CANDLERS MOUNTAIN ROAD CORRIDOR STUDY

BETWEEN US 460 AND WARDS ROAD

STARS

VDOT

Kimley»Horn

List of Acronyms

AADT - Annual Average Daily Traffic

AASHTO - American Association of State Highway and Transportation Officials

CEI - Construction Engineering and Inspection

CLRP - Constrained Long Range Plan

CN - Construction

CRF - Crash Reduction Factor

CVMPO - Central Virginia Metropolitan Planning Organization

GIS - Geographic Information System

HCM - Highway Capacity Manual

HSIP - Highway Safety Improvement Program

LOS - Level of Service

MOE - Measure of Effectiveness

MPO - Metropolitan Planning Organization

PCES - Project Cost Estimating System

PE - Preliminary Engineering

PDO - Property Damage Only

PHF - Peak Hour Factor

RNS - Roadway Network System

ROW - Right-of-Way

RRFB - Rapid Rectangular Flashing Beacon

RSA - Roadway Safety Assessment

SWG - Study Work Group

SYIP - Six-Year Improvement Program

TMC - Turning Movement Count

v/c - Volume-to-Capacity Ratio

VDOT - Virginia Department of Transportation

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INTRODUCTION

Background

In early 2015, a study was completed on the Lynchburg Expressway, which is also known as US 29 Business, in the City of Lynchburg. The Lynchburg Expressway Improvement Study examined existing and projected operational challenges on the Lynchburg Expressway between the Amherst County Line at the James River and the Wards Road, State Route 163, interchange and identified potential improvements along this corridor. The results of the Lynchburg Expressway Improvement Study analysis indicated that queued vehicles on Candlers Mountain Road significantly impact the operations on the Lynchburg Expressway. However, since the primary focus of the Lynchburg Expressway Improvement Study was mainline and ramp operations of the Lynchburg Expressway, a full assessment of the Candlers Mountain Road corridor was not included in the analysis.

Purpose of Study

The purpose of this study, the Candlers Mountain Road Corridor Study, was to supplement the Lynchburg Expressway Improvement Study by identifying the extent of the operational and safety challenges related to the congestion on Candlers Mountain Road. This study evaluated the existing and projected future conditions on Candlers Mountain Road between Wards Road and US 460; identified deficiencies in the road network; formulated alternatives and corrective measures; computed planning level cost estimates; and prioritized recommended improvements along Candlers Mountain Road and the interchange with the Lynchburg Expressway.

Study Work Group

A study work group (SWG) was formed for the Candlers Mountain Road Corridor Study to capture input from local stakeholders throughout the study process and to shape the development of improvement concepts. The SWG provided institutional knowledge of the corridor, reviewed study methodologies, provided input on key assumptions, and reviewed proposed improvements developed through the study process. The Candlers Mountain Road Corridor Study SWG included members representing the following organizations:

- Virginia Department of Transportation (VDOT)
- City of Lynchburg
- Liberty University
- Central Virginia Metropolitan Planning Organization (CVMPO)
- Kimley-Horn and Associates

General Description of the Study Area

The study area for the Candlers Mountain Road Corridor Study was approximately one mile long, located within the City of Lynchburg, and oriented in a general northwest/southeast direction. For the purposes of this study, the corridor was considered to have an east/west alignment throughout the study area. The western limit of the study corridor was the intersection of Candlers Mountain Road/Sheffield Drive at Wards Road and the eastern limit of the study corridor was the US 460 interchange at Candlers Mountain Road. **Figure 1** shows the limits of the Candlers Mountain Road Corridor Study.

Field reconnaissance of existing conditions in the study area revealed that the corridor exists within an urban setting. The posted speed limit on Candlers Mountain Road throughout the study area is 35 MPH. According to VDOT's 2014 Functional Classification Map, Candlers Mountain Road between Wards Road and US 460 is classified as an other principal arterial and Candlers Mountain Road from the Mayflower Drive intersection to the Westbound US 501 Ramp/Mountain View Road intersection is classified as a minor arterial. Based on the latest (2014) published VDOT traffic data, the approximate annual average daily traffic (AADT) on Candlers Mountain Road was:

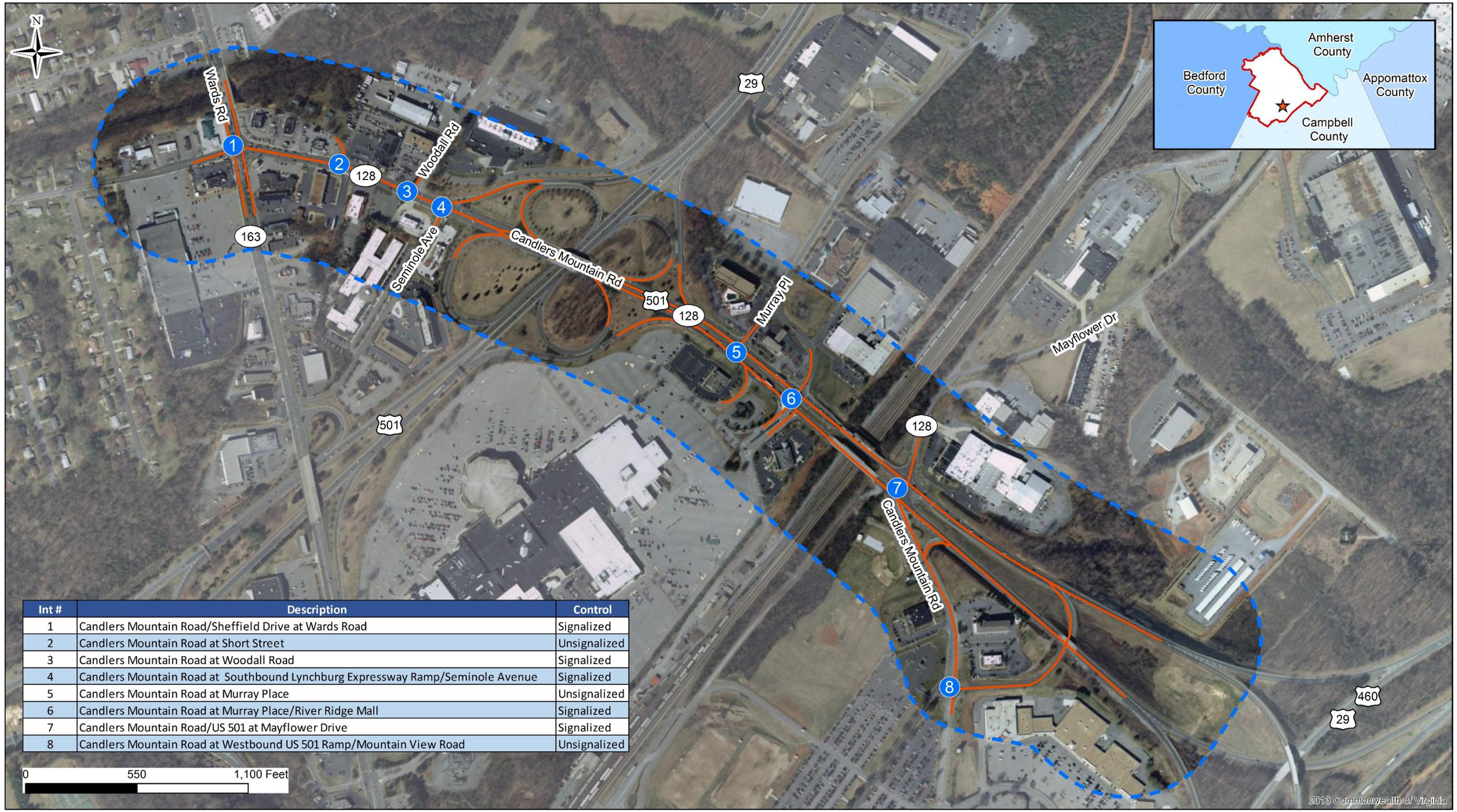
- 18,000 vehicles per day between Wards Road and the Lynchburg Expressway
- 39,000 vehicles per day between the Lynchburg Expressway and Mayflower Drive
- 16,000 vehicles per day between Mayflower Drive and US 460
- 14,000 vehicles per day between Mayflower Drive and the Westbound US 501 Ramp/Mountain View Road

The Candlers Mountain Road study area included eight at-grade intersections and 12 ramps. The eight intersections are listed below and shown in **Figure 1**.

Study Intersections

1. Candlers Mountain Road/Sheffield Drive at Wards Road - Signalized
2. Candlers Mountain Road at Short Street - Unsignalized
3. Candlers Mountain Road at Woodall Road - Signalized
4. Candlers Mountain Road at Southbound Lynchburg Expressway Ramp/Seminole Avenue - Signalized
5. Candlers Mountain Road at Murray Place - Unsignalized
6. Candlers Mountain Road at Murray Place/River Ridge Mall - Signalized
7. Candlers Mountain Road/US 501 at Mayflower Drive - Signalized
8. Candlers Mountain Road at Westbound US 501 Ramp/Mountain View Road - Unsignalized

Figure 1 – Study Area Location Map



Int #	Description	Control
1	Candlers Mountain Road/Sheffield Drive at Wards Road	Signalized
2	Candlers Mountain Road at Short Street	Unsignalized
3	Candlers Mountain Road at Woodall Road	Signalized
4	Candlers Mountain Road at Southbound Lynchburg Expressway Ramp/Seminole Avenue	Signalized
5	Candlers Mountain Road at Murray Place	Unsignalized
6	Candlers Mountain Road at Murray Place/River Ridge Mall	Signalized
7	Candlers Mountain Road/US 501 at Mayflower Drive	Signalized
8	Candlers Mountain Road at Westbound US 501 Ramp/Mountain View Road	Unsignalized

DATA COLLECTION AND INVENTORY

A preliminary field review of the study area was conducted on Wednesday, October 14, 2015 and Thursday, October 15, 2015 to verify existing conditions and traffic control devices, and observe peak hour traffic conditions and driver behavior. In addition to the field review, zoning, future land used, and other relevant studies in or near the Candlers Mountain Road study corridor were obtained; traffic data was acquired from a combination of turning movement counts, 48-hour vehicle classification tube counts, and recent studies; and speed data and crash data were provided by VDOT. The following subsections of the report summarize collected data and field review observations.

Zoning and Future Land Use

A review of existing zoning and future land use plans was conducted for the areas adjacent to the Candlers Mountain Road study corridor. Along the study corridor the primary zoning classifications are business and industrial. Future land uses along the study corridor are primarily commercial and employment. Maps showing the existing zoning and future land uses in the vicinity of the study corridor are provided in **Appendix A**. Zoning classification and future land use as of 1/7/2016 were provided by the City of Lynchburg Geographic Information System (GIS) Division.

Other Relevant Studies

Candler's Mountain Road Corridor Study (1999)

The Candler's Mountain Road Corridor Study was completed in June 1999. The study evaluated existing conditions, projected future traffic volumes, and evaluated potential improvement projects on Candlers Mountain Road between the Lynchburg Expressway and US 460.

The preferred alternatives developed as part of the Candler's Mountain Road Corridor Study included:

- Replacement of the pair of two-lane bridges on Candlers Mountain Road over the railroad tracks between Murray Place/River Ridge Mall and Mayflower Drive with a nine-lane bridge
- Reconstruction of the Candlers Mountain Road interchange on the Lynchburg Expressway in two phases
  - Phase 1: Construction of a diamond interchange with a loop ramp in the northeast quadrant
  - Phase 2: Construction of a new bridge on Candlers Mountain Road over the Lynchburg Expressway that provides horizontal clearance for four lanes in each direction on the Lynchburg Expressway and conversion of the diamond interchange to a partial cloverleaf interchange with loop ramps in the northeast and northwest quadrant

Candlers Mountain Road/Liberty Mountain Drive Bike/Pedestrian Study (2014)

The Candlers Mountain Road/Liberty Mountain Drive Bike/Pedestrian Study was completed in August 2014. The goal of the study was to develop bicycle and pedestrian improvements along Candlers Mountain Road and Liberty Mountain Drive and identify projects that may qualify for Highway Safety Improvement Program (HSIP) funding.

The improvement concepts developed as part of the Candlers Mountain Road/Liberty Mountain Drive Bike/Pedestrian Study included the following concepts in the Candlers Mountain Road study corridor:

Short Term Alternatives

- Complete the sidewalk network on the north and south sides of Candlers Mountain Road between Wards Road and the Lynchburg Expressway interchange

Mid Term Alternatives

- Install pedestrian signals and modify the intersection of Candlers Mountain Road at Woodall Road to accommodate pedestrian crossings across the north approach of Woodall Road and the west approach of Candlers Mountain Road
- Construct sidewalk on the south side of Candlers Mountain Road between Murray Place/River Ridge Mall and Mayflower Drive
- Construct sidewalk on the south side of Candlers Mountain Road between Seminole Avenue and Murray Place/River Ridge Mall with rapid rectangular flashing beacon (RRFB) pedestrian warning signs at the ramp crossing locations
- Install pedestrian signals and modify the intersection of Candlers Mountain Road/Sheffield Drive at Wards Road to accommodate pedestrian crossings across the west approach of Sheffield Drive and the south approach of Wards Roads

Long-Term Alternatives

- Reconstruct the Candlers Mountain Road bridge over the Lynchburg Expressway and include pedestrian accommodations in the design
- Develop a long-term planning concept to create an area-wide sidewalk/shared use path network around the Liberty University area and surrounding commercial and residential properties

Liberty University On-campus Development Program Traffic Study (2014)

The Liberty University On-campus Development Program Traffic Study was completed in October 2014. The purpose of the study was to evaluate the traffic impacts related to the projected increase in student enrollment and anticipated building projects at Liberty University and identify improvements to accommodate transportation needs. The recommended improvements included intersection improvements, bridge widening, and construction of a new eastbound US 460 exit ramp. None of the recommended improvements were located within the Candlers Mountain Road study corridor; however, it was referenced to consider how the projected traffic volume growth around Liberty University will impact traffic operations along Candlers Mountain Road.

Lynchburg Expressway Improvement Study (2015)

The Lynchburg Expressway Improvement Study was completed in February 2015. The study identified geometric and operational deficiencies and developed short-term and long-term improvement projects to improve safety and operations on the Lynchburg Expressway between the Amherst County line and the Wards Road (Route 163) interchange.

The Lynchburg Expressway Corridor Study identified the following geometric deficiencies at the Candlers Mountain Road interchange:

- Based on the guidelines for acceleration lane lengths identified in the 2011 American Association of State Highway Transportation Officials (AASHTO) *A Policy on Geometric Design of Highways and Streets*, Sixth Edition (heretofore referred to as the "AASHTO Green Book"), the following ramps had deficient acceleration lane lengths:
  - Northbound Lynchburg Expressway entrance ramp from eastbound Candlers Mountain Road
  - Northbound Lynchburg Expressway entrance ramp from westbound Candlers Mountain Road
  - Southbound Lynchburg Expressway entrance ramp from westbound Candlers Mountain Road
- Based on the guidelines for deceleration lane lengths identified in the AASHTO Green Book, the following ramps had deficient deceleration lane lengths:
  - Northbound Lynchburg Expressway exit ramp to westbound Candlers Mountain Road
  - Southbound Lynchburg Expressway exit ramp to eastbound Candlers Mountain Road
- The Candlers Mountain Road bridge over the Lynchburg Expressway does not meet the desired minimum bridge vertical clearance guideline of 16.5 feet provided in the *VDOT Manual of the Structure and Bridge Division – Volume V – Part 2 Design Aids* (Chapter 6 Geometrics)

In addition, the following existing (2014) operational deficiencies were identified at the Candlers Mountain Road interchange:

- The southbound Lynchburg Expressway entrance ramp from westbound Candlers Mountain Road operated at LOS F during the AM and PM peak hours
- The northbound Lynchburg Expressway exit ramp to eastbound Candlers Mountain Road operated at LOS F during the PM peak hour
- Extensive queuing existed on the northbound Lynchburg Expressway exit ramp to eastbound Candlers Mountain Road which spilled back onto the northbound Lynchburg Expressway mainline

The Lynchburg Expressway Improvement Study identified potential improvement projects that could be programed into the VDOT Six Year Improvement Program (SYIP). One of the candidate SYIP projects identified was the construction of auxiliary lanes between the loop ramps at the Candlers Mountain Road interchange in both the northbound and southbound travel directions of the Lynchburg Expressway.

Traffic Volume Data

Data Collection

Traffic volume data used in the Candlers Mountain Road Corridor Study was a combination of traffic volume data collected for the Lynchburg Expressway Improvement Study and traffic counts conducted in 2015.

Study area intersection traffic volumes were obtained from TMC data. TMC data from the Lynchburg Expressway Improvement Study was collected on Thursday, November 14, 2013 for four of the study area intersections and the supplemental TMC data was collected on Wednesday, October 14, 2015 and Thursday, October 15, 2015 for the remaining four study area intersections. All TMC data was collected between the hours of 6 AM – 10 AM and 3 PM – 7 PM.

Study area ramp traffic volumes were obtained from forty-eight-hour vehicle classification counts, TMC data, and calculation. Forty-eight-hour vehicle classification tube counts were collected for four of the Lynchburg Expressway ramps at Candlers Mountain Road on Wednesday, November 13, 2013 and Thursday, November 14, 2013 as part of the Lynchburg Expressway Improvement Study. Traffic counts for one of the Lynchburg Expressway ramps was collected as part of the TMC at Intersection 4 and traffic counts for the remaining two Lynchburg Expressway ramps were calculated based on the volume difference between intersections adjacent to the Lynchburg Expressway interchange. Additional forty-eight-hour vehicle classification tube counts were collected for the US 460 ramps at Candlers Mountain Road on Wednesday, October 14, 2015 and Thursday, October 15, 2015.

Table 1 summaries the date and source of the count data for each of the eight study area intersection and 11 ramps. TMC and tube count data is provided in **Appendix A.**

Table 1 – Count Data Locations and Source

Location	Count Date (Source)
STUDY AREA INTERSECTIONS	
1 Candlers Mountain Rd/Sheffield Dr at Wards Rd	10/14/15 (TMC)
2 Candlers Mountain Rd at Short St	10/14/15 (TMC)
3 Candlers Mountain Rd at Woodall Rd	11/14/13 (TMC)
4 Candlers Mountain Rd at Lynchburg Expressway Ramp/Seminole Ave	11/14/13 (TMC)
5 Candlers Mountain Rd at Murray Pl	11/14/13 (TMC)
6 Candlers Mountain Rd at Murray Pl/River Ridge Mall	11/14/13 (TMC)
7 Candlers Mountain Rd/US 501 at Mayflower Dr	10/15/15 (TMC)
8 Candlers Mountain Rd at Westbound US 501 Ramp/Mountain View Rd	10/15/15 (TMC)
STUDY AREA RAMPS	
A Southbound Lynchburg Expressway Exit Ramp to Eastbound Candlers Mountain Rd	Not Counted - Calculated
B Northbound Lynchburg Expressway Entrance Ramp from Eastbound Candlers Mountain Rd	11/13/13-11/14/13 (Tube)
C Northbound Lynchburg Expressway Exit Ramp to Eastbound Candlers Mountain Rd	11/13/13-11/14/13 (Tube)
D Northbound Lynchburg Expressway Entrance Ramp from Westbound Candlers Mountain Rd	11/13/13-11/14/13 (Tube)
E Northbound Lynchburg Expressway Exit Ramp to Westbound Candlers Mountain Rd	11/13/13-11/14/13 (Tube)
F Southbound Lynchburg Expressway Entrance Ramp from Westbound Candlers Mountain Rd	Not Counted - Calculated
G Southbound Lynchburg Expressway Exit Ramp to Eastbound/Westbound Candlers Mountain Rd	11/14/13 (TMC)
H Westbound US 460 Entrance Ramp from Eastbound Candlers Mountain Rd	10/14/15-10/15/15 (Tube)
I Eastbound US 460 Entrance Ramp from Eastbound Candlers Mountain Rd	10/14/15-10/15/15 (Tube)
J Eastbound US 460 Exit Ramp to Westbound Candlers Mountain Rd	10/14/15-10/15/15 (Tube)
K Westbound US 460 Exit Ramp to Westbound Candlers Mountain Rd	10/14/15-10/15/15 (Tube)

Peak Hour Determination

The overall AM and PM peak hours of the study area were determined by first evaluating the individual intersection and ramp peak hours. The individual intersection and ramp peak hour volumes were compared to hourly overall study area volumes to determine a common peak hour that best represents existing traffic conditions in the study area.

It was determined that the common peak hour of 7:15 – 8:15 AM best represented the volumes observed during the AM peak hour in the study corridor. This peak hour captured more than 99% of the total volumes observed during the individual peak hours at intersections and more than 93% of the total volumes observed during the individual peak hours at ramp locations.

Similarly, the common peak hour of 4:45 – 5:45 PM best represented the volumes observed during the PM peak hour in the study corridor. This peak hour captured more than 99% of the total volumes observed during the individual peak hours at intersections and more than 94% of the total volumes observed during the individual peak hours at ramp locations.

A table comparing individual intersections and ramp peak hours to the 7:15 – 8:15 AM and 4:45 – 5:45 PM overall study area peak hours is provided in **Appendix A**.

A peak hour factor (PHF) was calculated for each movement at each of the study area intersections during the overall study area AM and PM peak hours using the TMC data. **Appendix A** contains a summary of the AM and PM PHFs for each intersection movement.

Heavy Vehicle Percentages

Heavy vehicle percentages were calculated for each movement at all study area intersections and for all study area freeway ramps and mainline during the overall study area AM and PM peak hours. **Appendix A** contains a summary of the AM and PM peak hour heavy vehicle percentages for each intersection movement and ramp.

Seasonal Adjustment Factor

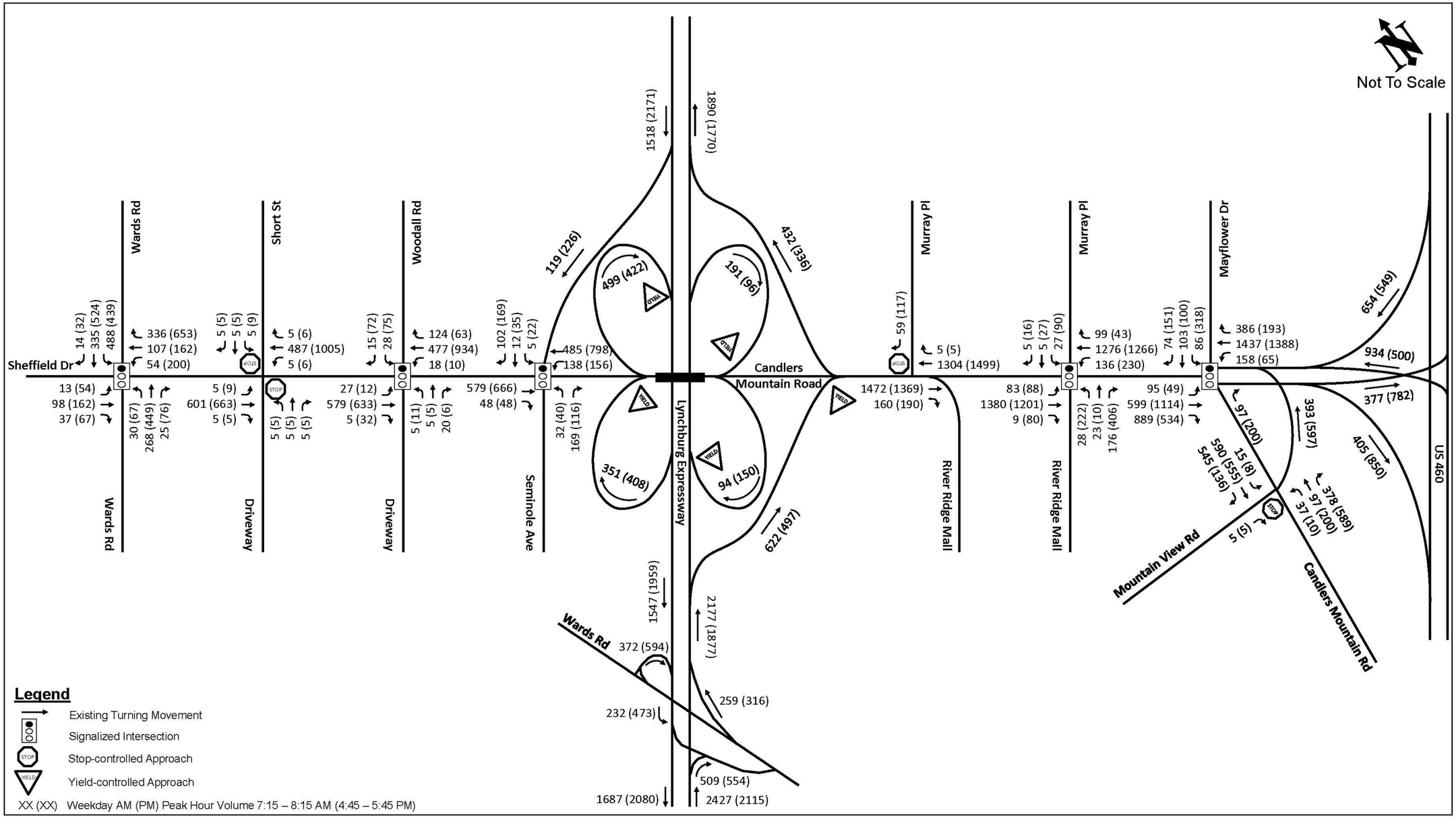
Seasonal adjustment factors were not applied to the traffic counts used for this study.

Traffic Volume Balancing

Using the available TMC and tube count data, the traffic volumes were balanced throughout the network in preparation for the existing conditions operational analyses. Traffic volume balancing was required due to the volume variations observed throughout the corridor. Peak hour traffic volumes were balanced using an iterative process of adjusting intersection and ramp volumes until the volumes were within a reasonable tolerance. The balanced intersection and ramp volumes were within ±10% for all movements in the AM peak hour and within ±12% or for all movements with more than 10 vehicles in the PM peak hour. **Appendix A** contains additional details on of the volume balancing methodology and a summary table showing the difference between unbalanced and balanced traffic volumes.

The Existing 2015 balanced AM and PM peak hour volumes in the study area are summarized in **Figure 2**.

Figure 2 – Existing (2015) Peak Hour Volumes



Existing Roadway Geometry

The existing roadway geometry in the Candlers Mountain Road study area was observed and documented during the field review. **Figure 3** summarizes the existing lane configurations, including storage and taper lengths for left- and right-turn storage bays, for the Candlers Mountain Road study area.

The cross section of Candlers Mountain Road varies throughout the study area. Between Wards Road and US 460 there are two through lanes in both the eastbound and westbound travel directions that range from 10-feet to 12-feet wide. At the eastern end of the study area, between Wards Road and Woodall Road, a two-way left-turn lane separates the two through lanes in each travel direction. In the vicinity of the Lynchburg Expressway interchange, opposing traffic is separated by either guardrail or a concrete barrier. At the western end of the study area, between the eastern side of the Lynchburg Expressway interchange and the US 460 interchange, a variable width grass median separates eastbound and westbound traffic. The portion of Candlers Mountain Road between the Mayflower Drive intersection and the westbound US 501 ramp/Mountain View Road intersection has two travel lanes in the southbound direction and one travel lane in the northbound direction and has no physical barriers between the two travel directions.

Speed Data

INRIX speed data was used to identify the average peak hour travel speeds at locations throughout the study area. VDOT provided INRIX speed data for a one week period from Sunday, October 11, 2015 to Saturday, October 17, 2015 for locations in the study area where INRIX data was available. The data from October 14, 2015 and October 15, 2015, which correspond with the dates the field review and traffic data collection was performed, was extracted from the data set and used to calculate the average travel speeds for segments during the AM (7:15 – 8:15 AM) and PM (4:45 – 5:45 PM) peak hour periods. A summary of the average travel speed by segment is provided in **Table 2.**

Average travel speed is an indicator of the level of congestion on a roadway. Average travel speeds at or near the posted speed limit are an indicator of minimal congestion, while average travel speeds significantly lower than the posted speed limit are an indicator of significant congestion. Based on the calculated average travel speeds from INRIX, the following roadway segments operated at travel speeds at least five miles per hour lower than the posted speed limit during the AM and PM peak hours:

- Northbound Lynchburg Expressway between Wards Road and Candlers Mountain Road
- Northbound Lynchburg Expressway Exit Ramp to Eastbound Candlers Mountain Road
- Westbound Candlers Mountain Road between US 460 Ramps and the Lynchburg Expressway
- Eastbound Candlers Mountain Road between the Lynchburg Expressway and US 460 Ramps
- Westbound US 460 Exit Ramp to Westbound Candlers Mountain Road

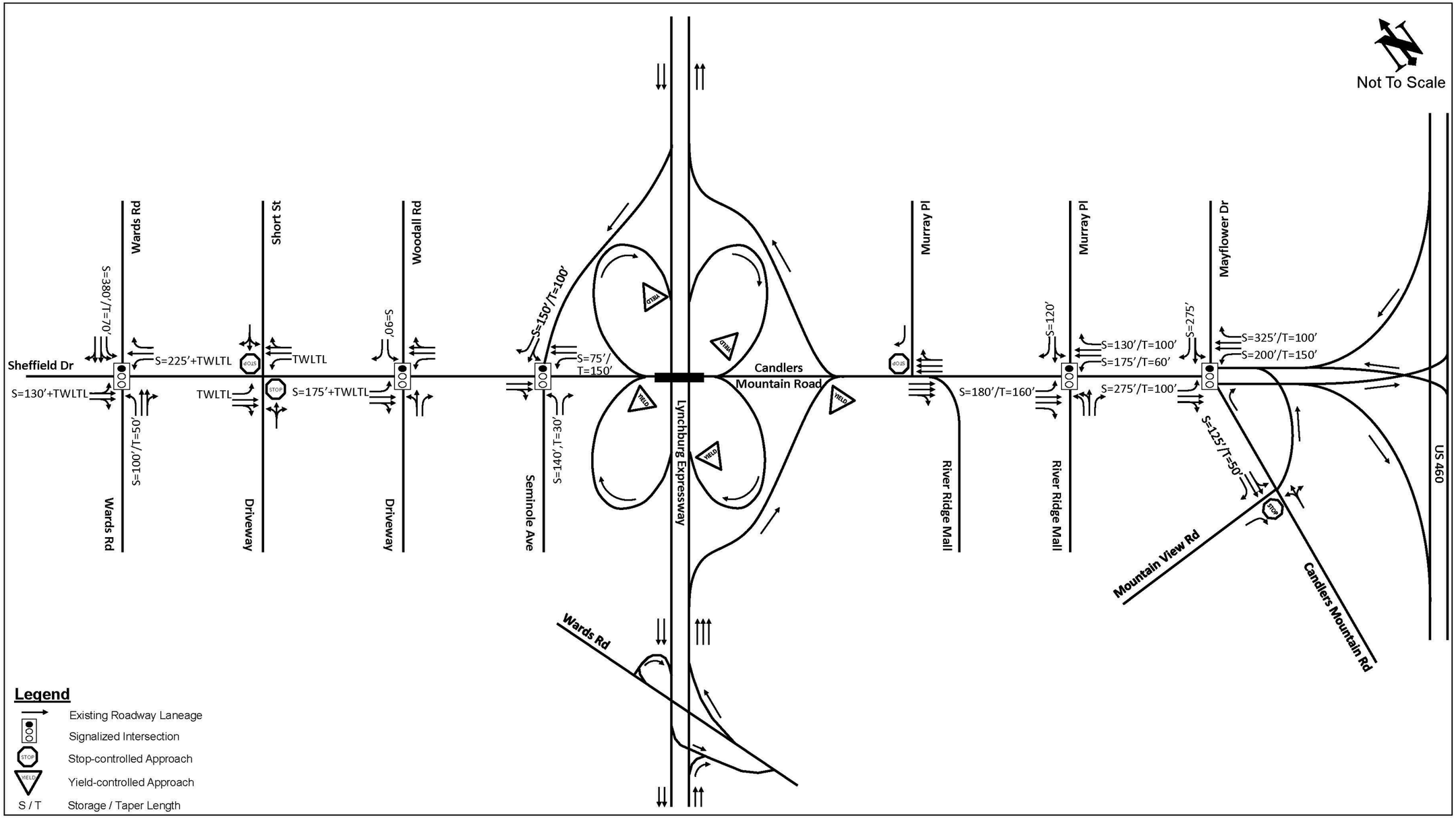
During the field review, congestion was observed in both the AM and PM peak hours at the locations listed above.

Table 2 – INRIX AM and PM Peak Hour Average Travel Speed

INRIX Segment	Posted Speed Limit (mph)	Average Speed (mph)	
		AM Peak Hour	PM Peak Hour
Northbound Lynchburg Expressway			
FROM: Entrance Ramp from Wards Rd TO: Exit Ramp to Eastbound Candlers Mountain Rd	55	45	44
FROM: Exit Ramp to Eastbound Candlers Mountain Rd TO: Entrance Ramp from Westbound Candlers Mountain Rd	55	55	56
FROM: Entrance Ramp from Westbound Candlers Mountain Rd TO: Exit Ramp to Odd Fellows Rd	55	58	57
Southbound Lynchburg Expressway			
FROM: Entrance Ramp from Odd Fellows Rd TO: Exit Ramp to Eastbound/Westbound Candlers Mountain Rd	55	57	57
FROM: Exit Ramp to Eastbound/Westbound Candlers Mountain Rd TO: Exit Ramp to Eastbound Candlers Mountain Rd	55	55	53
FROM: Exit Ramp to Eastbound Candlers Mountain Rd TO: Exit Ramp to Old Wards Rd	55	53	53
Lynchburg Expressway Ramps			
Northbound Lynchburg Expressway Exit Ramp to Eastbound Candlers Mountain Rd	25*	20	9
Westbound Candlers Mountain Road			
FROM: US 460 Exit Ramps TO: Lynchburg Expressway	35	17	13
Eastbound Candlers Mountain Road			
FROM: Lynchburg Expressway TO: US 460 Entrance Ramps	35	21	16
US 460 Ramps			
Westbound US 460 Ramp to Westbound Candlers Mountain Rd	35*	17	13
Eastbound US 460 Ramp to Eastbound Candlers Mountain Rd	45*	51	51

*Posted Ramp Advisory Speed

Figure 3 – Existing (2015) Lane Configurations



Crash Analysis and Roadway Safety Assessment

Crash data for the Candlers Mountain Road study corridor was used to evaluate corridor safety and identify crash patterns. VDOT Roadway Network System (RNS) crash data was obtained for the latest available five years of crash data (January 1, 2010 to December 31, 2014). This crash data was used to identify crash patterns and locations with high crash rates along the study corridor.

A Roadway Safety Assessment (RSA) was conducted on October 14 and 15, 2015 with VDOT and Liberty University staff to observe and document safety concerns along the study corridor. Special focus was given to areas where the crash data indicated a crash pattern or a high crash rate. The purpose of the RSA was to identify factors contributing to the crash patterns as well as identify potential improvements to mitigate crash risks and improve safety along the corridor.

The following sections summarize the crashes that occurred within the Candlers Mountain Road study corridor during the five-year crash analysis period and field observations made during the RSA.

Summary of Overall Study Area Crashes

Over the five-year period crash analysis period, 387 total crashes were reported within the Candlers Mountain Road study area. Of the reported crashes, there were zero fatal crashes, 89 injury crashes, and 298 property damage only (PDO) crashes. For the purposes of crash analysis, study area crashes included crashes located on Candlers Mountain Road or within 250 feet from the center of a study area intersection. Crashes located on the Lynchburg Expressway mainline, Lynchburg Expressway ramps, or US 460 ramps were not considered study area crashes and were not included in the crash analysis. A summary of the study area crashes is shown in **Table 3** and additional details are provided in the following sections.

Table 3 – Study Area Crash Summary

Year	Number of Crashes			
	Fatal	Injury	PDO	Total
2010	0	15	49	64
2011	0	18	79	97
2012	0	12	55	67
2013	0	23	62	85
2014	0	21	53	74
Total	**0**	**89**	**298**	**387**

Summary of Intersection Crashes

The Candlers Mountain Road study area crashes were further analyzed by intersection. The locations of the study area crashes were reviewed in GIS to determine, based on location, crashes in the vicinity of or related to intersections. In locations where intersections were closely spaced, two intersection were grouped together for the intersection crash analysis. Crashes not located near an intersection were not included in the intersection analysis. **Table 4** summarizes crashes at each intersection or group of intersections by severity (fatal, injury, or PDO). Intersection summary maps that include a break-down of crashes by crash type and severity are provided in **Appendix A**.

Table 4 – Crash Summary by Intersection(s)

Intersection(s)	Number of Crashes			
	Fatal	Injury	PDO	Total
Candlers Mountain Road/Sheffield Drive at Wards Road	0	7	32	**39**
Candlers Mountain Road at Short Street	0	5	13	**18**
Candlers Mountain Road at Woodall Road & Candlers Mountain Road at Southbound Lynchburg Expressway Ramp/Seminole Avenue	0	10	8	**18**
Candlers Mountain Road at Lynchburg Expressway Ramps	0	10	19	**29**
Candlers Mountain Road at Murray Place	0	4	13	**17**
Candlers Mountain Road at Murray Place/River Ridge Mall & Candlers Mountain Road/US 501 at Mayflower Drive	0	51	194	**245**
Candlers Mountain Road at Westbound US 501 Ramp/Mountain View Road	0	1	13	**14**

During the five-year analysis period, the majority of reported crashes in the study area occurred in the vicinity of the Candlers Mountain Road at Murray Place/River Ridge Mall and the Candlers Mountain Road/US 501 at Mayflower Drive intersections. The predominant crash type in the vicinity of these two intersections was rear end, which correlates to the congestion that was observed during the field review.

Summary of Candlers Mountain Road Crashes

The study area crashes were also analyzed by eastbound and westbound directions along Candlers Mountain Road between Wards Road and US 460. Study area crashes located on side streets and on Candlers Mountain Road south of the Mayflower Drive intersection were not included in the eastbound and westbound directional crash analysis. Over the five-year crash analysis period, 214 total crashes were reported on eastbound Candlers Mountain Road and 140 total crashes were reported on westbound Candlers Mountain Road. The predominant crash types in both the eastbound and westbound directions of Candlers Mountain Road were rear-end and angle crashes. Over the crash analysis period, similar total numbers of angle crashes were reported in both the eastbound and westbound directions; however, approximately twice the number of rear-end crashes were reported in the eastbound direction than in the westbound direction. Many of the eastbound rear-end crashes occurred between the northbound Lynchburg Expressway exit ramp and the Mayflower Drive intersection.

Additional details on the on the eastbound and westbound Candlers Mountain Road crashes are provided in the following sections.

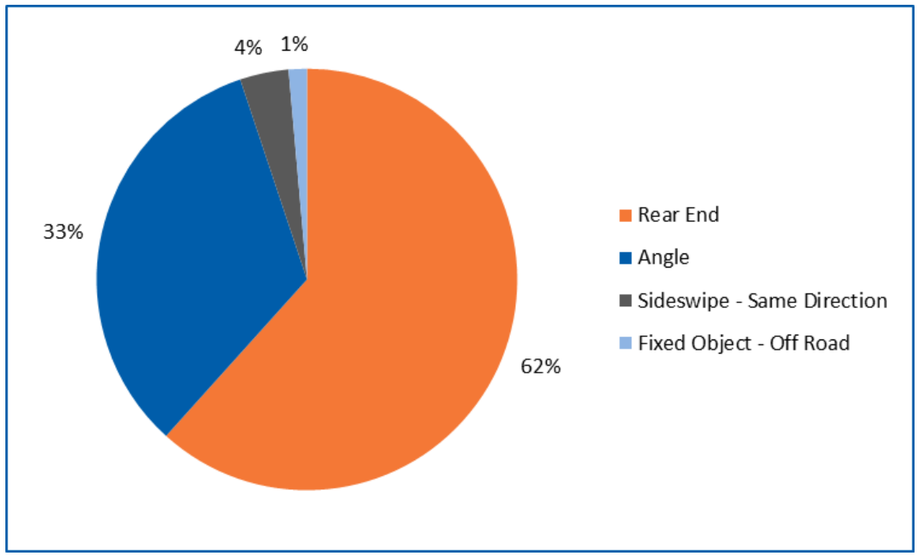
Eastbound Candlers Mountain Road Crash Summary

During the five-year period from January 1, 2010 to December 31, 2014, the following crashes were reported on eastbound Candlers Mountain Road between Wards Road and US 460:

- Total number of reported crashes: 214
- Total number of reported injury crashes: 51
- Total number of reported fatal crashes: 0

A summary of the eastbound Candlers Mountain Road crashes by crash type is provided in **Figure 4**. The majority of eastbound Candlers Mountain Road crashes (62%) were rear-end crashes. The next most frequent crash was angle, which accounted for 33% of all reported eastbound crashes.

Figure 4 – Eastbound Candlers Mountain Road Crash Type Summary



Other crash trends on eastbound Candlers Mountain Road included:

- 47% of the reported crashes occur in during the PM peak hour and 17% occur during the AM peak hour
- 76% of the reported crashes occur in daylight conditions
- 86% of the reported crashes occur in clear weather conditions

Appendix A contains additional details on the eastbound Candlers Mountain Road crashes.

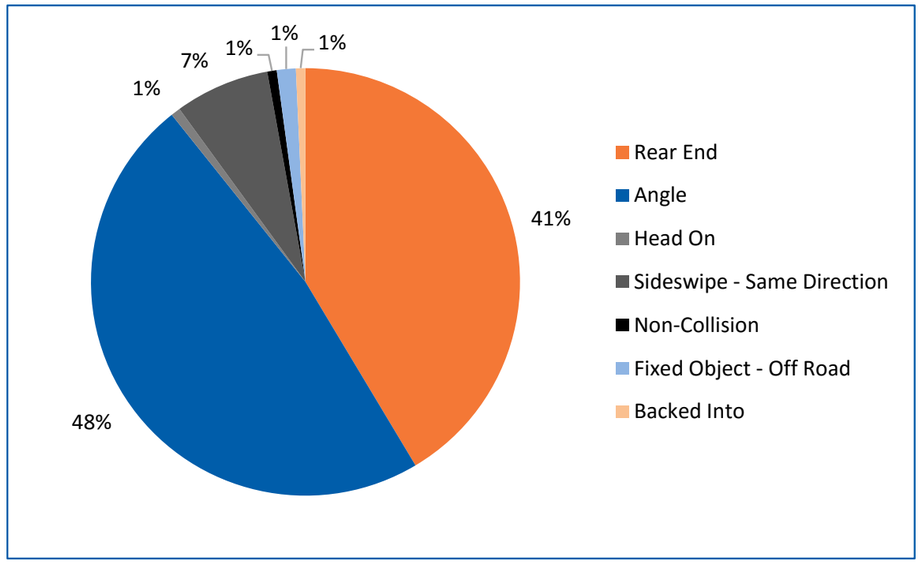
Westbound Candlers Mountain Road Crash Summary

During the five-year period from January 1, 2010 to December 31, 2014, the following crashes were reported on westbound Candlers Mountain Road between Wards Road and US 460:

- Total number of reported crashes: 140
- Total number of reported injury crashes: 33
- Total number of reported fatal crashes: 0

A summary of the westbound Candlers Mountain Road crashes by crash type is provided in **Figure 5**. The predominant crash type was angle crashes, which accounted for 48% of all reported crashes in the westbound direction. The next most frequent crash type was rear end, which accounted for 41% of all reported westbound crashes.

Figure 5 – Westbound Candlers Mountain Road Crash Type Summary



Other crash trends on westbound Candlers Mountain Road included:

- 26% of the reported crashes occur in during the PM peak hour and 14% occur during the AM peak hour
- 78% of the reported crashes occur in daylight conditions
- 92% of the reported crashes occur in clear weather conditions

Appendix A contains additional details on the westbound Candlers Mountain Road crashes.

Crash Histograms

Crash activity by 0.1 mile segments of roadway, or crash density, for the eastbound and westbound directions of Candlers Mountain Road is shown on the histograms in **Figure 6** and **Figure 7**. **Figure 6** shows crash density by crash type and **Figure 7** shows crash density by severity. In both the eastbound and westbound directions of Candlers Mountain Road, the segment of Candlers Mountain Road with the highest crash density extends from the east side of the Lynchburg Expressway interchange to east of Mayflower Drive.

Crash Rates

Crash rates were computed for the Candlers Mountain Road study corridor using the number of crashes during the five-year analysis period, AADT volumes, and the length of the study corridor. Separate crash rates were calculated for the undivided and divided portions of Candlers Mountain Road in the study area. **Table 5** provides the overall crash rate, injury crash rate, and fatal crash rate for the undivided segment of Candlers Mountain Road, between Wards Road and the southbound Lynchburg Expressway exit ramp/Seminole Avenue. **Table 6** provides the overall crash rate, injury crash rate, and fatal crash rate for the divided segment of Candlers Mountain Road, between the southbound Lynchburg Expressway exit ramp/Seminole Avenue and US 460. All crash rates are expressed in terms of crashes per 100 million vehicle-miles traveled.

Table 5 – Crash Rate Summary – Undivided

Crash Severity	Number of Crashes	Crash Rate - Undivided
		Candlers Mountain Road (2010-2014)*
Injury	19	**716.64**
Fatal	0	**0**
All	62	**2,338.52**

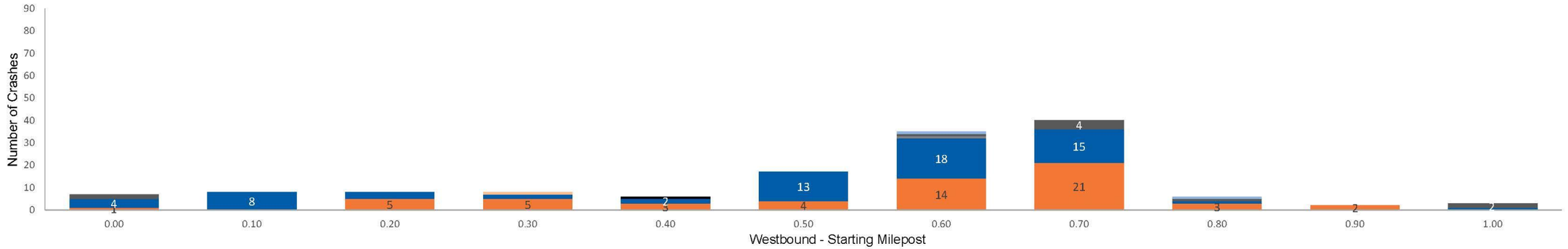
* Crash rates expressed in crashes per 100 million vehicle miles traveled

Table 6 – Crash Rate Summary – Divided

Crash Severity	Number of Crashes	Crash Rate - Divided
		Candlers Mountain Road (2010-2014)*
Injury	65	**178.36**
Fatal	0	**0**
All	292	**801.27**

* Crash rates expressed in crashes per 100 million vehicle miles traveled

Figure 6 – Candler Mountain Road Crash Histograms (Crash Type)



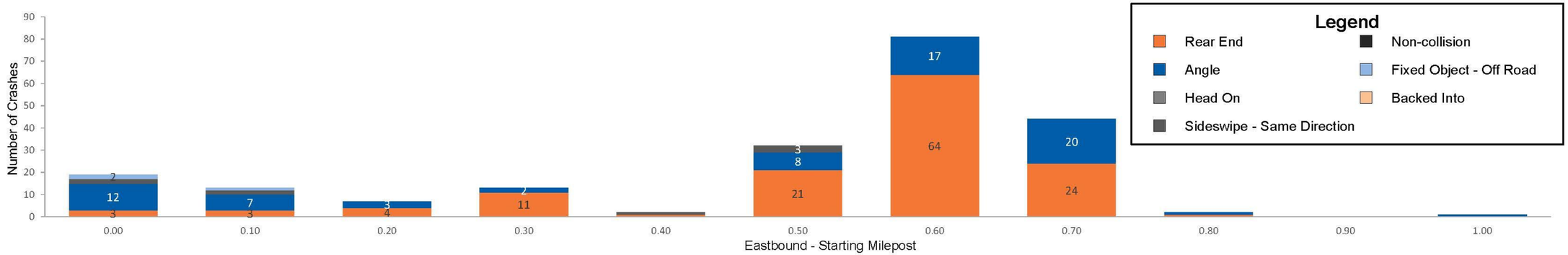
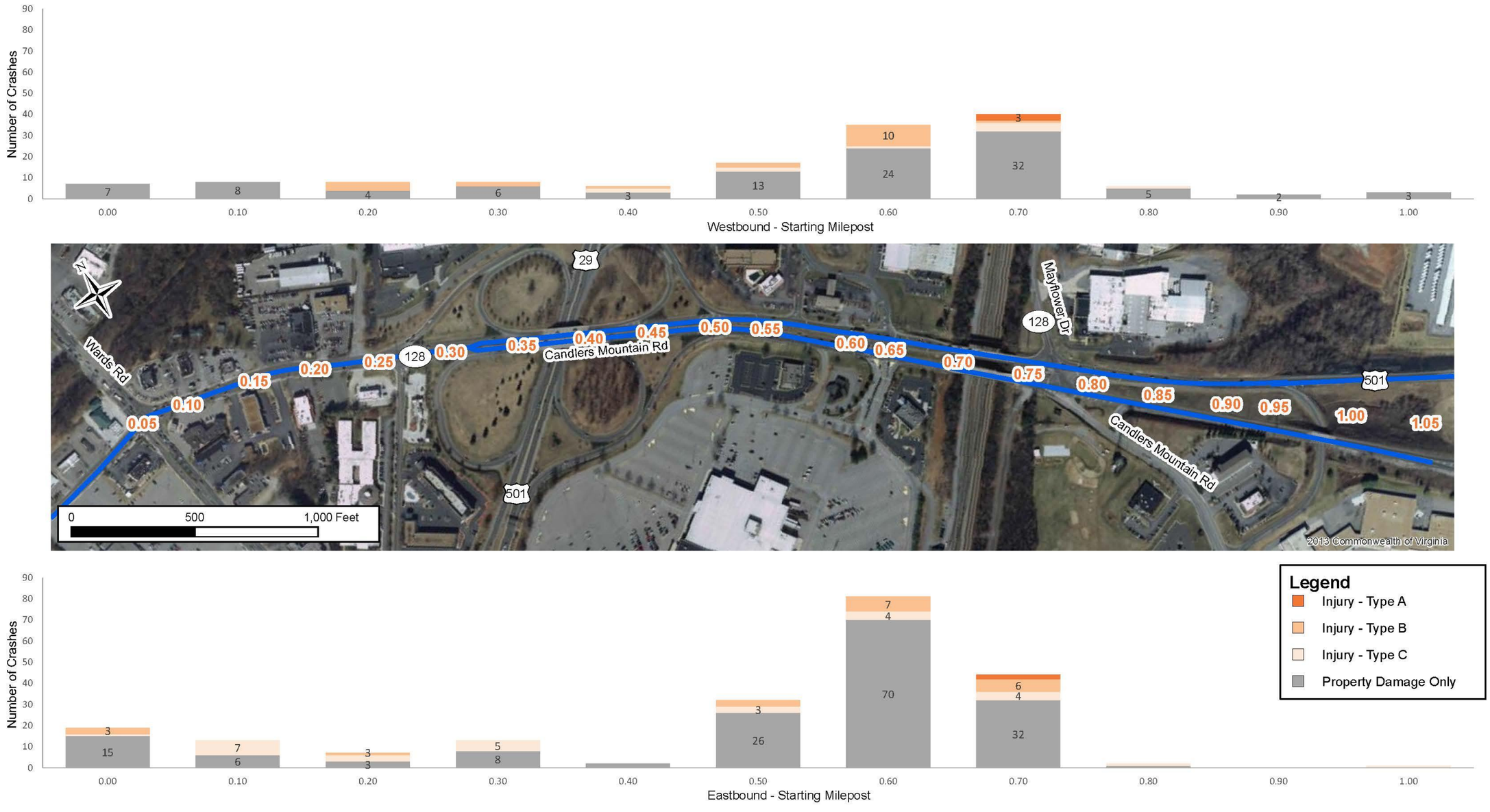


Figure 7 – Candler Mountain Road Crash Histograms (Crash Severity)



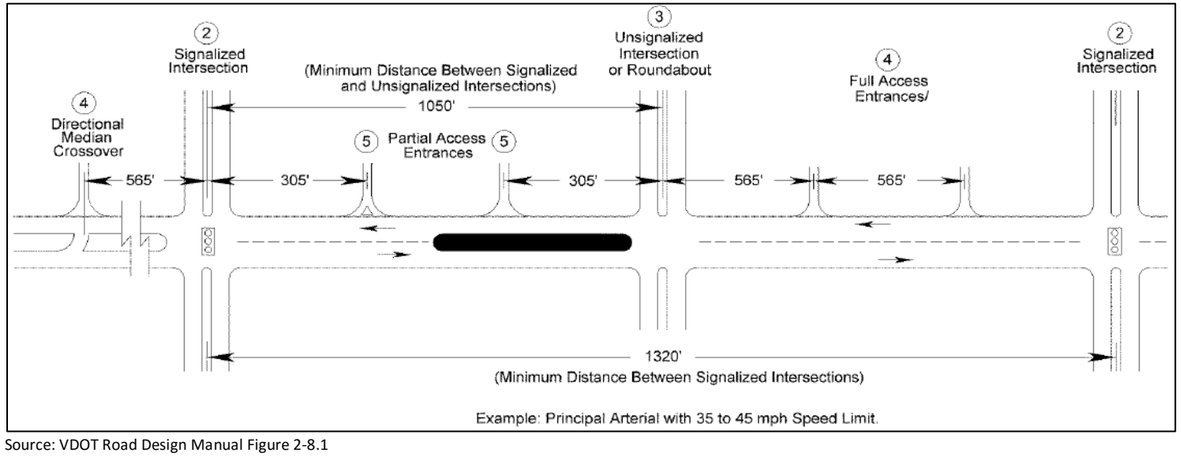
GEOMETRIC CHARACTERISTICS

Access Management Spacing

The existing intersection and entrance spacing on Candlers Mountain Road in the study area was evaluated according to the VDOT access management regulations in Appendix F of the *VDOT Road Design Manual*. Within the study area, Candlers Mountain Road has a posted speed limit of 35 MPH and is classified as a principal arterial. VDOT access management regulations applicable to principal arterials with a 35 MPH speed limit are listed below and shown in **Figure 8**.

- Minimum spacing between a signalized intersection and another signalized intersection – 1,320 feet
- Minimum spacing between an unsignalized intersection or a full median crossover and a signalized intersection, an unsignalized intersection, or a full median crossover – 1,050 feet
- Minimum spacing between a full access entrance or directional median and any intersection, full access entrance, or median crossover – 565 feet
- Minimum spacing between a partial access one- or two-way entrance and any type of entrance, intersection, or median crossover – 305 feet

Figure 8 – VDOT Access Management Regulations (Principal Arterial with 35-45 MPH Speed Limit)

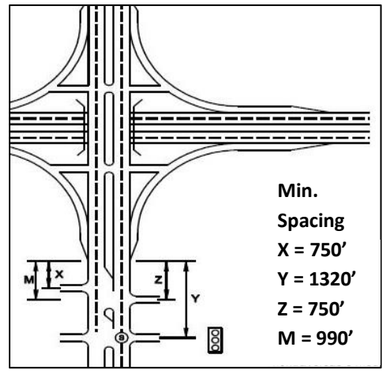


Source: VDOT Road Design Manual Figure 2-8.1

Appendix F of the *VDOT Road Design Manual* also provides minimum spacing standards between interchange ramps and other intersections. These standards are listed below and shown in **Figure 9** for multilane highways at interchanges. The start/end of a ramp terminal is defined as the start/end of the taper. In situations where the interchange ramp connects to a continuous auxiliary lane, the start/end of the ramp terminal is defined as the location where an AASHTO calculated acceleration or deceleration lane and taper would start/end.

- Minimum spacing between the start/end of a ramp terminal and any intersection, full access entrance, or median crossover – 1,320 feet
- Minimum spacing between the start/end of a ramp terminal and a directional median crossover – 990 feet
- Minimum spacing between the start/end of a ramp terminal and a right in/right out partial access entrance – 750 feet

Figure 9 – VDOT Access Management Regulations on Multilane Highways at Interchanges



Source: VDOT Road Design Manual Figure 2-9

The existing access point spacing on Candlers Mountain Road is shown in **Figure 10** through **Figure 12** and summarized in the following sections.

Signalized Intersection Spacing

There are five signalized intersections in the study area. The required spacing between signalized intersections in Appendix F of the *VDOT Road Design Manual* for an arterial with a posted speed of 35 mph is 1,320 feet. Signalized intersection spacing in the study area is summarized in **Table 7** below.

Table 7 – Signalized Intersection Spacing

Mainline	From	To	Existing Spacing	Required Spacing	Meets Standard?
Candlers Mountain Road	Wards Road	Woodall Road	895’	1,320’	No
Candlers Mountain Road	Woodall Road	Seminole Road	185’	1,320’	No
Candlers Mountain Road	Seminole Road	Murray Place / River Ridge Mall	1,965’	1,320’	Yes
Candlers Mountain Road	Murray Place / River Ridge Mall	Mayflower Drive	730’	1,320’	No
Candlers Mountain Road	Mayflower Drive	Regents Parkway	1,635’	1,320’	Yes

Unsignalized Intersection Spacing

There is one full access, unsignalized intersection in the study area at the intersection of Candlers Mountain Road/US 501 and Mountain View Road. This intersection does not meet the required spacing in Appendix F of the VDOT Road Design Manual of 1,050 feet from a full median crossover to an unsignalized intersection, signalized intersection, or other full median crossover.

Full Access Entrance Spacing

The existing full access entrances on Candlers Mountain Road between Lynchburg Expressway and Wards Road and between Candlers Mountain Road/US 501 and Mountain View Road do not meet the required spacing in Appendix F of the VDOT Road Design Manual of 565 feet between full access entrances and any entrance, intersection, or median crossover.

Partial Access Entrance Spacing

The existing partial access entrances on Candlers Mountain Road between Murray Place and Murray Place/River Ridge Mall do not meet the required spacing in Appendix F of the VDOT Road Design Manual of 305 feet between partial access entrances and any entrance, intersection, or median crossover.

Ramp Spacing

The existing spacing between the on- and off-ramp terminals and the first partial and full access entrances do not meet the required spacing in Appendix F of the VDOT Road Design Manual for the eastbound or westbound direction of Candlers Mountain Road. Lynchburg Expressway ramps, ramps to US 460, and the ramp from Candlers Mountain Road to westbound Candlers Mountain Road/US 501 do not meet spacing requirements.

Figure 10 – Existing Access Point Spacing (1 of 3)

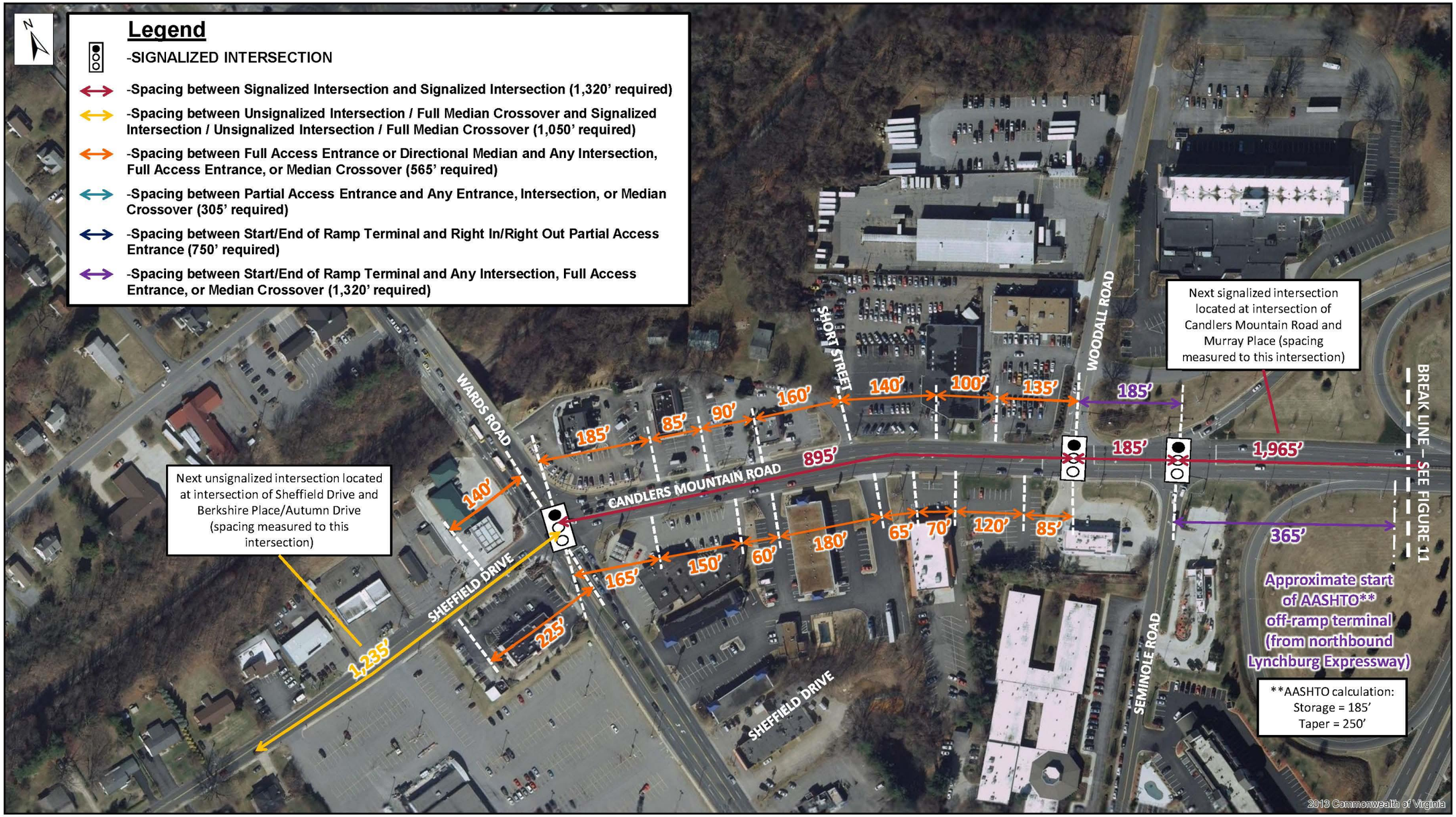


Figure 11 – Existing Access Point Spacing (2 of 3)

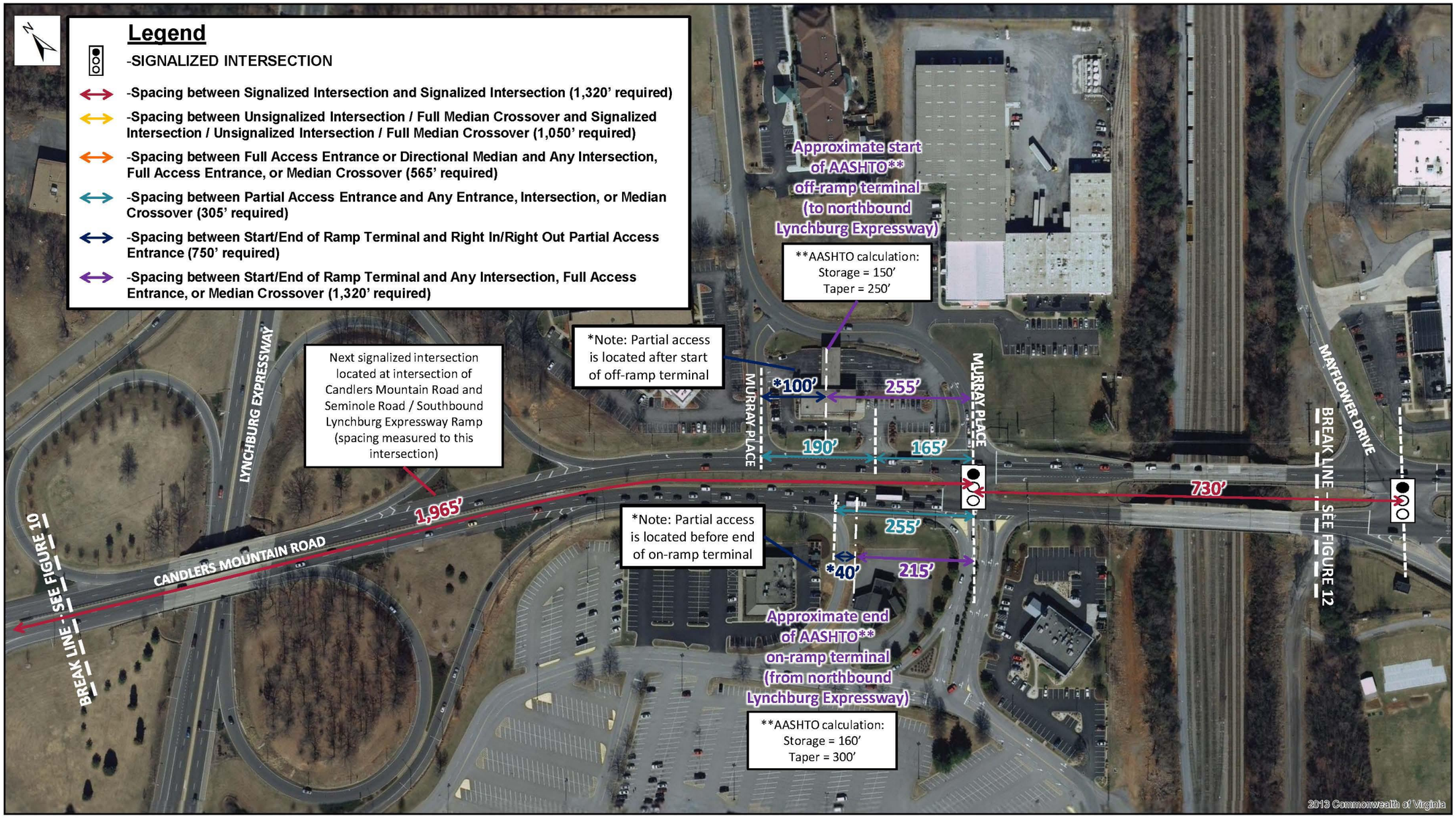
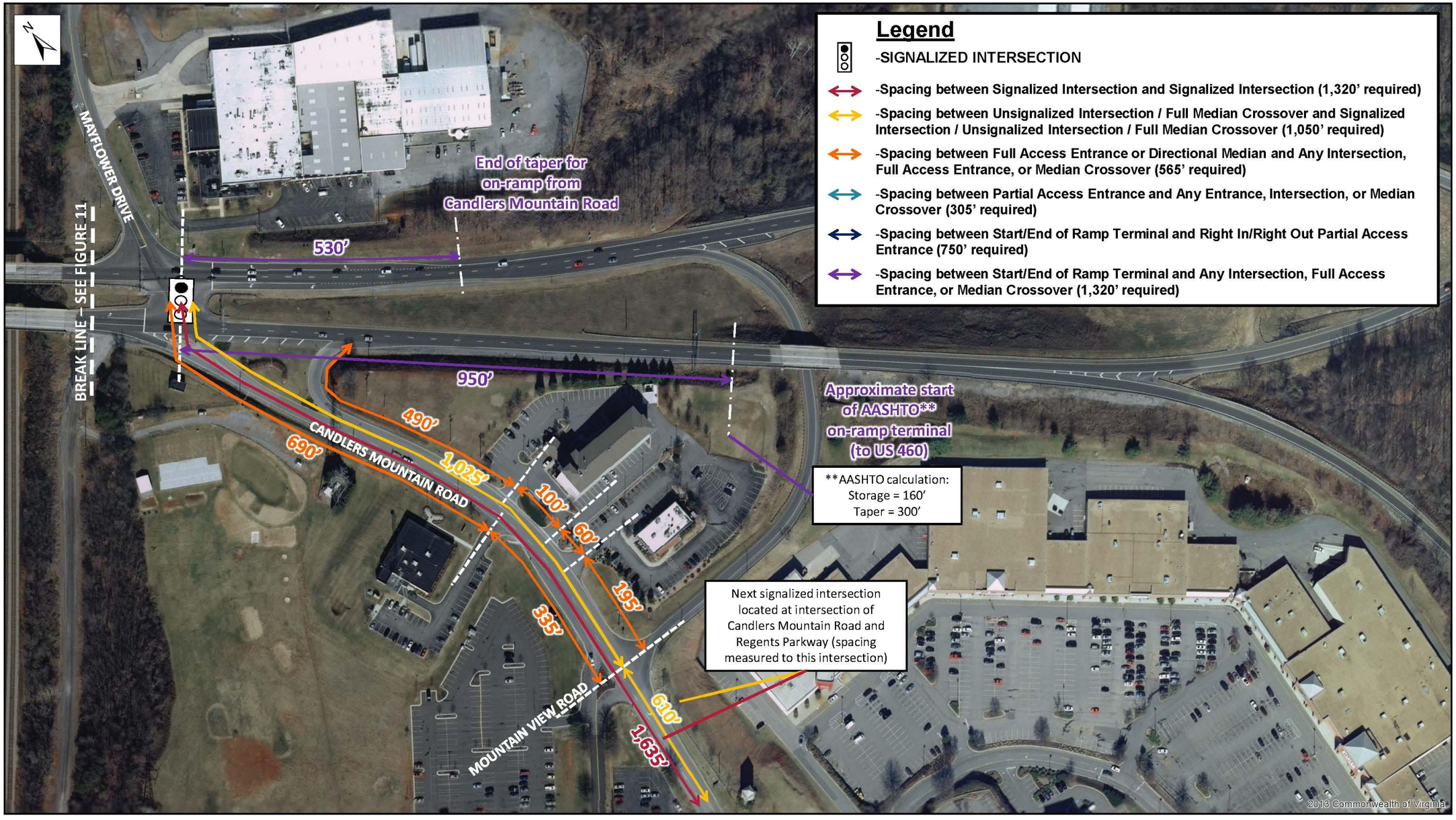


Figure 12 – Existing Access Point Spacing (3 of 3)



EXISTING CONDITIONS (2015)

Traffic operational analyses were conducted to evaluate the overall performance of the study corridor under existing (2015) AM and PM peak hour conditions. The intent of the existing conditions analyses was to provide a general understanding of the baseline traffic conditions as a starting point for developing future improvement strategies. Existing conditions were modeled using both CORSIM and Synchro/SimTraffic. CORSIM was used to evaluate the arterial operations of the Candlers Mountain Road study corridor, as well as the mainline, merge, diverge, and weaving segments of the Lynchburg Expressway near the Candlers Mountain Road interchange. Synchro/SimTraffic were used to analyze the operations of the study intersections. Existing conditions CORSIM and Synchro/SimTraffic modeling assumptions and results are described in more detail in the following sections.

CORSIM Analysis

CORSIM models were developed to analyze the arterial operation of Candlers Mountain Road as well as the freeway operation of the Lynchburg Expressway in the vicinity of Candlers Mountain Road under existing (2015) AM and PM peak hour conditions.

Modeling Assumptions

The existing AM and PM CORSIM models were developed based on a combination of collected data and visual observations from the field review. The models were calibrated for volume, speed, and queue length. A detailed summary of CORSIM modeling inputs, assumptions, and calibration is provided in **Appendix B**. A CORSIM calibration summary table is also provided in **Appendix B**.

The VDOT *Sample Size Determination Tool* was used to confirm that ten simulation runs would provide the acceptable 95% confidence level for both the AM and PM models. Ten simulation runs were conducted for both the AM and PM models using different random number seeds. The averages of these runs were reported. The VDOT *Sample Size Determination Tool* results are provided in **Appendix B**.

Results

The following measures of effectiveness (MOEs) were used to measure the quantitative performance of the freeway network:

- Vehicle density on freeways links – measured in vehicles per lane per mile
- Vehicle speeds on freeway links – measured in miles per hour

The following MOEs were used to measure the quantitative performance of the arterial network:

- Microsimulation delay – measured in seconds
- Maximum queue length – measured in vehicles per lane

Detailed simulation results including freeway lane schematics and intersection delay and queue tables are provided in **Appendix B**. Key findings from the CORSIM analysis are summarized in the subsequent sections.

Vehicle Density on Freeway Links

The *2010 Highway Capacity Manual* (HCM) methodologies govern the methodology for evaluating capacity and the quality of service provided to road users traveling through a roadway network. For freeway facilities, Level of Service (LOS) is defined by the HCM in terms of density measured in passenger cars per mile per lane. LOS ranges from A to F, where LOS A indicates a condition of little or no congestion and LOS F indicates a condition of severe congestion, unstable traffic flow, and stop-and-go conditions.

CORSIM reports density in terms of vehicles per mile per lane (veh/mi/ln), which is not directly comparable with the HCM LOS definition. Although CORSIM density outputs cannot be used to determine an HCM LOS, the LOS scale is still a useful measure to understand the relative difference between densities. For the purposes of this study, a simulation LOS scale, which is solely based on the HCM freeway facility LOS criteria for basic freeway segments, freeway weaving segments, and freeway merge/diverge segments, was used to relate CORSIM density to a LOS.

Summary tables with the CORSIM density results and corresponding simulation LOS for the AM and PM peak periods are provided in **Appendix B.**

Table 8 – Simulation Freeway Facility LOS Criteria

LOS	Density (veh/mi/ln)		
	Basic Freeway Segments	Freeway Weaving Segments	Freeway Ramps
A	≤11	≤10	≤10
B	>11-18	>10-20	>10-20
C	>18-26	>20-28	>20-28
D	>26-35	>28-35	>28-35
E	>35-45	>35	>35
F	>45 demand exceeds capacity	Demand exceeds capacity	Demand exceeds capacity

Critical links with a reported density that corresponds to a simulation LOS of D or worse are described below.

Southbound Lynchburg Expressway

Under existing conditions no overall mainline links on the southbound Lynchburg Expressway operate at a simulation LOS of D or worse in the AM or PM peak hours. One ramp, the entrance ramp from westbound Candlers Mountain Road, operates at a simulation LOS of D or worse in both the AM and PM peak hours. This ramp has a short acceleration lane and poor sight distance and many vehicles slow to almost a stop before margining onto the expressway. In CORSIM this ramp was modeled with a ramp meter to simulation the near stop condition of merging vehicles. The density and simulation LOS for southbound Lynchburg Expressway links with a simulation LOS of D or worse are summarized in **Table 9**.

Northbound Lynchburg Expressway

Under existing conditions no overall mainline links on the northbound Lynchburg Expressway operate at a simulation LOS of D or worse in the AM or PM peak hours. One ramp, the exit ramp to eastbound Candlers Mountain Road, operates at a simulation LOS of D or worse in both the AM and PM peak hours. Vehicles queue back on this ramp due to congestion on Candlers Mountain Road. The density and simulation LOS for southbound Lynchburg Expressway links with a simulation LOS of D or worse are summarized in **Table 9**.

Table 9 – CORSIM Links with Simulation LOS of D or Worse

Location	AM Peak Hour		PM Peak Hour	
	Density	Simulation LOS	Density	Simulation LOS
Southbound Lynchburg Expressway Mainline				
No overall links operate at simulation LOS of D or worse				
Southbound Lynchburg Expressway Ramps				
Southbound Lynchburg Expressway Entrance Ramp from Westbound Candlers Mountain Road (Ramp F)	96.4	F	68.0	F
Northbound Lynchburg Expressway Mainline				
No overall links operate at simulation LOS of D or worse				
Northbound Lynchburg Expressway Ramps				
Northbound Lynchburg Expressway Exit Ramp to Eastbound Candlers Mountain Road (Ramp C)	34.2	D	56.0	F

Vehicle Speeds on Freeway Links

Vehicle speeds on the Lynchburg Expressway were generally simulated within the average range of 50 to 58 mph during the AM and PM peak periods, with the exception of the following:

- During the AM peak hour, the northbound Lynchburg Expressway reported speeds of less than 50 mph at the exit ramp to and entrance ramp from Wards Road and at the exit ramp to eastbound Candlers Mountain Road
- During the PM peak hour, the northbound Lynchburg Expressway reported speeds of less than 50 mph at the exit ramp to and entrance ramp from Wards Road and at the entrance ramp from and the exit ramp to eastbound Candlers Mountain Road
- During the AM peak hour, the southbound Lynchburg Expressway reported speeds of less than 50 mph at the exit ramp to and entrance ramp from eastbound and westbound Candlers Mountain Road
- During the PM peak hour, the southbound Lynchburg Expressway reported speeds of less than 50 mph at the exit ramp to and entrance ramp from eastbound and westbound Candlers Mountain Road

Microsimulation Delay on Arterial Links

CORSIM microsimulation delay by movement, approach, and overall intersection was reported for the arterial intersections during the AM and PM peak periods. The complete microsimulation delay results by intersection are provided in **Appendix B**. This microsimulation delay from CORSIM cannot be directly correlated with a HCM LOS. For this reason, as well as some signal timing limitations of CORSIM, Synchro was used as the primary tool for reporting intersection delay and LOS. The CORSIM microsimulation delay results were reviewed and found to generally align with the Synchro results. A summary of the Synchro delay and LOS results is provided the Synchro/SimTraffic Analysis section of this report.

Maximum Queue Length on Arterial Links

While SimTraffic was the primary tool for reporting maximum queue length, the CORSIM maximum queue lengths were reviewed and found to generally align with the SimTraffic results. For reference, the complete maximum queue length results by movement and link during the AM and PM peak periods are provided in **Appendix B**. A summary of the SimTraffic maximum queue length results is provided in the Synchro/SimTraffic Analysis section of this report.

Synchro/SimTraffic Analysis

Synchro (version 8.0) and SimTraffic (version 8.0) models were developed to analyze the eight study-area intersections under existing (2015) AM and PM peak hour conditions. For all Synchro analyses, the HCM 2000 methodology was used due to the limitations of the HCM 2010 methodology to analyze clustered intersections and non-standard traffic signal phasing.

Modeling Assumptions

The existing AM and PM Synchro/SimTraffic models were developed based on a combination of collected data and visual observations from the field review. A detailed summary of Synchro/SimTraffic modeling assumptions is provided in **Appendix B**.

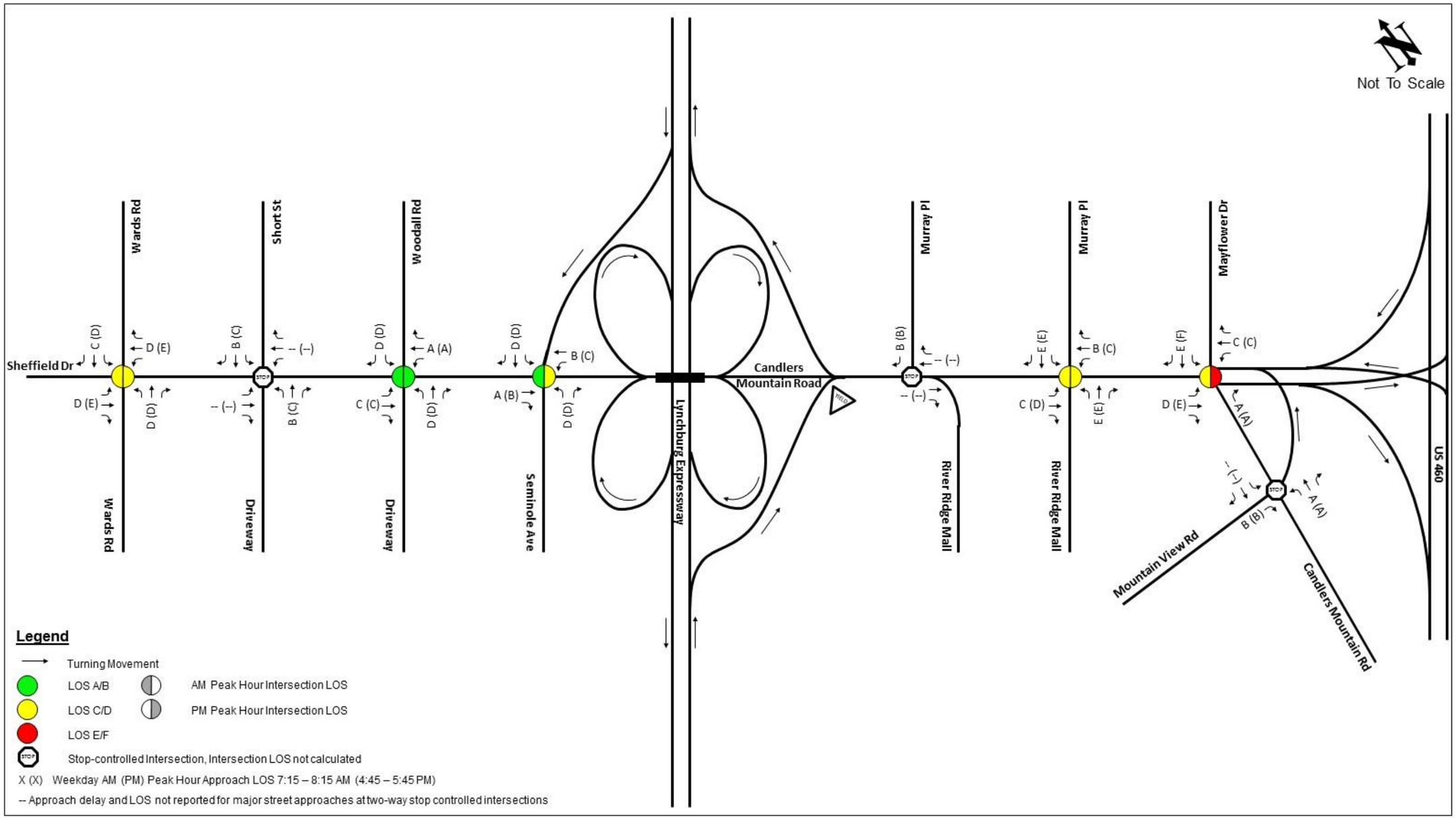
Results

The following MOEs were selected to measure the quantitative performance of the intersections within the network.

- Average vehicle delay and HCM LOS by movement, approach, and intersection – measured in seconds per vehicle
- Maximum queue length – measured in feet

Tables summarizing the delay, HCM LOS, and queuing results for the study area intersections are included in **Appendix B**. **Figure 13** shows a graphical representation of the LOS results in the study area. Key findings for the intersection analysis are summarized in the subsequent sections.

Figure 13 – Existing (2015) Levels of Service



Delay and Level of Service

Intersection capacity analysis allows traffic engineers to assess the operational conditions at intersections and identifies the impacts of traffic on the surrounding roadway network. The intersections are evaluated using control delay expressed in seconds per vehicles. Intersections with LOS E or F, overall volume-to-capacity ratio (v/c) greater than one, at least one approach with LOS F, or at least one lane group with v/c greater than one are summarized below.

Intersection 7 – Candlers Mountain Road / US 501 at Mayflower Drive

- The overall intersection operates at LOS E (55.3 sec/veh) during the PM peak hour and v/c greater than one during the PM peak hour.
- The southbound approach of Mayflower Drive operates at LOS F (123.5 sec/veh) and v/c greater than one during the PM peak hour.
- The eastbound through-right lane group operates with a v/c greater than one in both the AM and PM peak hours.

Queue Length

A queuing analysis was completed for the study area intersections under both Existing AM and PM peak hour conditions. Queue length is another key performance indicator of capacity at both signalized and unsignalized intersection. Queues exceeding the length of turn lane storage lengths may indicate capacity or operational issues. Understanding possible causes of significant queue lengths helps in the identification of potential solutions.

SimTraffic was used to perform a 60-minute simulation for the queuing analyses. The maximum queue length, measured in feet, was reported and is summarized in **Appendix B**. For movements without conflicting volumes, no queue length is reported by SimTraffic.

Movements with queues that exceed storage bays include:

Intersection 1 – Candlers Mountain Road / Sheffield Drive at Wards Road

- Westbound left turn, PM peak hour

Intersection 3 – Candlers Mountain Road at Woodall Road

- Southbound left turn, PM peak hour

Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue

- Westbound left turn, both AM and PM peak hours

Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall

- Eastbound left turn, both AM and PM peak hours
- Westbound left turn, both AM and PM peak hours
- Westbound right turn, both AM and PM peak hours

Intersection 7 – Candlers Mountain Road / US 501 at Mayflower Drive

- Westbound left turn, both AM and PM peak hours
- Westbound right turn, both AM and PM peak hours
- Southbound right turn, both AM and PM peak hours

Intersection 8 – Candlers Mountain Road at Westbound US 501 Ramp / Mountain View Road

- Southbound right turn, AM peak hour

Movements with queues that block the storage bays of adjacent lanes include:

Intersection 1 – Candlers Mountain Road / Sheffield Drive at Wards Road

- Westbound left-turn lane blocked by through movement, PM peak hour
- Northbound left-turn lane blocked by through movement, both AM and PM peak hours
- Southbound left-turn lane blocked by through-left movement, PM peak hour

Intersection 2 – Candlers Mountain Road at Short Street

- Westbound left-turn lane blocked by through movement, PM peak hour

Intersection 3 – Candlers Mountain Road at Woodall Road

- Eastbound left-turn blocked by through movement, both AM and PM peak hours
- Southbound left-turn blocked by right-turn movement, PM peak hour

Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue

- Westbound left-turn lane blocked by through movement, both AM and PM peak hours
- Northbound left-turn lane blocked by through movement, AM and PM peak hour

Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall

- Eastbound left-turn lane blocked by through movement, both AM and PM peak hours
- Westbound left-turn lane blocked by through movement, both AM and PM peak hours
- Westbound right-turn lane blocked by through movement, both AM and PM peak hours
- Southbound right-turn lane blocked by through-left movement, both AM and PM peak hours

Intersection 7 – Candlers Mountain Road / US 501 at Mayflower Drive

- Eastbound left-turn lane blocked by through movement, both AM and PM peak hours
- Westbound left-turn lane blocked by through movement, both AM and PM peak hours
- Westbound right-turn lane blocked by through movement, both AM and PM peak hours
- Southbound right-turn lane blocked by through-left movement, both AM and PM peak hours

Intersection 8 – Candlers Mountain Road at Westbound US 501 Ramp / Mountain View Road

- Southbound right -turn lane blocked by through movement, AM peak hour

Queues at several intersections extend through upstream intersections under existing conditions. These queues are summarized below.

Eastbound Candlers Mountain Road, AM Peak

- The queue at Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue extends through Intersection 3 – Candlers Mountain Road at Woodall Road.
- Beginning of the queue at Intersection 8 – Candlers Mountain Road at Westbound US 501 Ramp / Mountain View Road extends through Intersection 7 – Candlers Mountain Road/US 501 at Mayflower Drive; the queue at Intersection 7 extends through Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall.

Eastbound Candlers Mountain Road, PM Peak

- The queue at Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue extends through Intersection 3 – Candlers Mountain Road at Woodall Road; the queue at Intersection 3 extends through Intersection 2 – Candlers Mountain Road at Short Street.
- The queue at Intersection 7 – Candlers Mountain Road/US 501 at Mayflower Drive extends through Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall.

Westbound Candlers Mountain Road, AM Peak

- The queue at Intersection 3 – Candlers Mountain Road at Woodall Road extends through Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue.

TRAFFIC FORECASTING

In order to understand future traffic conditions on Candlers Mountain Road, traffic volumes were forecasted for the future year analysis. VDOT identified 2025 as the Interim Year and 2040 as the Design Year for traffic analysis to align with the previous planning efforts of the region's long-range vision, goals, and objectives. The following sections describe the methodology for developing growth rates and projecting traffic volumes for the study corridor.

Traffic Growth Rate Development

Traffic growth rates were developed as part of the Lynchburg Expressway Improvement Study using both historic growth trends and available travel demand models. Historic traffic growth rates were calculated using published VDOT traffic count data. Travel demand model forecasted growth rates were calculated as an average of the 2008 and 2035 traffic forecasts from the Lynchburg Regional Travel Demand Model, which is based on the 2010 MPO Constrained Long Range Plan (CLRP). After reviewing both the historic traffic growth rates and travel demand model forecasted growth rates, the Lynchburg Expressway Improvement Study SWG agreed upon conservative growth rates of 1% for both the Lynchburg Expressway mainline and Candlers Mountain Road. In addition, the Lynchburg Expressway Improvement Study assumed that heavy vehicle percentages would not change in the study area and, as a result, applied existing heavy vehicle percentages to future year analyses.

After the Lynchburg Expressway Improvement Study was completed, the Lynchburg Regional Travel Demand Model was updated. The update primarily consisted of adjustments to the baseline model (2008) to reflect current traffic volumes. This adjustment resulted in slightly lower projected volumes for the forecast years of 2025 and 2040 in the travel demand model. These projections were also assumed to take into consideration the anticipated growth in and around the Liberty University campus as shown in the campus master planning efforts.

Based on the available data, the growth rate assumptions previously agreed upon for the Lynchburg Expressway Improvement Study were determined to still be relevant and therefore were applied to the Candlers Mountain Road Corridor Study as shown in **Table 10**.

Table 10 – Growth Rate Assumptions

Roadway	Growth Rates
Expressway (US 29/US 501)	1.00%
Wards Road	1.00%
Candlers Mountain Road	1.00%

Supporting data for traffic growth rate development is included in **Appendix C**.

Projected Traffic Volumes

Standard linear growth rate calculations were applied to the 2015 existing peak hour traffic volumes to generate 2025 and 2040 no-build peak hour traffic volumes. The projected volumes were re-balanced throughout the study area. The balanced projected 2025 and 2040 no-build AM and PM peak hour volumes for the study corridor are summarized in **Figure 14** and **Figure 15**, respectively.

Figure 14 – Projected 2025 No-Build Peak Hour Volumes

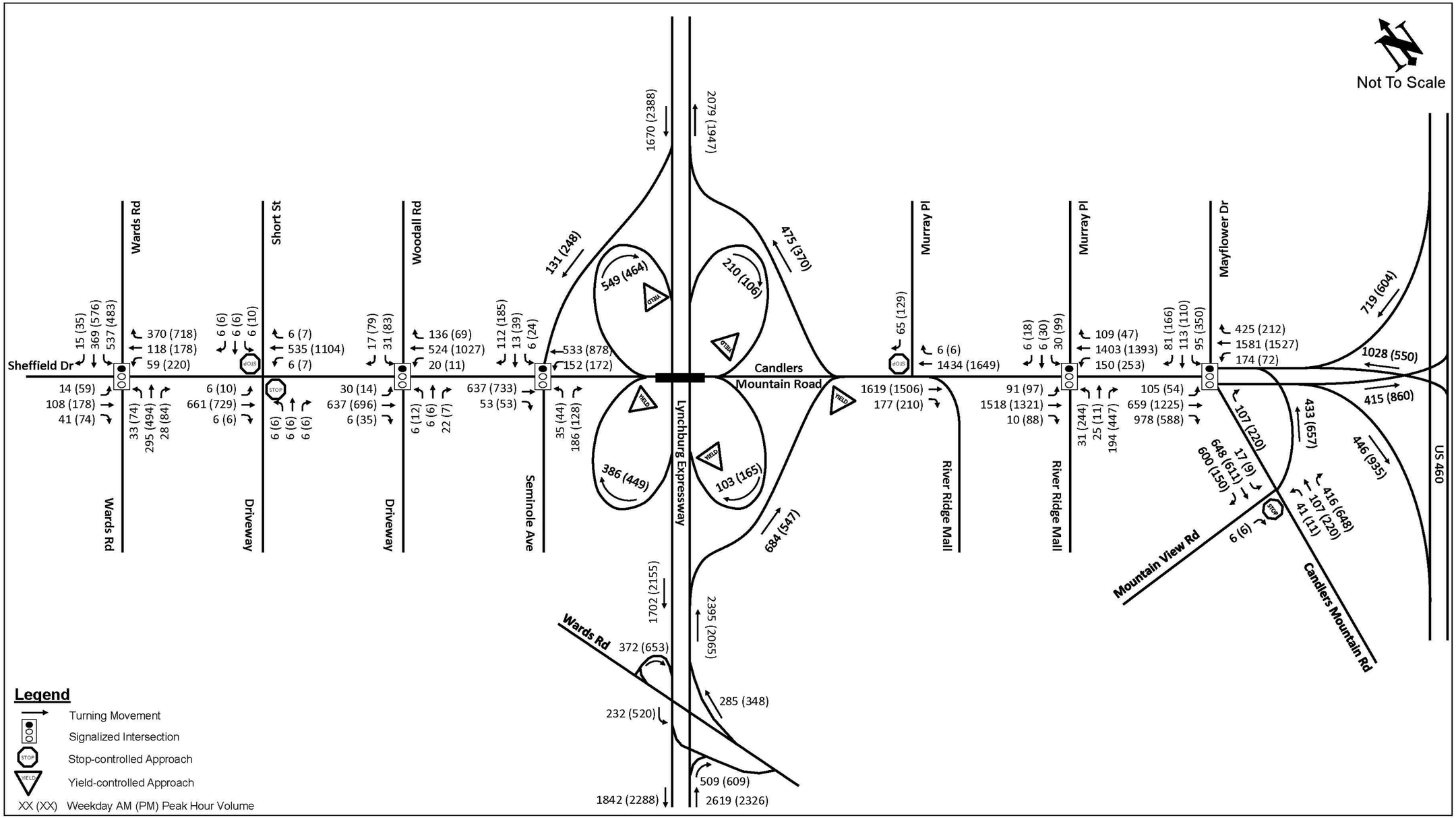
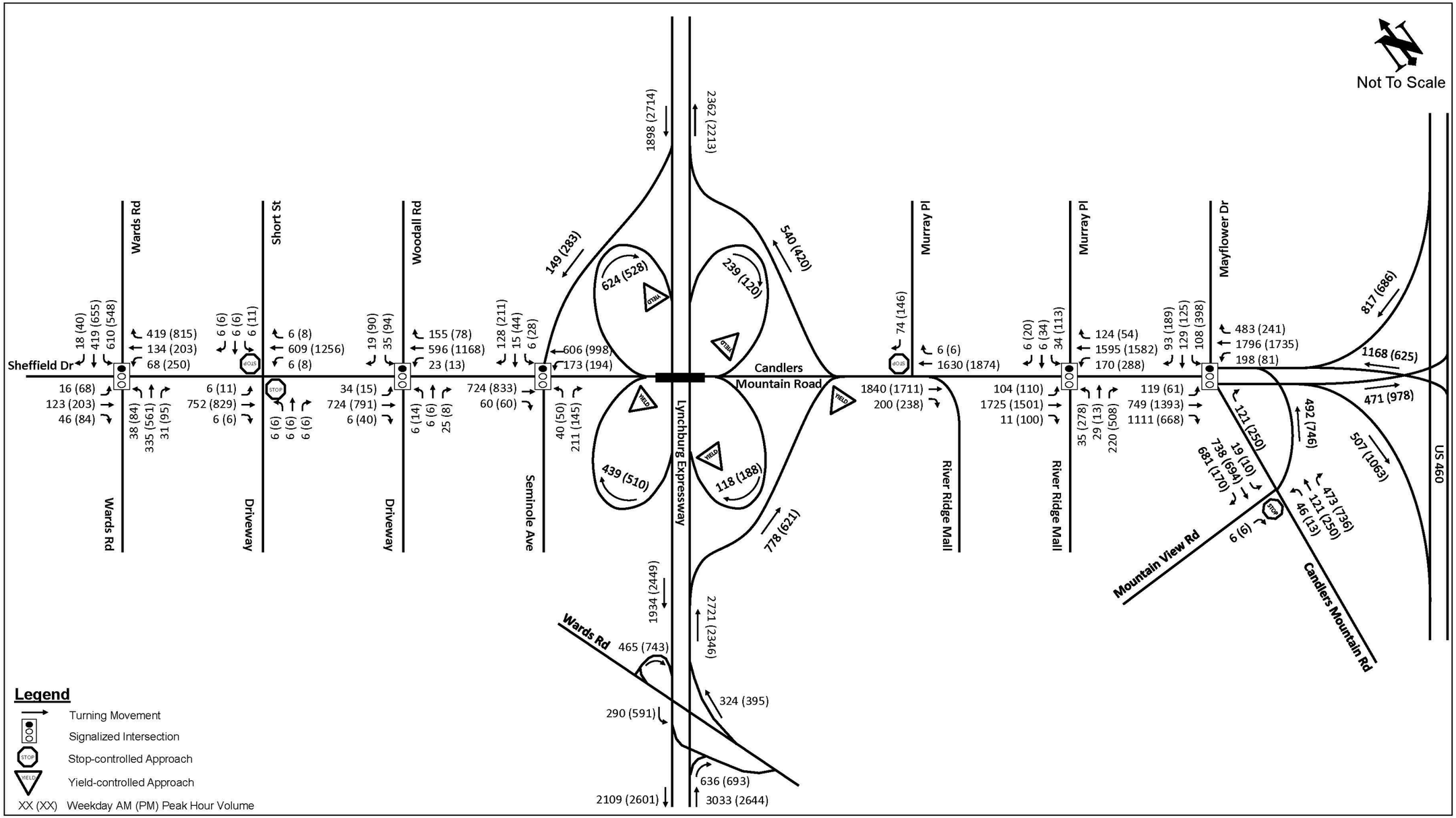


Figure 15 – Projected 2040 No-Build Peak Hour Volumes



NO-BUILD CONDITIONS (2025 AND 2040)

No-build conditions were analyzed to evaluate the results of future traffic demand on the existing roadway network. The intent of the no-build conditions analysis was to provide a general understanding of baseline future traffic conditions to be used to evaluate the effectiveness of potential future improvement strategies. CORSIM and Synchro modeling assumptions and analysis results for no-build conditions in Interim Year 2025 and Design Year 2040 are described in the following sections.

CORSIM Analysis

CORSIM models were developed to analyze the operation of the Candlers Mountain Road study area under Design Year 2040 no-build AM and PM peak hour conditions. Interim Year 2025 conditions were not analyzed in CORSIM.

Modeling Assumptions

The calibrated existing conditions CORSIM models were used as a basis to develop the no-build models. No geometric changes were made, but the models were updated with projected 2040 no-build traffic volumes and optimized signal timing splits. A detailed summary of CORSIM modeling inputs and assumptions for the no-build models is provided in **Appendix D**.

The VDOT *Sample Size Determination Tool* was used to determine the minimum number of simulation runs required for both AM and PM no-build models. Thirty simulation runs were conducted for both the AM and PM models using different random number seeds. The averages of these runs were reported. The VDOT *Sample Size Determination Tool* results are provided in **Appendix D**.

Results

The same MOEs used to evaluate existing conditions were used to measure the quantitative performance of the no-build CORSIM freeway and arterial networks:

- Vehicle density on freeway links
- Vehicle speeds on freeway links
- Microsimulation delay at arterial intersections
- Maximum queue length on arterial links

Detailed simulation results including freeway lane schematics and intersection delay and queue tables are provided in **Appendix D**. Key findings from the no-build CORSIM analysis are summarized in the subsequent sections.

As was observed in existing conditions, under no-build 2040 AM peak hour conditions, there were capacity constraints due to congestion from the school drop-off on southbound Candlers Mountain Road. The congestion from the school caused extensive queuing throughout the entire network. Queuing from the school backed up along the entire stretch of eastbound Candlers Mountain Road in the study area and caused queuing on the Lynchburg Expressway mainline and ramps.

Under no-build 2040 PM conditions, there were capacity constraints due to congestion on Candlers Mountain at the Murray Place/River Ridge Mall and Mayflower Drive intersections. The congestion in this area caused extensive queuing throughout the entire network. Queues extended along the entire stretch of Candlers Mountain Road in the study area and on the Lynchburg Expressway mainline and ramps.

Due to the extensive queuing under both AM and PM no-build 2040 conditions, simulated volumes on many links were lower than projected no-build volumes. These locations are discussed in more detail in **Appendix D**. The CORSIM no-build results should be interpreted understanding that the volumes simulated were lower than projected.

Vehicle Density on Freeway Links

Similar to the existing conditions analysis, the simulation LOS scale shown in **Table 8** was used to relate CORSIM density results to an LOS. Summary tables with the CORSIM density results and corresponding simulation LOS for the AM and PM peak periods are provided in **Appendix D**. Critical links with a reported density that corresponds to a simulation LOS of D or worse are described below.

Southbound Lynchburg Expressway

Under 2040 no-build conditions, all southbound Lynchburg Expressway mainline links report higher vehicle densities than under existing conditions in both the AM and PM peak hours. In the AM peak hour only the mainline link directly south of the entrance ramp from westbound Candlers Mountain Road operates at a simulation LOS of D or worse. In the no-build 2040 PM peak hour, all mainline links north of the exit ramp to eastbound Candlers Mountain Road operate at a simulation LOS of D or worse. In addition, in both the AM and PM peak hours, two ramps, the Lynchburg Expressway entrance ramp from westbound Candlers Mountain Road and the Lynchburg Expressway exit ramp to eastbound Candlers Mountain Road, operate at a simulation LOS of D or worse. Vehicles queue back onto these ramps due to congestion on eastbound and westbound Candlers Mountain Road.

The density and simulation LOS for southbound Lynchburg Expressway links with a simulation LOS of D or worse are summarized in **Table 11**. For segments composed of multiple links, the results for the link with the highest density were reported.

Northbound Lynchburg Expressway

Under 2040 no-build conditions, all northbound Lynchburg Expressway mainline links south of the exit ramp to eastbound Candlers Mountain Road report higher vehicle densities than under existing conditions in both the AM and PM peak hours. Northbound Lynchburg Expressway mainline links north of the Candlers Mountain Road interchange report lower vehicle densities under no-build conditions than under existing conditions due to lower vehicle throughput as a result of extensive queuing on Candlers Mountain Road that backed up onto the Lynchburg Expressway ramps and mainline. In both the AM and PM peak hours, all mainline links south of the exit ramp to eastbound Candlers Mountain Road operate at a simulation LOS of D or worse. In addition, in both the AM and PM peak hours, one ramp, the exit ramp to eastbound Candlers Mountain Road, operates at a simulation

LOS of D or worse in both the AM and PM peak hours. As in existing conditions, vehicles queue back onto this ramp due to congestion on Candlers Mountain Road.

The density and simulation LOS for northbound Lynchburg Expressway links with a simulation LOS of D or worse are summarized in **Table 11**. For segments composed of multiple links, the results for the link with the highest density are reported.

Table 11 – No-Build CORSIM Links with Simulation LOS of D or Worse

Location	AM Peak Hour		PM Peak Hour	
	Density	Simulation LOS	Density	Simulation LOS
Southbound Lynchburg Expressway Mainline				
Southbound Lynchburg Expressway north of exit ramp to EB/WB Candlers Mountain Road (Ramp G)			51.0	F
Southbound Lynchburg Expressway between exit ramp to EB/WB Candlers Mountain Road (Ramp G) and entrance ramp from WB Candlers Mountain Road (Ramp F)			59.6	F
Southbound Lynchburg Expressway between entrance ramp from WB Candlers Mountain Road (Ramp F) and exit ramp to EB Candlers Mountain Road (Ramp A)	38.5	E	63.1	F
Southbound Lynchburg Expressway Ramps				
Southbound Lynchburg Expressway Entrance Ramp from Westbound Candlers Mountain Road (Ramp F)	152.3	F	118.4	F
Southbound Lynchburg Expressway Exit Ramp to Eastbound Candlers Mountain Road (Ramp A)	43.5	E	87.1	F
Northbound Lynchburg Expressway Mainline				
Northbound Lynchburg Expressway south of exit ramp to Old Wards Road	43.7	E	46.5	F
Northbound Lynchburg Expressway between exit ramp to Old Wards Road and entrance ramp from Wards Road	34.9	D	42.2	E
Northbound Lynchburg Expressway weave between entrance ramp from Wards Road and exit ramp to EB Candlers Mountain Road (Ramp C)	36.1	E	44.9	E
Northbound Lynchburg Expressway Ramps				
Northbound Lynchburg Expressway Exit Ramp to Eastbound Candlers Mountain Road (Ramp C)	99.8	F	126.4	F

Vehicle Speeds on Freeway Links

Under no-build conditions, vehicle speeds on the Lynchburg Expressway were equal to or lower than under existing conditions for all links in both the AM and PM peak hours. The most significant speed differentials between existing and no-build conditions were in the vicinity of the Candlers Mountain Road interchange. The following areas reported speeds lower than 50 mph:

- During the AM Peak, the northbound Lynchburg Expressway reported speeds of less than 50 mph south of the Candlers Mountain Road interchange. The lowest northbound Lynchburg Expressway mainline speed reported in the AM peak hour was 15.6 mph in the weave segment between the entrance ramp from Wards Road and the exit ramp to eastbound Candlers Mountain Road.
- During the PM Peak, the northbound Lynchburg Expressway reported speeds of less than 50 mph south of the Candlers Mountain Road interchange. The lowest northbound Lynchburg Expressway mainline speed reported in the PM peak hour was 11.8 mph in the weave segment between the entrance ramp from Wards Road and the exit ramp to eastbound Candlers Mountain Road.
- During the AM Peak, the southbound Lynchburg Expressway reported speeds of less than 50 mph in the vicinity of the Candlers Mountain Road interchange. The lowest southbound Lynchburg Expressway mainline speed reported in the AM peak hour was 26.5 mph between the entrance ramp from westbound Candlers Mountain Road and the exit ramp to eastbound Candlers Mountain Road.
- During the PM Peak, the southbound Lynchburg Expressway reported speeds of less than 50 mph in the vicinity of the Candlers Mountain Road interchange. The lowest southbound Lynchburg Expressway mainline speed reported in the AM peak hour was 21.0 mph between the entrance ramp from westbound Candlers Mountain Road and the exit ramp to eastbound Candlers Mountain Road.

Microsimulation Delay on Arterial Links

CORSIM microsimulation delay by movement, approach, and overall intersection was reported for the arterial intersections during the no-build 2040 AM and PM peak periods. The complete microsimulation delay results by intersection are provided in **Appendix D**. This microsimulation delay from CORSIM cannot be directly correlated with a HCM LOS. For this reason, as well as some signal timing limitations of CORSIM, Synchro was used as the primary tool for reporting intersection delay and LOS. The CORSIM microsimulation delay results were reviewed and found to generally align with the Synchro results for the no-build 2040 AM and PM peak periods. A summary of the Synchro delay and LOS results is provided in the Synchro/SimTraffic Analysis section of this report.

Maximum Queue Length on Arterial Links

While SimTraffic was the primary tool for reporting maximum queue length, the CORSIM maximum queue lengths were reviewed and found to generally align with the SimTraffic results for no-build 2040 conditions. For reference, the complete maximum queue length CORSIM results by movement and link for the no-build 2040 AM and PM peak periods are provided in **Appendix D**. A summary of the SimTraffic maximum queue length results is provided in the Synchro/SimTraffic Analysis section of this report.

Synchro/SimTraffic Analysis

Synchro/SimTraffic models were developed to analyze the operation of the Candlers Mountain Road study area under Interim Year 2025 and Design Year 2040 no-build AM and PM peak hour conditions.

Modeling Assumptions

The calibrated existing conditions Synchro/SimTraffic models were used as a basis to develop the no-build models. No geometric changes were made, but the models were updated with projected 2025 and 2040 no-build traffic volumes and optimized signal timing splits. A detailed summary of Synchro/SimTraffic modeling inputs and assumptions for the no-build models is provided in **Appendix D**.

Results

The same MOEs used to evaluate existing conditions were used to measure the quantitative performance of the no-build Synchro/SimTraffic models:

- Average vehicle delay and HCM LOS by movement, approach, and intersection – measured in seconds per vehicle
- Maximum queue length – measured in feet

Tables summarizing the delay, HCM LOS, and queuing results for the study area intersections are included in **Appendix D**. **Figure 16** and **Figure 17** show graphical representations of the LOS results in the study area under 2025 and 2040 no-build conditions. Key findings for the intersection analysis are summarized in the subsequent sections.

Delay and Level of Service

Intersections with LOS E or F, overall volume-to-capacity ratio (v/c) greater than one, at least one approach with LOS F, or at least one lane group with v/c greater than one are summarized below.

Intersection 1 – Candlers Mountain Road / Sheffield Drive at Wards Road

- 2025 No-Build Model
  - The overall intersection operates at LOS E (64.4 sec/veh) in the PM peak hour.
  - The eastbound approach of Sheffield Drive operates at LOS F (84.0 sec/veh) in the PM peak hour.
  - The westbound approach of Candlers Mountain Road operates at LOS E (60.8 sec/veh) in the PM peak hour.
  - The northbound approach of Wards Road operates at LOS E (64.4 sec/veh) in the PM peak hour.
  - The southbound approach of Wards Road operates at LOS E (62.1 sec/veh) in the PM peak hour.
- 2040 No-Build Model
  - The overall intersection operates at LOS F (99.6 sec/veh) in the PM peak hour.
  - The eastbound approach of Sheffield Drive operates at LOS E (58.5 sec/veh) in the AM peak hour and LOS F (138.0 sec/veh) in the PM peak hour; this approach operates at v/c greater than one in the PM peak hour.
  - The westbound approach of Candlers Mountain Road operates at LOS F (91.2 sec/veh) and v/c greater than one in the PM peak hour.
  - The northbound approach of Wards Road operates at LOS F (96.8 sec/veh) and v/c greater than one in the PM peak hour.
  - The southbound approach of Wards Road operates at LOS F (98.0 sec/veh) and v/c greater than one in the PM peak hour.

Intersection 3 – Candlers Mountain Road at Woodall Road

- 2040 No-Build Model
  - The overall intersection operates at LOS B in the PM peak hour.
  - The southbound approach of Woodall Road operates at LOS E (56.7 sec/veh) in the PM peak hour.

Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall

- 2025 No-Build Model
  - The overall intersection operates at LOS E (77.9 sec/veh) and v/c greater than one in the PM peak hour.
  - The eastbound approach of Candlers Mountain Road operates at LOS E (79.8 sec/veh) and v/c greater than one in the PM peak hour.
  - The westbound approach of Candlers Mountain Road operates at LOS F (58.2 sec/veh) and v/c greater than one in the PM peak hour.
  - The northbound approach of Murray Place operates at LOS E (73.9 sec/veh) in the AM peak hour and LOS F (114.4 sec/veh) in the PM peak hour; this approach operates at v/c greater than one in the PM peak hour.
  - The southbound approach to River Ridge Mall operates at LOS E (62.7 sec/veh) in the AM peak hour and LOS F (96.7 sec/veh) in the PM peak hour.
- 2040 No-Build Model
  - The overall intersection operates at LOS F (82.4 sec/veh) in the AM peak hour and LOS F (131.6 sec/veh) in the PM peak hour; the overall intersection operates at v/c greater than one in both the AM and PM peak hours.
  - The eastbound approach of Candlers Mountain Road operates at LOS F (104.0 sec/veh) in the PM peak hour; this approach operates at v/c greater than one in both the AM and PM peak hours.
  - The westbound approach of Candlers Mountain Road operates at LOS F (96.8 sec/veh) and v/c greater than one in the PM peak hour.

- The northbound approach of Murray Place operates at LOS F (94.0 sec/veh) in the AM peak hour and LOS F (166.4 sec/veh) in the PM peak hour; this approach operates at v/c greater than one in the PM peak hour.
- The southbound approach to River Ridge Mall operates at LOS E (62.9 sec/veh) in the AM peak hour and LOS F (127.8 sec/veh) in the PM peak hour; this approach operates at v/c greater than one in the PM peak hour.

Intersection 7 – Candlers Mountain Road / US 501 at Mayflower Drive

- 2025 No-Build Model
  - The overall intersection operates at LOS F (80.6 sec/veh) in the PM peak hour; the overall intersection operates at v/c greater than one in both the AM and PM peak hours.
  - The eastbound approach of Candlers Mountain Road / US 501 operates at LOS F (108.2 sec/veh) in the PM peak hour; this approach operates at v/c greater than one in both the AM and PM peak hours.
  - The southbound approach of Mayflower Drive operates at LOS F (100.4 sec/veh) in the AM peak hour and LOS F (117.6 sec/veh) in the PM peak hour; this approach operates at v/c greater than one in both the AM and PM peak hours.
- 2040 No-Build Model
  - The overall intersection operates at LOS E (77.2 sec/veh) in the AM peak hour and LOS F (131.3 sec/veh) in the PM peak hour; the overall intersection operates at v/c greater than one in both the AM and PM peak hours.
  - The eastbound approach of Candlers Mountain Road / US 501 operates at LOS F (117.7 sec/veh) in the AM peak hour and LOS F (181.4 sec/veh) in the PM peak hour; this approach operates at v/c greater than one in both the AM and PM peak hours.
  - The westbound approach of Candlers Mountain Road / US 501 operates at LOS F (83.5 sec/veh) and v/c greater than one in the PM peak hour.
  - The southbound approach of Mayflower Drive operates at LOS F (122.2 sec/veh) in the AM peak hour and LOS F (165.3 sec/veh) in the PM peak hour; this approach operates at v/c greater than one in both the AM and PM peak hours.

Queue Length

A queuing analysis was completed for the study area intersections under 2025 and 2040 no-build AM and PM peak hour conditions. Queue length is another key performance indicator of capacity at both signalized and unsignalized intersection. Queues exceeding the length of turn lane storage lengths may indicate capacity or operational issues. Understanding possible causes of significant queue lengths helps in the identification of potential solutions.

SimTraffic was used to perform 60-minute simulations for the queuing analyses. The maximum queue lengths, measured in feet, were reported for 2025 and 2040 no-build AM and PM peak hour conditions and are summarized in **Appendix D**. For movements without conflicting volumes, no queue length is reported by SimTraffic.

Movements with queues that exceed storage bays include:

Intersection 1 – Candlers Mountain Road / Sheffield Drive at Wards Road

- 2025 No-Build Model
  - Westbound left turn, PM peak hour
  - Northbound left-turn, PM peak hour
  - Southbound left-turn, PM peak hour
- 2040 No-Build Model
  - Eastbound through-left turn, PM peak hour
  - Westbound left turn, PM peak hour
  - Northbound left-turn, both AM and PM peak hours
  - Southbound through-left, both AM and PM peak hours

Intersection 2 – Candlers Mountain Road at Short Street

- 2025 No-Build Model
  - Eastbound left turn, PM peak hour
- 2040 No-Build Model
  - Eastbound left turn, PM peak hour
  - Westbound left-turn, PM peak hour

Intersection 3 – Candlers Mountain Road at Woodall Road

- 2025 No-Build Model
  - Eastbound left turn, PM peak hour
  - Southbound left turn, PM peak hour
- 2040 No-Build Model
  - Eastbound left turn, both AM and PM peak hours
  - Southbound left turn, PM peak hour

Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue

- 2025 No-Build Model
  - Westbound left turn, both AM and PM peak hours
  - Southbound right turn, PM peak hour
- 2040 No-Build Model
  - Westbound left turn, both AM and PM peak hours
  - Northbound left-turn, both AM and PM peak hours
  - Southbound right turn, PM peak hour

Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall

- 2025 No-Build Model
  - Eastbound left turn, both AM and PM peak hours
  - Westbound left turn, both AM and PM peak hours
  - Westbound right turn, both AM and PM peak hours
  - Southbound right turn, PM peak hour
- 2040 No-Build Model
  - Eastbound left turn, both AM and PM peak hours
  - Westbound left turn, both AM and PM peak hours
  - Westbound right turn, both AM and PM peak hours
  - Southbound right turn, PM peak hour

Intersection 7 – Candlers Mountain Road / US 501 at Mayflower Drive

- 2025 No-Build Model
  - Eastbound left turn, PM peak hour
  - Westbound left turn, both AM and PM peak hours
  - Westbound right turn, both AM and PM peak hours
  - Southbound right turn, both AM and PM peak hours
- 2040 No-Build Model
  - Eastbound left turn, PM peak hour
  - Westbound left turn, both AM and PM peak hours
  - Westbound right turn, both AM and PM peak hours
  - Southbound right turn, both AM and PM peak hours

Intersection 8 – Candlers Mountain Road at Westbound US 501 Ramp / Mountain View Road

- 2025 No-Build Model
  - Southbound right turn, AM peak hour
- 2040 No-Build Model
  - Southbound right turn, AM peak hour

Movements with queues that block the storage bays of adjacent lanes include:

Intersection 1 – Candlers Mountain Road / Sheffield Drive at Wards Road

- 2025 No-Build Model
  - Westbound left-turn lane blocked by through movement, PM peak hour
  - Northbound left-turn lane blocked by through movement, both AM and PM peak hours
  - Southbound left-turn lane blocked by through-left movement, PM peak hour
- 2040 No-Build Model
  - Eastbound left-turn lane blocked by through movement, PM peak hour
  - Westbound left-turn lane blocked by through movement, PM peak hour
  - Northbound left-turn lane blocked by through movement, both AM and PM peak hours
  - Southbound left-turn lane blocked by through-left movement, both AM and PM peak hours

Intersection 2 – Candlers Mountain Road at Short Street

- 2025 No-Build Model
  - Eastbound left-turn lane blocked by through movements, both AM and PM peak hours
  - Westbound left-turn lane blocked by through movement, PM peak hour
- 2040 No-Build Model
  - Eastbound left-turn lane blocked by through movements, both AM and PM peak hours
  - Westbound left-turn lane blocked by through movement, PM peak hour

Intersection 3 – Candlers Mountain Road at Woodall Road

- 2025 No-Build Model
  - Eastbound left-turn blocked by through movement, both AM and PM peak hours
  - Southbound left-turn blocked by right-turn movement, both AM and PM peak hours

- 2040 No-Build Model
  - Eastbound left-turn blocked by through movement, both AM and PM peak hours
  - Southbound left-turn blocked by right-turn movement, both AM and PM peak hours

Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue

- 2025 No-Build Model
  - Westbound left-turn lane blocked by through movement, both AM and PM peak hours
  - Northbound left-turn lane blocked by through movement, AM and PM peak hour
  - Southbound right-turn lane blocked by through-left movement, PM peak hour
- 2040 No-Build Model
  - Westbound left-turn lane blocked by through movement, both AM and PM peak hours
  - Northbound left-turn lane blocked by through movement, AM and PM peak hour
  - Southbound right-turn lane blocked by through-left movement, PM peak hour

Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall

- 2025 No-Build Model
  - Eastbound left-turn lane blocked by through movement, both AM and PM peak hours
  - Westbound left-turn lane blocked by through movement, both AM and PM peak hours
  - Westbound right-turn lane blocked by through movement, both AM and PM peak hours
  - Southbound right-turn lane blocked by through-left movement, both AM and PM peak hours
- 2040 No-Build Model
  - Eastbound left-turn lane blocked by through movement, both AM and PM peak hours
  - Westbound left-turn lane blocked by through movement, both AM and PM peak hours
  - Westbound right-turn lane blocked by through movement, both AM and PM peak hours
  - Southbound right-turn lane blocked by through-left movement, both AM and PM peak hours

Intersection 7 – Candlers Mountain Road / US 501 at Mayflower Drive

- 2025 No-Build Model
  - Eastbound left-turn lane blocked by through movement, both AM and PM peak hours
  - Westbound left-turn lane blocked by through movement, both AM and PM peak hours
  - Westbound right-turn lane blocked by through movement, both AM and PM peak hours
  - Southbound right-turn lane blocked by through-left movement, both AM and PM peak hours
- 2040 No-Build Model
  - Eastbound left-turn lane blocked by through movement, both AM and PM peak hours
  - Westbound left-turn lane blocked by through movement, both AM and PM peak hours
  - Westbound right-turn lane blocked by through movement, both AM and PM peak hours
  - Southbound right-turn lane blocked by through-left movement, both AM peak hour

Intersection 8 – Candlers Mountain Road at Westbound US 501 Ramp / Mountain View Road

- 2025 No-Build Model
  - Southbound right -turn lane blocked by through movement, AM peak hour
- 2040 No-Build Model
  - Southbound right -turn lane blocked by through movement, AM peak hour

Queues at several intersections extend through upstream intersections under no-build conditions. These queues are summarized below.

Eastbound Candlers Mountain Road, AM Peak

- 2025 No-Build Model
  - The queue at Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue extends through Intersection 3 – Candlers Mountain Road at Woodall Road; the queue at Intersection 3 extends through Intersection 2 – Candlers Mountain Road at Short Street.
  - Beginning of the queue at Intersection 8 – Candlers Mountain Road at Westbound US 501 Ramp / Mountain View Road extends through Intersection 7 – Candlers Mountain Road/US 501 at Mayflower Drive; the queue at Intersection 7 extends through Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall.

- 2040 No-Build Model
    - The queue at Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue extends through Intersection 3 – Candlers Mountain Road at Woodall Road; the queue at Intersection 3 extends through Intersection 2 – Candlers Mountain Road at Short Street.
    - Beginning of the queue at Intersection 8 – Candlers Mountain Road at Westbound US 501 Ramp / Mountain View Road extends through Intersection 7 – Candlers Mountain Road/US 501 at Mayflower Drive; the queue at Intersection 7 extends through Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall.

Eastbound Candlers Mountain Road, PM Peak

- 2025 No-Build Model
    - The queue at Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue extends through Intersection 3 – Candlers Mountain Road at Woodall Road; the queue at Intersection 3 extends through Intersection 2 – Candlers Mountain Road at Short Street.
    - The queue at Intersection 7 – Candlers Mountain Road/US 501 at Mayflower Drive extends through Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall.
- 2040 No-Build Model
    - The queue at Intersection 7 – Candlers Mountain Road/US 501 at Mayflower Drive extends through Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall; the queue at Intersection 6 extends through Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue; the queue at Intersection 4 extends through Intersection 3 – Candlers Mountain Road at Woodall Road; the queue at Intersection 3 extends through Intersection 2 – Candlers Mountain Road at Short Street.

Westbound Candlers Mountain Road, AM Peak

- 2040 No-Build Model
    - The queue at Intersection 3 – Candlers Mountain Road at Woodall Road extends through Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue.

Westbound Candlers Mountain Road, PM Peak

- 2025 No-Build Model
    - The queue at Intersection 1 – Candlers Mountain Road / Sheffield Drive at Wards Road extends through Intersection 2 – Candlers Mountain Road at Short Street.
    - The queue at Intersection 3 – Candlers Mountain Road at Woodall Road extends through Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue.
    - Beginning of the queue at Intersection 7 – Candlers Mountain Road/US 501 at Mayflower Drive extends through Intersection 8 – Candlers Mountain Road at Westbound US 501 Ramp/Mountain View Road; the queue at Intersection 8 extends to the US 460 on-ramps. The queue would potentially impact the operations on US 460.
- 2040 No-Build Model
    - The queue at Intersection 1 – Candlers Mountain Road / Sheffield Drive at Wards Road extends through Intersection 2 – Candlers Mountain Road at Short Street.
    - The queue at Intersection 3 – Candlers Mountain Road at Woodall Road extends through Intersection 4 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramp / Seminole Avenue.
    - Beginning of the queue at Intersection 7 – Candlers Mountain Road/US 501 at Mayflower Drive extends through Intersection 8 – Candlers Mountain Road at Westbound US 501 Ramp/Mountain View Road; the queue at Intersection 8 extends to the US 460 on-ramps. The queue would potentially impact the operations on US 460.

Figure 16 – No-Build 2025 Levels of Service

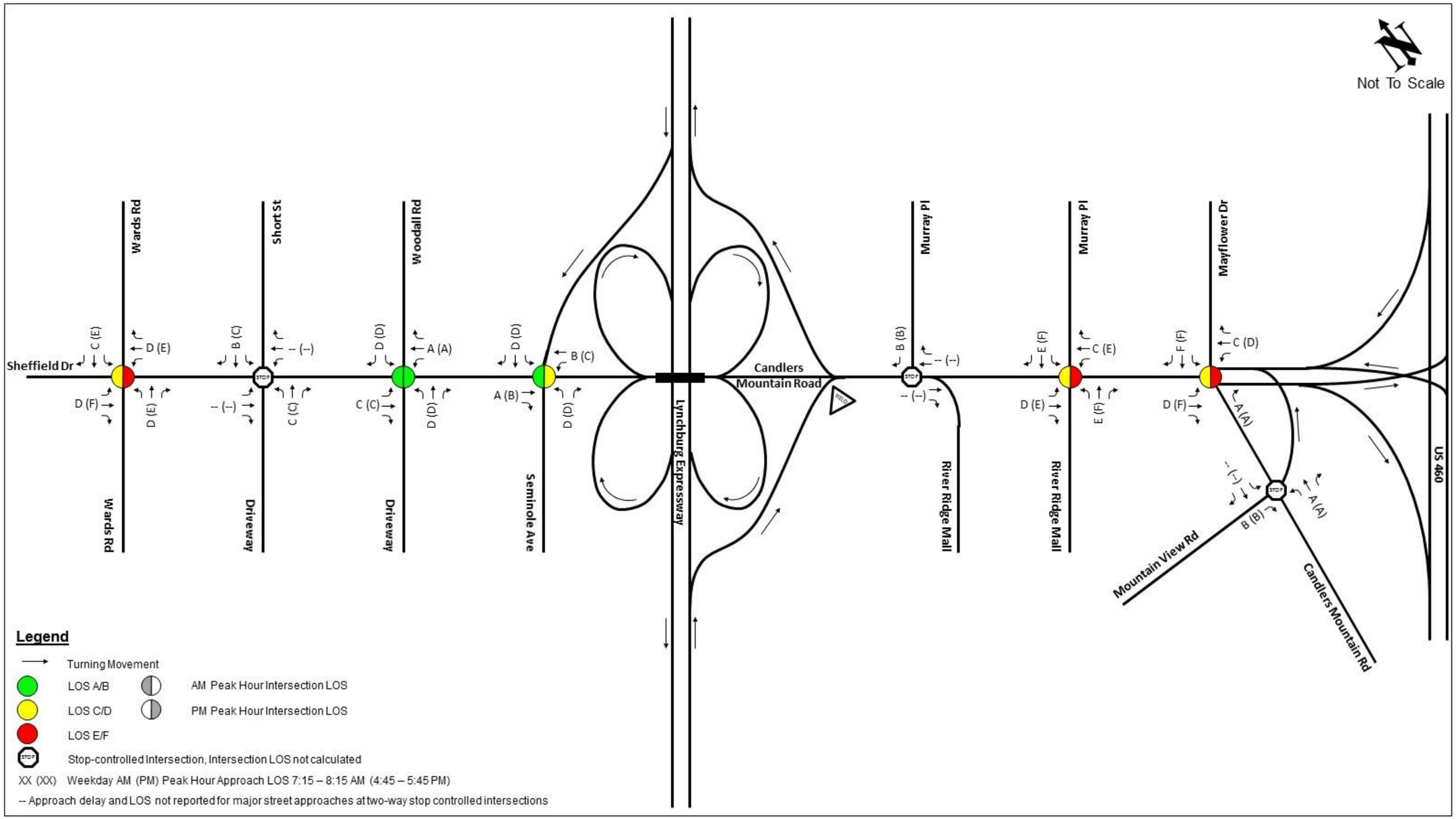
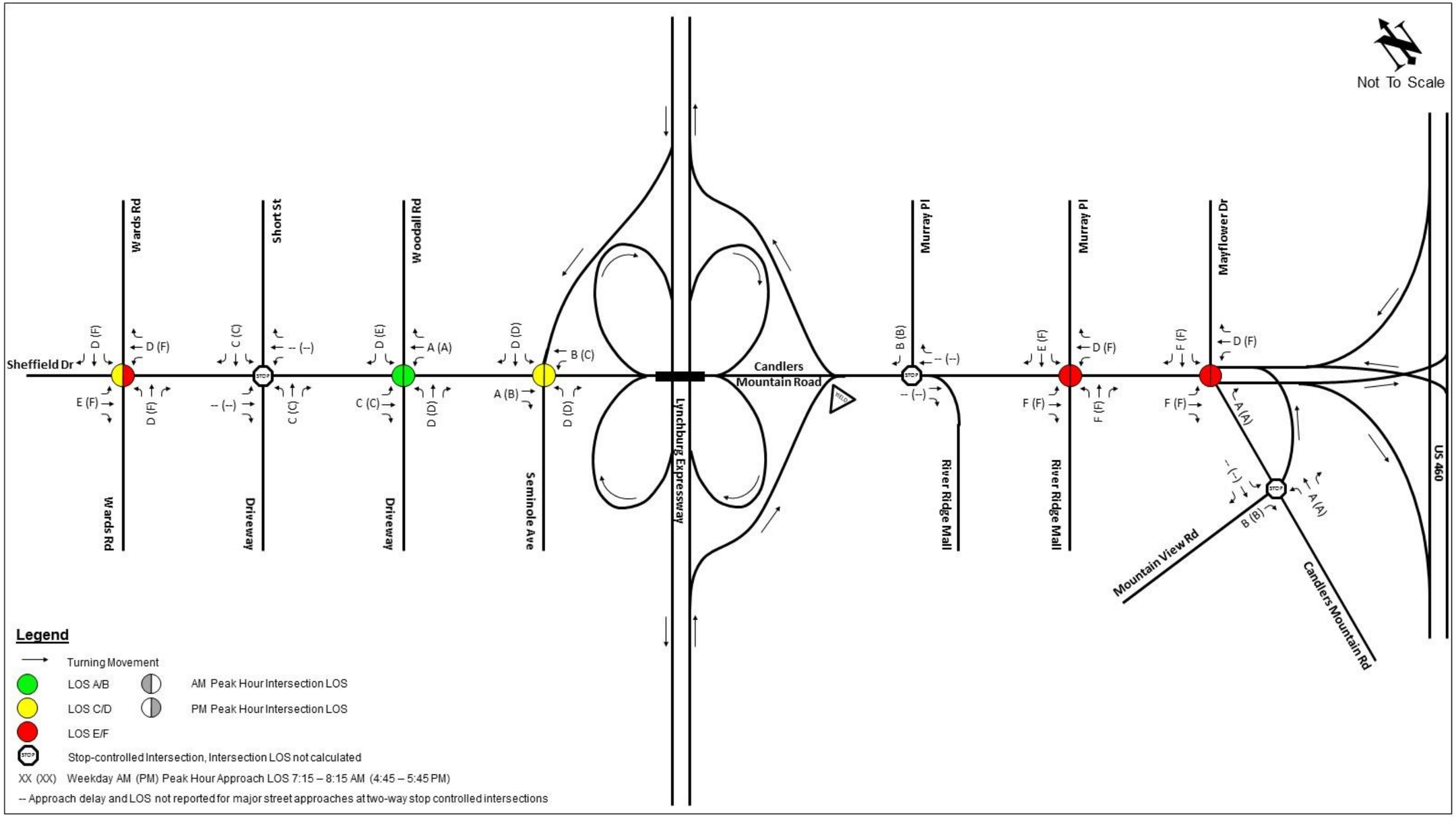


Figure 17 – No-Build 2040 Levels of Service



IMPROVEMENT SCREENING AND ANALYSIS

Potential improvement concepts were developed for Candlers Mountain Road and the Lynchburg Expressway to address operational, geometric, and safety deficiencies identified in the existing and no-build analyses as well as during the field review. A list of candidate projects was developed for consideration by the SWG. The candidate projects were then screened based on a combination of operational analyses, feasibility, and input from the SWG. The purpose of the screening process was to narrow down the list of potential improvements to projects that can be programmed into the VDOT SYIP.

Concept Development

The SWG developed a list of potential improvement concepts during the concept development phase. Improvement concepts were divided into the following categories:

- **West of the Lynchburg Expressway Improvement Concepts** – Potential improvement concepts at Wards Road, Woodall Road, and Seminole Avenue intersections
- **Lynchburg Expressway Interchange Improvement Concepts** – Potential improvement concepts on the Lynchburg Expressway mainline and entrance/exit ramps at Candlers Mountain Road
- **East of the Lynchburg Expressway Improvement Concepts** – Potential improvement concepts at Murray Place, Murray Place/River Ridge Mall, and Mayflower Drive intersections
- **Corridor-Wide Improvement Concepts** – Potential improvement concepts extending over the entire corridor
- **Further Study** – Potential improvement concepts that warrant further evaluation

During the concept development phase, the SWG qualitatively assessed the feasibility of the improvement concepts. The purpose of this qualitative assessment was to identify which alternatives would be analyzed for operational impacts. The improvement matrix in **Appendix E** provides a full list of the potential improvement concepts developed during the concept development phase.

Alternative Analysis

The second step of the screening process included operational analysis of selected improvement concepts from the concept development phase. Synchro and SIDRA were used to assess operational benefits of the alternative concepts. The alternatives were analyzed under 2040 PM peak hour traffic conditions and the operational results of the potential improvement concepts were compared to 2040 PM peak hour no-build results. The purpose of the alternative analysis was to screen the alternatives and select candidate projects to include in the 2025 and 2040 build models.

The geometric improvements listed below were selected for operational screening analysis. Additional details on the improvements and screening results are provided in **Appendix E**.

West of the Lynchburg Expressway Improvement Concepts

- Turn lane improvements at Wards Road intersection
- Dual lane roundabout at Wards Road intersection
- Median on Candlers Mountain Road between Wards Road and Woodall Road

Lynchburg Expressway Improvement Concepts

- Diamond interchange with loop in the northeast quadrant
- Partial cloverleaf interchange with loops in the northeast and northwest quadrants

East of the Lynchburg Expressway Improvement Concepts

- Dual lane roundabout at Murray Place/River Ridge Mall intersection
- Dual lane roundabout at Mayflower Drive intersection
- Turn lane improvements at Murray Place/River Ridge Mall intersection (with and without bridge widening)
- Turn lane improvements at Mayflower Drive intersection (with and without bridge widening)
- Double continuous Green-Ts at Murray Place/River Ridge Mall intersections (with and without bridge widening)
- Continuous Green-T at Mayflower Drive intersection (with and without bridge widening)
- Close River Ridge Mall free-flow right entrance
- Eliminate right-in, right-out Murray Place intersection

Improvement Project Selection

The final step of the screening process was the selection of improvements projects to carry further in the project development process. The selection of improvement projects was based on a review of the alternative analysis operational results, safety impacts, and general project feasibility. Project feasibility considered both constructability of improvements and project cost. The selected improvement projects are described in the following sections. Geometric improvement concepts were broken down into four stand-alone projects within the study area.

Geometric Improvements

Project 1: Wards Road Intersection and Access Management Improvements

Project 1 focused on improvements that would provide additional capacity to the Wards Road intersection and improve access management on Candlers Mountain Road between Wards Road and Woodall Road. A graphical representation of Project 1 is shown in **Figure 18**. Improvements included in Project 1 consisted of the following:

- Construct dual southbound left-turn lanes at the Wards Road intersection
- Construct dual westbound right-turn lanes at the Wards Road intersection
- Remove two-way left-turn lane and replace with a median on Candlers Mountain Road between Wards Road and Woodall Road
- Complete the sidewalk network on Candlers Mountain Road between Wards Road and the Lynchburg Expressway
- Install pedestrian crosswalks and signals on the north and west approaches of the Woodall Road intersection

Project 2: Lynchburg Expressway Ramps and Ramp Terminal Improvements

Project 2 focused on improvements to the Lynchburg Expressway interchange that would improve safety of entering and exiting vehicles by extending acceleration/deceleration lanes and reducing the number of weaving areas. A graphical representation of Project 2 is shown in **Figure 19**. Improvements included in Project 2 consisted of the following:

- Close the southbound Lynchburg Expressway exit ramp to eastbound Candlers Mountain Road
- Close the northbound Lynchburg Expressway entrance ramp from eastbound Candlers Mountain Road
- Realign the southbound Lynchburg Expressway exit ramp and install signal at ramp terminal
  - Construct two left-turn lanes and one right-turn lane at ramp terminal
- Realign the northbound Lynchburg Expressway entrance ramp and install signal at ramp terminal
  - Construct eastbound left-turn lane on Candlers Mountain Road at signal
  - Increase radius on ramp and provide acceleration and taper lengths that meet VDOT standards
- Lengthen the bridge over Lynchburg Expressway to allow for the construction of acceleration/deceleration lanes
  - Extend acceleration lane for the southbound Lynchburg Expressway entrance ramp
  - Extend deceleration lane for the northbound Lynchburg Expressway exit ramp to westbound Candlers Mountain Road
- Convert Seminole Avenue to a right-in, right-out, stop-controlled intersection and remove signal
- Construct sidewalks on the south side of Candlers Mountain Road between Seminole Avenue and the River Ridge Mall

Project 3: Murray Place and River Ridge Mall Continuous Green-T Intersection Improvements

Project 3 focused on improvements to the Murray Place and Murray/Place River Ridge Mall intersections that would improve operations on Candlers Mountain Road by eliminating signal phases and providing additional green time for vehicles. This project was constrained by the railroad bridge. Due to the good condition of the existing bridge and cost considerations, Project 3 were designed to remain within the footprint of the existing bridge. A graphical representation of Project 3 is shown in **Figure 20**. Improvements included in Project 3 consisted of the following:

- Construct a continuous Green-T at Murray Place (existing right-in, right-out) intersection
  - Construct a new signal
  - Construct an eastbound left-turn lane on Candlers Mountain Road
  - Eastbound through traffic does not stop at this intersection
  - Southbound traffic only permitted to make left-turn
  - Merge lane for southbound left turn continues through Murray Place/River Ridge Mall intersection
- Construct a continuous Green-T at Murray Place/River Ridge Road intersection
  - Construct a new signal
  - Construct a second westbound left-turn lane on Candlers Mountain Road
  - Construct a third receiving lane at the River Ridge Mall entrance to accommodate the dual westbound left-turn lanes and the free-flow right-turn lane
  - Construct a third northbound lane (one left-turn lane and dual right-turn lanes)
  - Westbound through traffic does not stop at this intersection
  - Merge lane for northbound left turn continues through eastern Murray Place intersection
  - Convert southbound approach to right-in, right-out, yield-controlled approach
- Close free-flow right-turn entrance ramp to River Ridge Mall
- Construct sidewalks on the north and south sides of Candlers Mountain Road between the Lynchburg Expressway and Murray Place/River Ridge Mall intersection

Project 4: Mayflower Drive Intersection Improvements

Project 4 focused on improvements to the Mayflower Drive intersection that would provide additional capacity to the Mayflower Drive intersection. A graphical representation of Project 4 is shown in **Figure 21**. Improvements included in Project 4 consisted of the following:

- Construct a southbound left-turn lane (in addition to the existing southbound left-through lane)
- Extend the eastbound right-turn lane back to the railroad bridge

Non-Geometric Improvements

Corridor-Wide Improvements

- Signal Communication – Incorporate the installation of signal communication infrastructure into design projects to align with VDOT's plans for a centralized signal software system

Further Study

- School Circulation Study – Perform a study to improve traffic flow during drop-off/pick-up at Liberty Christian Academy and identify circulation plans that eliminate queuing on Candlers Mountain Road
- Access Management Study – Perform additional study on opportunities to consolidate driveways on Candlers Mountain Road west of the Lynchburg Expressway interchange
- Pedestrian Crossing Study – Perform a study to evaluate alternatives for a pedestrian crossing at Murray Place/River Ridge Mall if double continuous Green-T's are constructed

Figure 18 – Project 1: Wards Road Intersection and Access Management Improvements

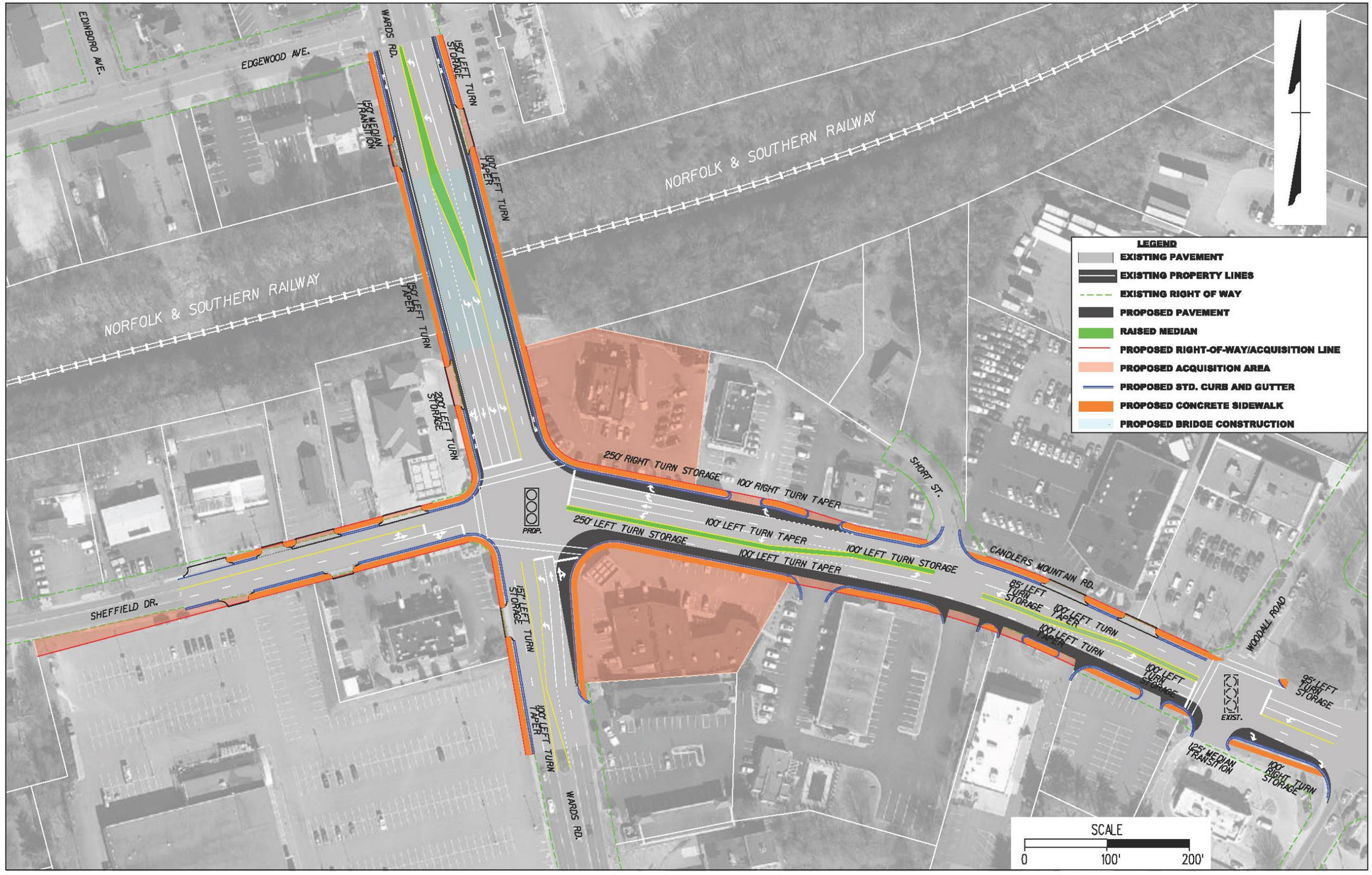


Figure 19 – Project 2: Lynchburg Expressway Ramps and Ramp Terminal Improvements

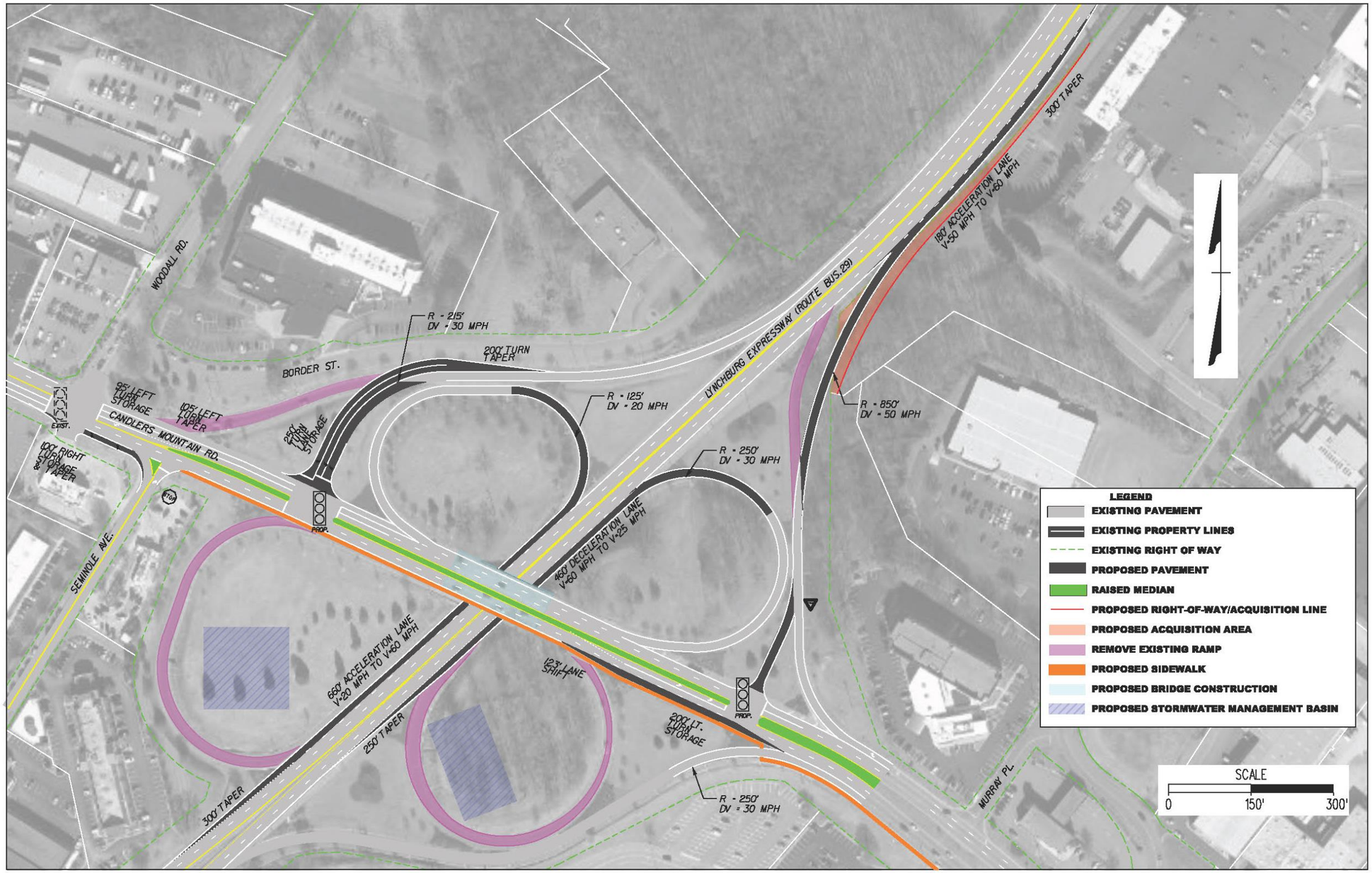


Figure 20 – Project 3: Murray Place and River Ridge Mall Continuous Green T Intersection Improvements

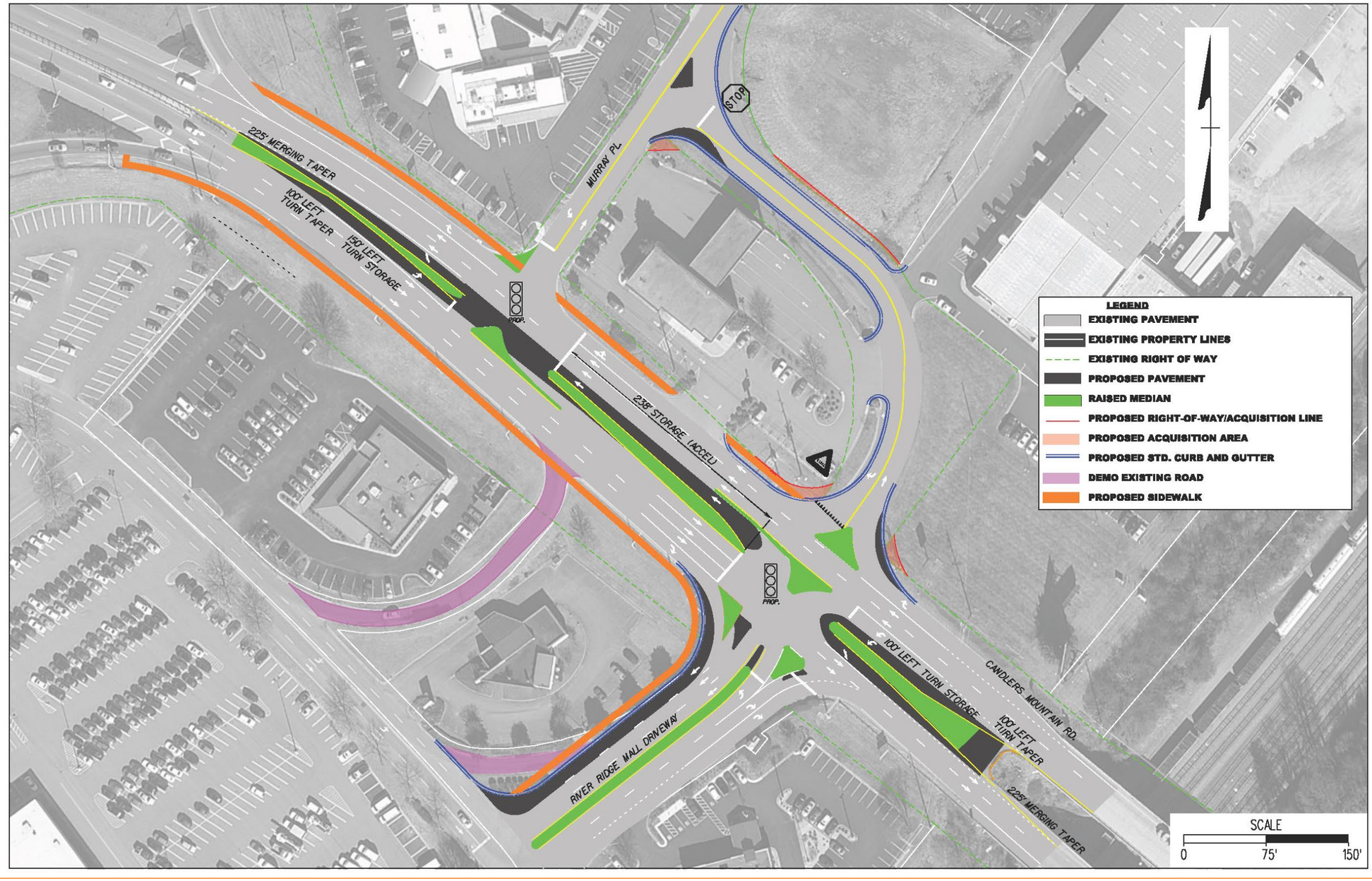
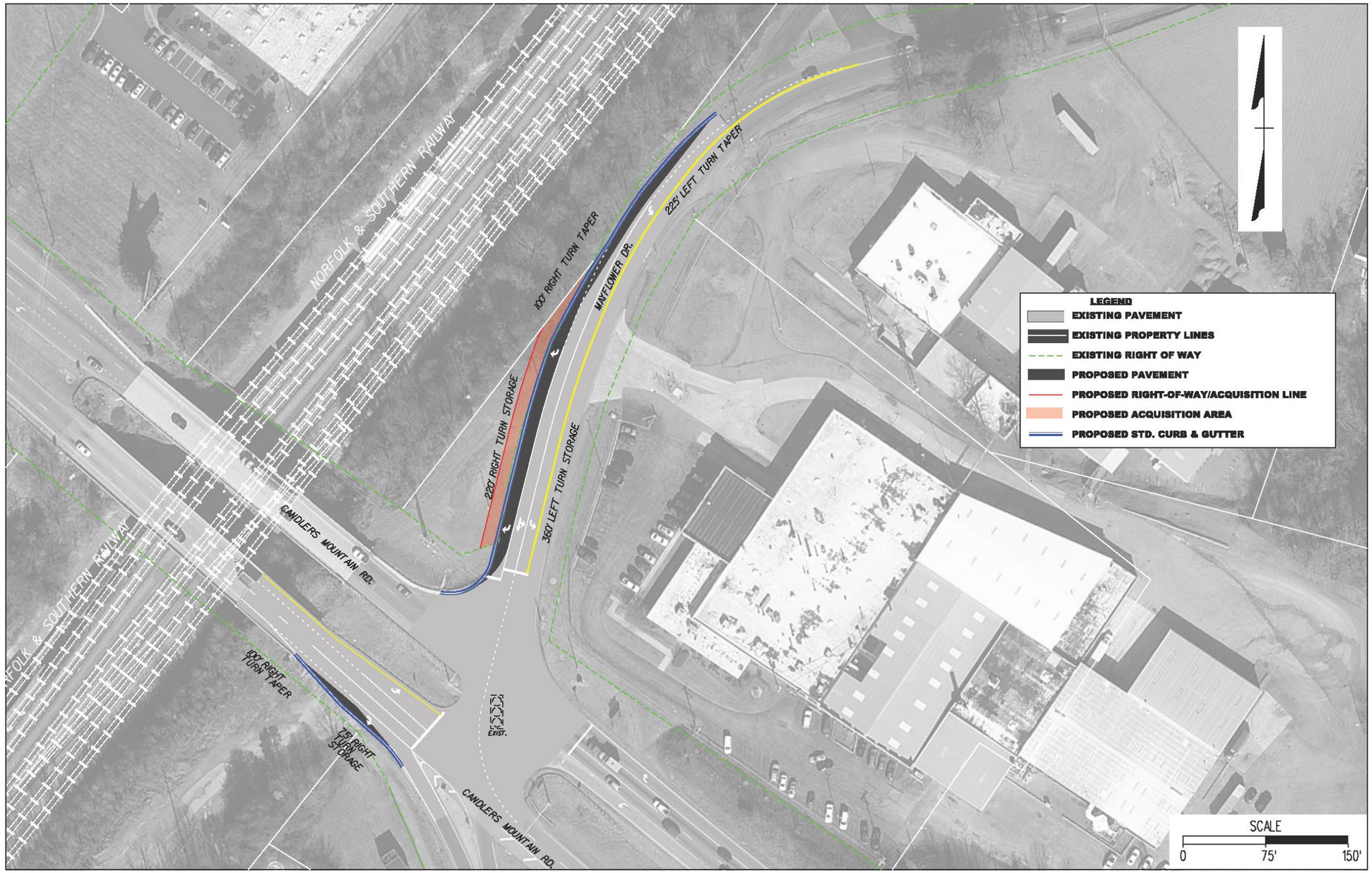


Figure 21 – Project 4: Mayflower Drive Intersection Improvements



BUILD CONDITIONS

Build conditions were analyzed to evaluate the results of future traffic demand on the proposed roadway network. The intent of the build analyses was to assess the effectiveness and operational benefits of the selected projects.

CORSIM and Synchro were used to analyze the build conditions. The CORSIM and Synchro build conditions models incorporated the geometric improvements associated with the four selected projects. The 2025 and 2040 build volumes were developed by from the 2025 and 2040 no-build AM and PM peak hour volumes. No-build volumes were rerouted to take into account the geometric improvements associated with the build conditions. The proposed build lane configurations are shown in **Figure 22**. Balanced projected 2025 and 2040 build AM and PM peak hour volumes are summarized in **Figure 23** and **Figure 24**, respectively.

CORSIM and Synchro modeling assumptions and analysis results for the build conditions in Interim Year 2025 and Design Year 2040 are described in the following sections.

CORSIM Analysis

CORSIM models were developed to analyze the operation of the Candlers Mountain Road study area under Design Year 2040 build AM and PM peak hour conditions. Interim Year 2025 build conditions were not analyzed in CORSIM.

Modeling Assumptions

The no-build conditions CORSIM models were used as a basis to develop the build models. Geometry in the build models was updated to reflect the proposed improvement concepts and the models were updated with projected 2040 build traffic volumes and optimized signal timing splits. A detailed summary of CORSIM modeling inputs and assumptions for the build models is provided in **Appendix F**.

The VDOT *Sample Size Determination Tool* was used to confirm that ten simulation runs would provide the acceptable 95% confidence level for both AM and PM build models. Ten simulation runs were conducted for both the AM and PM models using different random number seeds. The averages of these runs were reported. The VDOT *Sample Size Determination Tool* results are provided in **Appendix F**.

Results

The same MOEs used to evaluate existing conditions were used to measure the quantitative performance of the build CORSIM freeway and arterial networks:

- Vehicle density on freeway links
- Vehicle speed on freeway links
- Microsimulation delay at arterial intersections
- Maximum queue length on arterial links

Detailed simulation results including freeway lane schematics and intersection delay and queue tables are provided in **Appendix F**. Key findings from the build CORSIM analysis are summarized in the subsequent sections.

Vehicle Density on Freeway Links

Similar to the existing and no-build conditions analysis, the simulation LOS scale shown in **Table 8** was used to relate CORSM density results to an LOS. Summary tables with the CORSIM density results and corresponding simulation LOS for the AM and PM peak periods are provided in **Appendix F**. Critical links with a reported density that corresponds to a simulation LOS of D or worse are described below and summarized in **Table 12**.

Southbound Lynchburg Expressway

Under 2040 build conditions, no overall mainline links or ramps on the southbound Lynchburg Expressway operated at a simulation LOS of D or worse in the AM or PM peak hour.

Overall, the southbound Lynchburg Expressway mainline links reported lower vehicle densities under 2040 build conditions than under 2040 no-build conditions. Due to capacity constraints under no-build conditions that resulted in lower downstream simulated volumes, some mainline links south of the Candlers Mountain Road interchange reported slightly higher vehicle densities under 2040 build conditions than under 2040 no-build conditions. The difference between 2040 build and 2040 no-build densities at these locations were less than 2.0 vehicles per lane per mile.

Southbound Lynchburg Expressway ramp links reported equal or lower vehicle densities under 2040 build conditions than under 2040 no-build conditions, except at ramps with higher traffic volumes under build conditions due to the closure of another ramp. The Lynchburg Expressway entrance ramp from westbound Candlers Mountain Road, where the acceleration lane length was increased from 65 feet to 860 feet under build conditions, improved from simulation LOS F under no-build AM and PM peak hour conditions to simulation LOS C or better under build AM and PM peak hour conditions. The closure of the southbound Lynchburg Expressway exit ramp to eastbound Candlers Mountain road under build conditions resulted in higher traffic volumes and higher reported vehicle densities on the southbound Lynchburg Expressway exit ramp to eastbound/westbound Candlers Mountain Road under build conditions than under no-build conditions. With the additional traffic volumes under build conditions, the southbound Lynchburg Expressway exit ramp to eastbound/westbound Candlers Mountain Road operated at a simulation LOS B in the AM peak hour and LOS C in the PM peak hour.

Northbound Lynchburg Expressway

Under 2040 build conditions, overall mainline links on the northbound Lynchburg Expressway south of the exit ramp to Old Wards Road operated at a simulation LOS D in the AM and PM peak hours. No overall mainline links on the northbound Lynchburg Expressway operated at LOS E or LOS F under 2040 build AM and PM peak hour conditions. In addition, under 2040 build conditions, no ramps on the northbound Lynchburg Expressway operated at a simulation LOS of D or worse.

Figure 22 – Proposed Build Lane Configuration

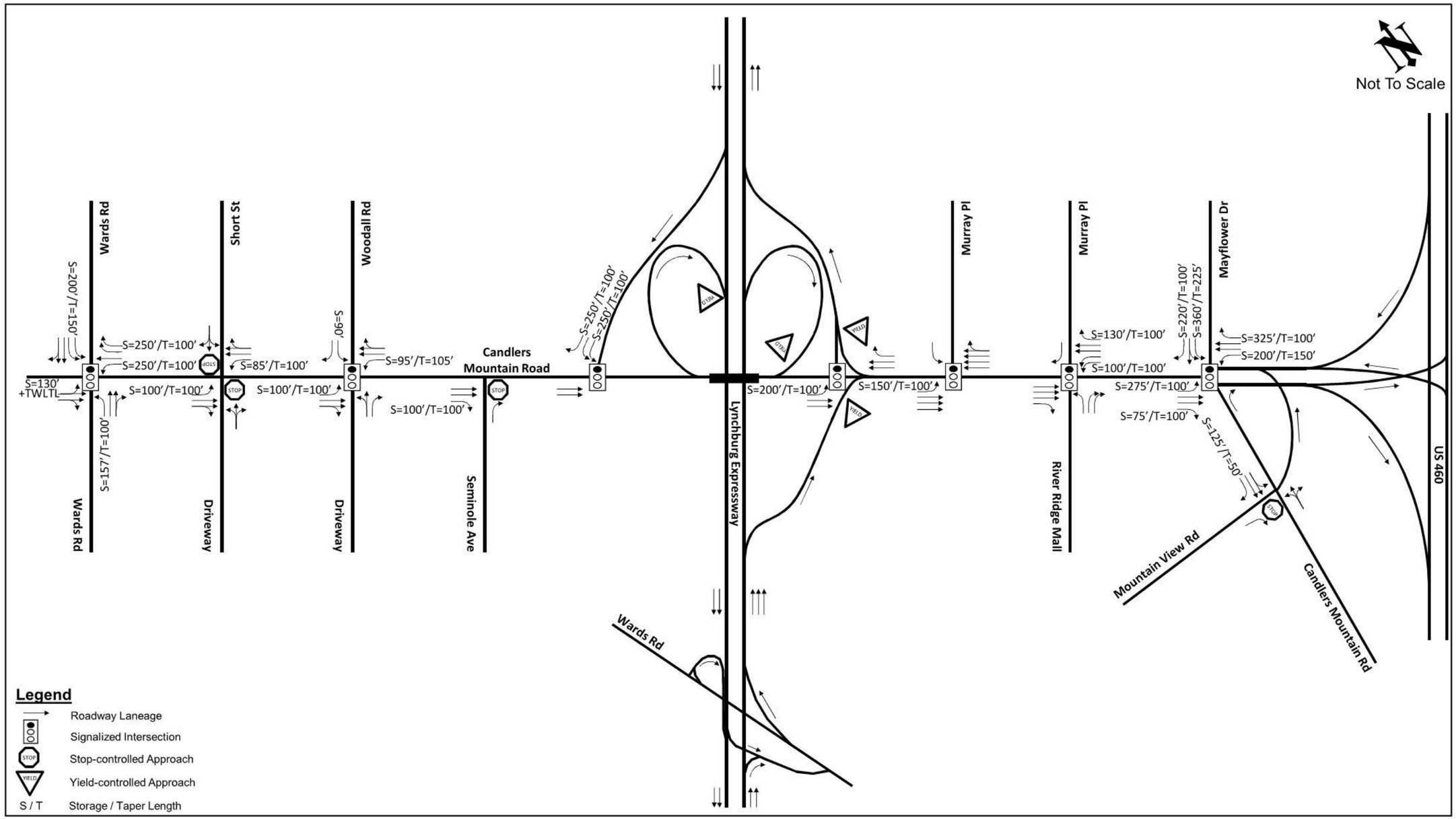


Figure 23 – Projected 2025 Build Peak Hour Volumes

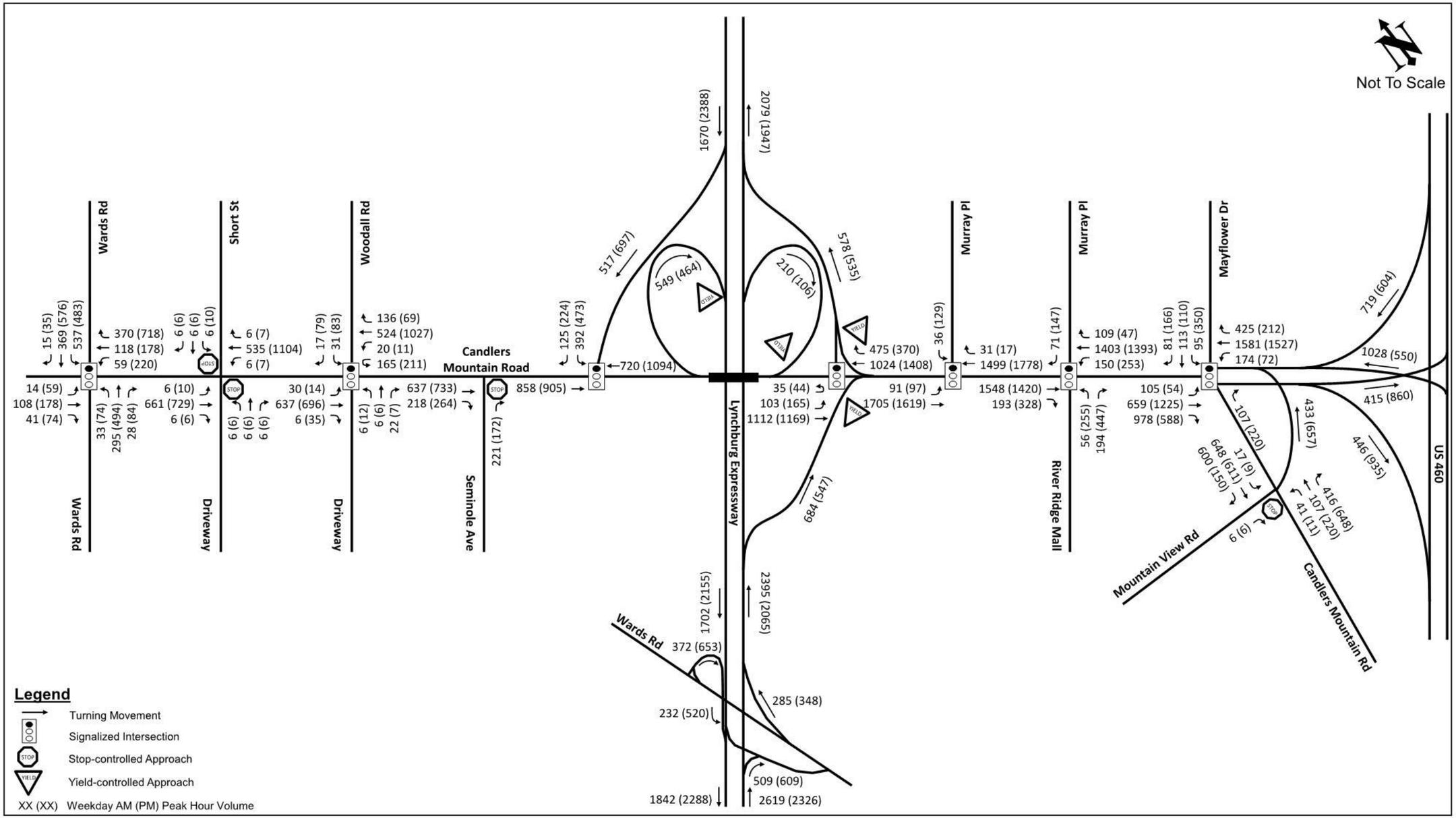
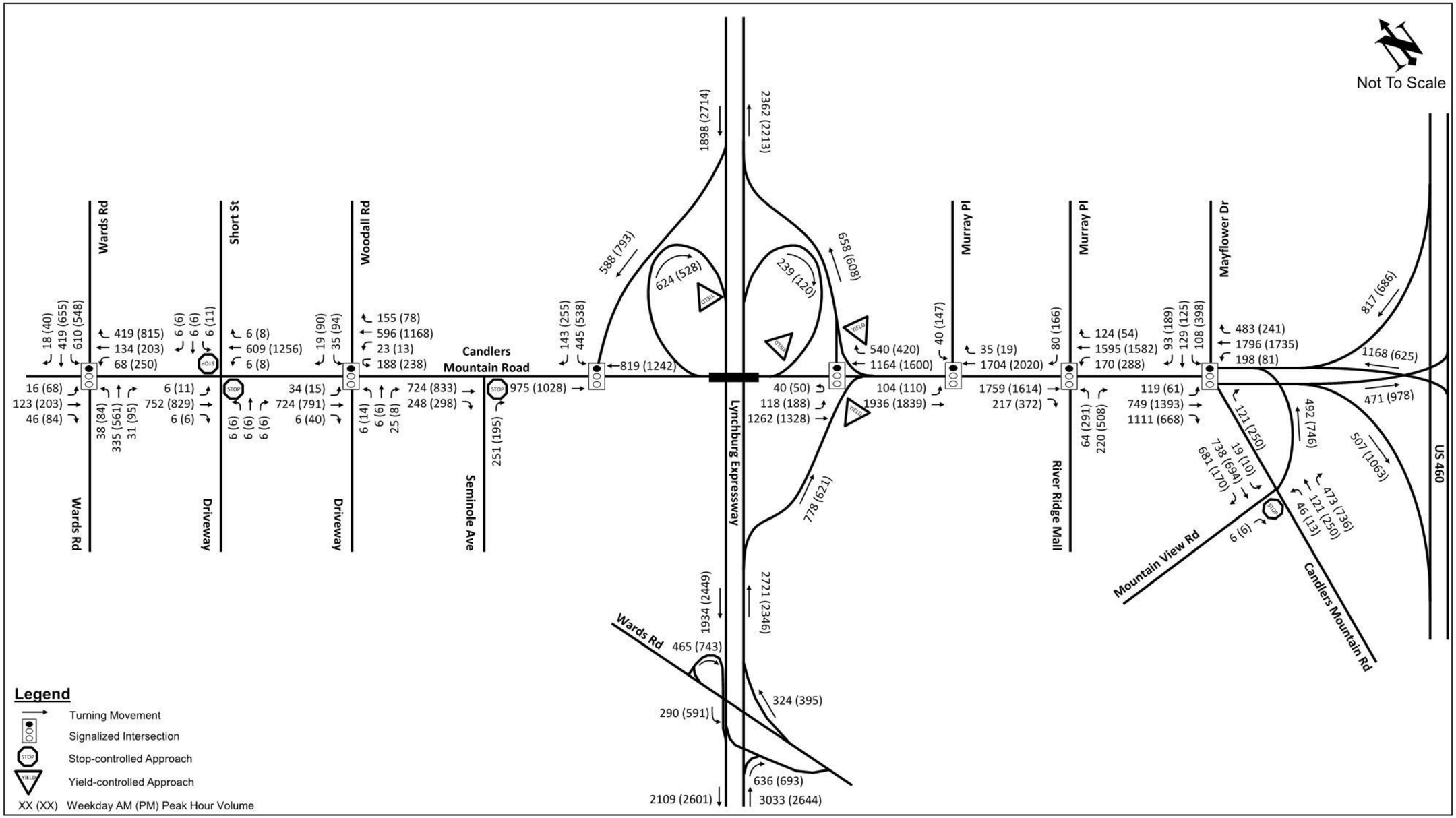


Figure 24 – Projected 2040 Build Peak Hour Volumes



Overall, the northbound Lynchburg Expressway mainline links reported lower vehicle densities under 2040 build conditions than other 2040 no-build conditions. Under 2040 no-build conditions, capacity constraints at the Lynchburg Expressway interchange resulted in simulated volumes more than 20% lower than actual volumes in both the AM and PM peak hours. As a result, northbound Lynchburg Expressway links north of the exit ramp to eastbound Candlers Mountain Road reported higher vehicle densities under 2040 build conditions than under 2040 no-build conditions. The difference between 2040 build and 2040 no-build densities at these locations was at most 6.1 vehicles per lane per mile.

Northbound Lynchburg Expressway ramp links reported lower vehicle densities under 2040 build conditions than under 2040 no-build conditions, except at ramps with higher traffic volumes under build conditions due to the closure of another ramp or due to capacity constraints under no-build conditions. The Lynchburg Expressway exit ramp to eastbound Candlers Mountain Road improved from simulation LOS F under no-build AM and PM peak hour conditions to LOS B under build AM and PM peak hour conditions because of improved operations on Candlers Mountain Road. The northbound Lynchburg Expressway exit ramp to Old Wards Road and exit ramp to westbound Candler Mountain Road both reported higher vehicle densities under 2040 build conditions than 2040 no-build conditions due to capacity constraints that resulted in lower simulated volumes on these ramps under 2040 no-build conditions. In addition, the closure of the northbound Lynchburg Expressway entrance ramp from eastbound Candlers Mountain Road under build conditions resulted in higher traffic volumes on the reconfigured northbound Lynchburg Expressway entrance ramp from eastbound/ westbound Candlers Mountain Road under build conditions than under no-build conditions. With the additional traffic volumes under build conditions, the entrance ramp from eastbound/westbound Candlers Mountain Road operated at a simulation LOS B in both the AM and PM peak hours.

Table 12 – Build CORSIM Links with Simulation LOS of D or Worse

Location	AM Peak Hour		PM Peak Hour	
	Density	Simulation LOS	Density	Simulation LOS
Southbound Lynchburg Expressway Mainline				
No overall links operate at simulation LOS of D or worse				
Southbound Lynchburg Expressway Ramps				
No ramps operate at simulation LOS of D or worse				
Northbound Lynchburg Expressway Mainline				
Northbound Lynchburg Expressway south of exit ramp to Old Wards Road	31.6	D	26.5	D
Northbound Lynchburg Expressway Ramps				
No ramps operate at simulation LOS of D or worse				

Vehicle Speeds on Freeway Links

Under build conditions, vehicle speeds on the Lynchburg Expressway were generally higher than or consistent with simulated speeds under no-build conditions. The most significant speed differentials between no-build and build conditions were reported at the following locations:

- The northbound Lynchburg Expressway reported speeds greater than 30 mph higher during the AM peak hour and greater than 35 mph higher during the PM peak hour under build conditions than under no-build conditions in the weave segment between the entrance ramp from Wards Road and the exit ramp to eastbound Candlers Mountain Road. Under build conditions, improved operations on Candlers Mountain Road reduced the queuing on mainline northbound Lynchburg Expressway from the exit ramp to eastbound Candlers Mountain Road, which allowed for increased vehicle speeds in the weave segment.
- The southbound Lynchburg Expressway reported speeds greater than 20 mph higher during the AM peak hour and greater than 25 mph higher during the PM peak hour under build conditions than under no-build conditions near the entrance ramp from westbound Candlers Mountain Road. Under build conditions, the acceleration lane was lengthened for this ramp, which allowed vehicles to maintain higher speeds when merging onto the Lynchburg expressway.

Overall, vehicle speeds on the Lynchburg Expressway under build conditions were simulated within the average range of 50-57 mph during the AM and PM peak periods. No Lynchburg Expressway mainline speeds were simulated under 43 mph during either the AM or PM peak periods. Simulated speeds less than 50 mph were reported at the following locations:

- During the AM and PM peak hours, the northbound Lynchburg Expressway reported speeds of less than 50 mph at the exit ramp to Old Wards Road and the exit ramp to eastbound Candlers Mountain Road
- During the AM and PM peak hours, the southbound Lynchburg Expressway reported speeds of less than 50 mph at the entrance ramp from westbound Candlers Mountain Road and the entrance ramp from Wards Road

Microsimulation Delay on Arterial Links

CORSIM microsimulation delay by movement, approach, and overall intersection was reported for the arterial intersections during the build 2040 AM and PM peak periods. The complete microsimulation delay results are provided in **Appendix F**. This microsimulation delay from CORSIM cannot be directly correlated with an HCM LOS. Similar to the existing and no-build conditions analysis, for this reason, Synchro was used as the primary tool for reporting intersection delay and LOS. The CORSIM microsimulation delay results were reviewed and found to generally align with the Synchro results for the build AM and PM peak periods. A summary of the Synchro delay and LOS results is provided in the Synchro/SimTraffic Analysis section of this report.

Maximum Queue Length on Arterial Links

While SimTraffic was the primary tool for reporting maximum queue length, the CORSIM maximum queue lengths were reviewed and found to generally align with the SimTraffic results for build 2040 conditions. For reference, the complete maximum queue length CORSIM results by movement and link for the build 2040 AM and PM peak

periods are provided in **Appendix F**. A summary of the SimTraffic maximum queue length results is provided in the Synchro/SimTraffic Analysis section of this report.

Synchro/SimTraffic Analysis

Synchro/SimTraffic models were developed to analyze the operation of the Candlers Mountain Road study area under Interim Year 2025 and Design Year 2040 build AM and PM peak hour conditions.

Modeling Assumptions

The no-build Synchro/SimTraffic models were used as a basis to develop the build models. Geometry in the build models was updated to reflect the proposed improvement concepts and the models were updated with projected 2040 build traffic volumes and optimized signal timing splits. A detailed summary of Synchro/SimTraffic modeling inputs and assumptions for the build models is provided in **Appendix F**.

Results

The same MOEs used to evaluate existing and no-build conditions were used to measure the quantitative performance of the build Synchro/SimTraffic models:

- Average vehicle delay and HCM LOS by movement, approach, and intersection – measured in seconds per vehicle
- Maximum queue length – measured in feet

Tables summarizing the delay, HCM LOS, and queuing results for the study area intersections are included in **Appendix F**. **Figure 25** and **Figure 26** show graphical representations of the LOS results in the study area under 2025 and 2040 build conditions. Key findings for the intersection analysis are summarized in the subsequent sections.

Delay and Level of Service

Under build conditions, all study area intersections operate at an overall intersection LOS of D or better under 2025 and 2040 build AM and PM peak hour conditions. All signalized intersections in the study area operate with lower overall intersection delay under 2025 and 2040 build conditions than under 2025 and 2040 no-build conditions. None of the overall intersections reported v/c greater than one under 2025 or 2040 build conditions.

When adjusting signal timings under build conditions, priority was given to through movement progression on eastbound and westbound Candlers Mountain Road. As a result, the overall eastbound and westbound Candlers Mountain Road approaches at all study area intersections operate at an LOS of D or better during the 2025 and 2040 AM and PM peak hours. However, some Candlers Mountain Road left-turn movements and side street movements operate at LOS E or LOS F during the AM and PM peak hours under 2025 and 2040 build conditions.

The Candlers Mountain Road eastbound and westbound left-turn movements listed below operate at a LOS E or LOS F under 2025 and/or 2040 build conditions. None of the movements on Candlers Mountain Road reported a v/c greater than one.

- Intersection 1 – Candlers Mountain Road / Sheffield Drive
  - Under 2040 build conditions, the westbound Candlers Mountain Road left-turn movement operates at LOS E (67.0 sec/veh) in the PM peak hour
- Intersection 5 – Candlers Mountain Road at Murray Place
  - Under 2025 build conditions, the eastbound Candlers Mountain Road left-turn movement operates at LOS E (70.3 sec/veh) in the AM peak hour and LOS E (75.2 sec/veh) in the PM peak hour
  - Under 2040 build conditions, the eastbound Candlers Mountain Road left-turn movement operates at LOS E (73.9 sec/veh) in the AM peak hour and LOS E (76.4 sec/veh) in the PM peak hour
- Intersection 6 – Candlers Mountain Road at Murray Place/River Ridge Mall
  - Under 2025 build conditions, the westbound Candlers Mountain Road left-turn movement operates at LOS F (80.8 sec/veh) in the AM peak hour and LOS E (68.4 sec/veh) in the PM peak hour
  - Under 2040 build conditions, the westbound Candlers Mountain Road left-turn movement operates at LOS F (80.4 sec/veh) in the AM peak hour and LOS E (61.9 sec/veh) in the PM peak hour
- Intersection 7 – Candlers Mountain Road / US 501 at Mayflower Drive
  - Under 2040 build conditions, the westbound Candlers Mountain Road left-turn movement operates at LOS E (67.0 sec/veh) in the AM peak hour and LOS E (57.0 sec/veh) in the PM peak hour

The side street approaches listed below operate at LOS E or LOS F under 2025 and/or 2040 build conditions:

- Intersection 2 – Candlers Mountain Road at Short Street
  - Under 2025 build conditions, the northbound commercial driveway approach operates at LOS F (66.5 sec/veh) in the PM peak hour
  - Under 2025 build conditions, the southbound Short Street approach operates at LOS F (82.7 sec/veh) in the PM peak hour
  - Under 2040 build conditions, the northbound commercial driveway approach operates at LOS E (36.8 sec/veh) and LOS F (132.8 sec/veh) in the PM peak hour
  - Under 2040 build conditions, the southbound Short Street approach operates at LOS F (209.4 sec/veh) in the PM peak hour
- Intersection 3 – Candlers Mountain Road at Woodall Road
  - Under 2025 build conditions, the northbound commercial driveway approach operates at LOS E (60.9 sec/veh) in the AM peak hour
  - Under 2025 build conditions, the southbound Woodall Road approach operates at LOS E (64.6 sec/veh) in the AM peak hour and LOS E (60.0 sec/veh) in the PM peak hour

- Under 2040 build conditions, the northbound commercial driveway approach operates at LOS E (60.4 sec/veh) in the AM peak hour
- Under 2040 build conditions, the southbound Woodall Road approach operates at LOS E (64.9 sec/veh) in the AM peak hour and LOS E (59.5 sec/veh) in the PM peak hour

- Intersection 5 – Candlers Mountain Road at Murray Place
  - Under 2025 build conditions, the southbound Murray Place approach operates at LOS E (67.4 sec/veh) in the AM peak hour and LOS F (88.5 sec/veh) in the PM peak hour
  - Under 2040 build conditions, the southbound Murray Place approach operates at LOS E (67.0 sec/veh) in the AM peak hour and LOS F (193.6 sec/veh) in the PM peak hour
- Intersection 6 – Candlers Mountain Road at Murray Place/River Ridge Mall
  - Under 2025 build conditions, the northbound River Ridge Mall approach operates at LOS E (59.9 sec/veh) in the AM peak hour and LOS F (91.3 sec/veh) in the PM peak hour
  - Under 2040 build conditions, the northbound River Ridge Mall approach operates at LOS E (60.1 sec/veh) in the AM peak hour and LOS F (127.7 sec/veh) in the PM peak hour
- Intersection 7 – Candlers Mountain Road / US 501 at Mayflower Drive
  - Under 2025 build conditions, the southbound Mayflower Drive approach operates at LOS E (64.4 sec/veh) in the AM peak hour and LOS E (62.5 sec/veh) in the PM peak hour
  - Under 2040 build conditions, the southbound Mayflower Drive approach operates at LOS E (68.1 sec/veh) in the AM peak hour and LOS F (81.6 sec/veh) in the PM peak hour
- Intersection 9 – Candlers Mountain Road at Southbound Lynchburg Expressway
  - Under 2025 build conditions, the southbound Lynchburg Expressway exit ramp approach operates at LOS E (58.4 sec/veh) in the AM peak hour and LOS E (58.5 sec/veh) in the PM peak hour
  - Under 2040 build conditions, the southbound Lynchburg Expressway exit ramp approach operates at LOS E (57.3 sec/veh) in the AM peak hour and LOS E (56.9 sec/veh) in the PM peak hour

Queue Length

A queuing analysis was completed for the study area intersections under 2025 and 2040 build AM and PM peak hour conditions. SimTraffic was used to perform 60-minute simulations for queuing analyses. The maximum queue lengths, measured in feet, were reported for 2025 and 2040 build AM and PM peak hour conditions and are summarized in **Appendix F**. For movements without conflicting volumes, no queue length is reported by SimTraffic.

The following turning movements reported maximum queue lengths that exceed storage bays under 2025 and/or 2040 build conditions for at least one percent of the peak hour analysis period:

Intersection 3 – Candlers Mountain Road at Woodall Road

- 2025 Build Model
  - Westbound left turn, 2% of PM peak hour
  - Southbound left turn, 12% of PM peak hour
- 2040 Build Model
  - Southbound left turn, 15% of PM peak hour

Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall

- 2025 Build Model
  - Westbound left turn, 5% of PM peak hour
- 2040 Build Model
  - Westbound left turn, 9% of PM peak hour

Intersection 7 – Candlers Mountain Road / US 501 at Mayflower Drive

- 2025 Build Model
  - Eastbound right turn, 1% of PM peak hour
  - Southbound right turn, 1% PM peak hour
- 2040 Build Model
  - Eastbound right turn, 2% of PM peak hour
  - Westbound right turn, 2% of AM peak hour and 1% of PM peak hour
  - Southbound right turn, 1% of PM peak hour

The following movements reported maximum queue lengths that block storage bays of adjacent lanes under 2025 and/or 2040 build conditions for at least one percent of the analysis period:

Intersection 1 – Candlers Mountain Road / Sheffield Drive at Wards Road

- 2025 Build Model
  - Northbound left-turn lane blocked by through movement, 3% of PM peak hour
- 2040 Build Model
  - Northbound left-turn lane blocked by through movement, 6% of PM peak hour

Intersection 3 – Candlers Mountain Road at Woodall Road

- 2025 Build Model
  - Eastbound left-turn lane blocked by through movement, 1% of PM peak hour
  - Westbound left-turn lane blocked by through movement, 1% of AM peak hour and 5% of PM peak hour
  - Southbound left-turn lane blocked by right-turn movement, 1% of PM peak hour
- 2040 Build Model
  - Eastbound left-turn lane blocked by through movement, 1% of AM peak hour and 4% of PM peak hour
  - Westbound left-turn lane blocked by through movement, 2% of AM peak hour and 10% of PM peak hour
  - Southbound left-turn lane blocked by right-turn movement, 2% of PM peak hour

Intersection 5 – Candlers Mountain Road at Murray Place

- 2025 Build Model
  - Eastbound left-turn lane blocked by through movement, 1% of AM peak hour and 2% of PM peak hour
- 2040 Build Model
  - Eastbound left-turn lane blocked by through movement, 9% of AM peak hour and 16% of PM peak hour

Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall

- 2025 Build Model
  - Westbound left-turn lane blocked by through movement, 5% of PM peak hour
- 2040 Build Model
  - Westbound left-turn lane blocked by through movement, 1% of AM peak hour and 5% of PM peak hour

Intersection 7 – Candlers Mountain Road / US 501 at Mayflower Drive

- 2025 Build Model
  - Eastbound left-turn lane blocked by through movement, 7% of PM peak hour
  - Eastbound right-turn lane blocked by through movement, 1% of AM peak hour and 14% of PM peak hour
  - Westbound left-turn lane blocked by through movement, 5% of AM peak hour and 7% of PM peak hour
  - Westbound right-turn lane blocked by through movement, 3% of AM peak hour and 3% of PM peak hours
  - Southbound right-turn lane blocked by through-left movement, 3% of PM peak hour
- 2040 Build Model
  - Eastbound left-turn lane blocked by through movement, 12% of PM peak hour
  - Eastbound right-turn lane blocked by through movement, 1% of AM peak hour and 17% of PM peak hour
  - Westbound left-turn lane blocked by through movement, 17% of AM peak hour and 21% of PM peak hour
  - Westbound right-turn lane blocked by through movement, 14% of AM peak hour and 18% of PM peak hours
  - Southbound left-turn lane blocked by through-left movement, 9% of the PM peak hour
  - Southbound right-turn lane blocked by through-left movement, 2% of the AM peak hour and 9% of PM peak hour

Intersection 9 – Candlers Mountain Road at Southbound Lynchburg Expressway Ramps

- 2025 Build Model
  - Southbound inner left -turn lane blocked by outer left-turn movement, 1% of AM peak hour and 2% of PM peak hour
  - Southbound right-turn lane blocked by left-turn movement, 1% of AM peak hour and 2% of PM peak hour
- 2040 Build Model
  - Southbound inner left -turn lane blocked by outer left-turn movement, 2% of AM peak hour and 3% of PM peak hour
  - Southbound right-turn lane blocked by left-turn movement, 2% of AM peak hour and 3% of PM peak hour

Intersection 10 – Candlers Mountain Road at Northbound Lynchburg Expressway Ramps

- 2040 Build Model
  - Eastbound left-turn lane blocked by through movement, 5% of AM peak hour and 2% of PM peak hour

Queues at several intersections extend through upstream intersections under build conditions. These queues are summarized below.

Eastbound Candlers Mountain Road, AM Peak

- 2025 Build Model
  - The maximum queue at Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall extends through Intersection 5 – Candlers Mountain Road at Murray Place
- 2040 Build Model
  - The maximum queue at Intersection 9 – Candlers Mountain Road at Southbound Lynchburg Expressway extends through Intersection 4 – Candlers Mountain Road at Seminole Avenue
  - The maximum queue at Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall extends through intersection 5 – Candlers Mountain Road at Murray Place; the maximum queue at Intersection 5 extends through Intersection 10 – Candlers Mountain Road at Northbound Lynchburg Expressway Ramps

Eastbound Candlers Mountain Road, PM Peak

- 2025 Build Model
  - The maximum queue at Intersection 3 – Candlers Mountain Road at Woodall Road extends through Intersection 2 – Candlers Mountain Road at Short Street
  - The maximum queue at Intersection 7 – Candlers Mountain Road / US 501 at Mayflower Drive extends through Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall; the maximum queue at Intersection 6 extends through intersection 5 – Candlers Mountain Road at Murray Place
- 2040 Build Model
  - The maximum queue at Intersection 3 – Candlers Mountain Road at Woodall Road extends through Intersection 2 – Candlers Mountain Road at Short Street
  - The maximum queue at Intersection 9 – Candlers Mountain Road at Southbound Lynchburg Expressway extends through Intersection 4 – Candlers Mountain Road at Seminole Avenue
  - The maximum queue at Intersection 7 – Candlers Mountain Road / US 501 at Mayflower Drive extends through Intersection 6 – Candlers Mountain Road at Murray Place / River Ridge Mall; the maximum queue at Intersection 6 extends through intersection 5 – Candlers Mountain Road at Murray Place; the maximum queue at Intersection 5 extends through Intersection 10 – Candlers Mountain Road at Northbound Lynchburg Expressway Ramps

Westbound Candlers Mountain Road, AM Peak

- 2025 Build Model
  - The maximum queue at Intersection 3 – Candlers Mountain Road at Woodall Road extends through Intersection 4 – Candlers Mountain Road at Seminole Avenue
  - The maximum queue at Intersection 10 – Candlers Mountain Road at Northbound Lynchburg Expressway Ramps extends through Intersection 5 – Candlers Mountain Road at Murray Place
- 2040 Build Model
  - The maximum queue at Intersection 3 – Candlers Mountain Road at Woodall Road extends through Intersection 4 – Candlers Mountain Road at Seminole Avenue
  - The maximum queue at Intersection 10 – Candlers Mountain Road at Northbound Lynchburg Expressway Ramps extends through Intersection 5 – Candlers Mountain Road at Murray Place

Westbound Candlers Mountain Road, PM Peak

- 2025 Build Model
  - The maximum queue at Intersection 3 – Candlers Mountain Road at Woodall Road extends through Intersection 4 – Candlers Mountain Road at Seminole Avenue
  - The maximum queue at Intersection 10 – Candlers Mountain Road at Northbound Lynchburg Expressway Ramps extends through Intersection 5 – Candlers Mountain Road at Murray Place
- 2040 Build Model
  - The maximum queue at Intersection 3 – Candlers Mountain Road at Woodall Road extends through Intersection 4 – Candlers Mountain Road at Seminole Avenue
  - The maximum queue at Intersection 10 – Candlers Mountain Road at Northbound Lynchburg Expressway Ramps extends through Intersection 5 – Candlers Mountain Road at Murray Place

Figure 25 – Build 2025 Levels of Service

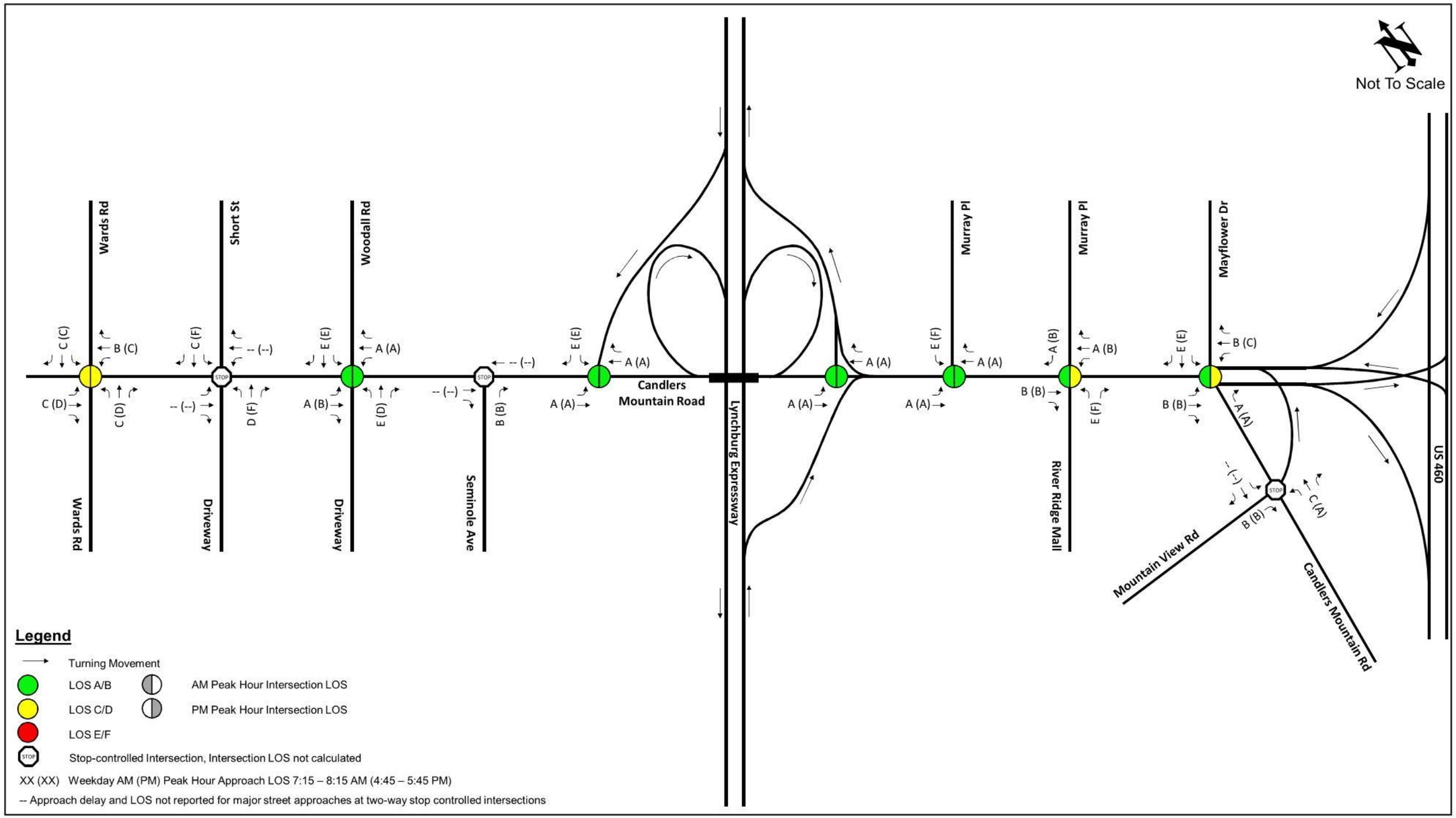
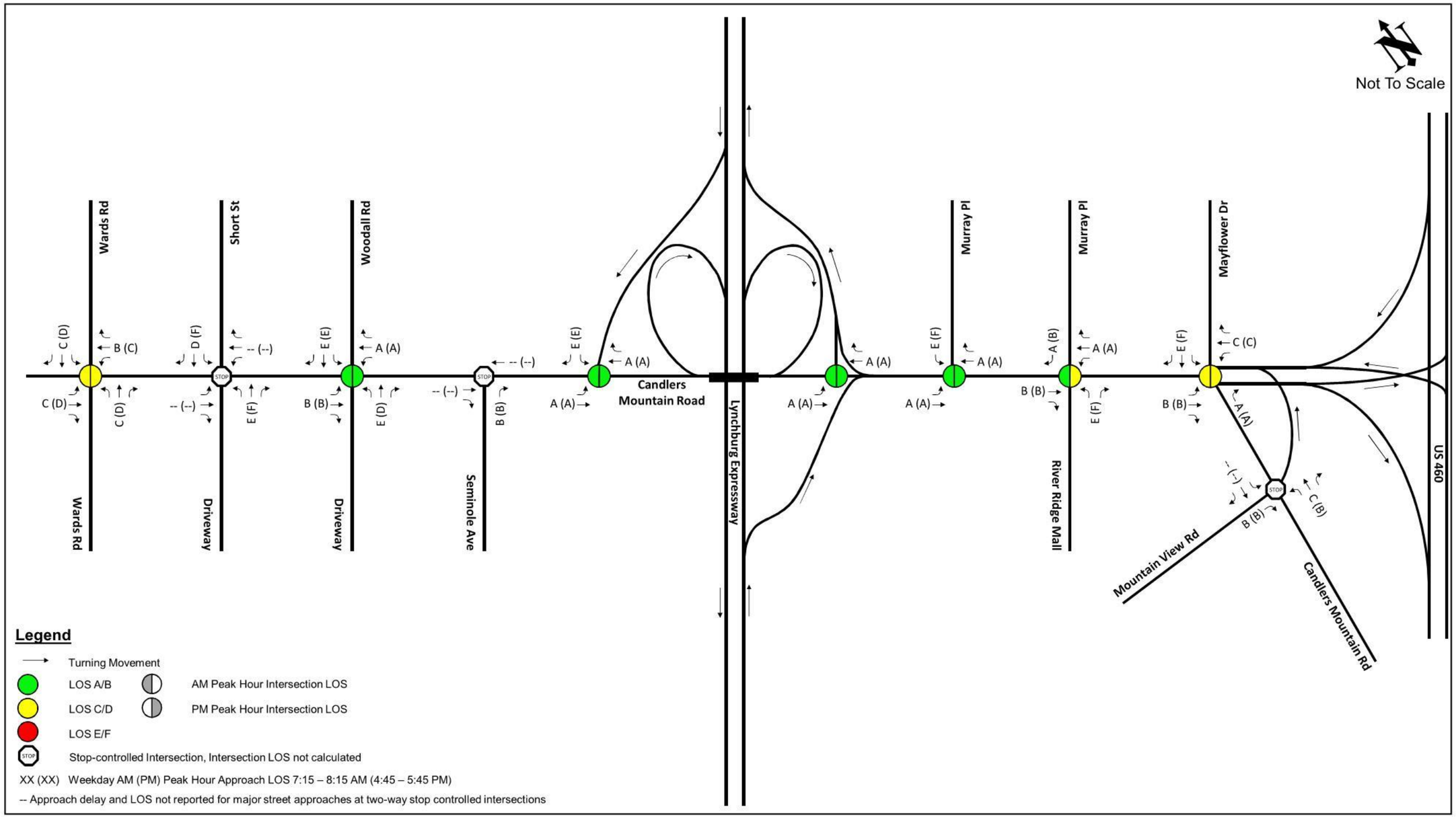


Figure 26 –Build 2040 Levels of Service



CONCEPTUAL DESIGN, COSTS, AND SCHEDULES

Conceptual Design

Conceptual design plans were developed for the four projects selected for further analysis. The design and geometric criteria for each project and the preferred project conceptual design is described in the following sections.

Conceptual design plans were developed in accordance with the following applicable guidelines:

- A Policy on Geometric Design of Highways and Streets (AASHTO 2011)
- A Policy on Design Standards – Interstate System, 5th Edition (AASHTO 2005)
- 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. The proposed design assumed a WB-67 as the design vehicle to determine the design impacts of the turning radius.

Conceptual design figures are shown in **Figure 18** through **Figure 21.**

Planning Level Cost Estimates and Schedules

Planning level cost estimates in 2016 dollars were also developed for each of the four projects. Construction (CN) costs were estimated using a combination of PCES, VDOT Planning Level Cost Estimate worksheet, and recent bid costs. Preliminary engineering (PE) and construction engineering and inspection (CEI) costs were estimated as a percentage of construction costs. A 20% contingency was included on the construction estimate not including mobilization and CEI. A detailed cost estimate should be prepared during the design phase of these projects.

A summary of the planning level costs estimates and schedules for each project are included in the following sections and in **Appendix G**.

Project 1: Wards Road Intersection and Access Management Improvements

Table 13 – Project 1 Planning Level Cost Estimate and Schedule

Description	Costs (2016)	Schedule (years)
Preliminary Engineering	$2,200,000	3.0
R/W and Utility Relocation	$5,100,000	2.5
Construction (CN)	$13,000,000	2.0
Total	**$20,300,000**	**7.5**

Project 2: Lynchburg Expressway Ramps and Ramp Terminal Improvements

Table 14 – Project 2 Planning Level Cost Estimate and Schedule

Description	Costs (2016)	Schedule (years)
Preliminary Engineering	$3,200,000	3.0
R/W and Utility Relocation	$310,000	0.5
Construction (CN)	$19,000,000	2.5
Total	**$22,510,000**	**6.0**

Project 3: Murray Place and River Ridge Mall Continuous Green T Intersection Improvements

Table 15 – Project 3 Planning Level Cost Estimate and Schedule

Description	Costs (2016)	Schedule (years)
Preliminary Engineering	$1,000,000	2.0
R/W and Utility Relocation	$980,000	1.0
Construction (CN)	$4,250,000	1.0
Total	**$6,230,000**	**4.0**

Project 4: Mayflower Drive Intersection Improvements

Table 16 – Project 4 Planning Level Cost Estimate and Schedule

Description	Costs (2016)	Schedule (years)
Preliminary Engineering	$700,000	1.0
R/W and Utility Relocation	$290,000	0.5
Construction (CN)	$1,400,000	0.5
Total	**$2,390,000**	**2.0**

PROJECT BENEFITS

Traffic operations and safety benefits were evaluated for the four projects selected for further analysis. Traffic operations benefits were evaluated by comparing the intersection delay under 2040 build conditions to the intersection delay under 2040 no-build conditions. Safety benefits were evaluated by calculating the potential reduction in crashes associated with each project. To calculate the potential reduction in crashes, crash reduction factors (CRFs) were applied to existing applicable crashes in the vicinity of the improvement project. The traffic operation and safety benefits for each of the projects are summarized in the following sections.

Traffic Operations Benefits

Project 1: Wards Road Intersection and Access Management Improvements

Table 17 – Project 1 Traffic Operations Benefits

	AM	PM
Candlers Mountain Road at Wards Road		
2040 No Build Intersection Delay	44.9 sec/veh	99.6 sec/veh
2040 Build Intersection Delay	23.8 sec/veh	38.2 sec/veh
Δ Intersection Delay	**-21.1 sec/veh**	**-61.4 sec/veh**
Candlers Mountain Road at Woodall Road		
2040 No Build Intersection Delay	16.9 sec/veh	18.0 sec/veh
2040 Build Intersection Delay	12.5 sec/veh	18.0 sec/veh
Δ Intersection Delay	**-4.4 sec/veh**	**0.0 sec/veh**

Project 2: Lynchburg Expressway Ramps and Ramp Terminal Improvements

Table 18 – Project 2 Traffic Operations Benefits

	AM	PM
Candlers Mountain Road at Southbound Lynchburg Expressway Ramp		
2040 No Build Intersection Delay	21.2 sec/veh	24.3 sec/veh
2040 Build Intersection Delay	14.4 sec/veh	15.7 sec/veh
Δ Intersection Delay	**-6.8 sec/veh**	**-8.6 sec/veh**
Candlers Mountain Road at Northbound Lynchburg Expressway Ramp		
2040 No Build Intersection Delay	- -	- -
2040 Build Intersection Delay	4.1 sec/veh	6.0 sec/veh
Δ Intersection Delay	**- -**	**- -**

Project 3: Murray Place and River Ridge Mall Continuous Green T Intersection Improvements

Table 19 – Project 3 Traffic Operations Benefits

	AM	PM
Candlers Mountain Road at Murray Place (west intersection)		
2040 No Build Intersection Delay	- -	- -
2040 Build Intersection Delay	4.2 sec/veh	13.4 sec/veh
Δ Intersection Delay	- -	- -
Candlers Mountain Road at Murray Place/River Ridge Mall		
2040 No Build Intersection Delay	61.8 sec/veh	126.2 sec/veh
2040 Build Intersection Delay	13.4 sec/veh	32.5 sec/veh
Δ Intersection Delay	**-48.4 sec/veh**	**-93.7 sec/veh**

Project 4: Mayflower Drive Intersection Improvements

Table 20 – Project 4 Traffic Operations Benefits

	AM	PM
Candlers Mountain Road at Mayflower Drive		
2040 No Build Intersection Delay	77.2 sec/veh	131.3 sec/veh
2040 Build Intersection Delay	23.7 sec/veh	31.3 sec/veh
Δ Intersection Delay	**-53.5 sec/veh**	**-100.0 sec/veh**

Safety Benefits

Project 1: Wards Road Intersection and Access Management Improvements

Table 21 – Project 1 Safety Benefits

Crash Reduction Factor (CRF)	CFR Crash Types	CRF Crash Severities	Study Area Applicable Crashes	Change in Crashes Due to Improvement
Replace two-way left-turn lane (TWLTL) with raised median[1]				
23	Angle, Fixed Object, Head On, Rear End, Run Off Road, Sideswipe, Single Vehicle	All	40	**-9.2**
Install left-turn lane[2]				
25	All	All	3	**-0.8**
Install right-turn lane[2]				
4	All	All	25	**-1.0**

Notes:
- CRFs were applied individually to the respective applicable crashes
- The median CRF was applied to crashes located within the limits of the proposed median
- The turn-lane CRFs were applied to crashes located on the specific approach and within the limits of the proposed turn lane

[1] Source: CMF Clearinghouse
[2] Source: FHWA Desktop Reference for Crash Reduction Factors

Project 2: Lynchburg Expressway Ramps and Ramp Terminal Improvements

Table 22 – Project 2 Safety Benefits

Crash Reduction Factor (CRF)	CFR Crash Types	CRF Crash Severities	Study Area Applicable Crashes	Change in Crashes Due to Improvement
SB Lynchburg Expressway Entrance Ramp from WB Candlers Mountain Road - Install acceleration lanes[1]				
75	All	All	39	**-29.3**
NB Lynchburg Expressway Entrance Ramp from WB Candlers Mountain Road – Install acceleration lanes[1]				
75	All	All	2	**-1.5**
NB Lynchburg Expressway Exit Ramp to WB Candlers Mountain Road - Install deceleration lanes[1]				
75	All	All	2	**-1.5**

Notes:
- CRFs were applied individually to the respective applicable crashes
- Crashes were separated by ramp based on the Lynchburg Expressway Improvement Study

[1] Source: FHWA Desktop Reference for Crash Reduction Factors

Project 3: Murray Place and River Ridge Mall Continuous Green T Intersection Improvements

Table 23 – Project 3 Safety Benefits

Crash Reduction Factor (CRF)	CFR Crash Types	CRF Crash Severities	Study Area Applicable Crashes	Change in Crashes Due to Improvement
Convert four-leg intersection into two three-leg intersections[1]				
57	All	All	101	**-57.6**
Install left-turn lane[1]				
25	All	All	7	**-1.8**

Notes:
- CRFs were applied individually to the respective applicable crashes
- The CRF for the conversion of a 4-leg intersection to two 3-leg intersections was applied to crashes located within the end of the turn lanes for approaches of the existing 4-leg intersection
- The turn-lane CRF was applied to crashes located on the specific approach and within the limits of the proposed turn lane

[1] Source: FHWA Desktop Reference for Crash Reduction Factors

Project 4: Mayflower Drive Intersection Improvements

Table 24 – Project 4 Safety Benefits

Crash Reduction Factor (CRF)	CFR Crash Types	CRF Crash Severities	Study Area Applicable Crashes	Change in Crashes Due to Improvement
Install left-turn lane[1]				
25	All	All	0	**- -**
Increase length of right-turn lane[1]				
15	All	Fatal, Injury	7	**-1.1**

Notes:
- CRFs were applied individually to the respective applicable crashes
- The turn-lane CRF was applied to crashes located on the specific approach and within 375 feet (the length of the proposed turn lane plus 200 feet to capture the effects of queuing) from the intersection

[1] Source: FHWA Desktop Reference for Crash Reduction Factors

PROJECT ADVANCEMENT

The Candlers Mountain Road Corridor Study should be used as a planning tool to achieve the next steps of planning, programming, designing, and constructing the identified operational and safety improvements in the study corridor. Specific steps include:

1. Gain consensus for projects and align with regional priorities

Conduct outreach meetings to stakeholders who were not part of the SWG for this study to gain acceptance for the proposed projects.

The SWG reached consensus on Project 1, Project 2 and Project 4. Project 3, the continuous green T intersection improvements, demonstrated the most feasibility for the River Ridge Mall and Murray Place intersections given funding constraints. However, the SWG expressed concerns about the applicability of the innovative design at this location. It is recommended that Project 3 be considered for further evaluation of operations in a more regional context to better understand the travel patterns of traffic to and from the River Ridge Mall property. This additional data and the use of a more detailed analysis tool may provide additional insight to the functionality and viability of Project 3 on the Candlers Mountain Road corridor.

2. Prepare projects for advancement

Once projects have been prioritized at the regional level, the highest priority projects should be advanced to the following:

- Constrained Long Range Transportation Plan (CLRP)
- Transportation Improvement Plan (TIP)
- Statewide Transportation Improvement Plan (STIP)
- VDOT Six-Year Improvement Program (SYIP)

Improvements identified in this study have been compiled into four project packages for consideration in implementation plans. However, some improvements could be implemented separately and/or with other projects based on funding availability and regional priorities to implement the projects in a more efficient timeframe. Examples may include the implementation of access management improvements, turn lanes, or pedestrian accommodations.

3. Apply for prioritized funding programs

Consider the following funding sources, or revenue sharing, for improvement projects identified in this study:

Highway Safety Improvement Program (HSIP)

Candidate improvement projects for HSIP funding:

- Project 2: Lynchburg Expressway Ramps and Ramp Terminal Improvements
  - Improves safety on the Lynchburg Expressway by eliminating weave areas and providing additional pavement for acceleration and deceleration lanes

SmartScale

Candidate improvement projects for SmartScale funding:

- Project 1: Wards Road Intersection and Access Management Improvements
- Project 2: Lynchburg Expressway Ramps and Ramp Terminal Improvements
- Project 3: Murray Place and River Ridge Mall Continuous Green-T Intersection Improvements
- Project 4: Mayflower Drive Intersection Improvements
- Signal Communication: Incorporate the installation of signal communication infrastructure into design projects to align with VDOT's plans for a centralized signal software system

Revenue Sharing

Candidate improvement projects for Revenue Sharing funding:

- Project 1: Wards Road Intersection and Access Management Improvements
- Project 3: Murray Place and River Ridge Mall Continuous Green-T Intersection Improvements
- Project 4: Mayflower Drive Intersection Improvements
- Signal Communication: Incorporate the installation of signal communication infrastructure into design projects to align with VDOT's plans for a centralized signal software system

Projects Identified for Further Study

Candidate improvement projects for further study:

- School Circulation Study – Perform a study to improve traffic flow during drop-off/pick-up at Liberty Christian Academy and identify circulation plans that eliminate queuing on Candlers Mountain Road
- Access Management Study – Perform additional study on opportunities to consolidate driveways on Candlers Mountain Road west of the Lynchburg Expressway interchange
- Pedestrian Crossing Study – Perform a study to evaluate alternatives for a pedestrian crossing at Murray Place/River Ridge Mall if double continuous Green-T's are constructed