



PROJECT PIPELINE

NV01: Fairfax County Route 236 – Little River Turnpike Final Report

From Prosperity Avenue to Wakefield Chapel Road



Route 236 (Little River Turnpike) from Prosperity Avenue to Wakefield Chapel Road

Final Report
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Prepared for



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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 vapipeline.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**.

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

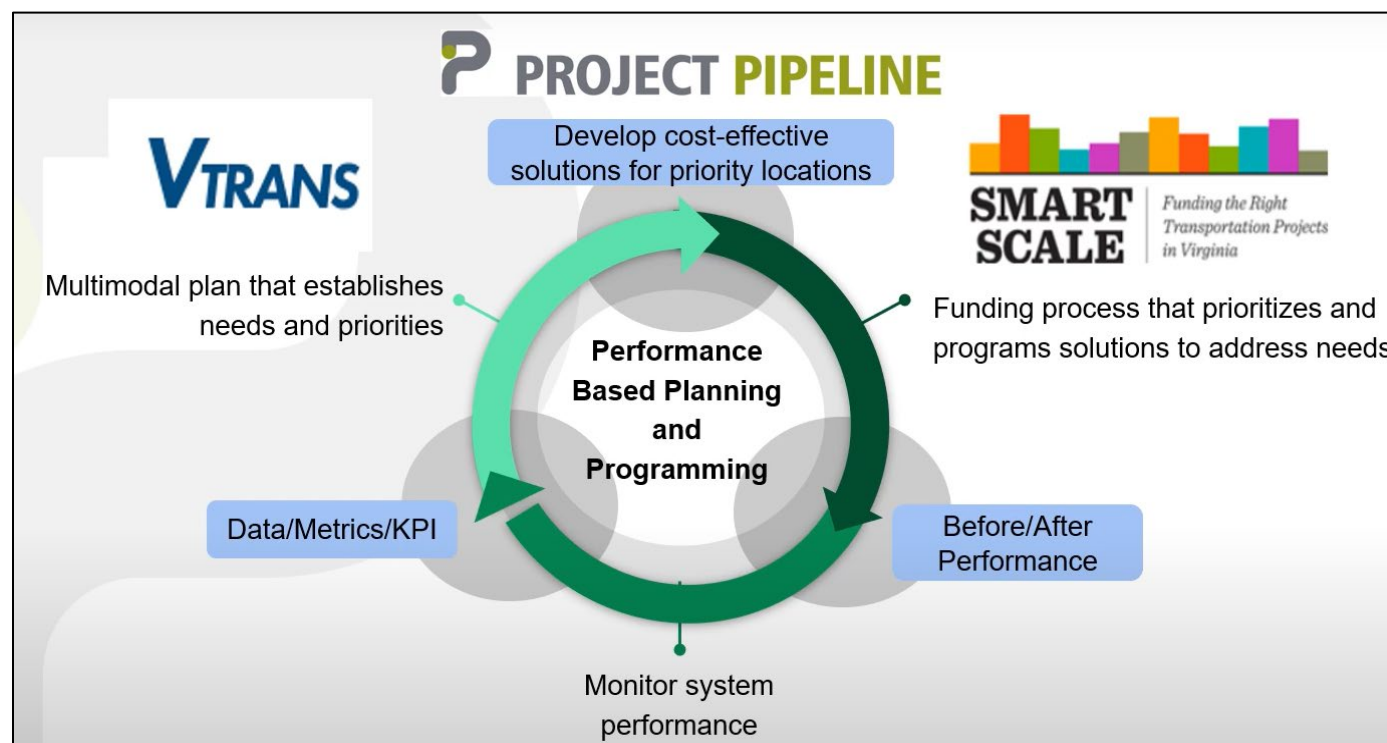


Figure 1: Project Pipeline Objectives

Methodology

The study is broken down into three phases. Phase I consists of the problem diagnosis and brainstorming of alternatives, Phase II includes 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**.

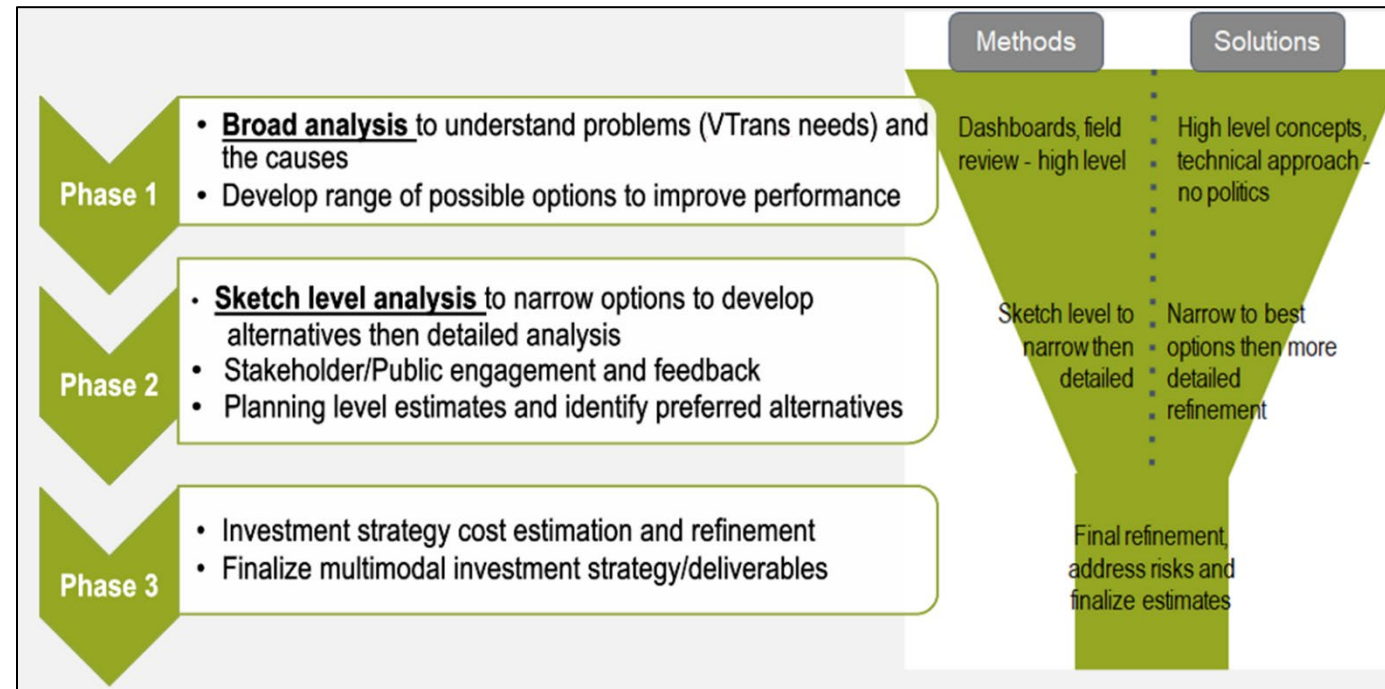


Figure 2: Study Phase Methods and Solutions

The study team is also broken down into three teams, with each team simultaneously working on different areas of the study. Team 1 focuses on Traffic Operations, Capacity, and Access, Team 2 focuses on Road Reliability and Safety, while Team 3 focuses on Rail, Transit, and Transportation Demand Management (TDM). As shown in **Figure 3**, Team 1 and Team 2 are led by ATCS, with support from KLS on the effort with respect to pedestrian and bicycle needs. Team 3 is led by Mead & Hunt, with support from Michael Baker under the Department of Rail and Public Transportation (DRPT) Program. The following details the focus areas of study for each team:

- Team 1 – Identify operation and access needs by conducting future traffic demand volume forecasts and performing operational analysis of future conditions using Synchro/SimTraffic. Evaluate operational mitigations such as geometric modifications, access management improvements, and installation of facilities for pedestrians and bicycles.
- Team 2 – Identify safety needs with respect to vehicles, pedestrians, and cyclists by evaluating existing roadway conditions as well as crash patterns and crash hot spot locations based on the most recent five-year crash history obtained from the Virginia Department of Transportation (VDOT) Crash Database Tableau Tool. Recommend safety improvement options through geometric modifications, access management improvements, and installation of facilities for pedestrians and bicycles.
- Team 3 – Identify needs with respect to rail, transit, and TDM by reviewing existing rail and transit routes and future traffic demand volume forecasts. Consider improvements recommended through public transit route extensions and the addition of Park and Ride lots.

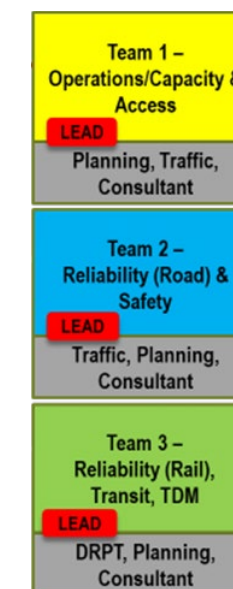


Figure 3: Study Team and Focus Area of Study

Study Area

The Route 236 (Little River Turnpike) study corridor from Prosperity Avenue to Wakefield Chapel Road is located in Fairfax County, Virginia, and runs for approximately 0.4 miles in an east-west direction. The Route 236 corridor is classified as an other principal arterial road within the study area, with a posted speed limit of 45 MPH. The corridor provides access for residential areas to the west to I-66 and to I-395 and I-495 to the east. Route 236 within the study area is a four-lane divided roadway, with a grass median and turn lanes present at both the signalized and unsignalized intersections. The area immediately surrounding the study area is primarily residential, with a small amount of commercial development at the western end of the corridor. A map detailing the study intersections along Route 236 is shown below in **Figure 4**.

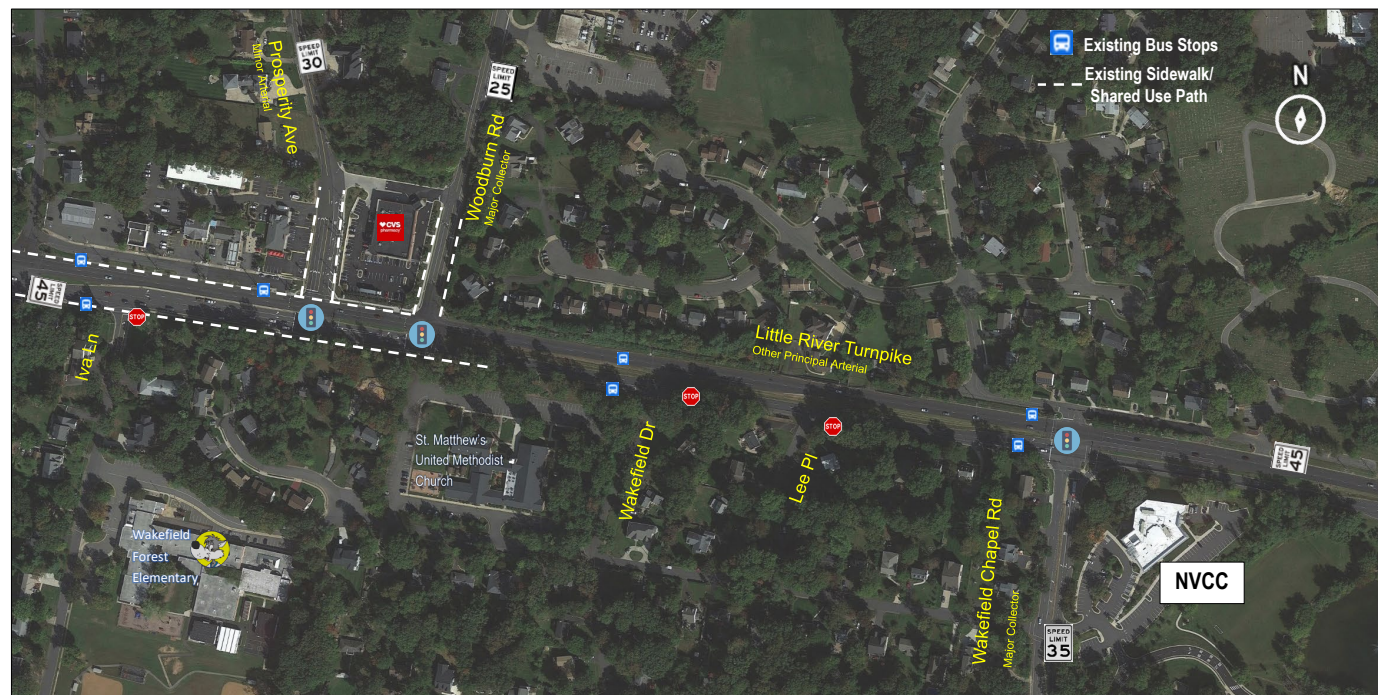


Figure 4: Route 236 Study Area Map

VTrans and Related Project Background Information

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 that correspond 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.

The mid-term needs, as identified in VTrans for the Route 236 study corridor, were identified as 'Very High' for Safety Improvement, Transit Access and TDM, 'High' for Capacity Preservation and Congestion Mitigation, 'Low' for Bicycle Access and Pedestrian Safety Improvement needs, as presented in **Table 2**.

Table 2: VTrans Needs in Study Area

VTRANS IDENTIFIED NEEDS	PRIORITIES
Bicycle Access	Low
Capacity Preservation	High
Congestion Mitigation	High
IEDA (UDA) Access	None
Pedestrian Access	None
Safety Improvement	Very High
Pedestrian Safety Improvement	Low
Reliability	None
Rail On-time Performance	None
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 in need. **Figure 5** presents a map of the study area with 2019 VTrans mid-term needs prioritized for district construction.

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

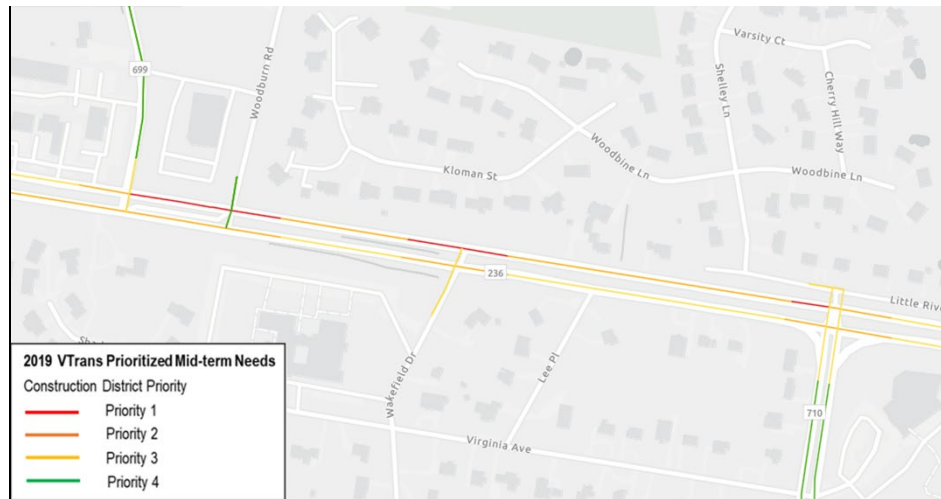


Figure 5: 2019 VTrans Prioritized Mid-term Needs in the Study Area

The study corridor needs congestion mitigation specific focus on the west end of the project area with two closely spaced traffic signals with high turning volumes. Multi-modal solutions need to be identified to improve bus ridership.

Safety improvements are another focus of the study. Historical crash data shows that crashes occurred at the intersections and along the segments, indicating the need for corridor level improvements. The Wakefield Drive intersection is ranked #64 and the Wakefield Chapel Road is ranked #72 in the Potential for Safety Improvement (PSI) ranking which is based on highway Safety Performance Function (SPF) developed by VDOT using the latest Highway Safety Manual (HSM) methods.

Traffic Operations and Accessibility:

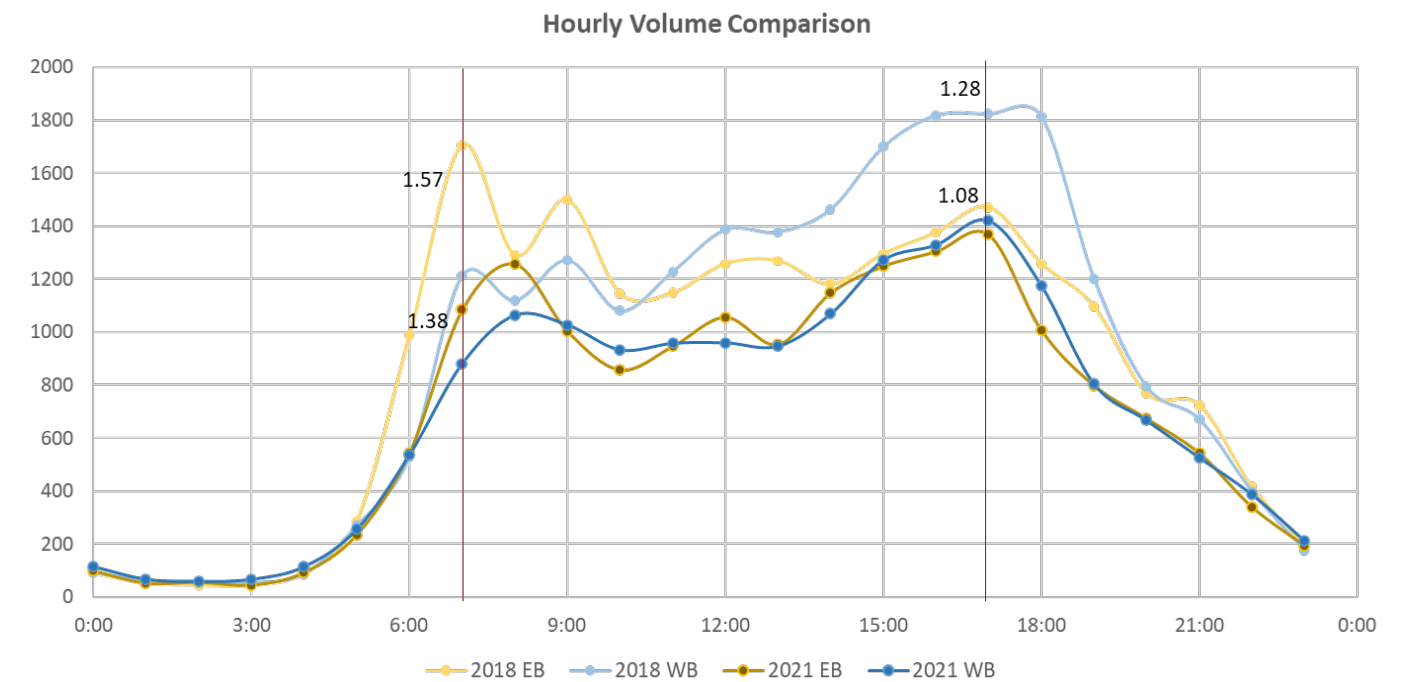
Traffic operational analysis was performed using Synchro 10 software for all study intersections along the Route 236 corridor. Inputs and analysis methodologies are consistent with the VDOT Traffic Operations and Safety Analysis Manual (TOSAM) guidelines. Both AM and PM peak hour analyses were performed for the existing year 2021.

Traffic Data

Average Daily Traffic (ADT) volumes and intersection turning movement counts were collected on June 29, 2021 (Tuesday) and June 30, 2021 (Wednesday), which were then compared to 2018 pre-COVID traffic counts. It was determined that the AM and PM peak hour volumes for both directions of travel had decreased since the pre-COVID conditions. Therefore, an adjustment factor was used to mitigate the

impact of COVID on traffic volumes. The impact of COVID on traffic volumes and the adjustments factors are shown in Figure 6.

The raw ADTs and intersection turning movement counts are provided in Appendix A.



COVID-19 Adjustment Factors

	EB	WB
AM Adj	1.57	1.38
PM Adj	1.08	1.28

Figure 6: Traffic Volume Adjustment Factors

The 2021 COVID-adjusted intersection turning movement counts are shown in Figure 7 and Figure 8 for the AM and PM peak hours, respectively.

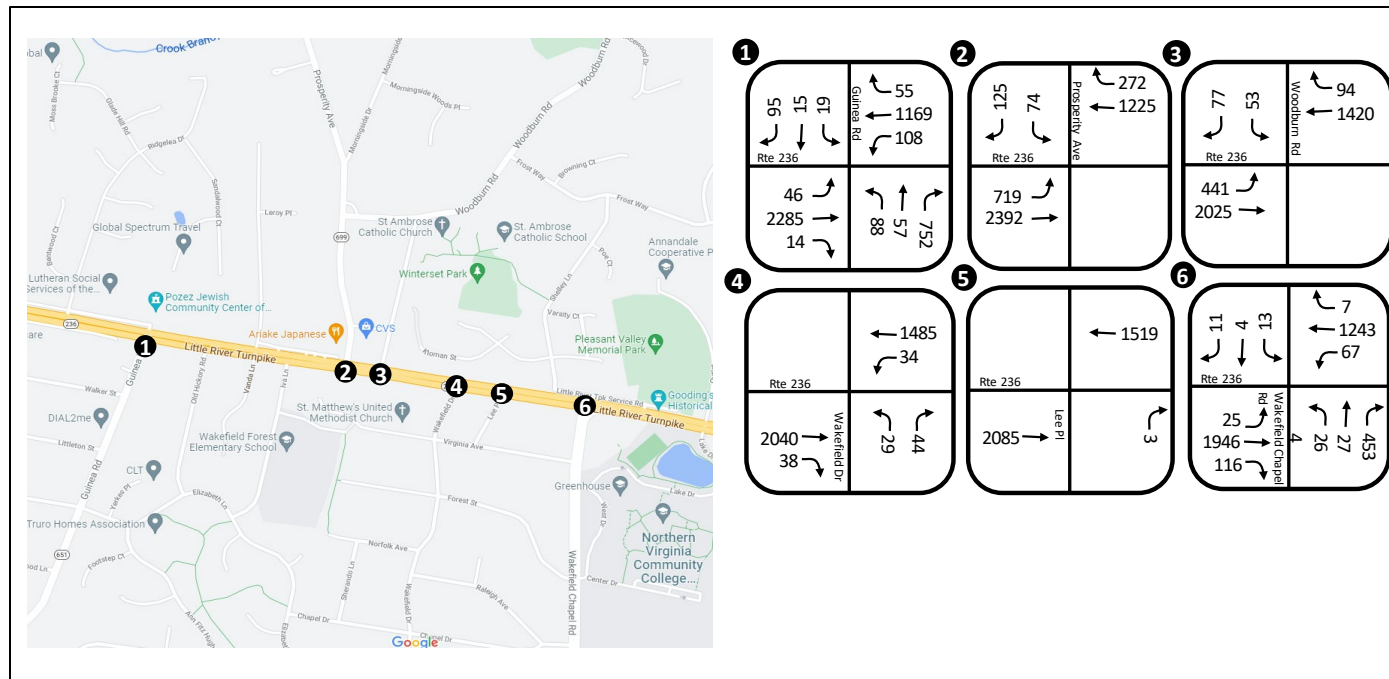


Figure 7: 2021 COVID-Adjusted AM Peak Hour Volumes

In the volume settings in Synchro, an overall Peak Hour Factor (PHF) was used per intersection as recommended by the Highway Capacity Manual. If PHFs for each individual approach or movement are used, they are likely to create demand volumes from one 15-minute period that are in apparent conflict with demand volumes from another 15-minute period. However, these peak volumes do not occur at the same time. Truck percentages for each movement were calculated and used in the models. Synchro roadway speeds were assumed to be the posted speed limit.

Measures of Effectiveness

There are many measures of effectiveness (MOE) in traffic operations analysis to quantify operational and safety objectives and provide a basis for evaluating the performance of a transportation network. Several MOEs for intersection analyses can be reported from Synchro/SimTraffic and SIDRA. For the purposes of this study, guidance for reporting MOEs for signalized and unsignalized intersections was obtained from Chapter 4 of the VDOT TOSAM. A summary of the MOEs evaluated for the study intersections is presented below:

- Control Delay (measured in seconds per vehicle – sec/veh)
- Level of service (LOS)
- 95th Percentile Queue Length via Synchro (measured in feet – ft)
- Volume-to-Capacity (v/c) Ratio

Traffic Operations Analysis Results

In an effort to identify operational and accessibility needs along the study corridor, Synchro analysis was performed for the existing year 2021. Due to the focus of Project Pipeline on addressing existing issues and fast-moving study schedule, modeling focus was on existing and near term issues. Study technical teams agreed to this approach and that future modeling would be completed during later efforts as needed.

The operational analysis shows that all the signalized intersections operate at a Level of Service (LOS) D or better during both AM and PM peak hours in 2021, except for the intersection of Wakefield Chapel Road during the AM peak hour, which operates at LOS E. Overall, the side streets along Route 236 operate at LOS E or worse with queues for some of the movements extending beyond the existing turn storage lanes.

The analysis shows that at the intersection of Route 236 and Prosperity Avenue, the eastbound left turn movement and southbound approach operate with excessive delays and queues during the AM and PM peak hours.

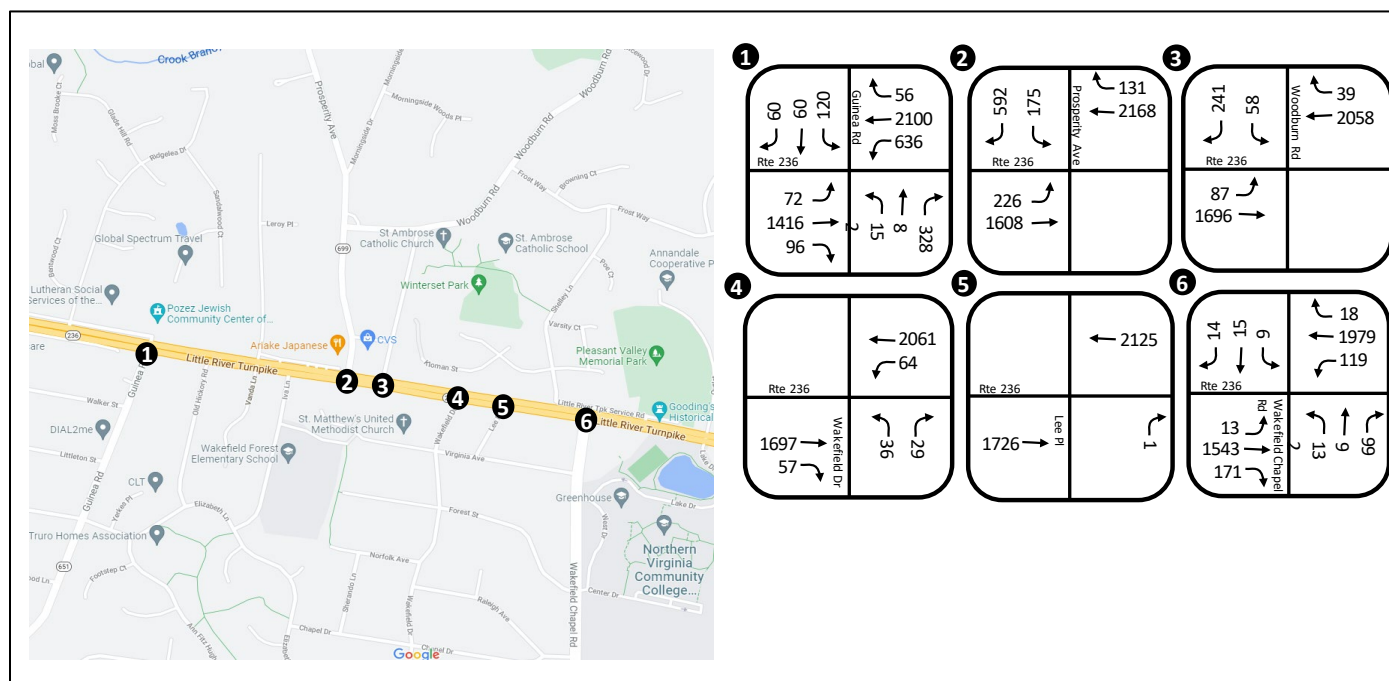


Figure 8: 2021 COVID-Adjusted PM Peak Hour Volumes

For the intersection of Route 236 and Woodburn Road, the analysis results show that the eastbound left turn (during AM and PM peak hours), the westbound through lanes (during AM peak hour), and the southbound approach (during AM and PM peak hours) operate with excessive delays and queues.

At the intersection of Route 236 and Wakefield Drive, the northbound approach operates with excessive delays during the AM and PM peak hours.

The intersection of Route 236 and Wakefield Chapel Road operates with excessive delays for the eastbound and westbound left turns, as well as the northbound approach during the AM and PM peak hours. The analysis shows that the northbound right turn queues spill over the available storage lane during the AM peak hour.

Table 3 presents the AM and PM peak hour Synchro analysis results summary for 2021 existing conditions. The Synchro reports are included in **Appendix B**. The traffic operations and accessibility needs are summarized in **Figure 10** to **Figure 13**.

Table 3: 2021 Existing Synchro Analysis Results Summary

Traffic Control	Intersection	Approach	Movement	Existing AM				Existing PM			
				LOS ¹	Delay ²	Queues (ft)		LOS	Delay	Queues (ft)	
						95% Queues ³	Available Storage			95% Queues	Available Storage
Signalized	Little River Turnpike & Guinea Rd / Service Rd	EB	L	F	123.8	130	410	F	146.9	215	410
			T	D	45.5	#2130	-	D	53.7	1175	-
			R	B	11.1	0	250	C	28.7	15	250
			Overall	D	46.8	-	-	E	56.4	-	-
		WB	L	F	85.9	125	500	F	97.0	445	500
			T	B	18.9	415	-	C	22.0	1315	-
			R	F	90.5	15	-	A	4.9	0	-
			Overall	C	27.3	-	-	D	38.8	-	-
		NB	LT	F	148.4	385	-	F	198.6	435	-
			R	A	0.9	0	-	A	0.3	0	-
			Overall	C	24.7	-	-	E	65.3	-	-
		SB	L	F	114.3	65	-	F	112.7	210	-
			LT	F	114.1	65	-	F	114.5	215	-
			R	F	110.9	75	50	F	89.6	0	50
			Overall	F	111.8	-	-	F	107.6	-	-
		Intersection Overall		D	38.9	-	-	D	50.0	-	-
Signalized	Little River Turnpike & Prosperity Ave	EB	L	F	89.2	1050	465	F	112.8	425	465
			T	A	1.9	135	-	B	12.5	515	-
			Overall	C	22.1	-	-	C	24.8	-	-
		WB	T	A	3.6	40	-	C	27.1	1590	-
			R	A	0.5	0	150	A	2.7	15	150
			Overall	A	3.0	-	-	C	25.7	-	-
		SB	LR	F	114.1	105	260	F	111.5	345	260
			R	F	108.7	65	260	F	146.1	485	260
			Overall	F	112.4	-	-	F	124.9	-	-
		Intersection Overall		B	19.9	-	-	D	40.9	-	-
Signalized	Little River Turnpike & Woodburn Rd	EB	L	E	79.2	720	-	F	86.5	100	-
			T	A	2.9	335	-	A	5.6	170	-
			Overall	B	16.5	-	-	A	9.6	-	-
		WB	T	E	74.6	1415	-	B	11.7	120	-
			R	C	34.6	145	95	A	1.9	5	95
			Overall	E	72.1	-	-	B	11.5	-	-
		SB	L	F	123.0	150	-	F	92.6	140	-
			R	F	107.0	65	300	F	237.9	465	300
			Overall	F	113.6	-	-	F	209.6	-	-
		Intersection Overall		D	40.1	-	-	C	24.8	-	-
Stop-Controlled	Little River Turnpike & Wakefield Dr ⁴	NB	LR (Overall)	F	69.9	75	-	E	38.0	40	-
		Intersection Overall		F	69.9	-	-	E	38.0	-	-

Table 3 (Cont.): 2021 Existing Synchro Analysis Results Summary

Traffic Control	Intersection	Approach	Movement	Existing AM				Existing PM			
				LOS ¹	Delay ²	Queues (ft)		LOS	Delay	Queues (ft)	
						95% Queues ³	Available Storage			95% Queues	Available Storage
Stop-Controlled	Little River Turnpike & Lee Pl ⁴	NB	R (Overall)	D	30.2	0	-	B	12.9	0	-
		Intersection Overall		D	30.2	-	-	B	12.9	-	-
Signalized	Little River Turnpike & Wakefield Chapel Rd / Service Rd	EB	L	F	111.2	60	150	F	106.1	30	150
			T	C	28.6	940	-	C	24.9	1220	-
			R	C	24.2	35	250	C	20.6	65	250
			Overall	C	29.4	-	-	C	25.0	-	-
		WB	L	F	121.2	85	400	F	104.8	120	400
			T	B	16.3	590	-	B	13.4	1105	-
			R	B	10.6	0	750	A	6.6	0	750
			Overall	C	21.6	-	-	B	18.5	-	-
		NB	L	F	113.1	350	-	F	107.0	170	-
			LT	F	107.8	345	-	F	102.4	170	-
			R	F	313.0	875	300	F	91.5	45	300
			Overall	F	233.8	-	-	F	99.3	-	-
		SB	LTR (Overall)	F	116.5	35	-	F	101.3	40	-
		Intersection Overall		E	63.9	-	-	C	26.7	-	-

¹ Level of Service (LOS) is obtained from Synchro per HCM 2000 criteria

² Delay is expressed as Seconds per Vehicle

³ Queues obtained from Synchro queueing output

⁴ Worst approach delay and LOS reported as the overall unsignalized intersection operation

95th percentile volume exceeds capacity, queue may be longer

The 95th percentile queues highlighted in pink represent those exceeding the available storage facility

Safety and Reliability:

For the analysis of existing safety conditions, the VDOT Crash Database Tableau Tool was utilized to determine the crash history at the study intersections and along the study corridor on Route 236. Crash data was collected and analyzed for a five-year period spanning from January 2015 to December 2019. The study team reviewed the FR-300 crash reports provided by VDOT to determine specific trends and “hot spot” areas for consideration in developing alternative improvement concepts. For the purposes of this analysis, “injury crashes” is defined as the sum of type A (severe injury), B (visible injury), and C (non-visible injury) crashes. Raw crash data is provided in **Appendix C**.

Safety Analysis Results

The crash severity within the study area is summarized by year and type in **Table 4** and **Table 5**, respectively.

Table 4: Study Area Crash Severity by Year

Crash Year and Severity	K. Fatal Injury	A. Severe Injury	B. Visible Injury	C. Nonvisible Injury	PDO. Property Damage Only	Total
2015	0	1	4	15	21	41
2016	0	1	3	14	16	34
2017	0	0	12	1	30	43
2018	0	1	5	1	19	26
2019	0	1	8	0	16	25
Total	0	4	32	31	102	169

Table 5: Study Area Crash Severity by Type

Crash Type and Severity	K. Fatal Injury	A. Severe Injury	B. Visible Injury	C. Nonvisible Injury	PDO. Property Damage Only	Total
Rear End	0	0	21	25	63	109
Deer	0	0	0	0	2	2
Ped	0	0	2	0	0	2
Other	0	0	0	0	3	3
Angle	0	2	5	5	27	39
Head On	0	1	1	1	1	4
Sideswipe - Same Direction	0	0	1	0	3	4
Sideswipe - Opposite Direction	0	0	0	0	1	1
Non-Collision	0	0	1	0	0	1
Fixed Object - Off Road	0	1	1	0	2	4
Total	0	4	32	31	102	169

A total of 169 crashes were reported within the Route 236 study area during the five-year study period. Key takeaways from the crash data are as follows:

1. Year over year crash occurrence varies with the highest number of crashes (43) occurring in 2017, followed by 41 in 2015.
2. The approximate average number of reported crashes per year is 34.
3. The majority of reported crashes within the corridor are rear end and angle crashes. Combined, these constitute approximately 88% of the total crashes.
4. A total of 67 crashes were associated with injuries, which account for approximately 40% of the total reported crashes within the corridor. There were no crashes that led to a fatality.
5. Crashes occurred at the intersections and along the segments, indicating the need for corridor level improvements.
6. There was a nighttime pedestrian crash at the Woodburn Road intersection in 2017, which involved a pedestrian in the north leg crosswalk that was struck by an eastbound left turning vehicle. This pedestrian crash is shown in **Figure 11**.

The safety and reliability needs and diagnosis identified during the analysis are summarized in **Figure 10** to **Figure 13**. Detailed collision diagrams at the Prosperity Avenue, Woodburn Road and Wakefield Chapel Road intersections are provided in **Appendix D**.

Pedestrian and Bicycle Access

In an effort to identify the needs with respect to accessibility, the study team reviewed existing conditions for pedestrian and bicycle accommodations. Sidewalks only exist at the western end of the Route 236 study corridor and there are no safe waiting areas at bus stops along the corridor. Some curb ramps and pedestrian push buttons are not Americans with Disabilities Act (ADA) compliant due to a lack of an accessible route for wheelchairs and/or do not meet distance standards. The paved shoulders are discontinuous and adjacent to vehicular travel lanes with no physical separation and therefore, do not safely accommodate bicyclists. An overview of the pedestrian and bicycle network is shown in **Figure 9**.



Figure 9: Pedestrian and Bicycle Network Overview.

Figure 10 to Figure 13 summarizes the pedestrian and bicycle accessibility findings.

Corridor Operation and Safety Needs and Diagnosis Summary:

Crash severity along the corridor

- The corridor has 169 total crashes from 2015 to 2019.
- A breakdown of the crash severity per year and overall crash severity by type is shown below.

REPORTED TRAFFIC CRASHES

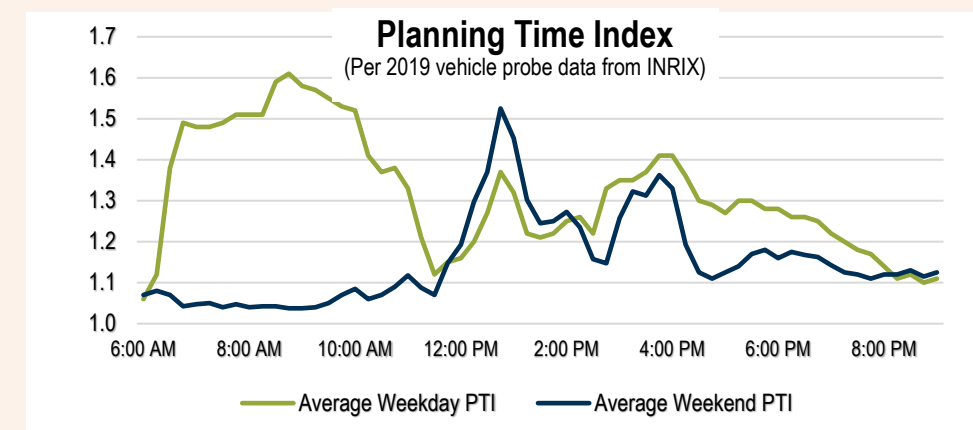
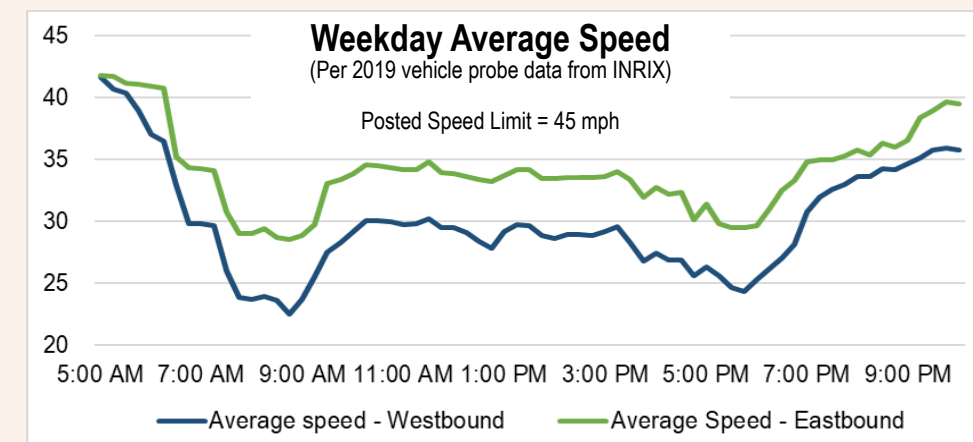
Crash Severity	2015	2016	2017	2018	2019	Total
Severe Injury	1	1	0	1	1	4
Visible Injury	4	3	12	5	8	32
Nonvisible Injury	15	14	1	1	0	31
Property Damage Only	21	16	30	19	16	102
Total	41	34	43	26	25	169

OVERALL CRASH SEVERITY



Traffic flow along the corridor

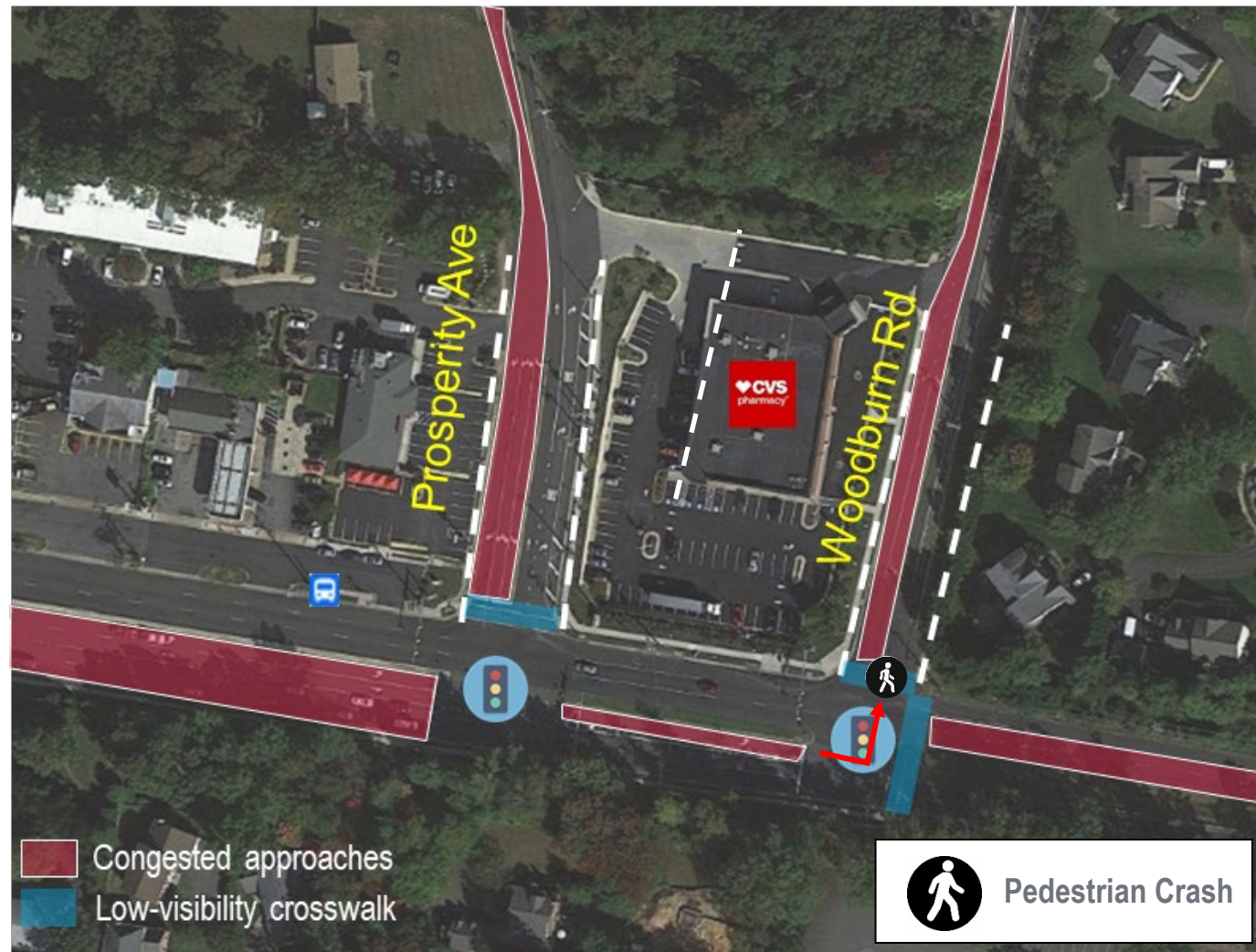
- High variability in average travel speeds along the corridor during the rush hours between 7 am – 10 am and 4 pm – 6 pm.
- Westbound direction experiences lower speeds and more congestion than the eastbound direction, which is worse during the AM rush hours compared to the PM rush hours.
- Slower speeds increase travel times and delay, causing congestion related increases in fuel consumption and air polluting emissions.
- Travel reliability decreases as the variability in average travel speeds increases requiring travelers to plan additional time to reach their destinations on time.



Planning Time Index (PTI) is a travel time reliability measure. It is the ratio of the 95th percent travel time to the free flow travel time.

Figure 10: Corridor Operations and Safety Needs and Diagnosis

Prosperity Avenue and Woodburn Road Operation and Safety Needs and Diagnosis Summary:



At Prosperity Avenue, eastbound left turn and southbound movements operate with excessive delays and queues (AM and PM). At Woodburn Road, eastbound left turn (AM and PM), westbound through lanes (AM), and southbound (AM and PM) movements operate with excessive delays and queues.



Angle and rear-end crashes at the intersections. Congestion is suspected to be a primary contributor. The eastbound traffic signal operates with the 'left turn must yield to through vehicles' mode, which might cause left-turn related angle crashes.

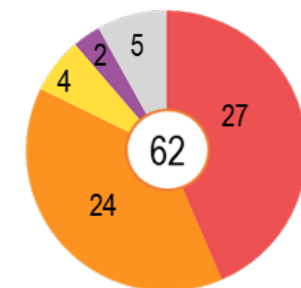


The paved shoulders are discontinuous and adjacent to vehicular travel lanes with no physical separation and therefore, do not safely accommodate bicyclists.



There is no accessible bus stop along eastbound Route 236 at Prosperity Avenue and Woodburn Road.

CRASH TYPES (2015 – 2019):



Rear-end Crashes



Angle Crashes



Sideswipe



Deer



Head on



Fixed Object



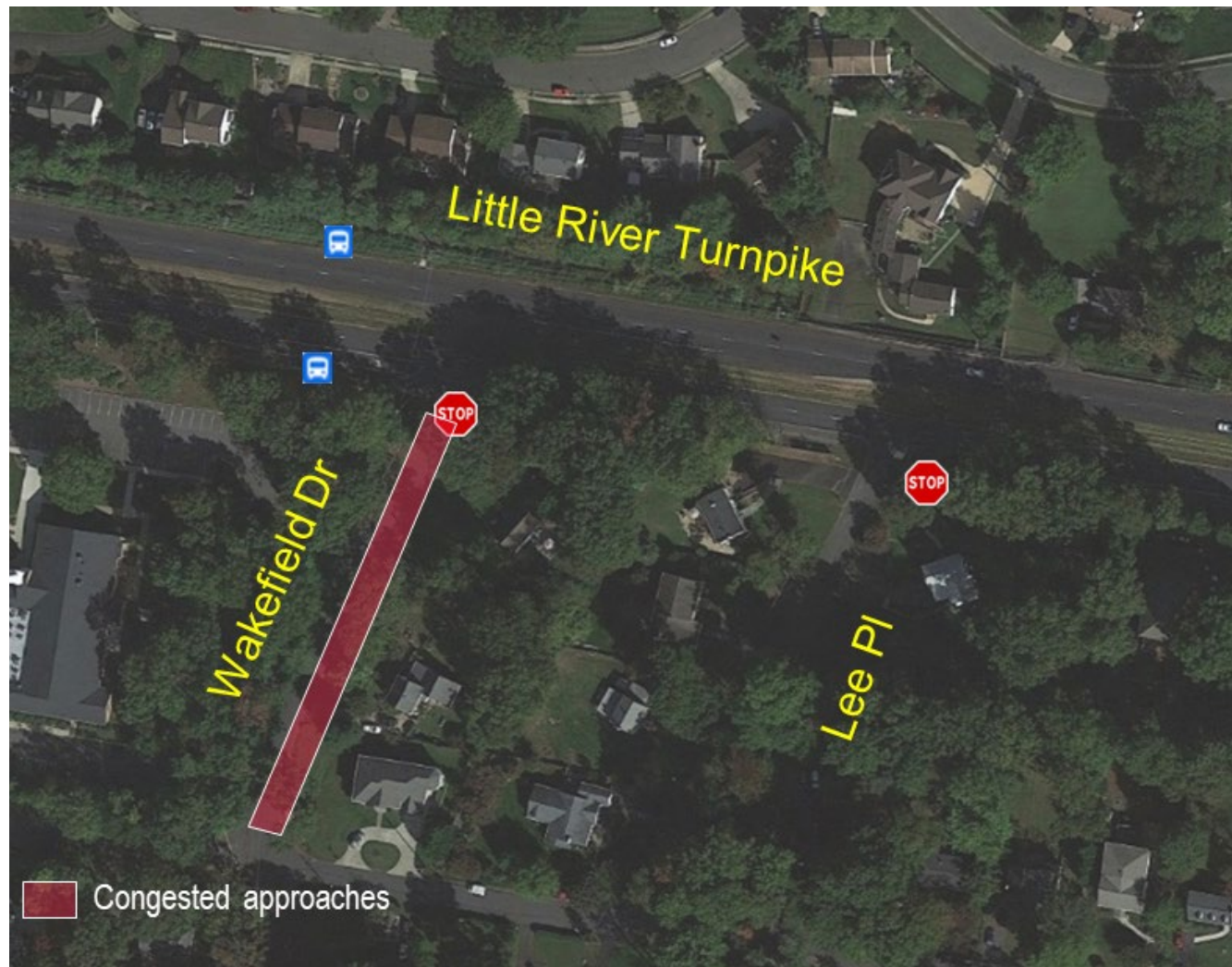
Others








Number of Crashes

Figure 11: Prosperity Avenue and Woodburn Road Operations and Safety Needs and Diagnosis

Wakefield Drive Operation and Safety Needs and Diagnosis Summary:



-  Northbound movements at Wakefield Drive with excessive delays (AM and PM).
-  Angle and rear-end crashes at the intersections. Congestion is suspected to be a primary contributor.
-  The paved shoulders are discontinuous and adjacent to vehicular travel lanes with no physical separation and therefore, do not safely accommodate bicyclists. Sidewalks exist at the western end of the study corridor only and no sidewalks are within this segment.
-  Bus stops are not connected to sidewalks.
-  Excessive delays along northbound Wakefield Chapel Road urges drivers to use Wakefield Drive to turn left onto Route 236, making this unsignalized intersection congested and crash prone.

CRASH TYPES (2015 – 2019):

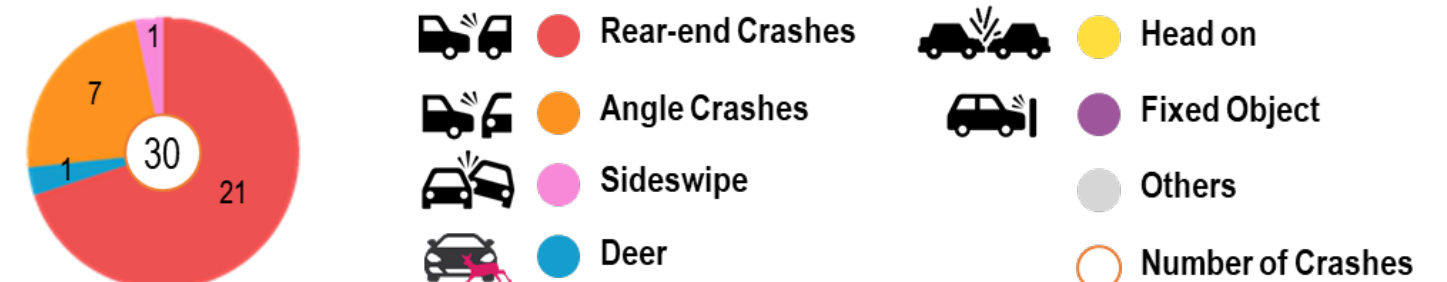


Figure 12: Wakefield Drive Operations and Safety Needs and Diagnosis

Wakefield Chapel Road Operation and Safety Needs and Diagnosis Summary:



Eastbound and westbound left turns and northbound movements operate with excessive delays and queues at Wakefield Chapel Road (AM and PM).



Angle and rear-end crashes at the intersections. Congestion is suspected to be a primary contributor. Improvements can be made to the channelized northbound right turn view angle and sight distance.

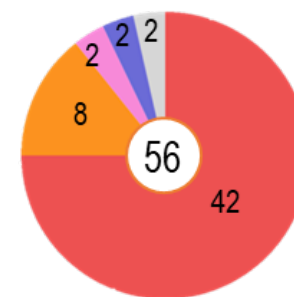


The paved shoulders are discontinuous and adjacent to vehicular travel lanes with no physical separation and therefore, do not safely accommodate bicyclists.



Bus stops are not connected to sidewalks. Sidewalks exist at the western end of the study corridor only and no sidewalks are within this segment.

CRASH TYPES (2015 – 2019):



Rear-end Crashes



Angle Crashes



Sideswipe



Deer



Head on



Fixed Object



Others



Number of Crashes

Figure 13: Wakefield Chapel Road Operations and Safety Needs and Diagnosis

Rail, Transit, and TDM:

With support from DRPT, the study team reviewed the existing rail infrastructure, Park and Ride locations, and public transit routes in the study area.

Transit service in the study area is provided by Metrobus (29K, 29N) and the Connector Bus (835) and the City of Fairfax. CUE Bus routes turn at Pickett Road/Route 236 and do not reach this part of the County. Overall, the transit ridership in the area is low.

There are no Park and Ride lots along Route 236 between the City of Fairfax and the project limits. Existing Park and Ride lots range between 3 to 4.5 miles south of the project limits, as shown in **Figure 14**.

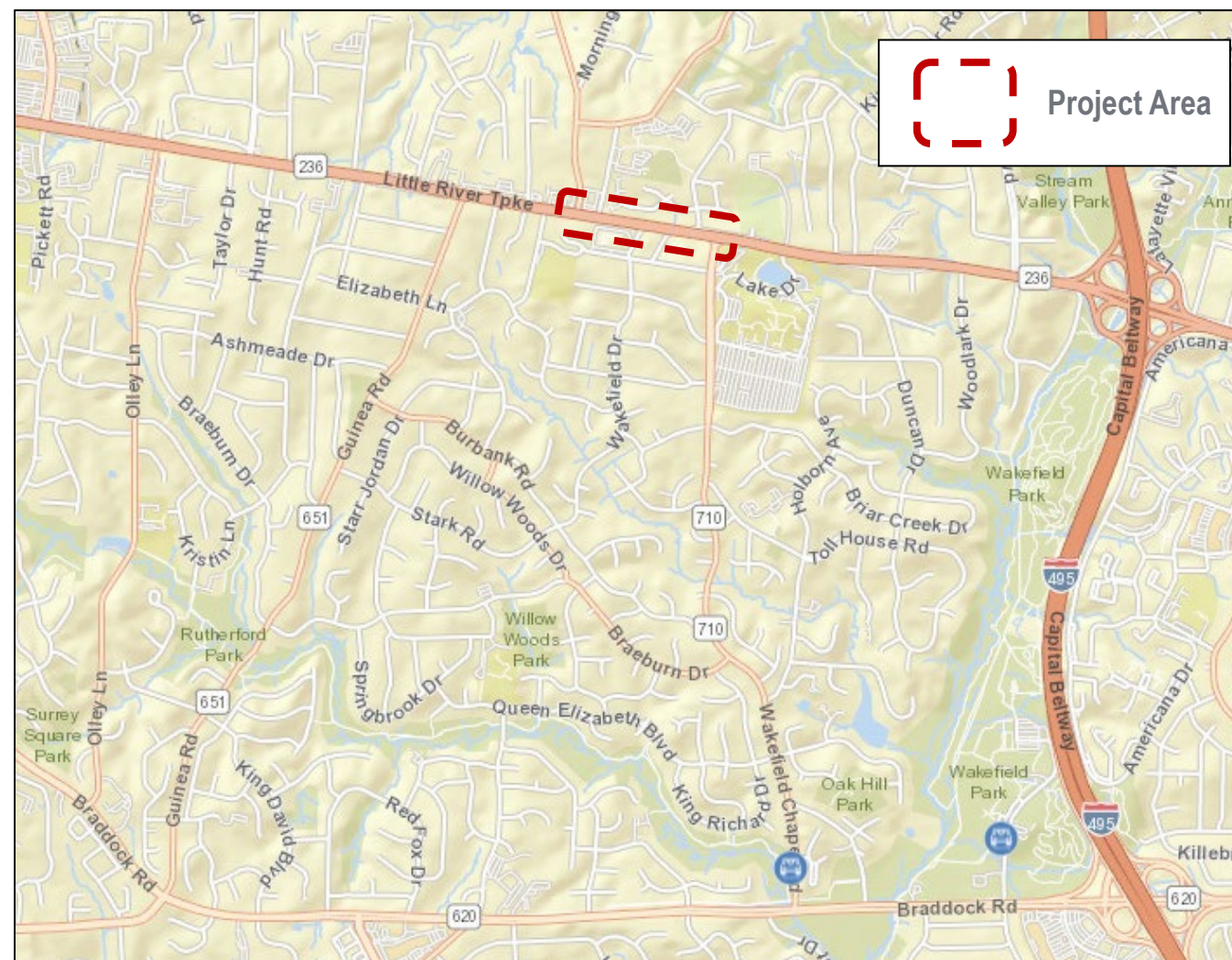


Figure 14: Existing Park and Ride Locations in the Study Area

Table 6 shows the existing Park and Ride characteristics, capacity, and utilization rate. The existing nearby Park and Ride lots are small (50 or less spaces) and are not convenient to the corridor

Table 6: Existing Park and Ride Locations Data

Park and Ride Location	Location	Characteristics	Capacity	Utilization
Canterbury Woods Park & Ride	On Wakefield Chapel Road near Braddock Road	Gravel lot with some limited paving No lighting No signs visible from Wakefield Chapel Road indicating lot is for Park & Ride.	21 parking spaces	67% Many of those parked were users of the Park
Wakefield Chapel Recreation Center Park & Ride	On Wakefield Park Road near Braddock Road	Identified online as Park & Ride lot within Wakefield Park	50 parking spaces (as designated online)	0% Not utilized as a Park & Ride lot

The rail, transit, and TDM needs identified by the study team are presented in **Figure 15**.

Rail, Transit, and TDM Needs and Diagnosis Summary:



Existing Conditions

- No rail infrastructure
- Fairfax County Commuter Services, Vanpool Alliance, and DRPT Programs (vanpool, carpool, etc.)
- No park and rides in area
- No bike-sharing or scooter programs
- Metrobus 29K, 29N
Fairfax Connector 835
- 5 shared stops; no benches or shelters;
1 ADA accessible stop (Prosperity)

- No high-speed commuter transit
- Bus stops lacking ADA accessibility
- No micro-mobility solutions

Per 2019 Metropolitan Washington Council of Governments Travel Forecasts,

- 15.3% of trip productions from the study area are transit trips, which includes 9% drive to transit trips, and 6.3% walk to transit trips.
- 2.8% trip attractions to the study area are transit trips, which includes 2.8% walk to transit trips and 0% drive to transit trips.

Figure 15: Rail, Transit, and TDM Needs and Diagnosis

Chapter 2:

Alternative Development and Refinement

Alternative Development and Screening:

In order to develop alternative concepts to address the needs and incorporate the diagnosis identified in Chapter 1, a thorough review of the existing conditions data was conducted. A screening-level analysis was performed in Synchro on potential alternatives at the study intersections. Three improvement tiers were developed while each tier builds upon the previous tier improvements. For instance, the Tier 2 improvements include the Tier 1 improvements, and the Tier 3 improvements include the Tier 2 and Tier 1 improvements. The following sections describes these three improvement tiers in detail.

The inputs and analysis methodologies are consistent with the VDOT TOSAM guidelines. For the purposes of alternative testing and screening, the AM and PM peak hour Synchro analyses were performed for the existing year 2021. As mentioned before, no future year analysis was performed based on the study framework/scoping document.

Tier 1 (Pedestrian and Bicycle) Improvements

Tier 1 improvements were developed to respond to the pedestrian, bicycle and transit accessibility needs in the study area. The study team reviewed existing conditions for pedestrian and bicycle accommodations to improve pedestrian and bicycle visibility and enhance access to the bus stops along the corridor. The Tier 1 improvements are as follows:

- Add high-visibility crosswalks at the study intersections.
- Add sidewalk along the south side of Route 236 between Woodburn Road and Wakefield Chapel Road.
- Add shared-use path along the north side of Route 236 between Woodburn Road and Wakefield Chapel Road.
- Relocate bus stops to improve accessibility.
- Modify the northbound right turn angle at Wakefield Chapel Road to improve sight distance.
- Add shared-use path along the east side of Wakefield Chapel Road.

No traffic operation improvements are included in the Tier 1 category and therefore, no Synchro analysis was performed for this improvement tier. A summary of the proposed improvements is shown in **Figure 16**.

Expected Crash Reduction:

A crash modification factor (CMF) is used to determine the expected crash reduction after implementing a countermeasure on a road or intersection. CMFs for the Tier 1 improvements along the Route 236 study area were obtained and are presented in **Table 7**.

Table 7: Tier 1 CMF List

CMF Name	Locations	CMF ID/Source	Crash Type	Crash Severity	Area Type	CMF Value
Add Shared Use Path / Install cycle tracks, bike lanes, or on-street cycling	Throughout the study limit	4102	Vehicle/ Bike	ABC	Urban	0.41
Add Crosswalk	Crosswalks at Prosperity Avenue east and west leg, at Woodburn Road and Wakefield Chapel Road west leg.	FHWA Safety Report	Vehicle/ Pedestrian	All	-	1
Convert Standard Crosswalk Pavement Marking to High-Visibility Crosswalk	All crosswalks.	2697	Vehicle/ Pedestrian	All	-	0.63
Improve angle of channelized right turn lane	NB RT at Wakefield Chapel Road	8428	All	All	-	0.558



Vehicular Congestion Mitigation

- No changes to mobility for the Tier 1 improvement option.



Safety Improvements

- Pedestrian related crashes at the Prosperity Avenue/Woodburn Road/Little River Turnpike intersection may be reduced by approximately 37%.
- Improve the right turn angle from Wakefield Chapel Road to improve visibility for drivers and reduce crashes.



Multimodal Accessibility

- Shared-use path on the north side of Route 236 and a sidewalk at the south side between Woodburn and Wakefield Chapel Road.
- High visibility crosswalks at all the intersections.
- Relocate bus stops closer to the crosswalks. Bus stops will be relocated from near side to the far side, minimizing impedance to right-turning traffic.

Figure 16: Route 236 Tier 1 Improvements

Tier 2 (Traffic Flow + Pedestrian and Bicycle) Improvements

Tier 2 improvements were developed to address some of the traffic flow and safety concerns that were identified in the previous sections. The Tier 2 improvements are as follows:

- This tier also includes all the improvements that were developed for Tier 1.
- Covert the southbound right turn at Prosperity Avenue to a channelized, free flow right turn and reconfigure the southbound lane markings.
- Restrict the left turns out of Wakefield Drive. The restricted traffic would use the Wakefield Chapel Road intersection to the east to make U-turn.
- Add a second northbound right turn lane at the Wakefield Chapel Road intersection. The new northbound right movement would operate under signal control with no right turn on red, and an overlap phase with the westbound left turn movement. The crosswalk for the northbound right turn lanes would have a separate pedestrian signal head to safely accommodate pedestrians. Therefore, crossing the east leg would happen under two stages.

Table 9 presents the year 2021 AM and PM peak hour Synchro analysis results at the study intersections with Tier 2 improvements. The analysis shows that the Tier 2 improvements are expected to improve the overall Prosperity Avenue intersection delays by a few seconds during the AM peak hour, and from LOS D to LOS B during the PM peak hour. The channelized southbound right is expected to significantly improve the delays and queues for this movement. Restricting the left turns from Wakefield Drive is expected to improve the delays during the AM peak hour, and from LOS E to LOS B during the PM peak hour. At the Wakefield Chapel Road intersection, the improvements are expected to improve the northbound right turn delays and queues and the overall intersection from LOS E to LOS D during the AM peak hour. A summary of the proposed improvements is shown in **Figure 17**.

Expected Crash Reduction:

CMFs for the Tier 2 improvements along the Route 236 study area are presented in **Table 8**. Please note that the Tier 1 CMFs that were presented in the previous section, would apply to Tier 2, but are not included in this table

Table 8: Tier 2 CMF List

CMF Name	Locations	CMF ID/Source	Crash Type	Crash Severity	Area Type	CMF Value
Convert an open median to a left-in only median	At Wakefield Drive	5465	Left Turn	All	Urban Suburban	0.55
Channelize Right Turn	SB RT at Prosperity Avenue	FHWA CMF Desktop Reference Guide	All	KABC	-	0.65
Add right turn to existing	NB RT at Wakefield Chapel Road	Smart Scale Planning Level CMFs	All	All		0.97
Increase the number of right-turn lanes on the major road from X to Y	NB RT at Wakefield Chapel Road	2385	Rear-end	All	Rural	e0.2194(Y-X)
Increase the number of right-turn lanes on the major road from X to Y	NB RT at Wakefield Chapel Road	2385	Sideswipe	All	Rural	e0.63(Y-X)

Table 9: 2021 Tier 2 Synchro Analysis Results

Traffic Control	Intersection	Approach	Movement	COVID Adjusted 2021								Tier 2							
				Existing AM				Existing PM				Existing AM				Existing PM			
				LOS ¹	Delay ²	Queues (ft)		LOS	Delay	Queues (ft)		LOS ¹	Delay ²	Queues (ft)		LOS	Delay	Queues (ft)	
						95% Queues ³	Available Storage			95% Queues	Available Storage			95% Queues ³	Available Storage			95% Queues	Available Storage
Signalized	Little River Turnpike & Guinea Rd / Service Rd	EB	L	F	123.8	130	410	F	146.9	215	410	F	123.8	130	410	F	146.9	215	410
			T	D	45.5	#2130	-	D	53.7	1175	-	D	45.5	#2130	-	D	53.7	1175	-
			R	B	11.1	0	250	C	28.7	15	250	B	11.1	0	250	C	28.7	15	250
			Overall	D	46.8	-	-	E	56.4	-	-	D	46.8	-	-	E	56.4	-	-
		WB	L	F	85.9	125	500	F	97.0	445	500	F	89.3	125	500	F	97.2	475	500
			T	B	18.9	415	-	C	22.0	1315	-	B	18.0	380	-	B	20.0	1110	-
			R	F	90.5	15	-	A	4.9	0	-	F	84.2	15	-	A	2.3	0	-
			Overall	C	27.3	-	-	D	38.8	-	-	C	26.5	-	-	D	37.2	-	-
		NB	LT	F	148.4	385	-	F	198.6	435	-	F	148.4	385	-	F	198.6	435	-
			R	A	0.9	0	-	A	0.3	0	-	A	0.9	0	-	A	0.3	0	-
			Overall	C	24.7	-	-	E	65.3	-	-	C	24.7	-	-	E	65.3	-	-
		SB	L	F	114.3	65	-	F	112.7	210	-	F	114.3	65	-	F	112.7	210	-
			LT	F	114.1	65	-	F	114.5	215	-	F	114.1	65	-	F	114.5	215	-
			R	F	110.9	75	50	F	89.6	0	50	F	110.9	75	50	F	89.6	0	50
			Overall	F	111.8	-	-	F	107.6	-	-	F	111.8	-	-	F	107.6	-	-
		Intersection Overall		D	38.9	-	-	D	50.0	-	-	D	38.6	-	-	D	49.2	-	-
Signalized	Little River Turnpike & Prosperity Ave	EB	L	F	89.2	1050	465	F	112.8	425	465	F	88.9	1045	465	F	112.4	430	465
			T	A	1.9	135	-	B	12.5	515	-	A	1.9	135	-	A	8.8	485	-
			Overall	C	22.1	-	-	C	24.8	-	-	C	22.0	-	-	C	21.6	-	-
		WB	T	A	3.6	40	-	C	27.1	1590	-	A	3.6	40	-	B	15.9	1365	-
			R	A	0.5	0	150	A	2.7	15	150	A	0.5	0	150	A	1.7	10	150
			Overall	A	3.0	-	-	C	25.7	-	-	A	3.0	-	-	B	15.1	-	-
		SB	LR	F	114.1	105	260	F	111.5	345	260	F	113.8	95	260	F	98.8	170	260
			R	F	108.7	65	260	F	146.1	485	260	A	0.1	0	260	A	0.8	0	260
			Overall	F	112.4	-	-	F	124.9	-	-	D	42.5	-	-	C	23.1	-	-
		Intersection Overall		B	19.9	-	-	D	40.9	-	-	B	16.9	-	-	B	18.8	-	-
Signalized	Little River Turnpike & Woodburn Rd	EB	L	E	79.2	720	-	F	86.5	100	-	E	79.0	720	-	E	68.7	100	-
			T	A	2.9	335	-	A	5.6	170	-	A	3.2	350	-	A	9.9	905	-
			Overall	B	16.5	-	-	A	9.6	-	-	B	16.8	-	-	B	12.8	-	-
		WB	T	E	74.6	1415	-	B	11.7	120	-	E	72.5	1415	-	B	10.2	140	-
			R	C	34.6	145	95	A	1.9	5	95	C	32.2	140	95	A	1.8	0	95
			Overall	E	72.1	-	-	B	11.5	-	-	E	70.0	-	-	A	10.0	-	-
		SB	L	F	123.0	150	-	F	92.6	140	-	F	123.0	150	-	F	92.6	140	-
			R	F	107.0	65	300	F	237.9	465	300	F	107.0	65	300	F	237.9	465	300
			Overall	F	113.6	-	-	F	209.6	-	-	F	113.6	-	-	F	209.6	-	-
		Intersection Overall		D	40.1	-	-	C	24.8	-	-	D	39.4	-	-	C	25.5	-	-

Table 9 (Cont.): 2021 Tier 2 Synchro Analysis Results

Traffic Control	Intersection	Approach	Movement	COVID Adjusted 2021								Tier 2							
				Existing AM				Existing PM				Existing AM				Existing PM			
				LOS ¹	Delay ²	Queues (ft)		LOS	Delay	Queues (ft)		LOS ¹	Delay ²	Queues (ft)		LOS	Delay	Queues (ft)	
						95% Queues ³	Available Storage			95% Queues	Available Storage			95% Queues ³	Available Storage			95% Queues	Available Storage
Stop-Controlled	Little River Turnpike & Wakefield Dr ⁴	NB	LR (Overall)	F	69.9	75	-	E	38.0	40	-	F	57.4	75	-	B	14.0	10	-
		Intersection Overall		F	69.9	-	-	E	38.0	-	-	F	57.4	-	-	B	14.0	-	-
Stop-Controlled	Little River Turnpike & Lee Pl ⁴	NB	R (Overall)	D	30.2	0	-	B	12.9	0	-	D	30.2	0	-	B	13.2	0	-
		Intersection Overall		D	30.2	-	-	B	12.9	-	-	D	30.2	-	-	B	13.2	-	-
Signalized	Little River Turnpike & Wakefield Chapel Rd / Service Rd	EB	L	F	111.2	60	150	F	106.1	30	150	F	119.5	135	150	F	128.5	125	150
			T	C	28.6	940	-	C	24.9	1220	-	C	28.8	945	-	C	24.4	1220	-
			R	C	24.2	35	250	C	20.6	65	250	B	18.6	45	250	B	19.6	65	250
			Overall	C	29.4	-	-	C	25.0	-	-	C	30.6	-	-	C	26.9	-	-
		WB	L	F	121.2	85	400	F	104.8	120	400	F	128.8	90	400	F	104.8	120	400
			T	B	16.3	590	-	B	13.4	1105	-	B	19.8	645	-	B	15.8	1135	-
			R	B	10.6	0	750	A	6.6	0	750	B	12.7	0	750	A	7.5	0	750
			Overall	C	21.6	-	-	B	18.5	-	-	C	25.3	-	-	C	20.7	-	-
		NB	L	F	113.1	350	-	F	107.0	170	-	F	107.1	345	-	F	107.0	170	-
			LT	F	107.8	345	-	F	102.4	170	-	F	106.9	345	-	F	106.3	170	-
			R	F	313.0	875	300	F	91.5	45	300	F	140.6	495	300	F	82.5	100	300
			Overall	F	233.8	-	-	F	99.3	-	-	F	127.5	-	-	F	96.7	-	-
		SB	LTR (Overall)	F	116.5	35	-	F	101.3	40	-	F	116.5	35	-	F	101.3	40	-
		Intersection Overall		E	63.9	-	-	C	26.7	-	-	D	46.6	-	-	C	28.4	-	-

¹ Level of Service (LOS) is obtained from Synchro per HCM 2000 criteria

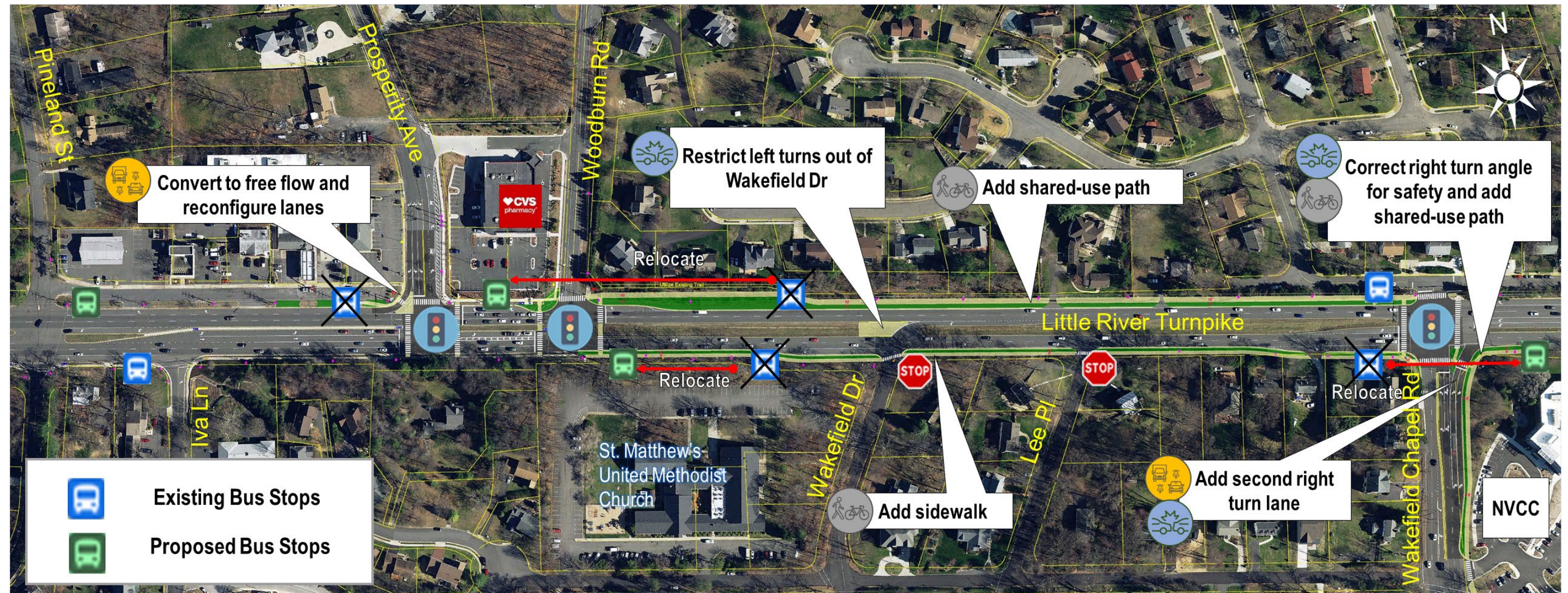
² Delay is expressed as Seconds per Vehicle

³ Queues obtained from Synchro queueing output

⁴ Worst approach delay and LOS reported as the overall unsignalized intersection operation

95th percentile volume exceeds capacity, queue may be longer

The 95th percentile queues highlighted in pink represent those exceeding the available storage facility



Vehicular Congestion Mitigation

- Convert the southbound right turn at Prosperity Ave to a channelized, free flow right turn which is expected to cut the delay in half.
- Restrict left turns from Wakefield Dr and reroute them to U-turn at Wakefield Chapel Rd to decrease delays.
- Add a dual right on Wakefield Chapel Rd to improve traffic flow and decrease queues up to 45% (AM peak hour).



Safety Improvements

- Includes Tier 1 benefits.
- Reduce angle crashes by approximately 18% by converting the southbound right turn at Prosperity Ave.
- Reduce crashes by approximately 7% by restricting the left turns from Wakefield Drive.
- Reduce crashes by approximately 14% by adding a dual right turn at Wakefield Chapel Road.



Multimodal Accessibility

- Includes Tier 1 benefits.
- Restricting left turns from Wakefield Drive may improve crosswalk visibility.

Figure 17: Route 236 Tier 2 Improvements

Tier 3 (Comprehensive Traffic Flow + Pedestrian and Bicycle) Improvements

Tier 3 improvements were developed to address additional traffic flow and safety concerns that were identified in the previous sections. Compared to Tier 2, Tier 3 includes additional traffic flow/capacity improvements at the Prosperity Avenue and Woodburn Road intersections that are explained below:

- This tier also includes all the improvements that were developed for Tier 2 (and Tier 1).
- Connect Prosperity Avenue and Woodburn Road through a new roadway.
- Close the eastbound left turn movement onto Woodburn Road. All the eastbound left turn volume would use Prosperity Avenue.
- Close the Prosperity Avenue southbound left turn movement. The restricted volume would use the Woodburn Road southbound left turn lanes.
- Since the eastbound left turn and the southbound left turn traffic are no longer in conflict, this alternative allows to run the eastbound left turn movement concurrently with the southbound left turn movement. Therefore, it would reduce the number of signal phases and provide the opportunity to reduce cycle length.

Table 11 presents the year 2021 AM and PM peak hour Synchro analysis results at the study intersections with Tier 3 improvements. The analysis shows that the Tier 3 improvements are expected to improve the overall Prosperity Avenue intersection delays from LOS D to LOS B during the PM peak hour. The overall Woodburn Road intersection delays are also expected to improve from LOS D to LOS C during the AM peak hour, and from LOS C to LOS B during the PM peak hour. Restricting the left turns from Wakefield Drive is expected to improve the AM peak hour operations from LOS F to LOS B, and the PM peak hour from LOS E to LOS B. At the Wakefield Chapel Road intersection, the improvements are expected to improve the northbound right turn delays and queues and the overall intersection from LOS E to LOS D during the AM peak hour. A summary of the proposed improvements is shown in **Figure 18**.

Expected Crash Reduction:

CMFs for the Tier 3 improvements along the Route 236 study area are presented in **Table 10**. Please note that the Tier 1 CMFs that were presented in the previous section would apply to Tier 3, but are not included in this table

Table 10: Tier 3 CMF List

CMF Name	Locations	CMF ID/Source	Crash Type	Crash Severity	Area Type	CMF Value
Convert an open median to a left-in only median	At Wakefield Drive	5465	Left Turn	All	Urban Suburban	0.55
Channelize Right Turn	SB RT at Prosperity Avenue	FHWA CMF Desktop Reference Guide	All	KABC	-	0.65
Add right turn to existing	NB RT at Wakefield Chapel Road	Smart Scale Planning Level CMFs	All	All		0.97
Increase the number of right-turn lanes on the major road from X to Y	NB RT at Wakefield Chapel Road	2385	Rear-end	All	Rural	e0.2194(Y-X)
Increase the number of right-turn lanes on the major road from X to Y	NB RT at Wakefield Chapel Road	2385	Sideswipe	All	Rural	e0.63(Y-X)
Convert intersection to displaced left turn intersection	SB LT at Prosperity Avenue	10889	All	All	Urban Suburban	1.112
Change from permitted-protected to protected on major approach	EB LT at Prosperity Avenue	339	Angle	All	Urban	0.01

Table 11: 2021 Tier 3 Synchro Analysis Results

Traffic Control	Intersection	Approach	Movement	COVID Adjusted 2021								Tier 3							
				Existing AM				Existing PM				AM				PM			
				LOS ¹	Delay ²	Queues (ft)		LOS	Delay	Queues (ft)		LOS ¹	Delay ²	Queues (ft)		LOS	Delay	Queues (ft)	
						95% Queues ³	Available Storage			95% Queues	Available Storage			95% Queues ³	Available Storage			95% Queues	Available Storage
Signalized	Little River Turnpike & Guinea Rd / Service Rd	EB	L	F	123.8	130	410	F	146.9	215	410	F	123.8	130	410	F	146.9	215	410
			T	D	45.5	#2130	-	D	53.7	1175	-	D	49.3	#2145	-	E	58.3	1220	-
			R	B	11.1	0	250	C	28.7	15	250	B	11.7	0	250	C	30.4	15	250
			Overall	D	46.8	-	-	E	56.4	-	-	D	50.6	-	-	E	60.6	-	-
		WB	L	F	85.9	125	500	F	97.0	445	500	F	97.1	165	500	F	88.7	520	500
			T	B	18.9	415	-	C	22.0	1315	-	B	17.4	365	-	C	27.3	1400	-
			R	F	90.5	15	-	A	4.9	0	-	E	67.6	15	-	A	6.4	0	-
			Overall	C	27.3	-	-	D	38.8	-	-	C	27.6	-	-	D	41.7	-	-
		NB	LT	F	148.4	385	-	F	198.6	435	-	F	148.4	385	-	F	198.6	435	-
			R	A	0.9	0	-	A	0.3	0	-	A	0.9	0	-	A	0.3	0	-
			Overall	C	24.7	-	-	E	65.3	-	-	C	24.7	-	-	E	65.3	-	-
		SB	L	F	114.3	65	-	F	112.7	210	-	F	114.3	65	-	F	112.7	210	-
			LT	F	114.1	65	-	F	114.5	215	-	F	114.1	65	-	F	114.5	215	-
			R	F	110.9	75	50	F	89.6	0	50	F	110.9	75	50	F	89.6	0	50
			Overall	F	111.8	-	-	F	107.6	-	-	F	111.8	-	-	F	107.6	-	-
		Intersection Overall		D	38.9	-	-	D	50.0	-	-	D	40.7	-	-	D	52.8	-	-
Signalized	Little River Turnpike & Prosperity Ave	EB	L	F	89.2	1050	465	F	112.8	425	465	E	78.2	910	465	D	52.1	215	465
			T	A	1.9	135	-	B	12.5	515	-	A	3.3	175	-	C	20.5	740	-
			Overall	C	22.1	-	-	C	24.8	-	-	C	31.7	-	-	C	26.2	-	-
		WB	T	A	3.6	40	-	C	27.1	1590	-	A	4.4	80	-	A	8.8	515	-
			R	A	0.5	0	150	A	2.7	15	150	A	1.9	5	150	A	1.4	10	150
			Overall	A	3.0	-	-	C	25.7	-	-	A	3.9	-	-	A	8.4	-	-
		SB	LR	F	114.1	105	260	F	111.5	345	260	-	-	-	-	-	-	-	-
			R	F	108.7	65	260	F	146.1	485	260	A	0.1	0	-	A	0.8	0	-
			Overall	F	112.4	-	-	F	124.9	-	-	A	0.1	-	-	A	0.8	-	-
		Intersection Overall		B	19.9	-	-	D	40.9	-	-	C	22.1	-	-	B	14.4	-	-
Signalized	Little River Turnpike & Woodburn Rd	EB	L	E	79.2	720	-	F	86.5	100	-	-	-	-	-	-	-	-	-
			T	A	2.9	335	-	A	5.6	170	-	A	2.0	55	-	A	2.6	45	-
			Overall	B	16.5	-	-	A	9.6	-	-	A	2.0	-	-	A	2.6	-	-
		WB	T	E	74.6	1415	-	B	11.7	120	-	E	60.9	1315	-	A	9.6	285	-
			R	C	34.6	145	95	A	1.9	5	95	C	29.0	125	95	A	1.7	0	95
			Overall	E	72.1	-	-	B	11.5	-	-	E	58.9	-	-	A	9.4	-	-
		SB	L	F	123.0	150	-	F	92.6	140	-	F	129.4	300	-	F	106.9	420	-
			R	F	107.0	65	300	F	237.9	465	300	F	97.2	65	-	F	120.6	420	-
			Overall	F	113.6	-	-	F	209.6	-	-	F	117.3	-	-	F	113.9	-	-
		Intersection Overall		D	40.1	-	-	C	24.8	-	-	C	31.9	-	-	B	19.0	-	-

Table 11 (Cont.): 2021 Tier 3 Synchro Analysis Results

Traffic Control	Intersection	Approach	Movement	COVID Adjusted 2021								Tier 3							
				Existing AM				Existing PM				AM				PM			
				LOS ¹	Delay ²	Queues (ft)		LOS	Delay	Queues (ft)		LOS ¹	Delay ²	Queues (ft)		LOS	Delay	Queues (ft)	
						95% Queues ³	Available Storage			95% Queues	Available Storage			95% Queues ³	Available Storage			95% Queues	Available Storage
Stop-Controlled	Little River Turnpike & Wakefield Dr ⁴	NB	LR (Overall)	F	69.9	75	-	E	38.0	40	-	B	13.0	15	-	B	12.7	10	-
		Intersection Overall		F	69.9	-	-	E	38.0	-	-	B	13.0	-	-	B	12.7	-	-
Stop-Controlled	Little River Turnpike & Lee Pl ⁴	NB	R (Overall)	D	30.2	0	-	B	12.9	0	-	B	11.6	0	-	B	12.2	0	-
		Intersection Overall		D	30.2	-	-	B	12.9	-	-	B	11.6	-	-	B	12.2	-	-
Signalized	Little River Turnpike & Wakefield Chapel Rd / Service Rd	EB	L	F	111.2	60	150	F	106.1	30	150	F	112.8	130	150	F	124.9	120	150
			T	C	28.6	940	-	C	24.9	1220	-	C	29.1	960	-	B	19.1	540	-
			R	C	24.2	35	250	C	20.6	65	250	C	20.7	50	250	B	16.6	55	250
			Overall	C	29.4	-	-	C	25.0	-	-	C	30.8	-	-	C	21.8	-	-
		WB	L	F	121.2	85	400	F	104.8	120	400	F	128.8	90	400	F	104.8	120	400
			T	B	16.3	590	-	B	13.4	1105	-	B	19.8	645	-	B	15.8	1135	-
			R	B	10.6	0	750	A	6.6	0	750	B	12.7	0	750	A	7.5	0	750
			Overall	C	21.6	-	-	B	18.5	-	-	C	25.3	-	-	C	20.7	-	-
		NB	L	F	113.1	350	-	F	107.0	170	-	F	107.1	345	-	F	107.0	170	-
			LT	F	107.8	345	-	F	102.4	170	-	F	106.9	345	-	F	106.3	170	-
			R	F	313.0	875	300	F	91.5	45	300	F	140.6	495	300	F	82.5	100	300
			Overall	F	233.8	-	-	F	99.3	-	-	F	127.5	-	-	F	96.7	-	-
		SB	LTR (Overall)	F	116.5	35	-	F	101.3	40	-	F	116.5	35	-	F	101.3	40	-
		Intersection Overall		E	63.9	-	-	C	26.7	-	-	D	46.7	-	-	C	26.3	-	-
Stop-Controlled	Prosperity Ave & Connector Rd Behind CVS ^{4, 5}	SB	LT (Overall)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	C	16.8	130	-	E	35.2	620	-
		Intersection Overall		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	C	16.8	-	-	E	35.2	-	-
Stop-Controlled	Woodburn Rd & Connector Rd Behind CVS ⁴	NB	LT (Overall)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	E	38.1	60	-	B	10.6	5	-
		SB	TR (Overall)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	F	66.7	120	-	C	20.2	90	-
		Intersection Overall		N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	F	66.7	-	-	C	20.2	-	-

¹ Level of Service (LOS) is obtained from Synchro per HCM 2000 criteria

² Delay is expressed as Seconds per Vehicle

³ Queues obtained from Synchro queueing output

⁴ Worst approach delay and LOS reported as the overall unsignalized intersection operation

95th percentile volume exceeds capacity, queue may be longer

The 95th percentile queues highlighted in pink represent those exceeding the available storage facility



Figure 18: Route 236 Tier 3 Improvements

Previously Considered Alternatives at Prosperity Avenue and Woodburn Road

The following alternatives were tested by the study team or were discussed during the kickoff/stakeholders' meetings and were ruled out based on the details explained below.

Extending the Left Turn Lane at Prosperity Avenue:

This alternative would extend the eastbound left turn lanes along Route 236 at Prosperity Avenue to provide additional storage and prevent queue spillovers to help with the traffic flow and safety along the eastbound direction. This alternative required closure of the Pineland Street/Vanda Lane median break and would make this intersection a right-in right-out. This alternative was ruled out since it provided insufficient benefits to justify the cost and the impact to the community. A concept sketch of this alternative is shown in Figure 19.



Figure 19: Eastbound Left Turn Lane Extension

One-Way Split Intersection Configuration #1:

Similar to the proposed Tier 3 improvements, this alternative would connect Prosperity Avenue and Woodburn Road through a new roadway. The difference between this alternative and the Tier 3 improvement is that Prosperity Avenue would be converted to a one-way roadway travelling northbound and Woodburn Road would convert to a one-way roadway travelling southbound. Since the eastbound left turn movement onto Woodburn Road would be closed, all left turning vehicles would use Prosperity

Avenue. This alternative provided the opportunity to run the eastbound left turn movement concurrently with the southbound left turn movement, which would reduce the number of signal phases and provide the opportunity to reduce cycle length. This alternative was ruled out due to the extremely high southbound right turn volume in the PM peak hour that would accumulate at the Prosperity Avenue signal after turning onto Route 236, resulting in long queues and high delay. A concept sketch of this option is shown in Figure 20.



Figure 20: Split Intersection Configuration #1

One-Way Split Intersection Configuration #2:

Similar to the proposed Tier 3 improvements and the Split Intersection Configuration #1, this alternative would connect Prosperity Avenue and Woodburn Road through a new roadway. The difference between this alternative and Configuration #1 is that Prosperity Avenue would be converted to a one-way roadway travelling southbound and Woodburn Road would be converted to a one-way roadway travelling northbound. Since the eastbound left turn movement onto Prosperity Avenue was closed, all the left turn volume would use Woodburn Road. This alternative provided additional storage for the eastbound left turn movement and relocated all the southbound right turn volume to Prosperity Avenue, allowing them to bypass the signal and preventing them from accumulating on Route 236. This alternative was ruled out since it did not provide enough benefits to justify its cost and impact on the community. A concept sketch of this option is shown in **Figure 21**



Figure 21: Split Intersection Configuration #2

Continuous Green T for Eastbound Direction:

A Continuous Green T (CGT) intersection was considered at the intersections of Prosperity Avenue and Woodburn Road. With the CGT, the eastbound direction could pass through the two intersections without stopping, and the westbound direction of travel would be controlled by a traffic signal. The left-turn vehicles from the side streets would use a channelized receiving lane on Route 236 to merge onto the major street. This alternative was ruled out because the main issue at these two intersections is with the excessive eastbound left turn queues and a CGT did not provide any benefits for the left turn movement.

Double Eastbound Left at Prosperity Avenue:

For this alternative, the eastbound left turn lane onto Woodburn Road that continues through Prosperity Avenue was utilized to make an additional left turn onto Prosperity Avenue (the left and through lanes were converted to a left and a shared left/through). Because of the additional lane, the left turn phasing was converted from permissive-protected to protected-only mode. This alternative did not provide major benefits for the traffic flow and was removed. A concept sketch of this option is shown in **Figure 22**.



Figure 22: Double Eastbound Left at Prosperity Avenue

Previously Considered Alternatives at Wakefield Chapel Road

The following alternatives were tested by the study team or were discussed during the kickoff/stakeholders' meetings and were ruled out based on the details explained below.

Single Westbound Left Turn Lane:

This alternative was similar to the proposed Tier 2 and Tier 3 improvements at Wakefield Chapel Road, but the westbound left turn was reduced from two lanes to one lane to prevent median removal along Wakefield Chapel Road for fitting the additional northbound lanes. This alternative worked with acceptable delays and queues with the available traffic volumes used in the Synchro models, but it was removed since there were concerns with the westbound left turn volumes going onto NoVA Community College being underestimated, as traffic counts were collected during COVID. A concept sketch of this option is shown in **Figure 23**.

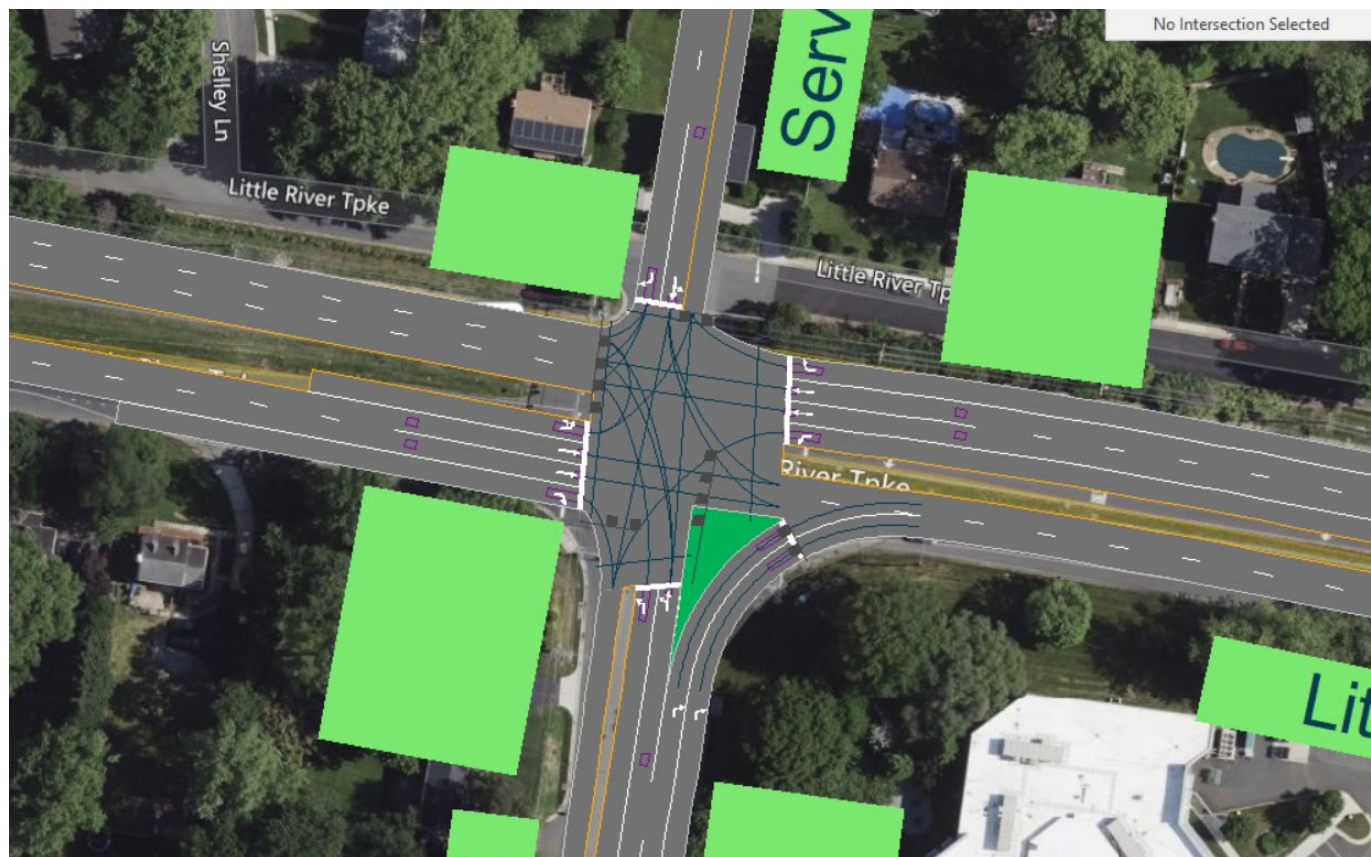


Figure 23: Single Westbound Left Turn Lane at Wakefield Chapel Road

Northbound Right Receiving Lane:

This alternative would add a receiving lane for the northbound right turn movement at Wakefield Chapel Road that continues until the next intersection at Lake Drive. It was ruled out since it did not provide sufficient benefits to justify the costs associated with construction and right-of-way acquisition. A concept sketch of this option is shown in **Figure 24**.

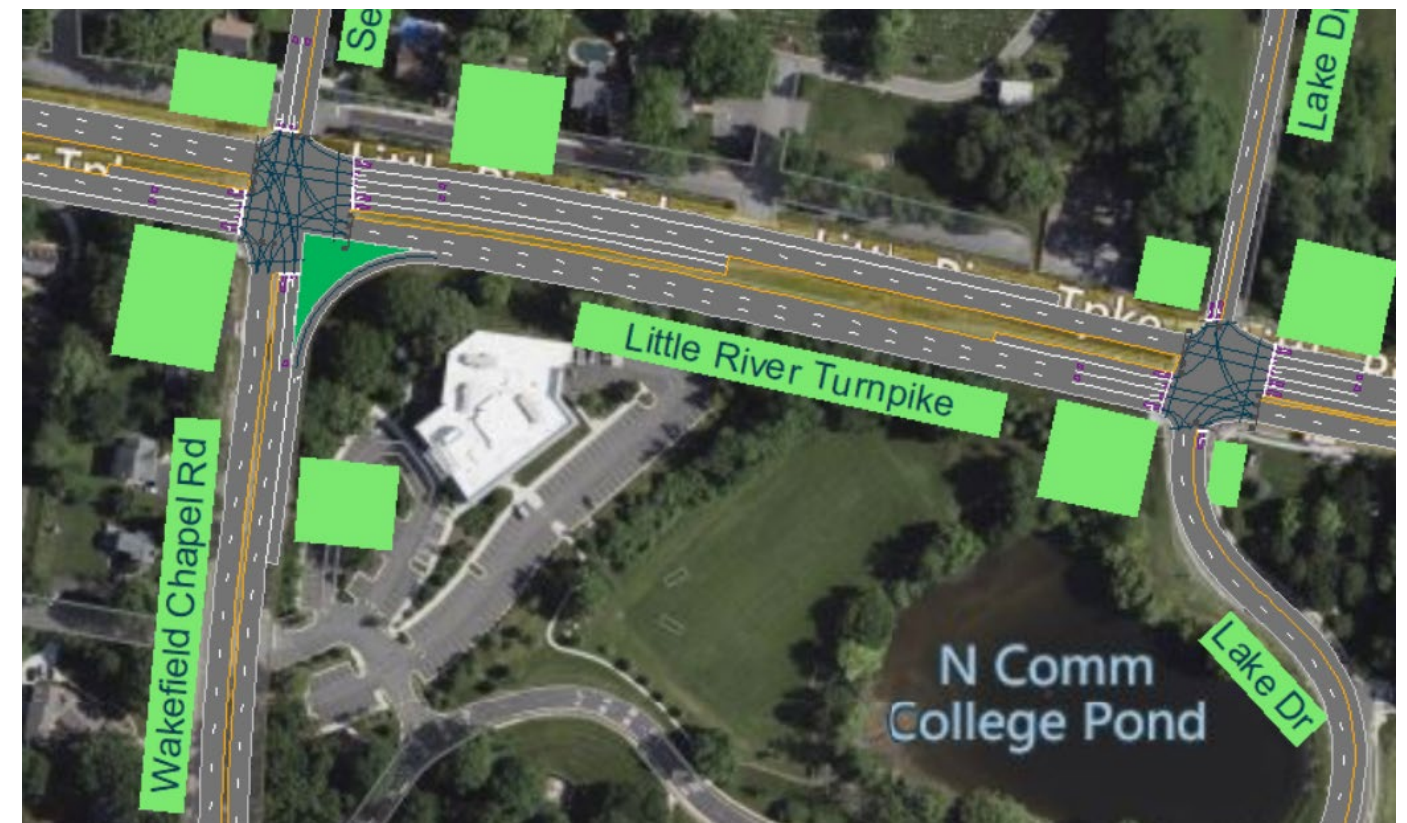


Figure 24: Wakefield Chapel Road Northbound Right Turn Receiving Lane

Northbound Right Short Receiving Lane:

This alternative would add a shorter receiving lane for the northbound right turn movement at Wakefield Chapel Road that continues midblock and merges back to Route 236. It was ruled out since it did not provide sufficient benefits to justify the costs associated with construction and right-of-way acquisition. A concept sketch of this option is shown in **Figure 25**.



Figure 25: Wakefield Chapel Road Short Northbound Right Turn Receiving Lane

Removal of North Leg:

This alternative would remove the north leg of the Wakefield Chapel Road intersection except for the right-out movement. All the restricted movements would use a new intersection to the east to access the Service Road. This alternative was ruled out since it did not provide sufficient benefits to justify the costs and the north leg volumes were considerably low that it did not provide major operational benefits. A concept sketch of this option is shown in **Figure 26**.



Figure 26: Wakefield Chapel Road North Leg Removal

Chapter 3:

Public and Stakeholder Outreach and Feedback

Public Involvement:

Following the development and analysis of the alternative designs for the study intersections, 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 2 to February 16, 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 sections, which include the following:

1. Welcome/introduction with overview of the project and study area
2. Prosperity Avenue and Woodburn Road Improvements
3. Wakefield Drive Improvements
4. Wakefield Chapel Road Improvements
5. Wrap up with demographic questions

The first section provides an overview of the study area and the project initiative. In the second section through fourth section, a summary of the improvement tiers and benefits was presented to the participants, as shown in **Figure 27**. For these improvement concepts, participants were asked to rate them based on their opinion from one to five, one being very unfavorable, three being neutral, and five 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 584 people participated in the survey and 233 comments were submitted.

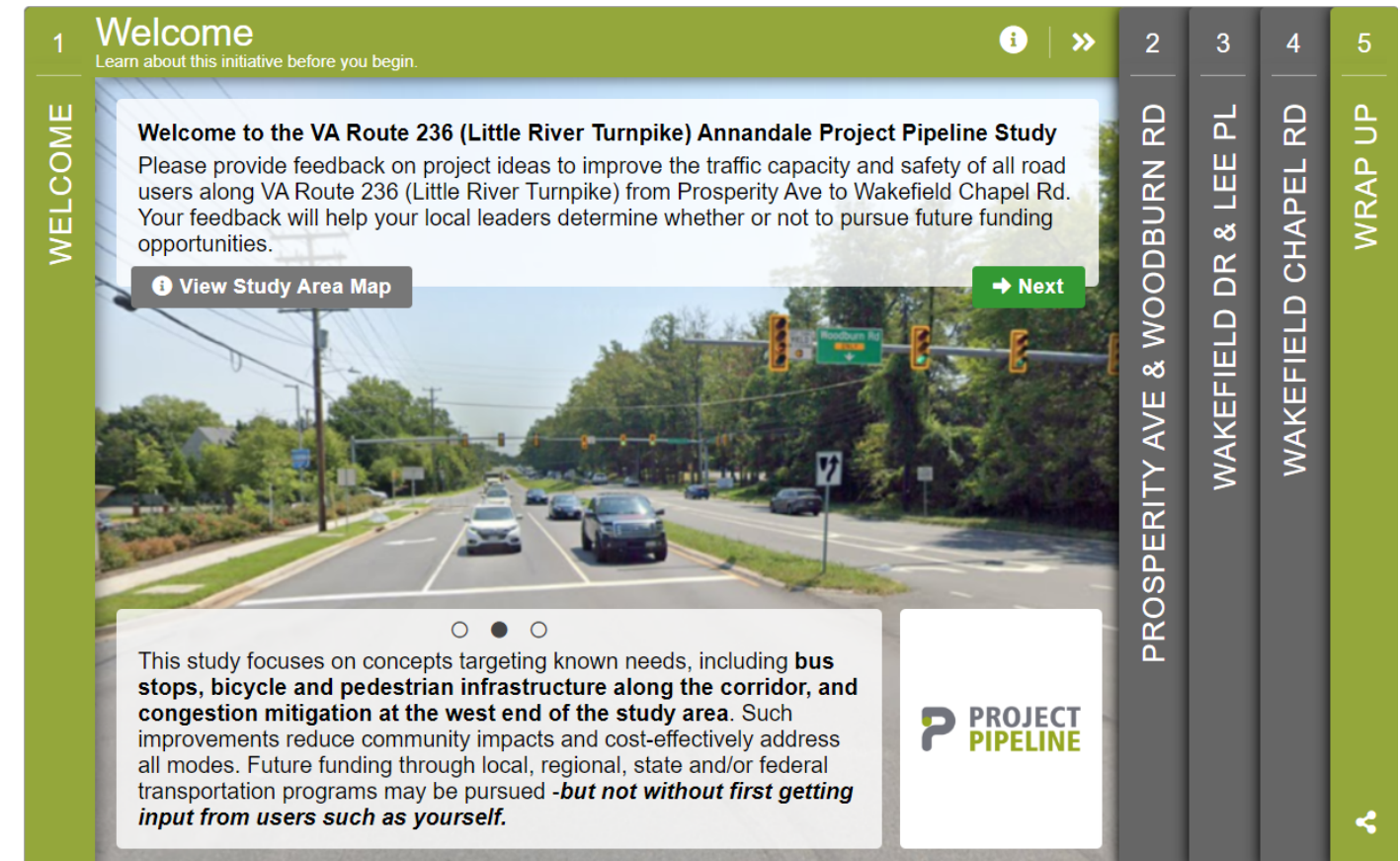


Figure 27: Public Survey Layout

Survey Questions and Results

The survey results on the participants' trip purpose, current and preferred modes of travel are presented in **Figure 28** to **Figure 30**. Overall, the majority of participants live and drive their personal vehicle within the study area. Approximately 69% of participants responded that they preferred active transportation (walking/biking/transit).

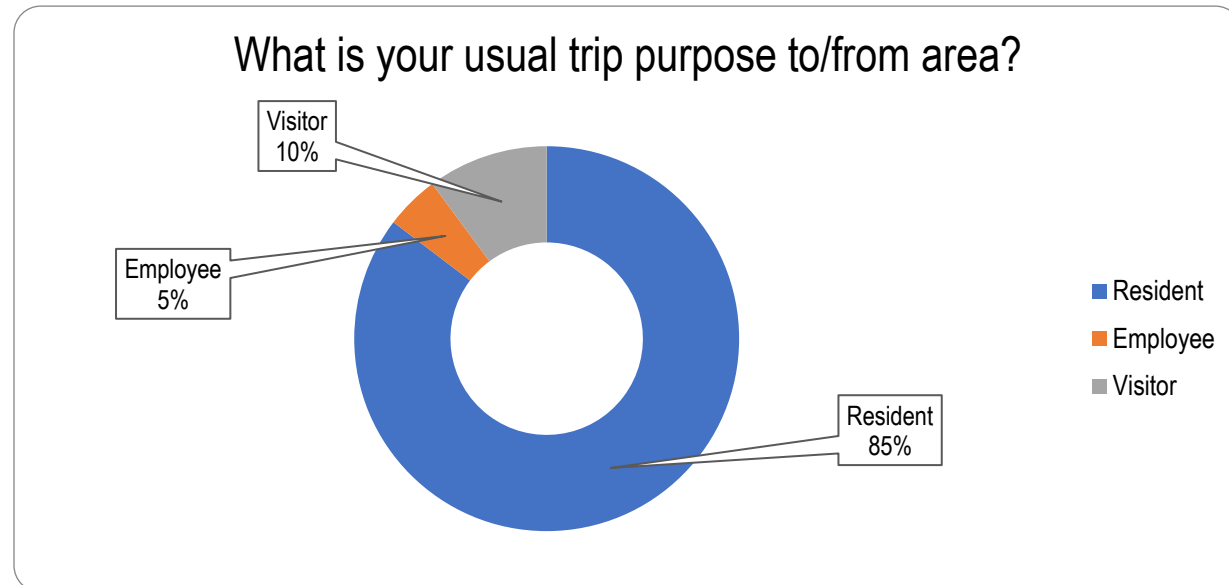


Figure 28: Participants' Trip Purpose

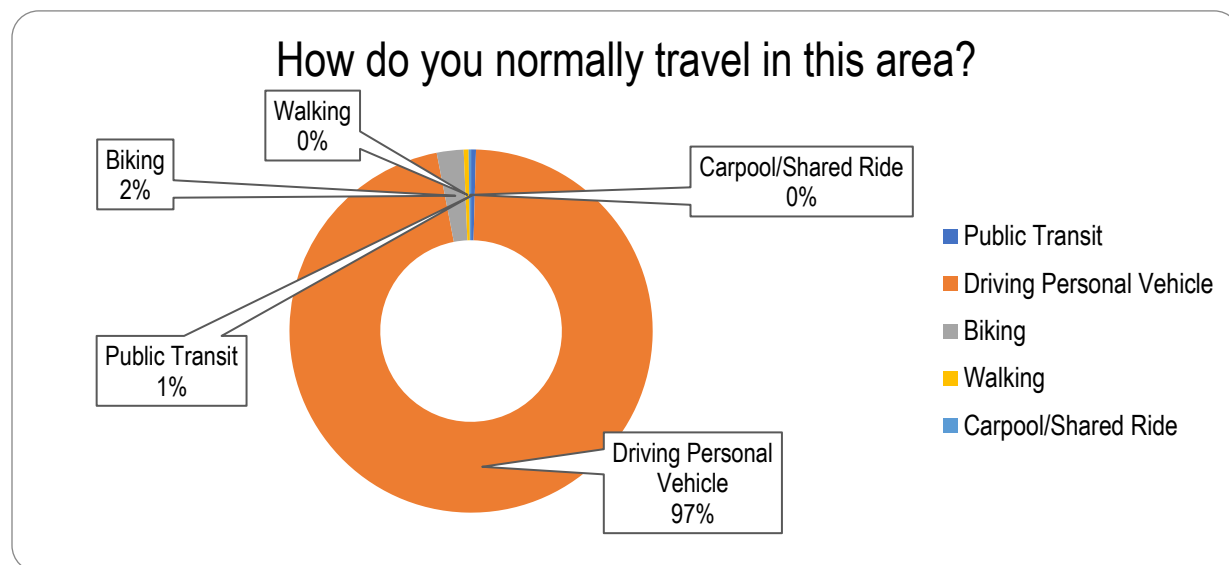


Figure 29: Participants' Current Mode of Travel

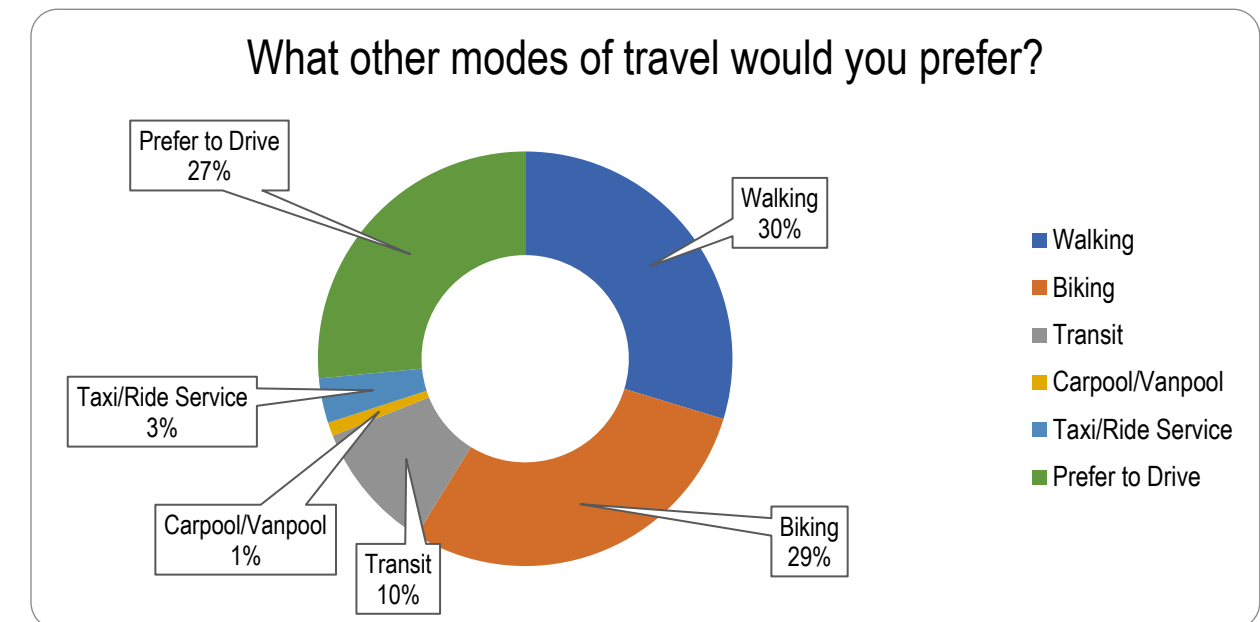


Figure 30: Participants' Preferred Mode of Travel

Next, participants were presented with the design concepts for the three improvement tiers to rate each tier on a scale from one to five stars. The ratings for each improvement tier at the Prosperity Avenue and Woodburn Road intersections are presented in **Figure 31**. The ratings for each improvement tier at the Wakefield Drive intersection are shown in **Figure 32**. The ratings for each improvement tier at the Wakefield Chapel Road intersection are presented in **Figure 33**. Majority of the respondents liked the improvements presented in the survey. The Tier 3 improvements at Prosperity Avenue and Woodburn Road were liked least by the participants.

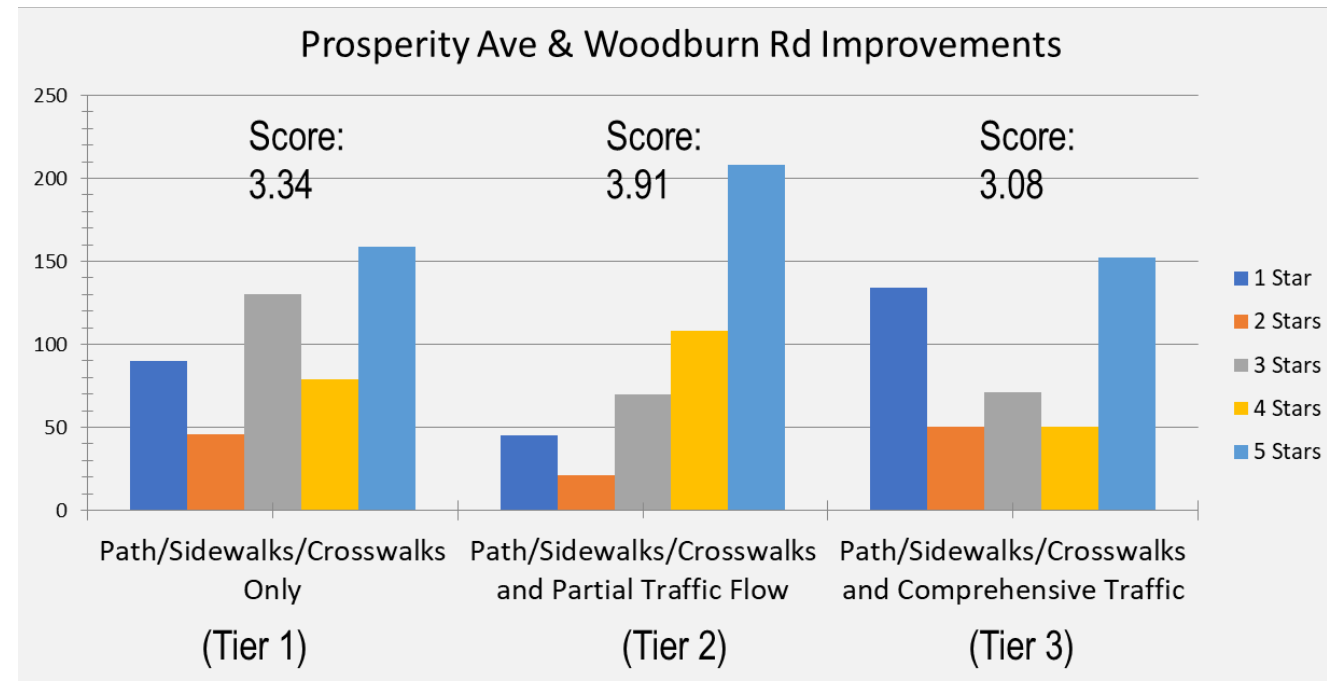


Figure 31: Prosperity Avenue and Woodburn Road Ratings

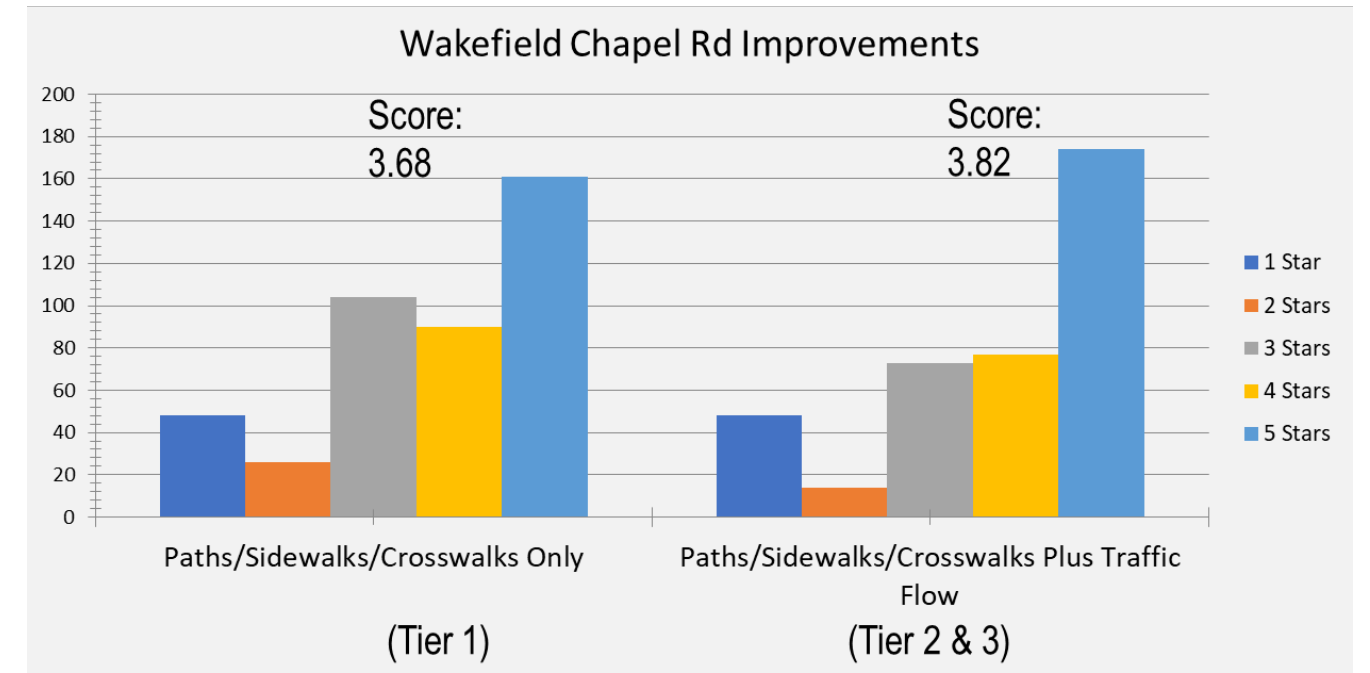


Figure 33: Wakefield Chapel Road Ratings

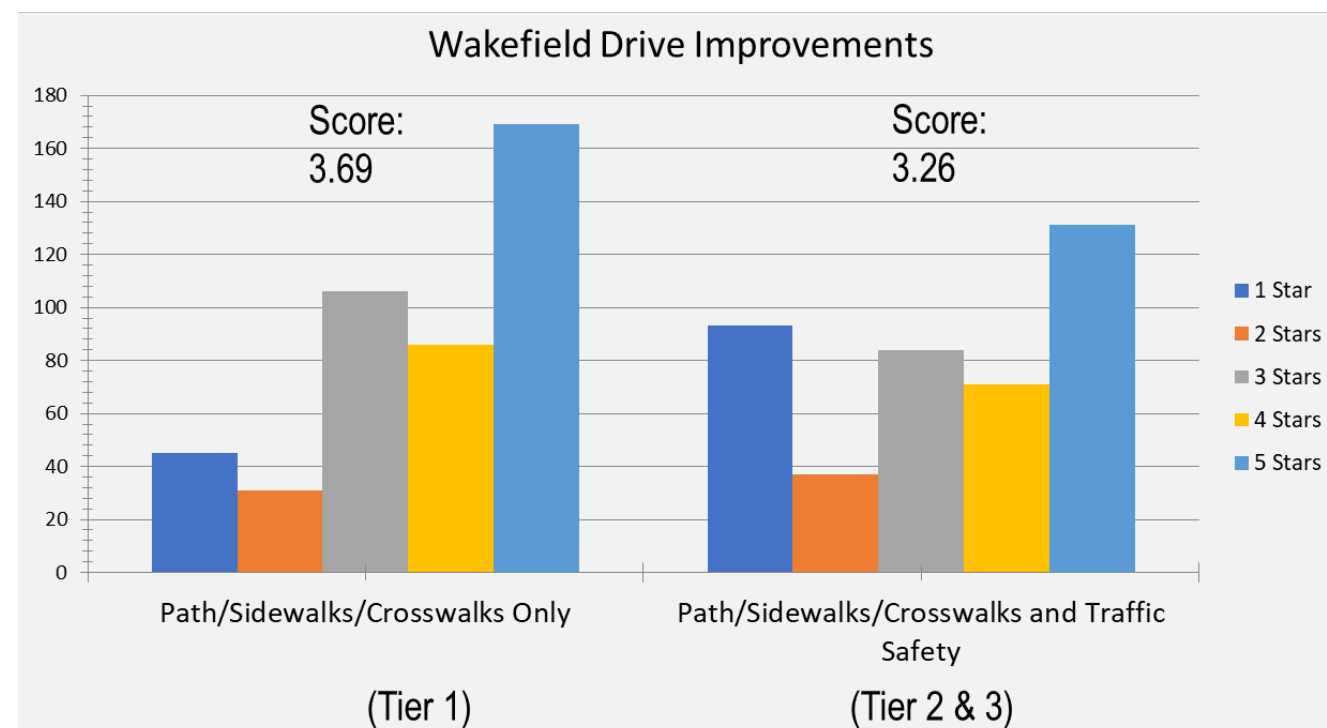


Figure 32: Wakefield Drive Ratings

A summary of public comments and concerns on the improvements is shown in **Table 12**.

Table 12: Summary of Public Comments and Concerns

Public Comments and Concerns	
Shared-use path	"I have seen people walking on the shoulder on the North side of 236. This would greatly increase their experience and safety."
Free flow right turn lane	"For traffic improvements, this will create a positive impact by removing backups from Prosperity and Woodburn, and keep traffic moving at pace along LRT. Only concern is with the crosswalk in the turn lane from Prosperity to LRT westbound"
Prosperity Avenue congestions	"The congestion at Prosperity/236 is caused by the left turn lanes. A free flow right turn lane is not necessary. Prosperity protected turn is a good idea. Narrowing LRT between Woodburn and the beltway is a bad idea."
New roadway in Tier 3	"A new road connecting Woodburn and Prosperity is unnecessary since they meet at Leroy PI a few hundred feet away."
Wakefield Drive left turn restriction	"This will make it difficult to leave St. Matthew's and many activities at the church are at non-peak times. This is horrible."

Chapter 4:

Preferred Alternative Design Refinement & Investment Strategy

Preferred Alternative:

The Preferred Alternative option was developed for the study area based on the results of the analysis as discussed in the previous *Alternative Development and Screening* section (Chapter 2), and *Public and Stakeholders Feedback* (Chapter 3). A summary of all the options, including the proposed alternatives and the previously considered options, is explained in **Table 13**. An overview of the Preferred Build Alternative and the explanations on expected operation and safety benefits are presented in **Figure 34** and **Figure 35**. The recommended considerations developed by Team 3 with respect to rail, transit, and TDM are shown in **Figure 36** to **Figure 38**.

Table 13: List of Preferred Alternative Improvements

Improvement	Description	Action	Reason if “Not Proceed”	Improvement Categories
Tier 1 Improvements	Pedestrian and bicycle improvements	Proceed	-	Multimodal
Tier 2 Improvements	Includes Tier 1 improvements + partial traffic flow improvements	Proceed	-	Multimodal, Traffic Flow, Traffic Safety
Tier 3 Improvements	Includes Tier 1 improvements + comprehensive traffic flow improvements	Not Proceed	Construction cost and impact to the community	Multimodal, Traffic Flow, Traffic Safety
Extending the Eastbound Left Turn Lane at Prosperity Avenue	Extend the left turn lane to provide additional storage and prevent queue spillbacks.	Not Proceed	Impact to the community because of closing the median break at Pineland Street/Vanda Lane	Traffic Flow, Traffic Safety
One-Way Split Intersection Configuration #1	Connect Prosperity Avenue and Woodburn Road through a new roadway. Prosperity Avenue one-way northbound and Woodburn Road one-way southbound.	Not Proceed	Extremely high southbound right turn volume in the PM peak hour that would get stuck behind the second signal at Prosperity Avenue.	Traffic Flow, Traffic Safety
One-Way Split Intersection Configuration #2:	Connect Prosperity Avenue and Woodburn Road through a new roadway. Prosperity Avenue one-way southbound and Woodburn Road one-way northbound.	Not Proceed	Did not provide enough benefits to justify its cost and impact on the community.	Traffic Flow, Traffic Safety
Double Eastbound Left at Prosperity Avenue:	The eastbound left turn lane onto Woodburn Road that continues through Prosperity Avenue was utilized to make an additional left turn onto Prosperity Avenue.	Not Proceed	Did not provide major benefits for the traffic flow.	Traffic Flow, Traffic Safety
Continuous Green T for Eastbound Direction	Continuous Green T at the intersections of Prosperity Avenue and Woodburn Road.	Not Proceed	Did not improve the main issue at these two intersections with the excessive eastbound left turn queues.	Traffic Flow, Traffic Safety
Single Westbound Left Turn Lane at Wakefield Chapel Road	Westbound left turn was reduced from two lanes to one lane.	Not Proceed	Concerns with the westbound left turn volumes going onto NoVA Community College being underestimated as there were recorded during COVID.	Traffic Flow, Traffic Safety
Northbound Right Receiving Lane at Wakefield Chapel Road	Add a receiving lane for the northbound right turn movement at Wakefield Chapel Road that continues until the next intersection at Lake Drive.	Not Proceed	Did not provide sufficient benefits to justify the costs associated with construction and right-of-way acquisition.	Traffic Flow, Traffic Safety
Northbound Right Short Receiving Lane at Wakefield Chapel Road	Add a shorter receiving lane for the northbound right turn movement at Wakefield Chapel Road that continues midblock.	Not Proceed	Did not provide sufficient benefits to justify the costs associated with construction and right-of-way acquisition.	Traffic Flow, Traffic Safety
Removal of North Leg at Wakefield Chapel Road	Remove the north leg of the Wakefield Chapel Road intersection except for the right-out movement and detour traffic to a new intersection to the east.	Not Proceed	The north leg volumes were considerably low that it did not provide major operational benefits.	Traffic Flow

Table 10 (Cont.): List of Preferred Alternative Improvements

Improvement	Description	Action	Reason if “Not Proceed”	Improvement Categories
Shared-Use Path Along the South Side	Add shared-use path along the south side of Route 236.	Not Proceed	Limited space to provide a shared-use path. A sidewalk is provided instead.	Multimodal
Queue Jump for Buses	Queue jump for buses at feasible intersections.	Under Consideration	-	Transit, Traffic Flow
Transit Signal Priority	Transit signal priority at feasible intersections.	Under Consideration	-	Transit, Traffic Flow
Park and Ride Improvements	Two potential Park and Ride locations.	Under Consideration	-	Transportation Demand Management

Preferred Alternative Summary:

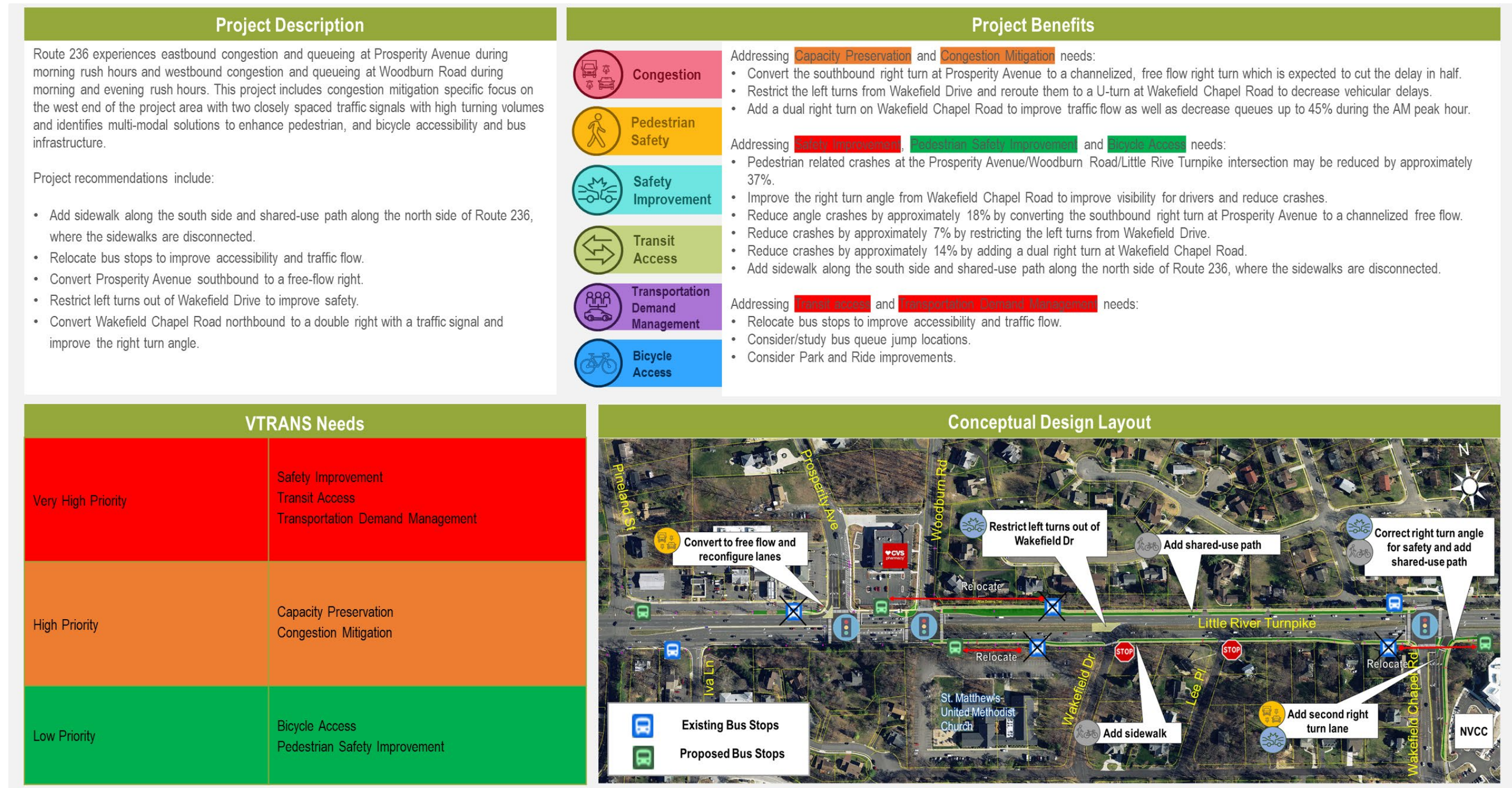


Figure 34: Route 236 Preferred Alternative Summary

Preferred Alternative Summary (Cont.):

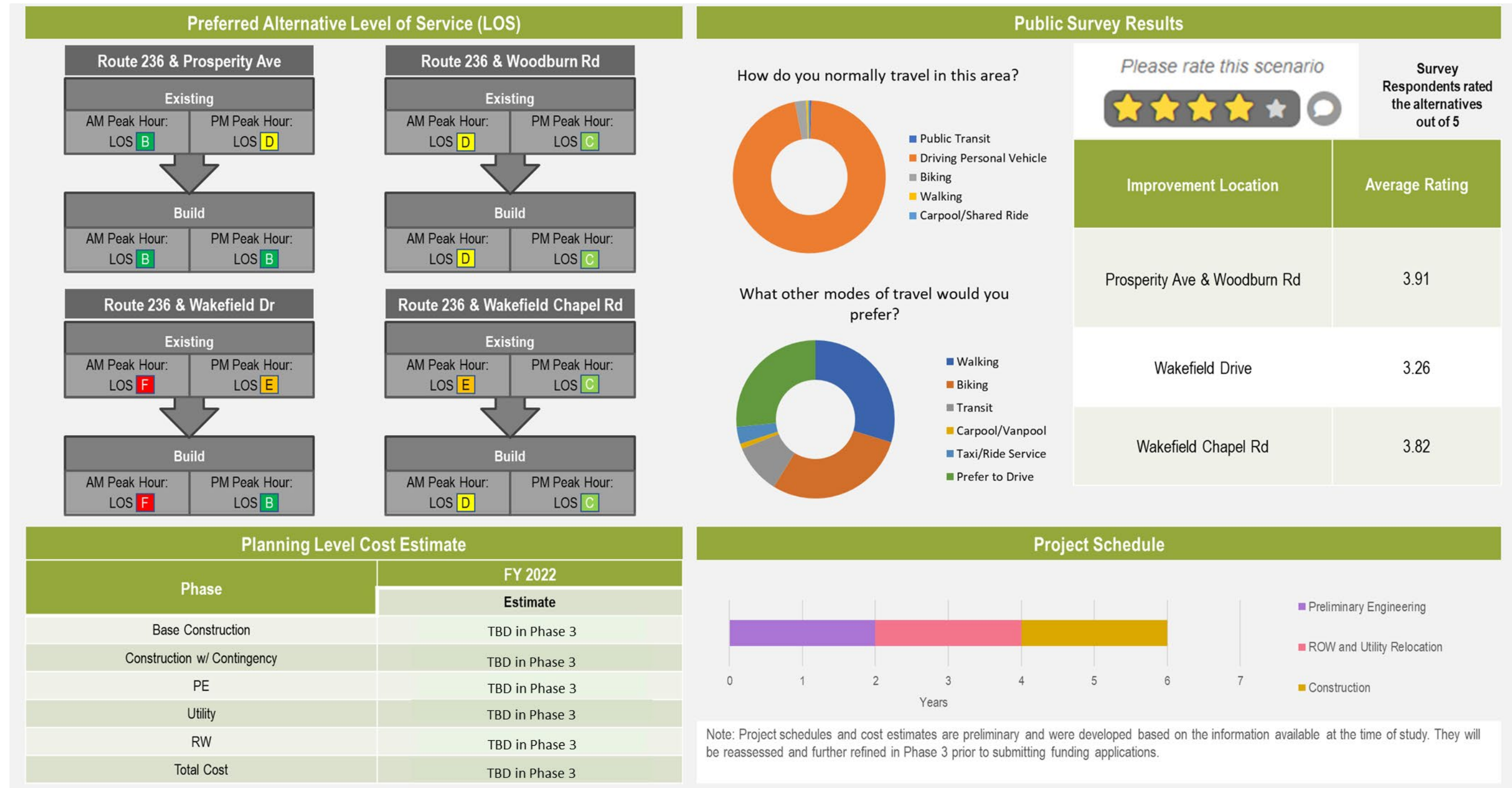
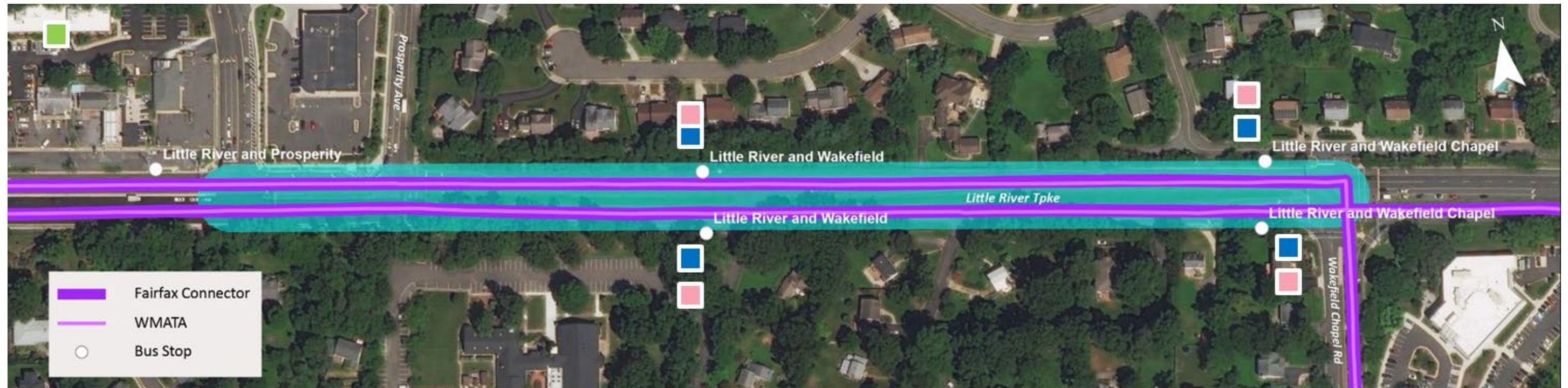


Figure 35: Route 236 Preferred Alternative Summary (cont.)

Rail, Transit, and TDM Recommended Considerations Summary:



Potential Improvements



Add ADA loading pads at Iva Lane eastbound, Wakefield Drive eastbound/westbound, Wakefield Chapel Road eastbound/westbound



Connect stops at Wakefield Drive eastbound/westbound and Wakefield Chapel Road eastbound/westbound into sidewalk/pathway network



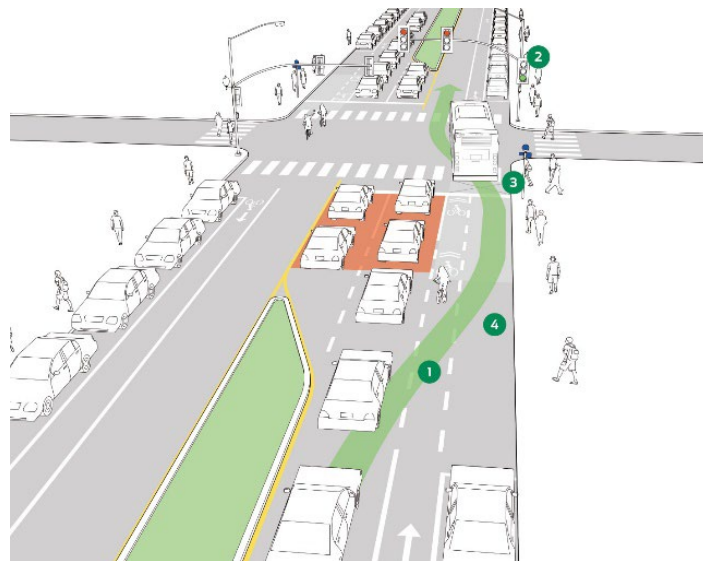
Leverage the existing Fairfax County commuter assistance programs to promote the use of transit, carpool and vanpool, and to provide ride-matching and commute options information to residents, employers and employees.

Consider extension of City's CUE Bus route to new Park & Ride lot

Add mobility hub elements to new Park & Ride lot

In the absence of convenient/direct access at the Beltway interchange and its Express Lanes, encourage the marketing and increased signing for commuters to use the northern connections (Pickett Rd) to the Vienna/Fairfax - GMU Metrorail Station and to use eastbound Braddock Rd which has Park & Ride facilities and more convenient/direct access to the Beltway Express Lanes.

Figure 36: Recommended Considerations for Rail, Transit, and TDM



Queue Jump Feasible Locations

- Prince William Drive in the eastbound direction.
- Guinea Road in the eastbound direction.
- Prosperity Avenue and Woodburn Road in the westbound direction for Tier 1; not feasible for Tier 2 and Tier 3.
- Lake Drive in the eastbound direction.
- Duncan Drive in both directions.

* Queue jumps can be designed with no special signal timing when the bus station is on the far side or with actuation by an approaching bus to give it a green signal before the adjacent through lanes when the bus station is on the near side.

NV01 - Fairfax County RTE 236 - Little River Turnpike



Queue Jump Feasible



Queue Jump Not Feasible



Extended TSP
Corridor



Project Corridor

2,000'

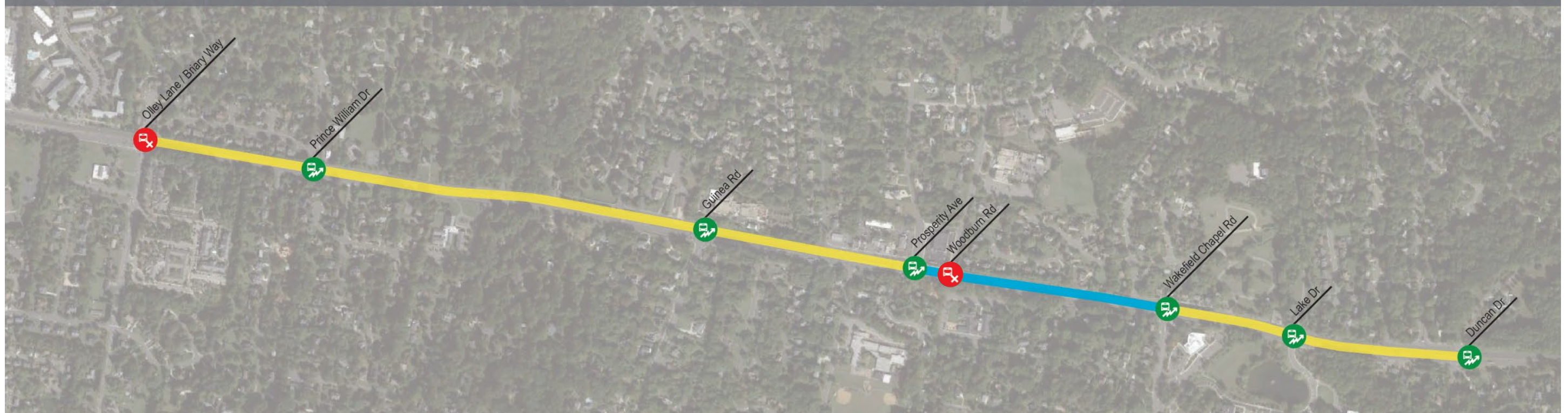


Figure 37: Feasible Queue Jump Locations

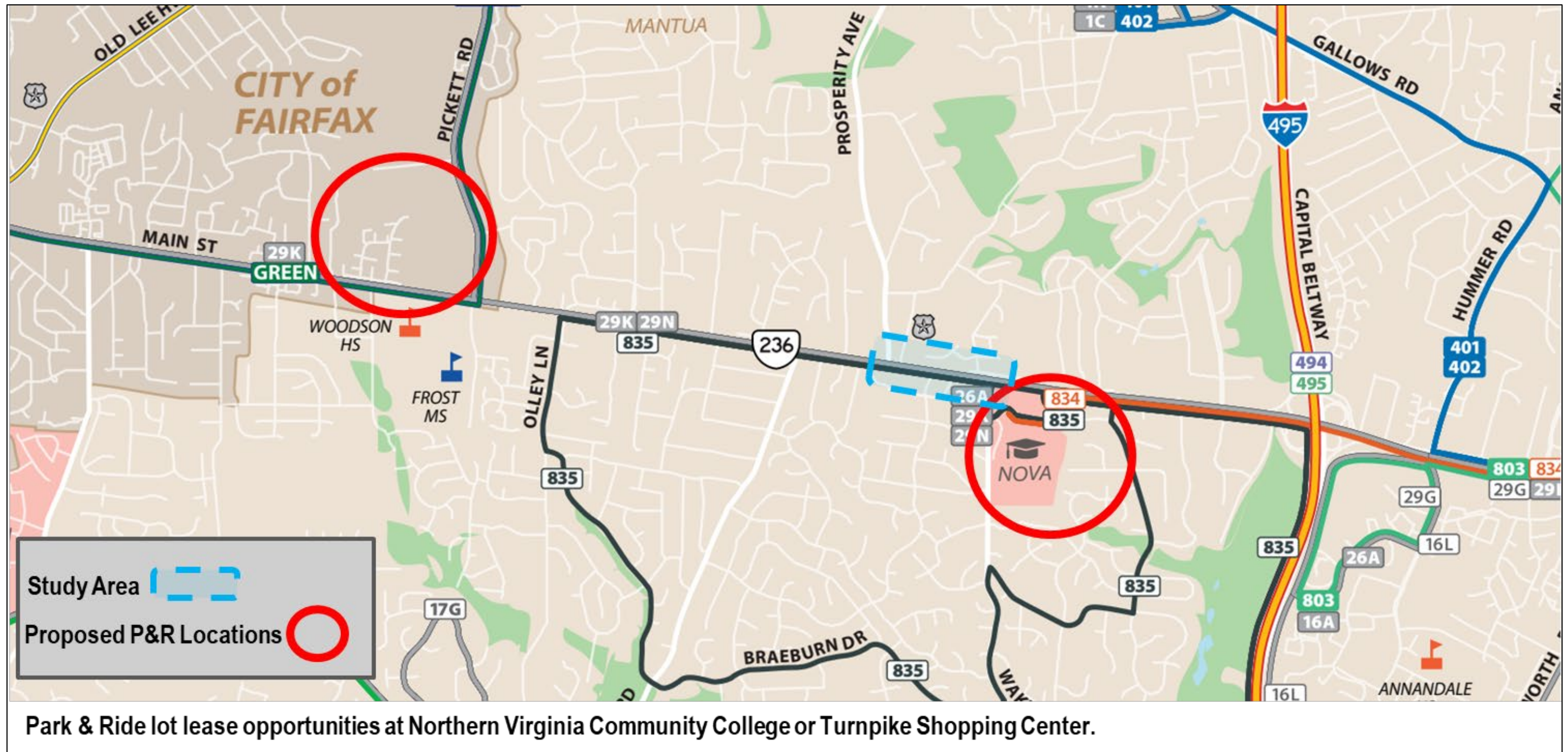


Figure 38: Potential Park and Ride Locations

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 keeping much of the existing roads pavement. A WB-62 and a passenger design vehicle was used to set edge geometrics at Wakefield Chapel Road intersections and a BUS-45 was used to set edge geometrics at Prosperity Ave intersections.
- Hydraulics and stormwater management – Median in-lets and drop in-lets will be added with the proposed curb and gutter between Woodburn Road and Wakefield Chapel Road.
- Utility impacts – Some utility poles along the north side of Little River Turnpike would need to be relocated to accommodate the proposed shared use path.
- Right of Way – The proposed improvements will involve acquiring right of way and easements on several parcels. This is primarily due to the proposed added shared use path and sidewalk. Refer to the concept design exhibits and Right of Way Data Sheet for more details.
- Schedule – Following is the anticipated project development schedule:
 - PE 8/2023 Start 8/2025 End
 - RW/Utility 2/2025 Start 8/2026 End
 - CN 8/2026 Start 8/2028 End

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, 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 for the trail is near private properties.
- Water and sewer lines are hugging the property line in the south side of the study area.
- Inadequate downstream flow if SWM cannot be added in the median.

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 Most Likely Estimate (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, maintenance of traffic (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 take offs and identifying unit prices based on Bid Express to develop “defined costs”.
- Developing “allowance costs” for some elements based on potential impacts and complexity. Allowances add costs for elements based on a percentage of the base construction cost.
 - Maintenance of Traffic 8% Allowance.
 - Erosion and Sediment Control 3% Allowance
 - Utility Relocations 5% Allowance
 - Traffic Items 2% Allowance
 - Seeding 1% Allowance
 - Landscape 1% Allowance
- Identifying proposed property impacts, developing a Right of Way Data Sheet and coordinating with VDOT to develop Right-of-Way costs. Note, only 7 parcels are anticipated to be impacted (5 with Fee Taking and easements, and an additional 2 with just easements).

- 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 (See the Cost Estimate for more details).

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, **shown in** Figure 39. As the design progressed, several elements were altered from the concept that resulted from Phase 2 to include:

- Removing the EB dual left turn at the intersection of Little River Tnpk/Prosperity Ave.
- Keeping the SB left turn at the intersection of Little River Tnpk/Prosperity Ave.
- Keeping the EB left turn at the intersection of Little River Tnpk/Woodburn Rd.
- Removing the proposed one-way road connecting Prosperity Ave and Woodburn Rd.

Cost Estimate Breakdown

The total project cost is estimated to be \$14,313,063 and broken down by Phase/Major area as shown in Table 13 below. This cost includes contingencies and represents uninflated July 2022 dollars.

Table 143: Cost Estimate Breakdown

Phase	Total
Preliminary Engineering Phase	\$1,685,600
Right-of-Way and Utilities Phase	\$1,387,120
Construction Phase (without CEI)	\$9,437,287
Construction Phase (with CEI)	\$11,240,342
Total	\$14,313,063

PREFERRED ALTERNATIVE

MARCH 2022



Figure 39. Little River Turnpike Improvements

Appendix A: ADTs and Turning Movement Counts

Appendix B: Synchro Reports

Appendix C: Raw Crash Data 2015 – 2019

Appendix D: Collision Diagrams

Appendix E: Phase 3 Basis of Design Memo