ARTERIAL
PRESERVATION PROGRAM

Arterial Management Plan: US 360 Corridor

VDOT Richmond District: Amelia and Chesterfield Counties

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September 2021 | Final Report

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List of Acronyms

APN - Arterial Preservation Network

APP - Arterial Preservation Program

AADT - Annual Average Daily Traffic

CoSS - Corridor of Statewide Significance

EDTT - Extra Distance Travel Time

ETT - Experienced Travel Time

HCM - Highway Capacity Manual

LOS - Level of Service

MOE - Measure of Effectiveness

MUT - Median U-Turn

MUTCD - Manual of Uniform Traffic Control Devices

PDO - Property Damage Only

PHF - Peak Hour Factor

PSAP - Pedestrian Safety Action Plan

PSI - Potential for Safety Improvement

RCUT - Restricted Crossing U-Turn

RNS - Roadway Network System

SPS - Statewide Planning System

TMC - Turning Movement Count

TOSAM - Traffic Operations and Safety Analysis Manual

TRB - Transportation Research Board

TSN - Targeted Safety Need

v/c – Volume-to-Capacity Ratio

VDOT - Virginia Department of Transportation

VJuST - VDOT Junction Screening Tool

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1 Background

1.1 Arterial Preservation Program Goals and Strategies

The Virginia Department of Transportation (VDOT) initiated the development of the **Arterial Preservation Program** in the spring of 2017. The overarching goal of the **Arterial Preservation Program** is to preserve and enhance the safety and capacity of the **Arterial Preservation Network** while ensuring:

- Increased safety for all users
- Local economic development goals are integrated into each plan
- Mainline through traffic is served with priority

Arterial Management Plans (AMPs) are developed in partnership with localities for corridors within the **Arterial Preservation Network** to implement the following preservation and enhancement strategies:

- Solicit public input throughout each planning process and in multiple forms
- Improve access management
- Educate communities on the benefits of improved mobility
- Inspire comprehensive transportation and zoning planning efforts
- Eliminate unjustified traffic signals
- Implement innovative intersection configurations

1.2 Arterial Preservation Network

The **Arterial Preservation Network** is the state-maintained portion of the National Highway System in Virginia including some additional highways that facilitate connectivity. Over time, additional facilities may be added to further enhance connectivity should the need arise. More information on the **Arterial Preservation Program**, including an interactive map of the **Arterial Preservation Network**, can be found at http://www.virginiadot.org/programs/vdot_arterial_preservation_program.asp

2 US 360 Corridor

The US 360 corridor in Amelia and Chesterfield Counties is unique in its function and geometric conditions. The eastern end of the corridor in Chesterfield County is a busy commercial route with operational and safety issues due to heavy traffic volumes during the morning and evening peak periods. Segments from Winterpock Road to Magnolia Green Parkway were identified as having VTrans Richmond District Capacity and Transportation Demand Management needs. The western end of the corridor, as it transitions from the western portions of Chesterfield County to Amelia County, is primarily rural residential and agricultural.

The purpose of this plan is to evaluate operational and safety conditions and identify improvements that preserve and enhance this key transportation corridor and can be programmed into the VDOT Six-Year Improvement Program. In addition, this plan aims to identify an access management strategy that accommodates future development safely and efficiently within the undeveloped area without large-scale roadway widenings or increased signal proliferation.

2.1 Study Work Group

A Study Work Group (SWG) was formed to provide local input and feedback to help guide the development of preferred alternatives throughout the planning process. The SWG consisted of representatives from the following entities:

- VDOT Transportation and Mobility Planning Division (TMPD)
- VDOT Richmond District Planning
- VDOT Richmond District Location and Design
- VDOT Richmond District Traffic Engineering
- VDOT Central Region Operations
- VDOT Chesterfield Residency
- Amelia County
- Chesterfield County
- Richmond Regional Transportation Planning Organization (TPO)
- Kimley-Horn

A framework document was developed prior to commencing this study that outlined the methods and assumptions for the US 360 Arterial Management Plan. The signed framework document is provided in **Appendix A**.

2.2 Study Area

The US 360 AMP study area limits are shown in **Figure 1**. The limits total approximately 30-miles in length, spanning US 360 (Hull Street Road) between Winterpock Road (Route 621) and Holly Farms Road (Route 307). The area includes the following corridor and intersections:

Intersections:

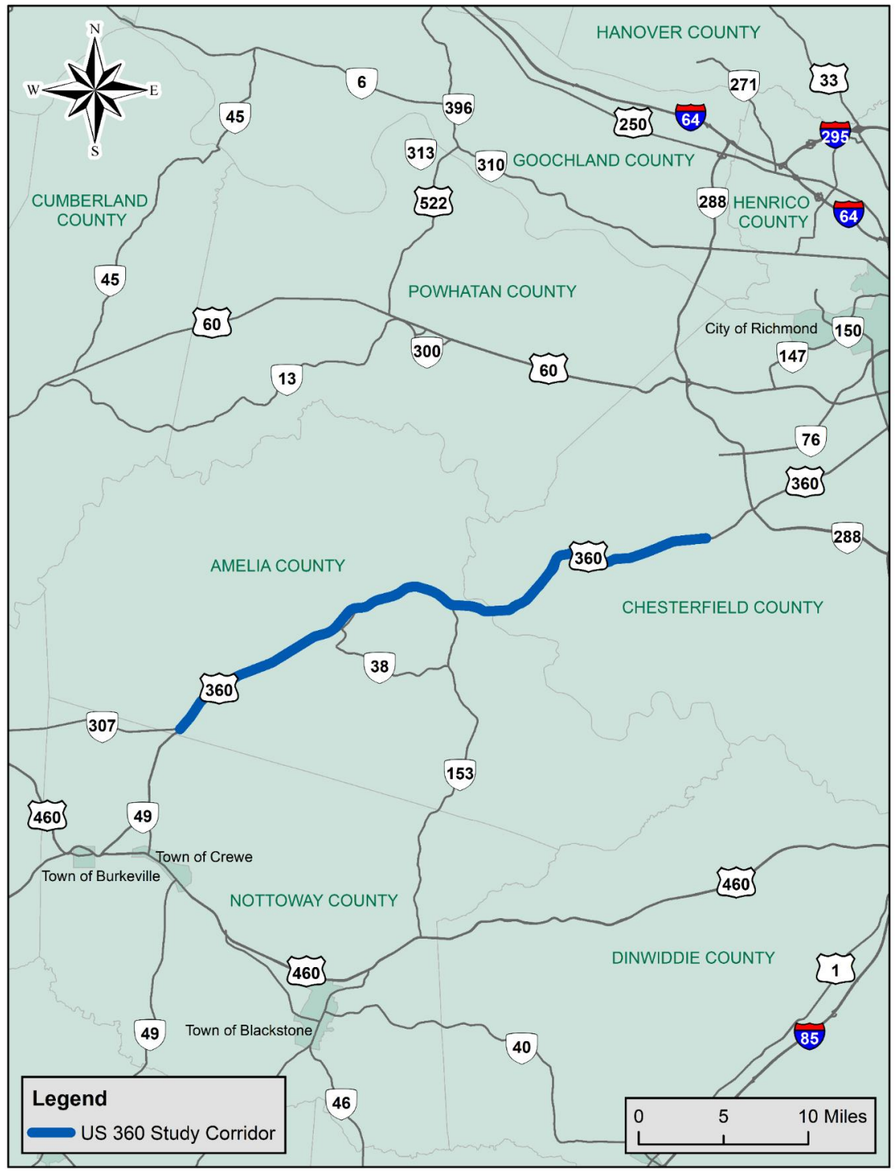
Chesterfield County

1. US 360 at Southshore Drive (Unsignalized)
2. US 360 at Winterpock Road (Signalized)
3. US 360 at Hancock Village Drive / Duckridge Boulevard (Signalized)
4. US 360 at Ashlake Parkway (Signalized)
5. US 360 at Woodlake Village Parkway (Signalized)
6. US 360 at Woodlake Commons (Unsignalized)
7. US 360 at Cosby Road (Unsignalized)
8. US 360 at Fox Club Parkway / Hampton Park Drive (Signalized)
9. US 360 at Otterdale Road (Signalized)
10. US 360 at Hampton Farms Drive (Unsignalized)
11. US 360 at Magnolia Green Parkway / Baldwin Creek Road (Signalized)
12. US 360 at Beaver Bridge Road (Unsignalized)
13. US 360 at Skinquarter Road (Unsignalized)

Amelia County

14. US 360 at Military Road (Unsignalized)
15. US 360 at Chula Road (Signalized)
16. US 360 at Goodes Bridge Road (Signalized)

FIGURE 1: US 360 STUDY CORRIDOR



3 Data Collection and Inventory

The following sections summarize field review observations and collected data that was used for this study. All assumptions pertaining to data collection and processing are based on the direction and guidance provided in the VDOT *Traffic Operations and Safety Analysis Manual (TOSAM) Version 1.0*.

3.1 Relevant Studies and Plans

Relevant studies and plans completed within the study area were collected and reviewed to identify previous recommendations along the study corridor. These studies and plans are listed in **Table 1**.

TABLE 1: PREVIOUS STUDIES AND COMPREHENSIVE PLANS

Previous Studies and Comprehensive Plans	Year
Previous Studies	
STARS Hull Street Road (US Route 360) at Winterpock Road Intersection Study	2011
STARS Hull Street Road (US Route 360) at Woodlake Village Parkway Intersection Study	2011
STARS US 360/Route 288 Interchange Study	2016
Traffic Signal Timing Implementation Plan	2019
VTrans Mid-Term Needs and Priorities	2019
Governance Documents	
Amelia County Comprehensive Plan 2017	Amended September 2019
Moving Forward: The Comprehensive Plan for Chesterfield County	Adopted May 2019
Chesterfield County Route 360 Corridor Plan	Adopted May 1995, Reformatted October 2006
Zoning Ordinance of Amelia County, US 360 Overlay District	Amended September 2019

3.2 Land Use and Zoning

The Code of Virginia requires localities to adopt a comprehensive plan that considers existing and projected conditions for the physical development of jurisdictions. Future and existing land use maps for Amelia County and Chesterfield County can be found in **Appendix B**.

3.2.1 Amelia County

Residential growth within Amelia County over the last decade has resulted in a reduction of farmland and agricultural operations. To preserve its rural and agricultural areas, the county identified concentrated growth areas for development. The Amelia County Comprehensive Plan, published in 2017, identifies four development areas and two economic development areas along the US 360 study corridor.

The 2017 Recommended Transportation Plan (**Appendix B**) depicts roadway and intersection improvements within the development areas. The following six intersections along the US 360 study corridor are targeted for intersection upgrades to support growth the development areas:

- US 360 at Circle Drive
- US 360 at Chula Road
- US 360 at Mount Olive Lane
- US 360 at Butlers Road
- US 360 at Superior Way
- US 360 at Amelia Avenue

US 360 Overlay District

Amelia County created the US 360 Overlay District to enhance and preserve the rural character specific to the US 360 corridor. The district applies to all properties adjacent to and within 1,200 feet of US 360. The following roadway access requirements are set forth by the overlay district:

- Direct access points shall occur at existing median breaks and shall be generally no more frequent than one access point per 1,000 feet.
- Direct vehicular access to US 360 is prohibited. Indirect access should be achieved via existing median breaks.
- Contiguous sites along US 360 shall create a continuous access road parallel to US 360. Roads shall be no closer than 800 feet from US 360 right-of-way.

3.2.2 Chesterfield County

Chesterfield County has a diverse land use composition, ranging from rural to suburban to urban environments. The area surrounding the US 360 study area is currently zoned Public/Semi-Public & Utilities, Commercial/Office, and Single-Family Subdivision.

The Chesterfield County Future Lane Use Map (**Appendix B**) reflects business uses surrounding the corridor to the east, while mixed-use and residential uses are predominant towards the west.

Specific future land-use priorities identified in the County Comprehensive Plan include:

- Regional Mixed Use surrounding the planned Powhite Parkway Extension interchange
- A ‘village center’ zoned compatible with Community Mixed Use in the area north of US 360, west of Otterdale Road and south/east of Magnolia Green Parkway.

The 2016 Thoroughfare Plan identifies the Powhite Parkway Extension from Route 288 to east of the US 360/Beaver Bridge Road intersection as a priority for the county as it experiences continued growth.

3.3 Traffic Data

All data collection efforts occurred during a Tuesday, Wednesday, or Thursday when public school was in session. VDOT provided existing traffic signal timing and design plans. Intersections east of Magnolia Green Parkway were retimed in January 2020. All traffic data is provided in **Appendix C**. Safety data is provided in **Appendix D**.

Turning Movement Counts

Four-hour turning movement counts (TMCs) were collected on Tuesday, May 21, 2019 and Wednesday, May 22, 2019 from 7:00 AM to 9:00 AM and 4:00 PM to 6:00 PM at the following locations:

- US 360 at Winterpock Road
- US 360 at Hancock Village Drive
- US 360 at Ashlake Parkway
- US 360 at Woodlake Village Parkway
- US 360 at Woodlake Commons
- US 360 at Cosby Road
- US 360 at Fox Club Parkway / Hampton Park Drive
- US 360 at Otterdale Road
- US 360 at Magnolia Green Parkway
- US 360 at Beaver Bridge Road
- US 360 at Skinquarter Road

Additional data collection locations were identified during the development of the framework document. TMCs were collected on Thursday, January 16, 2020 from 6:00 AM to 8:00 PM at the following intersections:

- US 360 at Southshore Drive
- US 360 at Hampton Farms Drive
- US 360 at Circle Drive
- US 360 at Military Road
- US 360 at Redfield Drive
- US 360 at Chula Road
- US 360 at Goodes Bridge Road

TMCs from March 2018 for the US 360 at Spring Run Road intersection was used to assist with calibration efforts, which is located east of the study corridor.

Tube Counts

72-hour tube counts were collected from Tuesday, January 14, 2020 through Thursday, January 16, 2020 at the following locations:

- US 360 between Woodlake Village Parkway and Otterdale Road
- US 360 between Otterdale Road and Magnolia Green Parkway
- US 360 between Beaver Bridge Road and Skinquarter Road
- US 360 between Pridesville Road and Amelia Avenue
- US 360 between Holly Farms Road and Scottland Lane

3.3.1 Peak Hour Determination

A network-wide peak hour was determined for both the AM and PM peak periods based on peak hours calculated for each study intersection. The hours that captured the highest percentage of overall traffic in the network was selected as the network peak hour.

The peak hour determination summary tables are provided in **Appendix E**. The network-wide peak hours were determined to be from 7:15 AM to 8:15 AM and 5:00 PM to 6:00 PM. These hours captured 99% of traffic during the AM and PM peak hours.

Heavy vehicle percentages were calculated for each movement, and peak hour factors were calculated for each intersection during the AM and PM peak hours.

3.3.2 Traffic Volume Balancing

The 2019 existing traffic volumes at each study intersection are depicted in **Appendix E**. Traffic volumes were balanced for intersections between Spring Run Road and Magnolia Green Parkway. Raw traffic volumes were not adjusted more than ten percent, where possible.

U-turns are prohibited at several locations along the corridor. U-turns during the AM and PM were removed from the following locations:

- Westbound US 360 at Winterpock Road
- Westbound US 360 at Hancock Village Drive / Duckridge Boulevard

3.4 Safety Data

The following data sources were used to assess safety within the study corridor and identify crash patterns:

- Latest five years of crash data obtained from the VDOT Roadway Network System (RNS)
- Potential for Safety Improvement (PSI) and Targeted Safety Need (TSN) locations

Additional information regarding each source is provided in **Section 5**.

3.5 Field Review

A field review of the study area was conducted on Wednesday, January 15, 2020 to observe existing geometric conditions, traffic control, peak hour traffic conditions, driver behavior, and existing conditions contributing to crash history. The existing lane configurations for each study intersection are depicted in **Appendix E**. Detailed safety and traffic observations are outlined in **Section 5** and **Section 6**, respectively.

4 Access Management Review

One of the goals of the Arterial Preservation Program is to improve access management so that access points and traffic controls do not degrade travel speed and safety. Access point types and spacings along the US 360 study corridor were reviewed to identify access management recommendations based on existing deficiencies. The review excluded right-in/right-out intersections and residential driveways.

The *VDOT Road Design Manual* provides access management design standards for entrances and intersections along roadways to provide access to land uses while preserving the flow of traffic. The standards are based on the functional classification and posted speed limit of the roadway. The US 360 corridor is classified as an "other principal arterial", with speed limits ranging from 45 mph to 60 mph. The access management standards applicable to the roadway are listed in **Table 2**.

TABLE 2: MINIMUM SPACING STANDARDS FOR COMMERCIAL ENTRANCES, INTERSECTIONS, AND MEDIAN CROSSOVERS

Highway Functional Classification	Legal Speed Limit (mph)	Minimum Centerline to Centerline Spacing (Distance) in Feet			
		Spacing from Signalized Intersections to Other Signalized Intersections	Spacing from Unsignalized Intersections & Full Median Crossovers to Signalized or Unsignalized Intersections& Full Median Crossovers	Spacing from Full Access Entrances & Directional Median to Other Full Access Entrances and Any Intersection or Median Crossover	Spacing from Partial Access One or Two Way Entrances to Any Type of Entrance, Intersection or Median Crossover
Principal Arterial	≤ 30 mph 35 to 45 mph ≥ 50 mph	1,050 1,320 2,640	880 1,050 1,320	440 565 750	250 305 495

Source: *VDOT Road Design Manual* (Appendix F, Table 2-2)

In addition, the Amelia County US 360 Overlay District requires median breaks along the corridor to be no more frequent than one access point per 1,000 feet for commercial entrances and industrial land uses. **Table 3** summarizes the access points along the corridor.

TABLE 3: ACCESS POINT TYPE AND SPACING

Access Point Type	Access Management Spacing Met?		Total
	Yes	No	
Signalized Intersection	3	6	9
Full Median Crossover	21	27	48
Unsignalized Intersection	19	28	47
Grand Total	**43**	**61**	**104**

5 Safety Analysis

Crash data from 2014-2018 was used to evaluate safety and identify crash patterns along US 360. The following sections provide a summary of the crashes that occurred within the study area during the crash analysis period. The crash data and safety analyses are summarized in **Appendix D**.

5.1 Safety Review Observations

Prior to conducting the field review, the study team conducted a preliminary review of locations where angle crashes and roadway departure crashes occurred during the crash analysis period. Observations are summarized in **Appendix E**.

5.2 Summary of Study Area Crashes

A total of 969 crashes were reported in the study area over the five-year crash analysis period. Of the reported crashes, there were 10 fatal crashes, 57 serious injury crashes, 204 minor/possible injury crashes, 28 no-apparent injury crashes, and 670 crashes involving property damage only. A yearly summary of crashes by crash severity is shown in **Table 4**. Crash severity is expressed according to the following KABCO scale classifications:

- K – Fatal
- A – Suspected Serious Injury
- B – Suspected Minor Injury
- C – Possible Injury
- O – Property Damage Only

TABLE 4: STUDY AREA CRASHES BY YEAR AND SEVERITY (2014-2018)

Year	K	A	B	C	O	Total
2014	0	8	42	9	125	**184**
2015	3	13	39	7	124	**186**
2016	3	13	43	4	150	**213**
2017	3	13	39	3	114	**172**
2018	1	10	41	5	157	**214**
Total	**10**	**57**	**204**	**28**	**670**	**969**

Fatal crashes occurred at the following locations along the study corridor:

- Between Military Road and Beaver Bridge Road (8 fatal crashes)
- At Whitaker Road (1 fatal crash)
- At Maplewood Road (1 fatal crash)

The study area crashes were assigned to intersections using intersection influence areas. Generally, the intersection influence areas extended to the back of tapers for turn lanes on each approach; however, influence areas were extended as needed to include intersection-related crashes beyond these limits.

[1] *2017-2021 Virginia Strategic Highway Safety Plan*
https://www.virginiadot.org/info/resources/SHSP/VA_2017_SHSP_Final_complete.pdf

Table 5 summarizes the study intersection crashes. 503 crashes within the study area occurred at a study area intersection. Key crash statistics between 2014 and 2018 at each study intersection are presented in **Appendix D**. There were no fatal crash occurrences at the study intersections.

TABLE 5: STUDY INTERSECTION CRASHES BY SEVERITY

Intersection	Control Type	K	A	B	C	O	Total
1. US 360 at Southshore Drive	Unsignalized	0	0	3	0	17	20
2. US 360 at Winterpock Road	Signalized	0	1	17	4	94	116
3. US 360 at Hancock Village Drive/Duckridge Boulevard	Signalized	0	1	16	2	53	72
4. US 360 at Ashlake Village Parkway	Signalized	0	2	5	2	33	42
5. US 360 at Woodlake Village Parkway	Signalized	0	1	11	0	46	58
6. US 360 at Woodlake Commons	Unsignalized	0	0	1	1	9	11
7. US 360 at Cosby Road	Unsignalized	0	0	4	0	4	8
8. US 360 at Fox Club Parkway/Hampton Park Drive	Signalized	0	2	7	1	49	59
9. US 360 at Otterdale Road	Signalized	0	2	6	5	25	38
10. US 360 at Hampton Farms Drive	Unsignalized	0	0	2	0	3	5
11. US 360 at Magnolia Green Parkway	Signalized	0	1	5	0	12	18
12. US 360 at Beaver Bridge Road	Unsignalized	0	0	2	0	1	3
13. US 360 at Skinquarter Road	Unsignalized	0	0	1	2	4	7
14. US 360 at Military Road	Unsignalized	0	1	6	1	5	13
15. US 360 at Chula Road	Signalized	0	1	5	1	8	15
16. US 360 at Goodes Bridge Road	Signalized	0	2	5	1	10	18
Grand Total		**0**	**14**	**96**	**20**	**373**	**503**

5.2.1 Roadway Departure Crashes

A roadway departure crash involves a vehicle that crosses the edge line or center line or leaves the travel way in another manner. The 2017-2021 Virginia Strategic Highway Safety Plan (SHSP) identifies roadway departure crashes as one of the Commonwealth's emphasis crash types. According to the plan, these crashes typically result in injuries to the driver due to inappropriate speed, impairment, or because they were not properly restrained[1].

Figure 2 shows the density of roadway departure crashes along the corridor. The following locations were identified with the highest concentrations of roadway departure crashes:

- US 360 between Mount Zion Road and Pridesville Road (Approx. 30 crashes)
- US 360 between Military Road and Beaver Bridge Road (Approx. 130 crashes)
- US 360 between Fox Club Parkway and Woodlake Village Parkway (Approx. 20 crashes)

Table 6 summarizes the roadway departure crashes along the US 360 study corridor by year and severity. 180 roadway departure crashes occurred along US 360 during the five-year crash analysis period. All fatal roadway departure crashes occurred between Military Road and Beaver Bridge Road. Of these crashes, 85% were classified as RD-left; one crash was classified as RD-unknown. This section of the study corridor is framed by trees and vegetation along the eastbound and westbound travel lanes, which leaves little to no

shoulder. In some areas, there is a roadside ditch adjacent to the roadway. The study team also noted a lack of rumble strips during the field review.

FIGURE 2: DENSITY HEAT MAP OF ROADWAY DEPARTURE CRASHES

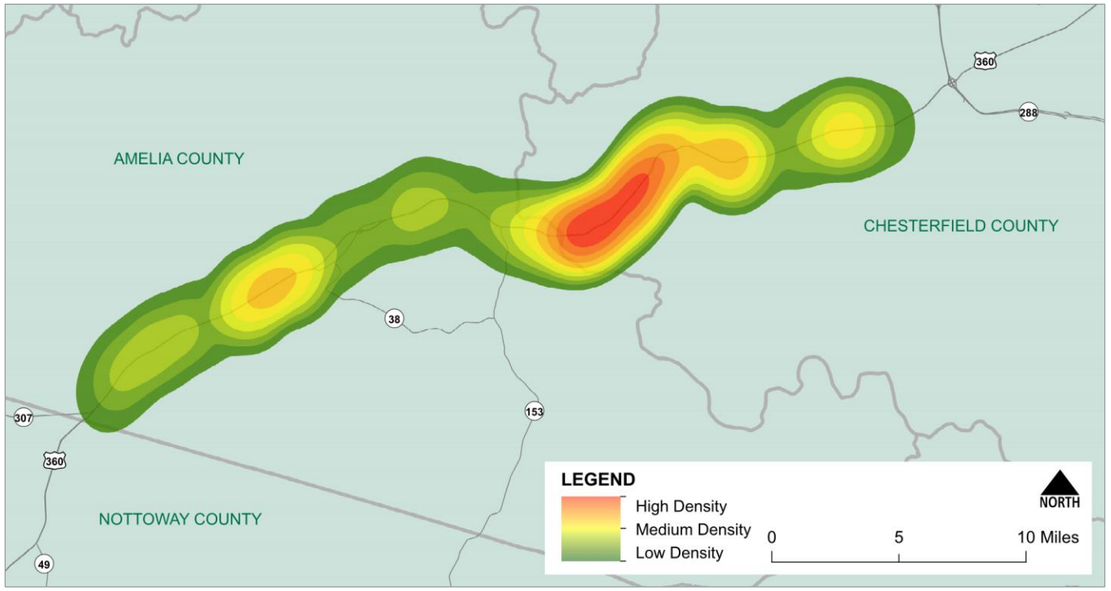


TABLE 6: ROADWAY DEPARTURE CRASHES BY YEAR AND SEVERITY

Year	K	A	B	C	O	Total
2014	0	4	8	1	19	32
2015	2	5	7	0	24	38
2016	2	7	5	0	26	40
2017	2	7	6	0	17	32
2018	1	3	9	0	25	38
Total	**7**	**26**	**35**	**1**	**111**	**180**

5.2.2 Bicycle and Pedestrian Crashes

During the 2014 to 2018 analysis period, there was one reported bicycle crash and two reported pedestrian crashes along the study corridor. The bicycle crash resulted in a minor injury (B). One pedestrian crash resulted in a severe injury (A), while the other resulted in a minor injury (B).

VDOT completed a pedestrian crash assessment in 2017 that led to the development of a Pedestrian Safety Action Plan (PSAP) in 2018. The PSAP identifies locations with high pedestrian crash potential and recommends policies and countermeasures to improve pedestrian safety. There were no PSAP locations identified within the study area.

5.3 PSI Intersections and Segments

All intersections and roadway segments within the VDOT linear referencing system (LRS) are evaluated annually by VDOT for their potential for safety improvement (PSI) based on the *Highway Safety Manual (HSM)*. The crash frequency, severity of crashes, volume, and length of segment are contributing factors in the predictive analyses. PSI estimates how much the long-term crash frequency could be reduced at an intersection or roadway segment and is based on the safety performance function (SPF) crash data files. PSI intersections and roadways segments are ranked within each District, but the crash prediction and PSI values are not released by VDOT.

Table 7 summarizes the 2017 PSI VDOT Richmond District intersections and segments within and adjacent to the study area. All PSI intersections and segments are within Chesterfield County.

TABLE 7: PSI INTERSECTIONS AND SEGMENTS

Location	County	2017 PSI Rank
Intersections		
US 360 at Winterpock Road	Chesterfield	12
US 360 at Hancock Village Drive/Duckridge Boulevard	Chesterfield	42
Segments		
US 360 from Woodlake Village Parkway to Cosby Road	Chesterfield	317
US 360 from Lake Harbour Drive to Hancock Village Drive/Duckridge Boulevard	Chesterfield	511

Crash characteristics at each PSI intersection are:

- **US 360 at Winterpock Road**
  - Predominant collision types include rear end (65%) and angle (38%).
  - A higher-than-average number of angle collisions occurred at Winterpock Road compared to other signalized intersections within the study corridor. Most angle crashes occurred between northbound and westbound vehicles.
  - 68% of angle crashes resulted from red light running.
  - Most crashes occurred during the off-peak or PM peak period.
  - A cluster of rear end crashes corresponds to the back of queue during the PM peak hour.
- **US 360 at Hancock Village Drive / Duckridge Boulevard**
  - Predominant collision types include rear end (65%) and angle (21%).
  - Nearly half of rear-end crashes reference congestion.
  - Rear-end crashes reduced 50% per year after US 360 widening was completed in October 2015.
  - Angle collisions resulting from red-light running and/or failure to yield increased in 2018.

VDOT also identifies Targeted Safety Need (TSN) locations, which are intersections or segments having PSI for three or more of the last five years. **Table 8** summarizes the 2017 TSN intersections and segments within and adjacent to the study area. All TSN intersections and segments are in Chesterfield County.

TABLE 8: TSN INTERSECTIONS AND SEGMENTS

Location	County	2017 PSI Rank
Intersections		
US 360 at Ashlake Parkway	Chesterfield	90
US 360 at Otterdale Road	Chesterfield	125
Segments		
Otterdale Road from Fox Creek Crossing to Hampton Glen Lane	Chesterfield	115
US 360 from Winterpock Road to Lake Harbour Drive	Chesterfield	288
Winterpock Road from Ashbrook Parkway to US 360	Chesterfield	325

Crash characteristics at each TSN intersection are:

- **US 360 at Ashlake Parkway**
  - Predominant collision types include rear end (79%) and angle (19%).
  - 85% of crashes occurred in the eastbound direction.
  - Rear-end crashes reduced 50% per year after US 360 widening was completed in October 2015.
- **US 360 at Otterdale Road**
  - Predominant collision types include rear end (71%) and angle (21%).
  - All angle crash descriptions reference red-light running.
  - 50% of angle crashes occurred in 2016.
  - Rear-end crashes reduced approximately 40% per year after the northbound and westbound turn-lane improvements were constructed in 2016, however, the total number of intersection crashes remained similar.

5.4 Equivalent Property Damage Only (EPDO)

Equivalent property damage only (EPDO) is a metric developed by FHWA to identify sites with potential for safety improvement based on crash cost by severity relative to the cost of a property damage only crash. **Table 9** summaries the EPDO weights, by crash severity, that VDOT developed and uses for scoring SMART SCALE applications.

TABLE 9: EPDO CRASH VALUE CONVERSION

Crash Severity	Rounded Value	Weight
Fatal and Severe Injury (K and A)	$850,000	85
Suspected Injury (B)	$100,000	10
Possible Injury (C)	$50,000	5

Table 10 summaries the EPDO ranking for each study intersection. EPDO scores were calculated for all fatal and injury crashes, excluding alcohol related crashes.

TABLE 10: STUDY INTERSECTIONS EPDO RANKING

Rank	Intersection	K	A	B	C	O	Grand Total[1]	EPDO
1	US 360 at Ashlake Village Parkway	0	2	5	2	33	42	263
2	US 360 at Winterpock Road	0	1	17	4	94	116	189
3	US 360 at Hancock Village Drive/Duckridge Boulevard	0	1	16	2	52	71	57
4	US 360 at Fox Club Parkway/ Hampton Park Drive	0	2	7	1	48	58	48
5	US 360 at Woodlake Village Parkway	0	1	11	0	45	57	45
6	US 360 at Otterdale Road	0	2	6	4	25	37	25
7	US 360 at Southshore Drive	0	0	3	0	14	17	14
8	US 360 at Magnolia Green Parkway	0	1	5	0	12	18	12
9	US 360 at Goodes Bridge Road	0	1	4	1	10	16	10
10	US 360 at Woodlake Commons	0	0	1	1	9	11	9
11	US 360 at Chula Road	0	1	4	1	8	14	8
12	US 360 at Military Road	0	1	5	1	5	12	5
13	US 360 at Cosby Road	0	0	4	0	4	8	4
14	US 360 at Skinquarter Road	0	0	1	2	4	7	4
15	US 360 at Hampton Farms Drive	0	0	2	0	3	5	3
16	US 360 at Beaver Bridge Road	0	0	2	0	1	3	1
	Grand Total	**0**	**13**	**93**	**19**	**367**	**492**	

[1]Driving while under the influence of alcohol crashes were removed from the data to be consistent with the SMART SCALE methodology.

The following top-ranked study intersections were identified as PSI and TSN segments, as detailed in **Section 5.3**:

- US 360 at Ashlake Village Parkway
- US 360 at Winterpock Road
- US 360 at Hancock Village Drive/Duckridge Boulevard
- US 360 at Otterdale Road

Characteristics for other intersections with an EPDO score greater than or equal to 25 are:

- **US 360 at Fox Club Parkway / Hampton Park Drive**
  - Predominant collision types include rear end (68%) and angle (25%).
  - More than half of crash descriptions reference vehicles following too closely or congestion.
- **US 360 at Woodlake Village Parkway**
  - Predominant collision types include rear end (71%), angle (12%), and sideswipe-same direction (9%).
  - 40% of crashes occurred during the AM or PM peak period.
  - 51% of crashes occurred in the westbound direction.

5.5 MetroQuest Survey #1 Safety Results

The US 360 MetroQuest survey was launched to collect feedback on existing traffic and safety issues within the study corridor. Feedback from the survey is summarized in **Appendix E**.

FIGURE 3: METROQUEST SURVEY SAFETY MAP MARKERS

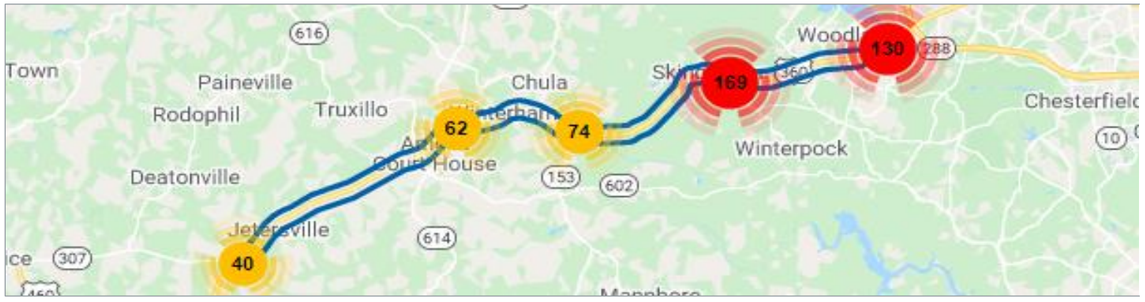


Figure 3 displays locations within the study corridor where participants indicated safety issues. More than 60% of the safety issues occur in Chesterfield County east of Skinquarter Road, clustered at PSI and TSN intersections. In Amelia County, clusters of map markers indicating safety issues were noted at the following locations:

- **US 360 at Military Road**
  - Survey participants indicated speeding, aggressive driving, and congestion.
  - Nearly 70% of crashes were angle collisions.
  - Almost all crashes occurred due to vehicles failing to yield within the crossover.
- **US 360 at Chula Road**
  - Survey participants indicated vehicles do not comply with the flashing yellow arrow.
  - Predominant collision types include angle (40%) and rear end (25%).
  - 25% of crashes resulted from vehicles making a left turn.
- **US 360 at Goodes Bridge Road**
  - Survey participants indicated vehicles do not comply with the flashing yellow arrow.
  - Predominant collision types include angle (55%) and rear end (28%).
- **US 360 at Superior Way**
  - Survey participants indicated speeding, aggressive driving, and congestion-related crashes.
  - Four crashes occurred at the intersections from 2014-2018.
  - All crashes were angle collisions.
- **US 360 at Holly Farms Drive**
  - Survey participants indicated speeding, aggressive driving, and limited visibility in the westbound direction during sunset.
  - 10 crashes occurred at the intersection from 2014-2018.
  - Nearly 60% of crashes were angle collisions.

6 Traffic Analysis

6.1 Traffic Observations and MetroQuest Survey #1 Results

The study team observed each study intersection to identify existing driving behavior and traffic operations, including queuing, signal phasing, and timings. Field review observations are summarized in **Appendix E**.

In addition, public feedback on existing traffic issues collected from the MetroQuest survey is summarized in **Appendix E**.

6.2 Existing Conditions Analysis

Traffic operational analyses were conducted to evaluate the performance of the study corridor under existing (2019) AM and PM peak hour conditions. The intent of the existing conditions analyses was to understand the baseline traffic conditions as a starting point for developing future improvement strategies.

Existing conditions were modeled using Synchro 10 and SimTraffic 10. Intersections west of Magnolia Green Parkway were modeled using Synchro, while intersections east of Magnolia Green Parkway were modeled using SimTraffic to simulate traffic in oversaturated conditions, as agreed upon in the framework document.

6.2.1 Traffic Analysis Assumptions

The existing Synchro and SimTraffic models were developed for the AM and PM peak hour conditions based on the existing roadway geometry and collected traffic count data. Inputs and analysis methodologies were consistent with the VDOT *Traffic Operations and Safety Analysis Manual (TOSAM), Version 1.0*. The AM and PM peak hour existing conditions SimTraffic models were calibrated based on the simulated traffic volumes and queue lengths according to the guidance and direction provided in the TOSAM. A detailed list of the calibration assumptions is provided in **Appendix E**.

6.2.2 Level of Service Criteria

The intersection level of service (LOS) is a qualitative measure that describes a driver's perception of the operating conditions. LOS ratings range from A to F, where LOS A indicates little or no congestion and LOS F indicates severe congestion, unstable traffic flow, and/or stop-and-go conditions.

Table 11 summarizes the LOS corresponding to the delay at unsignalized and signalized intersections, as specified in the HCM. The delay criteria for LOS differs slightly for unsignalized and signalized intersections due to driver expectations and behavior. For signalized intersections, LOS is calculated as the lost travel time caused by vehicles waiting at a traffic signal. For unsignalized intersections, LOS is calculated by determining the number of gaps that are available in the conflicting traffic stream, since the LOS analysis assumes that the traffic on the mainline is not affected by traffic on the side street.

TABLE 11: LEVEL OF SERVICE CRITERIA

LOS	Control Delay (seconds/vehicle)	
	Signalized Intersection	Unsignalized Intersection
A	≤ 10.0	≤ 10.0
B	> 10.0 to 20.0	> 10.0 to 15.0
C	> 20.0 to 35.0	> 15.0 to 25.0
D	> 35.0 to 55.0	> 25.0 to 35.0
E	> 55.0 to 80.0	> 35.0 to 50.0
F	≥ 80.0	≥ 50.0

HCM 6th Edition Exhibit 19-8 (Signalized Intersections), Exhibit 20-1 (Unsignalized Intersections),

6.2.3 Traffic Analysis Results

Ten simulations were conducted for both the AM and PM models. The VDOT *Sample Size Determination Tool* was used to confirm the number of SimTraffic model runs. The *Sample Size Determination Tool* results and full Synchro and SimTraffic reports are included in **Appendix E.**

The following measures of effectiveness were selected to quantitatively report the performance of each study intersection:

- Control delay – measured in seconds per vehicle
- Maximum queue length – measured in feet (from Winterpock Road to Magnolia Green Parkway)
- 95th percentile queue length – measured in feet (west of Magnolia Green Parkway)

Maximum queue lengths were reported from SimTraffic 10 and 95th percentile queue lengths were reported from Synchro 10. The 95th percentile queue is the length, from the stop bar, that has only a 5-percent probability of being exceeded during the analysis period.

Figures and tables summarizing the delay and queue by lane group, approach, and intersection are provided in **Appendix E**.

Control Delay and Level of Service

The HCM 6th Edition methodology was selected to analyze all signalized and unsignalized intersections. Where the HCM 6th Edition was not supported, the HCM 2000 methodology results were reported.

Under existing conditions, signalized intersections operate at LOS C or better except at the following locations:

- US 360 at Winterpock Road operates at LOS D during the PM peak hour.
- US 360 at Fox Club Parkway/Hampton Park Drive operates at LOS D during the AM and PM peak hours.
- US 360 at Otterdale Road operates at LOS D during the AM and PM peak hours.

Nearly all side street approaches operate at LOS D or worse during the AM and/or PM peak hours. The delay results at the following locations align with the extensive queuing that was observed during the field review:

- Northbound Winterpock Road during the AM and PM peak hours
- Southbound Woodlake Village Parkway during the AM and PM peak hours
- Northbound Hampton Park Drive during the AM peak hour
- Southbound Otterdale Road during the PM peak hour

Although the LOS indicates unfavorable conditions, the delay is less than the cycle length at each intersection.

Queue Length

Queue length measures how efficiently each intersection processes traffic and indicates whether turn lanes have adequate storage to accommodate turning vehicles. For movements without conflicting traffic volumes, no queue length was reported. Where intersection or lane blockages occur, queue lengths are reported as follows:

- *(X%) - Maximum queue extends full length of storage bay for X% of the analysis period.
- **(Y%) - Queue in the lane adjacent to storage bay extends beyond end of storage bay for Y% of the analysis period.
- ^Z(X%) - Maximum queue extends back to intersection Z for X% of the analysis period.

Under existing conditions, the following intersection approaches experience long queues during the AM and/or PM peak hours:

- The eastbound queue at Spring Run Road extends past the Southshore Drive intersection during the AM and PM. The queue blocks the right-turn lane for 9% of the peak hour.
- The eastbound through queue at Winterpock Road blocks the left-turn and right-turn lanes for 6% and 8% of the AM peak hour, respectively. During the PM peak hour, the eastbound through queue blocks the left-turn and right-turn lanes for 35% and 38% of the analysis period, respectively.
- There is a long northbound queue at Winterpock Road during the AM and PM. During the PM, the queue blocks the far-most left-turn lane.
- There is a long southbound queue at Woodlake Village Parkway. Vehicles are positioning in the middle lane, which blocks the right-turn lane 52% and 24% of the AM and PM peak hours, respectively.
- There is a long eastbound queue at Woodlake Village Parkway during the AM. The queue blocks the left-turn lane for 1% of the peak hour.
- The eastbound through queue at Fox Club Parkway/Hampton Park Drive extends beyond the crest of the hill during the AM and PM, blocking the left-turn and right-turn lanes. During the PM peak hour, the queue blocks the left-turn and right-turn lanes for 9% and 27% of the analysis period, respectively.
- There is a long northbound left/through queue at Fox Club Parkway/Hampton Park Drive during the AM peak hour, which corresponds with the Cosby High School start time.
- The eastbound through queue at Otterdale Road extends beyond the Aldi entrance during the AM. The queue blocks the left-turn lane for 14% and 9% of the AM and PM peak hours, respectively.
- There is a long southbound queue at Otterdale Road during the PM peak hour.

6.3 Traffic Forecasting

To understand future traffic conditions in the study area and assess the long-term benefits of proposed improvements, traffic volumes were forecasted for 2040 traffic conditions. The following section describes the methodology for developing traffic growth rates and projecting future traffic volumes for the study area. Traffic forecasting growth rates are summarized in **Appendix F**.

6.3.1 Traffic Growth Rate Development

The following sources were reviewed to determine the growth rates to apply to existing traffic volumes to forecast future (2040) traffic volumes:

- **Richmond TPO Regional Travel Demand Model (TDM)**
  Outputs from the Richmond TPO Regional TDM, which included base year data from 2012 and future year data from 2040, were adjusted using NCHRP-765 methodologies that incorporate project-specific and VDOT project traffic count data to calibrate future volume projections. Using the adjusted future year (2040) TDM output and existing available count data, linear growth rates for the study area were developed. The Richmond TPO Regional TDM did not include projections for Amelia County.

- **Historical traffic count data**
  Historical traffic count data were sourced primarily from official VDOT historical AADT counts. Trends were identified between years of significant development or regression, outliers were removed, and a linear regression analysis was performed to produce linear growth rates for segments throughout the study area.

- **VDOT Statewide Planning System (SPS) database**
  Unadjusted growth rates from VDOT's SPS database were provided and used as a reference to compare to historical traffic count data. The SPS growth rates were not adjusted to account for AADT outliers.

- **STARS US 360/Route 288 Interchange Study and Subarea Model**
  Portions of the STARS US 360/Route 288 Study overlapped with the US 360 AMP study area. Final approved growth rates from the study and adjusted growth rates from the US 360/Route 288 Subarea Model without the "Big Powhite" extension were reviewed and compared to the 2012-2040 Richmond TPO Regional TDM.

- **Socioeconomic data**
  Population and employment data from traffic analysis zones (TAZ) in the 2012-2040 Richmond TPO Regional TDM were reviewed and compared to the draft population and employment data from the 2017-2045 Richmond TPO Regional TDM.

The eastern end of the study area is expected to see future volume growth resulting from new development. The western end of the study area is expected to experience little to no growth, with development likely occurring at more localized spot locations. The SWG reviewed the traffic forecasts and growth rates on April 30, 2020 and reached consensus to apply the following:

- 1.5 percent linear growth rate applied from Spring Run Road to Otterdale Road
- 2.0 percent linear growth rate applied from Otterdale Road to Magnolia Green Parkway
- 0.5 percent linear growth rate applied from Magnolia Green Parkway to the western end of the study corridor

6.4 No-Build Conditions Analysis

The intent of the no-build conditions analyses was to understand the baseline future traffic conditions as a starting point for developing future improvement strategies. No-Build conditions were modeled using Synchro 10 and SimTraffic 10. The no-build volumes are summarized in **Appendix G.**

6.4.1 Traffic Analysis Assumptions

The existing conditions AM and PM peak hour Synchro models were used as the basis to develop the no-build models. The following planned roadway improvements are projected to be completed before 2040 and were included as background improvements in the No-Build Synchro models:

- Otterdale Road (US 360 to Woolridge Road) widening from two to four lanes
- Winterpock Road (US 360 to south of Royal Birkdale Parkway) widening from two to four lanes
- US 360 and Spring Run Road intersection improvements

Preliminary roadway plans for each improvement and lane configurations are provided in **Appendix G**.

For each study intersection, cycle lengths were assumed consistent with existing conditions, and traffic signal splits and offsets were optimized to account for the expected growth along the US 360 study corridor. No other geometric or traffic signal timing changes were made to the models.

6.4.2 Traffic Analysis Results

Ten simulations were conducted for both the AM and PM no-build models. The same measures as the existing conditions analysis were reported for the no-build analysis:

- Control delay – measured in seconds per vehicle
- Maximum queue length – measured in feet (from Winterpock Road to Magnolia Green Parkway)
- 95th percentile queue length – measured in feet (west of Magnolia Green Parkway)

Maximum queue lengths were reported from SimTraffic 10 and 95th percentile queue lengths were reported from Synchro 10.

Figures and tables summarizing the delay and queue by lane group, approach, and intersection are provided in **Appendix G**.

Control Delay and Level of Service

Section 6.2.2 outlines the LOS corresponding to the delay at unsignalized and signalized intersections, as specified in the HCM. Under no-build conditions, signalized intersections operate at LOS C or better except at the following locations:

- US 360 at Winterpock Road operates at LOS F during the AM and PM peak hours.
- US 360 at Hancock Village Drive / Duckridge Boulevard operates at LOS D during the PM peak hour.
- US 360 at Woodlake Village Parkway operates at LOS D during the AM peak hour.
- US 360 at Fox Club Parkway / Hampton Park Drive operates at LOS F during the AM peak hour and LOS E during the PM peak hour.
- US 360 at Otterdale Road operates at LOS D during the AM and PM peak hours.

- US 360 at Magnolia Green Parkway / Baldwin Creek Road operates at a LOS E during the AM peak hour and LOS D during the PM peak hour.

Queue Length

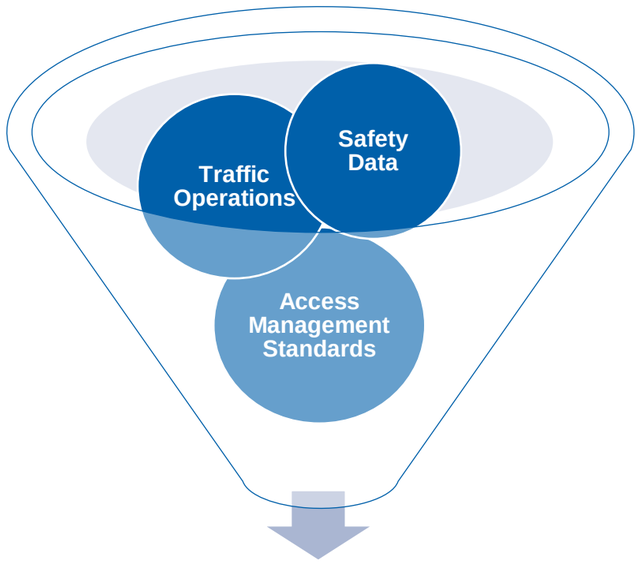
Under no-build conditions, the following intersection approaches experience long queues during the AM and/or PM peak hours:

- During the AM and PM peak hours, the eastbound through queue along US 360 extends from Spring Run Road to Woodlake Commons Loop, blocking turn lanes at multiple intersections.
- During the AM and PM peak hours, the westbound through queue along US 360 extends from Winterpock Road to east of Spring Run Road, blocking turn lanes at multiple intersections.
- The northbound through queue at Hancock Village Drive / Duckridge Boulevard blocks the right-turn lane for 84% of the PM peak hour.
- The southbound left queue at Woodlake Village Parkway extends out of the Synchro network and blocks the right-turn lane for 94% of the AM peak hour and 85% of the PM peak hour.
- During the AM and PM peak hours, the eastbound and westbound through queues at Fox Club Parkway / Hampton Park Drive block the left- and right-turn lanes. The eastbound through queue extends to Otterdale Road for 9% of the AM peak hour.
- During the AM peak hour, there is a long northbound right queue at Fox Club Parkway / Hampton Park Drive.
- During the AM and PM peak hours, the southbound queue blocks the turn lanes at Fox Club Parkway / Hampton Park Drive.
- During the AM and PM peak hours, the eastbound through queue at Otterdale Road blocks the left turn lane.
- During the AM and PM peak hours, the southbound left/through queue at Magnolia Green Parkway blocks the right-turn lane.

7 Alternatives Concept Screening and Development

Improvement concepts were developed to address safety, geometric, and operational deficiencies along the study corridor identified in the field review, existing and no-build analyses, as well as documented by the public in the MetroQuest survey. Concepts were vetted through internal meetings, shared with the SWG at a concept development meeting and the public via a second MetroQuest survey, and then screened based on operational analyses results and feedback from the SWG. Based on the screening results, final concepts were selected during a SWG preferred alternative selection virtual meeting. More detailed analysis, design, cost estimates, and schedule estimates were developed for these preferred improvement projects. **Figure 4** summarizes the components that were considered to develop preliminary concepts.

FIGURE 4: CONCEPT DEVELOPMENT COMPONENTS



7.1 Alternatives Concept Screening

Alternatives considered for each intersection consisted of both traditional capacity improvements, such as additional turn lanes, and innovative intersection improvements. Innovative intersections improve traffic operations and safety by modifying the way vehicles, bicyclists, and pedestrians navigate an intersection compared to a traditional design.

Table 12 summarizes the potential alternatives considered at each signalized study intersection. Each alternative was analyzed using Synchro 10 to evaluate the operational benefits of the improvements. The change in delay was calculated for each approach to compare traffic operations to no-build conditions. Since some improvement concepts are innovative intersection designs that involve diverting some traffic movements to other intersections, experienced travel time (ETT) was calculated following methodologies provided in the HCM 6th Edition for movements that are diverted by the intersection design.

Crash modification factors (CMFs) were reviewed to determine the potential safety benefits of each alternative. CMFs were selected from the approved list of CMFs applied during the VDOT SMART SCALE safety scoring process. In addition, potential pedestrian accommodations were considered for each alternative.

TABLE 12: POTENTIAL SIGNALIZED INTERSECTION ALTERNATIVES

Intersection	Alternative
Spring Run Road to Magnolia Green Parkway	RCUT Superstreet
Winterpock Road	Conventional Turn-Lane Improvements
	WB Shared T/R Extension (Southshore Rd to Winterpock Rd)
	Signalized RCUT
	Thru-Cut
Hancock Village Drive/Duckridge Boulevard	Conventional Turn-Lane Improvements
	Thru-Cut
	MUT
	Signalized RCUT
Ashlake Parkway	NBR Overlap (Short-Term)
	Continuous Green-T (Single NBL)
	Continuous Green-T (Dual NBL)
	Signalized RCUT
Woodlake Village Parkway	Conventional Turn-Lane Improvements
	Continuous Green-T
	Signalized RCUT
Fox Club Parkway/Hampton Park Drive	Conventional Turn-Lane Improvements
	Conventional (NBR accel-lane)
	MUT
	Signalized RCUT
	Quadrant Roadway
Otterdale Road	Conventional Turn-Lane Improvements
	RCUT
	Bowtie (potential long-term)
Magnolia Green Parkway/Baldwin Creek Road	Conventional Turn-Lane Improvements
	Thru-Cut
	Signalized RCUT
Chula Road	Signalized Continuous Green-T
	Signalized RCUT
	Unsignalized RCUT
	Unsignalized Continuous Green-T
	Targeted Safety Improvements
Goodes Bridge Road	Continuous Green-T (Close SB approach)
	Signalized RCUT
	Unsignalized RCUT
US 360 BUS to Goodes Bridge Road	Access Management Improvements

7.1.1 MetroQuest Survey #2 Results

The US 360 MetroQuest Survey #2 was launched to collect feedback on potential traditional and innovative intersection alternatives within the study corridor. The survey provided the SWG with an understanding of how the public viewed each alternative before selecting a preferred option. **Table 13** summarizes the average score for each intersection alternative. The public was in favor of all alternatives (indicated by score 3.0 or greater) except for the following:

- Ashlake Parkway RCUT
- Woodlake Village Parkway Eastbound Left-Turn Lane Removal
- Fox Club Parkway/Hampton Park Drive MUT
- Fox Club Parkway/Hampton Park Drive RCUT
- Otterdale Road Bowtie
- Magnolia Green Parkway/Baldwin Creek Road RCUT

Survey results for each alternative are summarized in **Appendix H**. Additional public comments referenced heavy traffic volumes along US 360 and indicated support for the Powhite Parkway Extension.

TABLE 13: METROQUEST SURVEY #2 RESULTS

Intersection	Alternative	Average Score
Winterpock Road to Hancock Village Drive/Duckridge Boulevard	Superstreet	3.0
Hancock Village Drive/ Duckridge Boulevard	Thru-Cut	3.2
Ashlake Parkway	RCUT	2.7
Woodlake Village Parkway	Turn Lane Improvements	3.7
Woodlake Village Parkway	Turn Lane Improvements + Eastbound Left-Turn Removal	2.2
Fox Club Parkway/ Hampton Park Drive	Turn Lane Improvements	3.7
	MUT	2.6
	RCUT	2.2
Otterdale Road	Turn Lane Improvements	3.6
	Bowtie	2.7
Magnolia Green Parkway/ Baldwin Creek Road	Turn Lane Improvements	3.7
	RCUT	2.5
Powhite Parkway Extension	Powhite Parkway Extension	4.5
Chula Road	Safety Improvements	3.7
Goodes Bridge Road	Access Management Improvements	3.3

7.1.2 Concept Development Meeting

The SWG participated in a concept development meeting on July 21, 2020 to review the traffic analysis results, safety benefit, roadway considerations, and MetroQuest Survey #2 results for each potential alternative. ETT was reported for each alternative for comparison to no-build conditions. Materials from the concept development meeting are provided in **Appendix H.**

7.2 Alternatives Sensitivity Analysis

Chesterfield County continues to experience rapid growth, particularly near the Magnolia Green Parkway/Baldwin Creek Road intersection. The study team performed a sensitivity analysis for the following five study intersections to understand how the selected alternatives would operate if the surrounding land uses develop beyond what was anticipated and agreed upon by the SWG during the traffic forecasting development. In addition, the sensitivity analysis analyzed how the Powhite Parkway Extension and other network improvements would affect travel patterns along US 360 within the study corridor.

1. US 360 at Fox Club Parkway / Hampton Park Drive
2. US 360 at Otterdale Road
3. US 360 at Magnolia Green Parkway
4. US 360 at Beaver Bridge Road
5. US 360 at Skinquarter Road

7.2.1 Volume Development

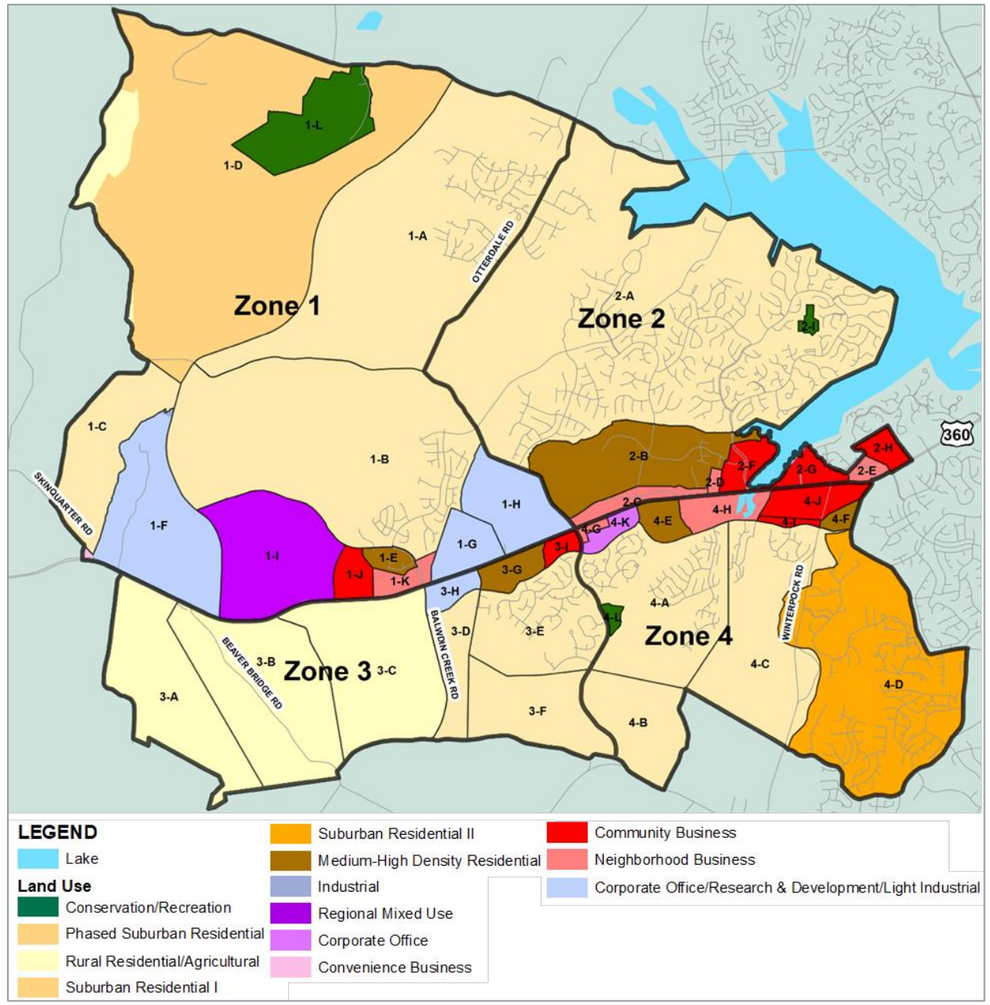
A “high density” land use scenario was considered for the area shown in **Figure 5**. The study area was segmented into development zones based on land use and trip characteristics, such as percent developable land and maximum density. Future land use was assumed to be consistent with the Chesterfield County Land Use Plan. For residential land uses, maximum density was assumed based on the 2019 Chesterfield County Comprehensive Plan; the median value was used where a range was provided. For non-residential land uses, a floor area ratio (FAR) of 0.20 was assumed. The percent of developable land for each subzone was determined based on existing aerial photography. Anticipated areas of open space and unusable land (e.g., flood zone) were subtracted from each area.

Table 14 summarizes the total daily and peak hour trips for each zone. Trip generation was determined in accordance with the Institute of Transportation Engineers (ITE) Trip Generation Manual, 10th Edition. A detailed summary of trip generation for each subzone is provided in **Appendix H**.

TABLE 14: HIGH DENSITY LAND USE TRIP GENERATION BY ZONE

Zone	Daily Trips	AM Trips	PM Trips	AM Trips In	AM Trips Out	PM Trips In	PM Trips Out
Zone 1	101,156	6,836	10,176	2,453	4,383	5,726	4,449
Zone 2	3,036	75	284	47	28	139	145
Zone 3	26,414	1,994	2,691	560	1,433	1,642	1,048
Zone 4	32,874	1,577	3,295	620	957	1,762	1,532
Total	**163,482**	**10,483**	**16,447**	**3,681**	**6,802**	**9,270**	**7,176**

FIGURE 5: HIGH DENSITY LAND USE TRIP GENERATION ZONES



Trips were distributed to/from each subzone based on StreetLight data and an understanding of existing travel patterns within the study; the Powhite Parkway, Ashbrook Parkway, and Magnolia Market connections were not considered. Trips to US 360 include southbound and northbound intersection movements, whereas trips from US 360 include eastbound and westbound movements.

The sensitivity analysis was completed assuming 25%, 50%, 75%, and 100% development build-out.

7.2.2 Sensitivity Analysis Results

The SWG participated in a meeting on September 22, 2020 to review the sensitivity analysis results. Materials from the meeting are included in **Appendix H** and detailed below for each intersection.

Fox Club Parkway/Hampton Park Drive

At Fox Club Parkway/Hampton Park Drive, the study team concluded that the RCUT and MUT would not be able to accommodate the high side street through and left-turn volumes; during the 100% high density land use scenario peak hour, nearly 550 and 700 vehicles would U-turn at the RCUT and MUT western intersections, respectively. Moreover, high eastbound and westbound volumes during the AM and PM peak hours resulted in excess delay along US 360. To align with the recommendations outlined in the STARS US 360/Route 288 Study, the study team considered the remaining alternatives with and without widening US 360.

The overall intersection delay for the Fox Club Parkway/Hampton Park Drive conventional turn lane improvements without widening exceeded 200 seconds for the 100% high density land use scenario. With widening, the eastbound and westbound directions experience LOS E once development reaches the 50% high density land use scenario, while the southwest quadrant alternative operated at LOS C or better in both directions during the AM and PM peak hours.

Otterdale Road

At Otterdale Road, the conventional turn lane improvements and full bowtie can accommodate future volume up to the 50% HDLU scenario without widening US 360. Although traffic operational results showed the full bowties operates better than the conventional, the westbound direction begins to experience LOS F for both alternatives beyond the 50% scenario.

Magnolia Green Parkway/Baldwin Creek Road

At Magnolia Green Parkway/Baldwin Creek Road, the conventional turn lane improvements can accommodate future volumes to up 50% HDLU scenario. Like Fox Club Parkway/Hampton Park Drive, the study team concluded that the RCUT would not be able to accommodate the high southbound volumes exiting Magnolia Green.

Beaver Bridge Road

All signalized concepts operated acceptably at the intersection, but the signalized RCUT with dual northbound and southbound right turns showed the highest operational benefits.

Skinquarter Road

Safety issues were identified at Skinquarter Road, including driveway access improvements can also improve safety. Kimley-Horn evaluated three alternatives: signalized intersection, unsignalized RCUT, signalized RCUT under the high-density land use scenario. Both signalized concepts operated acceptably at the intersection, but the signalized RCUT with dual northbound and southbound right turns showed the highest operational benefits. The realignment of Skinquarter is documented in the Chesterfield County Thoroughfare Plan. Kimley-Horn recommends considering realigning the intersection west of what is shown in the plan to improve sight-distance.

7.2.3 Powhite Parkway StreetLight Analysis

The SWG concluded that additional regional connections, such as extending Powhite Parkway, could alleviate some traffic along US 360. The study team completed an origin-destination (O-D) analysis using StreetLight data to understand existing travel patterns between destination within the study area to/from

destinations north of Route 288 and east of Powhite Parkway. Based on the available information, the study team concluded the extension would reduce eastbound volumes by approximately 10 percent (150-300 vehicles) during the AM peak hour and westbound volumes by approximately six percent (100-250 vehicles) during the PM peak hour.

8 Recommendations

Access management and roadway recommendations were identified based on crash history, roadway geometry (horizontal and vertical alignment, turn lane storage lengths, shoulder widths), pedestrian needs, and existing driveway and median opening spacing. Recommendations include installing rumble strips, improving signing, converting full median openings to directional median openings, and extending or constructing turn lanes. Corridor recommendations are provided in **Appendix I**.

Intersection improvements recommended within the study area are summarized in **Table 15** and depicted in **Figure 6** - **Figure 12**. Additional details for each intersection concept, including safety benefits and cost, are provided in **Appendix J**. Planning-level cost estimates were developed using quantities presented in 2021 dollars. A detailed, design-level cost estimate should be prepared once an improvement is advanced to the design phase.

TABLE 15: RECOMMENDED INTERSECTION IMPROVEMENTS

Intersection	Alternative
Spring Run Road to Hancock Village Drive/Duckridge Boulevard	RCUT Superstreet
Ashlake Parkway	NBR Overlap (Short-Term)
Woodlake Village Parkway	Conventional Turn-Lane Improvements
Fox Club Parkway/Hampton Park Drive	**Short Term:** Conventional Turn-Lane Improvements
	Long Term Option A: Quadrant Roadway **Long Term Option B:** Widen US 360 to six lanes from west of Woodlake Village Parkway to Otterdale Road
Otterdale Road	**Short Term:** Conventional Turn-Lane Improvements
	Long Term: Bowtie (potential long-term)
Magnolia Green Parkway/Baldwin Creek Road	Conventional Turn-Lane Improvements
Chula Road	Safety and Access Management Improvements
West of Goodes Bridge Road	Access Management Improvements

US 360 from Southshore Drive to Hancock Village Drive

The recommended superstreet alternative reconfigures the intersections at Hancock Village Drive/Duckridge Boulevard and Winterpock Road to RCUT intersections. Signalized median openings are proposed east and west of each intersection to accommodate U-turns. An access management waiver may be needed for driveway and/or signal spacing, however the proposed spacing is consistent with the VDOT *Roadway Design Manual Appendix F* guidance for innovative intersections.

Pedestrian accommodations include crosswalks and median refuge islands at each intersection. A thru-cut was identified as an interim solution at Hancock Village Drive before a RCUT is constructed.

US 360 at Ashlake Parkway

The recommended alternative includes installing a northbound right turn overlap and improving signal timings at Ashlake Parkway.

US 360 at Woodlake Village Parkway

The recommended turn lane improvements include constructing one additional southbound left-turn lane and extending the eastbound left-turn storage length at the Woodlake Village Parkway intersection. Pedestrian accommodations include crosswalks and a median refuge island across the west leg of the intersection.

US 360 Fox Club Parkway/Hampton Park Drive

The recommended alternative reconfigures the intersection into a southwest quadrant roadway intersection. Two new intersections are proposed: one signalized intersection to the west on US 360 and one unsignalized intersection south of Fox Club Parkway/Hampton Park Drive. Pedestrian accommodations include crosswalks on all approaches and median refuge islands.

Chesterfield County acknowledged challenges with the southwest quadrant right-of-way impacts during the concept development stage. Based on the operational analysis included in **Appendix H-1**, widening US 360 to six lanes from just west of Woodlake Village Parkway to Otterdale Road performs comparatively to the quadrant roadway in accommodating future demand. As a result, widening should be considered if implementation of the quadrant roadway alternative proves to be prohibitive due to right-of-way impacts or public acceptance. In addition, new roadway connections, such as extending Ashbrook Parkway to Hampton Park Drive, could alleviative traffic along US 360 and improve traffic operations at the Fox Club Parkway/Hampton Park Drive intersection.

US 360 at Otterdale Road

The recommended turn lane improvements include constructing one additional northbound left-turn and through lane.

US 360 at Magnolia Green Parkway/Baldwin Creek Road

The recommended turn lane improvements include constructing one additional southbound left-turn lane; one northbound left-turn lane; and one additional westbound left-turn lane.

US 360 at Chula Road

The recommendations at Chula Road improve safety and access management. Improvements include enhanced signing and pavement markings, closing the median west of the intersection, and consolidating adjacent driveways.

US 360 West of Goodes Bridge Road

The recommendations improve safety and access management along US 360 between US 360 BUS and Goodes Bridge Road by converting two full access median openings to directional medians and closing one median opening.

FIGURE 6: US 360 FROM SOUTHSHORE DRIVE TO HANCOCK VILLAGE DRIVE SUPERSTREET

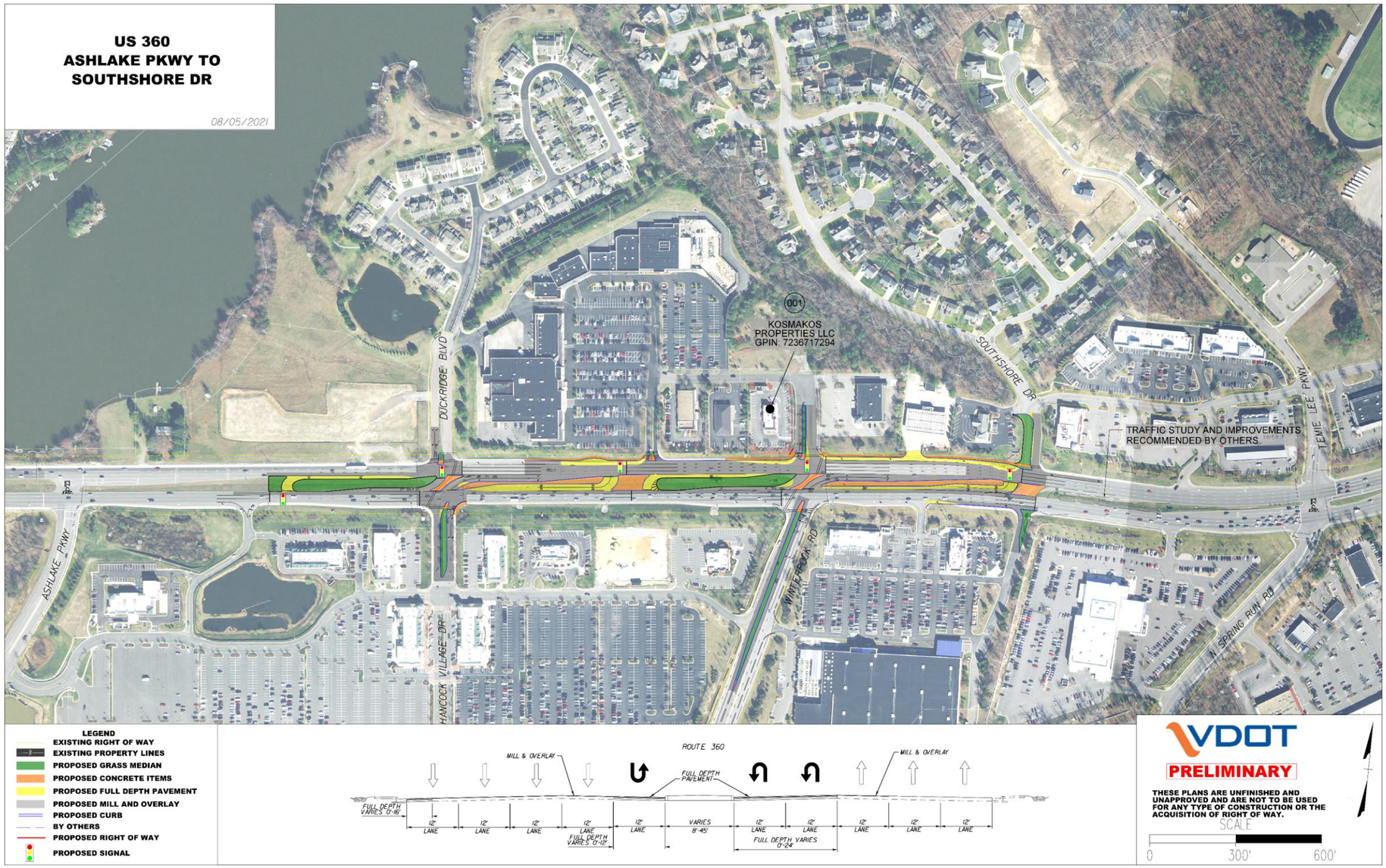


FIGURE 7: US 360 AT WOODLAKE VILLAGE PARKWAY TURN LANE IMPROVEMENTS

FIGURE 8: US 360 AT FOX CLUB PARKWAY/HAMPTON PARK DRIVE QUADRANT ROADWAY

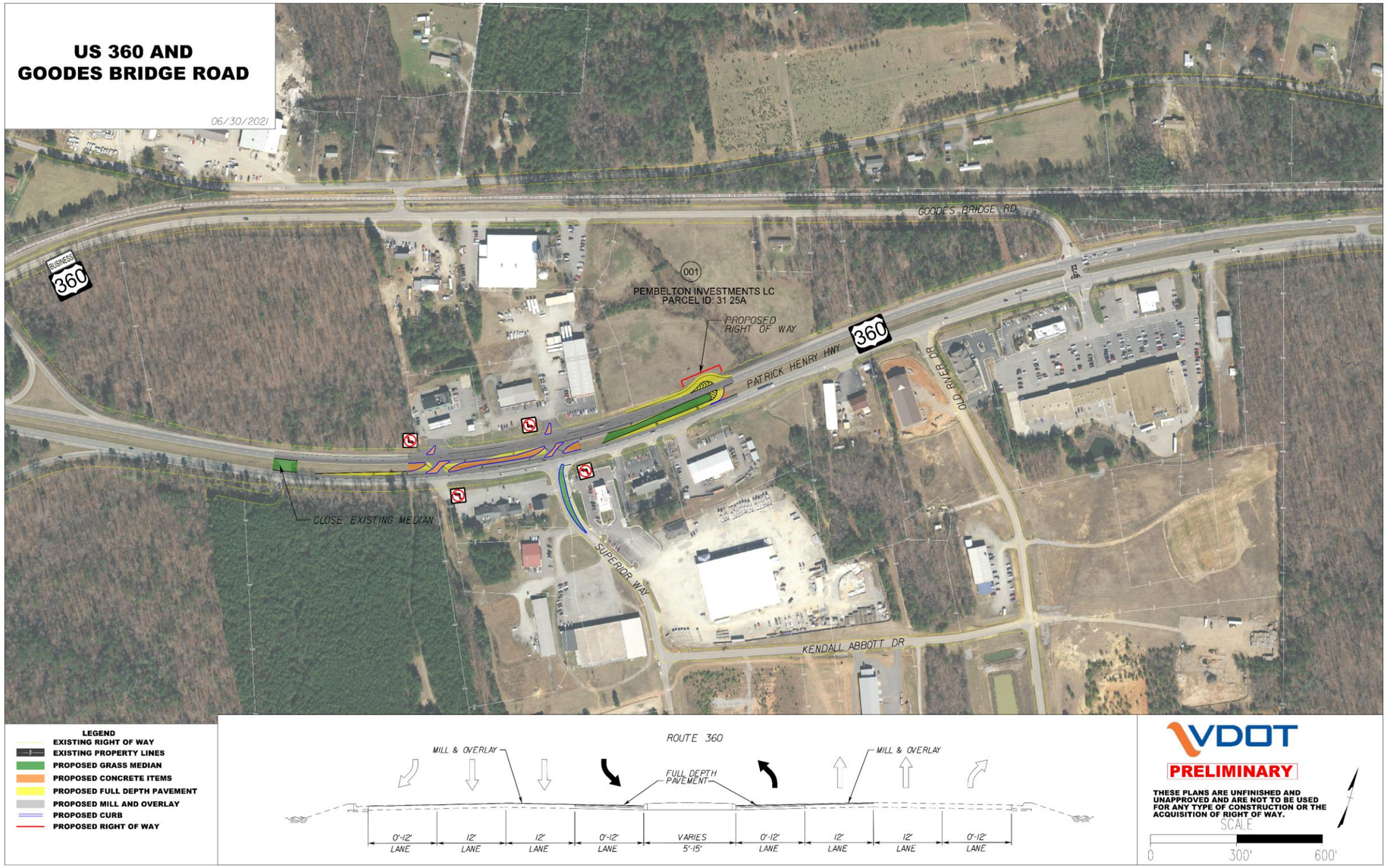
	ROUTE 360 (HULL STREET RD)	FOX CLUB PKWY	QUADRANT
POSTED SPEED (MPH)	50	35	
DESIGN SPEED (MPH)	55	35	30

FIGURE 9: US 360 AT OTTERDALE ROAD TURN LANE IMPROVEMENTS

FIGURE 10: US 360 AT MAGNOLIA GREEN PARKWAY/BALDWIN CREEK ROAD TURN LANE IMPROVEMENTS

FIGURE 11: US 360 AT CHULA ROAD SAFETY AND ACCESS MANAGEMENT IMPROVEMENTS

FIGURE 12: US 360 WEST OF GOODES BRIDGE ROAD ACCESS MANAGEMENT IMPROVEMENTS



8.1 Build Conditions Safety Analysis

The applicable CMFs and potential safety benefit of each recommended improvement, expressed as a reduction in fatal and injury crashes, is documented in **Table 16**. The best applicable CMF was applied to fatal and injury crashes within the influence area of each intersection. A reduction in crashes is expected at all intersections where improvements were recommended.

TABLE 16: PROJECTED REDUCTIONS IN EPDO CRASHES

Intersection	EPDO	CMF	F+I Crash Reduction
US 360 at Southshore Drive	44	0.65 (RCUT)	1
US 360 at Winterpock Road	369	0.65 (RCUT)	8
US 360 at Hancock Village Drive/Duckridge Boulevard	307	0.65 (RCUT)	7
US 360 at Woodlake Village Parkway	240	0.97 (Additional Turn Lane)	1
US 360 at Otterdale Road	275	0.97 (Additional Turn Lane)	1
US 360 at Magnolia Green Parkway	147	0.97 (Additional Turn Lane)	1

The following safety benefits are expected at intersections where no CMF was available:

- **Ashlake Village Parkway Signal Timing Improvements** – Reduces right-turn conflicts
- **Fox Club Parkway/Hampton Park Drive Quadrant Roadway** – Reduces conflict points at and adjacent to Fox Club Parkway/Hampton Park Drive
- **Chula Road** – Reduces conflict points at and adjacent to Chula Road
- **Goodes Bridge Road Access Management Improvements** – Reduces conflict points at Superior Way and improves sight distance

In addition, the corridor recommendations summarized in **Appendix I** include geometric, signing, and pavement marking recommendations that address roadway departure crashes and crashes within median openings.

8.2 Build Conditions Traffic Analysis

Build traffic conditions were analyzed to evaluate the results of future (2040) traffic demand with the recommended intersection improvements. The build volumes are summarized in **Appendix K.**

8.2.1 Traffic Analysis Assumptions

The no-build conditions Synchro model was used as a basis to develop the build model. The Synchro model was updated with the recommended intersection alternatives which involved geometric and traffic signal changes. Additionally, 2040 no-build traffic volumes were rerouted for innovative intersection concepts.

8.2.2 Traffic Analysis Results

Ten simulations were conducted for both the AM and PM build models. The following measures of effectiveness were reported to compare the performance between the no-build and build conditions scenarios:

- Control delay – measured in seconds per vehicle
- Maximum queue length – measured in feet (from Winterpock Road to Magnolia Green Parkway)
- 95th percentile queue length – measured in feet (west of Magnolia Green Parkway)
- ETT for innovative intersections – measured in seconds per vehicle

Maximum queue lengths were reported from SimTraffic 10 and 95th percentile queue lengths were reported from Synchro 10.

Figures and tables summarizing the delay and queue by lane group, approach, and intersection are provided in **Appendix K**.

8.2.3 Experienced Travel Time

Table 17 and **Table 18** compare the AM and PM peak hour no-build control delay to the experienced travel time (ETT) for each innovative intersection alternative. Although the side street delay increased for most approaches, the reduced eastbound and westbound delay improve the overall traffic operations for all intersections. In addition, the delay for most side streets is expected to be less than one cycle length.

TABLE 17: AM PEAK HOUR 2040 DELAY COMPARISON

Approach	HCM 2000 No-Build Delay	HCM 2000 Build ETT	Difference	Difference %
Winterpock Road (Superstreet)				
EB	174.6 (F)	73.3 (E)	-101.3	-58%
WB	20.2 (C)	9.7 (A)	-10.5	-52%
NB	74.4 (E)	112.4 (F)	38.0	51%
SB	89.8 (F)	288.8 (F)	199.0	222%
Intersection	**113.8 (F)**	**60.5 (E)**	**-53.3**	**-47%**
Hancock Village Drive/Duckridge Boulevard (Superstreet)				
EB	22.8 (C)	6.8 (A)	-16.0	-70%
WB	12.0 (B)	4.3 (A)	-7.7	-64%
NB	74.1 (E)	105.6 (F)	31.5	42%
SB	74.9 (E)	152.8 (F)	77.9	104%
Intersection	**21.9 (C)**	**11.3 (B)**	**-10.6**	**-48%**
Fox Club Parkway/Hampton Park Drive (Southwest Quadrant Roadway)				
EB	115.7 (F)	52.5 (D)	-63.2	-55%
WB	38.5 (D)	13.5 (B)	-25.0	-65%
NB	282.6 (F)	75.7 (E)	-206.9	-73%
SB	145.7 (F)	168.9 (F)	23.2	16%
Intersection	**120.3 (F)**	**55.1 (E)**	**-65.2**	**-54%**

TABLE 18: PM PEAK HOUR 2040 DELAY COMPARISON

Approach	HCM 2000 No-Build Delay	HCM 2000 Build ETT	Difference	Difference %
Winterpock Road (Superstreet)				
EB	175.7 (F)	24.7 (C)	-151.0	-86%
WB	107.7 (F)	15.9 (B)	-91.8	-85%
NB	58.1 (E)	66.8 (E)	8.7	15%
SB	423.6 (F)	107.5 (F)	-316.1	-75%
Intersection	**134.9 (F)**	**25.6 (C)**	**-109.3**	**-81%**
Hancock Village Drive/Duckridge Boulevard (Superstreet)				
EB	9.2 (A)	22.4 (C)	13.2	143%
WB	51 (D)	10.9 (B)	-40.1	-79%
NB	103.8 (F)	105.4 (F)	1.6	2%
SB	72.5 (E)	90.1 (F)	17.6	24%
Intersection	**40.9 (D)**	**25.8 (C)**	**-15.1**	**-37%**
Fox Club Parkway/Hampton Park Drive (Southwest Quadrant Roadway)				
EB	58.2 (E)	47.9 (D)	-10.3	-18%
WB	60.5 (E)	69.3 (E)	8.8	15%
NB	71.1 (E)	43.8 (D)	-27.3	-38%
SB	99.5 (F)	162.0 (F)	62.5	63%
Intersection	**66.6 (E)**	**58.6 (E)**	**-8.2**	**-12%**

8.2.4 Travel Time Comparison

The AM and PM peak hour travel times from Spring Run Road to Magnolia Green Parkway/Baldwin Creek Road for each analysis scenario are summarized in **Figure 13** and **Figure 14**, respectively. During the AM peak hour, the eastbound and westbound travel times are expected to decrease by approximately thirty percent (2-7 minutes) by implementing the proposed improvements. During the PM peak hour, the eastbound and westbound travel times are expected to decrease by approximately fifty percent (10-13 minutes). Build conditions travel times are expected to improve traffic operations in the peak direction of travel during the AM and PM peak hours.

FIGURE 13: US 360 AM PEAK HOUR TRAVEL TIME

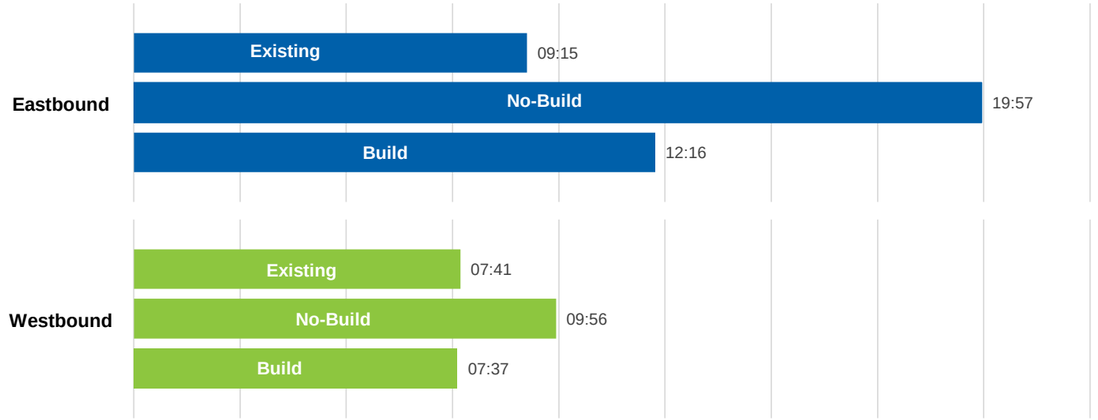
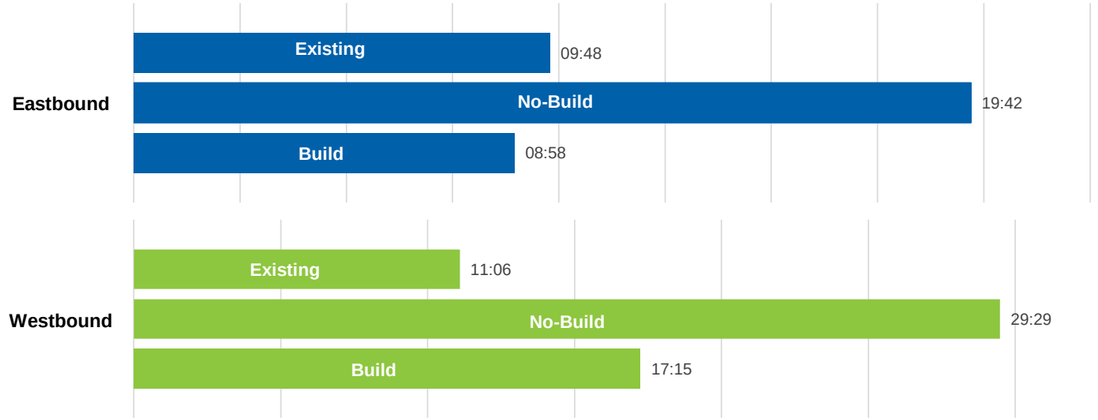


FIGURE 14: US 360 PM PEAK HOUR TRAVEL TIME



9 Conceptual Design and Cost

Conceptual designs, planning-level cost estimates, and schedule estimates were developed for each recommendation. Conceptual designs were developed in MicroStation for improvement projects along the US 360 corridor in accordance with the following applicable guidelines:

- A Policy on Geometric Design of Highways and Streets (AASHTO 2011)
- VDOT Road Design Manual (Issued January 2005, Revised July 2016)
- VDOT Road and Bridge Standards (VDOT 2016, latest revisions)
- Manual on Uniform Traffic Control Devices (MUTCD 2009)
- 2011 Virginia Supplement to the MUTCD

Design criteria and guidance from these documents were applied to roadways within the project limits based on functional classification and roadway design speeds.

A refined planning-level cost estimate, in 2021 dollars, was developed for each recommendation. A 20 percent preliminary engineering (PE) cost was estimated as a percentage of construction costs, including contingency. For projects with anticipated right-of-way and/or utility impacts, right-of-way and utility relocation costs were estimated on a project-by-project basis based on the size and complexity of the project, as well as the existing right-of-way limits. Construction (CN) costs were estimated based on the VDOT Planning Level Cost Estimation Spreadsheet and recent bid costs from VDOT and County projects. In addition, the construction cost included an additional 10 percent contingency of the base roadway construction cost, 20 percent for construction engineering and inspection (CEI), and a five percent incentive.

Table 19 summarizes the preliminary engineering (PE); right-of-way and utility relocation (RW); construction (CN); and total planning level cost estimates for each improvement project. A detailed breakdown of the planning-level cost estimates is provided in **Appendix J**.

TABLE 19: PLANNING LEVEL COST ESTIMATES

Improvement	Cost Estimate			
	PE	Right-of-Way & Utilities	Construction	Total
Superstreet	$1,562,000	$352,000	$11,984,000	$13,898,000
Woodlake Village Parkway Turn Lane Improvements	$764,000	$50,000	$1,971,000	$2,785,000
Fox Club Parkway/Hampton Park Drive Quadrant Roadway	$795,000	$798,000	$7,925,000	$9,518,000
Otterdale Road Turn Lane Improvements	$735,000	$0	$828,000	$1,563,000
Magnolia Green Parkway Turn Lane Improvements	$750,000	$299,000	$2,290,000	$3,339,000
Chula Road Safety and Access Management Improvements	$735,000	$20,000	$320,000	$1,075,000
West of Goodes Bridge Road Access Management Improvements	$764,000	$64,000	$2,493,000	$3,321,000

10 Project Implementation

This plan should be used as a planning tool to achieve the next steps of programming, designing, and constructing the identified safety and operational improvements within the study area. To continue the progress from this plan, VDOT, Chesterfield County, and Amelia County officials should coordinate with regional stakeholders to pursue the advancement and funding of the recommendations outlined in this plan.

10.1 Preparing Projects for Advancement

It is recommended that each project be prioritized on a local and regional level to applying for funding. Prior to submitting funding applications, applications must have one of the following:

- Inclusion of proven consistency with the Constrained Long-Range Transportation Plan, which includes projects and strategies that the Transportation Planning Board anticipates can be implemented over the next 25 to 30 years.
- Resolution of support from a governing body

10.2 Applying for Funding

The following funding sources may be considered to advance the recommendations identified in this plan:

- **Central Virginia Transportation Authority (CVTA) –** The regional authority that provides funding opportunities for priority transportation investments in Central Virginia.
- **Congestion Mitigation and Air Quality (CMAQ)** - A federal program that allocates funding to surface transportation projects that improve air quality by reducing congestion.
- **Highway Safety Improvement Program (HSIP)** - A federal program that provides funding for improvements that correct or improve safety on a section of roadway or at an intersection that experience high crash incidents.
- **Revenue Sharing** – A state program that provides a dollar-for-dollar state match to local funds for construction, reconstruction, improvement, and/or maintenance transportation projects.
- **SMART SCALE** – A state program that allocates funding to transportation projects based on congestion mitigation, economic development, accessibility, safety, environmental quality, and land use.

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