Western Boulevard Crossing Study

FINAL REPORT

PREPARED FOR: Capital Area MPO

PREPARED BY: Stantec Consulting Services Inc.

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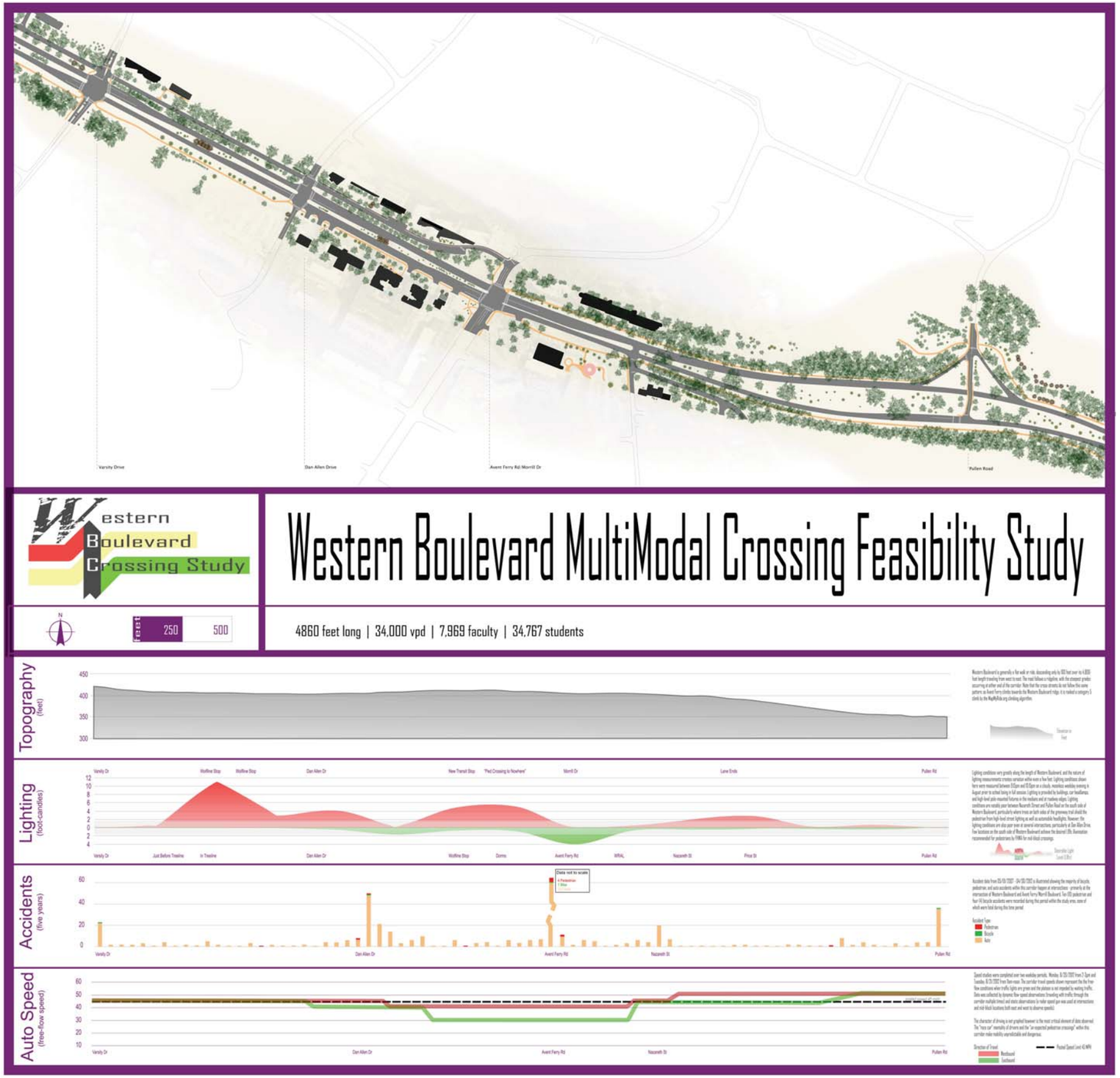
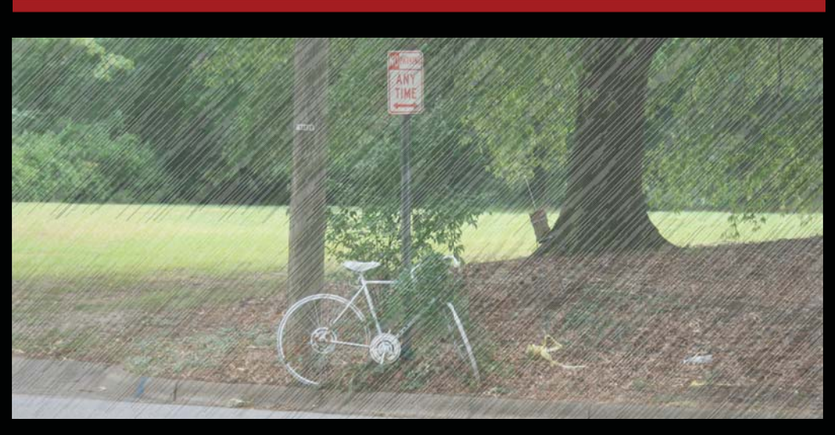


INTRODUCTION

"I saw a pedestrian hit on Western Boulevard and I am so grateful that options are being evaluated."

– Open House Attendee



INTRODUCTION

This report summarizes the need, vision, and recommendations to improve the corridor of Western Boulevard from Varsity Drive to Pullen Road in Raleigh, North Carolina. The project focused specifically on the safety and mobility of all users within this corridor to develop system level improvements as well as a grade-separated facility to effectively redirect the majority of pedestrian-bicycle movement across Western Boulevard. Many previous studies have been conducted to address the large volumes of pedestrian crossings occurring throughout this section of roadway. The purpose of this study was to provide a definitive solution for a grade crossing for cyclists and pedestrians, perhaps transit vehicles; secondarily, smaller-scale improvements would be identified to improve the active mode environment throughout the corridor.

The Capital Area Metropolitan Planning Organization (CAMPO), in collaboration with the City of Raleigh, North Carolina State University (NCSU), North Carolina Department of Transportation (NCDOT), Wake County, transit agencies and several interest groups (police, land owners, students, faculty and commuters), took part in a process to evaluate the existing conditions, needs, and opportunities to improve the mobility and safety of this corridor.

Western Boulevard is a major arterial roadway that bisects the southern and northern campuses of North Carolina State University (sometimes referred to as the Main and Centennial campuses), as well as serves as a major gateway into the core of downtown Raleigh. Pedestrian, bicycle, transit, and vehicular volumes are increasing each year and are projected to continue to do so as the university, city, county, and state experience infill development. A number of past studies have been conducted to address some of the same issues as this report; in five of the six prior studies a separated-grade crossing was a key recommendation. The approximately one-mile-long corridor has over 30,000 vehicles per day (vpd) and hundreds of students crossing at various locations throughout the corridor, with many crossing mid-block just west of Avent Ferry Road in order to avoid the delay at the intersection crosswalk. The study area corridor and major cross streets are illustrated below in Figure 1: Study Area.

Figure 1: Study Area

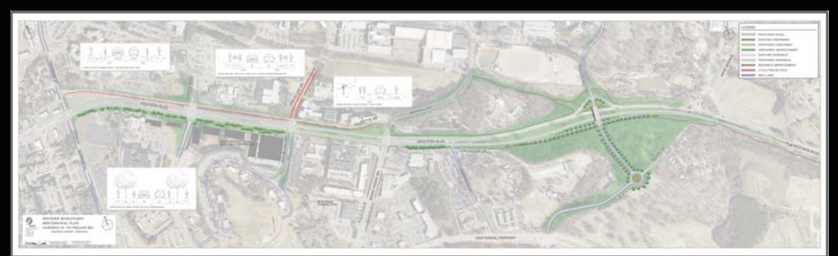
PROBLEM STATEMENT

There is a need to improve infrastructure, guide signs, and safety of bicycle and pedestrian travel across and along Western Boulevard. The improvements need to evaluate the feasibility of a multi-modal grade separation for bicycle, pedestrian, and potentially transit vehicles that connect the Main and Centennial campuses of NCSU.

VISION & OBJECTIVES

"…monorail is not being recommended in this 2012 Campus Mobility Plan, the provision of an underpass is highly desirable.

– NCSU Campus Mobility Plan, page 41



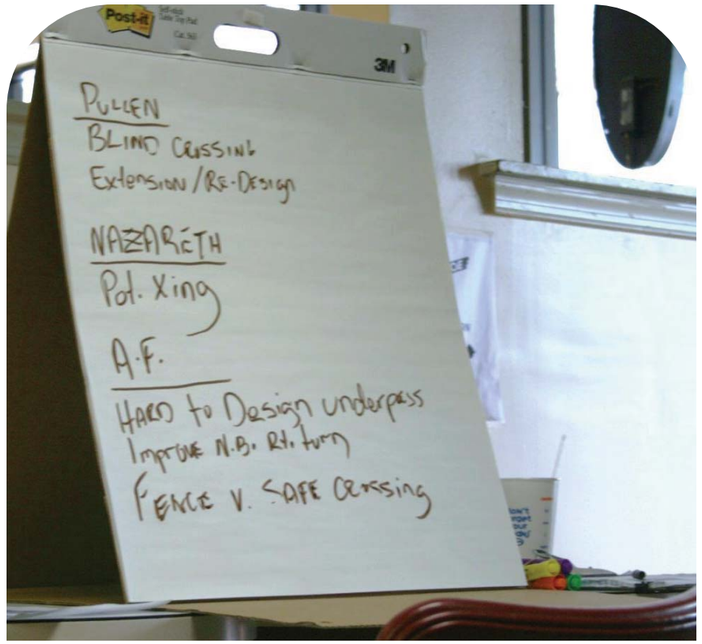
VISION & OBJECTIVES

Clarity to the objectives of this study and the vision for the future of the corridor were brought into focus by working with many users and decisionmakers over a period of months.

This section briefly highlights the outreach efforts that provided a solid foundation for this project. The public and committee involvement shaped and re-shaped the vision and objectives to build recommendations and options. Comprehensive documentation of the first phase of Committee & Public Involvement, Existing Conditions, and Previous Study Review is provided in the Diagnostic Report that was completed in November 2012 and is included as an Appendix to this report.

OUTREACH

The outreach began with a half-day field reconnaissance with members of the Core Technical Team (CTT) and the Study Oversight Committee (SOC). The CTT generally included professional staff from stakeholder agencies; the SOC were decision-makers dealing more with the realm of policy. This half-day inventory imparted a ground-level understanding of the existing conditions, operations, and issues to the people working on the project.



The outreach was conducted through multi-media interaction with the public. The following key outreach efforts connected the project with the spokes, wheels, and soles of those moving on the corridor:

- Media (Print, Radio, Internet)
- Intercept Survey/ Cycle Tracks
- Workshops

Media

The project media launch was distributed through a team of "communication volunteers" that directly tied into the university clubs, dormitories, media relations, and transit operations. Marketing material, with QR codes to the project website, was posted in all Wolfline buses, on the campus, in dormitories, and small project cards were handed out at all public engagement events.

The radio airwaves assisted in advertising and reaching the community through the partnership with the staff at WKNC 88.1 FM. The *Technician*, the *News and Observer*, and *Raleigh Times* all covered the process and promoted interest in the project.

The project website provided up-to-date information, involvement opportunities, documents, and visualizations through the planning process.

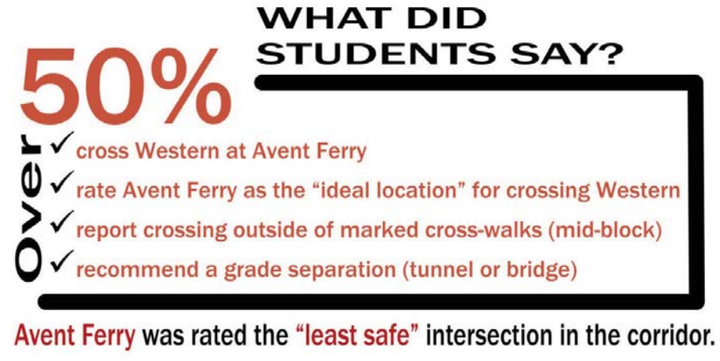
Intercept Survey/ Cycle Tracks

Our intercept survey team spent Tuesday, October 9, 2012 talking with pedestrians and cyclists along Western Boulevard. The surveyors recorded sixty-eight (68) responses to gain better understanding of the following:

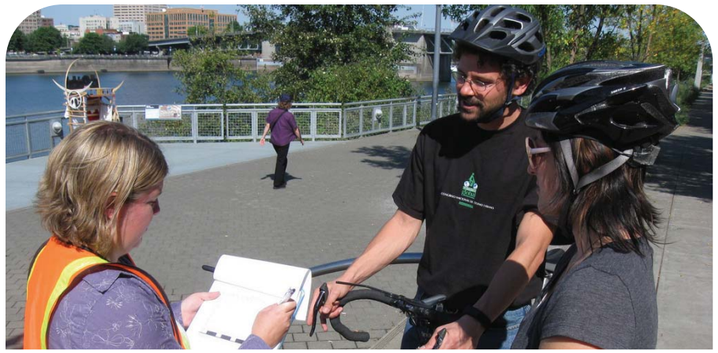
- The level of perceived safety when crossing Western Boulevard;
- Where people are coming from and going to;
- Where people typically cross;
- The ideal location of a potential grade-separated crossing;
- How safe people would feel using a tunnel crossing under Western Boulevard; and
- What would make people feel safer?

This information conveyed a common theme that users are open to a new method for crossing Western Boulevard, as long as it is convenient and safe.

Here is a summary of what we heard:

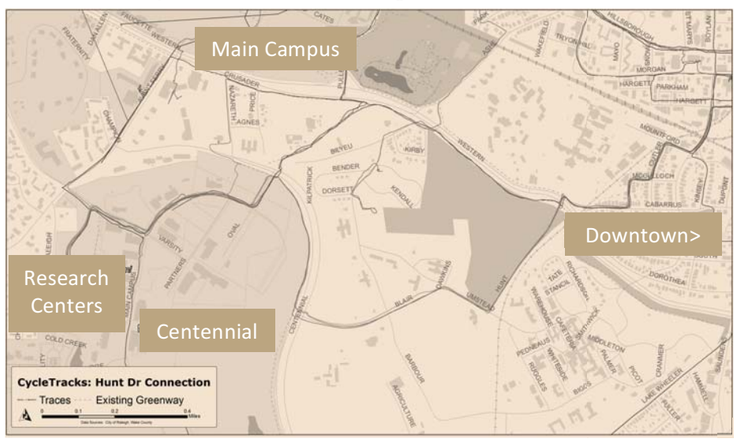


Appendix A provides detailed information on past studies, public engagement and data collection / results.



CycleTracks

CycleTracks used a smart phone's GPS to track users' movement across Western Boulevard and between campuses. Over 40 different users recorded their unique bicycling and walking trips using CycleTracks (*see sample image, below*). The traces confirmed the importance of a major separated grade crossing treatment at Avent Ferry and Western Boulevard, and added emphasis to the importance of Pullen Drive as a connection from Main Camus to Centennial Campus. Overall trips were connecting to and from the following key origins and destinations: Hillsborough Street, Main Campus, Centennial Campus, and downtown Raleigh.



Workshops

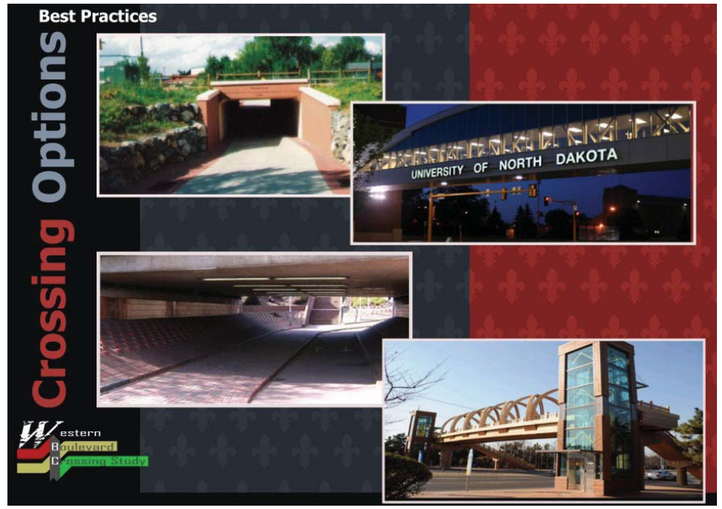
Public workshops provided a very energetic and personal opportunity for attendees to learn about the project, needs, goals, vision, and options for corridor improvements and grade-separated options. The two venues on Main Campus attracted over 300 attendees representing a wide cross-section including but not limited to: committee members, law enforcement, students, faculty, staff, transit users and operators, land owners, and city officials.

workshop 1

The first workshop focused on sharing the vision of the project and engaging attendees through four key stations and a survey in exchange for free pizza and soda. Over 150 attendees shared the following key highlights:

- Over 50% stated that they cross Western at Avent Ferry;
- Over 40% say they do not feel safe crossing Western Boulevard;
- Over 95% said they would use a tunnel; and
- Over 50% of the ideas to improve Western included a grade-separated facility.

This input provided confirmation to the consistent themes seen in the field, heard through the intercept survey, and recorded in many previous reports and studies.



workshop 2

The second workshop provided the attendees with the opportunity to vote for their favorite and least favorite of three options for the grade-separation at Western Boulevard and Avent Ferry. The attendees were able to review the operational analysis and view the three-dimensional model of the options as a video feed to further understand the coordination and movements. Attendees provided input on evaluation criteria (user benefits ranking very high, construction delays and aesthetics ranking lowest) as well as their preferred crossing option, which overwhelmingly favored a pedestrian/bicycle (or with transit) crossing option as opposed to a full interchange.

Only after several steering committee meetings and public outreach did the CTT and SOC finalize the project's Vision Statement and Objectives, which allowed for a more informed definition of the project's guiding principles.

VISION STATEMENT

The driving vision of this plan is to develop and evaluate corridor level and grade separated options that will improve the multi-modal safety, mobility, and future connectivity along Western Boulevard and between Main and Centennial Campuses.

OBJECTIVES

Objectives defined through the public outreach and coordination with the committee include:

- Gain public input and support;
- Evaluate grade-separation for bicycle and pedestrians within the study area *with* and *without* provisions for transit vehicles;
- Develop alternatives and conceptual designs connecting the southern and central sections of Western Boulevard, including alternative and conceptual designs for an underpass structure that can accommodate space for a future transit passageway at the intersection of Avent Ferry Road and Western Boulevard; and
- Identify any environmental constraints and impacts to structures, especially pertaining to adjacent property owners.

NEEDS ASSESSMENT

"...Many of our students arrive at NCSU without the understanding that traffic will not stop in all directions when the light turns red."

– Participant in Second Open House Workshop

NEEDS ASSESSMENT

"What needs improvement?" was a question asked throughout the planning process that provided insight, opinion and opportunity for meeting the goals of this project.

The base for our "needs" started in the field through the half-day field reconnaissance and was summarized in four main categories of improvement (see Figure 2. Issues Poster from Field Review):

- Facility
- Safety
- Aesthetics/Signage
- Context/Plans

A quick list of the main corridor needs include the following:

- Improve signal timing/coordination
- Improve the visibility and crossing provisions for bicyclists and pedestrians at Pullen Road
- Increase driver awareness of bicycle/ pedestrian crossing
- Continuous sidewalks and bicycle lanes
- Lower Speeds
- Safer Crossing
- Improved transit stops and amenities

These consistent needs provided direction for the corridor-level improvements and the consideration of a grade separation and how it will interface and connect with the existing transit, pedestrian, and cycling infrastructure and travel patterns.

Figure 2. Issues Poster from Field Review

RECOMMENDATIONS

59% said that they would feel comfortable walking through a tunnel by themselves at all times.

- Intercept Survey Result

RECOMMENDATIONS

During the course of the Western Boulevard Multi-Modal Crossing Feasibility Study, two broad categories of recommendations emerged and were detailed as recommendations. The System Level recommendations included provisions that were potentially shorter-term and less capital-intensive, and were identified throughout the length of the corridor based primarily on field observation and public input. The ultimate design goal, however, was to include a specific recommendation concerning provisions for a grade-separated crossing of Western Boulevard at some point in the corridor. The following is a summary of the recommendations that flowed from the technical analyses, stakeholder engagement, and comments from the Core Technical Team and Stakeholder Oversight Committee.

System-Level Recommendations

Western Boulevard serves as both a gateway to downtown Raleigh and the central spine of North Carolina State University. As such, the corridor experiences high volumes of traffic moving east/west channeling vehicles from Interstate 40 and points west of the City; as well as movement north/south pulling vehicles, pedestrians, and cyclists toward the urban center and into Main and Centennial Campuses.

Major populations of students and employees live along this spine, crossing Western Boulevard during peak commute hours. A labor force of over 8,000 and student population rising beyond 31,000 move in and around this corridor.

Since Western Boulevard is an integral component of the arterial system entering and exiting the urban core, it is unlikely to experience a decrease in traffic volume in the near- or long-term future. According to the 2011 Annual Average Daily Traffic Report, 35,000 vehicles pass through the study area daily. It appears vehicular movement along Western Boulevard will continue to grow. The number of lanes, character of the street, traffic volume, and street composition of Western Boulevard fit into the NCDOT Complete Streets Typology of Parkway. Speed and volume of traffic dictate needed amenities including pedestrian refuges, high visibility crosswalks, pedestrian countdown signals, bicycle facilities, and vegetation.

The NCDOT Complete Streets Planning and Design Guidelines defines the Parkway cross-section as having the following key characteristics.

Access and Function

- Most often functions as an arterial designed with control of access to carry vehicles at moderate to high speeds
- Land uses are set back from the street and are typically not oriented toward the parkway
- Convenient access to off-street transit stations, stops, and park-and-ride lots
- Design for the safety of all users, even though motor vehicle level of service is emphasized
- Tractor-trailer and semitrailer truck traffic is frequently present.
- Pedestrian and bicycle traffic usually provided for on separate multi-use paths ideally located adjacent to the facility

Bicycle and Pedestrian Provisions

While it is recommended to carry bicycle circulation via sidepaths or other parallel roadways, eventually, cyclists and pedestrians will cross these types of streets. Complete Streets policy and guidelines call for appropriate safety measures and treatments for crossing Parkways. Key elements include:

- Urban or rural thoroughfare often characterized by landscaping or natural vegetation along roadsides and medians.
- A refuge island within the pedestrian crossing (median and right lane channelization);
- Include multiple refuge islands if the street is seven-plus lanes wide. The location for multiple refuge islands will depend on the turn lane configuration, volumes, intersection geometry, etc. The intent is to ensure that pedestrians cross no more than five lanes and/or 50 feet without providing a refuge island to break up the crossing distance;
- Include high visibility crosswalks at locations where multi-use (shared use) paths cross through the intersection or where sidewalks on the intersecting street will connect destination land uses on either side of the parkway; and
- Do not typically allow bicycle lanes because bicycle and pedestrian traffic is typically supported by a separate multi-use (shared use) path, ideally located adjacent to the roadway, as is the case along almost all of Western Boulevard in the study corridor.

1

Gorman Street: North and South of Western Blvd

Gorman Street provides an important connection from Meredith College to NC State. This corridor also links Reedy Creek Greenway and House Creek Greenway to Rocky Branch along Western Boulevard. The existing curb-to-curb dimensions accommodate a buffered bike lane completing a safe, separated connection for greenway users and cyclists traveling from Hillsborough Street to NC State, retailers on Western Boulevard, and residences along Gorman Street. Buffered bike lanes are conventional bicycle lanes paired with a designated buffer space separating the bicycle lane from the adjacent motor vehicle travel lane and/or parking lane, allowing for a safer and more comfortable ride for more types of bicyclists. A buffered bike lane is allowed as per MUTCD guidelines for buffered preferential lanes (NACTO). Additionally, gaps in the sidewalk should be completed on both sides with crosswalk treatments at driveways.

- Recommended treatment: Complete gaps in sidewalk
- Recommended Treatment: Buffered Bike Lane

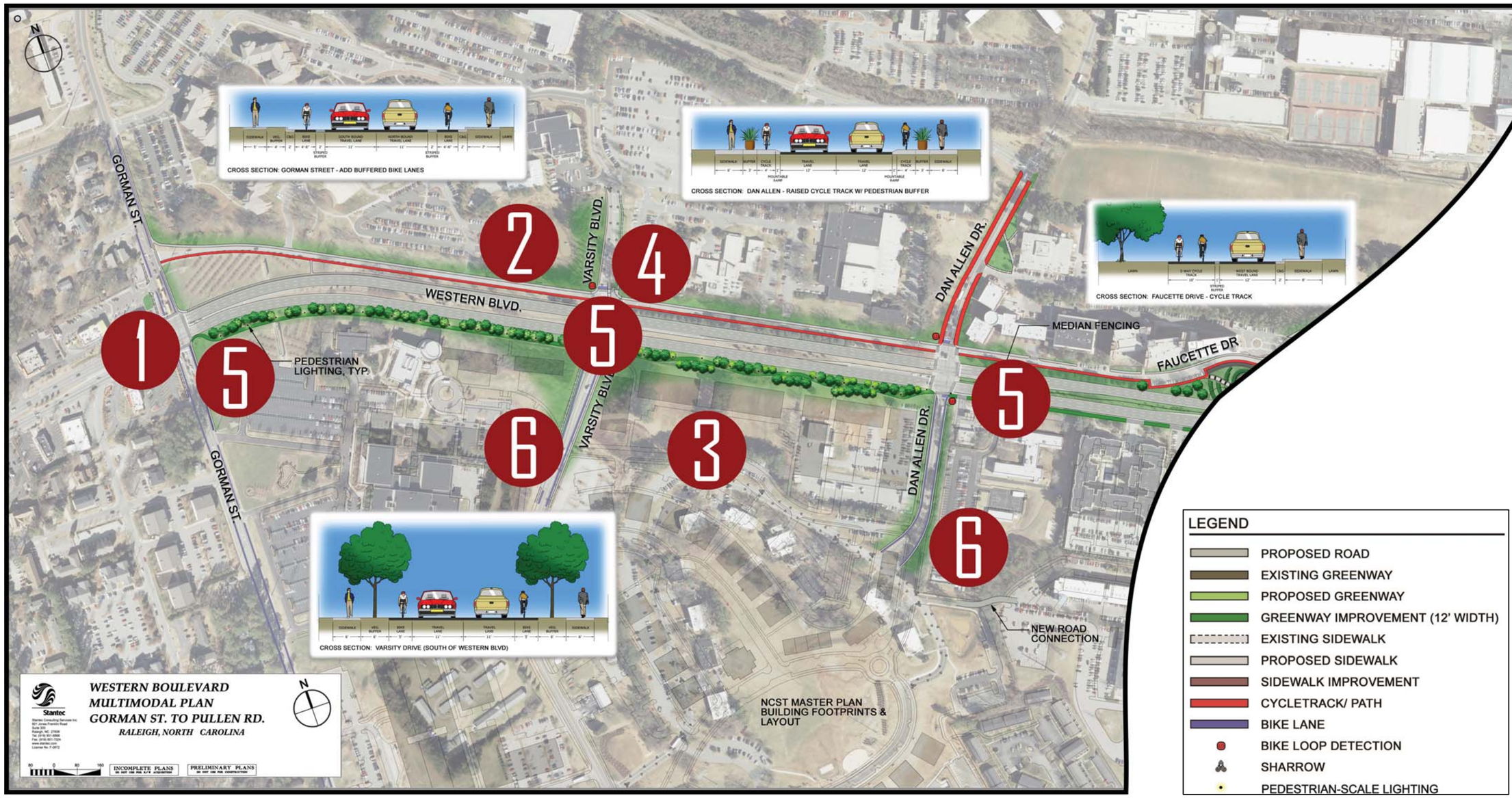


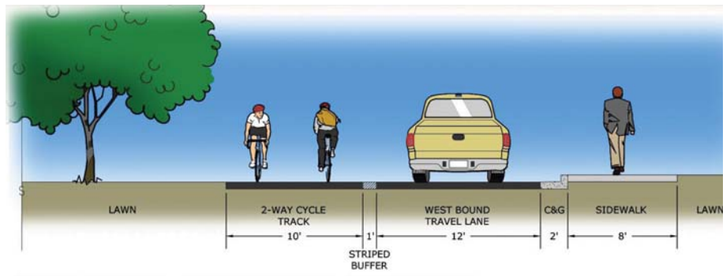
Figure 3. Location of Recommendations

Figure 4. Location of Recommendations (continued)

2 Faucette Drive

Faucette Drive is a one-way road (westbound) with parallel parking along the southern Magnolia tree-line. Cyclists are often observed traveling against traffic as this east/west connection is perceivably safer and more convenient than biking on or along Western Boulevard; in fact, the only fatality in the corridor was due to a cyclist traveling in the wrong direction on Faucette Drive. To create safe connections for pedestrians, gaps in the sidewalk should be completed. Brick is recommended to match the character of other campus sidewalks. Since Faucette is relatively level with low traffic volumes, it is a natural candidate for a two-way cycle track. This will provide separation from vehicles and cyclists and provide controlled, signalized crossings at Varsity Drive and Dan Allen Drive. Two-way cycle tracks are physically separated cycle tracks that allow bicycle movement in both directions on one side of the road. Two-way cycle tracks share some of the same design characteristics as one-way tracks, but may require additional considerations at driveway and side-street crossings (NACTO). Most, if not all, of the on-street parking along Faucette will be lost particularly east of Dan Allen Drive. The current transit stop at the west end is well-lit but needs a shelter and, preferably, bicycle parking.

- Recommended Treatment: Complete Gaps in Sidewalk
- Recommended Treatment: Improve Transit Stop at West End
- Recommended Treatment: Two-Way Cycle Track



3 Western Boulevard: South Side

A greenway exists along the south side of Western Boulevard; however, the path is too narrow, in need of repair, and experiencing overgrowth along the shoulders. This greenway (or sidepath) should be resurfaced and widened to a minimum width of 12 feet to accommodate cyclists and pedestrians. A vegetated buffer should separate this path from vehicular traffic varying from 10 feet to 30 feet between Varsity Drive and Dan Allen Drive. Lighting and emergency call boxes will improve safety in this campus environment. When possible, driveways should be consolidated; all driveways should be marked with crosswalks. To accommodate pedestrians and cyclists using transit, the bus stop between Dan Allen Drive and Avent Ferry Road should be improved to include a shelter and seating. Further studies will be needed to design the greenway alignment and slopes - which need to be ADA accessible as a component of campus circulation. Existing sidewalks should be widened, re-graded, and resurfaced to create a continuous greenway. On streets where physical separation of bicycle traffic from motoring traffic is appropriate (such as on very low-access, high-speed facilities like parkways and potentially some rural roads), multi-use paths should be considered in concurrence with NC projects identified in NC State *Bike and Pedestrian Master Plan*. Multi-use paths are paved pathways that accommodate both cyclists and pedestrians.

- Recommended Treatment: Resurface and Widen Greenway/Sidepath
- Recommended Treatment: Create Safe Campus Route with lighting, Emergency Lights, and ADA Accessibility
- Recommended Treatment: Improve Existing Transit Stop with Shelter and Seating Provisions
- Recommended Treatment: Conduct streetscaping and safety study along Avent Ferry Road, in part to determine optimum location and design for a possible mid-block pedestrian crossing south of Western Boulevard and north of Centennial Parkway.

4 Varsity Drive: North of Western Blvd

Varsity Drive narrows as it enters campus and cannot accommodate separated bicycle facilities. With no direct through route for vehicular traffic to Hillsborough Street, this segment of Varsity Drive is a candidate for sharrows also known as shared lane markings. Shared lane markings provide an alternative to bicycle lanes on streets where bicycle lanes cannot be accommodated. Sharrows indicate a shared-use lane for motorists and cyclists that provide a warning for the former and guidance on the proper travel "line" for the latter.

- Recommended Treatment: Sharrows

5 Intersection Treatments: Gorman Street, Varsity Drive and Dan Allen Drive

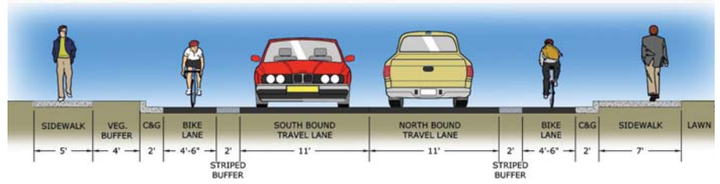
In addition to these pedestrian facilities, on-road bike facilities should also be provided. Campus environments experience high influxes of new drivers and cyclists to the area. Providing clear, marked separation and guidance for each mode increases safety for all. To brand the area, red bike lanes can be used at conflict points, including through bike lanes (motorists crossing bike lanes), driveway crossings, and intersections.

If solid red bicycle lanes are not used to channel cyclists across intersections, striping should be placed on the roadway to direct cyclists to the facility across the intersection. This will provide confidence and separation for cyclists crossing wide intersections.

It is also recommended to use bike boxes at each intersection, with the exception of Varsity Drive to the north of Western Blvd. These boxes will allow cyclists to queue in front of lead cars, increasing their visibility. This will also prevent right turns on red – which is recommended, as sightlines for cars are poor along this corridor. Bicycle detection should be implemented (as loop detectors or video/sensor) to allow cyclists to influence the traffic signals – particularly on Dan Allen Drive during the time period when there is restricted access to vehicular traffic.

Each of these intersections, as noted above, should include:

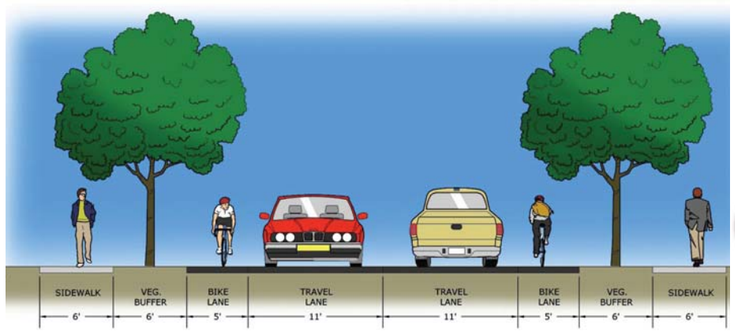
- High-Visibility Crosswalks
- Red pavement markings at conflict points/intersection approaches
- Pedestrian Countdown Signals
- Pedestrian detectors



6 Varsity Drive/Dan Allen Drive: South of Western Blvd

South of Western Blvd., Varsity Drive and Dan Allen Drive lead into Greek Village as well as a district of residences populated with college students. Continuous sidewalks and bike lanes should be added to accommodate the safe circulation of pedestrians. Dedicated bicycle lanes are the preferred option to provide for the greatest variety of cyclists on streets. Bicycle lanes are the backbone of a complete bicycle network, as they visually distinguish a bicycle-only travel lane in which a cyclist does not have to maneuver around motor vehicles and vice versa.

- Recommended Treatment: Bicycle Lanes



7 Pullen Road: North of Western Blvd

Pullen Road is currently marked with sharrows. These sharrows should remain, and be maintained, as cyclist traffic will increase when the Pullen Road extension is built. A sidewalk should be installed on the west side of Pullen Road – a "path of priority" is already worn in the grass beyond the curb. Many pedestrians use this route to travel to Centennial Campus. A curb bulbout or reduction of radius on the westbound Western Boulevard ramp will help slow traffic. Vegetation near this ramp needs to be trimmed and maintained to provide sightlines for pedestrians and motorists. High-visibility crosswalks are recommended at this ramp as well. A wide curb radius now enables high-speed turning movements by motorists, which can result in increased crashes with pedestrians and more serious outcomes when crashes occur. Reconstructing the vehicular turning radius to require a slower turn will reduce turning speeds, shorten the crossing distance for pedestrians, and also improve sight distance between pedestrians and motorists.

- Recommended Treatment: Maintain sharrows
- Recommended Treatment: Add sidewalk
- Recommended Treatment: Trim vegetation
- Recommended Treatment: Add bulb out (Curb radius reduction) and install high visibility crosswalk

8 Pullen Road Bridge

When the expansion plan for Pullen Road is designed, it should include raised sidewalks with a buffer zone for pedestrians and bike lanes for cyclists on the bridge. These sidewalks and bike lanes will continue along the extended road into Centennial Campus.

- Recommended Treatment: Raised sidewalks
- Recommended Treatment: Bike lanes
- Recommended Treatment: Pull ramps in closer to bridge when the structure is replaced

9 Pullen Road Extension / Roundabout

If the Pullen Road Extension is designed to include a roundabout, facilities should be provided for both pedestrians and cyclists. High visibility crosswalks with median islands should be located at each ingress and egress of the roundabout. Bike lanes can terminate at the circle giving cyclists an option to use a multi-use path, or remain in the flow of vehicular traffic.

- Recommended Treatment: Crossing Provisions at Roundabout
- Recommended Treatment: Adjacent Multi-Use Sidepath

Design guidance (from the National Association of City Transportation Officials *Urban Bikeway Design Guide*) on both bicycle lanes and cycle tracks are shown on the following pages (Figures 4 and 5. Design Guidance).

10 Bilyeu Street / Ashe Avenue

Although technically to the east of the study area, this section is relevant both to the Western Boulevard Corridor and to the residents of the Pullen/Bilyeu/Kirby community. A public workshop dedicated to their concerns was conducted on August 28, 2013 at the DesignBox center on Martin Street in downtown Raleigh. Approximately 12 residents were in attendance, and provided comments concerning through traffic volumes and speeds on Bilyeu Street; safety of turning movements on Western Boulevard at both Ashe Avenue and Bilyeu Street; and traffic circulation patterns related to the Pullen Road Extension as shown on the recommendations map. The following recommendations are related to that input and the original recommendations provided by the consulting team.

- Recommended Treatment: Closure of Bilyeu Street at Western Boulevard in conjunction with the Pullen Road Extension
- Recommended Treatment: Re-design of Ashe Avenue entrances from/to Western Boulevard
- Recommended Treatment: Relocate transit stop on Western Boulevard near Bilyeu Street to a location on the far side of the proposed Western Boulevard eastbound entrance ramp
- Recommended Treatment: Apply for traffic calming measures to the City of Raleigh on Bilyeu Street to slow construction-related traffic prior to the closure of Bilyeu Street at Western Boulevard.

Design Guidance

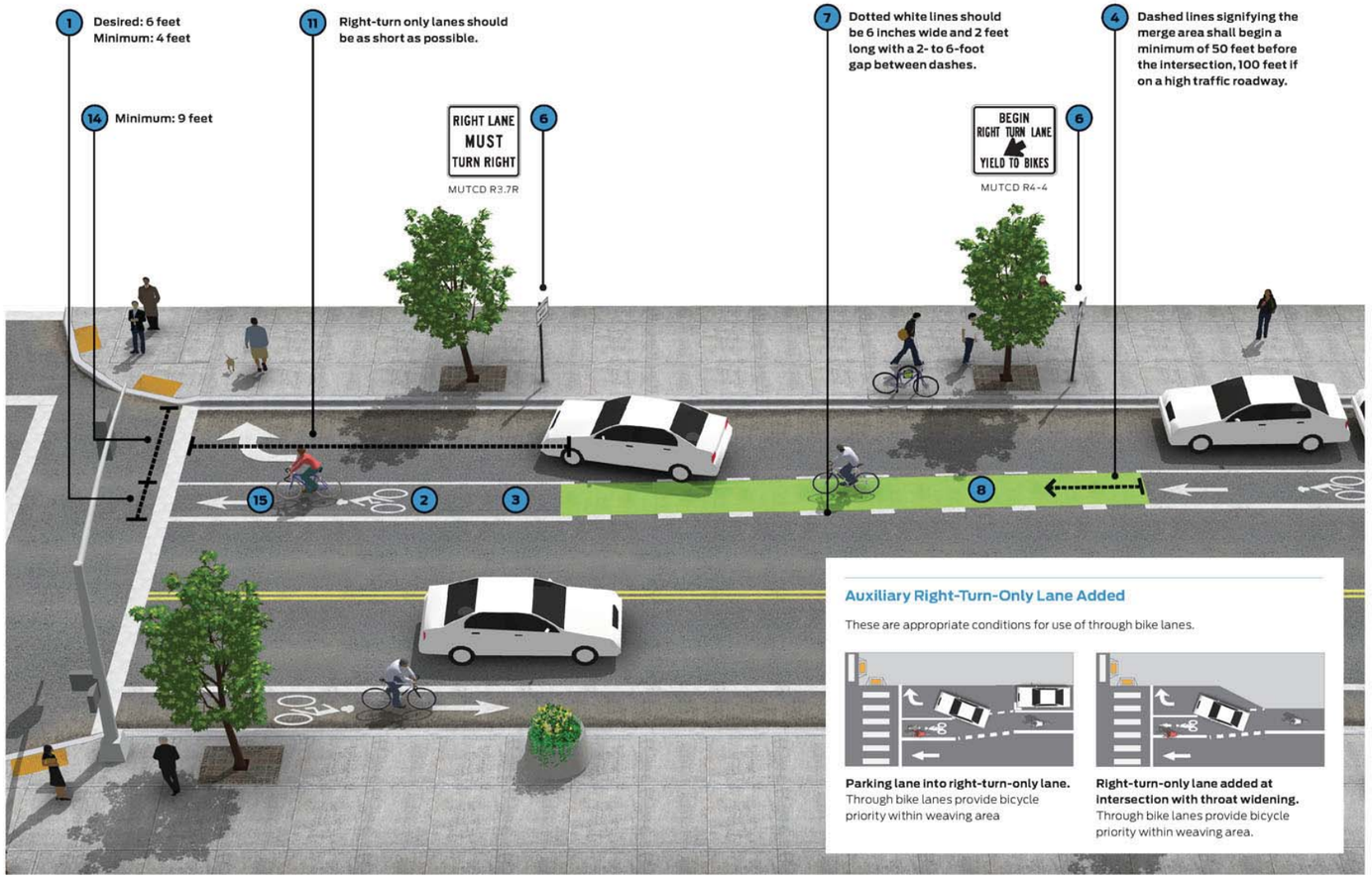
Through Bike Lanes

Required Features

1. The desired width of a dashed bike transition lane and through bike lane is 6 feet with a minimum width of 4 feet.
2. Bicycle lane word and/or symbol and arrow markings (MUTCD Figure 9C-3) shall be used to define the bike lane and designate that portion of the street for preferential use by bicyclists.
3. The through bike lane shall be placed to the left of the right-turn only lane.
4. Dotted lines signifying the merge area shall begin a minimum of 50 feet before the intersection (MUTCD). Dotted lines should begin 100 feet before the intersection if along a high speed/volume roadway.
5. Dotted lane line transition areas to through bike lanes shall not be used on streets with double right turn lanes. Double right turn lanes are extremely difficult for bicyclists to negotiate. Shared lane markings may be used in the center of the inside turn lane to designate the preferred path of through bicycle travel.

Recommended Features

6. Accompanying signage should include R3-7R "Right Lane Must Turn Right" and R4-4 "Begin Right Turn Yield to Bikes" (MUTCD).
7. Dotted white lines should be 6 inches wide and 2 feet long with a 2- to 6-foot gap between dashes (MUTCD).
8. Through bike lanes should be provided at any intersection approach where a right turn only auxiliary lane is created (also known as a right turn add lane). It is desirable for bicyclists to travel straight through the merging area to reinforce right-of-way.
9. Dotted lane line transition areas to through bike lanes should not be provided at any intersection approach where a through travel lane transitions into a right turn only lane (also known as a right turn drop or trap lane). In such instances consider utilizing an exclusive bicycle signal phase with the bike lane remaining to the right, or not delineating the merging area connecting to the through bicycle lane. Shared lane markings may be used to provide additional guidance.
10. At intersections with high right turning vehicle volumes, high bicyclist volumes, or along priority bicycle corridors, treatments beyond dotted white lines such as coloring and increased signing should be provided.
11. Right-turn only lanes should be as short as possible in order to limit the speed of cars in the right turn lane. Fast moving traffic on both sides can be uncomfortable for bicyclists.



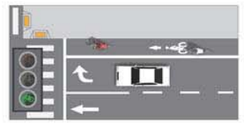
12. Terminating the bike lane in advance of the intersection is discouraged.
13. For intersections that lack the physical width to install a bicycle pocket, a combined bike/turn lane should be used.
14. Vehicle turn lane width should not be reduced to less than 9 feet.
15. Bicycle detection should be provided within the through bike lane.

Optional Features

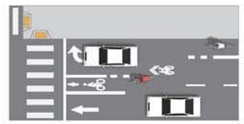
16. On streets with a combined turn and through lane, shared lane markings may be used in the center of the lane.
17. A bike box may be used in lieu of a designated through bike lane.
18. Bicycle warning signs may be used in advance of the merge/transition area.

Through Travel Lane Transitions into Right-Turn-Only Lane

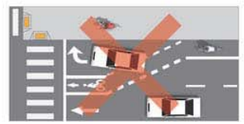
These are generally inappropriate conditions for use of through bike lanes. Consider alternate treatments.



Exclusive bicycle signal phase used to separate conflicting movements.



Bicycle lane dropped in advance of the intersection encourages bicyclists to merge across as gaps permit. Shared lane markings may be used to provide additional guidance.



Bicyclists are not provided priority in weaving area and must use caution to merge across potentially high-speed motor vehicle traffic. Dotted lane line transition areas to through bike lanes should not be provided at these locations.

Figure 5. Design Guidance: Bicycle Lanes (NACTO)

Design Guidance

Rasied Cycle Tracks

Required Features

(1) The cycle track shall be vertically separated from the street at an intermediate or sidewalk level.

(2) Bicycle lane word, symbol, and/or arrow markings (MUTCD Figure 9C-3) shall be placed at the beginning of a cycle track and at periodic intervals along the facility based on engineering judgment.

(3) A raised cycle track shall be protected from the adjacent motor vehicle travel lane. Protection strategies may include a raised or mountable curb, street furnishings, low vegetation or a parking lane.

(4) If used, the mountable curb should have 4:1 slope edge without any seams or lips to interfere with bike tires to allow for safe entry and exit of the roadway. This curb should not be considered a ridable surface when determining cycle track width.[31]

Recommended Features

(5) Desirable one-way raised cycle track travel surface width is 6.5 feet to allow side-by-side riding or passing. Desired minimum width is 5 feet at intersections and pinch points. Additional width may be needed for protection from traffic or parking and/or shy distance to sidewalks or furnishings.[32]

(6) When configured next to a parking lane, 3 feet is the minimum desired width for a parking buffer to allow for passenger loading and to prevent dooring collisions. The buffer can be at street level or at the level of the cycle track.[33]

(7) When configured next to a motor vehicle travel lane, the desired minimum width of a mountable curb is 1 foot, depending on elevation. Raised curbs may require additional width for added shy distance from the curb edge. Raised curb buffer minimum width should be increased to 3 feet or greater when buffer space is used to locate lamp posts, bollards, street furniture, low vegetation, and/or trees.[34]

(8) Vertical separation between the roadway and the cycle track should be between 1 and 6 inches. Higher separation values discourage illegal parking.

(9) Vertical separation between the cycle track and the sidewalk should be between zero (flush with the sidewalk surface) and 5 inches. A separation of 3 inches or greater discourages conflicts with pedestrians.

(10) If curb or median separated, careful consideration should be given to the curb design. Curbs of 6 inches can be hazards to bicyclists by interfering with the space needed for pedaling, but can be more effective deterrents to illegal parking or loading. Consider the use of alternative bicycle-friendly curb profiles where possible.[35]

(11) Supplemental shy distance striping should be added at the entrance to curb protected cycle tracks to encourage bicyclists to keep their distance.

(12) Driveways and minor street crossings are a unique challenge to cycle track design. A review of existing facilities and design practice has shown that the following guidance may improve safety at crossings of driveways and minor intersections:

- If the cycle track is parking protected, parking should be prohibited near the intersection to improve visibility. The desirable no-parking area is 30 feet from each side of the crossing.[36]
- For motor vehicles attempting to cross the cycle track from the side street or driveway, street and sidewalk furnishings and/or other features should accommodate a sight triangle of 20 feet to the cycle track from minor street crossings, and 10 feet from driveway crossings.
- Color, yield lines, 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.[37]
- Motor vehicle traffic crossing the cycle track should be constrained or channelized to make turns at sharp angles to reduce travel speed prior to the crossing.
- The crossing should be raised, in which the sidewalk and cycle track maintain their elevation through the crossing. Sharp inclines on either side from road to sidewalk level serve as a speed hump for motor vehicles.[38]
- If configured at a height flush with the sidewalk, color, pavement markings, textured surfaces, landscaping, or other furnishings should be used to discourage pedestrian use of the cycle zone.

(13) Drainage should slope to the street. Drainage grates should be in adjacent travel or parking lane.

(14) Two-stage turn boxes should be provided to assist in making turns from the cycle track facility.

Optional Features

(15) Cycle tracks may be shifted more closely to the travel lanes on minor intersection approaches to put bicyclists clearly in the field of view of motorists.[39]

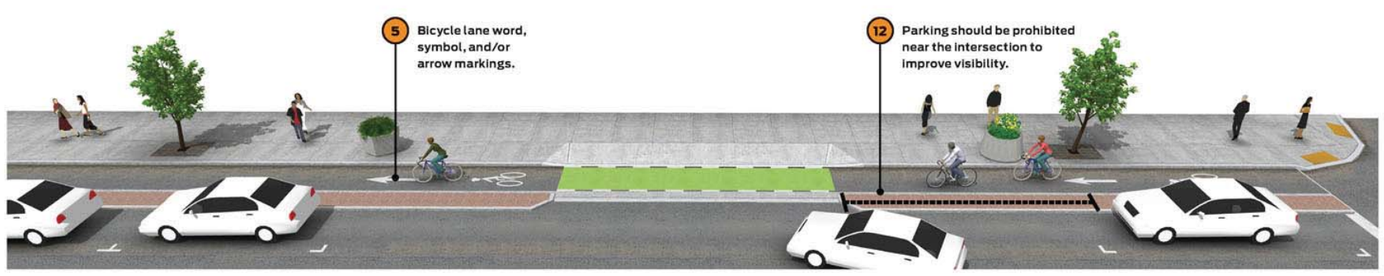
(16) When placed adjacent to a travel lane, one-way raised cycle tracks may be configured with a mountable curb to allow entry and exit from the bicycle lane for passing other bicyclists or to access vehicular turn lanes. This configuration has also been known as a "raised bike lane."

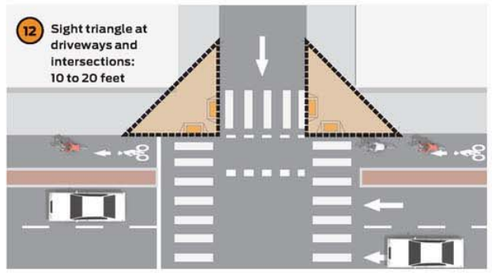
(17) If the cycle track is not already at sidewalk level, consider raising the cycle track to sidewalk level and wrapping the cycle track around the transit stop zone to reduce conflicts with transit vehicles at midblock or signal protected intersections. Bicyclists should yield to pedestrians in these areas.

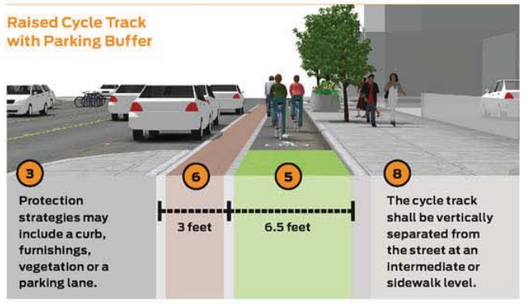
(18) Contra-flow bike lanes may be raised in a cycle track configuration to offer further physical protection for contra-flow riders.

(19) Cycle tracks may be configured on the left side of a one-way street to avoid conflicts at transit stops.

(20) Color may be used to contrast with the adjacent pedestrian area or to increase the visibility of the cycle track in conflict areas.







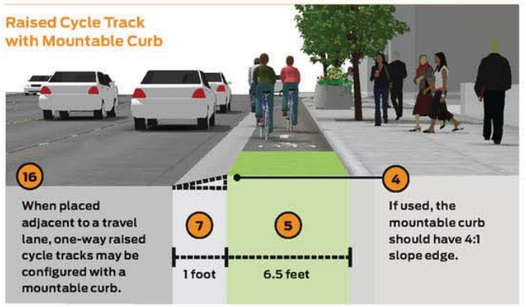


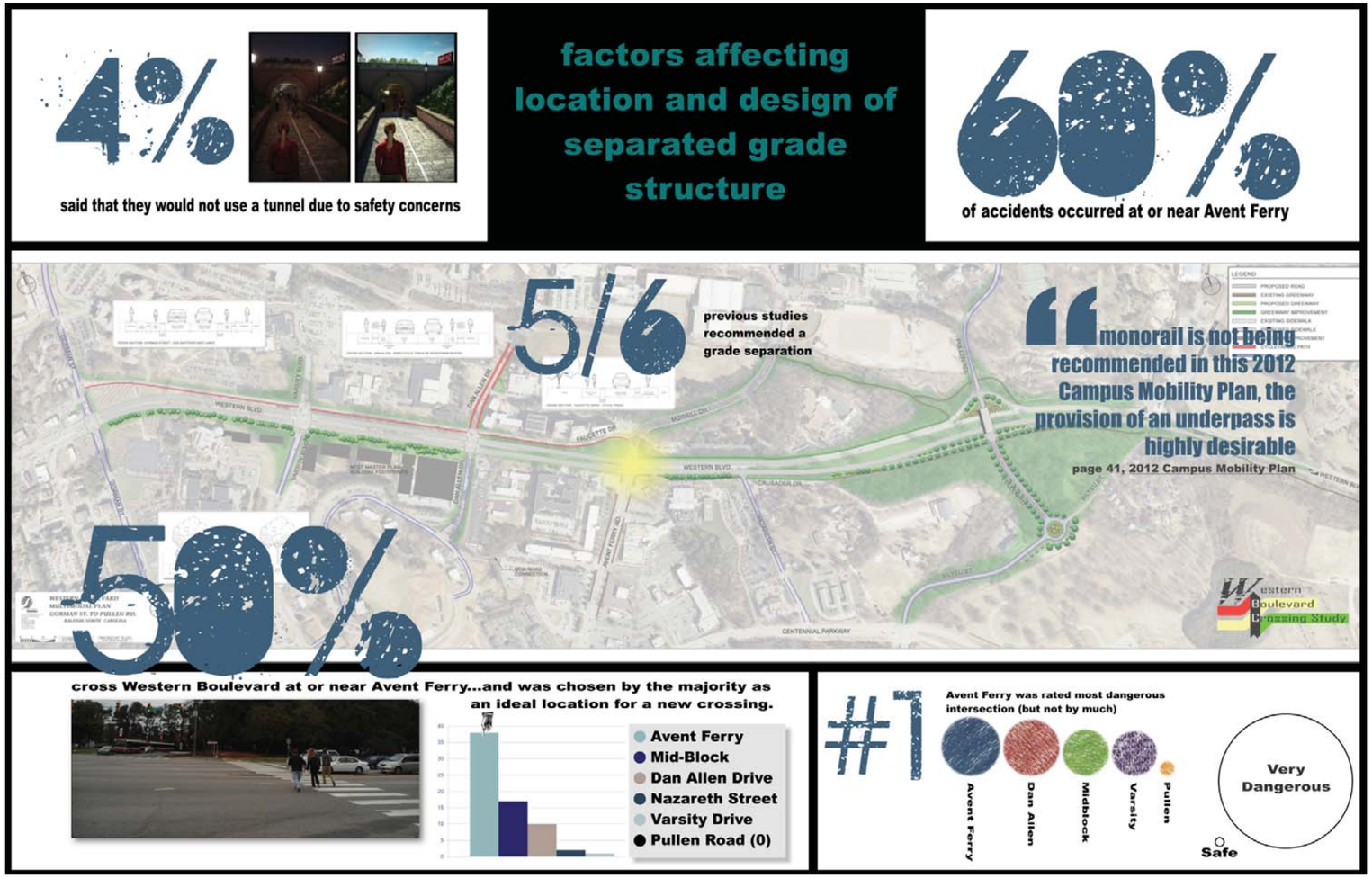
Figure 6. Design Guidance: Cycle Tracks (NACTO)

Grade Separation Recommendations

As mentioned previously, without a clear recommendation for a grade-separated solution for crossing Western Boulevard, the current study would have fallen far short of its intended purpose. From the outset bicycle, pedestrian, and perhaps transit movements over or under Western Boulevard were a core consideration. As time progressed and the initial options emerged, a full interchange option was also considered and analyzed since the costs of a bike/pedestrian/transit tunnel was approaching 50% of what a full interchange might cost. When considering any option, the initial challenge was to define exactly where to place the structure. Field observations and communication with students and faculty provided the answer: the grade separation had to be near the Avent Ferry/Morrill intersection, and preferably on the west side since that was the location where many students were crossing mid-block now. The graphic at right illustrates the main considerations for tunnel as opposed to bridge options (the time required to move vertically with a bridge was deemed too long, and the grades of the roadway indicated an underground solution was preferable) as well as the main factors driving the location decision.

Once the location and basic structure type was determined, other assumptions were put into place to refine the assessment process. These assumptions included the following key points:

- Pullen Road will be extended to Centennial Parkway. This project at the east end of the corridor will divert some portion of traffic away from the key Avent Ferry/Morrill Drive intersection with Western Boulevard, and will also play a key role in providing transit service to the growing Centennial Campus.
- Eventually, Western Boulevard will have a third through travel lane in the eastbound (toward Raleigh) direction. This additional capacity will help address some of the congestion issues and improve the timing of the Avent Ferry-Morrill Drive/Western Boulevard intersection, but create a slightly longer pedestrian/cyclist crossing.
- The Avent Ferry corridor will continue to have a strong demand for public transportation service. The current, adopted transit plan for NCSU suggests that headways (the amount of time between transit vehicles at any particular point along a route) will be less than five minutes, or 12 buses in an hour. However, this degree of service did not fully contemplate the impact of the improved routing potential offered by the Pullen Road extension.



- Students will use a tunnel option, if it is convenient. Our survey work indicated this statement to be true, although a small number of students said that personal security would be a concern. Our plan is to maintain a surface crossing option for those students and others, although not necessarily to make the surface crossing short enough to traverse within one signal phase. By creating a median barrier west of Avent Ferry Road and adjusting the signal timing to create a two-stage crossing north-south, traffic flow is improved for automobiles while encouraging safer crossing at the Avent Ferry Road intersection (as opposed to mid-block).
- Any transit tunnel option should accommodate a 40' passenger bus like those used by Wolfline, and any other, future vehicle type would need to fall inside the operational "envelope" suggested by those dimensions.

On the next page are brief descriptions of the three main options considered for the Western Boulevard separated-grade crossing.

Option 1: Bicycle and Pedestrian Tunnel

The construction of Option 1 would require significant excavation efforts and phased lane shifts and restrictions during construction. Traffic would remain operable along Western with reduced capacity during tunnel excavation, albeit at a reduced capacity on Western Boulevard for weeks at a time. The depth of this tunnel excavation is 12 feet from the existing elevation of Western Boulevard.

1. The opinion of probable cost for this option was $5million.
2. Faucette Drive would remain a functioning roadway and ADA-compliant ramps would connect to a sidewalk on Faucette Drive.
3. The existing pedestrian crosswalks would remain for all movements at the at-grade intersection.
4. Cyclists would be able to flow through the tunnel separated from the pedestrians with direct tie into the Cycle Track on Faucette Drive and multi-modal path on Avent Ferry Road.
5. Right-of-Way impacts from this option would be minimal.
6. Transit vehicles would continue to use the at-grade intersection of Avent Ferry/Morrill Drive to cross Western Boulevard, although some time savings for all motorized traffic may be realized by adjusting the signal timing to reflect the reduced pedestrian/cyclist crossings at grade level.

Option 2: Bicycle, Pedestrian and Transit Tunnel

Option 2 requires both widening and deepening the tunnel crossing under Western Boulevard to 17 feet to allow small, people-mover vehicles initially (phase 1; these vehicles were ultimately not deemed to be compatible with future transit services), and accommodating full-size buses later (phase 2) with the addition of grading, retaining walls and traffic control. Construction-era traffic disruptions are more substantial than Option 1 due to a likely longer period of construction and more work required on Morrill Drive, particularly during the second phase of work. The evaluation of this option considered both phases of work.

1. The opinion of probable cost for this option was estimated to be $9million for both phases of work.
2. The bulleted assumptions from two to five listed in Option 1 hold true for this Option as well, although minor ROW impacts to NCSU property on Morrill Drive are likely in the second phase if/when it is undertaken.
3. Only one-way bus traffic would be permitted in the second phase of this Option, southbound from Morrill Drive using a dedicated bus lane and slip ramp, then rejoining Avent Ferry Road traffic after crossing through the tunnel.
4. One substantial impact resulting from this Option in phase 2 only is the closure of Faucette Drive to achieve the grades necessary to accommodate a bus lane that bypasses the traffic queue at Morrill Drive/Western Boulevard.
5. One intangible advantage for this Option is that the larger tunnel preserves future options for other transit vehicles and technologies.

Option 3: Full Interchange

This Option represents a significant departure from the first two in that it would require “lowering” Avent Ferry/Morrill Drive to go under Western Boulevard. A compressed diamond interchange design would allow all motorized traffic to ingress and egress to minimize turning movement conflicts, thus substantially improving the performance of automobile traffic.

1. The cost for this Option cannot be known without design work, but similar interchanges in urban areas suggest that the cost would be approximately $19million, including right-of-way acquisition that would impact businesses on the southwest and southeast (Mission Valley) corners of the Avent Ferry/Western Boulevard intersection.
2. The level of traffic disruption would be more severe, with more lane closures required on Western Boulevard, perhaps as long as eight months.
3. Pedestrian and cyclist safety would have to be addressed at both crossings where traffic is exiting the main traffic stream on Western Boulevard.
4. Although a “double-teardrop” interchange was preferred going into the assessment of this option, the traffic analyses did not support its ability to handle the volumes of left turns from westbound Western Boulevard and northbound Avent Ferry Road. Hence, a compressed diamond interchange was recommended, which would move the level-of-service at this intersection in 2040 from an “E” to a “C.”

Evaluation of Grade-Separation Options

Two rounds of evaluation were conducted to assess the feasibility and performance of the three options described previously. The first evaluation was qualitative, with several members of the staff and Core Technical Team evaluating the three options in a ranking system using factors of cost, right-of-way impacts, traffic control during construction, and benefits to different modal users (see Figure 6: Qualitative Evaluation). The results indicated a preference for one of the first two options, although this assessment was based on relatively few data points. The second public workshop, conducted on April 18, 2013, also identified the first two options as being much more preferred compared to Option 3. Commentary on Option 3 from members of the CTT representing NCSU and the City of Raleigh indicated a lack of support for a full interchange due to the footprint/ROW impacts; aesthetic impacts; and concerns related to safe pedestrian and bicycle crossing movements. It is the top priority of NCSU to promote the safest and quickest way to move both pedestrians and bicycle traffic through this intersection; Option #1 meets that goal.

The second evaluation was targeted at describing the performance of the third option using travel time delay, construction costs, and crash reduction, among other factors (refer to Appendix B for the full technical memorandum on this assessment method). The results of the B/C assessment are shown in Figure 7 (Benefit/Cost Assessment). Option 3 provides a much shorter payback period (the amount of time it takes for the monetary value of the benefits to "catch up" to the monetary valuation of the costs) and a higher B/C value for the suggested 20-year lifespan of the project. However, these benefits depend heavily on the value of time to the many travelers (over 58,000) that would move through the intersection by car in the design year of 2040; if this value and factor were not present, the three options would be about the same in terms of their assessed overall benefits.

Option 1								Option 2								Option 3							
Cost	ROW	Traffic Control	Auto	Transit	Pedestrian	Cyclist	Summation	Cost	ROW	Traffic Control	Auto	Transit	Pedestrian	Cyclist	Summation	Cost	ROW	Traffic Control	Auto	Transit	Pedestrian	Cyclist	Summation
1			2		1	1	5	2			2	1	1	1	7	3			1				4
1	1	1	3	3	1	1	11	2	2	2	2	2	2	2	14	3	3	3	1	1	3	3	17
1	1	1	3	3	1	1	11	2	1	2	2	2	1	1	11	3	3	3	1	1	2	3	16
1	1	1	3	3	1	2	12	2	2	2	1	2	2	2	13	3	3	3	1	1	3	3	17
1	1	1	2	2	2	2	11	2	2	2	1	1	1	1	10	3	3	3	3	3	3	3	21

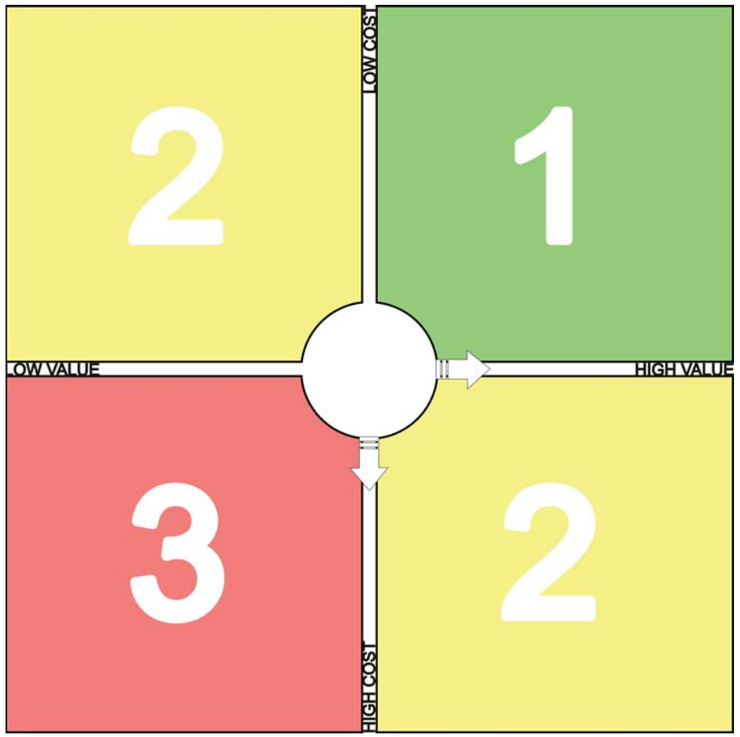
Figure 6. Qualitative Evaluation

	Cost or Benefit Element	Option 1	Option 2	Option 3
COST	Estimate of Probable Construction Cost	$5,000,000	$9,000,000	$18,000,000
	Traffic Control (Ease of Construction)	$21,904,918	$32,470,820	$25,770,492
	Right-of-way Impacts(1)	$0	$260,000	$350,000
BENEFIT	Person Level of Service Benefit/Year	$158,832	$158,832	$7,035,344
	Transit Rider Benefit/Year	$0	$201,600	$302,400
	Pedestrian Crash Benefit/Year	$58,968	$58,968	$25,272
	Cyclist Crash Benefit/Year	$9,828	$9,828	$4,212
	20-Year B/C Ratio	0.17	0.21	3.34
	Payback Period (Construction ONLY; Years)	22.0	21.0	2.4

Figure 7. Benefit/Cost Assessment

Project Costs and Priorities

The discussion of specific priorities relates strongly to cost feasibility and the utility of any improvement based on the proximate value to individual safety, transportation service, and input from our public and steering committees. The projects listed at right (Figure 8; see also location map in Figure 9 on the following page) are a summary of these primary recommendations evaluated according to a tiering strategy represented by the graphic below, where value is placed on one axis and cost (including disruption to traffic) is placed on the other axis. The total cost of all improvements, excluding the pedestrian/bicycle tunnel, is estimated at $1.825million (2013 dollars). Completing all of the Tier 1 as a package of improvements would carry an estimated cost of approximately $258,000.



ID No.	Description	Estimate of Probable Cost (2013 $)	Tier (1 –3)
1	Gorman Street: Complete Gaps in Sidewalk	$53,000	1
2	Gorman Street: Buffered Bicycle Lane	$23,000	1
3	Faucette Drive: Improve Transit Stop at west end (Shelter/Bicycle Rack)	$12,500	1
4	Faucette Drive: Complete Gaps in Sidewalk	$120,000	1
5	Faucette Drive: Create Two-Way Cycle Track	$37,000	2
6	East of Gorman/Southside: Resurface and Widen Greenway/Sidepath	$675,000	2
7	East of Gorman/Southside: Pedestrian-Scale Lighting	$105,000	3
8	Varsity Drive/Northside: Sharrows	$600	1
9*	Various Intersections: High Visibility Crosswalks	$3,600	1
10*	Various Intersections: Red pavement markings at conflict points / intersection approaches	$2,000	1
11	Varsity Drive/Southside: Bicycle Lane	$75,000	2
12	East of Dan Allen/Southside: Improve Transit Stop (Bench/Shelter)	$13,000	3
13	Dan Allen to Avent Ferry: Install Median Fencing / Replace Landscaping	$30,000	1
14	Avent Ferry/Southside: Mid-Block Crossing	$13,000	2
15	Avent Ferry: Pork Chop Island / Turn Lane Rerouting	$5,000	1
16	Avent Ferry: Textured/High Visibility Crosswalks	$8,000	1
17	East of Crusader Drive/Southside: Pedestrian-Scale Lighting	$67,500	3
18	Pullen Road: Bulb-Out Extension	$20,000	2
19	Pullen Road Bridge: Sidewalks and Bicycle Lanes	$64,000	3
20	Pullen Road Extension / Roundabout: Adjacent Sidepath	$470,000	3
21	Closure of Bilyeu Street at Western Boulevard; Re-Design of Ashe Avenue access	$35,000	3
22	Avent Ferry/Morrill Drive: Bicycle and Pedestrian Tunnel Under Western Boulevard	$5million	2

Figure 8. Estimates of Probable Costs

**Not Labeled on Map on Following Page*

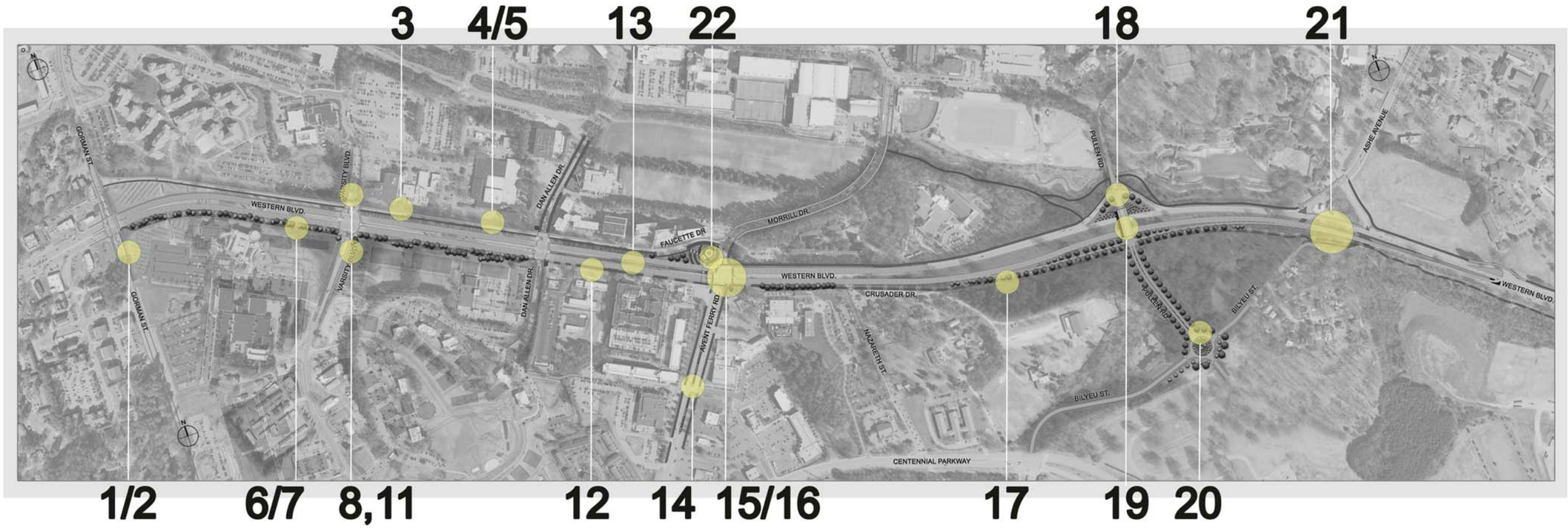


Figure 9. Location of Recommendations in Western Boulevard Corridor

1	Gorman Street: Complete Gaps in Sidewalk
2	Gorman Street: Buffered Bicycle Lane
3	Faucette Drive: Improve Transit Stop (Shelter/Bicycle Rack)
4	Faucette Drive: Complete Gaps in Sidewalk
5	Faucette Drive: Create Two-Way Cycle Track
6	East of Gorman/Southside: Resurface and Widen Greenway/Sidepath
7	East of Gorman/Southside: Pedestrian-Scale Lighting
8	Varsity Drive/Northside: Sharrows
9*	Various Intersections: High Visibility Crosswalks
10*	Various Intersections: Red pavement markings at conflict points / intersection approaches
11	Varsity Drive/Southside: Bicycle Lane
12	East of Dan Allen/Southside: Improve Transit Stop (Bench/Shelter)
13	Dan Allen to Avent Ferry: Install Median Fencing / Replace Landscaping
14	Avent Ferry/Southside: Mid-Block Crossing
15	Avent Ferry: Pork Chop Island / Turn Lane Rerouting
16	Avent Ferry: Textured/High Visibility Crosswalks
17	East of Crusader Drive/Southside: Pedestrian-Scale Lighting
18	Pullen Road: Bulb-Out Extension
19	Pullen Road Bridge: Sidewalks and Bicycle Lanes
20	Pullen Road Extension / Roundabout: Adjacent Sidepath
21	Closure of Bilyeu Street at Western Boulevard; Re-Design of Ashe Avenue access
22	Avent Ferry/Morrill Drive: Bicycle and Pedestrian Tunnel Under Western Boulevard