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I-395 Shirlington Interchange Improvements Study

UPC: 107831; State Project #0395-100-842

City of Alexandria & Arlington County, Virginia

Submitted to:

VDOT

Submitted by:

WSP | RK&K

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EXECUTIVE SUMMARY

The I-395 Shirlington interchange (Figure E-1) is situated at the City of Alexandria and Arlington County boundary, and provides access from adjacent communities to I-395, as well as cross-jurisdictional access linking residential, office, commercial and light industrial land uses. To the east in Alexandria, Park Fairfax is an established, multi-family residential community. Beyond Park Fairfax (further eastward) lies the North Ridge section of Alexandria, which is predominately a single-family residential neighborhood. To the west of the interchange in Arlington is The Village at Shirlington, a contemporary mixed-use neighborhood, as well as older, established office, residential, and light industrial land uses.

The I-395 Shirlington interchange was designed and constructed as a rotary to link multiple local roadways, such as N. Quaker Lane, Gunston Road, S. Shirlington Road and Campbell Avenue, with the I-395 general purpose and Express lanes. With recent development at The Village at Shirlington and ever-increasing peak period traffic volumes on I-395, the interchange processes high volumes of traffic leading to a range of operational and safety challenges. The interchange area also handles bus, pedestrian, and bicycle movements, which must be safely accommodated.

Figure E-1. I-395 Shirlington Interchange

In the existing interchange, there are several required merge and weave areas over short distances that create difficult, unsafe situations. Field observations and crash analyses show abrupt lane changes, multi-lane weaving, and sudden braking. Operationally, during morning and evening peak periods, traffic entering I-395 backs up through the interchange and into the local road system. In the AM peak hour, backups occur

on the ramp from N. Quaker Lane entering northbound I-395; in the PM peak hour, backups occur on the ramp from S. Shirlington Road entering southbound I-395.

The study area is generally defined by the I-395 southbound (SB) ramp from Glebe Road (Route 120), and the ramps and adjacent intersections of the I-395 Shirlington interchange, including the pedestrian bridge. This project was initiated with the intent of studying the existing interchange and providing a set of smaller-scale recommendations to improve the system's safety and functionality.

The project included traffic data collection, review of existing systems and conditions, and development of interchange modifications to improve the interchange's operations. Preliminary improvements consisted of a comprehensive list of improvement alternatives to both the I-395 Shirlington interchange and the I-395 SB ramp from Glebe Road. The preliminary improvement alternatives were presented to the municipal stakeholders (Arlington County and the City of Alexandria). Based on their feedback, several alternatives were removed from consideration, and eight alternative concepts moved forward for more detailed evaluation. These were presented to the public in May 2018.

Considering stakeholder and public feedback (as well as traffic simulation modeling results), the improvement alternatives were combined into a Hybrid Alternative. Traffic simulation analyses had shown that individually the alternatives worsened traffic congestion in the interchange area; however, it was found that when multiple improvements were combined, the interchange's operations and safety improved.

The Hybrid Alternative, shown in Figure E-2, consists of the following improvements to the interchange:

- ✓ Signalized T-intersection with rotary and N. Quaker Lane
- ✓ Signalized intersection with I-395 SB off-ramp and Campbell Avenue
- ✓ Signalized intersection with I-395 NB off-ramp and Gunston Road
- ✓ Additional lane on Arlington Mill Drive exit from the rotary

The improvement alternatives for the Glebe Road interchange were determined to be ineffective in terms of relieving traffic congestion or improving safety. It was concluded that the level of improvements required to address issues at this location would involve considerable reconfiguration of the Glebe Road interchange, which went beyond the scope and objectives of this study.

Figure E-2. Hybrid Alternative Concept

The Hybrid Alternative's total cost is estimated to be $9,690,000, which includes preliminary engineering, right-of-way, and construction.

1. Introduction and Study Purpose

The I-395 Shirlington interchange (shown in Figure 1) is situated at the City of Alexandria and Arlington County boundary, and provides access from adjacent communities to I-395, as well as cross-jurisdictional access linking residential, office, commercial, and light industrial land uses.

The I-395 Shirlington interchange was designed and constructed as a rotary to link multiple local roadways, such as N. Quaker Lane, Gunston Road, S. Shirlington Road and Campbell Avenue, with the I-395 general purpose and HOV lanes. With recent development at The Village at Shirlington and ever-increasing peak period traffic volumes on I-395, the interchange processes high volumes of traffic leading to a range of operational and safety challenges. The interchange area also handles bus, pedestrian, and bicycle movements, which need to be safely accommodated.

Figure 1. I-395 Shirlington Interchange

This study's overall purpose was to identify safety and operational issues, and develop and evaluate improvements to address these issues. Improvement alternatives that met the following objectives and parameters were developed and evaluated:

- ✓ Address locations with high crash frequency or severity.
- ✓ Address locations with existing or forecasted future traffic congestion or operational issues.
- ✓ Identify substandard or missing pedestrian and bicycle facilities.

- ✓ Identify improvement projects that maintain existing roadway access locations.
- ✓ Identify improvement projects that can be implemented in the near term—with no (or limited) right-of-way required and minimal utility impacts.
- ✓ Identify projects with low construction costs.

The process used to meet the study purpose and objectives is shown in Figure 2. Each step is documented in the following sections of this report.

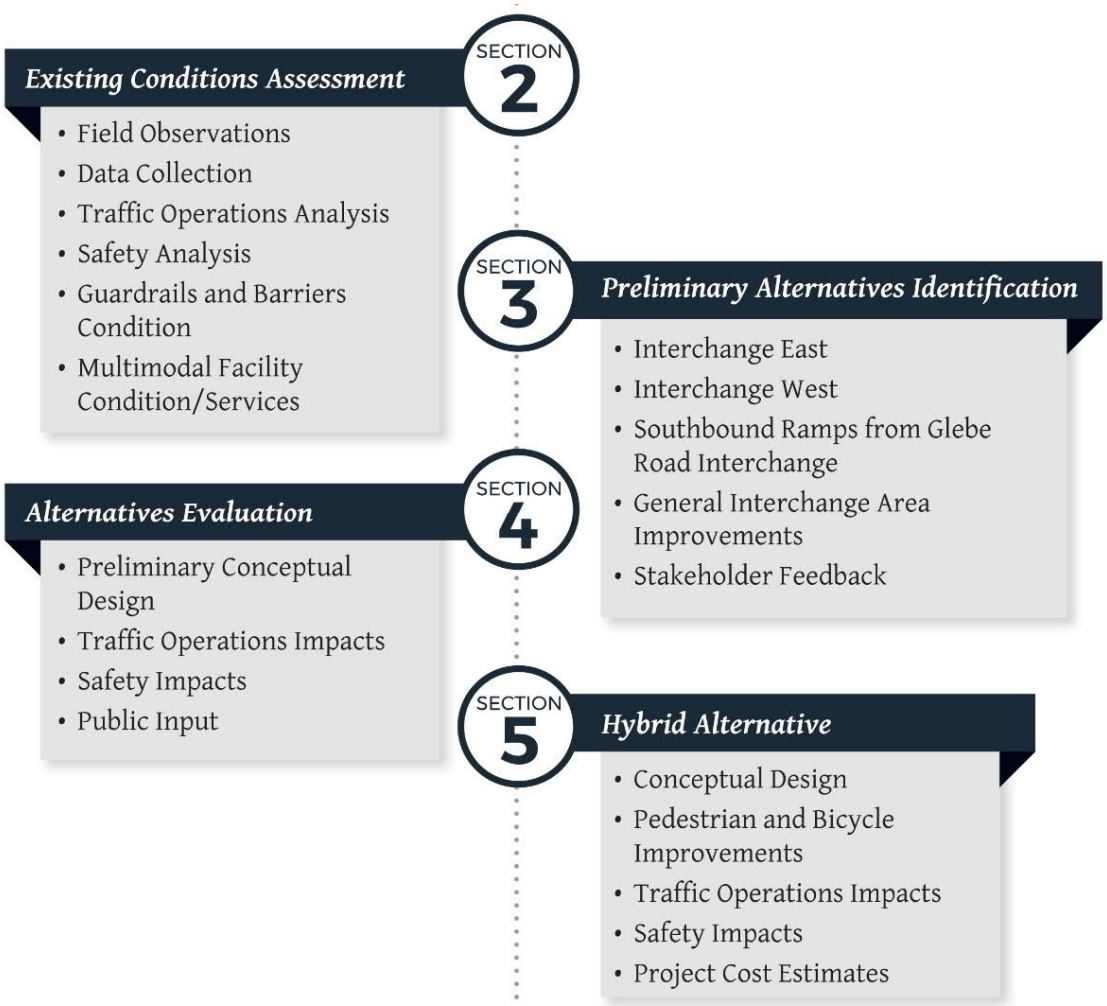

Figure 2. Study Process

2. Existing Conditions Assessment

A. Field Observations

Traffic engineers performed field observations during AM and PM peak periods. These observations are summarized below in the context of three subareas within the overall I-395 Shirlington and Glebe Road interchange areas:

1. Interchange East
2. Interchange West
3. Southbound Ramps from Glebe Road Interchange

1. Interchange East

This portion of the interchange on the Alexandria side includes the N. Quaker Lane and Gunston Road access points, as well as the ramp to the northbound (NB) I-395 general purpose lanes and the reversible ramp to the express lanes, as shown in Figure 3. This area sees high volumes in the AM peak period with traffic heading north into Arlington and Washington, DC.

Figure 3. Interchange East Area

Key issues observed included:

- High volumes in the AM peak period create queues that extend from the I-395 NB entrance ramp southward on the rotary past the N. Quaker Lane yield merge. This makes it difficult for traffic coming from Gunston Road to access the rotary to head around toward Shirlington or to SB I-395. It also complicates traffic attempting to turn right onto Gunston Road from the rotary.

- In a very short length (approximately 700 feet), there are several traffic movements occurring within the rotary:
  - Rotary traffic is weaving to the right to I-395 NB
  - Rotary traffic is weaving to the right to exit onto Gunston Road
  - N. Quaker Lane traffic is merging into the loop heading to I-395 NB, I-395 SB or to Shirlington
- Speeds from rotary traffic are high (45+mph) and there is no posted speed limit (although an advisory 30 mph sign exists before entering this segment). This creates problems when lower speed traffic must merge into higher speed traffic within a short distance. For example, both Gunston Road and N. Quaker Lane traffic must get up to speed quickly from either a stop or yield condition while merging into the correct lane on the rotary.
- This area is a crash hot spot. There was a large amount of rear-end crashes on the N. Quaker Lane approach and several same-direction swipe/angle crashes on the rotary.
- N. Quaker Lane traffic entering the rotary sometimes does not follow the signage and does not yield to rotary traffic.
- Sight distance approaching the merge area is limited because of the tight horizontal curves and overgrown vegetation.
- A high number of buses and shuttles enter and exit the I-395 express lanes at the ramp terminus on the rotary. These types of vehicles cannot get up to speed quickly to merge with faster traffic on the rotary from the upgrade ramp approach.

2. Interchange West

The western side of the interchange in Arlington County is comprised of the S. Shirlington Road and Campbell Avenue entrances and exits to the interchange, as well as the SB I-395 off- and on-ramps, as shown in Figure 4. This area sees high volumes in the PM peak period with traffic heading south away from Arlington and Washington, DC.

Figure 4. Interchange West Area

Key issues observed include:

- High volumes in the PM peak period create queues that extend from the I-395 SB signal-controlled entrance ramp and into the S. Arlington Mill Drive/S. Shirlington Drive intersection.
- Traffic coming SB on the I-395 off-ramp must stop across from Campbell Avenue and wait for gaps in S. Shirlington Road traffic to enter the rotary. They must also be aware of traffic entering the rotary from Campbell Avenue. It is difficult for drivers to identify gaps due to the angle of the off-ramp approach to the rotary. In addition, if this traffic wishes to proceed to N. Quaker Lane from the rotary, they must weave over to the far-right lane on the rotary within a short distance.
- Traffic existing I-395 on the NB off-ramp to the rotary seeking to head to S. Shirlington Road must weave across the rotary to the far-right lane within a short distance.
- Rotary traffic is merging across two lanes of traffic to exit to Campbell Avenue within a 300-foot section. This movement conflicts with traffic coming from S. Shirlington Road to enter the rotary.
- To avoid delays on the mainline, some I-395 SB traffic is jumping the queue by exiting for N. Quaker Lane and then merging with I-395 SB on-ramp traffic. The movement requires a difficult merge within a short distance.

- Campbell Avenue traffic is entering the interchange at a traffic light. Two right turn lanes are available. Buses and shuttles do not use the right-turn-on-red option and wait for green. This can create backups along Campbell Avenue.

3. Southbound Ramps from Glebe Road Interchange

The project's study limits included the I-395 SB exit lanes that take drivers to either Shirlington, N. Quaker Lane or I-395 SB. The issue area on this ramp is the point at which the two S. Glebe Road SB on-ramps merge, as outlined in Figure 5. The Glebe Road east ramp single-lane ramp yields to the Glebe Road west two-lane ramp.

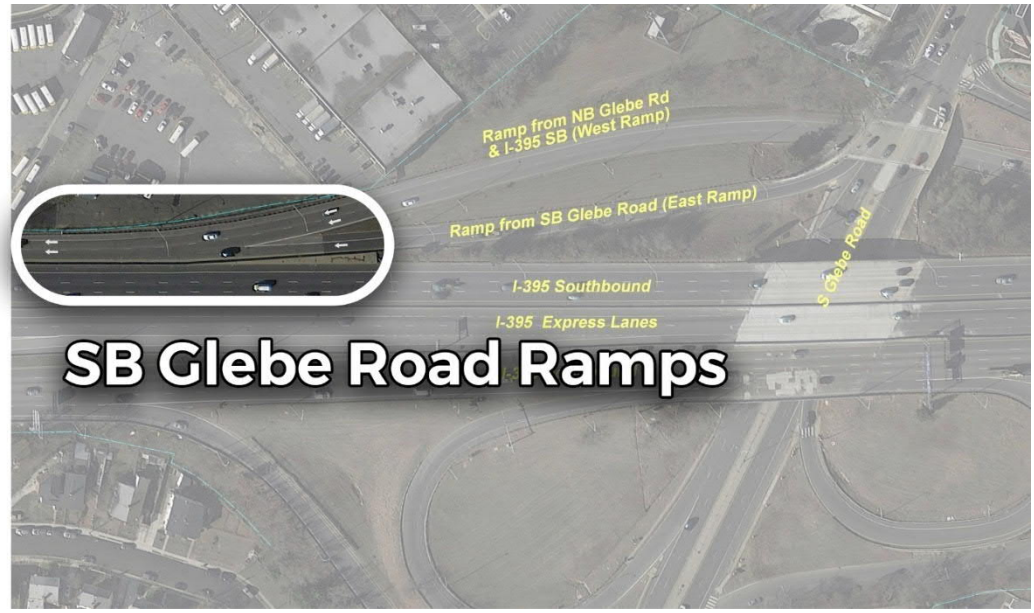

Figure 5. Southbound Ramps from Glebe Road Interchange Area

Key issues observed include:

- Moderate volumes in the PM peak period create queues on the east ramp.
- Queued traffic on the east ramp has an extremely short merge (less than 100 feet) to get up to speed with the west ramp traffic. The west ramp is travelling at relatively high speeds, increasing the difficulty for the east ramp traffic to merge successfully when starting from a stop.
- The potential for rear-end and sideswipe/angle crashes is very high at this location and this is manifested in the crash data. This area is a crash hot spot with over 100 crashes, mostly rear-ends, between November 2012 and May 2018.

B. Data Collection

Traffic Volume Data

Traffic volume count data is a critical input to the traffic operations analyses. For this study, vehicle turning movement counts were collected at 11 intersections in the study area during three-hour AM

and PM weekday peak periods in November 2015. Heavy trucks, buses, bicycles and pedestrian counts were also collected during these periods. Daily traffic volumes were collected at ten locations on weekdays in November 2015 using road tube counting equipment. All traffic volume count data is provided in Appendix A. A map showing existing turn movement counts at key interchange locations in provided in Appendix B.

Travel Time and Speed Data

Travel time and speed data provides valuable information for studies such as this one where an entire interchange area -- including rotary sections, intersections and ramp termini -- is being evaluated. For example, this data shows where slowdowns are occurring at specific locations within the interchange area (i.e., congested locations) or where operating speeds are different for vehicles in the same area (i.e., speed differentials within the same section can be unsafe). This type of data is also very important in validating the traffic flow simulation model that was used by this study to evaluate existing traffic operations conditions and assess the benefits of potential future improvements.

This data is collected by data collectors who drive around the interchange area multiple times and keep time for specified segments of the interchanges for each "loop." The travel time runs were performed in 2017 during weekday AM and PM peak periods. Four loops around the rotary were driven and timed multiple times for each AM and PM period:

- Starting and ending at Campbell Avenue
- Starting and ending at Gunston Road
- Starting and ending at N. Quaker Lane
- Starting and ending at S. Shirlington Road and S. Arlington Mill Drive

Appendix C presents the travel time and speed data collection results

Traffic Crash Data

Traffic crash data was obtained from VDOT covering a three-year period, November 2012 to November 2015. The most common collision type was rear-end crashes resulting in property damage, accounting for 87 out of 127 crashes. Angle, sideswipe-same direction, and fixed object-off road crashes made up most of the remaining crashes. Eighty-nine percent of all the crashes occurred during dry conditions, which was higher than the statewide average. Congestion can be considered a leading contributing factor to crashes; however, the rotary layout is likely also a key factor, as noted in the field observations in Section A.

Updated traffic crash information was collected and analyzed for the SB ramp merge area at the Glebe Road interchange. This additional information covered the period from January 2016 to May 2018. Crash types and frequency were consistent with the original three-year analysis period.

Appendix D contains the detailed crash data and summary analysis.

C. Traffic Operations Analysis

A microsimulation traffic flow model was calibrated for use in this study. Vissim Version 8.00-15 is a microsimulation tool used to model traffic flow and operations. The application of this type of model was necessary to be able to account for the traffic effects of this complex interchange area, which includes freeway sections, freeway ramps, local streets and multiple merge and weaving locations all interacting as a system. This system-level analysis capability was particularly important for this study since many of the traffic flow issues in the interchange area are related to the on and off-ramps associated with I-395. Using VDOT Traffic Operations and Safety Analysis Manual guidelines, the Vissim model was successfully calibrated to replicate existing field conditions. This calibrated traffic flow model was therefore critical to the evaluation of future improvement alternatives. The calibrated Vissim model files were approved by VDOT for use in this study in November 2018.

D. Safety Analysis

The three-year tabulation of crash data shows that a total of 127 reported crashes occurred at the I-395 Shirlington interchange, including on the rotary, at ramps and ramp termini, and on the SB ramp from Glebe Road. The 127 crashes resulted in 32 injuries with no fatalities. Figure 6 presents a summary of the study area crashes by year and location.

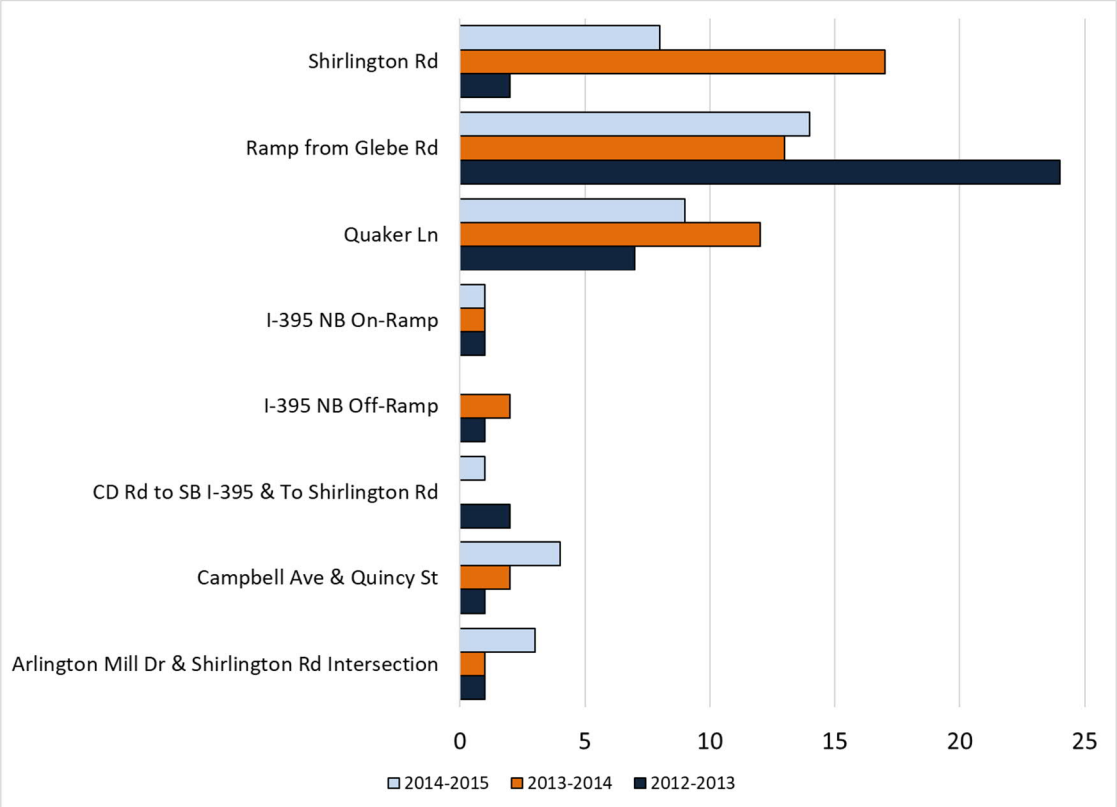

Figure 6. Crash Summary by Year and Location

In addition to summarizing crash data per location, type and severity, it is revealing to look at crash densities to determine if they are hot spots where crashes are concentrated. This can be an indication of an area that would benefit from safety-related improvements.

Crash density is a recommended metric to monitor crash experience along a roadway or interchange and identify high crash locations (hot spots), as recommended in the VDOT Crash Analysis Procedures for Roadway Safety Assessments. Crash density is the concentration of crash occurrence on a short segment of roadway, usually 0.25 miles. It compares the number of crashes occurring along segments of a consistent cross-section (length and number of lanes).

Crash densities were plotted on maps using different colors to represent ranges of densities throughout the interchange area with red and yellow indicating higher density locations, as shown in Figure 7. To identify crash hot spots, the crash density on each section is compared to a critical crash density. Critical crash density is a metric that can be used for prioritizing safety improvements.

Figure 7. I-395 Shirlington Interchange Hot Spot Locations

As noted in Figure 7, four major crash hot spot locations were identified from the crash density analysis.

Hot Spot 1: Southbound I-395 Off-Ramp and Glebe Road East and West Ramp Merge

There were over 40 collisions in this location and all but one were rear-end crashes on the East on-ramp. The crash data supports field observations that the yielding Glebe Road East on-ramp traffic does not have sufficient length to merge with the West ramp. During the peak PM hours, for example, this creates long queues and drivers have very narrow windows to get up to speed and merge with the dense free-flowing traffic on the West ramp. Many of the rear-end crashes are most likely due to drivers approaching the merge trying to look back up the West ramp to see if gaps are available, and not noticing that the vehicle in front of them has had to stop.

Hot Spot 2: Interchange West including Campbell Road Entrance and S. Shirlington Road Merge

Over one-half of the crashes in this section were rear-end crashes and the remainder were angle, fixed object off-road, and sideswipe crashes. This short length has several traffic movements, weaves, and merges in addition to high PM volumes. The weave created by traffic on the rotary trying to move to the right to exit onto Campbell Road conflicting with traffic entering the rotary on S. Shirlington Road can be particularly problematic.

Hot Spot 3: Interchange East including Gunston Road Entrance and N. Quaker Lane Merge

The collisions on the east side of the interchange mirror those on the west side. Crashes in this area were comprised mainly of rear-end crashes, but also included sideswipes, angle crashes, and fixed object crashes. This is an area where traffic is moving at a high speed (45+mph) on the rotary and required to merge and weave into traffic entering the loop on N. Quaker Lane leading to angle and sideswipe crash potential. In addition, during the AM peak, the I-395 NB on-ramp can back-up into the rotary and N. Quaker Lane traffic leading to rear-end crashes.

Hot Spot 4: S. Shirlington Road to N. Quaker Lane

The crashes in this crash hot spot were primarily angle and side-swipe same direction crashes. They can be attributed to high speeds (45+ mph) of vehicles travelling around the rotary and vehicles not prepared to be in the correct lane for the N. Quaker Lane exit. Traffic makes quick lane changes at higher than posted speeds in a short distance leading to collisions.

The findings of this safety and crash analysis provided critical input into the next phase of this study, which was to develop and evaluate improvement alternatives that will address these safety concerns.

E. Guardrail and Barrier Condition Assessment

Guardrail and concrete barrier condition assessments in the interchange area were conducted from November to December 2015, using the VDOT Guardrail System Upgrade Guidance manual dated March 8, 2013. This field evaluation included the following items:

- ✓ Examine the guardrail for damage, rust and deterioration.
- ✓ Assess compliance with current AASHTO/VDOT standards and specifications.
- ✓ Check height for compliance with current VDOT standards.
- ✓ Hardware checks for proper position and size.
- ✓ Check offset block for correct material and position.
- ✓ Check for fixed objects in the deflection area.
- ✓ Check guardrail location relative to any curb.
- ✓ Check the shoulder and area beneath the guardrail for excessive erosion.
- ✓ Check the shoulder width behind the posts to ensure proper support of the posts.
- ✓ Check all timber posts for visible damage, rot, and/or insect infestation.
- ✓ Check steel posts for rust, being bent, or badly deflected.

Guardrails were inspected for compliance with current standards, which are generally classified into one of four groups rated A, B, C and D. Each classification type is described below.

Grade A: Guardrail system is evaluated to be fully functional and capable of providing protection as intended. The guardrail system meets current VDOT standards, specifications, policy and/or current FHWA testing criteria based on field observations and measurements of rail heights.

Grade B: Guardrail system is evaluated to be adequately functional under most impacts, but may not meet all current VDOT standards.

Grade C: Guardrail system is evaluated to provide some protection for errant vehicles, but does not comply with current VDOT standards.

Grade D: Guardrail system is evaluated to provide little protection for errant vehicles.

Most of the guardrails for the ramps surrounding the interchange (except for a new section added to protect the new electrical generation equipment) are rusting due to galvanizing failure or wear, have steel blockouts without washers or steel backup plates, rail elevations that do not meet current VDOT criteria due to pavement overlays, sporadic damage, missing hardware and missing reflectors too numerous to count. No damage of a structural nature was seen on the concrete barrier walls or bridge walls, noting that the bridge barriers are not safety shaped.

Except for the new guardrail installed adjacent to the new generator station, the most common grade was a "D," primarily because of steel block outs, heavy rust and damage to posts and “W” beams.

Figure 8 shows locations of the guardrails and barriers that were assessed. Each location is keyed to the summary results shown in Table 1. The full assessment report is contained in Appendix E.

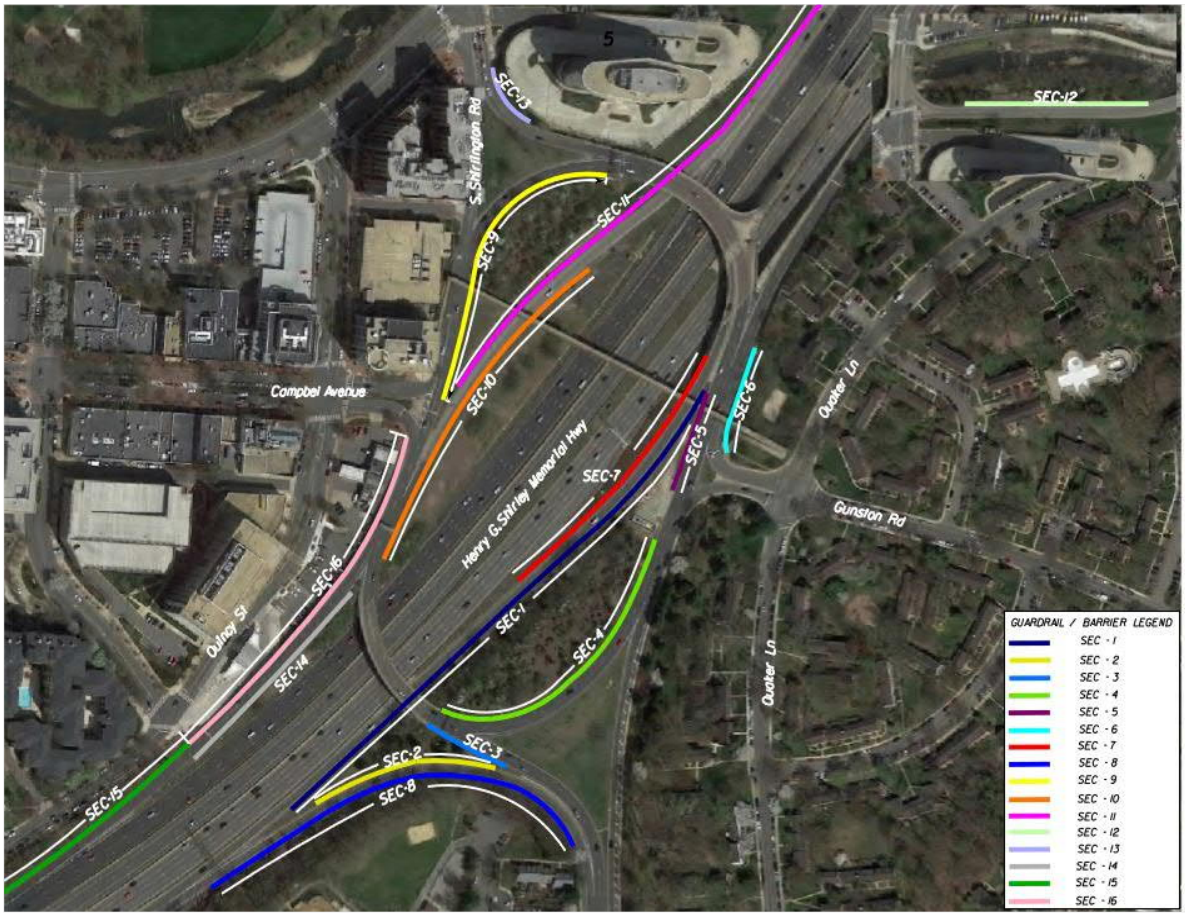

Figure 8. Guardrail and Barrier Assessment Locations

Table 1. Guardrail and Barrier Assessment Summary

Evaluation Criteria	No.		Guardrail Sections															
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	1	Post and Rail Deflection	X		X		New Guardrail, with old End Treatment				X					X		Concrete Barrier (some stress cracks)
	2	Rail Deflection Only		X		X												
	3	Missing Hardware / Loose Hardware	X	X	X	X			X	X	X	X		X	X	X	X	
	4	Erosion																
	5	Rail Flattening																
	6	Posts Separated from Rail		X	X	X							X					
	7	Missing or broken Posts				X		X							X	X	X	
	8	Missing Blockouts										X						
	9	Damage at Rail Splice																
	10	Vertical Tear																
	11	Horizontal Tear																
	12	Non Manufactured Holes																
	13	Twisted Blockouts / Posts				X					X	X				X		
	14	Improper location relative to the curb	X	X						X	X							
	15	Visible damage, rot or insect infestation on timber posts																
	16	Rusted, bent, or badly deflected steel posts,	X					X	X						X	X	X	
	17	Detached Rail from Concrete Barrier				X					X							
	18	Fading Galvanization	X					X	X	X				X			X	
	19	Missing Reflectors				X							X	X	X	X	X	
	20	Average Height above Pavement (inches)	31	31									32	28		31.5	27	
	21	Steel Blockouts	X	X		X												
	22	Wood Blockouts		X														
	23	Damaged / Missing End Treatments									X	X	X	X				
	24	Fixed Objects in deflection zone								X	X	X		X	X		X	

F. Multimodal Facility and Service Assessment

Personal vehicles, buses, bicycles, and pedestrian movements were observed in the interchange area on January 2016 and again, verified in January 2018. The Shirlington Station serves many transit routes and Capital Bikeshare is represented in the area with multiple stations. There are no Metro stations in the vicinity. A comprehensive assessment of these multimodal facilities, as well as transit services, was performed as part the preliminary stage of this study. As improvements are recommended and implemented, it is envisioned that deficiencies in the multimodal network will also be addressed. The full assessment report is provided in Appendix F.

Pedestrian and bicycle facilities and operations within the study area were inventoried and reviewed for general usage and safety. Areas of review included geometric deficiencies, ADA compliance, pedestrian and bicycle accommodations, queues, signing, signal phasing, and other safety issues related to pedestrians and bicyclists. All reviews were completed on January 2016 and again, verified in January 2018.

Existing pedestrian and bicycle amenities are shown in Figures 9 and 10, respectively.

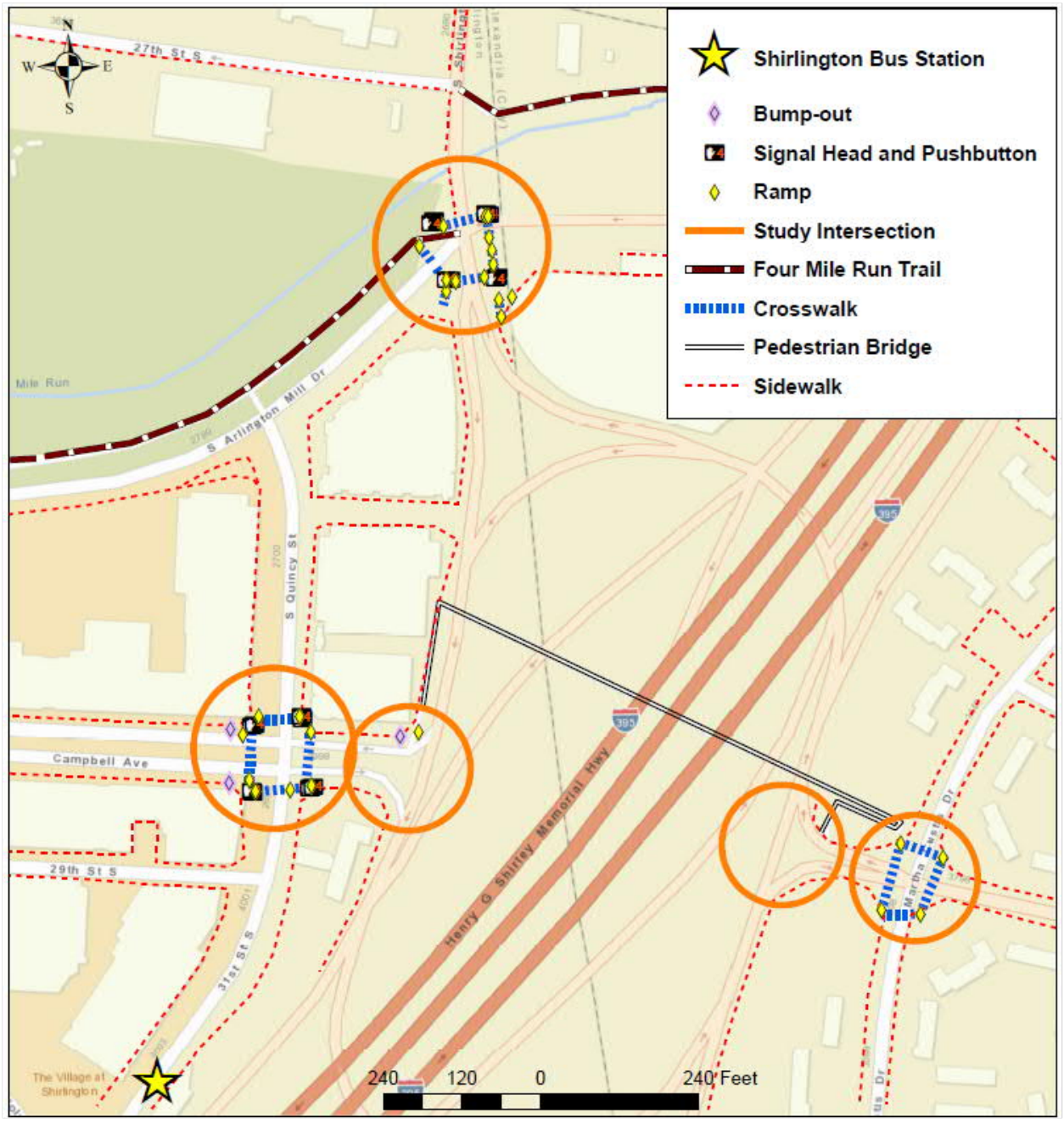

Figure 9. Pedestrian Amenities

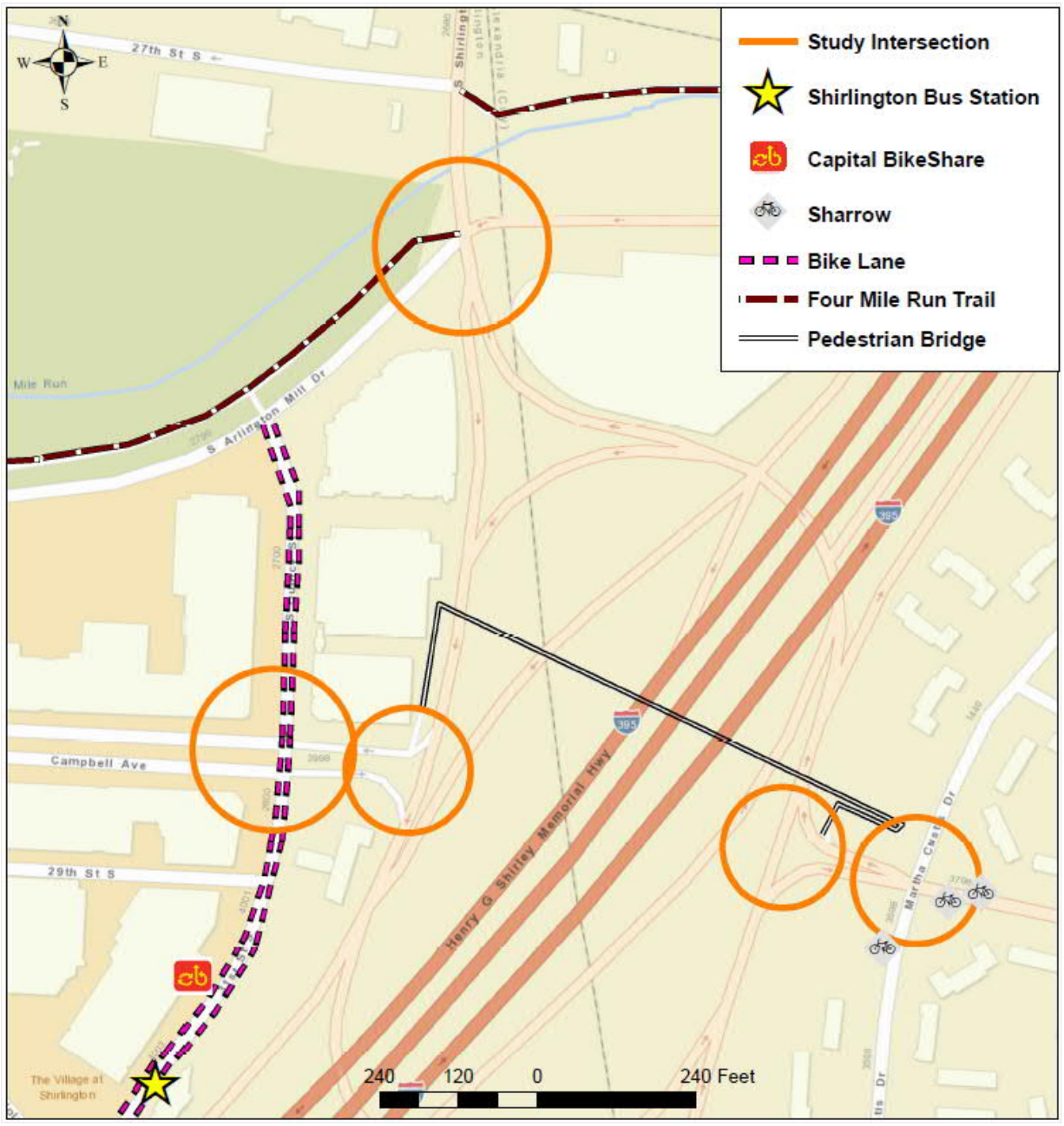

Figure 10. Bicycle Amenities

Four of the intersections that were evaluated as part of the multimodal analysis are adjacent to or near the interchange area. Existing conditions as of January 2018 for each of these areas described below.

Campbell Avenue and South Quincy Street

The signalized intersection of Campbell Avenue and South Quincy Street is directly north of the Shirlington Transit Center. Quincy Road is a four-lane road oriented north to south that runs parallel to I-395. The west leg of Campbell Avenue is a two-lane, divided roadway that passes through downtown Shirlington. The east leg has two eastbound lanes that access I-395, and three westbound

lanes (one right turn, one though, one left turn) at the intersection. There are offices, restaurants, ground-level retail, and apartments in the immediate vicinity. The Shirlington Transit Center is located approximately 300 feet south of the intersection along South Quincy Street.

Geometry

Wide brick and concrete sidewalks are present on each corner of the intersection, except the southeast corner that is approximately five feet wide. The two ramps on the northeast corner and the ramp for the west side of the northern crosswalk are ADA compliant. All others lack detectable warning surfaces. The northern median cut-through has a detectible warning surface but is only four feet wide. All ramp slopes are acceptable.

The ramps on the southwest corner are not ADA-compliant for multiple reasons. To bring this corner into compliance would require a significant rebuild to address the existing junction box, signal pole, manhole, landing area between ramps, and detectible warning surfaces.

Signalization

Traffic signals are loop activated along Campbell Avenue. Pedestrian signals are located on all four approaches. Pedestrian signals are activated automatically to cross Campbell Avenue and pushbuttons are used to cross South Quincy Street. Audible pedestrian equipment is located on both corners to cross the north side of South Quincy Avenue.

Bicycles

Exclusive bicycle lanes are striped along Quincy Avenue, as shown in Figure 11. Bicycle pavement markings along northbound and southbound Quincy Street do meet the meet NOVA standards , however, the skip lines currently installed are at an incorrect spacing of 3-foot line, 9-foot skip instead of the required 2-foot line, 4-foot skip.

Vehicles including buses were observed queueing along northbound South Quincy Street to turn right. The queue extended across the bicycle lane, thereby blocking it. No impeded bicyclists were observed. Only 75 feet are available for the right-turn lane before a 36-foot parking strip is present. The bike lane and right-turn lane are shown in Figure 11. While there are no pavement markings or signs that clearly identify bicycle routes along Campbell Avenue, there are several bicycle racks on both sides of the street.

Figure 11. Northbound South Quincy Street Approach

The Shirlington Transit Center/S. Quincy and Randolph Street Capital Bikeshare station is located approximately 300 feet south of Campbell Avenue along South Quincy Avenue across from Shirlington Station and is shown in Figure 12.

Figure 12. Shirlington Transit Center Capital Bikeshare Station

Pavement Markings

Pavement markings are in fair condition. Continental pedestrian pavement markings are used across all crossings except the west leg of Campbell Avenue where decorative red brick is used to delineate the pedestrian crossing, as shown Figure 13.

Figure 13. View from Southeast Corner of Campbell Avenue and South Quincy Street

Lighting

All four traffic signal poles provide overhead lighting at the intersection.

Campbell Avenue and South Shirlington Road

The intersection of Campbell Avenue and S. Shirlington Road is located east of Shirlington immediately west of I-395. It is partially signalized with a free southbound right-turn movement towards Shirlington. The signal controls southbound S. Shirlington Road and eastbound Campbell Avenue. The southbound I-395 off-ramp is stop-controlled and merges with S. Shirlington Road immediately south of the signal. The land use consists of a gas station on the southwest corner and WETA on the northwest corner. There are no bus stops at this intersection.

Geometry

Sidewalk is present on the southwest corner, but there are no destinations for pedestrians east of South Quincy Street. Access to the pedestrian bridge overpass crossing I-395, shown in Figure 14, is present on the northwest corner. There are no crosswalks, but a ramp is located on the northwest corner.

Figure 14. Pedestrian Bridge Connecting Fairlington/Park Fairfax and Shirlington

Signalization

The traffic signal controls two southbound through lanes and two eastbound right-turn lanes. A sign is posted prohibiting turns on red from the left lane. Loop detectors are present on Campbell Avenue.

Pavement Markings

Pavement markings are in fair condition.

Bicycles

No bicycle signs or pavement markings are present at the intersection.

Lighting

Street lighting is present at the intersection. While no lights are located directly on the northwest corner near the pedestrian overpass, there is lighting on the overpass and street lighting on both roadways.

Gunston Road and North Quaker Lane

The intersection of Gunston Road and North Quaker Lane is located immediately east of I-395. North Quaker Lane is uncontrolled with three northbound lanes; the right turn onto Gunston Road is channelized. A stop sign controls the westbound movement from Gunston Road onto northbound North Quaker Lane. Gunston Road is a two-lane, residential street. The pedestrian bridge overpass crossing I-395 connects the intersection with Shirlington. The land use is residential to the east. There are no bus stops at this intersection.

Geometry

Sidewalk is present on the southeast corner. There is no direct connection from this sidewalk to the pedestrian bridge on the northeast corner at this intersection without crossing Gunston Road at Martha Custis Road. No ramps or crosswalks are present.

Signalization

This intersection is unsignalized.

Pavement Markings

Pavement markings are in good condition.

Bicycles

No bicycle signs or pavement markings are present at the intersection.

Lighting

Street lighting is present at the intersection; however, no lights are located on the northeast corner near the pedestrian overpass.

Gunston Road and Martha Custis Drive

Both Gunston Road and Martha Custis Drive are two-lane, residential streets. The pedestrian bridge overpass crossing I-395 connects the intersection with Shirlington. The land use is mainly multifamily residential. There are WMATA, ART, and DASH bus stops along Martha Custis Drive in both directions.

Geometry

Sidewalk is present on all four corners. All four ramps were recently rebuilt and are ADA complaint with the correct slopes and detectable warning surfaces.

Pavement Markings

The crosswalks and stop bars for all four approaches were recently repainted. Standard parallel line pedestrian crossing markings were clearly striped on each approach. The southern crosswalk is striped at an angle as is shown in Figure 15. Low volume pedestrian activity was observed.

Figure 15. Intersection of Gunston Road and Martha Custis Drive

Bicycles

There are pavement markings south of the intersection along Martha Custis Drive and east on Gunston Drive and in new condition. Bicycle signs are present at the intersection, such as the ones shown in Figure 16. No bicyclists were observed during the field visit.

Figure 16. Bicycle Signs on Northbound Martha Custis Drive at Gunston Road

Lighting

Overhead lighting was provided at every corner except the southeast corner.

The interchange area is well-served by transit services. The hub of these services is the Shirlington Station, which is located south of downtown Shirlington along South Quincy Street. The station has five bus bays, an indoor waiting area, a staffed commuter store offering transit information, and audible schedule devices. The station, shown in Figure 17, serves over 2,000 commuters daily.

Figure 17. Shirlington Station Transit Center

Eight bus routes, plus variations on some of the routes, traverse the study area. Figure 18 maps the roadways within the study area that each of these routes travel on. Figure 19 depicts the amenities at each bus stop including the presence of a shelter, bus pad, landing pad, and lighting.

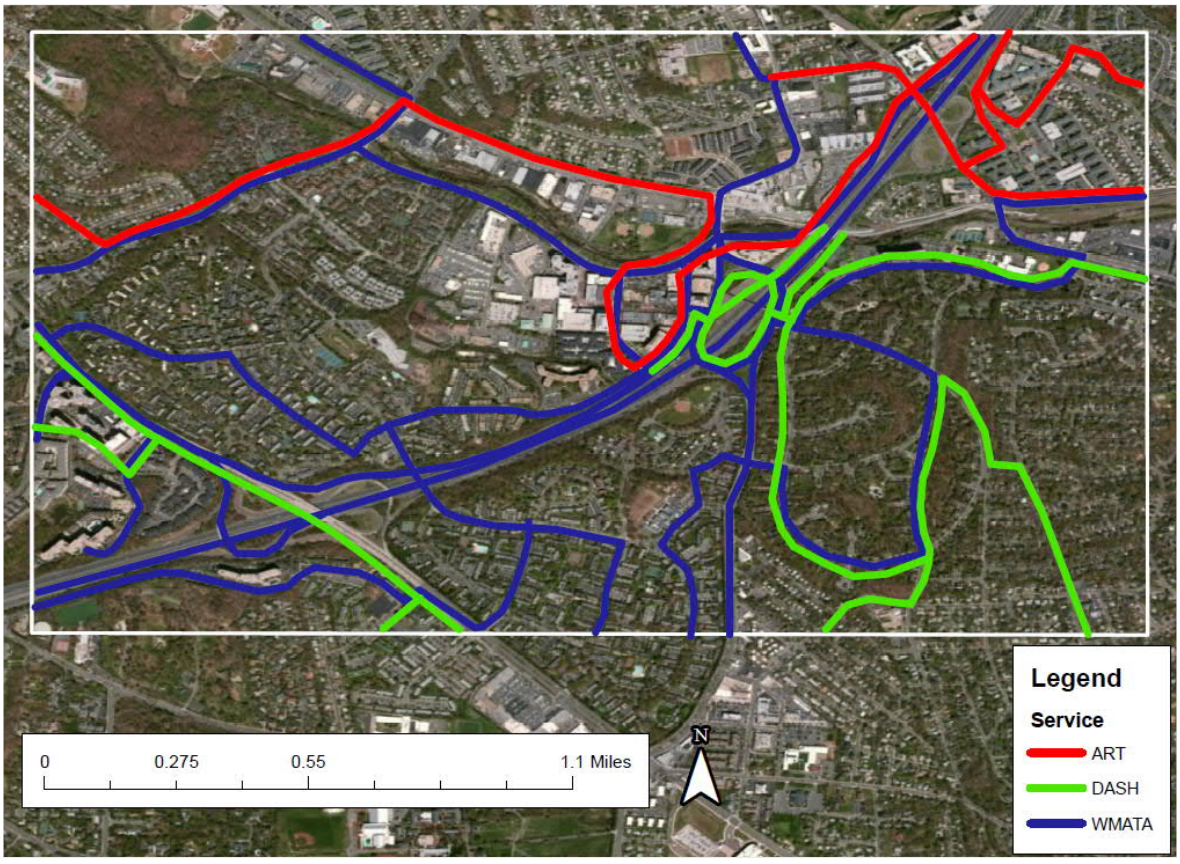

Figure 18. Interchange Area Bus Routes

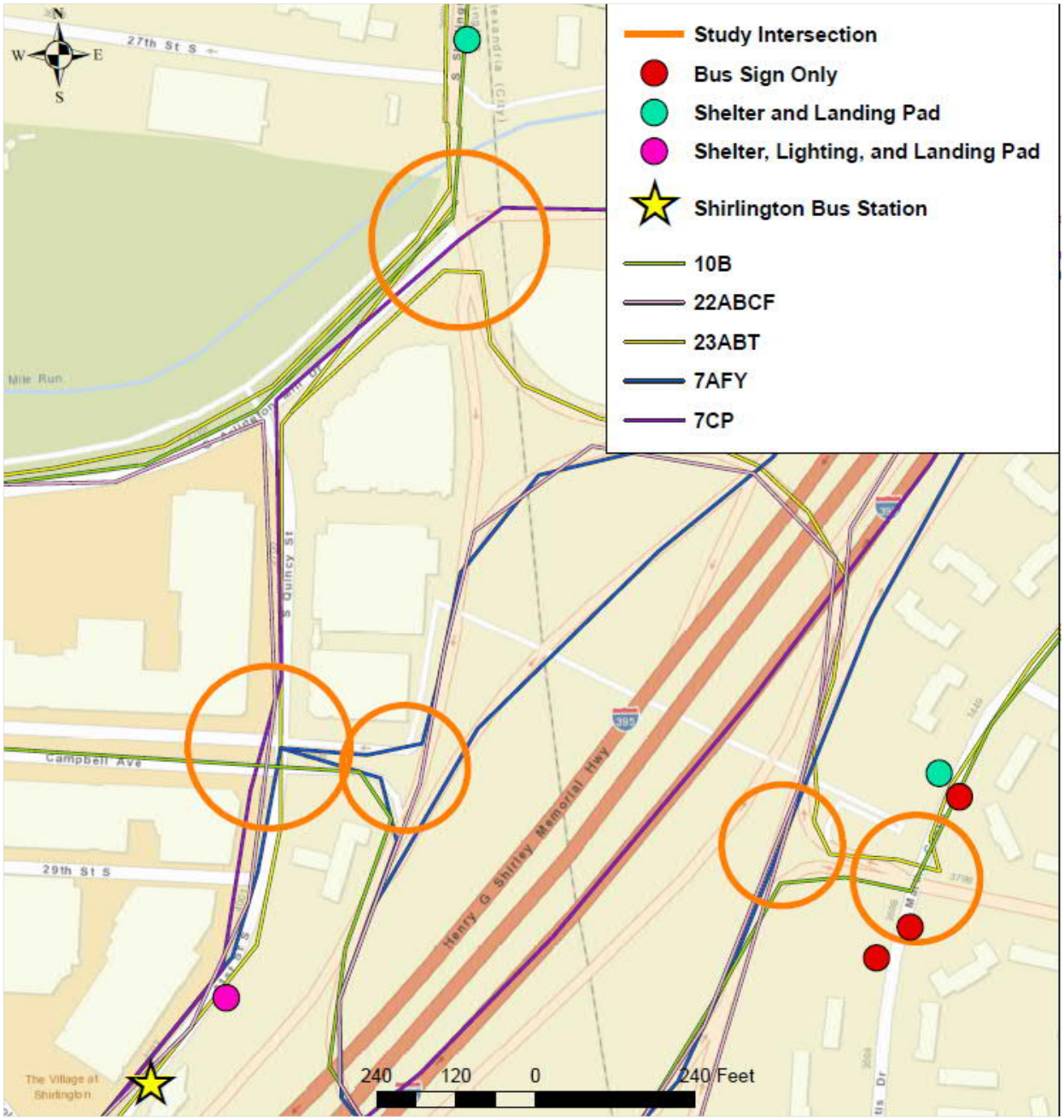

Figure 19. Transit Amenities

Table 2 on the next page presents a summary of the multimodal condition assessment in the context of the five major intersections in the interchange area.

Table 2. Multimodal Assessment Summary

Summary of Existing Pedestrian, Bicycle, & Transit Amenities and Deficiencies													
Intersection	Sidewalks?	Marked Crosswalks?	Pedestrian Signals?	Push-buttons?	Signs?	Bike Facilities?	Lighting Provided?	Bus Stops or Routes?	Curb Ramps?	Ramps ADA Complaint?	Pavement Markings in Good Condition?	Signal Equipment Operational?	Bus Access?
	[Legs of Intersection]								[Corner]	[Deficiencies]			
Arlington Mill Drive and Shirlington Road	Yes	Yes	Yes	Yes	Improperly installed W11-2 signs	Four Mile Run Trail north of Arlington Mill Dr	Yes	no bus stops; multiple routes	Yes	Yes, except SE quadrant and east median crossing	Yes, except faded crosswalk on east leg	Yes, except south crossing pushbuttons are not operational	N/A
Cambell Avenue and South Quincy Street	Yes	Yes	Yes	Yes	Yield to Ped signs and bike route signs need updating	Bike lanes Quincy Street	Yes	no bus stops; multiple routes	Yes	Only in NE corner and one ramp in NW corner; SE and SW ramps are not ADA compliant	Yes	Yes	NB RT queues exceed available storage
Campbell Avenue and South Shirlington Road	Yes, on west side of intersection	No	No	No	N/A	No	Yes	no bus stops; multiple routes	One on NW corner to nowhere	No	Yes	N/A for Peds	N/A
Gunston Road and North Quaker Lane	Yes, on east side of Quaker Ln and on Gunston Rd	No	unsignalized	N/A	N/A	No	Yes	no bus stops; multiple routes	No	N/A	Yes	N/A	N/A
Gunston Road and Martha Curtis Drive	Yes	Yes	unsignalized	N/A	stop signs not placed at stop lines	Sharrows on east and south legs	Yes, except SE corner	multiple stops; multiple routes; shelter at SB bus stop	Yes	Yes	Yes	N/A	Parking at NB bus stop

3. Preliminary Alternatives Identification

The existing conditions assessment revealed a wide range of safety and operational challenges in the I-395 Shirlington interchange area, as well as the SB ramps in the Glebe Road interchange area. Under future 2040 no build conditions, no physical improvements are proposed but the volume of traffic using the express reversible lanes in the median is expected to increase relative to existing conditions. Specific trouble spots are anticipated, based upon the traffic model simulation results, along the single lane entry on N. Quaker Lane at the rotary and along the stop- controlled approach of the I-395 southbound off-ramp at the S. Shirlington Road/Campbell Avenue. Both locations are expected to worsen compared to existing conditions due increased traffic demand and inadequate capacity due to the existing yield and stop control configurations.

The study team recognized that potential solutions to these existing and future challenges would be multi-faceted and could include roadway and intersection geometric improvements, new signalization, multimodal improvements, general maintenance activities and lighting, signing and wayfinding enhancements.

A brainstorming session was held in April 2016 with VDOT and the design team to develop initial ideas for safety and operational improvements. Improvements were identified to address the following study objectives and parameters:

- ✓ Address locations with high crash frequency or severity.
- ✓ Address locations with existing or forecasted future traffic congestion or operational issues.
- ✓ Identify substandard or missing pedestrian and bicycle facilities.
- ✓ Identify improvement projects that maintain existing roadway access locations.
- ✓ Identify improvement projects that can be implemented in the near term—with no or limited right-of-way required and minimal utility impacts.
- ✓ Identify projects with low construction costs.

The preliminary improvement alternatives that were identified during the brainstorming session are summarized below in the context of the three major portions of the interchange areas.

A. Interchange East

The primary goals of the improvement alternatives in this area were to address the problematic weaving areas as well as the high speeds of traffic entering the rotary from N. Quaker Lane. Figure 20 shows the locations of the roadway improvement alternatives that were identified in this eastern portion of the I-395 Shirlington interchange. Table 3 provides a description of each.

Shirlington Interchange East Modifications

1. Reduce required weave movements by repurposing existing lanes and eliminating low-volume lanes. This can be accomplished with signing and pavement markings.
2. Convert I-395 NB Shirlington off-ramp to an intersection with Gunston Road.
3. Eliminate Gunston Road intersection thereby removing two critical weaving points.
4. Control entrances and speeds into the interchange through new synchronized traffic signal at North Quaker Lane and Gunston Road intersection.
5. Control entrances and speeds into the interchange by converting yield-controlled to stop sign-controlled at North Quaker Lane.
   Control entrances and speeds into the interchange through signalization at North Quaker Lane.
6. Create signalized T-intersection with rotary and North Quaker Lane.
7. Realign and increase deflection angle of the entrance ramp to reduce speed of North Quaker Lane traffic entering the rotary.

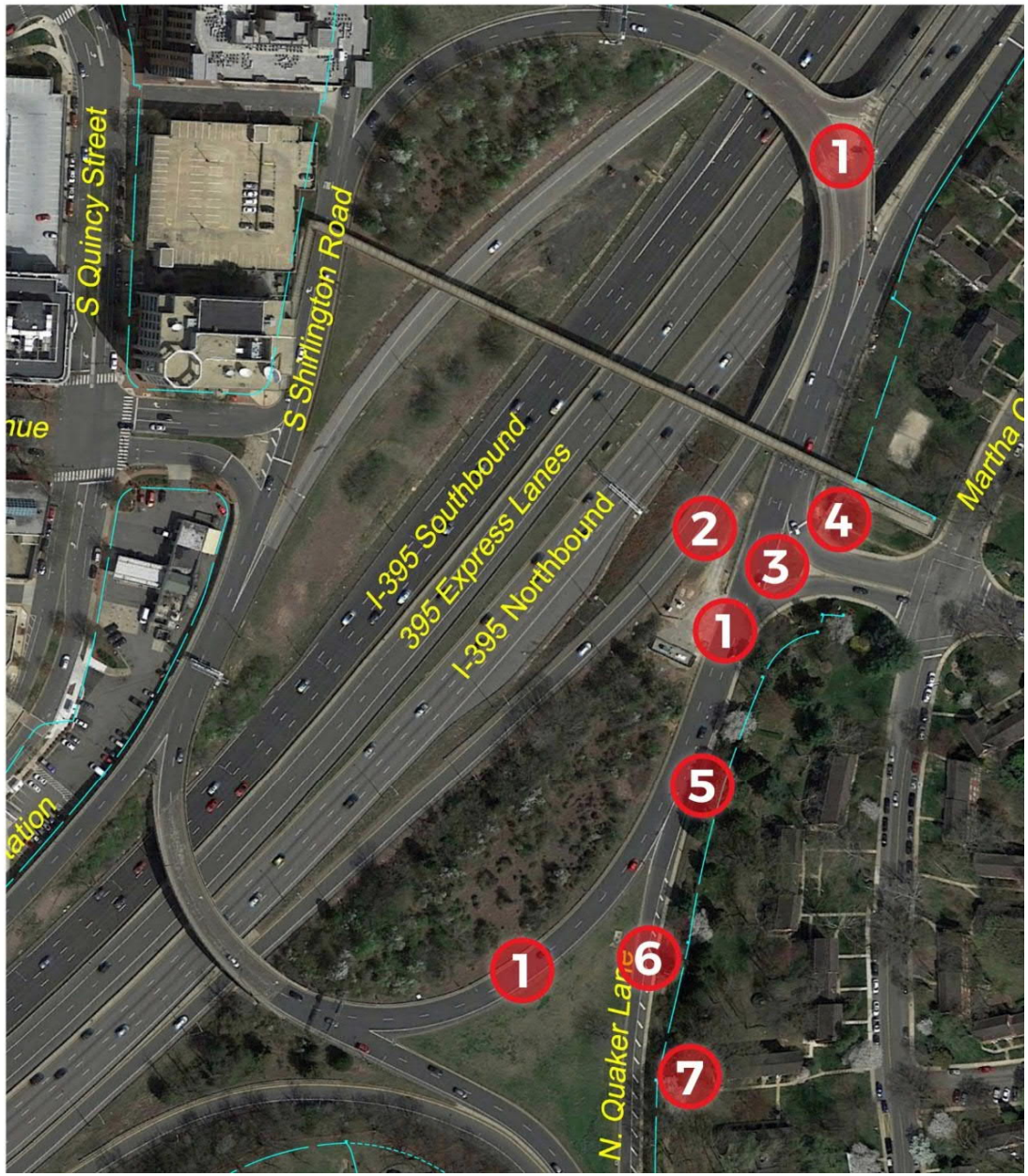

Figure 20. Shirlington Interchange East Modifications

Table 3. Interchange East – Preliminary Improvement Alternatives

Improvement	Description	Benefits	Negative Impacts
1. Reduce required weave movements by repurposing existing lanes and eliminating low-volume lanes. This can be accomplished with signing and pavement markings.	This would convert the left lane of the rotary into a striped shoulder, thereby reducing the number of lanes from three to two south of Gunston Road, and from four to three lanes north of Gunston Road.	Eliminates multi-lane weaves south of Gunston Road and at point where NB I-395 off-ramp traffic heading to Arlington Mill Road weaves into the rotary.	Potential increase in queueing along N. Quaker Lane entering the rotary.
2. Convert I-395 NB off-ramp to Shirlington to an intersection with Gunston Road.	This would eliminate the direct connection of the I-395 NB off-ramp to the rotary, and instead connect the ramp to a new signal at Gunston Road.	Would relieve weaves on northern section of the rotary and would provide unconflicted traffic movement into the rotary from Gunston Road during green phase.	May have negative operations impacts for N. Quaker Lane and rotary traffic flow.
3. Eliminate Gunston Road intersection.	This would close the Gunston Road access to the interchange area.	Removes two problem weaving areas.	Closes convenient access to Shirlington and I-395 for residents of Park Fairfax. Many Alexandria DASH buses use Gunston Road as well.
4. Control entrances and speeds into the interchange by adding synchronized signal at N. Quaker Lane and Gunston Road.	This would add a traffic signal at Gunston Road.	Would provide unconflicted traffic movement into the rotary from Gunston Road during green phase.	May have negative operations impacts for N. Quaker Lane and rotary traffic flow.
5. Control entrances and speeds into the interchange by converting yield controlled to stop sign/signal at N. Quaker Lane merge into rotary.	These would either add a stop sign or a new traffic signal at the point where N. Quaker Lane merges with the rotary.	Reduces speed of vehicles entering rotary from N. Quaker Lane. Allows gaps for vehicles in rotary weaving over to Gunston Road.	May have negative operations impacts for N. Quaker Lane traffic flow.
6. Create signalized T-intersection with rotary and Quaker Lane.	This would eliminate the N. Quaker Lane merge into the rotary by re-configuring the southeastern section of the rotary to connect directly to N. Quaker Lane at a new traffic signal.	Would eliminate weaving movements on rotary and reduce speeds on N. Quaker Lane.	May have negative operations impacts for N. Quaker Lane and rotary traffic flow.

Improvement	Description	Benefits	Negative Impacts
7. Realign and increase the deflection angle of the entrance ramp to reduce speed of N. Quaker Lane traffic entering the interchange.	This would add a bend in the downhill section of N. Quaker Lane just prior to the rotary.	Slows down vehicle speeds on N. Quaker Lane before they enter the rotary.	None identified.

B. Interchange West

The primary goal of the improvement alternatives in this area was to address the problematic weaving areas. Figure 21 shows the locations of the roadway improvement alternatives that were identified in this western portion of the I-395 Shirlington interchange. Table 4 provides a description of each.

Shirlington Interchange West Modifications

8 Add a lane to Arlington Mill Road exit to reduce number of lanes necessary for weave.

9 Remove I-395 SB off-ramp to North Quaker Lane to eliminate weave movements.

10 Convert I-395 SB off-ramp to intersection with Campbell Avenue.

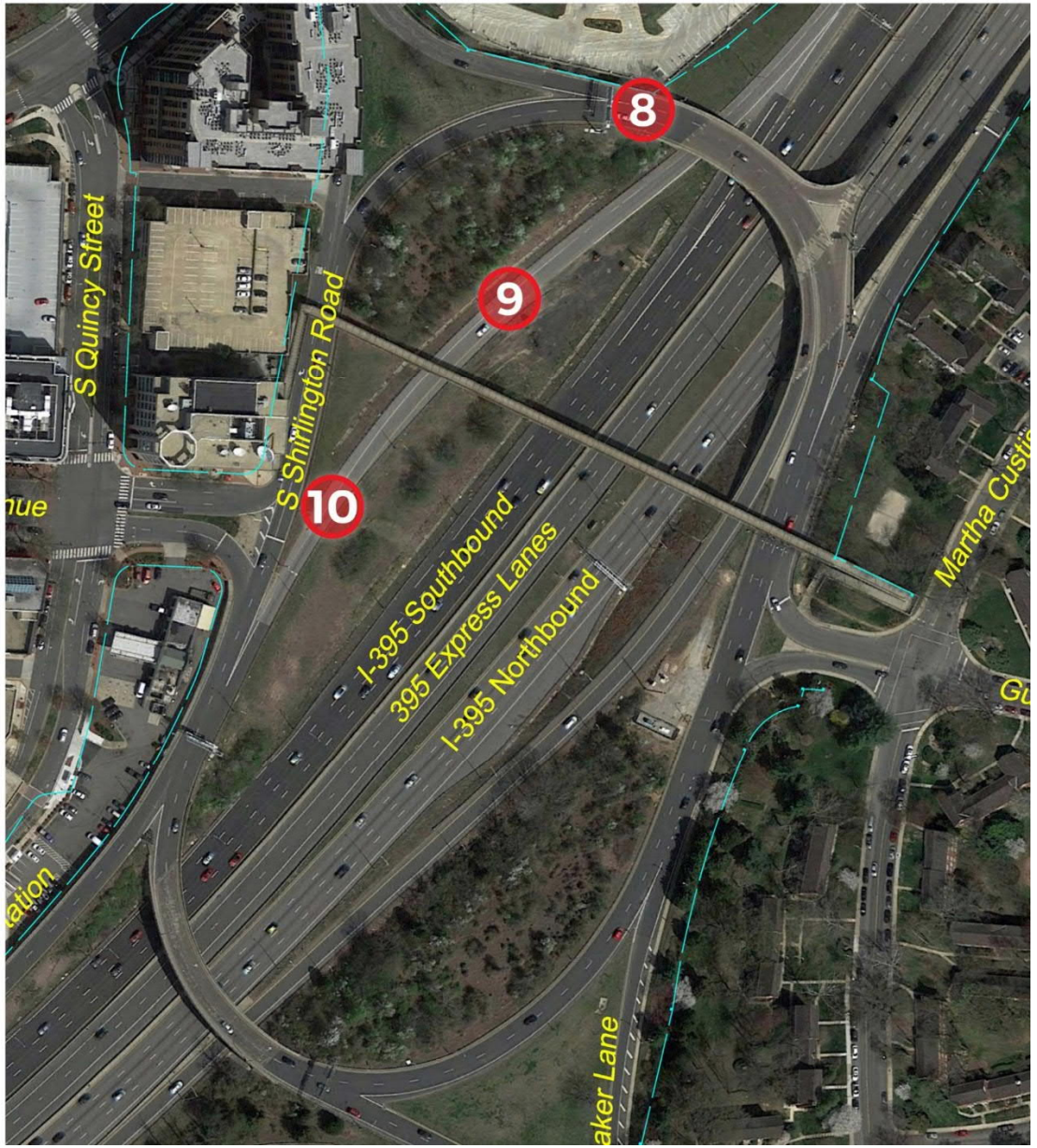

Figure 21. Shirlington Interchange West Modifications

Table 4. Interchange West – Preliminary Improvement Alternatives

Improvement	Description	Benefits	Negative Impacts
8. Add lane to Arlington Mill Road exit.	This would add a second lane to the exit to Arlington Mill Road from the northern section of the rotary.	Reduces multi-lane weave on the northern section of the rotary to a single lane weave.	None identified.
9. Remove SB I-395 exit ramp to N. Quaker Lane.	This would eliminate the SB connection from the Glebe Road interchange directly to the rotary where the ramp currently ties in across from Campbell Avenue.	Eliminates weaving movement from the current ramp terminus on the rotary to exit to NB N. Quaker Lane. It would also preclude vehicles avoiding queues on SB I-395 from using this ramp to return to SB I-395 on the S. Shirlington Road on-ramp.	SB I-395 traffic seeking to access the rotary must divert from existing ramp to the Arlington Mill Road exit and then make a left onto S. Shirlington Road.
10. Convert I-395 SB exit ramp terminus to form a four-legged intersection with Campbell Avenue.	This would realign the current terminus of SB exit ramp to form a four-legged intersection with Campbell Avenue and S. Shirlington Road.	Addresses weaving movement from current ramp terminus on the rotary to exit to NB N. Quaker Lane. It would also address the conflict between right-turning vehicles from Campbell Avenue entering the rotary with vehicles entering the rotary from the current ramp terminus.	None identified.

C. Southbound Ramps from Glebe Road Interchange

The primary goal of the improvement alternatives in this area was to address the merge of the east ramp traffic with the west ramp traffic. This area was the highest priority safety hotspot in the study area. Figure 22 shows the locations of the roadway improvement alternatives that were identified for this area. Table 5 provides a description of each.

Southbound Glebe Road Ramps

1. Merge 2-lane west ramp to 1 lane prior to east ramp to increase merge length for east ramp.
2. Shift west ramp to right shoulder as much as possible to increase merge length for east ramp.
3. Relocate Glebe Road east ramp further east on Glebe Road and tie to I-395 NB on ramp.

Figure 22. Southbound Ramps from Glebe Road Interchange

Table 5. Southbound Ramp from Glebe Road Interchange – Preliminary Improvement Alternatives

Improvement	Description	Benefits	Negative Impacts
1. Merge two-lane west ramp to one-lane prior to east ramp merge.	This would merge the two-lane west ramp into a one-lane ramp prior to east ramp merge area.	Eliminates the east ramp yield and significantly extends the merge area.	This would create a need for west ramp traffic coming from SB I-395 to merge with NB Glebe Road ramp traffic in a short distance. This merge could cause operational issues on the west ramp given the relatively high traffic volumes.
2. Shift west ramp lanes to right shoulder as much as possible.	West ramp would continue to be two lanes but they would be shifted northward.	Allows an extension of the east ramp merge lane.	This would require additional right-of-way.
3. Relocate Glebe Road east ramp further east on Glebe Road, and tie to I-395 NB on ramp.	This would relocate the SB Glebe Road to SB I-395 east traffic movement to tie into existing NB Glebe Road off-ramp to I-395 SB. This would require a new traffic signal on Glebe Road.	Eliminates the existing east ramp and therefore eliminates the merge issue with the west ramp.	The new signal on Glebe Road would be very closely spaced with an existing traffic signal at 26th Road South. This could cause operational issues along Glebe Road.

D. General Interchange Area Improvements

In addition to the site-specific roadway section, ramp and intersection improvements described above, the study team noted a range of general improvements that should be undertaken throughout the study area. These were identified through the field assessment as well through stakeholder and public input. These general improvements are not necessarily linked to any of the site-specific improvements but rather would be implemented as part of ongoing maintenance and safety enhancement activities. These general improvements include the following:

- Fix and replace lighting throughout interchange areas to increase visibility of guardrail, curbs, and islands.
- Refresh pavement markings throughout interchange areas.
- Increase and adjust advanced signing throughout interchange areas to improve driver wayfinding.
- Clear overgrown vegetation throughout interchange areas.
- Upgrade and repair deficient guardrails and concrete barriers.

E. Stakeholder Feedback

Sketches of the preliminary improvement alternatives were created and presented to Arlington County and City of Alexandria staff in June 2016. These stakeholders were given the opportunity to ask questions and discuss their initial reviews and ideas. Their feedback was used to develop a more focused set of potential improvement alternatives that would be the subject of more detailed traffic operations and safety analyses and evaluation in the next phase of this study. This evaluation is documented in the next section of this report.

4. Alternatives Evaluation

Table 6 summarizes the improvements selected for further analysis. Conceptual design plans and a discussion of the traffic and safety impacts of each are then provided following the table. The improvement alternatives associated with the I-395 Shirlington interchange are designated with an "S" (i.e., S-1, S-2, etc.) and improvement alternatives associated with the Glebe Road interchange ramps are designated with a "G" (i.e., G-1, G-2, etc.). At this stage in the study, each improvement alternative concept was evaluated as a stand-alone improvement.

Table 6. Summary of Improvement Alternatives Selected for Further Analysis

Improvement	Description
S-1	Reduce required weave movements by repurposing existing lanes and eliminating low-volume lanes. This can be accomplished with signing and pavement markings.
S-2	Realign and increase the deflection angle of the entrance ramp to reduce speed of North Quaker Lane traffic entering the rotary.
S-3	Add lane to Arlington Mill Road exit to reduce the number of lanes necessary for the weave section on the rotary.
S-4	Create a signalized T-intersection with rotary and North Quaker Lane.
S-5	Convert I-395 NB Shirlington off-ramp to an intersection with Gunston Road.
S-6	Convert I-395 SB off-ramp to intersection with Campbell Avenue.
G-1	Merge two-lane west ramp to one-lane prior to east ramp to increase merge length for east ramp.
G-2	Shift west ramp to right shoulder as much as possible to increase merge length for east ramp.

A. Improvement S-1: Reducing and Repurposing Existing Lanes

This improvement, shown in Figure 23, would convert the left lane on the east side of the rotary into a striped shoulder thereby reducing the number of lanes from three to two south of Gunston Road and from four to three lanes north of Gunston Road.

Improvement S-1 is expected to reduce required weaving maneuvers within the eastern portion of the rotary; however, preliminary analysis indicated an increase in queueing along N. Quaker Lane entering the rotary as those vehicles would have more difficulty finding gaps to enter the rotary. This queuing would potentially negatively impact operations at the upstream Preston Road intersection.

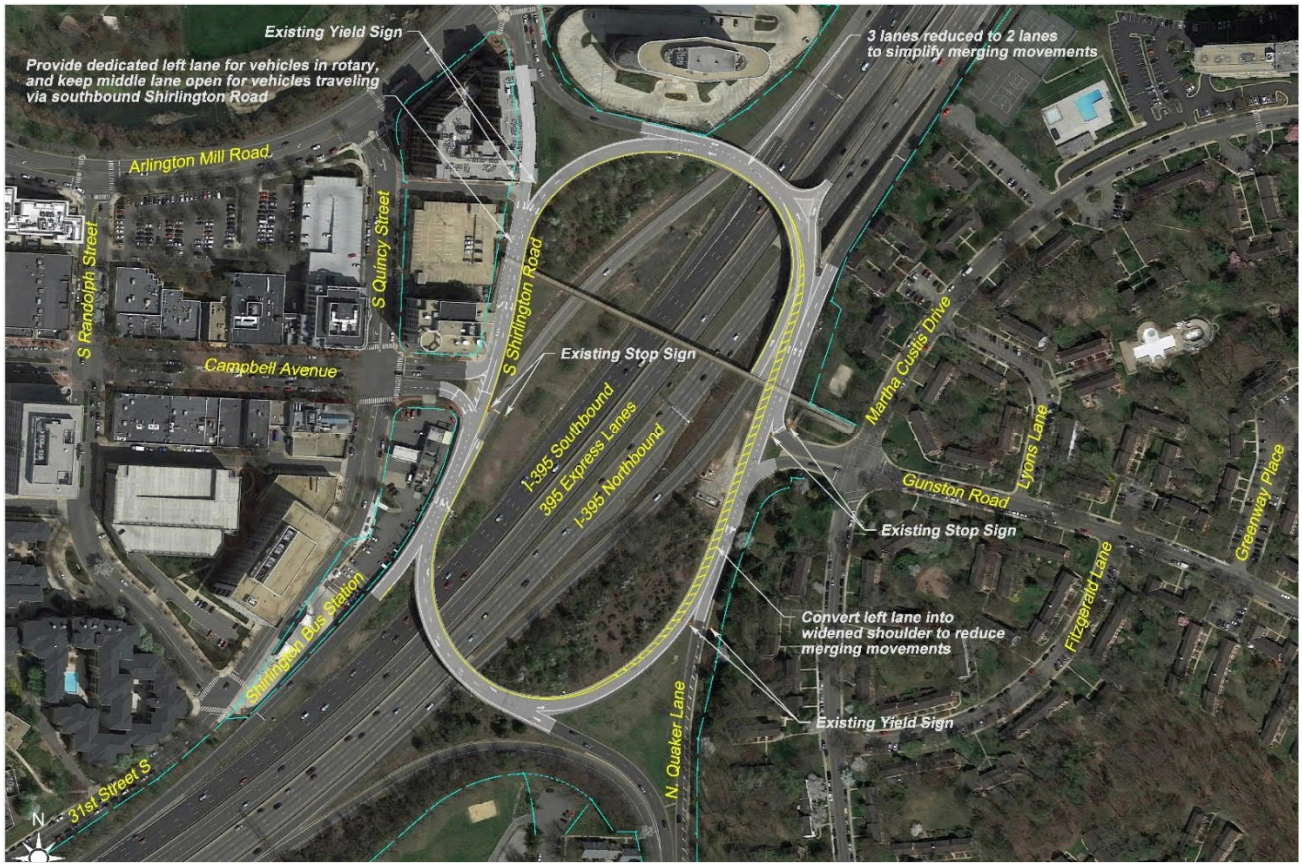

Figure 23. Improvement S-1 Concept

B. Improvement S-2: Realign N. Quaker Lane Ramp

This improvement, shown in Figure 24, would add a bend in the downhill section of N. Quaker lane just prior to the rotary.

Improvement S-2 is expected to improve safety along the N. Quaker Lane approach by better controlling the speeds at which vehicles approach the rotary. Although the safety benefits of S-2 cannot be directly quantified, it is anticipated that the proposed change in entrance angle would slow down entering vehicles, like a roundabout entry, and improve safety for motorists along N.

Quaker Lane and circulating within the rotary. However, from an operations standpoint, Improvement S-2 would not provide any benefits compared to the No Build condition. If anything, S-2 would be expected to slightly worsen the queueing along the N. Quaker Lane approach.

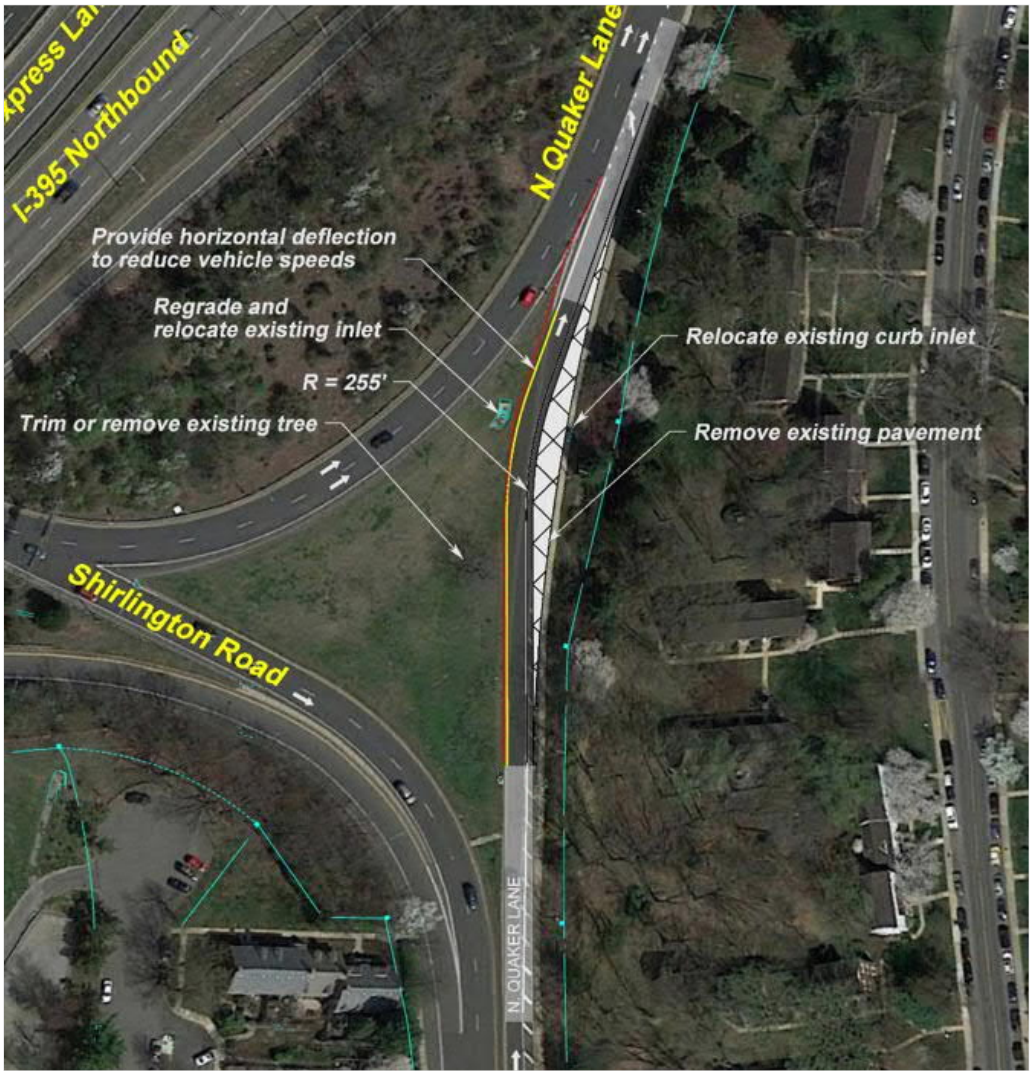

Figure 24. Improvement S-2 Concept

C. Improvement S-3: Add Lane to Arlington Mill Drive Exit

This improvement, shown in Figure 25, would add a second lane to the exit to Arlington Mill Road from the northern section of the rotary. This would reduce the multilane weave on the northern section of the rotary to a single lane weave. Currently, the outside lane of the rotary exits towards Arlington Mill Drive. This configuration requires vehicles entering the rotary on the left from I-395 northbound off-ramp to make two lane changes to exit towards Arlington Mill Drive, where there is only approximately 250 feet between the entry and exit points for drivers to complete these lane changes. Under S-3, the center lane within the rotary would be converted to a choice lane to either exit towards Arlington Mill Drive or continue within the rotary. This would provide two exit lanes

towards the Arlington Mill Drive intersection. The dual-lane exit under S-3 would also provide additional queue storage for the downstream intersection and is not expected to result in any safety or operational deficiency.

Figure 25. Improvement S-3 Concept

D. Improvement S-4: Create Signalized T-Intersection with Rotary and N. Quaker Lane

This improvement, shown in Figure 26, would eliminate the N. Quaker Lane merge into the rotary by re-configuring the southeastern section of the rotary to connect directly to N. Quaker Lane at a new traffic signal. This would eliminate weaving movements on the rotary and reduce speeds on N. Quaker Lane.

The new signalized intersection will operate as a two-phase signal to serve two single lane approaches (one lane coming from the rotary and one lane along N. Quaker Lane). However, with a single lane approach, the preliminary traffic operations evaluation indicated substantial queueing along the rotary approach that would eventually spillback onto S. Shirlington Road, Arlington Mill Drive and I-395 during both AM and PM peak hours. N. Quaker Lane queues would also be lengthy, as well, with only a single lane approaching the proposed signal. Therefore, the traffic analysis results indicated that both approaches should be two lanes with a two-phase signal at this intersection.

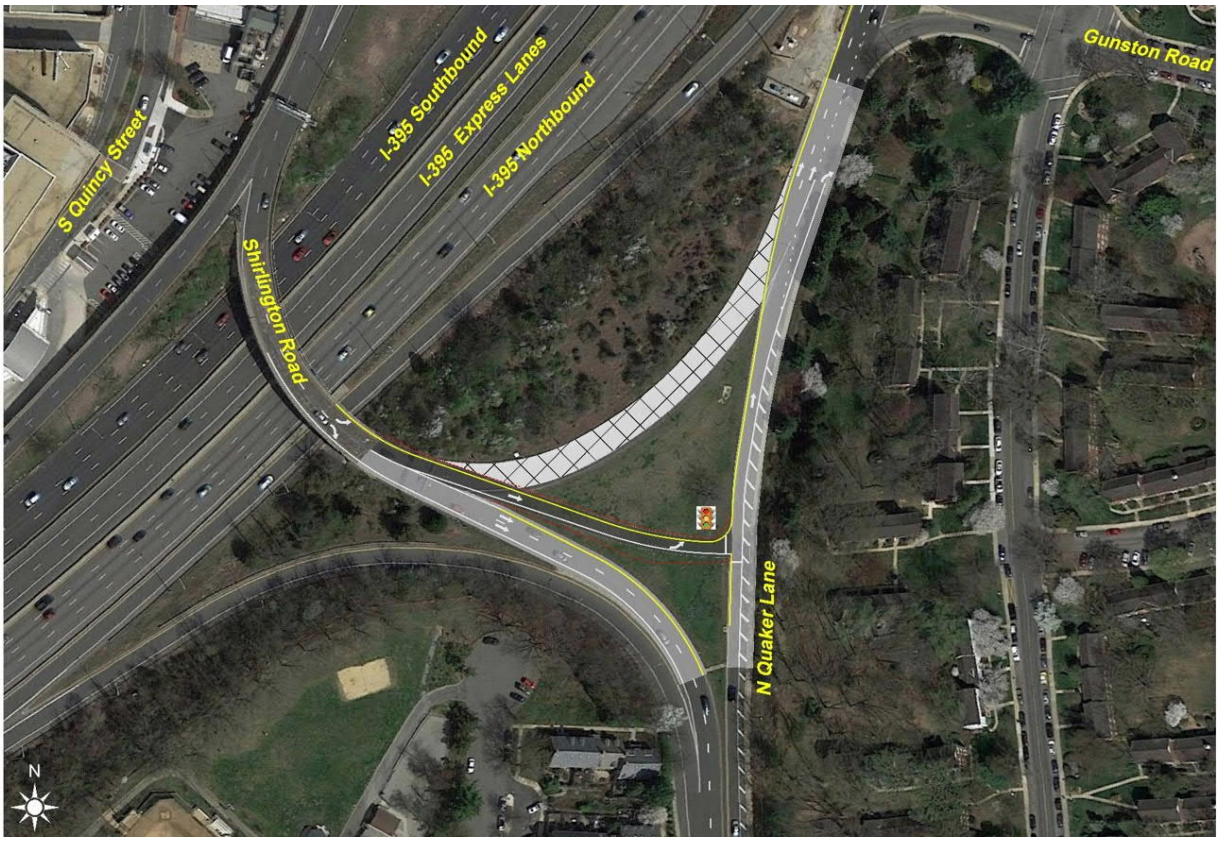

Figure 26. Improvement S-4 Concept

E. Improvement S-5: Create Signalized Intersection with I-395 NB Off-Ramp and Gunston Road

This improvement, shown in Figure 27, would eliminate the connection of the I-395 NB off-ramp to the rotary and instead connect the off-ramp to a new signal at Gunston Road. This would relieve weaves on the northern section of the rotary and would provide unconflicted traffic movement into the rotary from Gunston Road during that approach's green phase. The proposed signal would be expected to induce additional stops for N. Quaker Lane traffic resulting in some increased queuing along N. Quaker Lane.

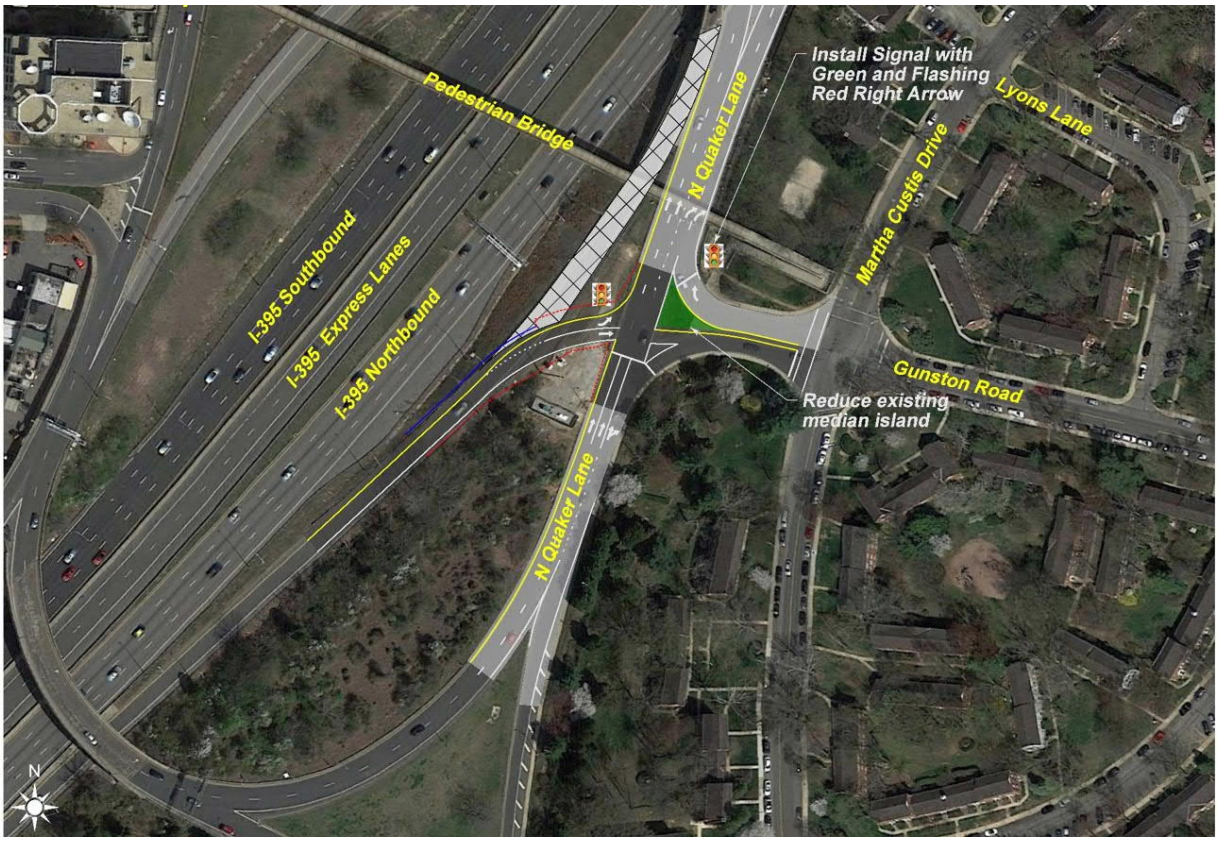

Figure 27. Improvement S-5 Concept

F. Improvement S-6: Create Signalized Intersection with I-395 SB Off-Ramp and Campbell Avenue

This improvement, shown in Figure 28, would realign the current terminus of the SB exit ramp to form a four-legged intersection with Campbell Avenue and S. Shirlington Road. This would address the weaving movement from the current ramp terminus on the rotary to exit to NB N. Quaker Lane. It would also address the conflict between right-turning vehicles from Campbell Avenue entering the rotary with vehicles entering the rotary from the current ramp terminus. Traffic analyses of this improvement showed that it could be expected to reduce queueing along the off-ramp if the new ramp approach leg were made to be a dual left. This improvement could potentially worsen operations along the S. Shirlington Road and Campbell Avenue approaches due to the additional traffic signal phase required for the ramp terminus.

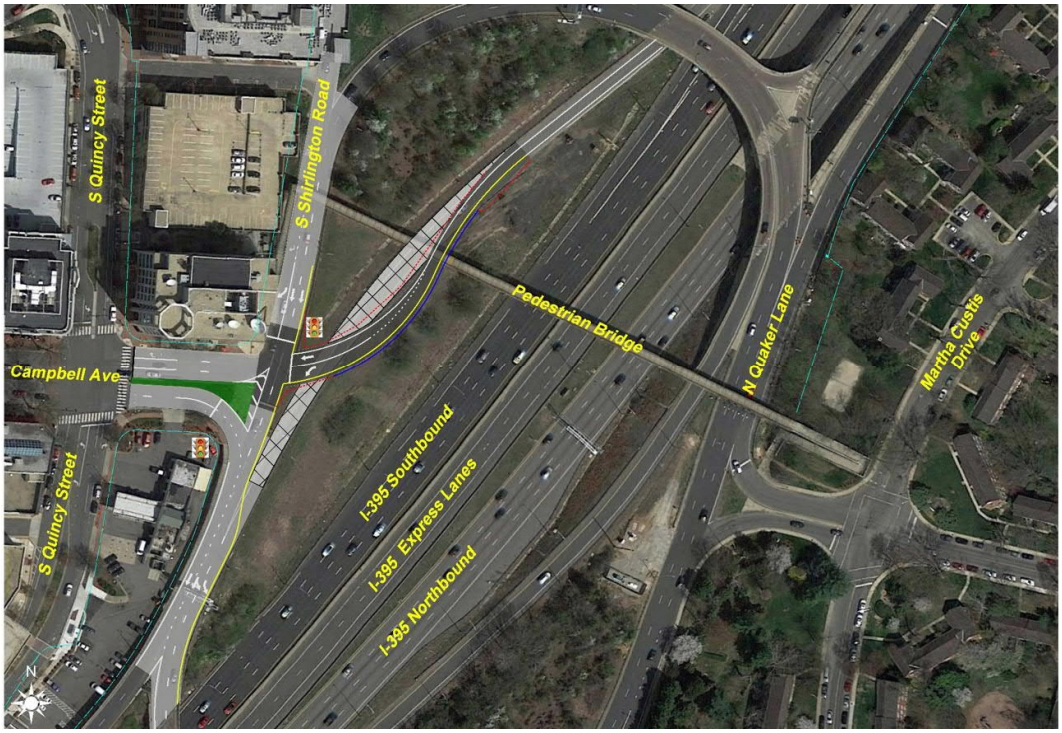

Figure 28. Improvement S-6 Concept

G. Improvement G-1: Merge Two-Lane West Ramp to One-Lane

This proposed improvement, shown in Figure 29, would merge the two-lane west ramp into a one-lane ramp prior to the east ramp merge area. This would eliminate the east ramp yield and significantly extend the merge area. This improvement could have negative impacts on the west ramp as the new one-lane section could result in significant back-ups to SB I-395. In addition, the section where the two-lanes merge down to one lane would be relatively short and could result in unsafe merging movements.

Figure 29. Improvement G-1 Concept

H. Improvement G-2: Shift West Ramp to Shoulder

Under this improvement (shown in Figure 30), the west ramp would continue to be two lanes but they would be shifted northward, thereby allowing an extension of the east ramp merge lane. The fact there would only be a 65-foot extension of the east ramp merge lane indicates the improvement would not result in significant benefit.

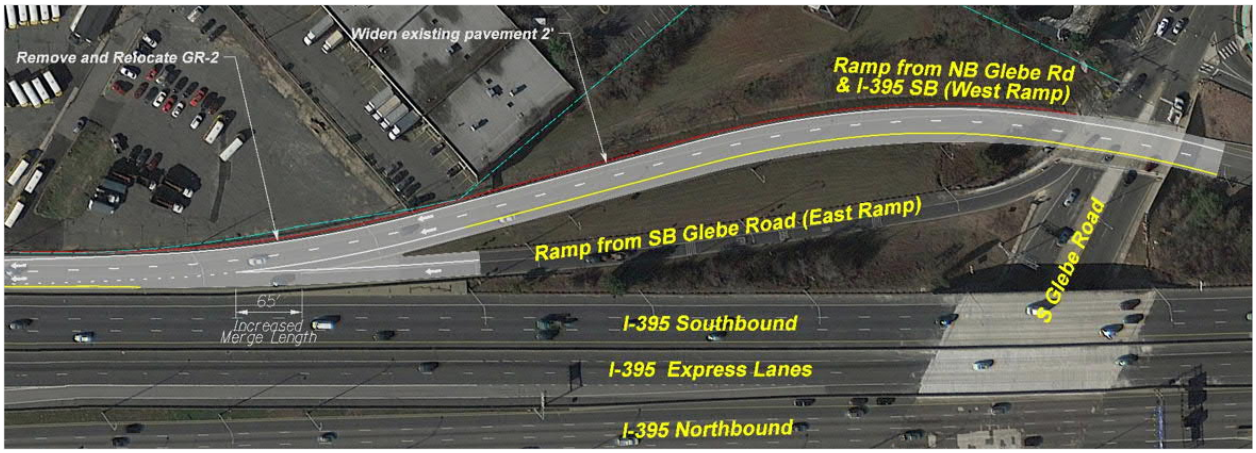

Figure 30. Improvement G-2 Concept

I. Public Input

VDOT hosted a public information meeting on May 21, 2018 to inform and gain feedback on the proposed improvements at the I-395 interchange areas of interest. In addition to receiving feedback from attendees, VDOT collected feedback via email. The public was asked to review each proposed alternative (S-1 through S-6, G-1, and G-2) and explain why they did or did not support each alternative.

Feedback indicated a perception that many drivers entering the rotary from N. Quaker Lane disregard the yield sign. There were multiple comments regarding how dangerous this merge is. There was also a perception that vehicles entering from N. Quaker Lane were traveling too fast. Numerous people suggested additional pavement markings and signage, replacing the yield sign with a stop sign, or even adding a new traffic signal. There were also numerous comments concerning the lack of maintenance of the median between the rotary and the N. Quaker Lane ramp. Several people also commented that pedestrian facilities could be improved.

In response to “What alternative(s) you would support and why?” - the results from the comment sheets that were returned resulted in the following breakdown shown in Figure 31.

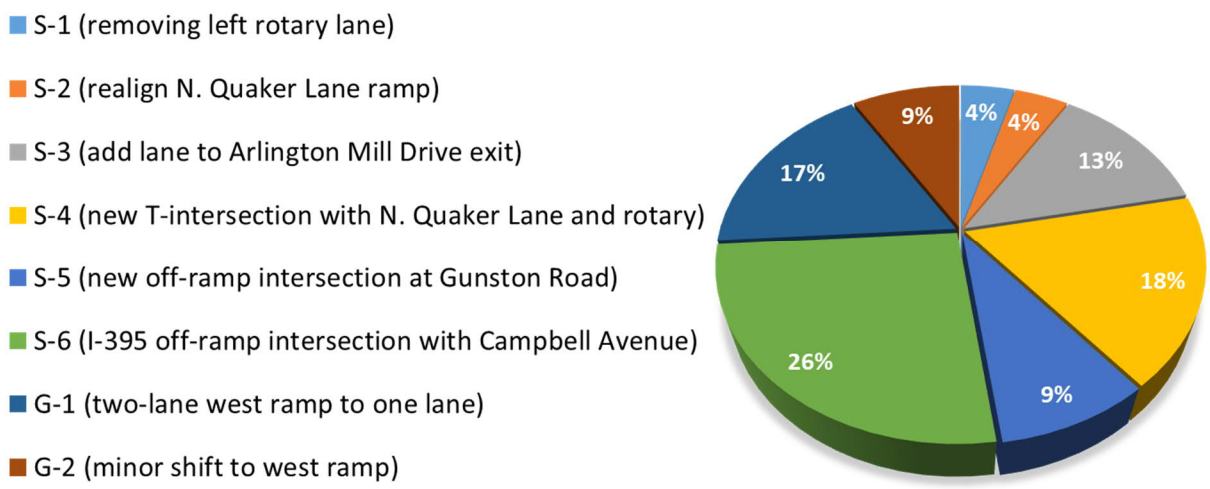

Figure 31. Public Support of Alternatives

5. Hybrid Alternative

A. Conceptual Design

Considering the public input provided on the improvement alternatives and traffic modeling results, design elements from multiple improvement alternatives were combined into one Hybrid Alternative. This alternative, shown in Figure 32, incorporates design elements from S-3, S-4, S-5, and S-6. The proposed improvements include:

- ✓ Additional lane to Arlington Mill Drive exit (Alternative S-3)
- ✓ Signalized T-intersection with rotary and N. Quaker Lane (Alternative S-4)
- ✓ Signalized intersection with I-395 NB off-ramp and Gunston Road (Alternative S-5)
- ✓ Signalized intersection with I-395 SB off-ramp and Campbell Avenue (Alternative S-6)

Both proposed improvement alternatives for the Glebe Road interchange, G-1 and G-2, were determined to be ineffective. The lane reduction improvement G-1 from two lanes to one lane proved to have too negative of a traffic operational impact to implement. The lane shift in improvement G-2 would likely have such a small safety or operational improvement that it would not be cost effective. Thus, neither improvement alternative was advanced. It was determined that improvements required to address issues at this location would include considerable reconfiguration of the Glebe Road interchange, which goes beyond the scope and objectives of this study.

Figure 32. Hybrid Alternative Concept

B. Pedestrian and Bicycle Improvements

As part of the preliminary multimodal assessment, pedestrian and bicycle improvements were developed for the four intersections evaluated as part of the existing conditions assessment documented in Section 2 of this report. These suggestions would be under consideration for implementation as part of ongoing or future projects, and are accurate as of January 2018.

Campbell Avenue and South Quincy Street

The following improvements to pedestrian and bicycle facilities are proposed at this intersection and are shown in Figure 33.

- ✓ Replace the overhead "Turning Vehicles Yield to Pedestrians in Crosswalk" signs with MUTCD R10-15 image signs.
- ✓ Install MUTCD R4-4 "Begin Right Turn Lane Yield to Bikes" sign on northbound approach
- ✓ Install new Bike Route sign on northbound Quincy Street.
- ✓ Remove existing left arrow under the southbound bike route sign since the sign below shows through and left-turn options.
- ✓ Install ADA-compliant curb ramps on southwest, southeast, and northwest corners.
- ✓ Remove detectible warning surface on north median since it is too narrow.
- ✓ Restripe bike lanes and pavement markings to match VA MUTCD requirements.
- ✓ Extend northbound right-turn lane to provide additional storage.

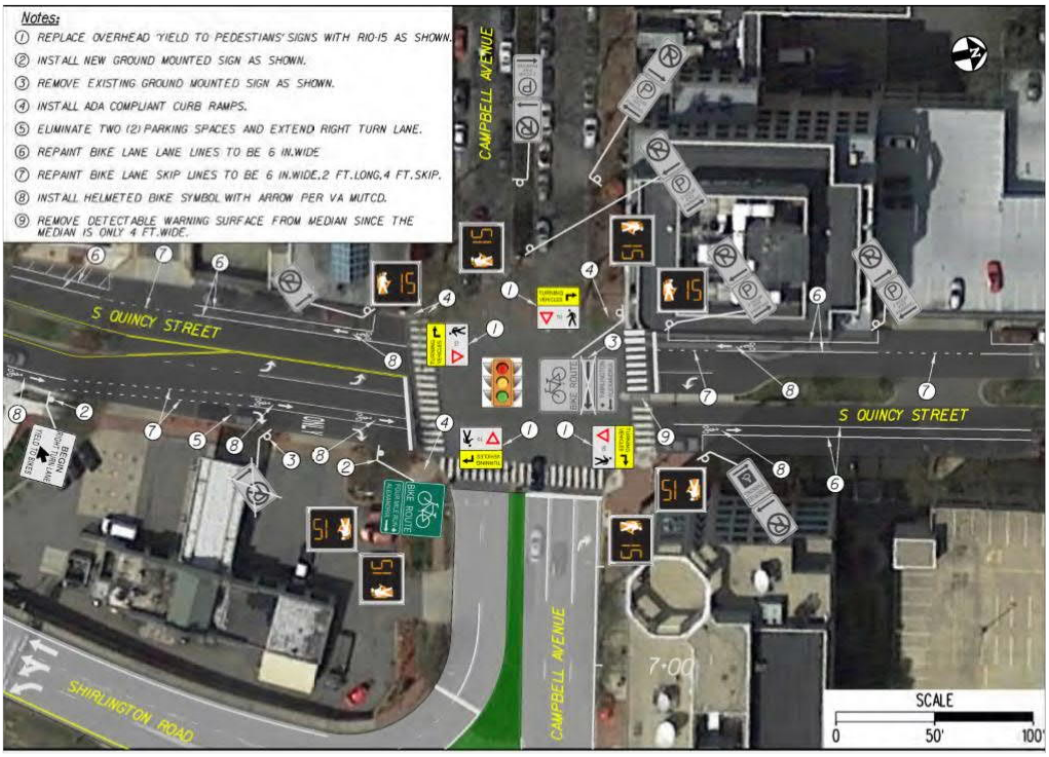

Figure 33. Multimodal Improvements at Campbell Avenue and South Quincy Street

Campbell Avenue and South Shirlington Road

The only existing pedestrian or bicycle facility is the sidewalk on the northwest corner and the southwest corner. No crosswalk exists to connect these two. With the realignment of the eastern leg and updated signalization, pedestrian and bicycle access should be considered. Due to the nature of this intersection, pedestrians are neither expected nor encouraged to use the southwest sidewalk; therefore, no crosswalks are necessary at this study intersection. The following improvements are proposed and are shown in Figure 34.

- ✓ Eliminate the ramp on the northwest corner and rebuild the curb and sidewalk.
- ✓ Install signs indicating pedestrians should use the crosswalk at Quincy Street (R9-3 and R9-3bP assembly.)
- ✓ Install pedestrian lighting in the northwest corner at the start of the pedestrian overpass entrance.

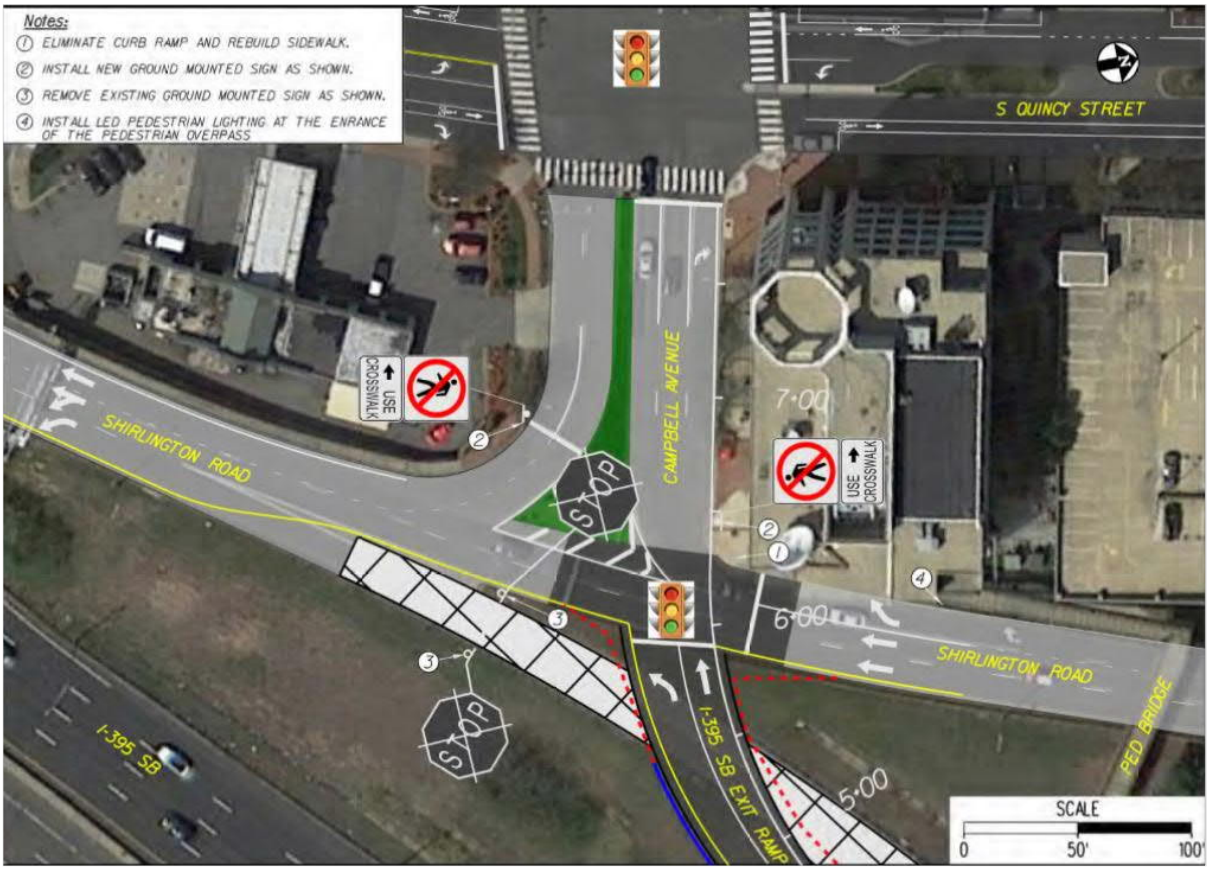

Figure 34. Multimodal Improvements at Campbell Avenue and South Shirlington Road

C. Traffic Operations Impacts

The Vissim traffic flow simulation model that was calibrated and approved by VDOT was used to evaluate the traffic operations impacts of the Hybrid Alternative. Future 2040 traffic operations under the Hybrid Alternative were compared to future 2040 No Build conditions. Under the 2040 No Build condition, the existing lane geometry along all roadways within the interchange area would be retained. The No Build condition assumes conversion of the existing I-395 HOV lanes to HOT lanes as part of the I-395 Express Lanes project and is the only change associated with I-395 outside of this study. Existing trouble spots are anticipated to worsen under the 2040 No Build along the single lane entry on N. Quaker Lane to the rotary and along the stop-controlled approach of the I-395 southbound off-ramp as it approaches the S. Shirlington Road and Campbell Avenue intersection. The Build Condition Hybrid Alternative assumes identical traffic Origin-Destination (O-D) patterns as in the No Build or Existing condition. No additional O-D development efforts were conducted to identify traffic volumes with respect to any new movements (I-395NB Off-Ramp to Gunston Road and I-395SB to Campbell Avenue) introduced as part of the Hybrid Alternative. As these movements do not exist in the Existing or No Build conditions, the corresponding volumes were derived as zero vehicles per hour. Appendix G shows the 2040 traffic volumes that were used for this analysis and Appendix H presents the traffic study memorandum for Hybrid Alternative improvement evaluation and a detailed summary of intersection analysis results.

Overall travel times within the interchange area arterial network under the Hybrid Alternative, including along the rotary, are expected to increase by up to 15% (See Table 7) during peak hours, as compared to 2040 No Build conditions. This increase is mainly attributed to the addition of three new traffic signals that are expected to introduce additional stops along the rotary. It is noted that under the 2040 No Build condition, the delays or congestion are mostly endured by unsignalized entry points or movements, such as northbound N. Quaker Lane at the rotary and southbound S. Shirlington Road at the rotary. However, the new traffic signals under the Hybrid Alternative will reduce the number of unsignalized entry points within the interchange area, and are expected to improve safety and mobility. The new traffic signals in the Hybrid Alternative Model also allow for a protected movement for N. Quaker Lane or time-separated gaps for safe merging for southbound S. Shirlington Road.

Compared to future 2040 No Build conditions, approximately 59% of intersection turning movements (See Attachment E of Appendix H) during the AM and PM peak hour will experience reduced delays under the Hybrid Alternative.

The Hybrid Alternative proposes roadway modifications to the surface streets in the study area without any impacts to the I-395 mainline. The Hybrid alternative AM and PM peak hour travel times along (See Table 8) I-395 peak directions (northbound during AM and southbound during PM) are expected to remain within marginal differences (within 2%) to the No Build condition. Lastly, the vehicular densities are expected to remain at failing level of service, similar to the No Build conditions.

Table 7: Comparison of No Build and Hybrid Alternative Arterial Travel Time Results

Segment	VISSIM ID	Location	AM Peak Hour			% Hybrid (Build) vs No Build
			2016 Model	2040 No Build	2040 Hybrid	
			7AM-8AM	7AM-8AM	7AM-8AM	7AM-8AM
Quaker Ln Northbound	28	Preston Rd to Gunston Rd	64.8	54.2	67.3	24%
	24	Gunston Rd to I-395 NB Ramps	10.6	10.7	10.8	1%
	25	I-395 NB Ramps to Arlington Mill Dr	50.3	53.4	55.8	4%
	26	Arlington Mill Dr to Four Mile Run	24.3	26.0	27.5	6%
	Total Northbound		150.0	144.3	161.3	12%
Shirlington Rd Southbound	21	Four Mile Run to Arlington Mill Dr	37.0	39.6	39.7	0%
	22	Arlington Mill Dr to Campbell Ave	44.2	43.2	38.6	-11%
	27	I-395 SB On Ramp to Preston Rd	47.8	47.0	48.4	3%
	Total Southbound		129.0	129.9	126.8	-2%
Loop Northbound	30	I-395 NB On-Ramp to Campbell Ave	40.8	40.0	41.5	4%
	Total Northbound		40.8	40.0	41.5	4%
Loop Southbound	23	Campbell Ave to Gunston Rd/Quaker Ln	46.0	46.2	89.7	94%
	Total Southbound		46.0	46.2	89.7	94%
Total Arterial Travel Time			365.8	360.4	419.2	16%
Segment	VISSIM ID	Location	PM Peak Hour			% Hybrid (Build) vs No Build
			2016 Model	2040 No Build	2040 Hybrid	
			5PM-6PM	5PM-6PM	5PM-6PM	7AM-8AM
Quaker Ln Northbound	28	Preston Rd to Gunston Rd	44.3	122.9	77.5	-37%
	24	Gunston Rd to I-395 NB Ramps	10.3	11.0	10.8	-2%
	25	I-395 NB Ramps to Arlington Mill Dr	47.9	64.8	59.1	-9%
	26	Arlington Mill Dr to Four Mile Run	17.0	25.3	21.0	-17%
	Total Northbound		119.6	224.0	168.3	-25%
Shirlington Rd Southbound	21	Four Mile Run to Arlington Mill Dr	83.4	87.4	87.9	1%
	22	Arlington Mill Dr to Campbell Ave	48.1	54.9	78.5	43%
	27	I-395 SB On Ramp to Preston Rd	46.8	52.9	58.7	11%
	Total Southbound		178.2	195.2	225.1	15%
Loop Northbound	30	I-395 NB On-Ramp to Campbell Ave	41.2	43.2	62.1	44%
	Total Northbound		41.2	43.2	62.1	44%
Loop Southbound	23	Campbell Ave to Gunston Rd/Quaker Ln	42.6	43.2	109.3	153%
	Total Southbound		42.6	43.2	109.3	153%
Total Arterial Travel Time			381.6	505.6	564.8	12%

Table 8: Comparison of No Build and Hybrid Alternative I-395 Travel Time Results

Direction	Location	Existing	2040 No Build	2040 Hybrid
		AM Peak Hour (7AM-8AM)		
I-395 Northbound	NB Between King St Ramps	114.5	121.0	123.4
	NB Between Quaker St Ramps	53.7	53.7	54.7
	NB Weaving Btwn Quaker & Glebe	89.6	90.3	91.2
	NB Btwn Glebe Rd NB Ramps	63.6	64.7	65.0
	NB North of Glebe Rd	128.2	128.2	128.4
	Total Northbound	449.6	458.0	462.6
I-395 Southbound	SB Btwn Glebe Rd SB Ramps	34.3	34.4	34.4
	SB Weaving Btwn Quaker & Glebe	28.3	28.5	28.5
	SB Btwn Quaker Ln Ramps	13.1	13.1	13.1
	SB Btwn Quaker Ln & King St	8.5	8.5	8.5
	SB Between King St Ramps	44.5	44.7	44.7
	Total Southbound	128.7	129.2	129.2
Direction	Location	Existing	2040 No Build	2040 Hybrid
		PM Peak Hour (5PM-6PM)		
I-395 Northbound	NB Between King St Ramps	43.2	46.4	46.6
	NB Between Quaker St Ramps	17.9	19.2	19.2
	NB Weaving Btwn Quaker & Glebe	32.5	34.5	35.3
	NB Btwn Glebe Rd NB Ramps	25.6	25.9	26.0
	NB North of Glebe Rd	53.0	53.2	53.3
	Total Northbound	172.2	179.3	180.4
I-395 Southbound	SB Btwn Glebe Rd SB Ramps	118.6	80.6	81.2
	SB Weaving Btwn Quaker & Glebe	93.0	71.0	74.6
	SB Btwn Quaker Ln Ramps	47.2	38.0	40.3
	SB Btwn Quaker Ln & King St	43.9	38.3	40.0
	SB Between King St Ramps	148.1	148.6	148.8
	Total Southbound	450.9	376.4	384.9

D. Safety Impacts

It is anticipated that the elimination of the uncontrolled merging and weaving maneuvers would result in safer streets. The Hybrid Alternative will reduce the number of non-signal-controlled entry lanes to the rotary from seven to three. In addition, the number of weaving sections will be reduced from five to two. The reduction in non-signal-controlled entry lanes and weaving sections should reduce the potential for crashes at these locations. Under the Hybrid Alternative concept, conflicts between rotary traffic and entering traffic would be time-separated at up to three additional

locations compared to No Build conditions. This will not only reduce the potential for conflicts directly at the entry points, but also reduce weaving movements between access points and enhance safety compared to the existing configuration. Below is a summary of expected safety benefits at the hot spot crash locations identified earlier in this report.

Hot Spot 1: Southbound I-395 Off-Ramp and Glebe Road East and West Ramp Merge

This rear-end crash hot spot is located outside of the vicinity of the proposed Hybrid Alternative concept improvements. The No Build conditions analysis anticipates significant congestion at this location with queue spillback from the S. Shirlington Road and Campbell Avenue intersection, which is a safety concern for rear-end crashes. However, improved traffic operations at the downstream I-395 SB off-ramp and Campbell Avenue would preclude spillback into this hot spot crash location.

Hot Spot 2: Interchange West including Campbell Avenue Entrance and S. Shirlington Road Merge

Under the No Build conditions, the I-395 SB off-ramp would operate as a stop-controlled approach with significant congestion and over a one-half-mile queue spillback reaching the upstream Glebe Road interchange. Furthermore, the off-ramp traffic is expected to merge with the rotary traffic within a relatively short distance of approximately 100-feet. The existing crash data indicate a mix of rear-end, angle and sideswipe collisions. The Hybrid Alternative concept proposes signalizing the off-ramp approach, which is anticipated to reduce the potential conflict for sideswipe and angle crashes due to non-signal controlled entering traffic. Additionally, the improved overall intersection operations under the Hybrid Alternative concept would reduce the number of stops and would potentially lead to fewer rear-end crashes.

Hot Spot 3: Interchange East including Gunston Road Entrance and N. Quaker Lane Merge

The existing crash data indicate a mix of rear-end, sideswipes, angle and fixed object crashes at this location. This location is also known to experience high speed (45+mph) traffic in lanes alongside of merging and weaving maneuvers. Most notably, at the weaving junction along the rotary between Gunston Road entrance and N. Quaker Lane merge. The Hybrid Alternative concept proposes two closely spaced signals within this junction that would eliminate weaving maneuvers upstream of the Gunston Road intersection resulting to a potential reduction in angle and sideswipe crashes.

Hot Spot 4: S. Shirlington Road to N. Quaker Lane

The primary crash types at this location are angle and side swipes attributed to high speeds (45+ mph). New signalization of the SB I-395 off-ramp to N. Quaker Lane/Campbell Avenue intersection and the new T-intersection with the rotary and N. Quaker Lane will mitigate the excessive speed and weaving issues at this location.

E. Potential Project Phasing

With limited available funding for transportation projects, the project team conducted an assessment to determine if the proposed Hybrid Alternative could feasibly be separated into separate phased construction projects. This could allow some improvements to be completed earlier or for each jurisdiction (City of Alexandria and Arlington County) to proceed at their own pace to

complete. The Hybrid Alternative can be separated into four distinct projects with independent utility, which means these projects can function independently of each other. They are:

1. Signalized T-intersection with rotary and N. Quaker Lane
2. Signalized intersection with I-395 SB off-ramp and Campbell Avenue
3. Signalized intersection with I-395 NB off-ramp and Gunston Road
4. Additional lane on Arlington Mill Drive exit from the rotary

An evaluation matrix was developed to assess how well each potential project meets the identified needs and project goals in the areas of Safety, Operations, and Public Opinion (identified as an area of significant concern). This evaluation matrix is presented in Figure 35.

Each project was ranked according to its performance in the metrics. The findings of the evaluation determined that "Signalize Rotary at N. Quaker Lane" would be the most effective standalone project. This option would address the most notable safety hotspot identified in the study are and eliminate a high-speed entry to the rotary and an uncontrolled weaving segment. This area was identified by the public as being of primary concern.

The second highest ranked project was "Signalize I-395 SB off-ramp and Campbell Avenue." This project similarly addressed a crash hotspot while providing a widened off-ramp from I-395 SB with additional queue storage to reduce upstream impacts along I-395. The next ranked project was "Signalize I-395 NB off-ramp & Gunston Road." This option addressed a safety hotspot, eliminated additional uncontrolled weaving segments, and addressed an area of significant public concern. The final ranked project was "Widen Exit to Arlington Mill Drive" This project addresses a concern with uncontrolled weaving across lanes, but was not an identified crash hotspot and not viewed by the public as an area of significant concern.

These project rankings are not intended to prioritize these projects, but provide additional information to stakeholders and local elected officials when considering potential funding opportunities to make the proposed improvements. Completing all projects together as the Hybrid Alternative would still provide the best overall benefits to safety and operations in the study area.

Goal/Need	Metric	Hybrid Alternative	Signalize Rotary and N Quaker Ln	Signalize I-395 SB off-ramp & Campbell Ave	Signalize NB I-395 off ramp & Gunston Rd	Widen Exit to Arlington Mill Drive
Safety	Addresses crash hot spots	●	●	●	●	○
	Addresses weaving across lanes	●	●	◐	●	●
Operations	Adds capacity to the roadway	●	●	●	○	○
	No additional queuing	●	◐	●	○	●
	Does not significantly affect the travel time	●	◐	◐	◐	●
Public Opinion	Area of significant concern	●	●	◐	●	○
Rankings	Determined by above metrics	-	1	2	3	4

● - Meets goal/need ◐ - Partially meets goal/need ○ - Does not meet goal/need

Figure 35. Project Phasing Evaluation Matrix

F. Cost Estimate

Scoping level cost estimates were developed using quantity takeoffs from the concept level plans, unit prices from VDOT's AASHTOWare system, and applying planning-level contingency amounts. Table 9 summarizes the project cost for the Hybrid Alternative and presents the costs if the individual elements were to be constructed as separate construction projects. There is a cost savings in designing and constructing the Hybrid Alternative as one project due in part to economy of scale, as a proportionate savings in cost would be gained for Preliminary Engineering (e.g., plan/bid document preparation and public involvement) and Construction (e.g., mobilization and maintenance of traffic) activities by delivering one larger project rather than four separate smaller projects. Please refer to Appendix I for complete cost estimates including costing assumptions.

Table 9. Cost Estimate Summary

Alternatives		Preliminary Engineering	Right of Way/ Utilities	Construction	TOTAL
Single Construction Project					
Hybrid Alternative		$1,240,000	$400,000	$8,050,000	$9,690,000
Ranking	Phased Construction Projects				
1	Signalize Rotary and N. Quaker Ln	$700,000	$75,000	$2,480,000	$3,255,000
2	Signalize I-395 SB off-ramp and Campbell Ave	$700,000	$200,000	$2,520,000	$3,420,000
3	Signalize NB I-395 off-ramp and Gunston Rd	$740,000	$75,000	$2,700,000	$3,515,000
4	Widen Exit to Arlington Mill Drive	$355,000	$50,000	$510,000	$915,000
	Total	$2,495,000	$400,000	$8,210,000	$11,105,000

G. Public Input

VDOT hosted a second public information meeting on June 12, 2019. This public meeting presented the Hybrid Alternative concept developed for the study interchange, including an evaluation matrix ranking the proposed improvements at each of concerned locations. It included display boards depicting the elements of the recommended Hybrid Alternative, a video simulation, and a formal presentation by VDOT, followed by an open question and answer session. There were 22 questions raised by citizens attending the PIM#2; they covered topics of enforcing traffic laws, funding, personal observations at the various intersections, and how long before improvements could be implemented if fully funded. Twenty-five comments were received during the month-long comment period following the meeting. Approximately 55 percent of the comments were in favor of the Hybrid Alternative, with approximately 15 percent of the comments expressing disfavor with the recommended option. The remaining (approximately 30 percent) comments were not in opposition to the recommended Hybrid Alternative, but were related to potential modifications or additions to the recommended improvements (some of which were beyond the scope of this study).

The areas most frequently commented upon by the public included the intersection of the rotary at Gunston Road and the proposed relocated I-395 NB off-ramp (eight comments), the intersection of the rotary at Campbell Avenue and the I-395 SB off-ramp (seven comments), and the dual-lane Shirlington Road entry into the rotary. For the Gunston Road area, the input generally focused on the need to ensure safety and not increase delays within the Fairlington neighborhood, especially along Gunston Road and Martha Custis Drive. For Campbell Avenue, the public input was mixed related to providing direct access from the I-395 SB off-ramp to Campbell Avenue, and focused on ensuring that Campbell Avenue operations were improved. For the dual-lane Shirlington Road entry into the rotary, some citizens expressed concern with the current lane configuration and who had the right of way at the dual lane entry; no specific improvements were proposed at this location as part of the Hybrid Alternative. Lastly, several comments suggested that lower cost improvements (signing, striping, and enforcement) could address the issues at this interchange without the need for more substantial infrastructure improvements.

6. CONCLUSIONS

A. RECOMMENDATIONS

This study's primary purpose was to identify safety and operational issues, develop and evaluate improvements, and recommendations to improve them. It was envisioned that the recommendations would be implemented with a future project (or projects) that will provide the necessary improvements and will address safety and operational issues.

The crash analyses demonstrate that the interchange has four distinct hot spots that are addressed with this study. The safety improvements identified through this project address conflicts between rotary traffic and entering traffic at the four locations compared to No Build conditions. The improvements reduce potential vehicular conflicts directly at the entry points and weaving movements between access points, enhancing safety compared to the existing configuration.

The recommended improvements were developed by gathering information from field observations, crash analyses, operational analyses, traffic studies, and public input. The outcome of this process is a list of four recommended improvements and associated planning-level cost estimates, which are summarized in Appendix I. The total planning level cost of the improvements is estimated between $9,690,000 and $11,105,000. The range of costs of the improvements is based on whether it is constructed all at once or if it will be phased by implementing the individual alternatives separately as funding is available.

The new traffic signals will reduce the number of unsignalized entry points within the interchange area, and are expected to improve safety by removing high-speed approaches into the interchange and reducing weaving movements.

The overall traffic operations under the Hybrid Alternative are improved as compared to the 2040 No Build conditions. Overall travel times within the interchange area arterial network under the Hybrid Alternative, including along the rotary, are expected to increase by up to 15% during peak hours, as compared to 2040 No Build conditions. This increase in travel times is primarily based on

the introduction of the new signals. Based on funding and project scope, a tradeoff may be required between travel times and safety. However, 56% of intersection turning movements during the AM peak hour will experience reduced delays under the Hybrid Alternative, while 54% of the turning movements during the PM peak hour will also experience reduced delays compared to future 2040 No Build conditions. It is anticipated that there would be minimal operational impacts, if any, along the I-395 mainline.

There are many challenges for pedestrians and bicyclists traversing the interchange from Arlington County to the City of Alexandria. Fortunately, crossing I-395 is facilitated by a grade separation pedestrian bridge providing a grade separated means to get from the Shirlington to the Fairlington neighborhoods sides of the interchange without having to negotiate vehicular traffic. Where pedestrians and bicyclists do encounter crossings on the perimeter of the interchange, the introduction of signals with the alternatives enhance the safety of the pedestrians/bicycles and reduce severity of vehicular conflicts.

Based on the input received from the public and localities, there appears to be moderate support for changes to the I-395 Shirlington Interchange to address current and future safety and operational issues. Many citizens cited safety and crash concerns. However most crashes resulted in property damage and not in personal injury or fatalities. Operational issues mentioned such as queuing from I-395 and the disregard of proper driving etiquette will not necessarily be addressed with these improvements.

It is recommended that the improvements identified in Section 5 for the Hybrid Alternative be carried forward for implementation. Currently, the impetus for funding projects has fallen to the localities, as funding sources that were previously available to VDOT have become application based and locality-driven. Therefore, in order for a project to be funded, localities must prioritize it and submit applications for the appropriate funding sources. In this way, a project may receive some or all of the necessary funds.

B. Next Steps

The next steps for this project are presented to assist VDOT, localities, and other stakeholders and parties to plan for progressing and further defining the improvements associated with this project. These next steps include:

- ✓ Localities commit to sponsoring the project and provide additional funds should the project moves forward as a Single Construction Project.
- ✓ Localities commit to sponsoring various phases of the project and provide additional funds so that the project moves forward as a Multi-phased Construction Project.
- ✓ Develop the Interstate System Change Request that describes the project and a statement of need for the Hybrid Alternative; if approved by FHWA, move forward with the preparation of the IMR.

- ✓ Obligate and designate the VDOT funds that are available for this project to initiate the Interchange Modification Report (IMR) and if warranted, construct Arlington Mill Drive alternative.

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