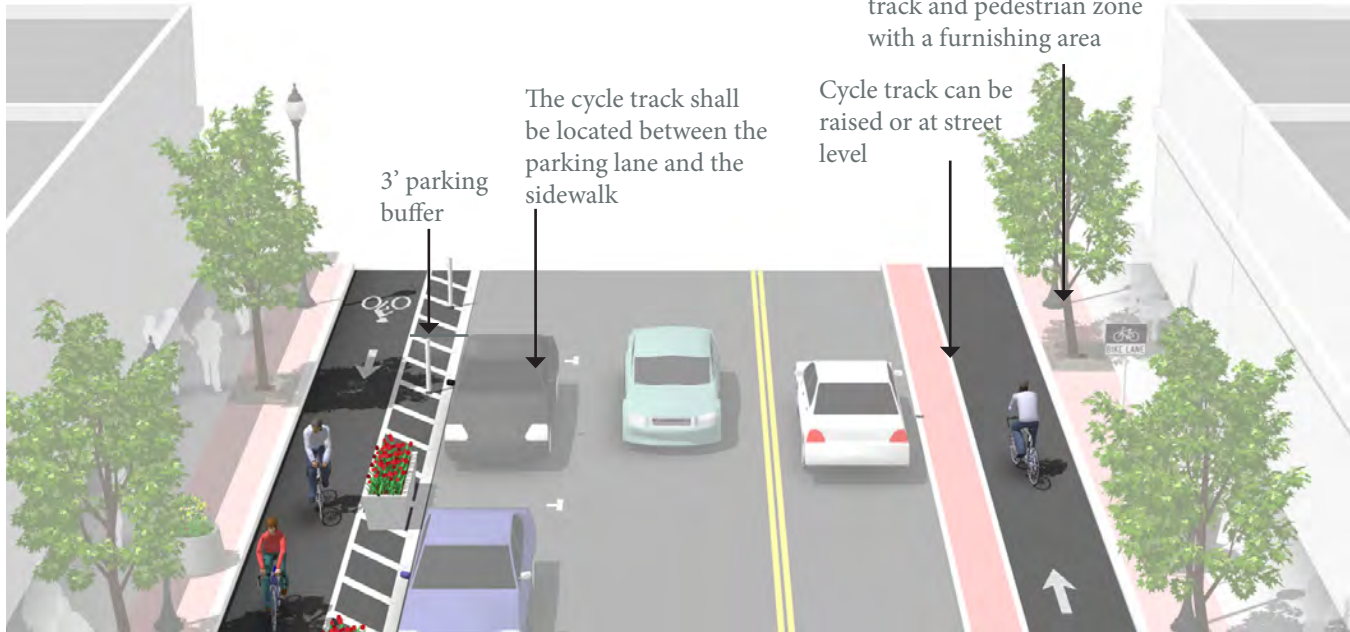
One-Way Cycle Tracks

- 7 foot recommended minimum to allow passing.
5 foot minimum width in constrained locations.

Two-Way Cycle Tracks

- Cycle tracks located on one-way streets have fewer potential conflict areas than those on two-way streets.
- 12 foot recommended minimum for two-way facility.
8 foot minimum in constrained locations

If possible, separate cycle track and pedestrian area with a furnishing area



DISCUSSION

Special consideration should be given at transit stops to manage bicycle and pedestrian interactions. Driveways and minor street crossings are unique challenges to cycle track design. Parking should be prohibited within 30 feet of the intersection to improve visibility. Color, yield markings and “Yield to Bikes” signage should be used to identify the conflict area and make it clear that the cycle track has priority over entering and exiting traffic. If configured as a raised cycle track, the crossing should be raised so that the sidewalk and cycle track maintain their elevation through the crossing.

ADDITIONAL REFERENCES

NACTO. *Urban Bikeway Design Guide*. 2012.

MATERIALS AND MAINTENANCE

In cities with winter climates, barrier separated and raised cycle tracks may require special equipment for snow removal.



BICYCLE SUPPORT FACILITIES

Support facilities such as bicycle parking, repair stations, and bicycle friendly stairways can significantly enhance the bicyclist experience across campus. Bicycle friendly stairways will enhance connectivity. Bicyclists expect a safe, convenient place to secure their bicycle when they reach their destination. Along with increased use and connectivity, bicycle repair stations will complement not only infrastructure improvements, but a cultural shift that will allow faculty, staff, students, and visitors to engage simple bicycle maintenance and functionality.

WAYFINDING

The ability to navigate through Wake Forest University is informed by landmarks, natural features and other visual cues. Signs throughout the campus should indicate to bicyclists and pedestrians:

- Direction of travel
- Location of destinations
- Travel time/distance to those destinations

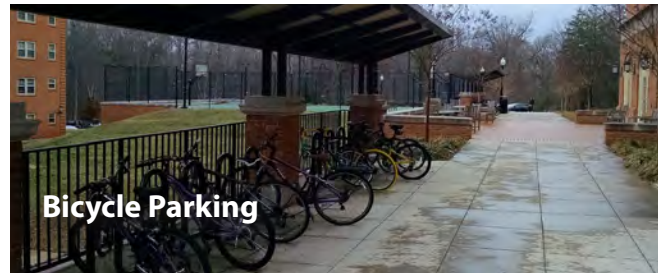
These signs will increase users' comfort and accessibility to the bicycle and pedestrian systems.

Signage can serve both wayfinding and safety purposes including:

- Helping to familiarize users with the network
- Helping users identify the best routes to destinations
- Helping to address misconceptions about time and distance
- Helping overcome a “barrier to entry” for people who are not frequent bicyclists (e.g., “interested but concerned” bicyclists)

A community-wide wayfinding signage plan would identify:

- Sign locations
- Sign type – what information should be included and design features
- Destinations to be highlighted on each sign – key destinations for bicyclists
- Approximate distance and travel time to each destination



Bicycle Parking



Bicycle Repair Station



Bicycle Friendly Stairways



Wayfinding signs also visually cue motorists that they are driving along a bicycle/pedestrian route and should use caution. Signs are typically placed at key locations leading to and along routes, including the intersection of multiple routes. Too many road signs tend to clutter the right-of-way, and it is recommended that these signs be posted at a level most visible to bicyclists and pedestrians rather than per vehicle signage standards.



BICYCLE PARKING

DESCRIPTION

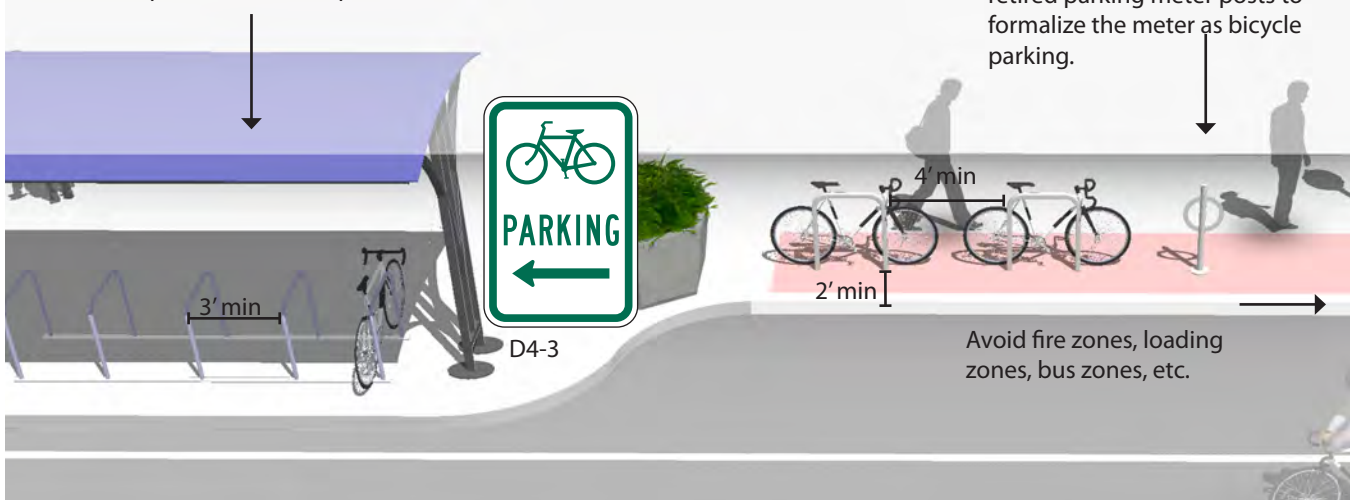
Short-term bicycle parking is meant to accommodate visitors, customers, and others expected to depart within two hours. It should have an approved standard rack, appropriate location and placement, and weather protection. The Association for Pedestrian and Bicycle Professionals (APBP) recommends selecting a bicycle rack that:

- Supports the bicycle in at least two places, preventing it from falling over.
- Allows locking of the frame and one or both wheels with a U-lock.
- Is securely anchored to ground.
- Resists cutting, rusting and bending or deformation.

GUIDANCE

- 2' minimum from the curb face to avoid 'dooring.'
- Close to destinations; 50' maximum distance from main building entrance.
- Minimum clear distance of 6' should be provided between the bicycle rack and the property line.
- Should be highly visible from adjacent bicycle routes and pedestrian traffic.
- Locate racks in areas that cyclists are most likely to travel.

Bicycle shelters consist of bicycle racks grouped together within structures with a roof that provides weather protection.



DISCUSSION

Where the placement of racks on sidewalks is not possible (due to narrow sidewalk width, sidewalk obstructions, street trees, etc.), bicycle parking can be provided in the street where on-street vehicle parking is allowed in the form of on-street bicycle corrals.

Some types of bicycle racks may meet design criteria, but are discouraged except in limited situations. This includes undulating “wave” racks, schoolyard “wheel bender” racks, and spiral racks.

ADDITIONAL REFERENCES

AASHTO. *Guide for the Development of Bicycle Facilities*. 2012.
APBP. *Bicycle Parking Guide 2nd Edition*. 2010.

MATERIALS AND MAINTENANCE

Use of proper anchors will prevent vandalism and theft. Racks and anchors should be regularly inspected for damage. Educate snow removal crews to avoid burying racks during winter months.



BICYCLE REPAIR STATION

DESCRIPTION

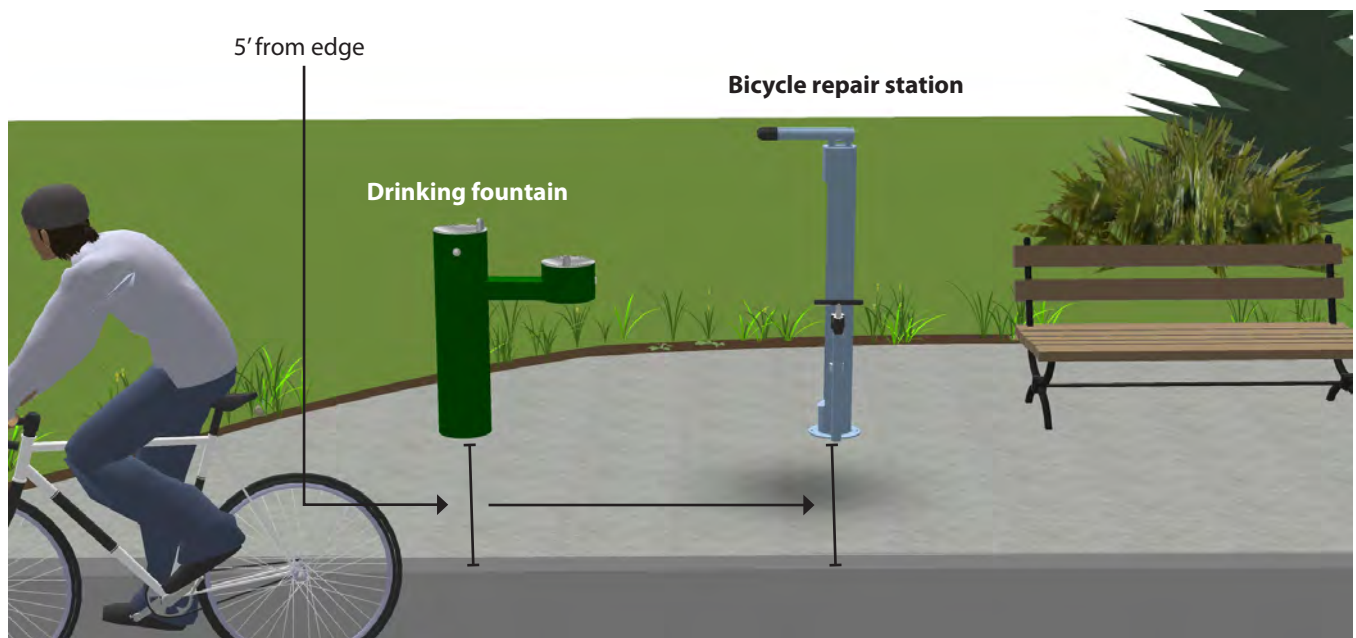
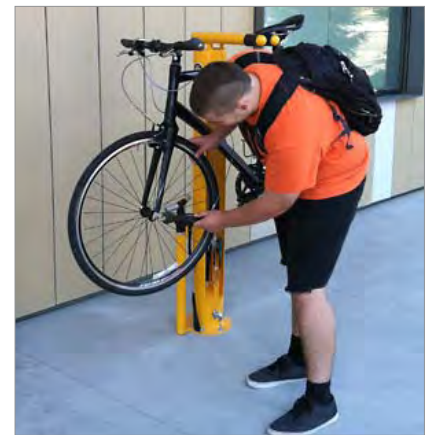
Bicycle repair stations are small kiosks designed to offer a complete set of tools necessary for routine bicycle maintenance. Bicycle repair stations have become a popular amenity in bicycle friendly places because they provide bicyclists with access to tools on-the-go and encourage people to teach and learn bicycle maintenance in an informal setting. They can also help to reduce the number of abandoned or trashed bikes in a community; bikes are often abandoned by their owners when they have a minor mechanical issue that they do not have the tools or knowledge to fix. Bicycle repair stations encourage people to learn bicycling skills from one another and send a message to residents and visitors that bicycling is supported in the community. These fixtures can be placed in a park or in another public place and require little upkeep or oversight, since the tools and stand are designed to be self-contained and theft-resistant.

GUIDANCE

- Bicycle repair station tools are secured by high security cables, but will still be an attractive target for theft. Proper placement of kiosks in areas of high activity is one key strategy to reduce potential vandalism.
- Consider grouping repair stations together with other amenities such as bicycle parking, seating, and drinking fountains.



Public bicycle maintenance and tool stand examples.





BICYCLE FRIENDLY STAIRWAYS

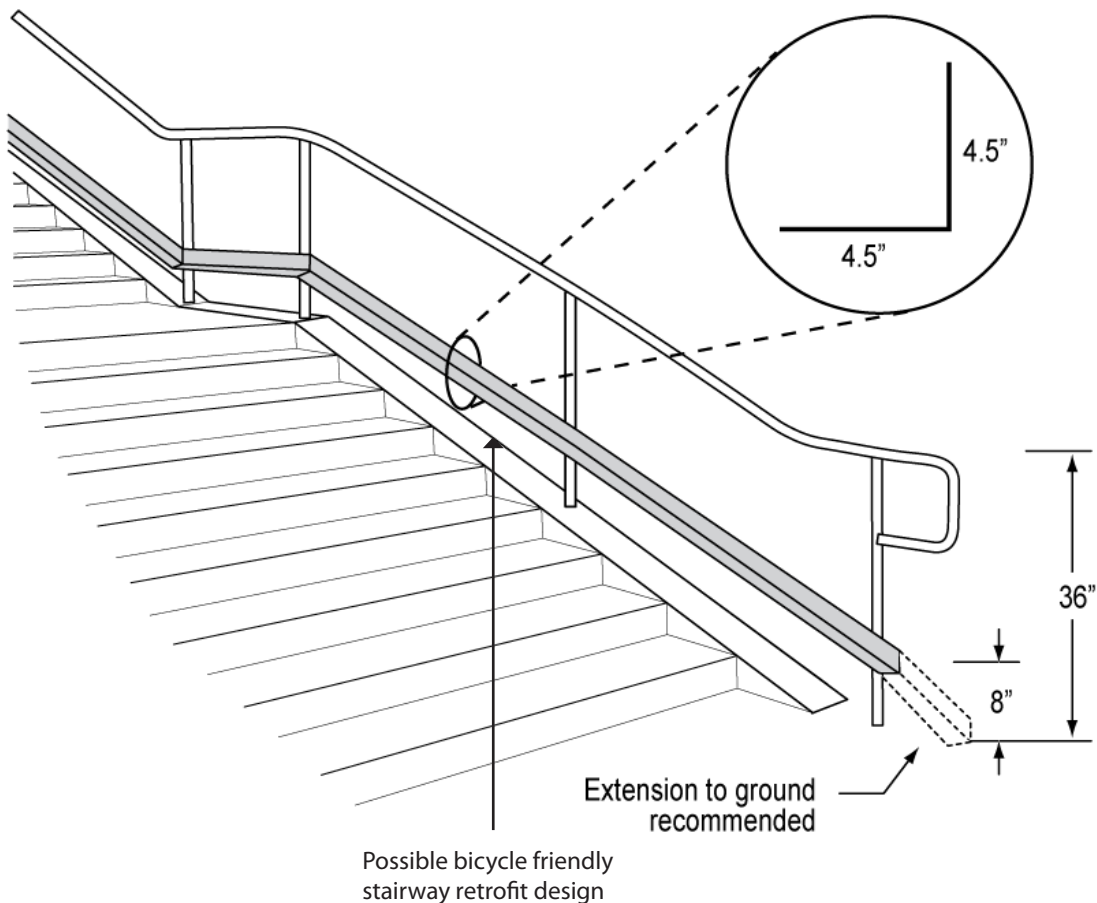
DESCRIPTION AND GUIDANCE

Wake Forest University campus features prominent pathways that support significant levels of bicycle and pedestrian traffic. To accommodate the changing topography, many of these pathways also include stairways for pedestrians. These stairways present significant barriers to bicyclists and individuals with limited mobility. Many bicyclists choose to ride around staircases, thereby damaging grass areas and other landscaping.

To avoid this behavior and to encourage higher levels of bicycling, staircases should be avoided within identified bikeway corridors where bicycle connectivity is prioritized. It is desirable from a bicycling standpoint to also limit the use of stairs in other areas where bicycle use is expected. When staircases are constructed, they should accommodate bicycles through the use of a channel that allows bicyclists to push their bicycle up or down the staircase without the need to carry it. The University will need to determine an acceptable design that meets state code and can be used within future projects. Signage should be placed at the stairs to inform bicyclists of the trough location and purpose. The figure and photo below provides design examples would be a possible solution to retrofit or provide a bicycle channel with new construction.



Bicycle friendly stairway new construction that incorporates a bicycle channel





WAYFINDING SIGNAGE

DESCRIPTION

A bicycle wayfinding system consists of comprehensive signing and/or pavement markings to guide bicyclists to their destinations along preferred bicycle routes. There are three general types of wayfinding signs:

Confirmation Signs

Indicate to bicyclists that they are on a designated bikeway. Make motorists aware of the bicycle route. This signage can include destinations and distance/time, but does not include arrows.

Turn Signs

Indicate where a bikeway turns from one street onto another street. This signage can be used with pavement markings, and does include destinations and arrows.

Decisions Signs

Mark the junction of two or more bikeways and informs bicyclists of the designated bike route to access key destinations. Destinations and arrows, distances and travel times are optional but recommended.



Alternative Designs

A customized alternative design may be used to include pedestrian-oriented travel times, campus logos, and sponsorship branding. Wake Forest University has developed customized specifications for pedestrian orientation as part of its Campus Signage Study and Guidelines.



Pedestrian Orientation
See Specification—
WF.Ped.1



Pedestrian Orientation
See Specification—
WF.Ped.2

DISCUSSION

There is no standard color for bicycle wayfinding signage. Section 1A.12 of the MUTCD establishes the general meaning for signage colors. Green is the color used for directional guidance and is the most common color of bicycle wayfinding signage in the US, including those in the MUTCD. Wake Forest University exterior sign specifications could be applied to bicycle wayfinding signage.

ADDITIONAL REFERENCES

AASHTO. (2012). *Guide for the Development of Bicycle Facilities*.
FHWA. (2009). *Manual on Uniform Traffic Control Devices*.
NACTO. (2012). *Urban Bikeway Design Guide*.
Wake Forest University Campus (2011) *Signage Study and Guidelines*
exterior sign specifications.

MATERIALS AND MAINTENANCE

Maintenance needs for wayfinding signs are similar to other signs and will need periodic replacement due to wear.





APPENDIX B: COST ESTIMATES

COST SUMMARY

PRIORITY PROJECTS	COST
#1: Welcome Center Intersection Improvements	\$6,617
#2: Jasper Memory Lane/Wingate Road Intersection Improvements	\$2,448
#3: Aaron Lane to Wake Forest Road Sidewalk/Crosswalk (Parking Lot Q)	\$10,728
#4: Wake Forest Road Bike Lanes	\$6,027.84
#5: Bicycle Repair Stations	\$6,062
#6: Reynolda Greenway Extension	\$40,416
Total (including 20% contingency)	\$72,359

PRIORITY INVESTMENTS	COST
#1: Dogwood/Magnolia Cycle Track	\$23,940
#2: Allen Easley Street Greenway	*TBD
#3: Spry Stadium Sidepath and Trail	\$149,098
#4: Reynolda Campus to Athletic Campus Greenway	\$283,869
#5: Campus Core Major Ramps	*TBD
Total (including 20% contingency)	**\$456,906

*Further analysis is needed for these cost estimates

**Total does not include Priority Investment 2& 5 which require further analysis for proper estimates

COST ESTIMATE ASSUMPTIONS

The cost estimates provided in this appendix represent preliminary estimates of construction costs based upon the recommendations. Important assumptions used to arrive at these estimates include:

- Costs are primarily based on *Costs for Pedestrian and Bicyclist Infrastructure Improvements*, released in October, 2013 by the UNC Highway Safety Research Center.
- Costs do not include property acquisition, utilities, and custom overpasses/underpasses (except where explicitly identified).
- Standard construction methods and materials are used.

Since these preliminary estimates are based on a planning-level understanding of project components, rather than on a detailed design, they should be considered as “Order of Magnitude”. Planning level-costs are appropriate given the level of uncertainty in project design at this point in the process. Many factors can affect final construction costs, including but not limited to:

- Final construction phasing
- Selected alignment
- Fluctuations in commodity prices during the design and permitting processes
- Selected construction materials
- Property Acquisition

As the project progresses through preliminary, semi-final and final design phases, these uncertainties begin to diminish. With each round of refinement a range of expected construction costs will become more accurately known.



PRIORITY PROJECT #1: WELCOME CENTER INTERSECTION IMPROVEMENTS

LOCATION	IMPROVEMENT TYPE	UNIT TYPE	UNITS	UNIT COST	IMPROVEMENT COST
West side of Allen Easley Street/Wake Forest Road intersection	High-Visibility Crosswalk	Each	1	\$2,540	\$2,540
Allen Easley Street/Wake Forest Road intersection	Stop Signs	Each	2	\$300	\$600
	Curb Ramps*	Each	2	\$1,062	\$2,124
West of intersection	Advanced Warning Sign	Each	1	\$300	\$300
TOTAL					\$5,564
20% Contingency					\$1,113
GRAND TOTAL					\$6,677

Additional considerations:

- *Costs related to minimizing curb radii will also impact the cost of this project. While average costs for curb ramps are included above, the curb corner reconstruction will vary depending on design and materials and are not included.
- As the greenway system along Allen Easley Street is developed, future intersection improvements should include crossing improvements linking the northwest and northeast corners of the intersection with a new crosswalk, and minimizing curb radii of the northeast corner (with curb ramp).

PRIORITY PROJECT #2: JASPER MEMORY LANE/WINGATE ROAD INTERSECTION IMPROVEMENTS

LOCATION	IMPROVEMENT TYPE	UNIT TYPE	UNITS	UNIT COST	IMPROVEMENT COST
South side of Jasper Memory Lane at Wingate Road intersection	Sidewalk link	Linear foot	45	\$32	\$1,440
Both directions along Wingate Road at intersection	Stop Signs	Each	2	\$300	\$600
TOTAL					\$2,040
20% Contingency					\$408
GRAND TOTAL					\$2,448

Additional considerations:

- The removal of 1-2 trees that are currently covering the sidewalk is needed. Improvements could also include street furniture under the remaining trees. Variables related to these improvements will need further analysis and are not included in these planning level costs.
- Redesign of the western corner of Parking Lot F that may include a trailhead and other amenities related to the proposed greenway trail will incur additional costs. Further analysis will be needed for that project.

PRIORITY PROJECT #3: AARON LANE TO WAKE FOREST ROAD SIDEWALK/CROSSWALK (PARKING LOT Q)

LOCATION	IMPROVEMENT TYPE	UNIT TYPE	UNITS	UNIT COST	IMPROVEMENT COST
South side of parking lot Q	*Sidewalk	Linear foot	200	\$32	\$6,400
Driveway between parking lot Q and Scales Fine Arts Center	High-Visibility Crosswalk	Each	1	\$2,540	\$2,540
TOTAL					\$8,940
20% Contingency					\$1,788
GRAND TOTAL					\$10,728



(Priority Project #3 continued) Additional considerations:

- *Further analysis should also consider painted pavement markings (instead of new sidewalk construction) to indicate pedestrian space on the existing pavement of the southern edge of parking lot Q. If this option is chosen, include a barrier on the north side of the walkway to separate pedestrians and motorists from the recommended one-way traffic along the southern segment of parking lot Q. Costs for this option are variable depending on design and materials and would need further study.

PRIORITY PROJECT #4: WAKE FOREST ROAD BIKE LANES

LOCATION	IMPROVEMENT TYPE	UNIT TYPE	UNITS	UNIT COST	IMPROVEMENT COST
Wake Forest Road (both sides) from Wingate Road to the front of the Worrell Professional Center	Solid 4" striping	Linear foot	1840	\$1.85	\$3,404
Wake Forest Road (both sides) from Wingate Road to the front of the Worrell Professional Center	Bicycle symbol markings	1/250 ft	7.36	\$220	\$1,619.20
				TOTAL	\$5,023.20
				20% Contingency	\$1,004.64
				GRAND TOTAL	\$6,027.84

PRIORITY PROJECT #5: REYNOLDA GREENWAY EXTENSION

LOCATION	IMPROVEMENT TYPE	UNIT TYPE	UNITS	UNIT COST	IMPROVEMENT COST
Between Parking Lot T and Winston Hall from the Reynolda Greenway to the pathway linking to Gulley Drive.	Paved Multi-Use Trail	Mile	0.07	\$481,140	\$33,679.80
				TOTAL	\$33,679.80
				20% Contingency	\$6,735.96
				GRAND TOTAL	\$40,415.76

PRIORITY PROJECT #6: BICYCLE REPAIR STATIONS

LOCATION	IMPROVEMENT TYPE	UNIT TYPE	UNITS	UNIT COST	IMPROVEMENT COST
1. Near the large bicycle racks west of Farrell Hall; 2. Near the coffee shop at Taylor Hall and Hearn Plaza; 3. Near the bicycle racks between Leuter & Babcock Hall Plaza; 4. Near Wingate Road and Jasper Memory Lane, where the proposed greenway to the Athletic Campus would start.	*Bicycle Repair Station	Each	4	\$1,263	\$5,052
				TOTAL	\$5,052
				20% Contingency	\$1,010
				GRAND TOTAL	\$6,062

Additional consideration:

- *Approximate costs for a bicycle repair station include typical components such as a bike pump, tool kit, and work stand. Cost estimate based on Dero Fixit - <http://www.dero.com/product/fixit/>.



PRIORITY INVESTMENT #1: DOGWOOD/MAGNOLIA CYCLE TRACK

LOCATION	IMPROVEMENT TYPE	UNIT TYPE	UNITS	UNIT COST	IMPROVEMENT COST
Through parking lot Q	Solid 4" striping (for Cycle track)	Linear foot	560	\$1.85	\$1,036
Through parking lot Q	Dashed 4" line striping (for Cycle track)	Linear foot	445	\$0.46	\$204.70
Parking lot Q north end crossing	Crosswalk	Each	1	\$2,540	\$2,540
North/south of parking lot Q links	Paved trail/ramp	Mile	0.03125 miles	\$481,140	\$15,035.63
Through parking lot Q	*Solid 4" line removal	Linear foot	476	\$2.00	\$952
Through parking lot Q	**Solid 4" line striping	Linear foot	98	\$1.85	\$181.30
TOTAL					\$19,949.63
20% Contingency					\$3,989.93
GRAND TOTAL					\$23,939.55

Additional considerations:

- *This refers to the removal of parking lines of one row of parking
- **This refers to the striping of one row of parallel parking

PRIORITY INVESTMENT #2: ALLEN EASLEY STREET GREENWAY

LOCATION	IMPROVEMENT TYPE	UNIT TYPE	UNITS	UNIT COST	IMPROVEMENT COST
East side of Allen Easley Street	Natural Surface Trail	Mile	0.5	\$121,390	*\$60,695
East side of Allen Easley Street	Boardwalk	Mile	0.5	\$2,219,470	*\$1,109,735
East side of Allen Easley Street	Paved Multi-Use Trail	Mile	0.5	\$481,140	*\$240,570

Considerations:

- *The chart above compares the average costs of natural surface trail, boardwalk, and paved multi-use trail as applied to the 0.5 mile proposed Allen Easley Street greenway. While the trail will likely be some combination of the three, a trail feasibility study is needed to determine environmental permitting needs, proper trail surfaces types, and trail alignment. The above costs are shown for comparison purposes and a basic idea of potential trail costs.
- Three crosswalks and curb ramps will also be needed as part of this project.



PRIORITY INVESTMENT #3: SPRY STADIUM SIDEPATH AND TRAIL

LOCATION	IMPROVEMENT TYPE	UNIT TYPE	UNITS	UNIT COST	IMPROVEMENT COST
East and south of Spry Stadium	Paved Multi-Use Trail	Mile	0.22	\$481,140	\$104,338.10
Long Road and Polo Road intersection	Pedestrian signal with countdown	Each	3	\$1,480	\$4,440
Long Road/Polo Road intersection and Wingate Road/Carroll Weathers Drive intersection	Crosswalks	Each	4	\$2,540	\$10,160
Long Road/Polo Road intersection and Wingate Road/Carroll Weathers Drive intersection	Curb ramps	Each	5	\$1,062	\$5,310
				TOTAL	\$124,248.10
				20% Contingency	\$24,849.62
				GRAND TOTAL	\$149,097.72

PRIORITY INVESTMENT #4: REYNOLDA CAMPUS TO ATHLETIC CAMPUS GREENWAY

LOCATION	IMPROVEMENT TYPE	UNIT TYPE	UNITS	UNIT COST	IMPROVEMENT COST
Wingate Road to University Parkway	Paved Multi-Use Trail	Mile	0.49	\$481,140	\$236,557.29
				20% Contingency	\$47,311.46
				GRAND TOTAL	\$283,868.75

Additional consideration:

- This estimate does not include costs for a proposed redesign of parking lot F to include a trailhead and amenities. Costs will vary and need further analysis.

PRIORITY INVESTMENT #5: CAMPUS CORE MAJOR RAMPS

LOCATION	IMPROVEMENT TYPE	UNIT TYPE	UNITS	UNIT COST	IMPROVEMENT COST
Northeast and northwest corners of Hearn Plaza	*Major Ramp	Each	2	\$	\$
Manchester Plaza/Reynolda Hall	*Major Ramp	Each	2	\$	\$
				TOTAL	\$
				20% Contingency	\$
				GRAND TOTAL	\$

- *Cost TBD based on design and materials



WAKE FOREST
UNIVERSITY

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