PROJECT PIPELINE

ST-23-10: FREDERICK COUNTY
US 50 (MILLWOOD PIKE) FROM I-81 SOUTHBOUND OFF-RAMP TO TULANE DRIVE

DRPT Virginia Department of Rail and Public Transportation

Office of INTERMODAL Planning and Investment

VDOT Virginia Department of Transportation

US 50 (Millwood Pike) from I-81 Southbound Off-Ramp to Tulane Drive

Final Report

July 2024

Prepared for

VDOT Virginia Department of Transportation

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Chapter 1:

Needs Evaluation and Diagnosis

Introduction:

Project Pipeline is a performance-based planning program to identify cost-effective solutions to multimodal transportation needs in Virginia. Through this planning process, projects and solutions may be considered for funding through programs, including SMART SCALE, revenue sharing, interstate funding, and others. Visit the Project Pipeline webpage for additional information: vaprojectpipeline.org.

This study focuses on concepts targeting identified needs including congestion mitigation, safety improvement, pedestrian and bicycle infrastructure along the corridor, and transit access. The objectives of Project Pipeline are shown below in **Figure 1.**

Figure 1: Project Pipeline Objectives

Background

The Office of Intermodal Planning and Investment (OIPI) prepared the VTrans Virginia's statewide transportation plan for the Commonwealth Transportation Board (CTB) in which mid-term needs (0 - 10 years) were identified for different categories listed in **Table 1**. This study focuses on addressing needs identified in VTrans, and those previously identified by the localities.

Table 1: List of VTrans Needs

VTrans Needs
Safety Improvement
Transportation Demand Management
Congestion Mitigation
Pedestrian Safety Improvement
Transit Access
Capacity Preservation
Bicycle Access

Methodology

The study is broken down into three (3) phases. Phase I is the problem diagnosis and brainstorming alternatives, Phase II is the alternative evaluation and sketch level analysis, and Phase III is the investment strategy and cost estimates. Details on methods and solutions for each study phase are outlined below in **Figure 2**.

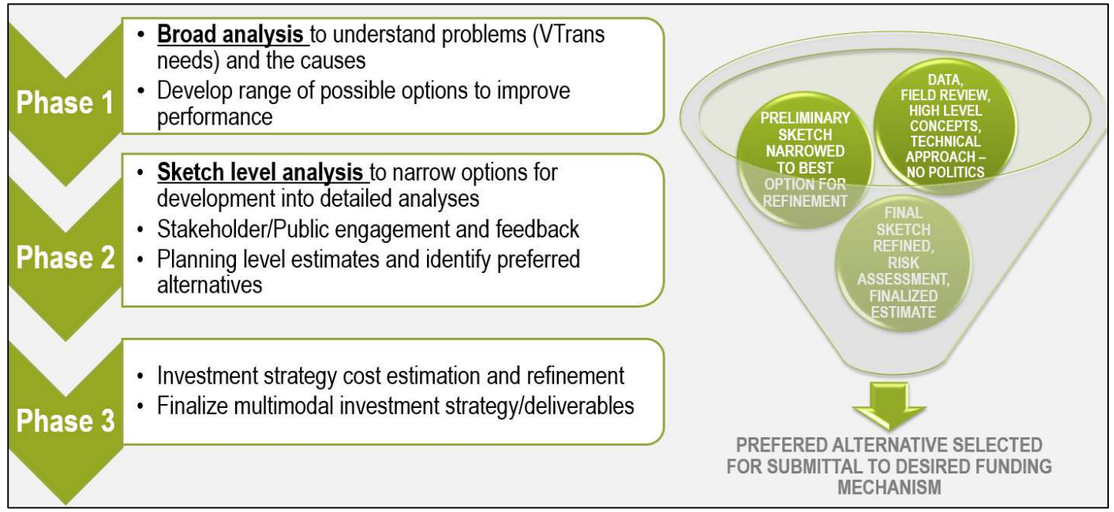


Figure 2: Study Phase Methods and Solutions

The study team is broken down into Technical Teams to improve the efficiency and effectiveness of the study process through extensive collaboration and synchronicity. To achieve the intended efficiency and consistency, it is generally expected that the same Technical Team will be responsible for all studies within a district for the duration of the cycle.

Each Technical Team will include certain leadership and technical roles that will be needed for each study, including the following:

- VDOT District Planning Project Manager – Provides leadership and direction; has overall responsibility for the study progress and outcomes.
- Consultant Team Manager – Provides direct support to the VDOT District Planning Project Manager; coordinates the work and technical efforts of consultant staff.
- District Planning Staff – Provides technical input regarding capacity, forecasting, land use, multimodal, and planning.
- District Traffic Engineering Staff – Provide technical input regarding safety and operations.
- Consultant Team Technical Staff – Provides multidisciplinary input, analysis, technical support, and expertise for the identified VTrans need categories.

A sample organizational chart, including the roles, responsibilities, and structure of a Technical Team is shown below in **Figure 3**.

Figure 3: Structure of a Technical Team

Additional team members and roles should be considered where appropriate. Certain roles may not be necessary for all studies. However, the following roles may contribute to study success during different stages and/or for different types of study areas, as shown in **Table 2**.

Table 2. Roles and Responsibilities for the Technical Team and SWGs

Phase	Responsibility	Role					
		OIPI/Program Support	District	Consultant	DRPT	Locality	VDOT Central Office
Study Selection & Initiation	Identify Study Needs and Priorities		X		X	X	
	Coordinate with CTB Members	X	X				
	Approve final study locations	X					
	Data Collection Planning		X				
	Data Dashboards	X					
	Assign Consultants & Issue Consultant Task Orders	X					X
Phase 1	Initiate Study & Hold Kickoff Meeting		X	X	X		
	Prepare Framework Document		X	X			
	Approve Framework Document		X		X	X	
	Provide Existing Data		X		X	X	
	Collect New Data			X			
	Coordinate with local leaders					X	
	Conduct & Support Initial Public Outreach (if desired)	X	X	X		X	X
	Diagnose Existing Needs			X			
	Brainstorm & Develop Preliminary Alternatives		X	X	X		X
	Present Diagnosis & Alternatives to SWG			X			
	Provide Feedback and Input on Analysis & Alternatives					X	
	Develop Phase 2 Scope of Work			X			
	Approve Scope & Issue Consultant Task Orders	X					X
Phase 2	Conduct Detailed Analysis of Alternatives			X			
	Develop Refinements to Alternatives		X	X	X		X
	Present Alternative Analysis Findings to SWG		X	X			
	Provide Feedback on Alternatives				X	X	X
	Prepare Planning Level Cost Estimates			X			
	Conduct & Support Public Outreach on Alternatives	X	X	X		X	
	Concurrence on Preferred Alternative(s)		X		X	X	X
	Develop Phase 3 Scope of Work			X			
	Approve Scope & Issue Consultant Task Orders	X					X
Phase 3	Conduct Alternative Risk Assessment		X	X			X
	Develop Practical Concept Design & Address Risk of Preferred Alternative		X	X			
	Prepare Cost Estimate with Workbook			X			
	Document Assumptions & Basis of Cost			X			
	Review & Concur with Concept & Estimate		X		X		X
Investment, Application, & Closeout	Prepare Final Study Deliverables, Design Packages, and Estimates			X			
	Apply for Funding of Preferred Alternative(s)				X	X	
	Application Support	X	X	X			
	Submit and Documentation and All Related Work			X			
	Review and approve final deliverables for public visibility		X		X		
	Program Closeout and Summary	X					

Study Area

The US 17/ US 50 (Millwood Pike) study corridor, extending from I-81 Southbound Off-Ramp to Tulane Drive is located in Frederick County, Virginia. The operations analysis model also includes the intersection of US 50 at Mall Boulevard/University Inn and US 522 and Delco Plaza/Travelodge Inn to account for their impact on the study area. Within the study area, the eastern leg of US 17/US 50 and US 522 is classified as minor arterial, while the western leg of US 17/US 50 is classified as "other principal arterial". The posted speed limit is 35 MPH for US 522 and US 17/US 50. **Figure 4** below is a map detailing the locations of the study intersections.

Figure 4: US 50 Study Area Map

VTrans is Virginia's statewide transportation plan. It identifies and prioritizes locations with transportation needs using data-informed transparent processes. The policy for identifying VTrans mid-term needs establishes multimodal need categories corresponding to the Commonwealth Transportation Board-adopted VTrans visions, goals, and objectives.[1] Each need category has one or more performance measures and thresholds to identify one or more needs. Visit the Vtrans policy guide for additional information: https://vtrans.org/resources/VTrans_Policy_Guide_v6.pdf.

[1] Commonwealth Transportation Board, Actions to Approve the 2019 VTrans Vision, Goals, Objectives, Guiding Principles and the 2019 Mid-term Needs Identification Methodology and Accept the 2019 Mid-term Needs, January 15, 2020

The mid-term needs, as identified in VTrans for the US 50 study corridor, were identified as 'Very High' for Bicycle Access, Pedestrian Access, Transit Access, and Transportation Demand Management, 'High' for Capacity Preservation and Safety Improvement and 'Low' for Congestion Mitigation, as presented in **Table 3.**

Table 3: VTrans Needs in Study Area

Bicycle Access	Very High
Capacity Preservation	High
Congestion Mitigation	Low
IEDA (UDA) Access	None
Pedestrian Access	Very High
Safety Improvement	High
Pedestrian Safety Improvement	None
Reliability	None
Rail On-time Performance	Select
Transit Access	Very High
Transit Access for Equity Emphasis Areas	None
Transportation Demand Management	Very High

These mid-term needs, identified in VTrans, are prioritized on a tier from 1 to 4, with 1 being the most critical and 4 being the least critical. The segments ranked as "Priority 1" represent those with multiple categories identified as high need. **Figure 5** presents a map of the study area with 2019 VTrans mid-term needs prioritized for District Construction, and **Figure 6** provides an overview of the project.

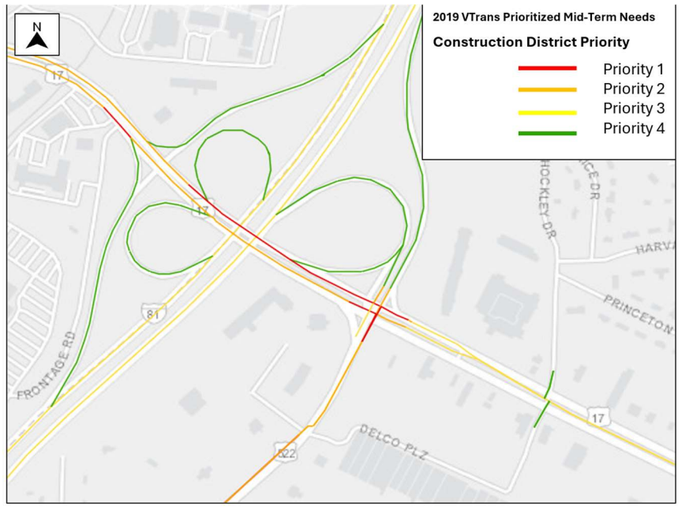
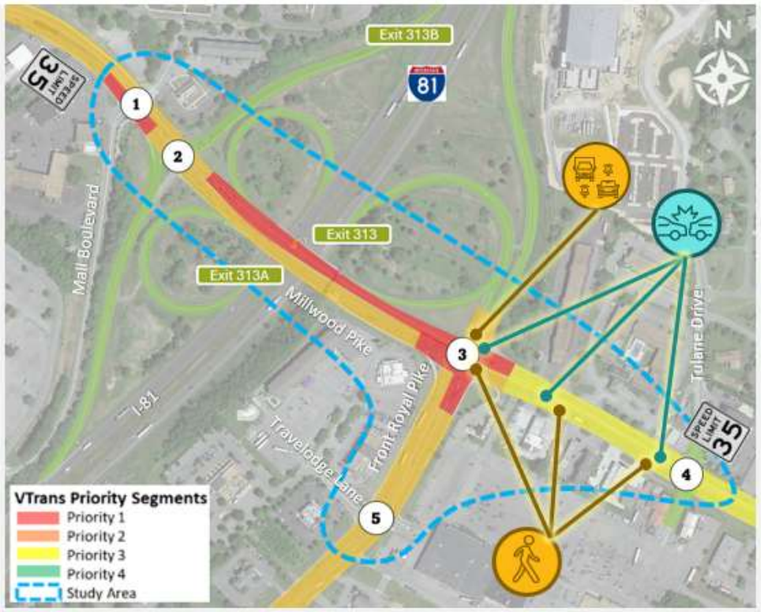


Figure 5: 2019 VTrans Prioritized Mid-term Needs in the Study Area



Rear-end crash incidents at Front Royal Pike and Millwood Pike (65 crashes). Crash hotspot at right-turn from Eastbound Millwood Pike to Front Royal Pike (17 crashes). Angle crash incidents between Tulane Drive and Front Royal Pike, primarily at Red Roof Inn, Shell, and Dunkin' access points (23 crashes). Rear-end crash incidents at Tulane Drive and Millwood Pike are likely due to congestion (9 crashes).

Insufficient crosswalks and inconsistent sidewalks within the study area. Two crashes involving pedestrians between Tulane Drive and Front Royal Pike. The crosswalk across Front Royal Pike and Southbound On-Ramp is currently worn off. No crosswalks are present at the Tulane Drive intersection. Existing Millwood Pike sidewalk ramps are not ADA-compliant.

There are no existing bike facilities within the study area.

Current transit service provided by the WinTran; Laurel Ridge Route departs downtown Winchester every 70 minutes connecting to Laurel Ridge Community College. There are no existing bus stops in the study area.

The closest existing Park & Ride lot is north of I-66 at Riverton Commons Shopping Center (~7.5 miles to the east). There are no existing park-and-ride lots in the study area.

One Logistics Park-approved development will have a significant traffic impact. The I-81/Route 50 bridge reconstruction project will shift Millwood Pike to the north. The Millwood Pike and Front Royal Pike intersection is projected to operate at an LOS grade F by 2028 as per One Logistics Park TIA Study.

Project Purpose, Goals, & Objectives

Analyze the operational and safety issues identified along US 50 (Millwood Pike) near I-81, focusing on providing operational improvements.

Identify cost-effective preferred improvement alternatives that address the deficient conditions and prioritize safety and accessibility.

Project Fact Sheet	
VDOT District	Staunton
Locality	Frederick
# of Study Intersections	5
Transit Routes	WinTran Route: Laurel Ridge
Nearby Transit Connections	Oranda Park and Ride (~ 9 miles to the south) Waterloo Park and Ride (north of I-66 at Riverton Commons Shopping Center, ~7.5 miles to the east) Double Tollgate/White Post Park and Ride (~ 8 miles to the south)
Functional Classification	Minor Arterial/Other Principal Arterial
Speed Limit	35 mph

Study Area Crashes (2015-2022 Data)

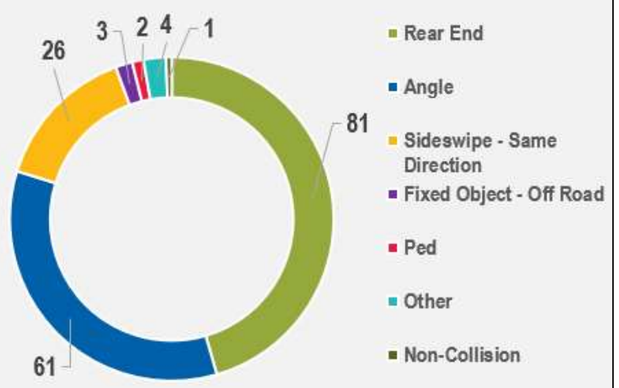


Figure 6: Project Overview for US17/US 50 (Millwood Pike) from Mall Boulevard to Tulane Drive

Funded/Completed Projects

Two (2) in-progress projects will impact geometric and traffic conditions in the study area, which are discussed in greater detail in the following subsections.

US 17/US 50 Bridge Replacement Project[2]

The US 17/US 50 bridge replacement over I-81 at Exit 313 is anticipated to be completed in late 2027 under the VDOT State of Good Repair (SGR) Program. The new bridge will be constructed just north of the existing bridge location, and it will consist of nine (9) lanes; two (2) more lanes than existing including a third westbound through lane and a second westbound left turn lane at I-81 southbound ramps. A design concept sketch developed for the previous bridge replacement project is presented in **Figure 7**.

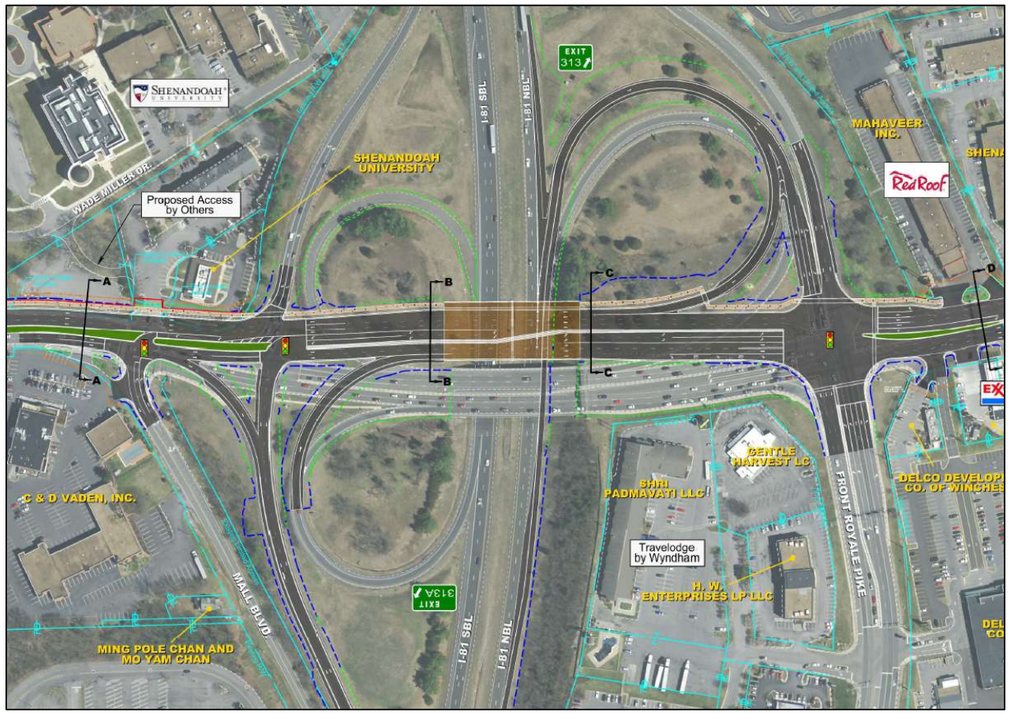


Figure 7: New Bridge Concept Developed from the Pipeline Round One Study

One Logistics Park Development

Although the additional westbound through lane on US 17/US 50 will provide increased capacity, it will not be sufficient to handle the increased traffic from the One Logistics Park development that will be constructed adjacent to the study area. One Logistics Park, a proposed multi-phased industrial development, will be located approximately 0.8 miles east of the study intersection at US 17/US 50/US 522. Therefore, significant traffic growth is anticipated on US 17/US 50 to and from I-81 and the City of Winchester. **Figure 8** shows the approved One Logistics Park development site and its relative location to the US 17/US 50 and US 522 intersection and US 17/US 50 study corridor.

Figure 8: Approved One Logistics Park Development adjacent to the Study Area

[2] https://www.vdot.virginia.gov/projects/staunton-district/frederick-county--route-1750522-millwood-pike-bridge-over-interstate-81/

Previous Study Efforts

The US 17/US 50 and US 522 intersection and US 522 corridor from Travelodge Lane/Delco Plaza to Costello Drive, together as one study area were studied in 2022, as part of Pipeline Round One. The recommended improvements at the US 17/US 50 and US 522 intersection were not submitted for funding as an Operational and Safety Analysis Report (OSAR) was required due to the proximity to the I-81 Exit 313 Interchange. However, the recommended improvements along US 522 from Travelodge Lane/Delco Plaza to Costello Drive were submitted as funding applications through the VDOT SMART SCALE Round 5 program and were funded. The VDOT SMART SCALE process facilitates selecting the most critical transportation needs for funding, ensuring the best use of limited tax dollars. The proposed improvements for the US 17/US 50 and US 522 intersection, as well as US 522 from Travelodge Lane/Delco Plaza to Costello Drive, are described in greater detail in the following subsection. The Project Pipeline Round One study covering US 17/US 50 and US 522 intersection and US 522 from Travelodge Lane/Delco Plaza to Costello Drive is provided in **Appendix A**.

Previous Recommendations for Improvements at US 17/US 50 and US 522 Intersection

The Project Pipeline Round One study identified a partial Median U-Turn (MUT) as the preferred alternative for the US 17/US 50 and US 522 intersection. The conversion is shown in **Figure 9** and includes the following:

- Restricting US 17/US 50 left turns and redirecting them to signalized median openings
- Increasing capacity on the southbound through, eastbound through and right, and westbound right turn movements
- Expanding pedestrian accommodations and access to Tulane Drive

These recommendations were proposed for capacity preservation, congestion mitigation, traffic safety, and pedestrian access. The partial MUT was analyzed using SimTraffic, a traffic simulation software, for the future years 2032 and 2042. The results suggested that the intersection would operate significantly better with the preferred alternative compared to the No Build conditions (this study also considered the US 17/US 50 bridge replacement) in both 2032 and 2042. Redirecting the left turn movements on US 17/US 50 allows for fewer traffic signal phases, reducing delay and increasing capacity. The increased capacity is expected to reduce congestion.

The partial MUT configuration is expected to reduce conflict points compared to a conventional four-leg intersection, particularly crossing conflict points, which typically have higher crash severity. Additionally, the pedestrian improvements are expected to enhance pedestrian safety and comfort.

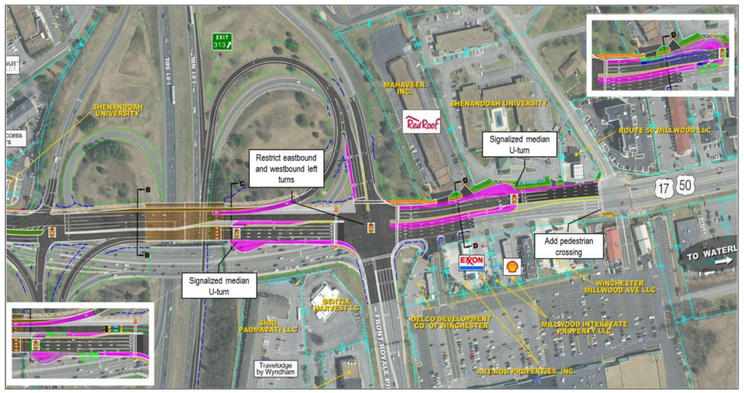


Figure 9: US 17/US 50 and US 522 Intersection, Proposed Improvements from the Previous Study

Previous SMART SCALE Application for Improvements on US 522[3]

Several operational improvements were proposed as part of the previous SMART SCALE study on US 522 from Travelodge Lane/Delco Plaza to Costello Drive and they were approved for funding. As illustrated in **Figure 10**, previously proposed improvements along US 522 included the following; 1) Install a raised median along US 522, 2) Convert US 522 and Costello Drive to a Thru-Cut with dual southbound left turn lanes onto Costello Drive and 3) Install pedestrian improvements at Travelodge Lane and at Costello Drive.

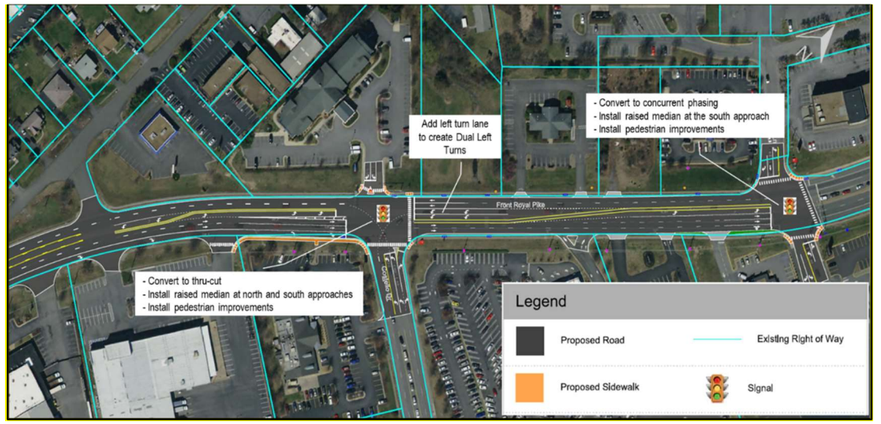


Figure 10: US 522, Proposed Improvements from the Previous Study

[3] https://smartportal.virginiahb2.org/#/forms/ss/2024/full/F42-0000009620-R01/

FHWA STEAP Tool Analysis

The FHWA Screening for Equity Analysis of Projects (STEAP) Tool was reviewed for the corridor and surrounding areas. This tool is used to identify the key population metrics and needs of the study area to raise awareness of equity needs in selecting alternatives. The data source used for the analysis was the American Community Survey 2016 – 2020 and a 0.5-mile radius was used for the analysis buffer. The results, presented in **Figure 11** through **Figure 15**, indicate that:

- Of the residents within a 0.5-mile radius of the study area, 22% are 0-17 years old, 65% are 18-64 years old, and 13% are greater than 65%. This is similar to the percentages for the City of Winchester, Frederick County, and the State of Virginia's averages. Approximately 1% of the area residents are seniors (+65 years old). The percentage populations by age group are shown in **Figure 11**.
- The percentage of households with household income of $35,000-$50,000 is 23% which is greater than the City, County, and State averages (15%, 11%, and 11% respectively). The percentage of households with household income greater than $75,000 is 44%. This is slightly lower than the state average of 51%. Only 4% of the households make less than $15,000, whereas 8% (City), 5% (County), and 8% (State) households make less than $15,000, as shown in **Figure 12**.
- The percentage of one (1) vehicle households is only 14% which is significantly lower than the City, County, and State (41%, 25%, and 30%, respectively). However, the percentage of two (2) vehicle households is 56% which is significantly higher than the City, County, and State (33%, 38%, and 38%) as shown in **Figure 13**.
- Of the non-English speakers (age 5+), 2% speak English "not well" and 1% do not speak English at all as shown in **Figure 14**.
- The percentage of vulnerable populations or households in the study area is equal to or lower than the City, County, and State averages across the categories of "Veterans", "People with Disability", "Households with No Computers", and "Households with No Internet Connection" as shown in **Figure 15**.

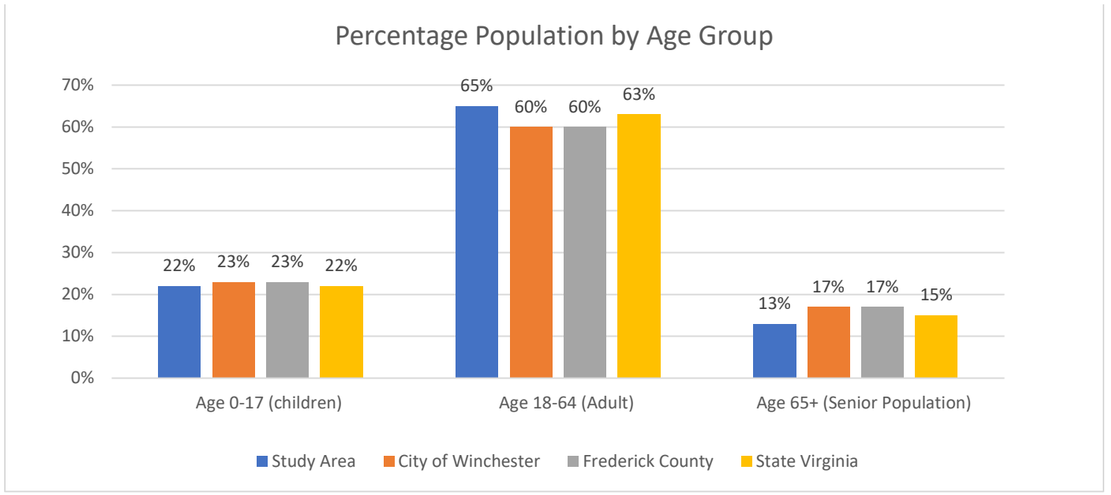


Figure 11: STEAP Tool Analysis Population by Age Group

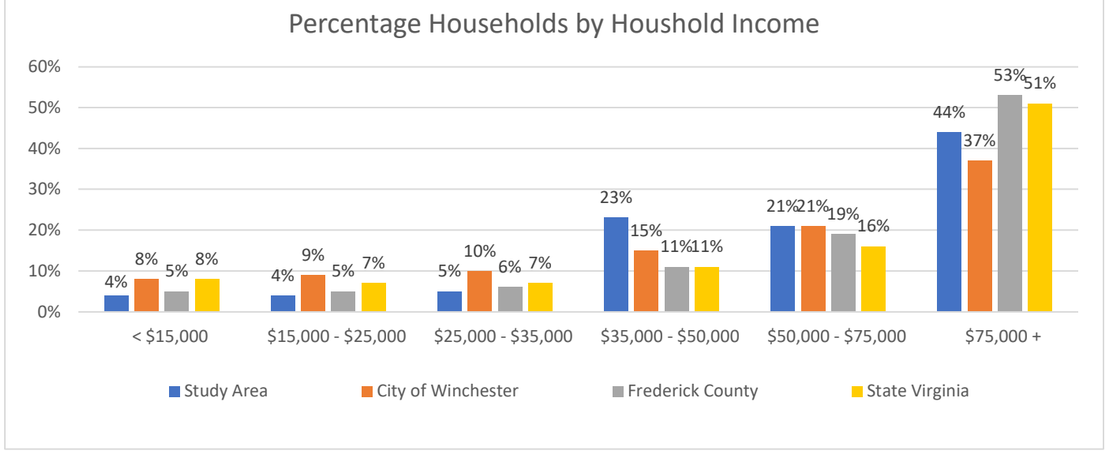


Figure 12: STEAP Tool Analysis Household Income

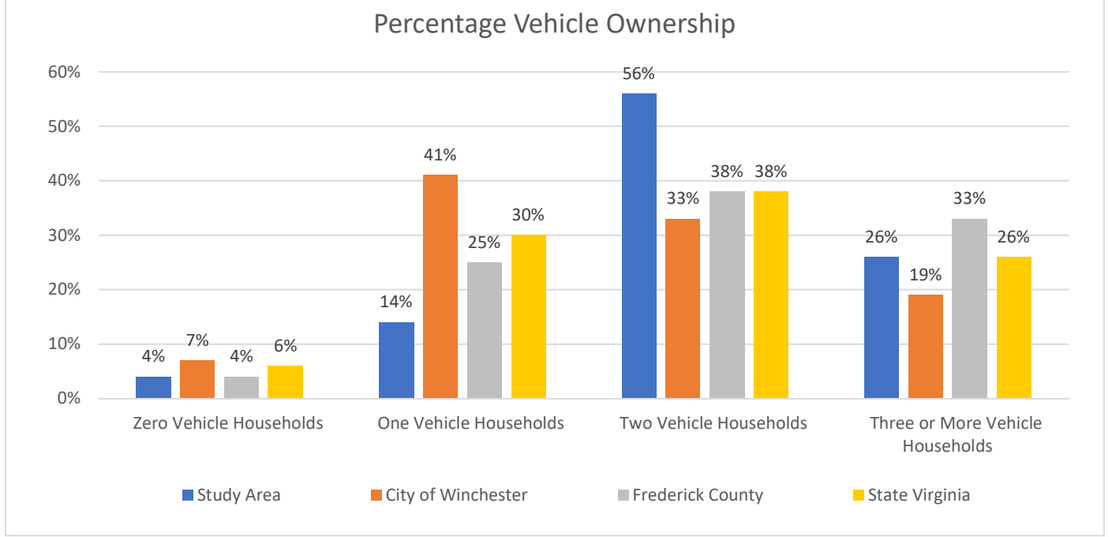


Figure 13: STEAP Tool Analysis Vehicle Ownership

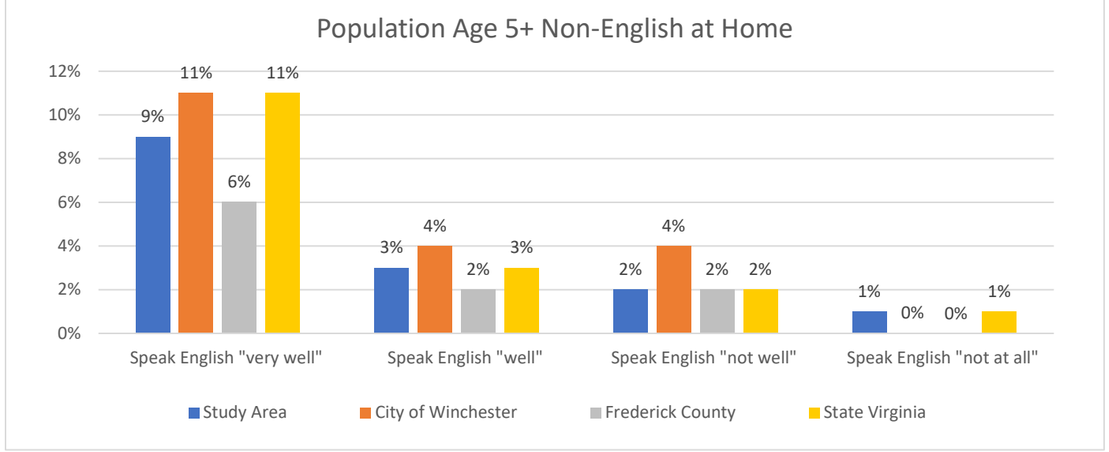


Figure 14: STEAP Tool Analysis Non-English at Home

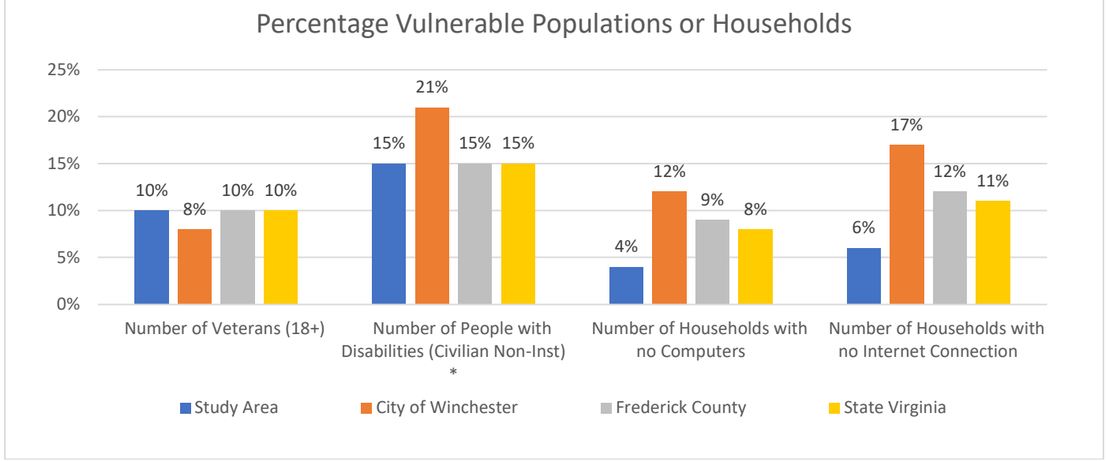


Figure 15: STEAP Tool Analysis of Vulnerable Populations

Traffic Operations

Existing conditions traffic operational analysis was performed using Vissim 11 software. Vissim, a microscopic traffic simulation software developed by PTV Group, is used for modeling traffic flow and analyzing transportation systems. The Vissim modeling inputs and analysis methodologies followed the VDOT Traffic Operations and Safety Analysis Manual (TOSAM) Version 2.0 guidelines.

Traffic Data

Traffic data for the study corridor, used for Vissim modeling input, were collected on Wednesday, April 26th, and Thursday, April 27th, 2023, typical weekdays when schools were in session. The traffic counts were collected by *MCV Associates, Inc.* as per the data collection plan shown in **Figure 16.** The corridor AM peak hour was determined to be 7:30 AM to 8:30 AM, and the PM peak hour was determined to be 4:45 PM to 5:45 PM. The balanced peak hour Turning Movement Counts (TMC) are shown in **Figure 17.** The raw traffic data is presented in **Appendix B**. The signal timing data was obtained from VDOT.

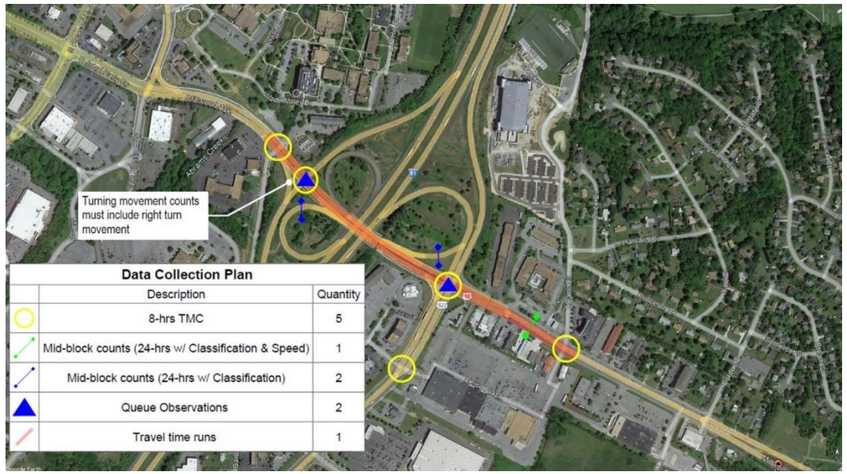


Figure 16. Data Collection Plan

Measures of Effectiveness

A Measure of Effectiveness (MOEs) is a factor in traffic operations analysis used to quantify operational and safety objectives and provide a basis for evaluating the performance of a transportation network. The following Traffic Operations Analysis MOEs are utilized for the evaluation of the study corridor performance:

- Microsimulation Delay (measured in seconds per vehicle – sec/veh)
- Travel Time (measured in seconds – sec)
- Maximum Queue Length (measured in feet – ft)

Existing Conditions Calibration

Existing Conditions traffic simulation models were developed using Vissim 11 software to replicate both morning (AM) and evening (PM) peak hours. The models were calibrated to reflect local, existing traffic operational behavior. TOSAM guidelines were followed for the calibration process. The detailed existing conditions model development and calibration memorandum is provided in **Appendix C**. **Table 4** and **Table 5** present the volume versus throughput comparison for the PM peak hour. **Figure 18** presents a comparison of the observed versus simulated queue lengths. The calibrated existing condition Vissim models will serve as the basis for the future no build and build conditions.

Table 4. 2023 Existing Conditions PM Peak Hour Traffic Operations Results (west)

Intersection	Approach	Mov't	Lane Group	Demand Volume (vph)	Throughput Volume (vph)	Vol Diff (vph)	Delay (s/veh)	Approach Delay (s/veh)	Intersection Delay (s/veh)
US Route 50 @ Mall Boulevard/University Inn	US Route 50, EB	U	L/U	3	3	0	256.2	144.8	70.1
		L		6	6	0	222.0		
		T	T	1,338	1,319	-19	144.2		
		R	R	11	12	1	139.8		
	US Route 50, WB	U	L	15	14	-1	17.6	10.6	
		L		142	138	-4	48.4		
		T	T/R	1,364	1,332	-32	6.5		
		R		12	12	0	18.7		
	Mall Boulevard, NB	L	L/T	33	37	4	70.5	31.2	
		T		4	4	0	60.2		
		R	R	229	222	-7	24.2		
	University Inn, SB	L	L/T	12	13	1	83.5	51.3	
		T		10	9	-1	64.3		
		R	R	17	15	-2	15.6		
US Route 50 @ I-81 Southbound Ramps	US Route 50, EB	T	T	1,221	1,204	-17	2.1	1.7	27.5
		R	R	372	367	-5	0.4		
	US Route 50, WB	L	L	180	195	15	121.2	33.4	
		T	T	1,138	1,109	-29	18.0		
	I-81 Southbound Off-Loop, NB	R	R	524	522	-2	1.8	1.8	
	I-81 Southbound Off-Ramp, SB	R	R	395	386	-9	147.3	147.3	

Table 5. 2023 Existing Conditions PM Peak Hour Traffic Operations Results (east)

Intersection	Approach	Mov't	Lane Group	Demand Volume (vph)	Throughput Volume (vph)	Vol Diff (vph)	Delay (s/veh)	Approach Delay (s/veh)	Intersection Delay (s/veh)
US Route 50 @ US Route 522/ I-81 Northbound Off-Loop	US Route 50, EB	U	L/U	0	0	0	0.0	38.1	46.0
		L		433	416	-17	95.3		
		T	T	648	655	7	34.2		
		R	R	664	655	-9	5.7		
	US Route 50, WB	U	L/U	1	1	0	184.5	49.8	
		L		85	82	-3	189.4		
		T	T	614	608	-6	40.0		
		R	R	488	492	4	38.4		
	US Route 522, NB	L	L	412	402	-10	82.9	64.2	
		T	T	471	468	-3	58.5		
		R	R	96	97	1	14.1		
	I-81 Northbound Off-Loop, SB	U	L/U	0	0	0	0.0	25.8	
		L		59	61	2	89.7		
		T	T	66	64	-2	74.6		
		R	R	291	290	-1	1.7		
US Route 50 @ Tulane Drive/Delco Plaza (Assumed Entrance 1)	US Route 50, EB	U	L/U	2	2	0	1.2	4.7	13.0
		L		28	26	-2	3.1		
		T	T	728	739	11	4.9		
		R	R	46	45	-1	1.6		
	US Route 50, WB	L	L	27	25	-2	14.8	14.2	
		T	T	1,082	1,082	0	14.3		
		R	R	15	15	0	5.9		
	Delco Plaza, NB	L	L	59	57	-2	78.2	56.7	
		T	TR	4	4	0	64.9		
		R		28	27	-1	10.2		
	Tulane Drive, SB	L	LTR	11	10	-1	80.5	37.0	
		T		8	7	-1	82.4		
		R		46	46	0	20.6		
US Route 50 @ US Route 522/Delco Plaza (Assumed Entrance 2)	Travelodge Lane, EB	L	L/T	73	71	-2	79.9	59.3	18.6
		T		1	1	0	63.4		
		R	R	29	29	0	8.6		
	Delco Plaza, WB	L	L/T	49	50	1	83.2	49.5	
		T		1	1	0	119.7		
		R	R	42	43	1	8.6		
	US Route 522, NB	U	L/U	2	2	0	99.8	16.9	
		L		35	33	-2	85.1		
		T	T, TR	861	855	-6	14.4		
		R		39	42	3	11.1		
	US Route 522, SB	L	L	24	22	-2	106.6	11.8	
		T	T	702	687	-15	9.9		
		R	R	87	86	-1	2.8		

Traffic Operations Analysis Results

The observations from the existing conditions traffic analysis for PM Peak Hour are presented in this section. A comparison of intersection delays for both peak hours at the study intersections, shown in **Table 6**, indicates that the PM peak hour experienced more delays than the AM peak hour. Consequently, the PM peak hour analysis results will be used to discuss the findings throughout this report.

Table 6. Existing Conditions - Intersection Delays (sec/veh)

Intersection*	Intersection Delays (sec/veh)	
	AM Peak	PM Peak
US 50 & Mall Boulevard/University Inn	23.7	70.1
US 50 & I-81 SB Ramps	25.1	27.5
US 50 & US 522/ I-81 NB Off-loop	34.0	46.0
US 50 & Tulane Dr/Delco Plaza	8.2	13.0
US 522 & Delco Plaza	9.5	18.6

* All intersections are signalized

In the PM peak hour, the study intersection of US 17/US 50 & US 522/ I-81 NB Off-loop experienced an intersection delay of 46.0 sec/veh. The left turn movements at all four approaches of this intersection experienced delays greater than 80 sec/veh, as shown in **Table 7.** The through movements from the minor streets of US 522 and I-81 NB Off-Loop also experienced significant delays, greater than 55 sec/veh.

Table 7. Left Turn Movement Delays at US 50 & US 522/ I-81 NB Off-loop

Approach/Movement	Demand Volume	Delay (sec/veh)	Field Max Queue Length	Available Storage
US 50 EBL	433	95.3	650	365
US 50 WBL	85	189.4	200	175
US 522 NBL	412	82.9	680	800
I-81 NB Off loop, SBL	59	89.7	150	185

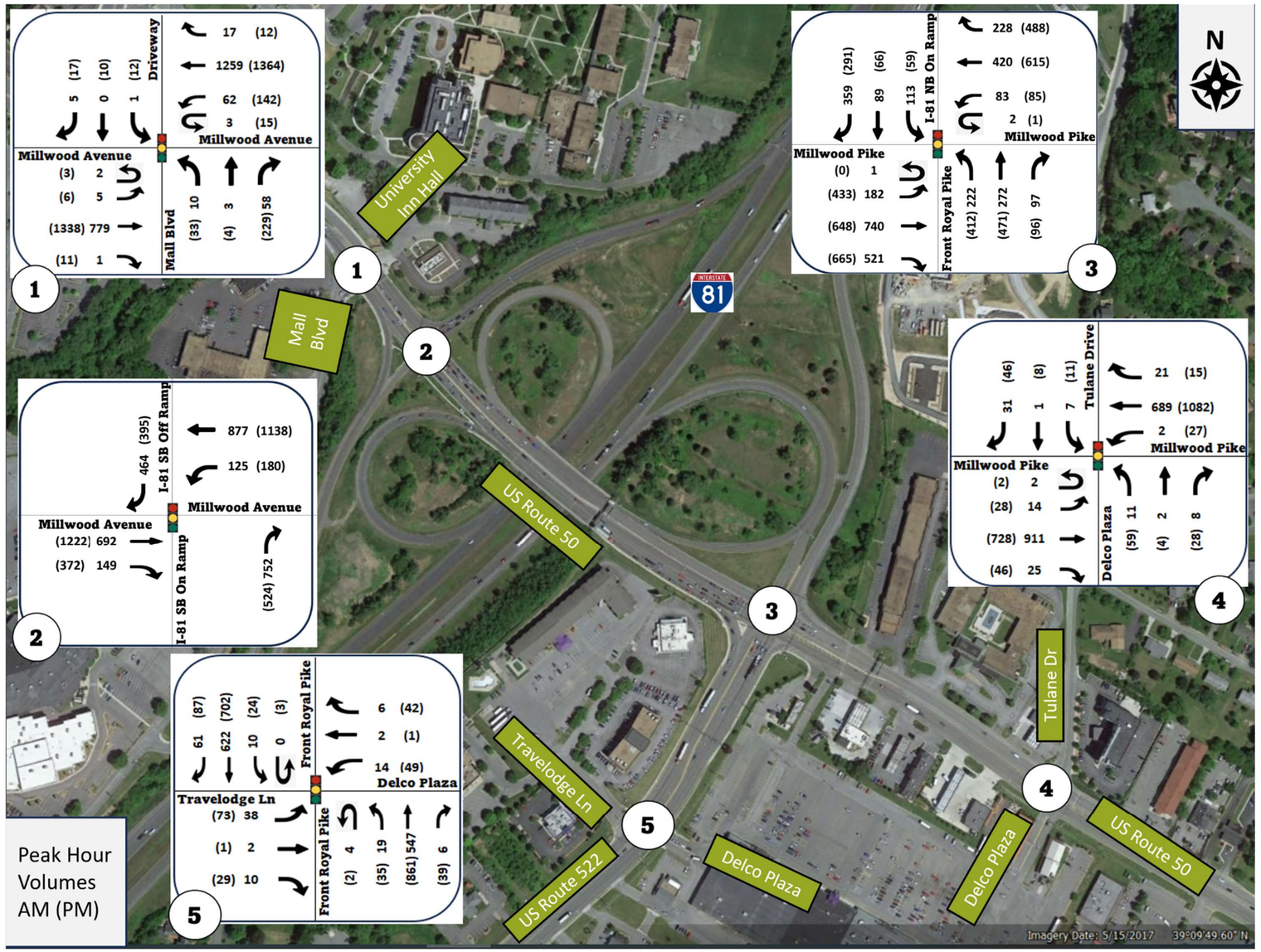


Figure 17: Peak Hour Turning Movement Counts

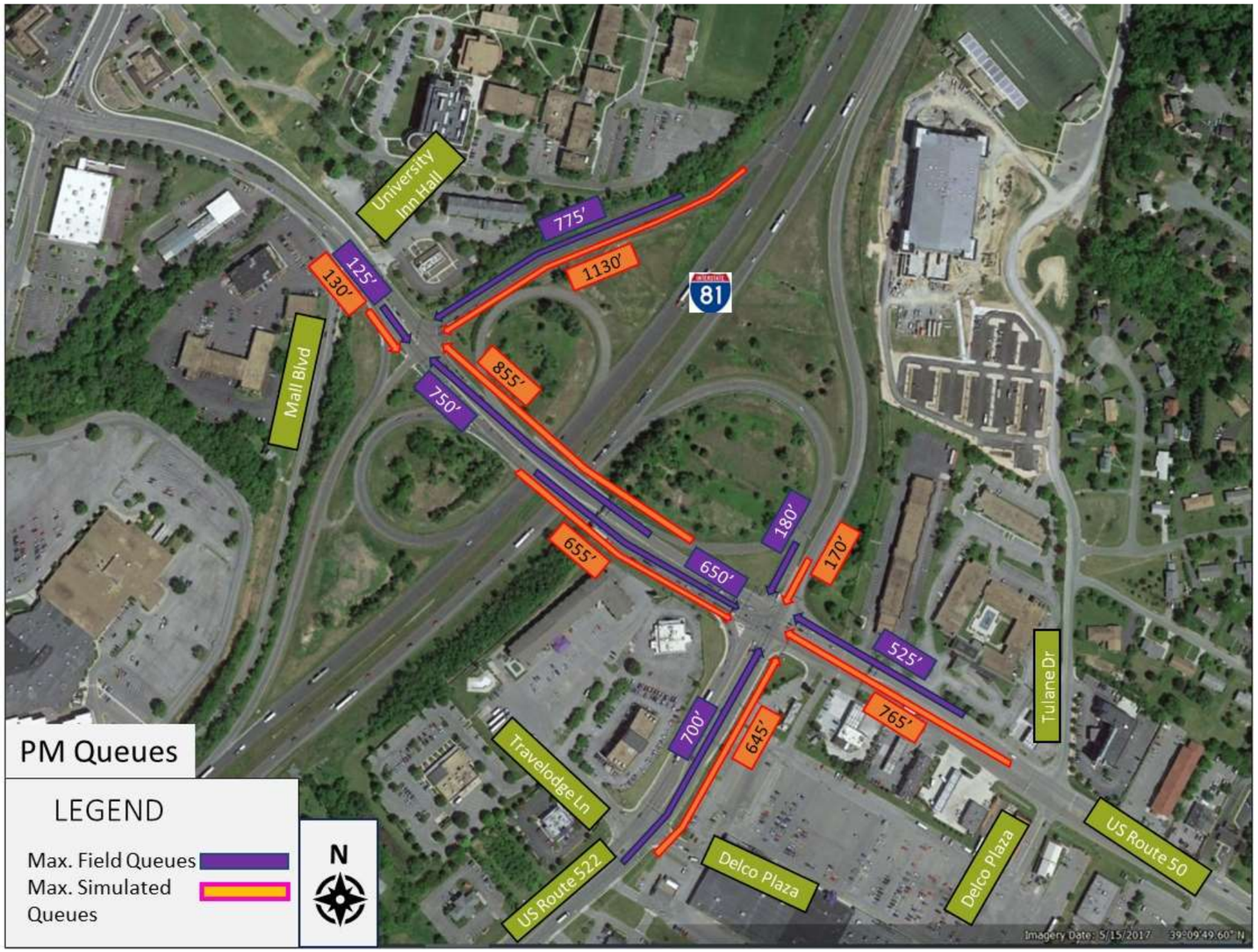
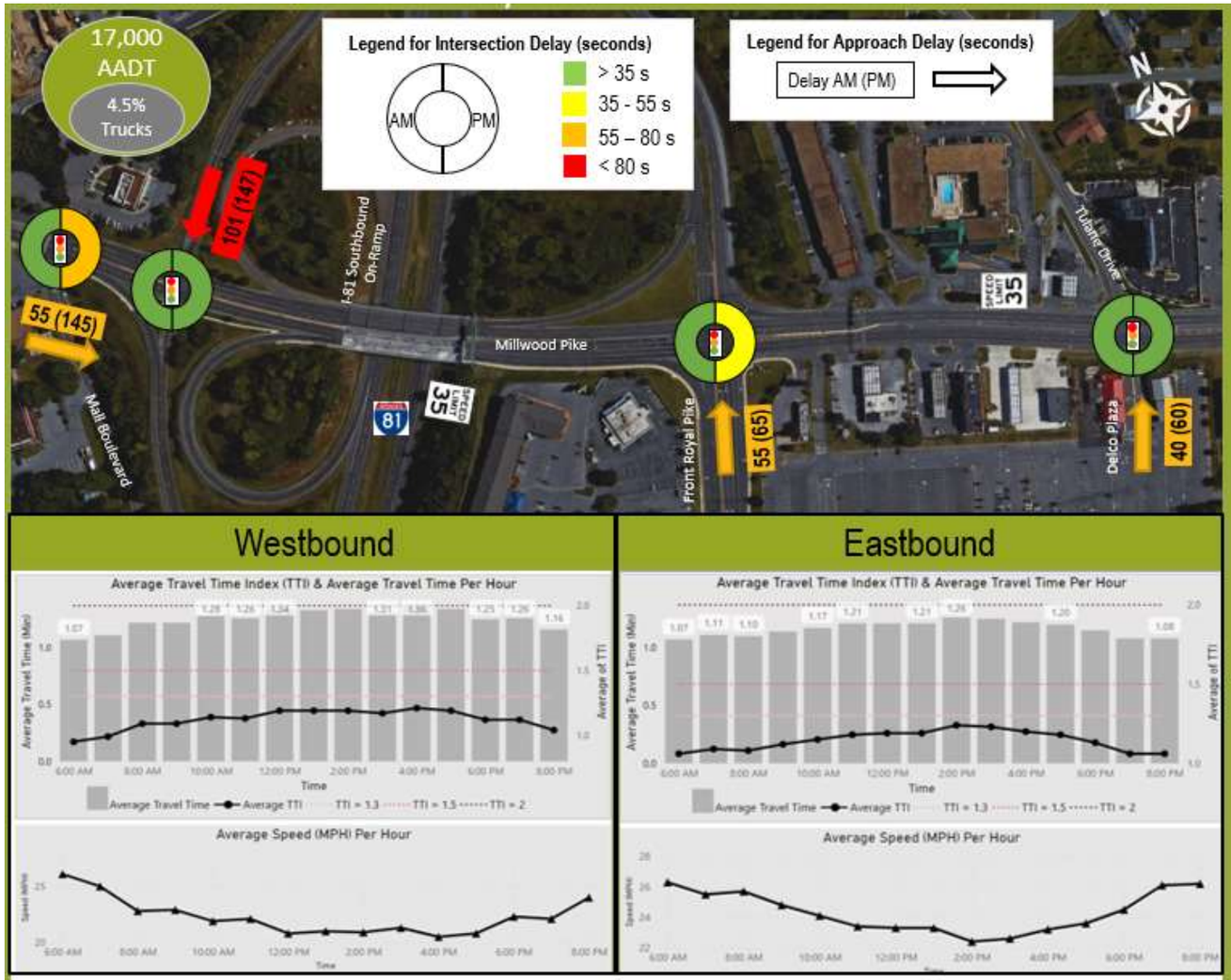


Figure 18. Observed vs. Simulated Queue Length Comparison in the PM Peak Hour

Operation and Accessibility Needs and Diagnosis Summary:



Operations Summary

1. All study intersections operate at a delay of 55 seconds or better during both AM and PM peak hours in 2023, apart from Millwood Pike and Mall Boulevard in the PM peak hour, which operates at a 70-second intersection delay.
2. The southbound exit ramp off I-81, northbound approach on Front Royal Pike, and eastbound approach on Millwood Pike at Mall Boulevard experience a delay of 55 seconds or greater in both peak hours. Northbound Delco Plaza experiences a delay of 60 seconds in the PM peak hour while maintaining a delay of 40 seconds in the AM peak hour.
    - The southbound exit ramp off I-81 experiences delays worse than 100 seconds during both AM and PM peak hours, posing a future risk for queue spillback onto the interstate.
3. Maximum queues at the following lane group are expected to extend beyond storage facilities during the PM peak hour:
    - Millwood Pike eastbound left turn to I-81 Northbound On-Ramp
    - Millwood Pike westbound right turn to I-81 Northbound On-Ramp
    - Millwood Pike westbound left turn to I-81 Southbound On-Ramp
    - Front Royal Pike northbound left turn to Millwood Pike (AM and PM Peak)

Safety / Reliability Needs

NEED	PRIORITY
Congestion Mitigation	Low
Capacity Preservation	High
Reliability	No Need

Note: Travel Time Analysis is conducted along Millwood Pike, from Tulane Drive to Mall Boulevard. The yellow-outlined box represents vehicles traveling westbound while the blue-outlined box represents vehicles traveling eastbound.

Figure 19: Operations and Accessibility Needs and Diagnosis

Safety

For the analysis of existing safety conditions, the VDOT Crash Analysis PowerBI Tool was utilized to determine the crash history at the study intersections. Crash data was collected and analyzed for an eight-year period spanning from January 2015 to December 2022. The study team reviewed the FR-300 reports provided by VDOT to determine specific trends and "hot spot" areas for consideration in developing alternative improvement concepts. For this analysis, "injury crashes" is defined as the sum of type A (severe injury), B (visible injury), and C (non-visible injury) crashes. The collision diagram maps for the study corridor along US 50 (Millwood Pike) between Front Royal Pike (US 522) and Tulane Drive are provided in **Appendix D**.

Safety Analysis Results

The crash severity within the study area is summarized by year, type, and lighting condition as shown in **Table 8** and **Table 9.** A total of 178 crashes were reported within the US 50 (Millwood Ave) from I-81 Northbound Ramps to Tulane Drive study area during the eight-year study period. Key takeaways from the crash data are as follows:

1) The majority of reported crashes within the corridor are rear-end crashes, which constitute approximately 45% of the total crashes. The next highest crash type within the corridor is angle, which makes up 35% of the total crashes, as shown in **Table 8**
2) Year-over-year crash occurrence varies with the highest number of crashes (29) occurring in 2019, followed by 28 in 2017 and 204 in 2016, as shown in **Table 9.**
3) The approximate average number of reported crashes per year is 22.
4) A total of 37 crash incidents are associated with injuries, which account for approximately 21% of the total reported crashes within the corridor.
5) Two (2) pedestrian crashes are reported, with both occurring along eastbound US 50 (Millwood Pike) and during dark lighting conditions.

A summary of the safety diagnosis is provided in **Figure 20** . Rear end crashes made up the majority of crashes at the intersections, while the high number of access points along US 50 is the driving factor for the high rate of angle crashes in the segment between US 522 and Tulane Drive. Crashes occurred more frequently in the mid-afternoon to late evening. The crash rate has dropped since the COVID-19 pandemic.

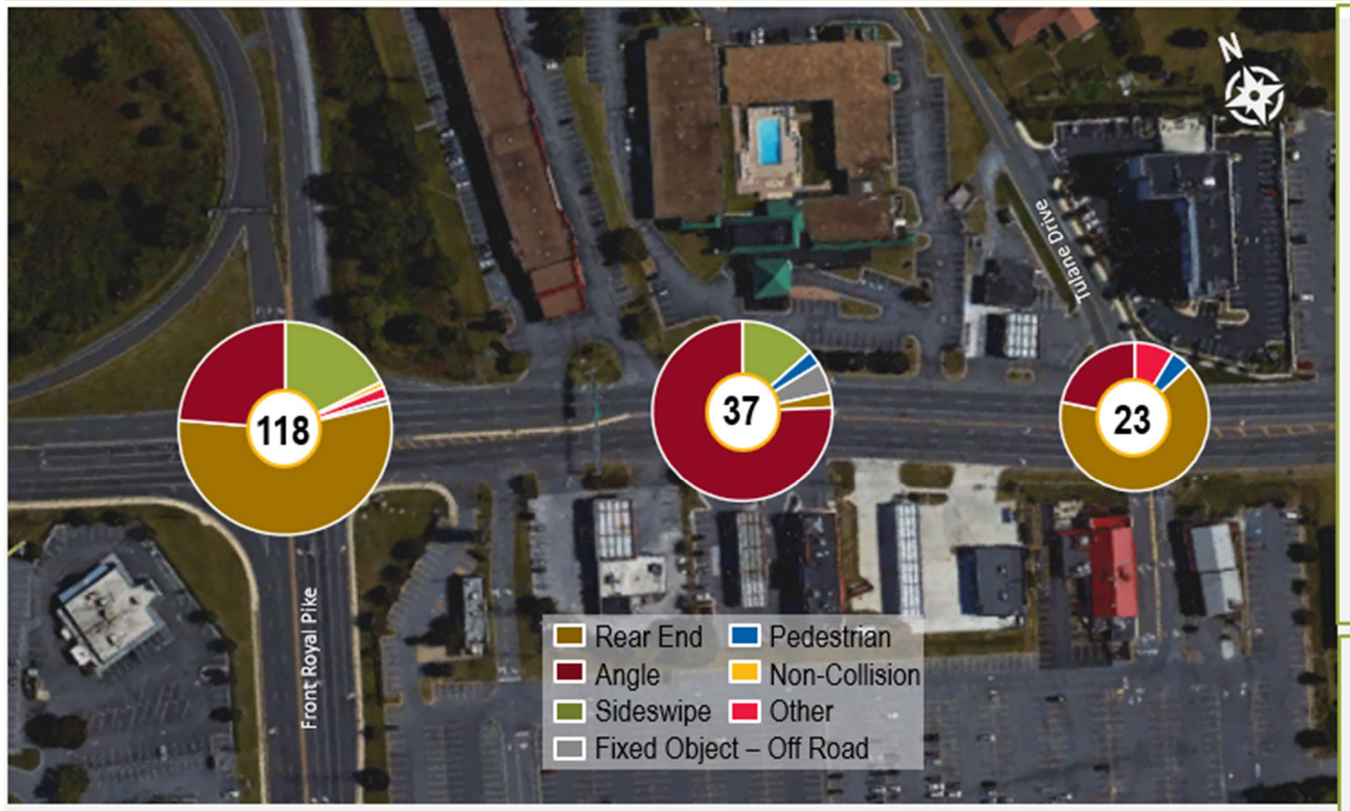
Table 8. Study Area Crash Severity by Type

Crash Type	K	A	B	C	PDO	Total within Study Area
Rear End	0	3	10	2	65	**80**
Angle	1	1	10	1	49	**62**
Sideswipe - Same Direction	0	1	2	1	22	**26**
Other	0	0	1	0	3	**4**
Fixed Object - Off Road	0	0	1	0	2	**3**
Ped	0	1	0	1	0	**2**
Non-Collision	0	0	1	0	0	**1**
Total within Study Area	**1**	**6**	**25**	**5**	**141**	**178**

Table 9. Study Area Crash Type by Year

Year	Rear End	Angle	Sideswipe - Same	Fixed Object - Off Road	Ped	Other	Non-Collision	Total within Study Area
2015	8	10	2	0	0	2	0	**22**
2016	12	10	2	0	0	0	0	**24**
2017	11	13	3	1	0	0	0	**28**
2018	10	4	5	0	0	1	0	**20**
2019	14	6	6	0	2	0	1	**29**
2020	10	8	1	0	0	0	0	**19**
2021	10	3	4	2	0	1	0	**20**
2022	6	7	3	0	0	0	0	**16**
Total within Study Area	**81**	**61**	**26**	**3**	**2**	**4**	**1**	**178**

Safety Needs and Diagnosis Summary:

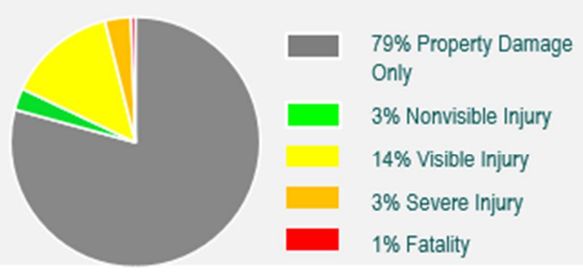


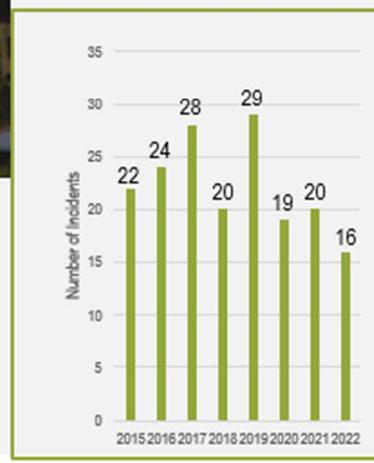
Safety Summary

- Total of **178 crashes** from **2015 to 2022**.
- Average number of annual crashes: ~ 23 crashes/year
- Angle and rear end crashes: ~ 80% of total crashes
- About 21% of crashes resulted in injuries.
- 65 of the 118 crashes at the Millwood Pike intersection with Front Royal Pike were rear end crash incidents
  - Twenty (20) of the rear end crash incidents at Millwood Pike and Front Royal Pike occurred while one vehicle was waiting at the intersection's traffic light
- Rear ends were the predominant crash type at the Millwood Pike and Tulane Drive intersection (15 of the 23 crashes).
- Thirty-seven (37) crashes occurred between Front Royal Pike and Tulane Drive; the abundance of development's access points was a contributing factor to most of these crashes.
  - Angle crashes were the predominant crash type, accounting for twenty-eight (28) crashes.

Safety / Reliability Needs

NEED	PRIORITY
Reliability (RN)	No Need
Safety Improvement	High
Pedestrian Safety Improvement	No Need





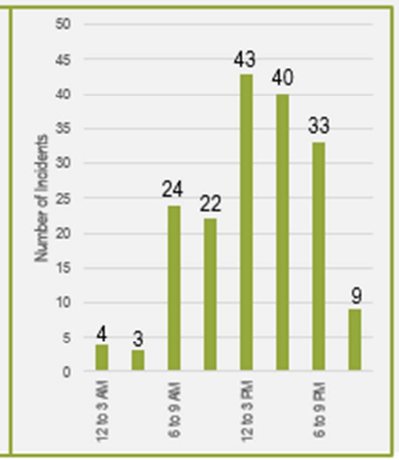


Figure 20: Safety and Reliability Needs and Diagnosis

Pedestrian and Bicycle Access

Pedestrian and Bicycle Access Needs

The VTrans Mid-Term needs in the study area include:

- Very High Pedestrian Access needs
- Very High Bicycle Access needs

The study team assessed and validated the pedestrian and bicycle access needs in the study area using crash data, local area plans, StreetLight data, and on-site observations.

Pedestrian and Bicycle Access Needs Overview

- Between 2015 and 2022 there were two (2) crashes involving pedestrians (1 serious injury and 1 non-visible injury).
- There is a continuous sidewalk along the southern side of US 50(Millwood Pike) from Mall Boulevard to just east of Front Royal Pike.
- There is a short stretch of sidewalk on the northern side of US 50(Millwood Pike) over the bridge but it does not connect to any other sidewalk or pedestrian facility.
- There is one (1) pedestrian signal with countdown heads and pushbuttons. Existing curb ramps feature truncated domes but require upgrade to reach ADA compliance. **Figure 21** summarizes existing pedestrian and bicycle facilities.

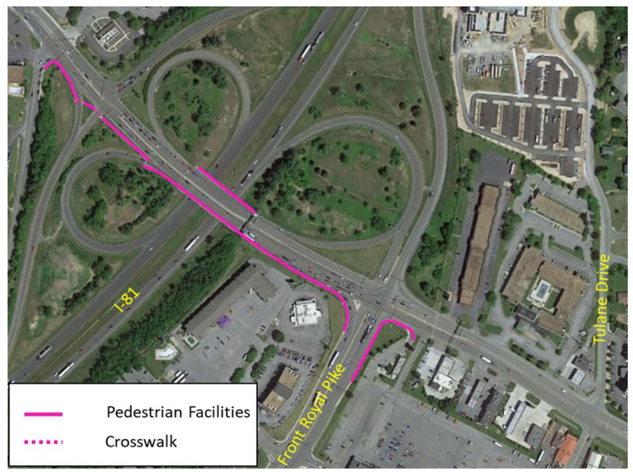


Figure 21: Existing Pedestrian and Bicycle Conditions

Rail, Transit, and TDM:

This location has a Very High TDM (Transportation Demand Management) need in VTrans. Transit service in the study area is provided by Winchester Transit, also known as WinTran. Frederick County staff previously requested consideration of a park-and-ride lot in the study corridor vicinity.

There are currently no existing park-and-ride locations within the study area. The closest existing park-and-ride location is to the south at Double Tollgate/White Post (off Rte. 522, 8 miles south of Winchester). Additional locations are farther away at Crooked Run (north of Front Royal, near I-66) and at Waterloo (east of Winchester, along Rte. 17/50). Currently, there is no Virginia Breeze intercity bus service in the study area. Virginia Breeze intercity buses serve many urban areas and campuses along I-81 to the south, but the service only extends north as far as I-66. The closest bus stop is located just off I-66 at Front Royal (north of I-66 at Riverton Commons Shopping Center).

The following recommendations were made to improve TDM in the study area. New or expanded park-and-ride lot locations and feasibility based on park-and-ride demand forecasts, as well as the prospect of creating a mobility hub through the incorporation of shared mobility services, EV and ITS infrastructure, and enhanced multimodal access, have been recommended at the Costco Parking Lot, Delco Plaza Parking Lot, and Big Lots Parking Lot, all nearby to the south of Route 50. Each of these locations should consider:

- EV charging spaces
- Bus stops/shelters
- Real-time ITS traveler information
- Bike parking/bike share
- Designated vanpool/Zipcar spaces

These collective elements enhance the ability of these park-and-ride locations as mobility hubs to serve the immediate vicinity. It is also recommended that the Virginia Breeze service area be extended north to the study corridor at Exit 313 and serve those urban areas and higher education campuses north of Front Royal along I-81, connecting to the east towards the Washington Metropolitan Area.

Chapter 2:

Alternative Development and Refinement

Alternative Development and Screening:

The study corridor will undergo significant changes in its geometry and lane configuration after the anticipated completion of the US 17/US 50 bridge replacement in late 2027. As previously mentioned, the new bridge will be constructed just north of the existing bridge location. It will consist of nine (9) lanes; two (2) more lanes than the existing bridge including a third westbound through lane and a second westbound left turn lane at the US 50 & I-81 southbound ramps intersection as shown in **Figure 22**. The third westbound through lane through the study corridor will start from Tulane Drive and terminate at Millwood Avenue. This $38.4 million project will improve traffic operations along the study corridor by providing additional capacity, upgradation of traffic signals, and by installing a shared-use path along the north side of Millwood Pike beginning on the western side at Abrams Creek, extending across the new bridge to the Front Royal Pike intersection on the eastern side of the project.

With the anticipated future growth forecasted in the study area from the proposed One Logistics Park to the east of the study corridor, the intersections were evaluated for their capacity to handle future demand. The intersection of US 50 & US 522/ I-81 NB Off-loop was identified as the critical intersection under the future year scenario. A screening-level analysis was performed in the VDOT Junction Screening Tool

(VJuST) to identify potential alternative intersection options at the critical intersection of US 50 & US 522/ I-81 NB Off-loop. VJuST is a screening tool that helps in the decision-making process of identifying innovative intersection configurations, that are most appropriate in reducing congestion and improving safety to advance to further study, analysis, and design. Alternative intersection configurations were evaluated using the future design year volumes as part of the screening process. The following section discusses the future year traffic forecasting. Details of the VJuST analysis performed and the alternative intersections considered at US 50 & US 522/ I-81 NB Off-loop intersection are provided in the subsequent section.

Future Traffic Forecasting

The 171-acre One Logistics Park is scheduled to be fully open before 2034. The site is located on the south side of US 50 (Millwood Pike), approximately one mile east of the I-81 interchange. As per the 2020 Traffic Impact Analysis (TIA) Study, by *Pennoni*, the site is forecasted to generate 17,606 daily trips. To be consistent with the Round One Pipeline Study forecasting methodology, the following growth rates were applied to the 2028 TIA study peak hour volumes to generate future opening year 2034 and design year 2054 volumes. The forecasted trips generated from the site developments were added at the end. The Traffic Forecasting Memo, showing the full methodology and validation, is provided in **Appendix E**.

- 2.0% annual linear growth rate for all movements on US 522 and the side street approaches
- 1.1% annual linear growth rate for the eastbound US 17/US 50 approach and the side street approaches west of US 522 (including the I-81 SB ramps)
- 1.9% annual linear growth rate for the westbound US 17/US 50 approach
- 0.2% growth rate for the Tulane Drive /Delco Plaza side street approaches east of US 522
- 1.1% and 1.4% growth rates for movements entering and exiting northbound I-81, respectively

The 2034 PM peak hour turning movement volumes used for the analysis discussion are shown in **Figure 23**, these volumes are displayed in the No Build conditions.

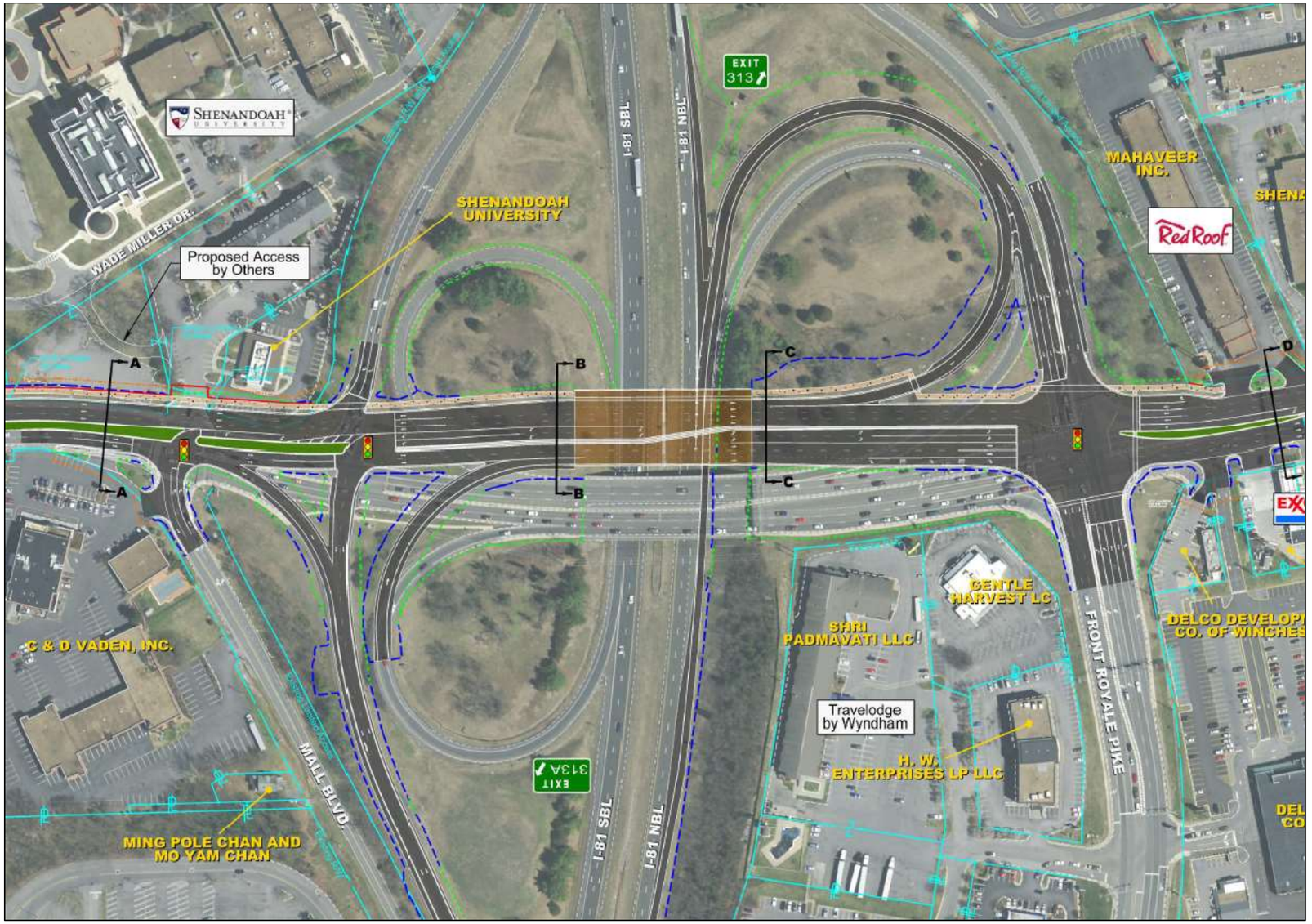


Figure 22. New US17/US 50 Bridge Concept

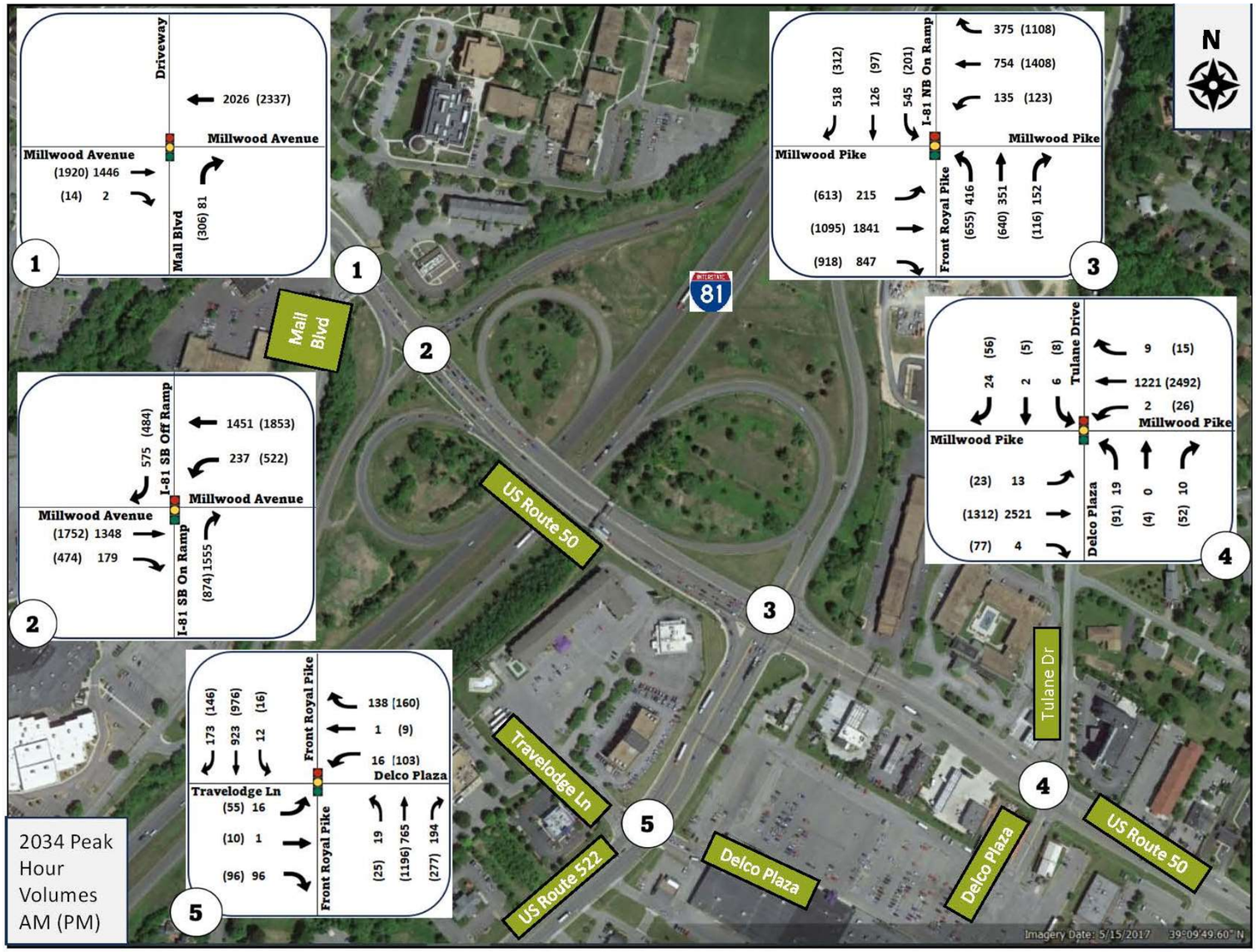


Figure 23: 2034 Peak Hour Turning Movement Volumes

VJuST Analysis

As part of future alternative intersection screening, a VJuST analysis was performed for the critical intersection of US 17/US 50 and US 522. The VJuST aids transportation engineers and planners in determining which innovative intersection might be appropriate at a specific location[4]. It uses traffic volume as input and generates alternatives along with their maximum volume-to-capacity (v/c) ratio. The v/c ratio also known as the degree of saturation, is a measure of how well an intersection can handle vehicular demand. A v/c ratio less than 0.85 generally indicates adequate capacity is available, and vehicles are not expected to experience significant queues and delays. As the v/c ratio approaches 1.0, traffic flow may become unstable, and delay and queuing conditions may occur. Once the demand exceeds the capacity, a v/c ratio greater than 1.0, traffic flow is unstable, and excessive delay and queuing are expected. **Table 10** provides a description of capacity based on the v/c ratio.

Table 10. Capacity Description based on v/c Ratio

V/C Ratio	Description of Capacity
<0.85	Under capacity
0.85-0.95	Near capacity
0.95-1.0	At capacity
>1.0	Overcapacity

Source: Highway Capacity Manual 2010

It is important to note that VJuST analysis does not consider the influence of adjacent intersections on traffic patterns. Therefore, it was conducted for screening purposes only, with detailed analyses performed using the microsimulation software Vissim. The VJuST analysis was completed for the future years 2034 and 2054. Alternatives were selected based on design feasibility. The lane configuration for each alternative was tested for optimal conditions given the geometric constraint of the number of lanes on the new bridge. See **Appendix F** for VJuST analysis spreadsheets. **Table 11** compares weighted total conflict points and maximum v/c ratio for the alternatives considered with the lowest v/c ratio highlighted in bold. The 2054 PM peak hour (critical hour) VJuST analysis results suggest that a partial MUT overall provides the best operational and safety benefit at the intersection, with significantly fewer conflict points and increased capacity when compared to the conventional intersection and other alternative options. The partial MUT recommendation, consistent with the Pipeline Round One study recommendation, was selected as the preferred alternative.

[4] https://www.vdot.virginia.gov/about/our-system/highways/innovative-intersections/virginia-icap/

Table 11. 2054 PM Peak Hour VJuST Analysis Results Summary at US 50 & US 522/ I-81 NB Off-loop

Alternative	Weighted Total Conflict Points	US 50 & US 522/ I-81 NB Off-loop Maximum V/C
Conventional	48	1.64
Median U-Turn*	20	1.62
Partial Displaced Left Turn	44	1.64
Partial Median U-Turn*	28	**1.09**
Restricted Crossing U-Turn*	20	2.05

**All intersections coded as signalized*

Preferred Alternative:

The Partial Median U-Turn was selected as the Preferred Alternative option based on the results of the VJuST screening-level analysis. The design feasibility of Partial MUT was evaluated and a concept sketch was developed. A summary detailing all the proposed improvements as part of the Preferred Alternative option is provided in **Table 12.**

Table 12: List of Preferred Alternative Improvements

Intersection	Description	Improvement Categories
US 522 at US 17/US 50	Convert the intersection to a partial Median U-turn Restrict US 50/US 17 left turns and redirect to signalized median openings	Capacity Preservation Congestion Mitigation Traffic Safety
	Increase capacity on southbound through, eastbound through and right, and westbound right turn movements	Congestion Mitigation
	Expand pedestrian accommodations and access to Tulane Drive	Pedestrian Access Bicycle Access
US 17/ US 50	Install raised median for access management	Traffic Safety

A full design concept sketch of the recommended improvements at the intersection of US 522 and US 17/US 50 is presented in **Figure 25**. The partial MUT option with dual eastbound and westbound right turns is recommended at the intersection of US 522 and US 17/US 50 as the Preferred Alternative. Median openings for the re-routed U-turn traffic are located at the hotel/gas station entrance and before

the bridge at I-81 Exit 313, approximately 450 feet east and 400 feet west of the intersection, respectively.

The partial MUT design is expected to improve safety, increase efficiency, decrease wait times, and be cost effective. The expected safety improvement is attributed to the reduction in conflict points at the intersection. The conflict points are categorized as crossing, merging, or diverging; in general, the merging and diverging conflict points are associated with less severe crash types than crossing conflict points. At a conventional intersection, there are 32 conflict points of which 16 are crossing. At a partial MUT, there are 22 conflict points of which 6 are crossing. See **Figure 24** for conflict point diagrams of typical conventional and partial MUT intersections.

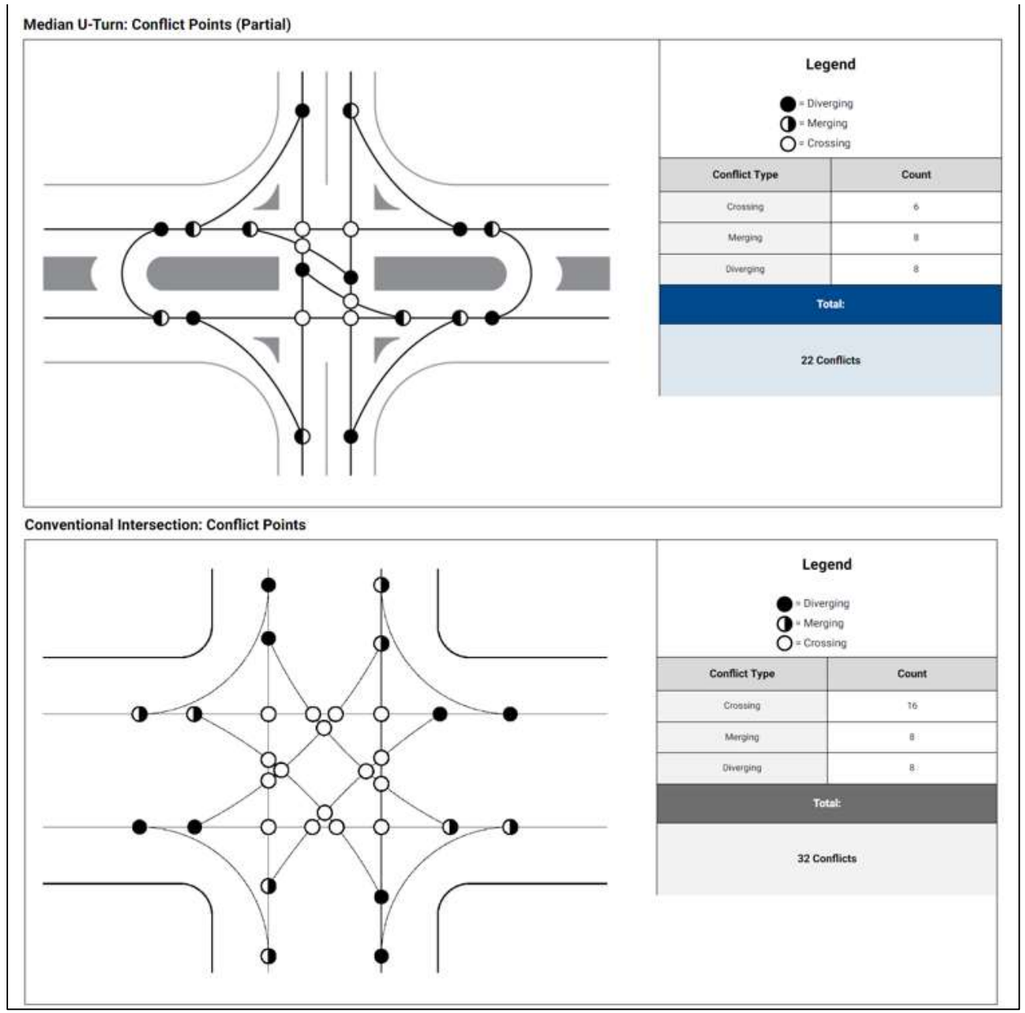


Figure 24: Conventional and Partial MUT Intersection Conflict Points[5]

[5] https://www.vdot.virginia.gov/about/our-system/highways/innovative-intersections/median-u-turn/

Figure 25: Recommended Improvements at US 17/US50 and US 522

Operations Analysis

To evaluate and compare traffic operations between the No Build and the Preferred Alternative of Partial MUT at US 50 & US 522/ I-81 NB Off-loop, a detailed analysis was performed using Vissim microsimulation software. The results from the opening year 2034 PM Peak Hour analysis are used for discussion in this section; the No Build results are shown in **Table 13** and **Table 14**, and the Preferred Alternative results are shown in **Table 15** and **Table 16**. **Table 17** compares the intersection delays for the two alternatives. The results indicate that the preferred alternative, partial MUT operates significantly better than the No Build scenario. The detailed Vissim analysis results are provided in **Appendix G**.

Table 13: 2034 No Build PM Peak Hour Traffic Operations Results (west)

Intersection	Approach	Movement	Lane Group	PM Peak					
				Demand Volume (vph)	Throughput Volume (vph)	Vol Diff (vph)	Movement Delay (s/veh)	Approach Delay (s/veh)	Intersection Delay (S/veh)
US Route 50 @ Mall Boulevard/University Inn	US Route 50, EB	T	T	1,920	1,907	13	39.4	39.1	49.9
		R	R	14	15	-1	9.9		
	US Route 50, WB	T	T/R	2,337	1,836	501	0.7	0.7	
	Mall Boulevard, NB	R	R	306	176	130	680.4	680.4	
US Route 50 @ I-81 Southbound Ramps	US Route 50, EB	T	T	1,752	1,631	121	11.6	9.2	20.8
		R	R	474	451	23	0.3		
	US Route 50, WB	L	L	522	342	180	63.0	19.5	
		T	T	1,853	1,356	497	14.0		
	I-81 Southbound Off-Loop, NB	R	R	874	872	2	10.9		
	I-81 Southbound Off-Ramp, SB	R	R	484	481	3	77.9	77.9	

Table 14: 2034 No Build PM Peak Hour Traffic Operations Results (east)

Intersection	Approach	Movement	Lane Group	PM Peak					
				Demand Volume (vph)	Throughput Volume (vph)	Vol Diff (vph)	Movement Delay (s/veh)	Approach Delay (s/veh)	Intersection Delay (S/veh)
US Route 50 @ US Route 522/ I-81 Northbound Off-Loop	US Route 50, EB	L	L	613	547	66	233.6	78.3	90.2
		T	T	1,095	1,054	41	46.6		
		R	R	918	890	28	20.5		
	US Route 50, WB	L	L	123	62	61	95.1	105.8	
		T	T	1,408	723	685	60.4		
		R	R	1,108	595	513	162.1		
	US Route 522, NB	L	L	655	648	7	78.0	85.7	
		T	T	640	624	16	104.9		
		R	R	116	120	-4	27.3		
	I-81 Northbound Off-Loop, SB	L		201	200	1	205.1	114.2	
		T	T	97	94	3	145.4		
		R	R	312	301	11	44.0		
US Route 50 @ Tulane Drive/Delco Plaza (Assumed Entrance 1)	US Route 50, EB	L	L	23	19	4	10.5	2.6	259.5
		T	T	1,312	1,269	43	2.5		
		R	R	77	76	1	1.7		
	US Route 50, WB	L	L	26	13	13	423.8	566.9	
		T	T	2,492	1,251	1,241	568.4		
		R	R	15	8	7	552.9		
	Delco Plaza, NB	L	L	91	87	4	95.4	68.6	
		T	TR	4	5	-1	88.1		
		R		52	54	-2	23.6		
	Tulane Drive, SB	L	LTR	8	8	0	93.1	73.7	
		T		5	6	-1	100.2		
		R		56	54	2	67.8		
US Route 50 @ US Route 522/Delco Plaza (Assumed Entrance 2)	Travelodge Lane, EB	L	LT	55	55	0	50.5	26.0	21.9
		T		10	8	2	43.7		
		R	R	96	96	0	10.5		
	Delco Plaza, WB	L	LT	103	105	-2	49.8	35.9	
		T		9	10	-1	58.6		
		R	R	160	156	4	25.1		
	US Route 522, NB	L	L	25	24	1	52.5	23.0	
		T	T, TR	1,196	1,192	4	23.2		
		R		277	287	-10	19.5		
	US Route 522, SB	L	L	16	17	-1	46.5	16.2	
		T	T	976	904	72	17.3		
		R	R	146	133	13	5.2		

Table 15: 2034 Build PM Peak Hour Traffic Operations Results (west)

Intersection	Approach	Movement	Lane Group	PM Peak					
				Demand Volume (vph)	Throughput Volume (vph)	Vol Diff (vph)	Movement Delay (s/veh)	Approach Delay (s/veh)	Intersection Delay (S/veh)
US Route 50 @ Mall Boulevard/University Inn	US Route 50, EB	T	T	1,920	1,917	3	13.7	13.6	41.9
		R	R	14	16	-2	5.0		
	US Route 50, WB	T	T/R	2,337	2,216	121	0.7	0.7	
	Mall Boulevard, NB	R	R	306	177	129	866.1	866.1	
US Route 50 @ I-81 Southbound Ramps	US Route 50, EB	T	T	1,752	1,658	94	8.5	6.8	22.3
		R	R	474	439	35	0.4		
	US Route 50, WB	L	L	522	478	44	75.6	29.1	
		T	T	1,853	1,740	113	16.3		
	I-81 Southbound Off-Loop, NB	R	R	874	872	2	16.2	16.2	
	I-81 Southbound Off-Ramp, SB	R	R	484	478	6	69.6	69.6	
US Route 50 @ WB U-Turn	US Route 50, EB	T	T	2,626	2,533	93	8.0	8.0	5.8
	US Route 50, WB	U	U	123	108	15	52.9	3.4	
		T	T	2,375	2,219	156	1.0		

Table 16: 2034 Build PM Peak Hour Traffic Operations Results (east)

Intersection	Approach	Movement	Lane Group	PM Peak					
				Demand Volume (vph)	Throughput Volume (vph)	Vol Diff (vph)	Movement Delay (s/veh)	Approach Delay (s/veh)	Intersection Delay (S/veh)
US Route 50 @ US Route 522/ I-81 Northbound Off-Loop	US Route 50, EB	T	T	1,708	1,645	63	8.8	7.5	27.1
		R	R	1,041	998	43	5.3		
	US Route 50, WB	T	T	1,531	1,371	160	7.0	10.9	
		R	R	1,721	1,597	124	14.2		
	US Route 522, NB	L	L	655	654	1	117.0	89.2	
		T	T	640	611	29	74.1		
		R	R	116	122	-6	15.5		
	I-81 Northbound Off-Loop, SB	L	L	201	200	1	99.4	49.9	
		T	T	97	100	-3	85.7		
		R	R	312	306	6	5.8		
US Route 50 @ EB U-Turn	US Route 50, EB	U	U	613	594	19	84.2	26.0	21.7
		T	T	1,412	1,381	31	1.0		
	US Route 50, WB	T	T	2,639	2,370	269	18.1	18.1	
US Route 50 @ Tulane Drive/Delco Plaza (Assumed Entrance 1)	US Route 50, EB	L	L	23	21	2	60.4	2.6	86.5
		T	T	1,312	1,282	30	1.7		
		R	R	77	79	-2	0.8		
	US Route 50, WB	L	L	26	22	4	115.7	135.9	
		T	T	2,492	2,198	294	136.1		
		R	R	15	15	0	129.1		
	Delco Plaza, NB	L	L	91	89	2	122.5	122.6	
		T	TR	4	8	-4	142.7		
		R		52	52	0	119.5		
	Tulane Drive, SB	L	LTR	8	9	-1	134.8	92.8	
		T		5	6	-1	130.3		
		R		56	54	2	81.6		
US Route 50 @ US Route 522/Delco Plaza (Assumed Entrance 2)	Travelodge Lane, EB	L	LT	55	53	2	63.8	30.2	31.3
		T		10	7	3	51.3		
		R	R	96	99	-3	10.7		
	Delco Plaza, WB	L	LT	103	105	-2	46.0	28.0	
		T		9	9	0	59.2		
		R	R	160	157	3	14.2		
	US Route 522, NB	L	L	25	21	4	101.0	46.0	
		T	T, TR	1,196	1,186	10	50.5		
		R		277	280	-3	22.9		
	US Route 522, SB	L	L	16	21	-5	51.7	12.2	
		T	T	976	934	42	12.2		
		R	R	146	140	6	6.2		

Table 17. Alternative Analysis Comparison- Intersection Delays (sec/veh)

Intersection	Intersection Delay (sec/veh)	
	No Build	Preferred Alternative
US 50 & Mall Boulevard/University Inn*	49.9	41.9
US 50 & I-81 Southbound Ramps	20.8	22.3
US 50 & WB U-Turn	-	5.8
US 50 & US 522/I-81 Northbound Off-Loop	90.2	27.1
US 50 & EB U-Turn	-	21.7
US 50 & Tulane Drive/Delco Plaza	259.5	86.5
US 50 & US 522/Delco Plaza	21.9	31.3

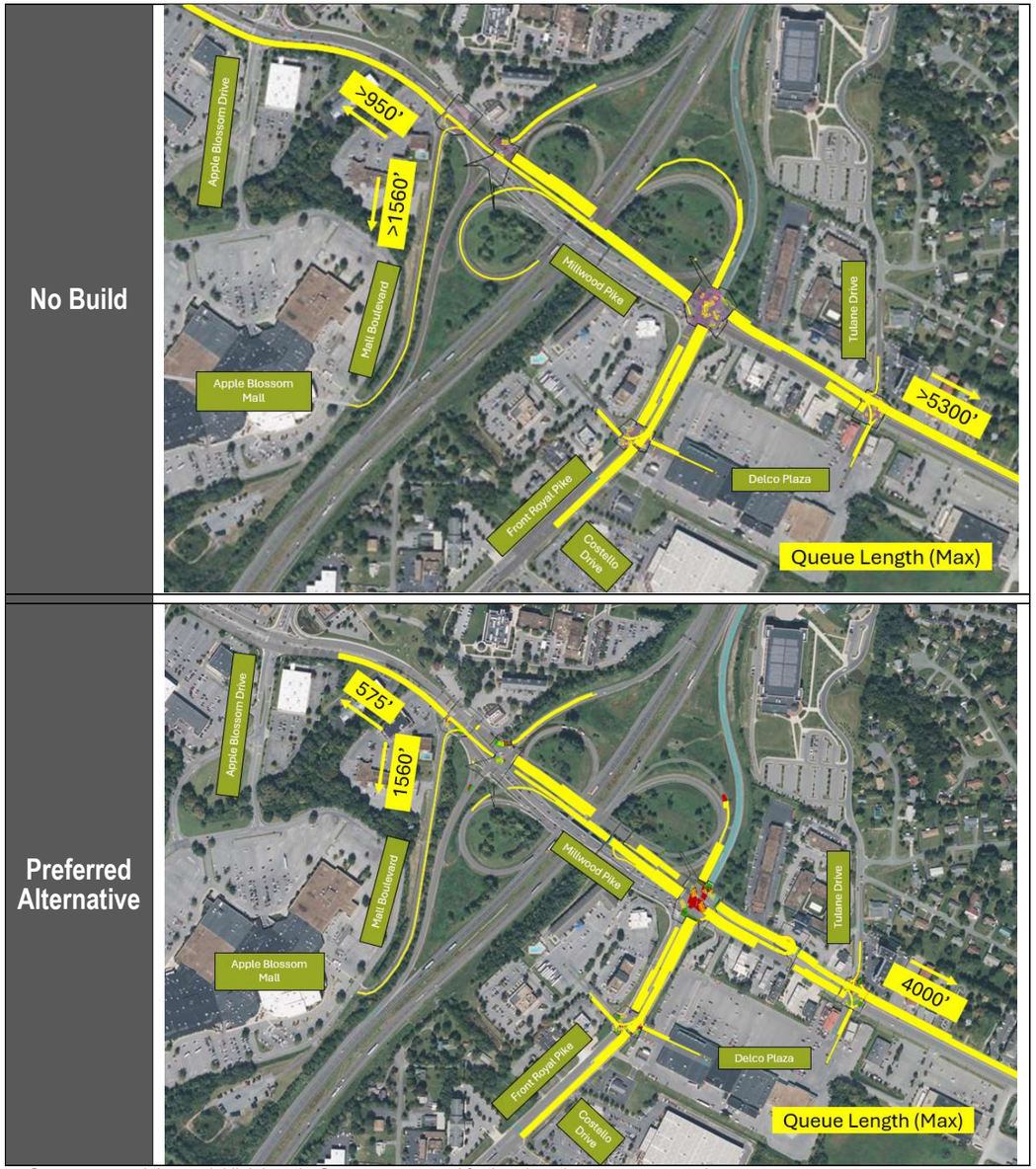
* Stop control on Mall Boulevard

In the future year analysis, oversaturated conditions were observed along the study corridor, where the network is unable to provide capacity to meet the demand. In such scenarios, it is desirable to quantify the network performance using latent demand and delays. Latent demand refers to the number of vehicles that could not be deployed in the network, while latent delay is the total waiting time for vehicles that, since the beginning of the simulation were not able to enter the network from the origin zone at the time of deployment. A comparison of the latent demand and delay between the two alternatives is provided in **Table 18**. Both the latent demand and latent delay show significant reduction between the No Build and Preferred Alternative scenarios; a 67% reduction in demand and a 60% reduction in delay.

Table 18. Vissim Network Performance Results Comparison

	No Build	Preferred Alternative	% Change
Latent Demand (count)	1,166	383	- 67%
Latent Delay (sec)	1,862,521	741,978	- 60%

The network performance of the preferred alternative compared to the No Build scenario is illustrated through the maximum queue lengths observed in **Figure 26**. In the No Build scenario, the queues on the I-81 northbound and southbound off-loop are forecasted to spill back onto the I-81 mainline in the opening year, 2034. The long maximum queues observed for the US 50 westbound approach in the preferred alternative scenario at the Tulane Drive intersection on the easternmost side of the study corridor were due to latent demand. Under the Preferred Alternative scenario, the eastbound queue at the US 17/US 5 and Mall Boulevard intersection saw a significant reduction and no longer spills back past the available storage area. The northbound queue at the US 17/US 50 and Mall Boulevard intersection also saw a reduction in the Preferred Alternative scenario and no longer spills past the available storage. While the westbound queue at the US 17/US 50 and Tulane Drive intersection still has a significant queue in the Preferred Alternative, there is a greater than 1,300-foot queue reduction compared to the No Build scenario.



>Queues exceed the model link length. Queue may extend further than the measurement shown

Figure 26: Alternative Analysis Comparison - Maximum Queue Lengths

The travel time for the 0.5-mile section of US 50 between Mall Boulevard and Tulane Drive intersections in both directions was evaluated, as shown in **Table 19.** The travel time benefits of the Preferred

Alternative were significantly better than the No Build scenario with savings of 61% in the eastbound direction and a more substantial 48% in the westbound direction.

Table 19. Alternative Analysis Comparison- US 50 Corridor Travel Times

Direction	Travel Time (mm:ss)		% Change
	No Build	Preferred Alternative	
Eastbound	03:32	01:22	-61%
Westbound	03:12	01:39	-48%

At US 50 & US 522/I-81 Northbound Off-Loop intersection, US 50 eastbound & westbound left turns are rerouted to median openings on either side of the intersection for the preferred alternative. The HCM defines Experienced Travel Time (ETT) for a given origin-destination movement as "the sum of extra distance travel time (the free flow travel time required to traverse the alternative intersection minus the hypothetical shortest-path free-flow travel time making right-angle turns) and the control delay experienced at each junction encountered.

To quantify the rerouting of US 50 eastbound left and westbound left turn movements, ETT for these movements between the two alternatives was compared, as shown in **Table 20**. The ETT to make the eastbound left turn at US 50 & US 522/I-81 Northbound Off-Loop intersection significantly improves by 38%.

Table 20. Alternative Analysis Comparison- Experienced Travel Time at US 50 & US 522/ I-81 NB Off-loop

Movement	Experienced Travel Time (mm:ss)		% Change
	No Build	Preferred Alternative	
US 50 Eastbound Left Turn	03:54	02:26	-38%
US 50 Westbound Left Turn	01:35	01:27	-8%

Safety Analysis

A Crash Modification Factor (CMF) is used to determine the expected number of crashes after implementing a countermeasure on a road or intersection. A summary of the applicable CMFs and the expected reduction in crash incidents is provided in the following section for (1) the intersection of US 522 and US 17/50 and (2) the US 17/50 segment between US 522 and Tulane Drive. The targeted crashes for each of the improvements are shown in the collision diagrams in **Appendix H**. The CMF values for the proposed improvements are provided in **Table 21**. The total number of predicted crashes after applying the CMFs and the percentage of crashes reduced are displayed in **Table 22**.

PARTIAL MEDIAN U-TURN (MUT) AND ADDITIONAL TURN LANES AT US 17/50 AND US 522

Partial MUT – The installation of a Partial MUT at US 17/US 50 and US 522 (concept sketch shown in **Figure 25**) reduces conflict points for left-turning vehicles on the major road approach. Targeted crashes include angle crashes and rear-ends associated with left turns from US 50 approaches. The CMF from the Virginia State Preferred List for full MUT is used for this analysis, as no research is currently available for the safety analysis of a Partial MUT. Significant safety benefits are expected for this improvement due to the reduced conflict points from 32 (traditional intersection) to 22 (Partial MUT intersection). The partial MUT restricts the eastbound and westbound left turn movements, resulting in fewer traffic signal phases, reducing congestion and time stopped at the intersection.

Additional EB and WB Right Turn Lane – Installing additional right turn lanes on the eastbound and westbound approaches of US 50 would reduce the number of rear-end and sideswipe (same direction) crashes on both major approaches by providing extra storage length for right-turning vehicles.

Additional SB Left Turn Lane –Installing an additional left turn lane on the southbound approach would reduce rear-end crashes for vehicles exiting the I-81 Northbound Off-Loop by providing extra storage length for left-turning vehicles.

CONCRETE MEDIAN BETWEEN US 522 AND TULANE DRIVE

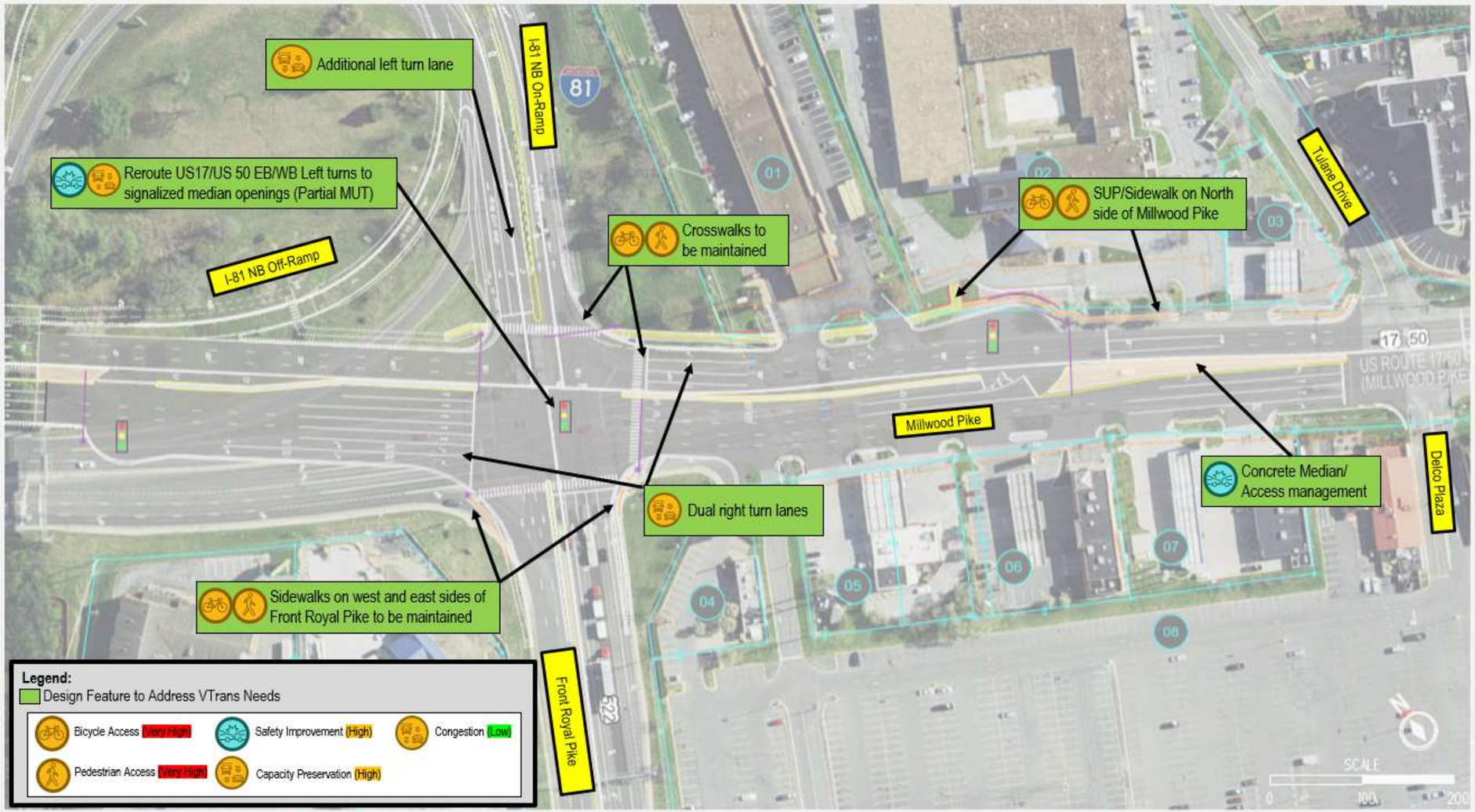
Installing a raised concrete median along US 50 between US 522 and Tulane Drive would reduce the angle crashes caused when vehicles attempt to enter or exit several access points along US 17/50. These crashes included one (1) severe injury, one (1) minor injury, one (1) non-visible injury, and one (1) fatal crash. The fatal crash happened when a westbound driver turning left into a gas station collided with an eastbound vehicle on US 17/50. The left-turning vehicle failed to yield the right-of-way, resulting in the fatalities of both passenger-side occupants.

Table 21. CMF Table for Proposed Improvements

Location	Proposed Improvements	Applicable Crash Type	Crash Severity	CMF Value					Source
				All	K	A	BC	PDO	
US 522 and US 17/US 50	Convert existing intersection to a Partial Median U-turn (MUT)	All	All	0.63	0.70	0.70	0.70	0.91	FHWA TechBrief; CMF ID: 10851
	Provide additional right turn lane on EB and WB approaches	All	All	0.92	0.92	0.92	0.92	0.92	CMF Clearinghouse; CMF ID: 290
	Provide additional left turn lane on SB approach	All	All	0.79	0.79	0.79	0.79	0.80	CMF Clearinghouse; CMF ID: 3948, 3950
US 17/50	Raised median for access management	Angle	All	0.45	0.45	0.45	0.45	0.45	CMF Clearinghouse; CMF ID: 2220

Table 22: Total Number of Crashes and % Crash Reduction

	All	K	A	BC	PDO
Total Crashes	178	1	6	30	141
Predicted Crashes After Applying CMFs	144	0	5	26	113
Percent Crash Reduction	19%	100%	17%	13%	20%



VTrans Needs Addressed

The VTrans Needs at this location and the proposed improvements to alleviate the needs include:

Capacity Preservation/Safety Improvement

- Partial median U-turn at the Millwood Pike and Front Royal Pike/I-81 Northbound Ramps intersection
- Restriction of left turns in the eastbound and westbound direction on Millwood Pike, with these movements redirected to signalized median openings (partial median U-turns)
- Additional right turn lanes in the eastbound and westbound directions on Millwood Pike
- Additional left turn lane on the I-81 Northbound Off-Ramp
- Median restricting access management

Pedestrian Access

- SUP/sidewalk on the North side of Millwood Pike
- Sidewalks on the west and east sides of Front Royal Pike to be maintained
- Crosswalks on Millwood Pike and I-81 Northbound Ramps to be maintained

Figure 27. Summary of Design Features to Address VTrans Needs

Chapter 3:

Public and Stakeholder Outreach and Feedback

Public Involvement:

In Pipeline Round One Study. following the development and analysis of the Preferred Build Alternative, a public involvement survey was developed to determine the public's response to the recommended improvements and what they perceived as the relevant issues within the study area. This survey was available online for 14 days spanning from February 22, 2022 to March 7, 2022.

Survey Design

Public involvement for this study took place in the form of an online survey developed in MetroQuest, which is an online engagement platform that is designed to educate the public while gathering informed output. The goals of this public outreach effort were to present relevant issues, educate the public on the recommended improvement concepts outlined in Chapter 2, and to receive the public's feedback on the proposed improvements.

Overall, the survey is divided into five (5) sections, which include the following:

1. Welcome/introduction with overview of the project and study area
2. Corridor improvement needs
3. Recommended improvements at I-81 Exit 313 and US 50/US 522
4. Recommended improvements at US 522 and Costello Drive
5. Wrap up with demographic questions

The first section provides an overview of the study area and the project initiative. In the second section, participants were presented with corridor improvement needs, as shown in **Figure** 28. Then, participants were asked to provide feedback on whether they agreed or disagreed with the presented need. Next, in the third and fourth sections, a summary of the recommended improvements and benefits at the intersections of US 522 at US 17/US 50 and Costello Drive was provided, respectively. For these recommended improvement concepts, participants were asked to rate them based on their opinion from one (1) to five (5), one (1) being very unfavorable, three (3) being neutral, and five (5) being strongly in favor. They were also provided with an option to input comments or concerns. At the end of the survey, the participants were asked a few demographic questions such as; "How do you normally travel in this area?" and "What other modes of travel would you prefer?". A total of 477 people responded to the survey.

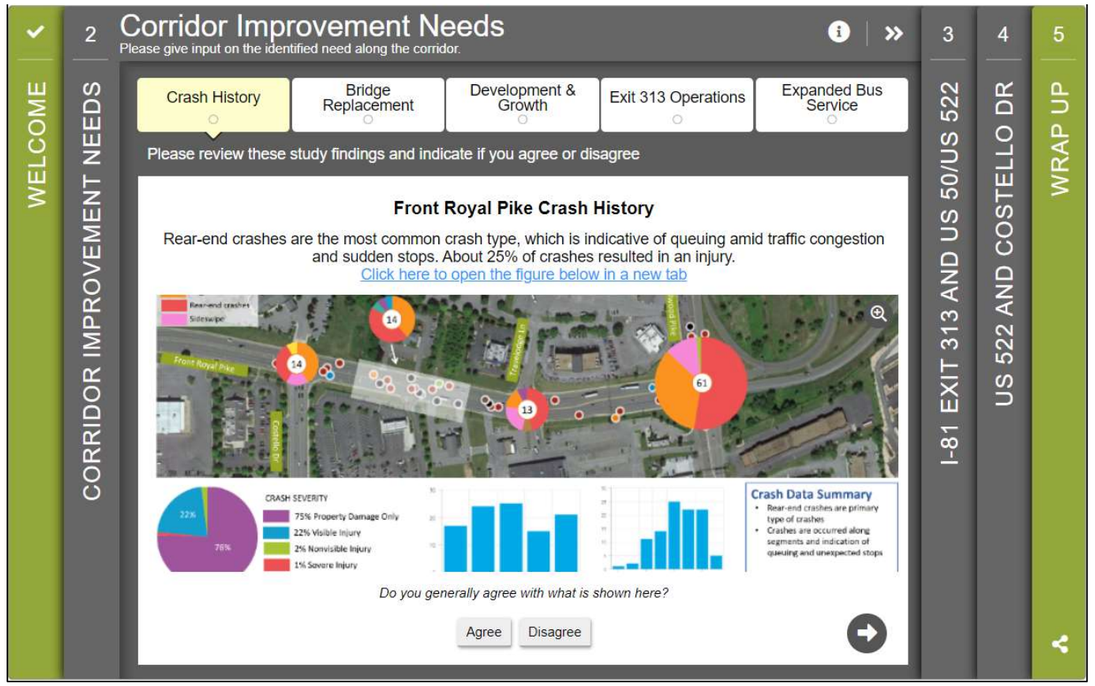


Figure 28: Public Survey Layout

Survey Questions and Results

The survey results on the participants' current and preferred modes of travel are presented in **Figure 29** and **Figure 30**, respectively. Overall, the majority of participants drive their personal vehicle within the study area. Approximately 37% of participants responded that they preferred active transportation (walking/biking/transit).

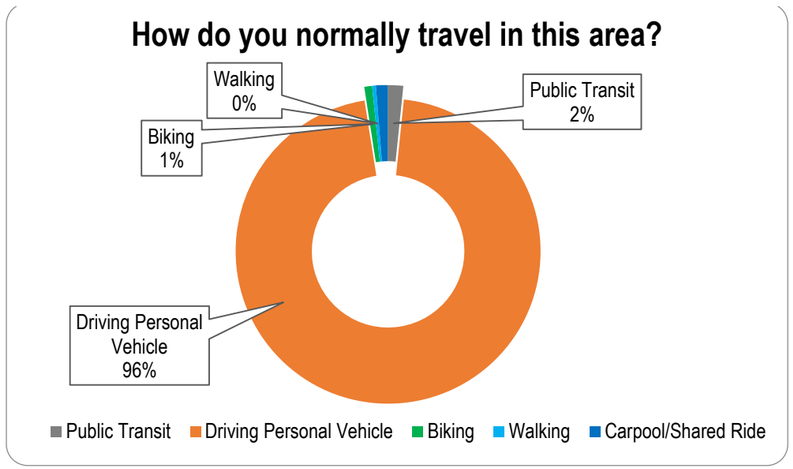


Figure 29: Participants' Current Mode of Travel

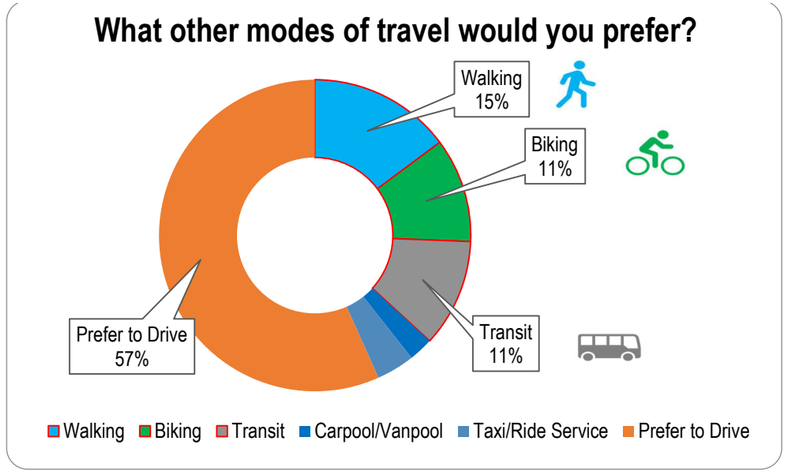


Figure 30: Participants' Preferred Mode of Travel

To understand what participants perceived as the relevant issues within the study area, five (5) improvement needs were presented. Participants were then asked to respond whether they agreed or disagreed on the presented need. **Figure 31** shows the first improvement need, which pertains to the crash history with a high number of rear-end and corridor-related crashes, both indicating queuing amid traffic congestion and sudden stops.

Figure 31: US 522 Crash History

The second improvement need presented to the public is regarding the approved One Logistics Park development discussed in Chapter 1. As shown in **Figure 32**, approximately 17,000 daily trips are estimated from One Logistics Park, which will heavily impact the study area on US 50/US 17.

Figure 32: Project Development and Growth

With additional trips from the One Logistics Park development, the US 522 and US 17/US 50 intersection is expected to experience high levels of delay in the future year 2054. **Figure 33** presents the 2042 AM and PM peak hour delays at the subject intersection by movement. Without any improvements, the future 2042 traffic demand exceeds the capacity for the movements marked with a red exclamation point.

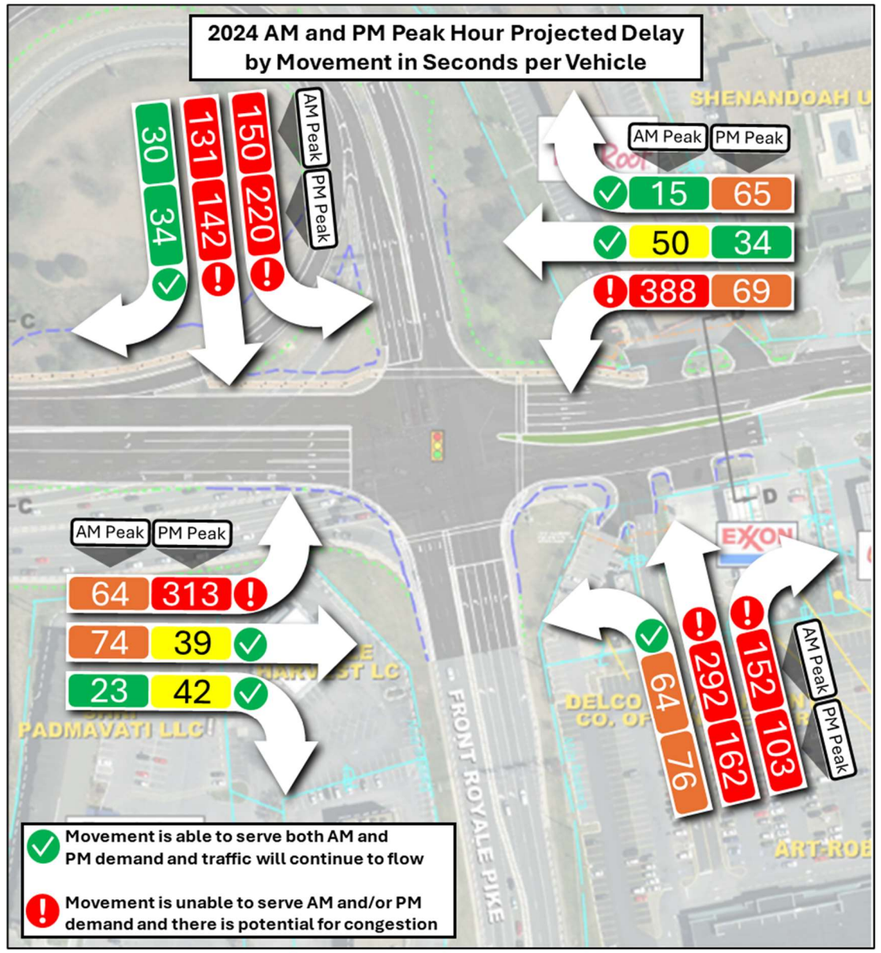


Figure 33: US 522/US 17/US 50 and I-81 Exit 313 Operations

As mentioned in Chapter 1, there is a bridge replacement project on US 17/US 50, which is projected to be completed in late 2023. As shown in **Figure 34,** a design concept of the new bridge that was previously developed from the bridge replacement study was presented to the public to educate them on the proposed changes and their impact on the study area while receiving feedback.

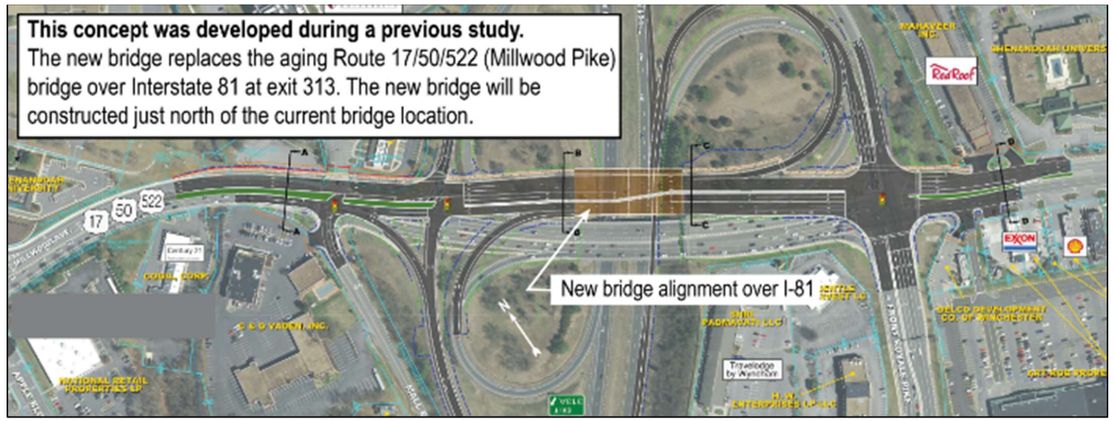


Figure 34: Replacement of Bridge over I-81

The last improvement need presented to the public is regarding transit service. Currently, WinTran's existing route does not serve east of I-81, as shown below in **Figure 35**. With the anticipated future traffic growth, expansion of transit service to the east side of I-81 may help meet the mobility needs, particularly for those who selected transit as their preferred mode of travel.

Figure 35: Existing Transit Service Route

Table 23 presents the results of the participants' perceptions of corridor improvement needs.

Table 23: Participants' Perception of Corridor Improvement Needs

Improvement Need	Description	Agree	Disagree
US 522 Crash History	Rear end crashes are the most common crash type, which is an indicative of queuing amid traffic congestion and sudden stops	**96%**	**4%**
Project Development and Growth	Future development, including the One Logistics Park project, will significantly increase trips on US 17/US 50 to and from I-81 and Winchester	**89%**	**11%**
US 17/US 50 and I-81 Exit 313 Operations	The US 522 at US 17/US 50 intersection and I-81 northbound ramps are expected to experience heavy delays with future development to the east projected into 2042	**90%**	**10%**
Replacement of Bridge over I-81	Replacement of the aging US 17/US 50 bridge over I-81 at Exit 313 is necessary	**92%**	**8%**
Expanded Bus Service	Transit could help meet the mobility needs of US 522 in Frederick County as WinTran's existing route does not serve east of I-81	**80%**	**20%**

As shown above, the participants showed general agreement on the potential issues presented. A significant rear end crash history leading to the need for capacity improvements on US 522 was what the public perceived as the most relevant issue, while transit and expanded bus service were the least perceived issue.

Next, participants were presented with the Preferred Alternative design concepts for the intersections of US 522 at US 17/US 50 and Costello Drive to rate each improvement on a scale from one (1) to five (5) stars. A partial MUT design concept for the US 522 and US 17/US 50 intersection is presented along with the operational benefits in **Figure 36.** The safety benefits of the partial MUT option and the reduced number of conflict points as compared to the conventional intersection are presented in **Figure 37.** Finally, the public ratings on the proposed partial MUT concept are summarized in **Figure 38**.

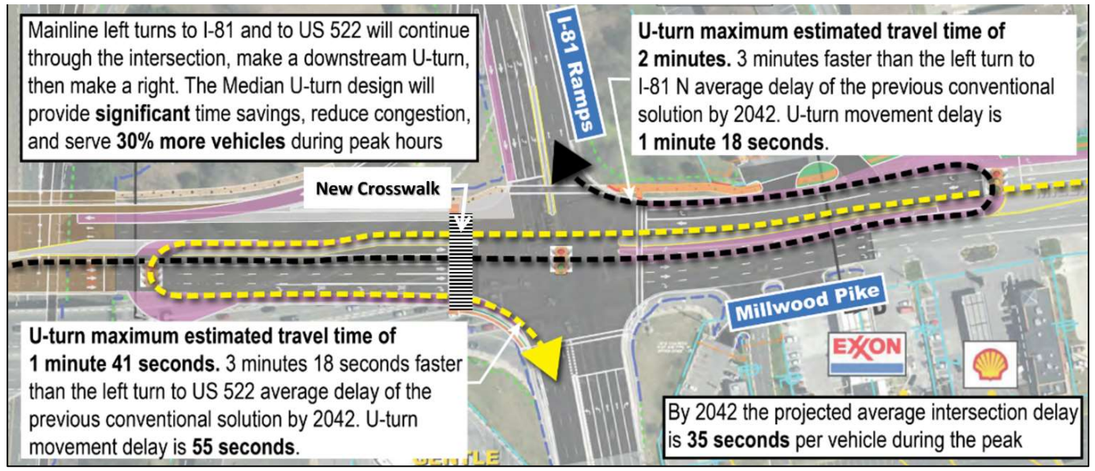


Figure 36: US 552 at US 17/US 50 Partial MUT Design Concept

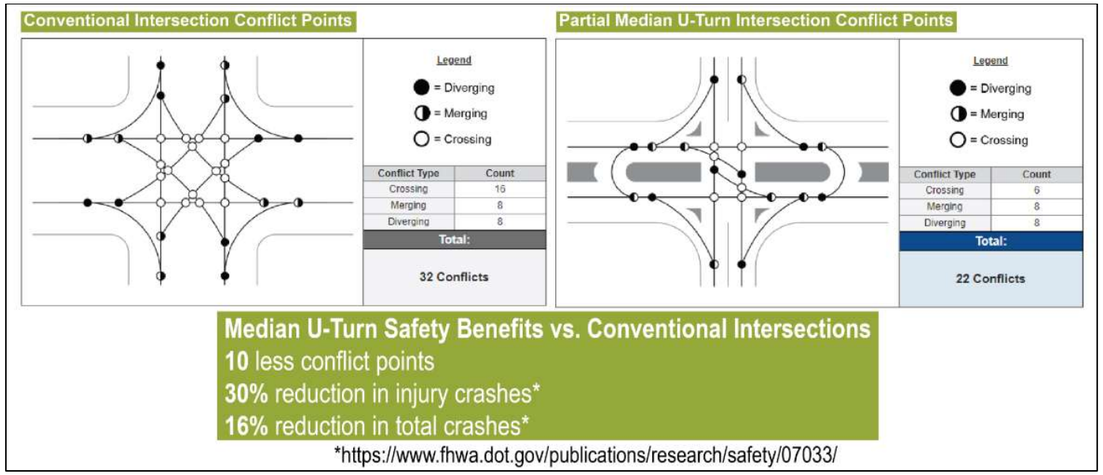


Figure 37: US 552 at US 17/US 50 Partial MUT Safety Benefits

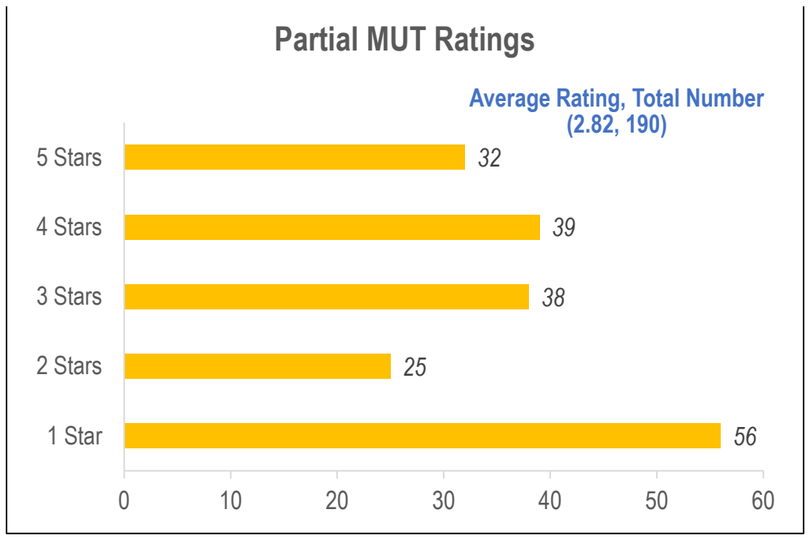


Figure 38: Survey Results - US 552 at US 17/US 50 Partial MUT Ratings

A total of 190 participants responded to the partial MUT concept proposed at the intersection of US 522 and US 17/US 50. Mixed ratings were received from the public, with an average rating of 2.82 and approximately 37% giving four (4) to five (5) stars.

A Thru-Cut design concept for the US 522 and Costello intersection provided to the participants is presented in **Figure 39** and the ratings are summarized in **Figure 40**.

Figure 39: US 522 at Costello Drive Thru-Cut Design Concept

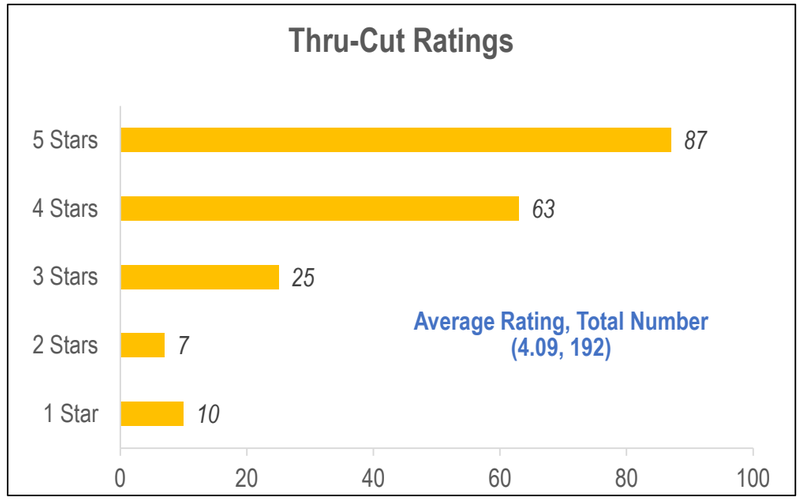


Figure 40: Survey Results - US 522 at Costello Drive Thru-Cut Ratings

A total of 192 participants responded to the Thru-Cut concept proposed at the intersection of US 522 and Costello Drive. Overall, the Thru-Cut intersection was well-received by the public, with an average rating of 4.09 and approximately 78% giving four (4) to five (5) stars.

A summary of public comments on the Preferred Alternative improvements and the study team responses is shown in **Table 24**.

Table 24: Summary of Public Comments and Study Team Responses

Public Comments and Study Team Responses		
	Public Comment	**Study Team Response**
Truck Trailers Maneuvers	"The area has a great deal of commercial traffic (tractor-trailers) and residential traffic, causing significant traffic. Improvement is badly needed."	Based on the evaluation in AutoTURN, the proposed u-turn signals on US 17/ US 50 are able to handle heavy vehicles such as WB-67 semi-truck trailer.
Entrance Location to Costco	"Those cars wishing to go to Costco would all still fight for that inside lane closest to Costco's entrance."	Future improvements should be considered at the unsignalized Costco entrance to accommodate increased traffic regardless the proposed dual left on southbound US 522.
Pedestrians' Safety and Students Walking	"I am a student at Shenandoah University, and I think that the entire area surrounding exit 313 from I-81 could do with some work. The traffic is worse than ever, and students at SU who live past the exit 313 intersections either need a car or have to walk alongside crowded and dangerous roads with limited sidewalks."	A new sidewalk is proposed as part of the Preferred Alternative. In addition, the Preferred Alternative recommends new crosswalks at the study intersections to improve pedestrian accommodations.
First Responders' Access	"Consider First Responder input too. This will increase response time for ISO ratings."	Emergency Vehicle Preemption (EVP) system can be installed for the new signals. In addition, a significant reduction in delays for the Preferred Alternative results in a significant reduction in response time.
Request Better Public Transit in the Area	"WinTran needs to expand outside of Winchester to serve more areas around Frederick County. Adding more lanes to roads will only make the problem worse over time and is terrible for the environment."	According to the WinTran Transportation Development Plan, it is recommended the existing Berryville and Apple Blossom Mall routes be extended. Improvements proposed as part of the Preferred Alternative are focused on intersection reconfigurations, not road widening.

Chapter 4:

Preferred Alternative Design Refinement & Investment Strategy

Intent of Phase 3

Phase 3 of the Pipeline Effort is intended to develop detailed concepts of the Phase 2 Preferred Alternative that will carry through to funding applications and project validation. The goal is to ensure that projects are defined to the maximum extent possible and to identify and mitigate potential risks. Utilizing technical resources of both VDOT and consultant teams, a multidisciplinary design approach is part of the overall effort that provides the needed input and problem-solving to ensure funding applications are thoroughly vetted and taken past a planning level sketch and estimate.

The goal is to develop more detailed, quantity based, deterministic estimates and designs paired with thoughtful risk assessment and mitigation. The team will use practical design and common-sense engineering methods to document the assumptions and approaches that lead to the most efficient and effective project scopes. The effort maintains focus on the purpose and needs identified through Phase 1 and 2 that address the VTRANS priorities.

Technical resources utilize Phase 3 for thorough communication and collaboration with District, Central Office, FHWA, or other key partners and stakeholders that may have decision making authority or input on final designs if projects are selected for funding. An intended outcome is that projects, if funded, will have the documentation and support for innovation and flexibility that may be necessary to achieve success.

The Phase 3 Technical Team developed the analysis, design, deliverables, and documentation that will serve as the basis for future Preliminary Engineering work on the projects. At the conclusion of Phase 3, projects should achieve a solid foundation of understanding from a planning and preliminary engineering focus that will ensure applications are well validated, reasonably scoped, meet the needs originally established in studies, and have a high probability of success.

Assumptions

The following are key design assumptions that informed the concept development and cost estimate preparation:

- Roadway geometry:
    - The design assumes widening the existing roadway to provide U-turn accommodations with minimal profile changes. To minimize impacts to Shenandoah University Commons parking, and to provide a buffered sidewalk within the U-turn area, Route 17/50 will be shifted approximately 8-ft to the south in the area of the U-turn. The easterly U-turn is assumed to have an adverse cross slope to further minimize impacts to the Shenandoah University Commons parking area creating a flow line between the turn around and the adjacent travel lane. Access to Shenandoah University Commons would be reduced to one entrance.
- Pedestrian accommodations:
    - The proposed 8-ft shared use path being designed as part of the Route 17/50/522 (Millwood Ave./Pike) Bridge Over I-81 project will be extended to the existing primary entrance to Shenandoah University Commons. At this location a 5-ft sidewalk is extended to connect to the existing sidewalk at Tulane Drive. At the service station at the corner of Route 17/US Route 50 and Tulane Drive (parcel 03), the curb line is adjusted to the edge of the existing travel lane to minimize impacts to the existing entrance grades and one entrance is closed to allow safe pedestrian access to the proposed crossing across Tulane Drive.
- Hydraulics:
    - New storm drain system will be required to accommodate the new curb lines. The new system will be able to connect to the existing system as planned with the Route 17/50/522 (Millwood Ave./Pike) Bridge Over I-81 project. Existing median drainage associated with the new Route 17/50/522 (Millwood Ave./Pike) Bridge Over I-81 project would need to be abandoned and inlets to be capped or removed.
- Stormwater management:
    - Stormwater management would be provided with two new pond locations west of Route 522.

- Traffic:
    - New traffic signals will be required at the Route 522 intersection and at both U-turn locations. The Route 522 intersection is a large intersection and will require multiple pole configurations to accommodate all movements. New overhead guide signs will need to be further evaluated during final design for proper placement. This design accounts for two new overhead sign structures west and east of Route 522, the final locations and messages will be determined during final design.
- Utility impacts:
    - The widening will impact overhead utility poles east of Route 17/50/522 (Millwood Ave./Pike) Bridge Over I-81 project limits. These overhead poles will have limited area to be relocated due to existing site conditions.
- Right of Way:
    - The proposed improvements will involve acquiring right of way and easements on eight (8) commercial parcels east of Route 522. The project is proposing to remove one entrance on parcel 02 and one entrance on parcel 03 to provide pedestrian accommodations and improve access management. Refer to the concept design exhibits and Right of Way Data Sheet for more details.
    - Per VDOT Estimate dated 7/17/2024: "*SS Est Rnd #6. Prop acq areas calc from R/W DS prov by PM. Asphalt, Concrete, Trees & Shrubs, Sign, Parking lot light, & IP's. Assumptions: No TTs; No well / septic impacts; All parcels to retain reasonable access; Condemnation elev due to recent attorney involvement; Dams elev due loss of 17 parking spots during const, 22 prime parking spots totally, and 3 Comm entrance closures; Canopy & UG tanks will not be disturbed on Parcel 005; (30% Contingency added to Manual Inflation Rate). [DWL]*"

Risk Assessment/Contingency

As part of the risk assessment process, a risk register was developed to identify major/high impact project risk elements. The guidance provided in VDOT's Cost Estimating Manual (Chapter 5) and IIM PMO-15.0 was followed and identified after assessing collected data, field visits, stakeholder input, and concept development. Risks were organized by broad categories including Maintenance of Traffic (MOT), Roadway Design, Right-of-Way, Utilities, Mobilization/Construction Survey, Hydraulics, Traffic, Structures/Bridge Design, Geotechnical, and Environmental. The major risks identified in this project include:

- Right-of-Way due to the likely damages associated with the right-of-way impacts, and the limited right-of-way for relocation of utility poles.
- MOT plans have not been developed at this stage, while the MOT is not anticipated to be complex the Most Likely Estimate (MLE) for pre-scoping is recommended.
- The concept has been developed using design level survey, incorporating the Route 17/50/522 (Millwood Ave./Pike) Bridge Over I-81 project field inspection plan information. In coordination with VDOT the design team has identified potential risks with the traffic signals at the Route 522 intersection and the overhead sign structures located west and east of Route 522. These items account for a significant percent of the traffic budget.
- The hydraulic design is based on general field conditions and the Route 17/50/522 (Millwood Ave./Pike) Bridge Over I-81 project field inspection plan information, any changes to the concept may impact the conceptual design. Drainage calculations have not been performed and pipe sizes are based on engineering judgement.

The project is considered Moderately Complex. However, the level of concept design development is relatively detailed (between Pre-Scoping and PFI level of design); therefore, the MLE contingency would be more accurately in the 40% to 45% range. Each individual risk was "scored" based on probability, cost impacts, and time impacts. Scoring was used to assign contingencies per risk line item. These line-item risk contingencies were then aggregated to determine a contingency amount per category to include preliminary engineering, right-of-way and utilities, mobilization/construction survey, MOT, roadway design, hydraulics, traffic, and earthwork/geotechnical.

Cost Estimate

The project cost estimate was developed using the following methodology:

- Understanding the goals of the project and scope of improvements to be implemented.
- Gathering and reviewing as much information about the project as possible including site visits and stakeholder input.
- Establishing design criteria and developing a detailed design concept.
- Performing quantity takes offs and identifying unit prices based on Bid Express, and historical VDOT cost data (2-year District and Statewide average) to develop "defined costs".
- Developing "allowance costs" for some elements based on potential impacts and complexity. Allowances add costs for elements based on percentage of the base construction cost.
    - MOT 7.5% Allowance.
    - 1.5% for a field office.
    - Roadside Development at 2.5%.

    - $75,525 for additional pavement overlay to correct pavement cross slopes.
    - In-Plan Utilities 2% Allowance to cover minor water and sanitary sewer adjustments.
    - Traffic Signals: $700,000 Route 522 intersection + $150,000 at each U-turn location.
    - Overhead Signs: $300,000 per sign structure.
    - An allowance of 2% is included each for pavement markings and signing replacement/improvements.
- Identifying proposed property impacts, developing a Right of Way Data Sheet and coordinating with VDOT to develop Right-of-Way costs. Note, eight (8) parcels are anticipated to be impacted, including $15,000 for administrative costs.
- Performing a risk assessment as outlined above and identifying appropriate contingency percentages by category.
- Developing Preliminary Engineering costs by category based on a percentage of the Construction cost.

Concept Revisions & Final Estimate

Based on VDOT and Stakeholder input from Phase 2 and the site visit performed at the commencement of Phase 3, the concept was advanced, refining key elements of the preferred alternative, as shown in **Figure 41**.

Cost Estimate Breakdown

The total project cost is estimated to be $13,504,184 and broken down by Phase/Major area as shown in **Table 25** below. This cost includes contingencies and represents uninflated 2024 dollars.

Table 25: Cost Estimate Breakdown

Phase	Total
Preliminary Engineering Phase	$1,852,500
Right-of-Way and Utilities Phase	$1,582,302
Construction Phase (without CEI)	$8,483,653
Construction Phase (with CEI)	$10,069,382
Total	**$13,504,184**

Figure 41: US 17/US 50/US 522 Intersection Improvements