



Port Republic Road

Safety and Operations Study

Harrisonburg, Virginia

April 2019



Table of Contents

EX-1	Executive Summary.....	1
	Operational and Safety Analyses.....	3
	Operational and Safety Recommendations.....	3
	Traffic Control Measures.....	3
	Geometric Changes.....	4
	Access Management Strategies.....	4
	Miscellaneous Recommendations.....	4
	Future Considerations.....	4
1	Introduction and Methodology.....	5
	Purpose.....	5
	Study Background.....	5
	Study Area Roadways.....	8
	Port Republic Road.....	8
	South Main Street.....	8
	Hillcrest Drive.....	8
	Crawford Avenue.....	8
	Bluestone Drive.....	8
	Hillside Avenue.....	9
	I-81.....	9
	Forest Hill Road.....	9
	Hunters Road.....	9
	Bradley Lane.....	10
	Devon Lane.....	10
	Pedestrian Activity.....	10
	Transit Operation.....	10
2	Operational Analysis.....	11
	Existing Conditions Review.....	11
	Geometry.....	11
	Intersection Control.....	11
	Traffic Volume Collection.....	12
	Static Routing Decisions.....	12
	Measures of Effectiveness.....	14
	2030 No Build Conditions Analysis.....	32
	Measures of Effectiveness.....	36
	2030 Build Conditions Analysis.....	54
	Geometric Changes.....	54
	Access Management Strategies.....	56
	Traffic Control Measures.....	59
	Measures of Effectiveness.....	63
	2018 Existing, No Build 2030, and Build 2030 Model Comparisons.....	79

3	Safety Analysis	89
	Methodology	89
	Crash Modification Factors.....	89
	Systemic Risk Factor Analysis	95
	Primary Focus Areas.....	98
	Crash Frequency Analysis.....	98
	Crash Rates	100
	Risk Factor Determination	102
	Rear-End Crashes at Signalized Intersections	103
	Rear-End Crashes at Unsignalized Intersections.....	105
	Angle Crashes.....	106
	Angle Crashes at Signalized Intersections	107
	Angle Crashes at Unsignalized Intersections.....	108
	Pedestrian Crashes.....	110
	Bicycle Crashes.....	111
	Site Specific Analysis.....	112
	Site Specific Location #1 – Port Republic and Forest Hill Road.....	113
	Site Specific Location #2 – Port Republic Road and Devon Lane.....	116
	Recommendations.....	118
	Safety Recommendations	118
	Congestion Mitigation	119
	Access Management.....	120
	Signal Optimization.....	120
	Conclusion	120
4	Conclusion and Cost Estimate	121
	Traffic Control Measures	121
	Geometric Changes.....	122
	Access Management Strategies.....	122
	Miscellaneous Recommendations	122
	Future Considerations	122
	Probable Estimate of Cost	123
	Short Term Projects.....	124
	Mid Term Projects.....	124
	Long Term Projects.....	125

List of Figures

Figure 1.1	Vicinity Map	2
Figure 1.2	Study Area Map.....	6
Figure 1.3	Existing Lane Configuration.....	7
Figure 2.1	2018 Existing Traffic Volumes	13
Figure 2.2	HCM Level of Service Criteria.....	14
Figure 2.3	Existing 2018 AM Level of Service.....	21
Figure 2.4	Existing 2018 PM Level of Service	22
Figure 2.5	Existing AM Speed Map	30
Figure 2.6	Existing PM Speed Map.....	31
Figure 2.7	Interchange Alternative	33
Figure 2.8	2030 No Build Lane Geometrics.....	34
Figure 2.9	2030 No Build Network Balanced Traffic Volumes	35
Figure 2.10	2030 AM No Build Level of Service.....	43
Figure 2.11	2030 PM No Build Level of Service	44
Figure 2.12	2030 No Build AM Speed Map	52
Figure 2.13	2030 No Build PM Speed Map	53
Figure 2.14	2030 Build Lane Geometrics	55
Figure 2.15	2030 Build Network Balanced Traffic Volumes.....	62
Figure 2.16	2030 AM Build Level of Service	69
Figure 2.17	2030 PM Build Level of Service.....	70
Figure 2.18	2030 Build AM Speed Map	77
Figure 2.19	2030 Build PM Speed Map.....	78
Figure 3.1	Heat Map of Crash Locations.....	91
Figure 3.2	Heat Map of Crash Locations and Severity.....	92
Figure 3.3	Crash Diagram – Forest Hill Road and Port Republic Road.....	93
Figure 3.4	Crash Diagram – Devon Lane and Port Republic Road.....	94
Figure 3.5	Intersection Crash Area	96
Figure 3.6	Crash Type by Intersection.....	97
Figure 3.7	Percent of Total Crashes	98
Figure 3.8	Crash Severity.....	99

List of Tables

Table 2.1	2018 AM Existing Level of Service.....	17
Table 2.2	2018 PM Existing Level of Service	19
Table 2.3	2018 AM Simulated Queue Lengths.....	24
Table 2.4	2018 PM Simulated Queue Lengths	26
Table 2.5	2018 Observed Travel Times	28
Table 2.6	2018 Simulated Travel Times.....	29
Table 2.7	2030 AM No Build Level of Service.....	39
Table 2.8	2030 PM No Build Level of Service	41
Table 2.9	2030 No Build AM Simulated Queue Lengths.....	47
Table 2.10	2030 No Build PM Simulated Queue Lengths	49
Table 2.11	2030 No Build Summary of Travel Time.....	51
Table 2.12	Planning Level Signal Warrant Analysis.....	57
Table 2.13	Devon Lane Alternatives	58
Table 2.14	2030 AM Build Level of Service	65
Table 2.15	2030 PM Build Level of Service.....	67
Table 2.16	2030 Build AM Simulated Queue Lengths	72
Table 2.17	2030 Build PM Simulated Queue Lengths.....	74
Table 2.18	2030 Build Summary of Travel Time.....	76
Table 2.19	Travel Time and Total Stops	79
Table 2.20	Average and Total Vehicle Stops.....	79
Table 2.21	Average and Total Vehicle Delay Time	80
Table 2.22	AM LOS Comparison	81
Table 2.23	PM LOS Comparison.....	83
Table 2.24	AM Queue Comparison.....	85
Table 2.25	PM Queue Comparison	87
Table 3.1	Proposed Countermeasures for the Study Area	90
Table 3.2	Crash Frequency.....	95
Table 3.3	Percentage of Total Crashes by Type.....	99
Table 3.4	Crash Severity.....	99
Table 3.5	Segment Crash Analysis	101
Table 3.6	Intersection Crash Rate Analysis	101
Table 3.7	Rear-End Crashes.....	102
Table 3.8	Rear-End Crashes by Time.....	103
Table 3.9	Angle Crashes.....	106
Table 3.10	Angle Crashes by Time	107
Table 4.1	Short Term Projects.....	124
Table 4.2	Mid Term Projects.....	125
Table 4.3	Long Term Projects	126

Appendices

- Appendix A Technical Memorandum – Existing Conditions
- Appendix B Signal Time Data
- Appendix C October 3, 2018 Port Republic Road Turning Movement Counts
- Appendix D VDOT Ramp Relocation Design Plans
- Appendix E Technical Memorandum – 2030 No Build Conditions
- Appendix F Technical Memorandum – 2030 Build Conditions
- Appendix G Port Republic Road and South Main Street Alternative Intersection Analysis
- Appendix H Crash Locations Per Intersection
- Appendix I Intersections and Improvements

EX-1 Executive Summary

A team comprised of members from the Harrisonburg Rockingham Metropolitan Planning Organization (HRMPO), City of Harrisonburg, Harrisonburg Department of Public Transportation (HDPT), and Virginia Department of Transportation (VDOT) identified the need to evaluate Port Republic Road for improved safety and operations within the City of Harrisonburg. Port Republic Road is a major urban arterial, providing access to commercial and residential areas of the City of Harrisonburg as well as the primary entrance into the James Madison University (JMU) campus. The project corridor spans from the intersection of Port Republic Road and South Main Street to the intersection of Port Republic Road and Devon Lane as shown in Figure 1.1. Closely spaced intersections, including the I-81 ramp interchange ramps, create congestion and safety concerns. This report documents the findings of the safety and operational analysis and presents the final recommendations for the corridor.





FIGURE 1.1
VICINITY MAP

Port Republic Road Safety and Operations Study
Harrisonburg, Virginia

Operational and Safety Analyses

As part of the study, an operational analysis of signalized and key unsignalized intersections along the project corridor was conducted. The evaluation examined (2018) existing conditions, 2030 no build and 2030 build conditions. The analysis of existing and no build conditions demonstrates that several intersections within the corridor are operating over capacity, creating undesirable level of service metrics as well as significant queues which contribute to slow speeds and increased travel times throughout the corridor. The results of these analysis guided the operational recommendations that were included in the 2030 build model.

A safety analysis was conducted along the corridor to measure current crash trends and develop site specific improvements to achieve a reduction in the number of crashes or the severity of crashes. Five (5) years and six months (January 2013-June 2018) of crash data was used to assess the current safety of the Port Republic Road study corridor. The crash reports were categorized by several factors, including crash frequency per location, time of day, and crash types. The data was processed from multiple perspectives to provide the most comprehensive evaluation of the roadway conditions. The results were used to recommend a set of countermeasures which can predictively produce facilities with reduced crash rates after implementation.

Operational and Safety Recommendations

The recommendations can be organized into four (4) categories: traffic control measures, geometric changes, access management strategies and miscellaneous.

Traffic Control Measures

- Optimize corridor signal timings including cycle lengths, splits, offsets, and phasing sequences;
- Eliminate the split phase operation at the relocated NB I-81 off-ramp and Forest Hills;
- Eliminate the split phase operation at Port Republic Road and Devon Lane;
- Eliminate the northbound and southbound pedestrian crossing at Port Republic Road and Bluestone Drive;
- Signalize Port Republic Road and Bradley Lane;
- Install flashing yellow arrows (FYAs) where protected/permissive left turns are used. This allows for lead/leg left turn phasing which will assist in bi-directional coordination.
- Install High Visibility Backplates;
- Evaluate the implementation of red-light running cameras;
- Install yield sign on the right side of the roadway for the northbound channelized right turn at Port Republic Road and South Main Street;
- Relocate the crosswalk within the channelized northbound right turn lane at Port Republic Road and Devon Road;

- Install green markings in the bike lane across driveways and intersections; and,
- Restripe the westbound left turn lane at the intersection of Port Republic Road and Devon Road to clearly designate the transition from a two-way-left-turn-lane to a dedicated left turn lane.

Geometric Changes

- Construct a westbound right turn lane with 100 feet of storage and a 100 foot taper on Port Republic Road at the intersection of Port Republic Road and Forest Hill Road;
- Increase the eastbound left turn lane storage length on Port Republic Road and Bluestone Drive from 100 feet to 300 feet;
- Increase the southbound left turn lane and right turn lane storage length on the south I-81 off ramp from 100 feet to 500 feet;
- Reconfigure the westbound Port Republic Road approach at South Main Street to include two left turn lanes, one through lane, one through/right and one right turn lane;
- Reconfigure the northbound approach of Devon Lane at Port Republic Road to include one left turn lane, one through lane and one right turn lane. Widen the southbound approach to include one left turn lane, one through lane and one right turn lane; and,
- Construct a pedestrian overpass over Port Republic at Bluestone Drive/Hillside Avenue.

Access Management Strategies

- Implement peak hour turning restrictions at Hillcrest Drive, Crawford Ave, and Hunters Road;
- Install a median to restrict turning movements within the proximity of all signalized intersections; and,
- Close the gas station driveway located on the north side of Port Republic Road just east of Forest Hill Road on Port Republic Road.

Miscellaneous Recommendations

- Install high friction surface course at downhill approaches to increase skid resistance and reduce stopping distances.

Future Considerations

Below are considerations that are excepted to involve significant financial investment, or will require more study, and should be considered in the future.

- Transit stop enhancements;
- Evaluate intersection sight distance;
- Install left turn lanes at the unsignalized intersections;
- Evaluate the design of the vertical curves to current geometric design standards to provide adequate sight distance; and,
- Investigate a bus pull-out for transit vehicles in the westbound direction on Port Republic Road just east of Forest Hill Road.

1 Introduction and Methodology

Purpose

A team comprised of members from the Harrisonburg Rockingham Metropolitan Planning Organization (HRMPO), City of Harrisonburg, Harrisonburg Department of Public Transportation (HDPT), and Virginia Department of Transportation (VDOT) identified the need to evaluate Port Republic Road for improved safety and operations within the City of Harrisonburg. Port Republic Road is a major urban arterial, providing access to commercial and residential areas of the City of Harrisonburg as well as the primary entrance into the James Madison University (JMU) campus. The project corridor spans from the intersection of Port Republic Road and South Main Street to the intersection of Port Republic Road and Devon Lane as shown above in Figure 1.1. Closely spaced intersections, including the I-81 ramp interchange ramps, create congestion and safety concerns.

The purpose of this study was to identify improvements that should improve transportation safety and operations within the Port Republic Corridor through the study area.

Study Background

The study area is along Port Republic Road from South Main Street to Devon Lane and is approximately one (1) mile in length. Ten (10) intersections located along the corridor were chosen for the study as shown in Figure 1.2. Port Republic Road is classified as a major urban arterial and provides access to commercial and residential areas of the City of Harrisonburg as well as serves as the primary access onto the JMU Campus. Population growth and expansion of the JMU campus and student housing has significantly increased motor vehicle traffic as well as bicycle and pedestrian traffic over the past few years.

The intersections included in the study are:

- Port Republic Road and South Main Street;
- Port Republic Road and Hillcrest Drive;
- Port Republic Road and Crawford Avenue;
- Port Republic Road and Bluestone Drive/Hillside Avenue;
- Port Republic Road and Southbound I-81 Ramps;
- Port Republic Road and Northbound I-81 Ramps;
- Port Republic Road and Forest Hill Road;
- Port Republic Road and Hunters Road;
- Port Republic Road and Bradley Drive; and,
- Port Republic Road and Devon Lane.

The study area includes six (6) signalized intersections and four (4) unsignalized intersections. The study area map is shown in Figure 1.2 and displays the study intersections and the street network serving the site. Figure 1.3 shows the existing lane configurations at each of the intersections.

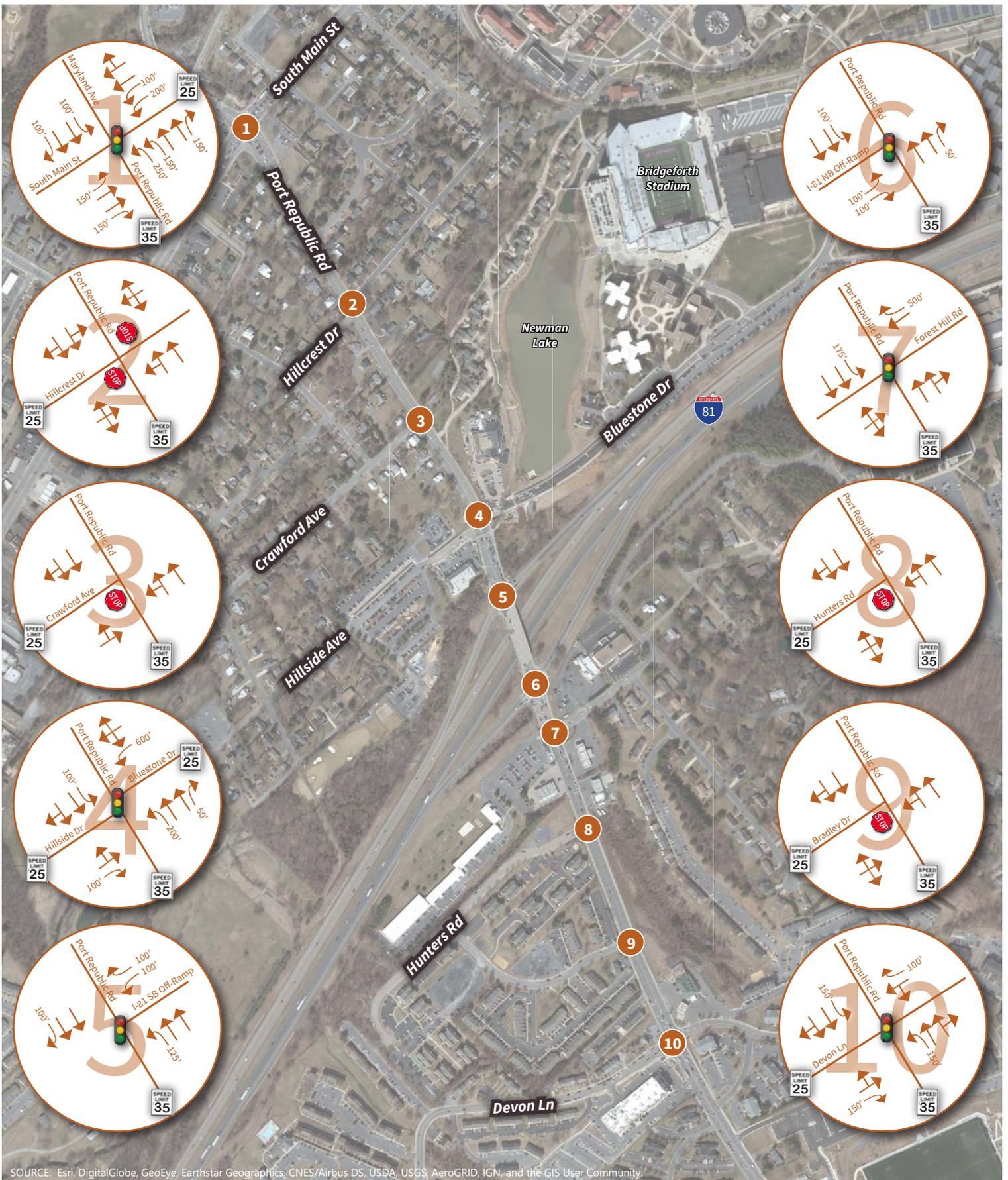


SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 1.2
STUDY AREA MAP

Port Republic Road Safety and Operations Study
Harrisonburg, Virginia



SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 1.3
EXISTING LANE CONFIGURATION
 Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

Study Area Roadways

Port Republic Road

Port Republic Road is a four-lane major urban arterial which provides access to commercial and residential areas of the City of Harrisonburg as well as access to JMU campus. Turn lanes are provided at each signalized intersection within the study area. Painted bike lanes are present east of the I-81 interchange. In 2017 VDOT reported an annual average daily traffic along the Port Republic corridor both east and west of I-81 within the study area at 27,000 vehicles per day. The posted speed limit is 35 miles per hour (mph).

South Main Street

South Main Street is a five-lane major urban arterial which provides access to commercial and residential areas of the City of Harrisonburg as well as access to JMU campus. Dedicated right turn lanes are provided for the eastbound, westbound and northbound right turning movements. Dual left turn lanes are provided for the westbound and southbound turning movements, and single left turn lanes are provided for the eastbound and northbound movements. Painted bike lanes are present both north and south of the intersection with Port Republic Road. In 2017 VDOT reported an annual average daily traffic along South Main Street 19,000 vehicles per day south of the intersection with Port Republic Road and 23,000 vehicles per day north of the intersection with Port Republic Road. The posted speed limit is 25 mph north of the intersection with Port Republic Road and 35 mph south of the intersection with Port Republic Road.

Hillcrest Drive

Hillcrest Drive is an unsignalized two-lane roadway that runs both north and south of Port Republic Road. Hillcrest Drive provides access to a neighborhood with single family homes. The posted speed limit on the north side of Port Republic Road is 25 mph. The speed limit is not posted on the south side of Port Republic Road and is considered 25 mph due to its classification as a residential street.

Crawford Avenue

Crawford Avenue is an unsignalized two-lane roadway that runs both north and south of Port Republic Road. Hillcrest Drive provides access to a neighborhood with single family homes. The posted speed limit is 25 mph.

Bluestone Drive

Bluestone Drive extends from the north side of Port Republic Road and serves as a primary access for JMU's main campus. It is a signalized two-lane roadway with a left turn lane provided for southbound traffic onto Port Republic Road. The Bluestone Trail runs parallel to Bluestone Drive along the north side of the roadway. The posted speed limit is 25 mph.

Hillside Avenue

Hillside Avenue extends from the south side of Port Republic Road across from Bluestone Drive. It is a signalized two-lane roadway with a dedicated northbound right turn lane onto Port Republic Road. It provides access to a commercial property as well as a permitted parking lot for JMU. The Bluestone Trail runs parallel to Hillside Avenue on the north side of the roadway and crosses Port Republic Road at a signalized marked crosswalk. There is no posted speed limit.

I-81

Interstate 81 that traverses through the City of Harrisonburg serving long-range travelers, regional travelers from the surrounding areas, and local users. I-81 bisects the City of Harrisonburg and JMU.

I-81 Southbound

It is anticipated the I-81 southbound on- and off-ramps will retain their existing alignment through 2030. In 2017 the average annual daily traffic along I-81 south was 4,300 vehicles per day. The advisory speed of this exit is 30 mph.

I-81 Northbound

Currently the on- and off-ramps of I-81 northbound are signalized with a configuration of dedicated left and right northbound turn lanes onto Port Republic Road. In 2017 the average annual daily traffic along I-81 south was 4,600 vehicles per day. The advisory speed of this exit is 30 mph.

Design plans are currently being developed to relocate the northbound off-ramp to align with Forest Hill Drive to the east. This realignment will provide direct access to University Boulevard, which provides access to the east campus of JMU. The on-ramp to travel north on I-81 will retain its existing alignment.

Forest Hill Road

Forest Hill Road on the north side of Port Republic Road is a two-lane roadway with a dedicated southbound right turn lane onto Port Republic Road. It provides access to a multitude of uses including a hotel, multi-family households and single-family households, as well as JMU east campus. Currently the south leg is access into and out of a parking lot of JMU. This parking lot access will be relocated to Hunters Road and the south leg will become the relocated northbound I-81 ramp. The posted speed limit is 25 mph.

Hunters Road

Hunters Road is a two-lane roadway which provides access to multi-family housing. There is no posted speed limit. The speed limit is considered 25 mph due to its classification as a residential street.

Bradley Lane

Bradley Lane is a two-lane roadway and provides access to multi-family housing. There is no posted speed limit. The speed limit is considered to be 25 mph due to its classification as a residential street.

Devon Lane

Devon Lane is a two-lane roadway with dedicated north and southbound right turn lanes onto Port Republic Road. A 25 mph speed limit is posted on the north leg. It is not posted on the south leg. The speed limit is considered to be 25 mph due to the classification as a residential street. Devon Lane provides access to multi-family housing and a gas station/restaurant on the northwest corner.

Pedestrian Activity

The Port Republic Road corridor experiences heavy pedestrian activity. Crosswalks are provided at all the signalized intersections and pedestrian signal heads are provided. Leading pedestrian intervals are used at the intersections of Port Republic Road with Bluestone Drive/Hillside Avenue and Main Street.

Transit Operation

Harrisonburg Department of Public Transportation (HDPT) operates a number of bus lines along the study corridor, primarily serving JMU students traveling between campus and off-campus housing. Transit route maps and time schedules from HDPT's website were obtained, and a HDPT representative provided typical loading volumes at bus stops along the corridor.

2 Operational Analysis

As part of this study, an analysis of the operational conditions along the corridor was conducted to determine areas for improved operations. This evaluation examined the 2018 existing, 2030 no build and 2030 build conditions. Additionally, the analyses included an alternative intersection analysis at the Port Republic Road and Main Street intersection using VDOT's Vjust program.

The analyses utilized the microsimulation traffic software, *PTV VISSIM 8.0*, and were coded according to the procedures outlined in Virginia Department of Transportation's (VDOT) Traffic Operations and Safety Analysis Manual (TOSAM) and VDOT's *VISSIM* User Guide.

Existing Conditions Review

The existing conditions for the AM and PM peak hours were developed and calibrated according to field observations, field measurements, and the factors provided in this report. These details are discussed in detail in Appendix A. This model was created to replicate the traffic volumes, travel time, queue data and the overall congestion observed in the field so that improvements can accurately be assessed.

Geometry

Links were coded over aerial imagery within *VISSIM* to model accurate 2-D link geometry such as length and curvature. Turn bays were coded as separate parallel links according to the procedures in the guide. Due to the significant gradients on Port Republic Road, VHB obtained 3-D data from a topographic map on the City of Harrisonburg's website and utilized this map to code the elevations of each link. Link gradient was calculated from elevation change rather than from default gradient values.

Intersection Control

Six (6) of the study intersections are signalized. The City of Harrisonburg provided timing plans for each of the signalized intersections from which the signal controllers in *VISSIM* were coded. Video detection is utilized along the corridor. During the field visit, VHB verified the locations of the stop signs on the stop controlled approaches. Timing information provided by the City of Harrisonburg is in Appendix B. Detailed information about traffic control parameters used in the *VISSIM* model are provided in Appendix A.

Traffic Volume Collection

The traffic counts for the 10 study intersections on the Port Republic Road corridor were not collected on the same day. Two (2) of the unsignalized intersection counts (Hunters Road and Bradley Drive) date further back to a 2016 Traffic Impact Analysis report, performed by DRW Consultants, LLS. In this study, 2017 traffic counts were projected at these two (2) intersections with the opening of the associated retail parcel. The City pulled counts from their GRIDSMAART cameras at the intersections of Main Street and Devon Lane on October 3, 2018 to coincide with the field data collection effort. These counts are shown in Appendix C.

A microsimulation traffic network requires a balanced volume network to accurately model conditions. Unbalanced volumes always exist due to uncaptured and unmodeled minor streets and driveway entrances, but unbalanced volumes were particularly prevalent in this study due to the varying dates traffic volumes were collected. After corridor-wide peak hours of 8:00 AM - 9:00 AM and 4:45 PM - 5:45 PM were determined from the count data, a balanced volume network was developed. The intersection counts taken at Port Republic Road and Main Street and Port Republic Road and Devon Lane, which were taken October 3, 2018, were held as key balancing nodes. Existing (2018) peak hour turning movements are shown in Figure 2.1.

Static Routing Decisions

Due to the short distance between many of the study intersections, VHB decided to develop a full origin-destination (O-D) matrix for the network in which vehicles entering on each link were assigned a destination exiting the network. This methodology improved the accuracy of modeled lane changes as vehicles realistically positioned themselves in the appropriate lane upstream of their next turning movement. The O-D matrix was developed based on the existing traffic patterns/turning movements, engineering judgment, and specified input from VDOT on certain vehicle movements.



SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 2.1
2018 EXISTING TRAFFIC VOLUMES
 Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

Measures of Effectiveness

The measures of effectiveness (MOEs) obtained from the model are average queue length, maximum queue length, control delay (and corresponding level of service), and travel time. These MOE's are described in detail below.

Delay and Level of Service Analysis

Capacity analysis results are expressed in terms of Level of Service (LOS). LOS is a qualitative measurement of traffic operations. It is translated from a measure of delay to drivers in units of time, seconds per vehicle. The Transportation Research Board's Highway Capacity Manual (HCM) defines six levels of service for intersections with LOS "A" representing operating conditions with minimal constraints on traffic movements and LOS "F" representing extremely congested operating conditions. LOS "D" is considered the threshold of acceptable operations for an overall intersection. Exhibit 18-4 of the HCM gives the criteria for signal controlled intersections, while HCM Exhibit 19-1 gives the criteria for unsignalized intersections.

HCM Exhibit 18-4: Level of Service Criteria		HCM Exhibit 19-1: Level of Service Criteria	
Signalized Level of Service	Signal Delay per Vehicle (sec/veh)	Unsignalized Level of Service	Stopped Delay per Vehicle (sec/veh)
A	≤ 10.0	A	≤ 10.0
B	> 10.0 and ≤ 20.0	B	> 10.0 and ≤ 15.0
C	> 20.0 and ≤ 35.0	C	> 15.0 and ≤ 25.0
D	> 35.0 and ≤ 55.0	D	> 25.0 and ≤ 35.0
E	> 55.0 and ≤ 80.0	E	> 35.0 and ≤ 50.0
F	> 80.0	F	> 50.0

Figure 2.2 HCM Level of Service Criteria

PTV VISSIM 8.0 was the software tool used in determining the delay, capacity and corresponding LOS of the study intersections. The delay and LOS information for the 2018 existing conditions are presented in Tables 2.1 and 2.2. A graphical representation of the LOS condition is shown in Figures 2.3 and 2.4.

Based on the existing conditions analysis, all intersections in the study area currently operate at acceptable levels of service D or better during the AM peak hour. There are several movements, however, that operate at level of service E.

Movements that are expected to operate at a LOS of E in the 2018 AM peak hour are:

- Port Republic Road and Main Street:
 - eastbound left;
 - southbound left; and,
 - northbound left.
- Port Republic and Bluestone Drive/Hillside Avenue:
 - northbound through; and,
 - southbound through.
- Port Republic and I-81 Northbound ramps:
 - northbound left.
- Port Republic Road and Forest Hill Road:
 - northbound through;
 - southbound left; and,
 - southbound through.

During the existing PM peak period, all intersections in the study area currently operate at an acceptable level of service D or better. However, there are several movements that operate at a level of service E. This occurs more in the PM peak period than the AM period. Additionally, there are four (4) movements that operate at a level of service F.

The movements that are expected to operate at a LOS of E in the 2018 PM peak hour are:

- Port Republic Road and Main Street:
 - eastbound through;
 - southbound left; and,
 - northbound left.
- Port Republic Road and Crawford Avenue:
 - westbound left.
- Port Republic and Bluestone Drive/Hillside Avenue:
 - northbound left;
 - northbound through; and,
 - southbound left.
- Port Republic and I-81 Southbound ramps:
 - southbound left.

- Port Republic and I-81 Northbound ramps:
 - northbound left; and,
 - northbound right.
- Port Republic Road and Forest Hill Road:
 - northbound left;
 - northbound through;
 - southbound left; and,
 - southbound through.

The movements that are expected to operate at a LOS of F in the 2018 PM peak hour are:

- Port Republic Road and Main Street:
 - eastbound left.
- Port Republic and Bluestone Drive/Hillside Avenue:
 - southbound through;
 - southbound right; and,
 - eastbound left.

Table 2.1 2018 AM Existing Level of Service

Node No.	Intersection	Traffic Control	Approach	Movement	Movement Delay (sec/veh)	Estimated Movement LOS	Approach Delay (sec/veh)	Estimated Approach LOS
1	Port Republic Road / Maryland Avenue / South Main Street	Signal	Maryland Avenue	EBL	70.9	E	42.3	D
				EBT	50.7	D		
				EBR	7.3	A		
			Port Republic Road	WBL	47.6	D	38.5	D
				WBT	41.1	D		
				WBR	35.2	D		
			South Main Street	SBL	58.3	E	37.4	D
				SBT	26.0	C		
				SBR	28.1	C		
			South Main Street	NBL	56.2	E	25.1	C
				NBT	31.6	C		
NBR	4.1	A						
Intersection				34.8	C	34.8	C	
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBL	11.1	B	0.4	A
				EBT	0.3	A		
				EBR	0.0	A		
			Port Republic Road	WBL	2.9	A	1.9	A
				WBT	1.9	A		
				WBR	2.6	A		
			Hillcrest Drive	SBL	18.1	C	15.5	C
				SBR	8.4	A		
			Hillcrest Drive	NBL	0.0	A	8.5	A
				NBR	8.5	A		
			Intersection				1.5	A
3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBL	0.0	A	9.9	A
				NBR	9.9	A		
			Port Republic Road	EBT	0.3	A	0.3	A
				EBR	0.0	A		
			Port Republic Road	WBL	5.7	A	1.9	A
				WBT	1.9	A		
			Intersection				1.4	A
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal	Hillside Avenue	NBL	50.1	D	32.2	C
				NBT	55.6	E		
				NBR	8.6	A		
			Bluestone Drive	SBL	49.6	D	44.7	D
				SBT	55.5	E		
				SBR	32.3	C		
			Port Republic Road	EBL	44.1	D	31.8	C
				EBT	29.9	C		
				EBR	23.8	C		
			Port Republic Road	WBL	18.0	B	18.0	B
				WBT	19.1	B		
WBR	13.6	B						
Intersection				24.3	C	24.3	C	
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	54.9	D	49.5	D
				SBR	44.7	D		
			Port Republic Road	EBT	1.2	A	1.1	A
				EBR	0.8	A		
			Port Republic Road	WBL	11.1	B	19.0	B
				WBT	20.1	C		
			Intersection				18.3	B

Table 2.1 2018 AM Existing Level of Service (Cont)

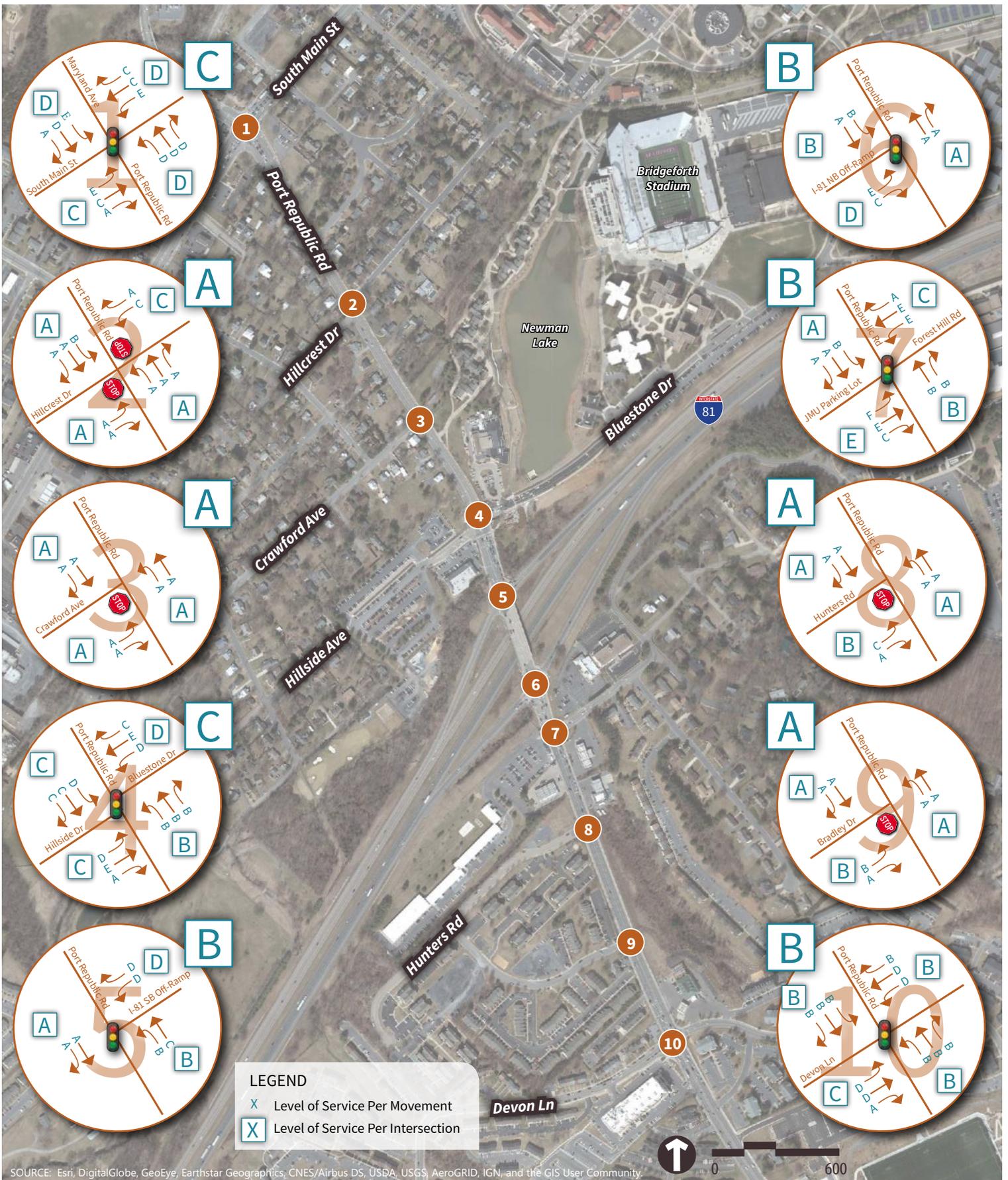
Node No.	Intersection	Traffic Control	Approach	Movement	Movement Delay (sec/veh)	Estimated Movement LOS	Approach Delay (sec/veh)	Estimated Approach LOS		
6	Port Republic Road at NB I-81 Ramps	Signal	NB I-81 Off-Ramp	NBL	68.6	E	46.0	D		
				NBR	23.9	C				
			Port Republic Road	EBL	15.5	B	9.3	A		
				EBT	8.1	A				
			Port Republic Road	WBT	5.0	A	4.6	A		
				WBR	2.1	A				
			Intersection				13.9	B	13.9	B
7	Port Republic Road at JMU Parking / Forest Hill Road	Signal	JMU Parking Lot	NBL	80.5	F	58.1	E		
				NBT	55.4	E				
				NBR	20.1	C				
			Forest Hill Road	SBL	60.5	E	27.6	C		
				SBT	62.2	E				
				SBR	9.8	A				
			Port Republic Road	EBL	17.4	B	5.5	A		
				EBT	2.4	A				
				EBR	1.9	A				
			Port Republic Road	WBT	16.0	B	16.2	B		
				WBR	17.4	B				
				Intersection					13.7	B
			8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBL	16.4	C	14.9
NBR	8.9	A								
Port Republic Road	EBT	0.8				A	1.0	A		
	EBR	3.5				A				
Port Republic Road	WBL	4.2				A	2.7	A		
	WBT	2.6				A				
Intersection						2.7	A	2.7	A	
9	Port Republic Road at Bradley Drive	Two-Way Stop	Bradley Drive	NBL	13.8	B	11.7	B		
				NBR	9.6	A				
			Port Republic Road	EBT	0.4	A	0.4	A		
				EBR	2.5	A				
			Port Republic Road	WBL	2.4	A	0.5	A		
				WBT	0.5	A				
			Intersection				1.0	A	1.0	A
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	36.4	D	34.2	C		
				NBT	36.1	D				
				NBR	4.4	A				
			Devon Lane	SBL	38.6	D	14.8	B		
				SBT	44.3	D				
				SBR	10.5	B				
			Port Republic Road	EBL	14.7	B	13.9	B		
				EBT	14.1	B				
				EBR	10.8	B				
			Port Republic Road	WBL	13.6	B	16.4	B		
				WBT	16.5	B				
				WBR	17.0	B				
			Intersection				17.9	C	17.9	B

Table 2.2 2018 PM Existing Level of Service

Node No.	Intersection	Traffic Control	Approach	Movement	Existing MOEs									
					Movement Delay (sec/veh)	Estimated Movement LOS	Approach Delay (sec/veh)	Estimated Approach LOS						
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	104.0	F	49.1	D						
				EBT	60.3	E								
				EBR	11.7	B								
			Port Republic Road	WBL	53.1	D	35.0	D						
				WBT	38.8	D								
				WBR	16.1	B								
			South Main Street	SBL	68.1	E	50.6	D						
				SBT	35.5	D								
				SBR	38.9	D								
			South Main Street	NBL	62.7	E	34.1	C						
				NBT	44.2	D								
				NBR	13.1	B								
			Intersection					41.8	D	41.8	D			
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBL	15.7	C	1.0	A						
				EBT	0.9	A								
				EBR	0.8	A								
			Port Republic Road	WBL	8.4	A	1.3	A						
				WBT	1.2	A								
				WBR	2.5	A								
			Hillcrest Drive	SBL	19.3	C	13.9	B						
				SBR	7.7	A								
				NBL	0.0	A								
			Hillcrest Drive	NBR	10.4	B	10.4	B						
				Intersection					1.2	A	1.2	A		
				Intersection					1.2	A	1.2	A		
			3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBL	0.0	A	26.6	D			
NBR	26.6	D												
Port Republic Road	EBT	9.5				A	9.5	A						
	EBR	0.0				A								
Port Republic Road	WBL	40.1				E	4.3	A						
	WBT	3.8				A								
Intersection						7.3	A	7.3	A					
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal	Hillside Avenue	NBL	63.5	E	30.0	C						
				NBT	59.2	E								
				NBR	13.2	B								
			Bluestone Drive	SBL	70.6	E	76.4	E						
				SBT	100.3	F								
				SBR	84.9	F								
			Port Republic Road	EBL	82.3	F	41.9	D						
				EBT	37.0	D								
				EBR	30.7	C								
			Port Republic Road	WBL	22.1	C	20.9	C						
				WBT	22.3	C								
				WBR	15.7	B								
			Intersection					38.7	D	38.7	D			
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	58.7	E	54.4	D						
				SBR	50.5	D								
			Port Republic Road	EBT	4.1	A	3.7	A						
				EBR	1.9	A								
			Port Republic Road	WBL	32.0	C	21.0	C						
				WBT	18.5	B								
			Intersection					16.4	B	16.4	B			

Table 2.2 2018 PM Existing Level of Service (Cont)

Node No.	Intersection	Traffic Control	Approach	Movement	Existing MOEs						
					Movement Delay (sec/veh)	Estimated Movement LOS	Approach Delay (sec/veh)	Estimated Approach LOS			
6	Port Republic Road at NB I-81 Ramps	Signal	NB I-81 Off-Ramp	NBL	74.9	E	70.7	E			
				NBR	67.6	E					
				EBL	30.7	C					
			Port Republic Road	EBT	7.7	A	11.5	B			
				WBT	6.3	A					
				WBR	2.7	A					
			Intersection					16.9	C	16.9	B
7	Port Republic Road at JMU Parking / Forest Hill Road	Signal	JMU Parking Lot	NBL	58.4	E	58.5	E			
				NBT	64.4	E					
				NBR	33.6	C					
			Forest Hill Road	SBL	55.6	E	31.1	C			
				SBT	59.5	E					
				SBR	12.5	B					
			Port Republic Road	EBL	27.5	C	9.8	A			
				EBT	6.4	A					
				EBR	7.5	A					
			Port Republic Road	WBT	35.7	D	36.5	D			
				WBR	41.1	D					
				Intersection					24.2	C	24.2
			8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBL	24.4	C	21.6	C
NBR	15.2	C									
Port Republic Road	EBT	1.6				A	1.8	A			
	EBR	4.2				A					
Port Republic Road	WBL	9.1				A	7.9	A			
	WBT	7.9				A					
Intersection						5.0	A	5.0	A		
9	Port Republic Road at Bradley Drive	Two-Way Stop	Bradley Drive	NBL	17.4	C	14.2	B			
				NBR	11.9	B					
			Port Republic Road	EBT	1.4	A	1.5	A			
				EBR	3.1	A					
			Port Republic Road	WBL	7.4	A	0.8	A			
				WBT	0.7	A					
			Intersection					1.5	A	1.5	A
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	40.1	D	35.8	D			
				NBT	41.5	D					
				NBR	5.5	A					
			Devon Lane	SBL	45.9	D	22.7	C			
				SBT	44.7	D					
				SBR	9.1	A					
			Port Republic Road	EBL	18.9	B	18.1	B			
				EBT	18.4	B					
				EBR	16.7	B					
			Port Republic Road	WBL	17.0	B	22.0	C			
				WBT	22.3	C					
WBR	20.4	C									
Intersection					21.7	C	21.7	C			



SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 2.3
EXISTING 2018 AM LEVEL OF SERVICE

Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

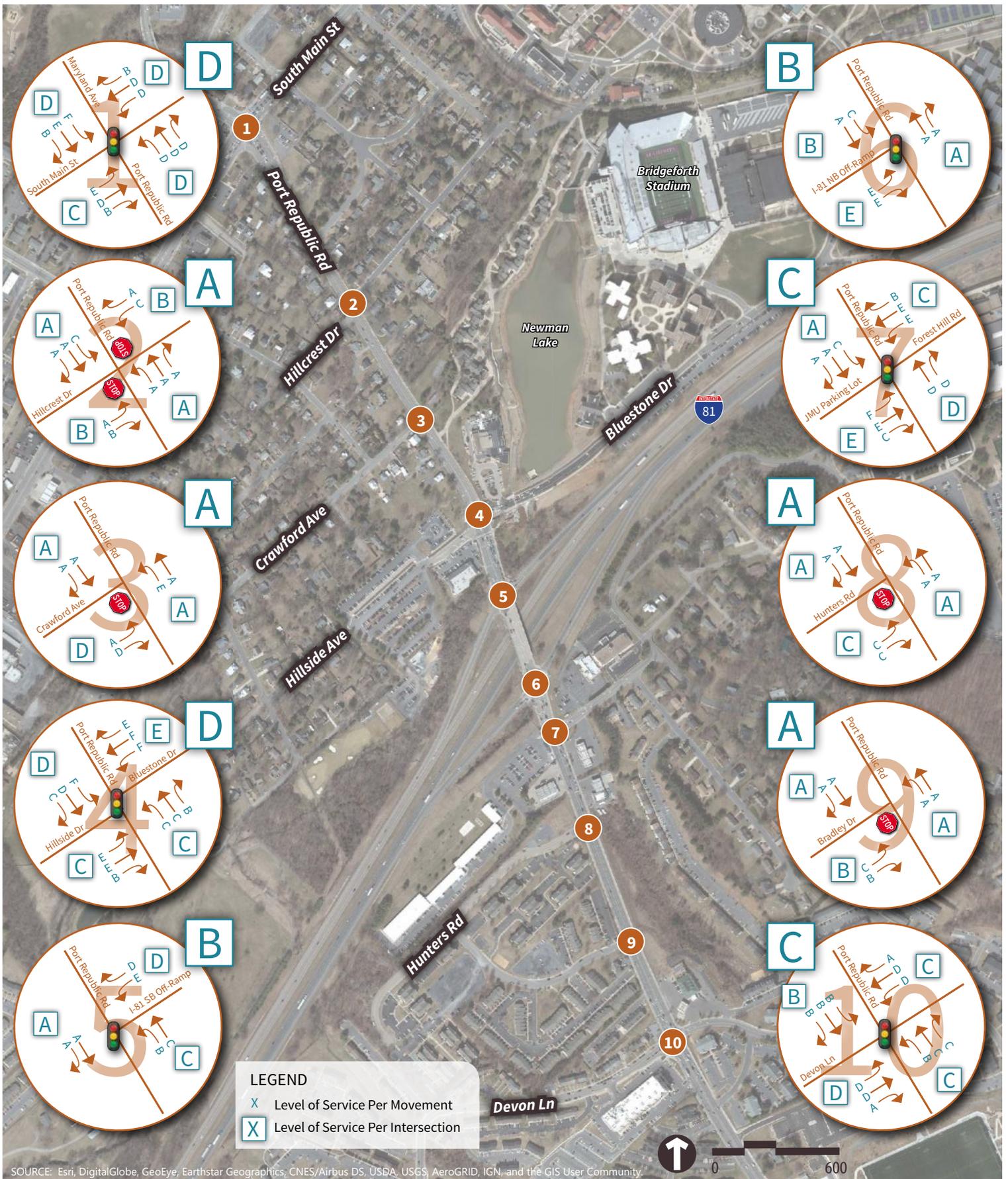


FIGURE 2.4
EXISTING 2018 PM LEVEL OF SERVICE

Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia



Queue Analysis

Queue length, expressed as feet and represented as the number of vehicles queued in a lane behind the stop line at an intersection, measures the level of congestion on an intersection approach. After the *VISSIM* model was created and validated, 10 runs, with random seeding, were modeled to simulate vehicle loadings and the nature of vehicle arrivals. One of the key elements of saturated flow is that traffic flow is affected by downstream conditions. This flow description applies to the peak periods of both the 2018 existing AM and PM peak hour on Port Republic Road, where multiple downstream signals (particularly around the I-81 interchange) impact upstream flow in both directions based on the *VISSIM* model. Tables 2.3 and 2.4 show the simulated maximum queue lengths for all movements. Locations where average or maximum queue lengths extend beyond the available storage are shown in red.

The storage length for through movements or turning movements that do not have a dedicated turn lane are shown in the column labeled link distance in Table 2.3 and 2.4. These lengths along Port Republic Road are the distance between the stop bar and the downstream study intersection. The eastbound storage on Port Republic Road west of Main Street extends to Keister Elementary. The westbound storage on Port Republic Road east of Devon Lane extends to Deer Run. The intersecting streets are measured from the stop bar to the roadway terminus, or a downstream intersection.

Turn lane lengths are reported as the storage length plus half of the taper length in *VISSIM*. While the taper length is intended to be used as a space for deceleration, not for storage, this method more accurately reflects the real-world conditions. In analyzing the queue lengths in comparison to the available turn lane capacity, only the storage space was considered. The existing lane configuration, including the available turn lane storage lengths, are shown in Figure 1.3.

The storage capacity of many of the existing turn lanes is insufficient to accommodate the maximum queue lengths. The maximum queue length is the longest anticipated queue which occurs during the heaviest period of the peak hour. There are several auxiliary lanes that do not contain enough storage for the average queue lengths. As aptly named, these queue lengths represent the average queue length that is anticipated to occur during the peak hours. These locations are:

- Port Republic Road and Main Street:
 - westbound left; and
 - southbound left;
- Port Republic Road and I-81 Northbound ramps:
 - northbound left; and
 - northbound right

It is worthwhile to note *VISSIM* reports queues based upon vehicles moving at speeds less than 6.2 mph; so, vehicles traveling just over this speed are not considered in the queue values. The perception to the motorists, however, is that the roadway is congested.

Table 2.3 2018 AM Simulated Queue Lengths

Node No.	Intersection	Traffic Control	Approach	Movement	Existing MOEs			
					Average Queue Length (ft)	Max Queue Length (ft)	Link Distance (ft)	Storage Length (ft)
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	19	146		150
				EBT	49	217	225	
				EBR	0	55		100
			Port Republic Road	WBL	29	137		250
				WBT	72	742	875	
				WBR	197	813		150
			South Main Street	SBL	34	153		200
				SBT	26	185	200	
				SBR	24	188	200	
			South Main Street	NBL	22	153		150
				NBT	54	328	350	
NBR	1	111		150				
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBL	0	25	275	
				EBT	0	7	275	
				EBR	0	7	275	
			Port Republic Road	WBL	0	54	525	
				WBT	1	98	525	
				WBR	0	80	525	
			Hillcrest Drive	SBL	2	64	525	
				SBR	1	65	525	
			Hillcrest Drive	NBL	0	41	375	
				NBR	0	42	375	
			3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBL	1
NBR	2	113					275	
Port Republic Road	EBT	0				0	525	
	EBR	0				0	525	
Port Republic Road	WBL	1				137	450	
	WBT	1				97	450	
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal				Hillside Avenue	NBL	17
			NBT	17	151		200	
			NBR	1	63			100
			Bluestone Drive	SBL	18	120		600
				SBT	18	120	600	
				SBR	18	143	600	
			Port Republic Road	EBL	24	260		100
				EBT	63	353	475	
			Port Republic Road	EBR	5	245	475	
				WBL	10	121		200
				WBT	139	354	225	
WBR	14	311			50			
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	53	351		100
				SBR	40	302		100
			Port Republic Road	EBT	2	75	250	
				EBR	0	34		100
			Port Republic Road	WBL	5	186		125
				WBT	61	454	350	

Table 2.3 2018 AM Simulated Queue Lengths (Cont)

Node No.	Intersection	Traffic Control	Approach	Movement	Existing MOEs			
					Average Queue Length (ft)	Max Queue Length (ft)	Link Distance (ft)	Storage Length (ft)
6	Port Republic Road at NB I-81 Ramps	Signal	NB I-81 Off-Ramp	NBL	144	699		100
				NBR	29	455		100
			Port Republic Road	EBL	6	151		125
				EBT	16	173	325	
			Port Republic Road	WBT	20	301	150	
				WBR	1	178		50
7	Port Republic Road at JMU Parking / Forest Hill Road	Signal	JMU Parking Lot	NBL	4	56	400	
				NBT	4	56	400	
				NBR	1	68	400	
			Forest Hill Road	SBL	29	167	500	
				SBT	29	167	500	
				SBR	29	167		500
			Port Republic Road	EBL	13	171		175
				EBT	4	117	125	
				EBR	2	134	125	
			Port Republic Road	WBT	362	1262	375	
				WBR	362	1262	375	
			8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBL	8
NBR	6	106					725	
Port Republic Road	EBT	0				35	375	
	EBR	1				85	375	
Port Republic Road	WBL	8				832	525	
	WBT	6				832	525	
9	Port Republic Road at Bradley Drive	Two-Way Stop	Bradley Drive	NBL	5	101	900	
				NBR	5	101	900	
			Port Republic Road	EBT	0	21	525	
				EBR	0	51	525	
			Port Republic Road	WBL	0	232	425	
				WBT	0	232	425	
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	63	371	4250	
				NBT	63	371	4250	
				NBR	0	21		150
			Devon Lane	SBL	7	109	300	
				SBT	7	109	300	
				SBR	8	167		100
			Port Republic Road	EBL	3	76		150
				EBT	29	260	425	
				EBR	27	262	425	
			Port Republic Road	WBL	2	58		150
				WBT	50	382	800	
				WBR	49	382	800	

Table 2.4 2018 PM Simulated Queue Lengths

Node No.	Intersection	Traffic Control	Approach	Movement	Existing MOEs			
					Average Queue Length (ft)	Max Queue Length (ft)	Link Distance (ft)	Storage Length (ft)
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	9	65		150
				EBT	63	287	225	
				EBR	1	73		100
			Port Republic Road	WBL	60	382		250
				WBT	101	593	875	
				WBR	30	413		150
			South Main Street	SBL	272	1266		200
				SBT	210	1271	200	
				SBR	210	1272	200	
				NBL	35	183		150
			South Main Street	NBT	93	536	350	
NBR	13	317			150			
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBL	1	84	275	
				EBT	0	61	275	
				EBR	0	61	275	
			Port Republic Road	WBL	1	155	525	
				WBT	0	36	525	
				WBR	0	7	525	
			Hillcrest Drive	SBL	1	61	525	
				SBR	1	61	525	
			Hillcrest Drive	NBL	0	37	375	
				NBR	0	38	375	
			3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBL	2
NBR	4	116					275	
Port Republic Road	EBT	38				506	525	
	EBR	38				506	525	
Port Republic Road	WBL	20				376	450	
	WBT	15				334	450	
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal				Hillside Avenue	NBL	16
			NBT	16	119		200	
			NBR	2	77			100
			Bluestone Drive	SBL	139	838		600
				SBT	139	838	600	
				SBR	153	859	600	
			Port Republic Road	EBL	99	915		100
				EBT	0	1572	475	
				EBR	7	1572	475	
			Port Republic Road	WBL	5	80		200
				WBT	140	345	225	
				WBR	16	314		50
			5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	62
SBR	64	429						100
Port Republic Road	EBT	19				333	250	
	EBR	1				71		100
Port Republic Road	WBL	44				357		125
	WBT	41				426	350	

Table 2.4 2018 PM Simulated Queue Lengths (Cont)

Node No.	Intersection	Traffic Control	Approach	Movement	Existing MOEs			
					Average Queue Length (ft)	Max Queue Length (ft)	Link Distance (ft)	Storage Length (ft)
6	Port Republic Road at NB I-81 Ramps	Signal	NB I-81 Off-Ramp	NBL	171	789		100
				NBR	198	793		100
			Port Republic Road	EBL	37	318		125
				EBT	21	250	325	
			Port Republic Road	WBT	24	301	150	
				WBR	1	112		50
7	Port Republic Road at JMU Parking / Forest Hill Road	Signal	JMU Parking Lot	NBL	28	217	400	
				NBT	28	217	400	
				NBR	27	231	400	
			Forest Hill Road	SBL	72	321	500	
				SBT	72	321	500	
				SBR	72	321		500
			Port Republic Road	EBL	55	275		175
				EBT	46	273	125	
				EBR	27	319	125	
			Port Republic Road	WBT	227	801	375	
				WBR	227	801	375	
			8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBL	8
NBR	6	103					725	
Port Republic Road	EBT	1				162	375	
	EBR	3				208	375	
Port Republic Road	WBL	26				371	525	
	WBT	21				371	525	
9	Port Republic Road at Bradley Drive	Two-Way Stop	Bradley Drive	NBL	5	97	900	
				NBR	4	97	900	
			Port Republic Road	EBT	1	260	525	
				EBR	2	260	525	
			Port Republic Road	WBL	1	0	425	
				WBT	1	0	425	
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	63	382	4250	
				NBT	63	382	4250	
				NBR	0	31		150
			Devon Lane	SBL	22	171	300	
				SBT	22	171	300	
				SBR	5	123		100
			Port Republic Road	EBL	15	201		150
				EBT	68	765	425	
				EBR	68	765	425	
			Port Republic Road	WBL	2	57		150
				WBT	59	355	800	
				WBR	58	355	800	

Travel Time Analysis

VHB collected average corridor travel time data on October 3, 2018 and October 4, 2018 during field visits. Travel time run segments were collected to/from 480 feet north of South Main Street and to/from 390 feet south of Devon Lane. The corridor travel times were displayed across the entire study area and broken down between the segments of eastbound between 480 feet north of South Main Street to the I-81 northbound ramps, and westbound between 390 feet south of Devon Lane to the I-81 southbound ramps. These observed travel times are shown in Table 2.5.

Table 2.5 2018 Observed Travel Times

Peak Hour	Travel Time Run	Observed Travel Time (sec)	Observed Travel Time (M:SS)
	Segment		
AM Peak Hour	Port Republic Road Eastbound	233.92	03:53.9
	Port Republic Road Westbound	265.7	04:25.7
	Port Republic Road EB to I-81 NB Ramps	156.66	02:36.7
	Port Republic Road WB to I-81 SB Ramps	140.27	02:20.3
PM Peak Hour	Port Republic Road Eastbound	238.03	03:58.0
	Port Republic Road Westbound	247.39	04:07.4
	Port Republic Road EB to I-81 NB Ramps	177.83	02:57.8
	Port Republic Road WB to I-81 SB Ramps	102.33	01:42.3

TOSAM specifies a 30% maximum difference between observed and modeled travel times on an arterial network for the model to be considered properly calibrated. The differences between the observed travel time and the simulated traffic time for each segment along the corridor are within the calibration threshold of 30%, as shown in Appendix A. The simulated travel times are shown in Table 2.6.

To better reflect the operating conditions and the perception of congestion felt by motorists who are traveling at speeds lower than desired, the operating speeds were mapped to visually display operating conditions. The dark green color represents expected vehicle speeds near the speed limit of the corridor, which is 35 mph, and the red and pink colors denote areas of slower speed vehicles traveling through the model, with pink representing the highest level of congestion.

These slow speeds are the result of more congestion and signal queuing. These speed maps are presented in Figures 2.5 and 2.6.

Table 2.6 2018 Simulated Travel Times

Peak Hour	Travel Time Run	Simulated Travel Time (sec)	Simulated Travel Time (M:SS)
	Segment		
AM Peak Hour	Port Republic Road Eastbound	217.55	03:37.5
	Port Republic Road Westbound	232.73	03:52.7
	Port Republic Road EB to I-81 NB Ramps	152.75	02:32.8
	Port Republic Road WB to I-81 SB Ramps	103.23	01:43.2
PM Peak Hour	Port Republic Road Eastbound	261.92	04:21.9
	Port Republic Road Westbound	256.04	04:16.0
	Port Republic Road EB to I-81 NB Ramps	185.4	03:05.4
	Port Republic Road WB to I-81 SB Ramps	127.73	02:07.7

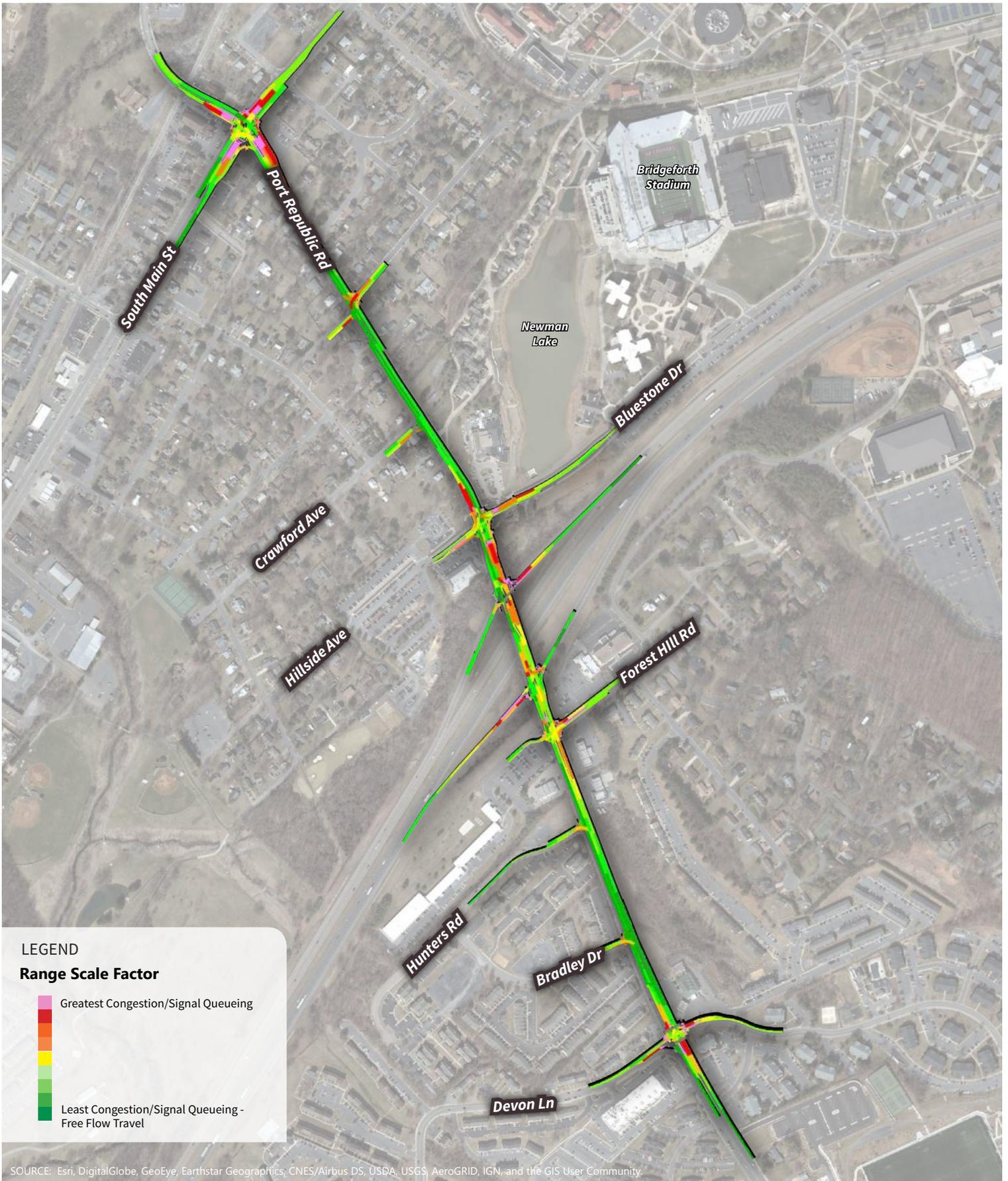


FIGURE 2.5
EXISTING AM SPEED MAP

Port Republic Road Safety and Operations Study
Harrisonburg, Virginia

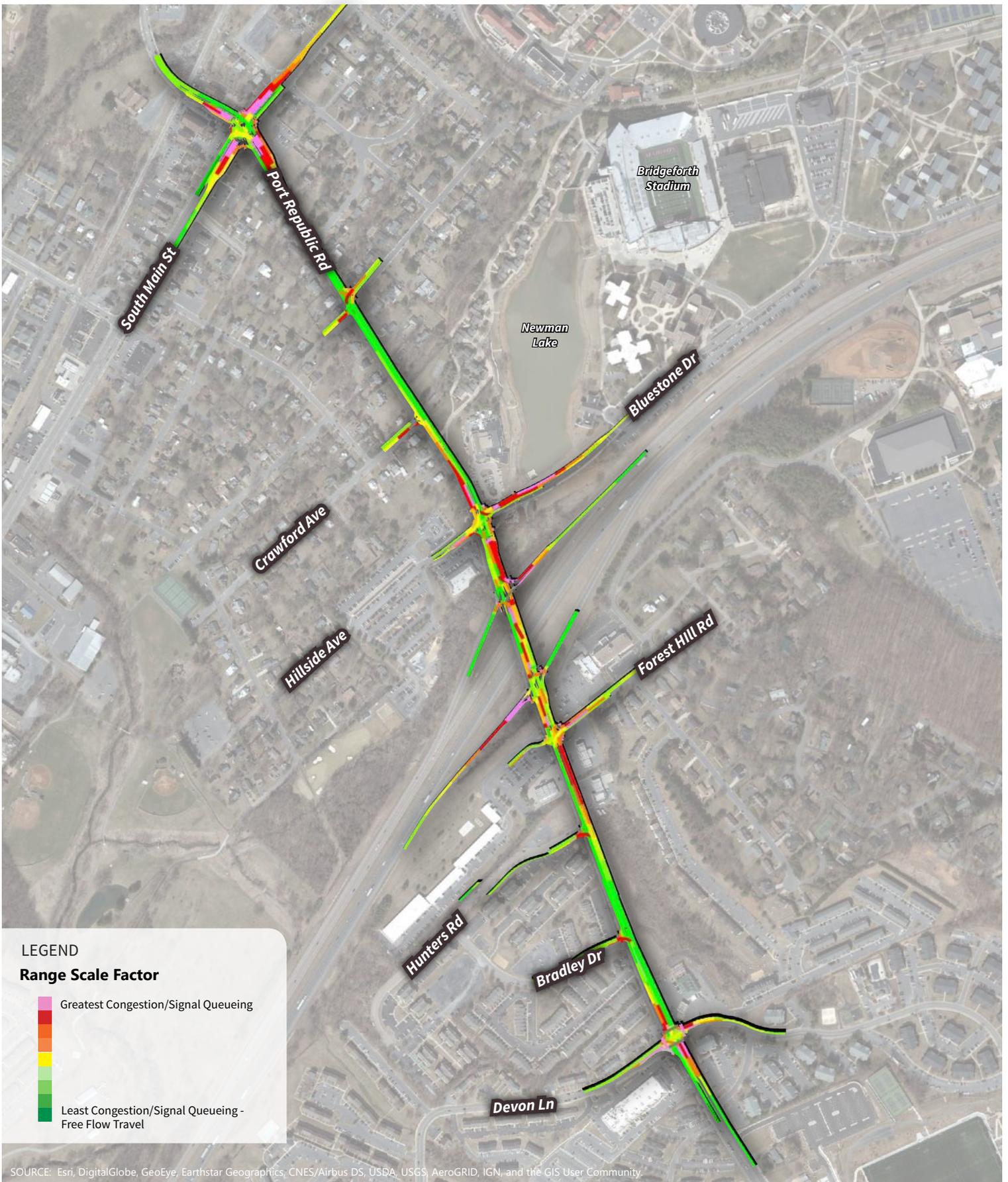


FIGURE 2.6
EXISTING PM SPEED MAP

Port Republic Road Safety and Operations Study
Harrisonburg, Virginia

2030 No Build Conditions Analysis

The calibrated and validated 2018 existing conditions AM and PM *VISSIM* models were utilized as the foundation for the 2030 models. The coded *VISSIM* geometry was modified to reflect the upcoming roadway projects consisting of the lengthening of the southbound left turn lanes at Port Republic Road and South Main Street and the I-81 northbound ramp relocation, including the JMU parking lot change of access from Forest Hill Road to Hunters Road as shown in Figure 2.7. No additional geometric modifications in addition to those referenced above were entered in the model (see Figure 2.8).

Modifications to signal phasing were applied at the intersections of Port Republic Road with the I-81 northbound on-ramp and the Forest Hill Road/relocated I-81 northbound off-ramp as shown in the ramp relocation design plans provided by VDOT (see Appendix D) and in Figure 2.7. Signal timing parameters including cycle length, splits, and offsets were optimized for the 2030 no build geometry and volumes utilizing the traffic software *Synchro Professional Version 9*. Cycle length optimization was limited to 5-second interval values between 110 and 135 seconds to maintain minimum timing parameters, and limit pedestrian wait time. This cycle length closely matches the existing coordinated cycle length of 134 seconds.

A one percent (1%) annual growth rate was used to increase the traffic volumes to represent future traffic volumes. The projected 2030 volumes were computed and coded in *VISSIM* using the same methodology as the existing conditions models (see Appendix E). The 2030 no build traffic volumes are depicted in Figure 2.9.

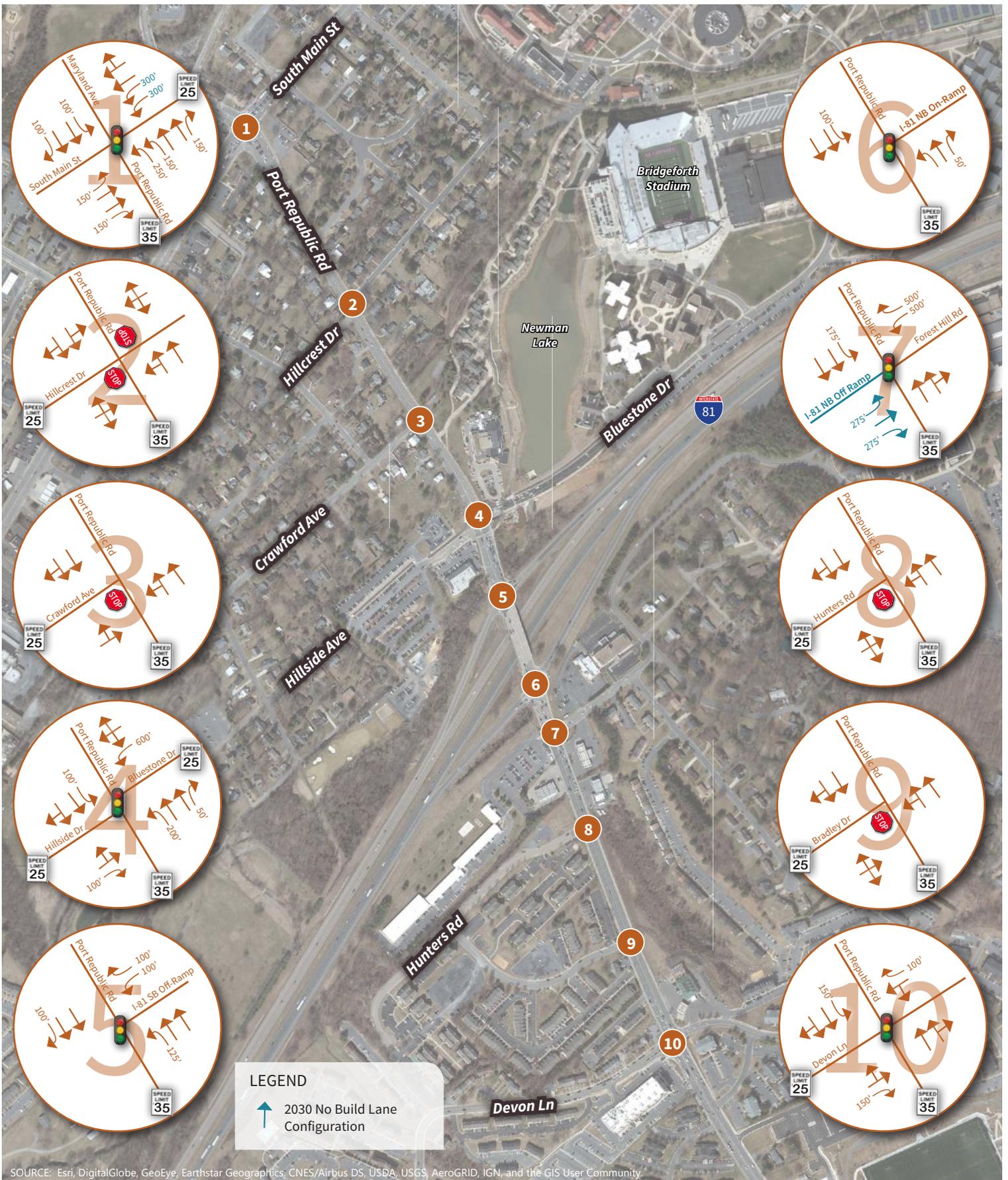
Initial *VISSIM* simulation of the no build conditions assumed that 100% of the JMU parking lot traffic would now utilize Hunters Road to access Port Republic Road; however, initial model results in the PM peak hour revealed excessive delay and queueing on Hunters Road at Port Republic Road. This delay is due to the high volume of left turns that were unable to enter Port Republic Road due to the heavy westbound queueing on Port Republic Road at Forest Hill Road and the absence of a signal to facilitate the left turn. Vehicles exiting the new JMU parking lot access can easily use Bradley Drive to access Port Republic Road, which places them farther upstream where they are more likely to avoid the Forest Hill Road queue and should be able to complete the left turn. Analysis indicated that rerouting 90% of the parking lot traffic that intends to travel west on Port Republic Road balanced the system, meaning Hunters Road and Bradley Drive had similar delay and queueing metrics. This can be accomplished by restricting movements to and from Hunters Road to right in, right out only during peak hour so that left turns must be made from Bradley drive. Restricting left turns onto Port Republic Road from Bradley Drive is a recommendation due to safety concerns. In order to balance the operational and safety needs at this intersection, it is shown as signalized in the 2030 build model which is discussed later in the report.



SOURCE: (c) 2015 Microsoft Corporation and its data suppliers.



FIGURE 2.7
INTERCHANGE ALTERNATIVE
 Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia



SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 2.8
2030 NO BUILD LANE GEOMETRICS

Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia



SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 2.9
2030 NO-BUILD NETWORK BALANCED TRAFFIC VOLUMES

Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

Measures of Effectiveness

As described previously, the no build model includes the extension of the southbound dual left turn lanes at Port Republic Road and South Main Street, the relocation of the I-81 northbound off-ramp, and the relocation of the JMU parking lot access. The signal cycle lengths, splits, and offsets throughout the corridor were optimized.

This analysis demonstrated that several intersections within the corridor are operating over capacity, creating undesirable level of service metrics as well as significant queues which contribute to slow speeds and increased travel times throughout the corridor.

Delay and Level of Service Analysis

Based on the 2030 no build conditions analysis, all intersections in the study area are expected to operate at acceptable levels of service C or better during the AM peak hour. There are several movements, however, that operate at LOS of E and four (4) that operate at a LOS F which will be listed below and shown in Table 2.7 and Table 2.8 and in Figures 2.10 and 2.11.

Movements that are expected to operate at a LOS of E in the 2030 no build AM peak hour are:

- Port Republic Road and South Main Street:
 - southbound left; and,
 - northbound left.
- Port Republic Road and Bluestone Drive/Hillside Avenue:
 - northbound through; and,
 - eastbound left.
- Port Republic and I-81 southbound ramps:
 - southbound left.
- Port Republic Road and I-81 northbound off ramp/Forest Hill Road:
 - northbound left; and,
 - southbound left.
- Port Republic Road and Bradley Drive:
 - northbound left.

Movements that are expected to operate at a LOS of F in the 2030 no build AM peak hour are:

- Port Republic Road and South Main Street:
 - eastbound left.
- Port Republic Road and I-81 southbound ramps:
 - southbound right.
- Port Republic Road and Hunters Road:
 - northbound left; and,
 - northbound right.

During the 2030 no build PM peak period, all intersections in the study area are expected to operate at an acceptable LOS D or better except for Port Republic Road and Hunters Road; Port Republic Road and Bradley Drive; and Port Republic Road at Devon Lane which operate at an overall LOS E. There are a number of movements that operate at a LOS E and 21 movements that operate at LOS F 2030 PM peak period as shown in Table 2.8.

It is important to note that *VISSIM* calculates the delay at an intersection based on the difference between the free flow travel time and the simulated travel times between the study intersections. This differs from Synchro, which calculates delay based on an intersection by intersection basis and does not account for queueing from upstream or downstream intersections. The method that *VISSIM* uses to calculate delay is a more realistic and useful metric for corridors under saturated conditions, such as this corridor. In the PM peak hour, westbound traffic on Port Republic Road at Forest Hill Road queues past the intersections of Port Republic Road with Hunters Road and Bradley Drive. The corresponding delay is assigned to the westbound movements at Hunters Road and Bradley Drive, resulting in a LOS of F at these intersections in the PM peak hour.

Movements that are expected to operate at a LOS of E in the 2030 no build PM peak hour are:

- Port Republic Road and South Main Street:
 - southbound left; and,
 - northbound left.
- Port Republic Road and Hillcrest Drive:
 - northbound right.
- Port Republic Road and Bluestone Drive/Hillside Avenue:
 - northbound through; and
 - northbound left.
- Port Republic and I-81 southbound ramps:
 - southbound left.
- Port Republic Road and I-81 northbound off-ramp and Forest Hill Road:
 - northbound left;
 - southbound left; and,
 - westbound through.
- Port Republic Road and Devon Lane:
 - southbound left;
 - southbound through
 - eastbound left; and
 - westbound right.

Movements that are expected to operate at a LOS of F in the 2030 PM peak hour are:

- Port Republic Road and South Main Street:
 - eastbound left.
- Port Republic Road and Crawford Avenue:
 - northbound right; and,
 - westbound left.
- Port Republic Road and Bluestone Drive/Hillside Avenue:
 - southbound left;
 - southbound through;
 - southbound right; and,
 - eastbound left.
- Port Republic Road and I-81 southbound ramps:
 - southbound right.
- Port Republic Road and I-81 northbound off-ramp and Forest Hill Road:
 - westbound right.
- Port Republic Road and Hunters Road:
 - northbound left;
 - northbound right;
 - westbound left; and,
 - westbound through.
- Port Republic Road and Bradley Drive:
 - northbound left;
 - northbound right;
 - westbound left; and,
 - west bound through.
- Port Republic Road and Devon Lane:
 - northbound left;
 - northbound through;
 - northbound right; and,
 - westbound through.

Table 2.7 2030 AM No Build Level of Service

Node No.	Intersection	Traffic Control	Approach	Movement	No Build MOEs			
					Movement Delay (sec/veh)	Estimated Movement LOS	Approach Delay (sec/veh)	Estimated Approach LOS
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	89.6	F	45.1	D
				EBT	50.3	D		
				EBR	8.9	A		
			Port Republic Road	WBL	32.4	C	32.1	C
				WBT	22.3	C		
				WBR	36.2	D		
			South Main Street	SBL	60.6	E	36.9	D
				SBT	24.1	C		
				SBR	26.4	C		
			South Main Street	NBL	59.5	E	22.4	C
				NBT	26.5	C		
NBR	4.7	A						
Intersection					31.8	C	31.8	C
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBL	13.4	B	0.4	A
				EBT	0.4	A		
				EBR	0.0	A		
			Port Republic Road	WBL	2.2	A	3.9	A
				WBT	3.9	A		
				WBR	5.6	A		
			Hillcrest Drive	SBL	21.1	C	17.1	C
				SBR	7.9	A		
			Hillcrest Drive	NBL	0.0	A	8.8	A
				NBR	8.8	A		
			Intersection					2.7
3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBL	0.0	A	9.5	A
				NBR	9.5	A		
			Port Republic Road	EBT	0.3	A	0.3	A
				EBR	0.0	A		
			Port Republic Road	WBL	2.5	A	2.4	A
				WBT	2.4	A		
			Intersection					1.7
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal	Hillside Avenue	NBL	53.1	D	34.1	C
				NBT	55.5	E		
				NBR	10.2	B		
			Bluestone Drive	SBL	50.0	D	42.9	D
				SBT	53.0	D		
				SBR	28.8	C		
			Port Republic Road	EBL	58.1	E	33.4	C
				EBT	29.3	C		
				EBR	22.4	C		
			Port Republic Road	WBL	22.8	C	20.1	C
				WBT	20.8	C		
WBR	15.9	B						
Intersection					26.1	C	26.1	C
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	67.6	E	148.7	F
				SBR	217.0	F		
			Port Republic Road	EBT	7.7	A	7.1	A
				EBR	3.0	A		
			Port Republic Road	WBL	15.1	B	17.5	B
				WBT	17.8	B		
			Intersection					31.3

Table 2.7 2030 AM No Build Level of Service (Cont)

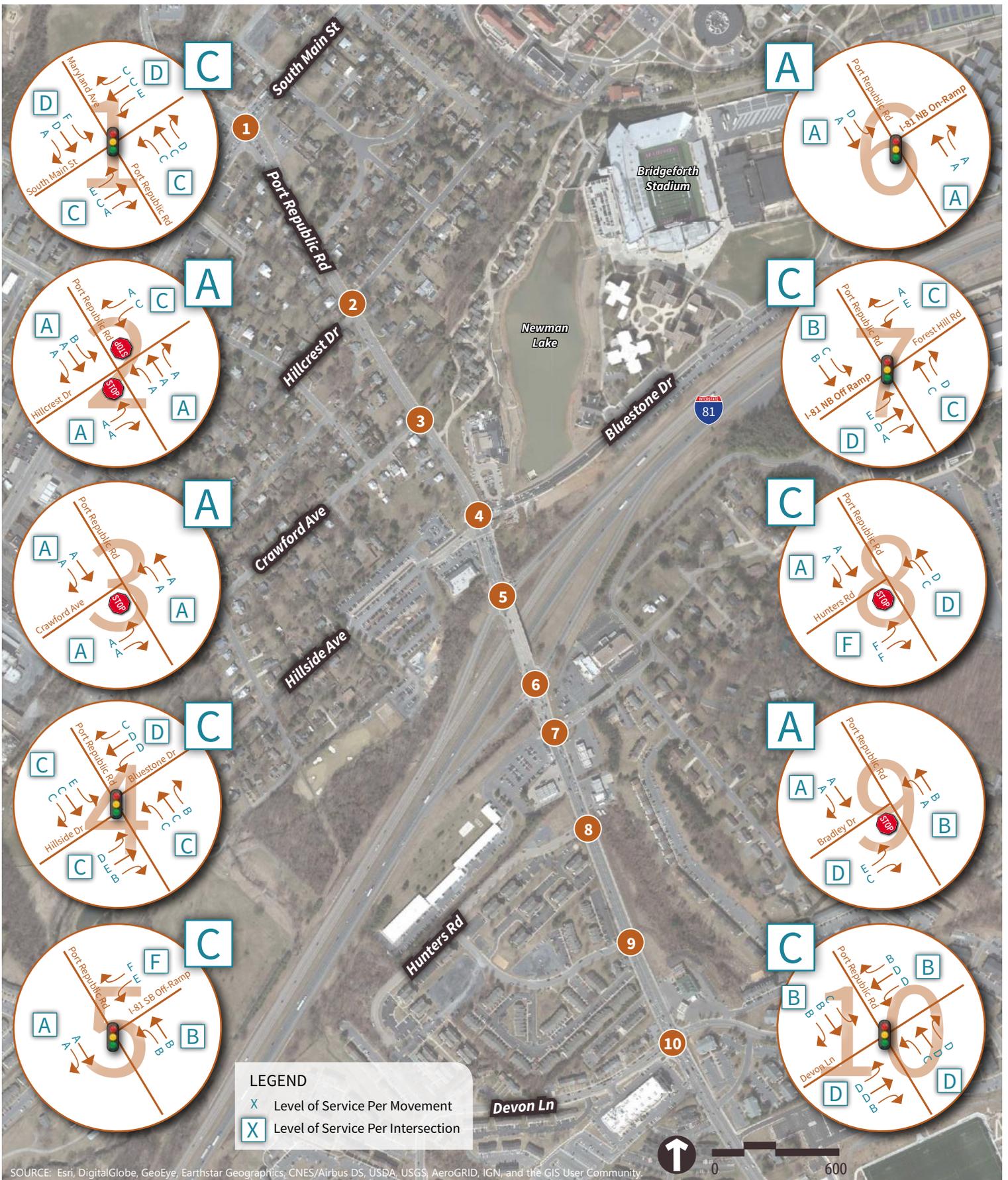
Node No.	Intersection	Traffic Control	Approach	Movement	No Build MOEs					
					Movement Delay (sec/veh)	Estimated Movement LOS	Approach Delay (sec/veh)	Estimated Approach LOS		
6	Port Republic Road at NB I-81 On-Ramp	Signal	Port Republic Road	EBL	50.2	D	12.6	B		
				EBT	4.3	A				
			Port Republic Road	WBT	4.5	A	4.1	A		
				WBR	1.3	A				
			Intersection				6.9	A	6.9	A
7	Port Republic Road at NB I-81 Off-Ramp / Forest Hill Road	Signal	NB I-81 Off-Ramp	NBL	62.4	E	47.1	D		
				NBT	53.9	D				
				NBR	9.8	A				
			Forest Hill Road	SBL	79.3	E	33.6	C		
				SBR	9.8	A				
			Port Republic Road	EBL	33.5	C	16.8	B		
				EBT	15.1	B				
			Port Republic Road	WBT	31.8	C	33.3	C		
				WBR	41.3	D				
			Intersection				32.2	C	32.2	C
			8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBL	139.5	F	135.5
NBR	120.4	F								
Port Republic Road	EBT	2.0				A	2.1	A		
	EBR	2.8				A				
Port Republic Road	WBL	21.5				C	26.3	D		
	WBT	26.6				D				
Intersection							22.8	C	22.8	C
9	Port Republic Road at Bradley Drive	Two-Way Stop	Bradley Drive	NBL	35.6	E	28.3	D		
				NBR	21.2	C				
			Port Republic Road	EBT	0.5	A	0.5	A		
				EBR	0.7	A				
			Port Republic Road	WBL	6.9	A	12.8	B		
				WBT	12.8	B				
			Intersection				9.7	A	9.7	A
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	43.8	D	41.7	D		
				NBT	42.4	D				
				NBR	14.6	B				
			Devon Lane	SBL	37.6	D	17.4	B		
				SBT	43.1	D				
			Port Republic Road	SBR	13.6	B	18.5	B		
				EBL	22.2	C				
			Port Republic Road	EBT	18.5	B	38.3	D		
				EBR	14.7	B				
			Port Republic Road	WBL	29.2	C	38.3	D		
				WBT	38.7	D				
Intersection				36.1	D	30.5	C			

Table 2.8 2030 PM No Build Level of Service

Node No.	Intersection	Traffic Control	Approach	Movement	No Build MOEs			
					Movement Delay (sec/veh)	Estimated Movement LOS	Approach Delay (sec/veh)	Estimated Approach LOS
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	91.8	F	43.3	D
				EBT	52.8	D		
				EBR	11.4	B		
			Port Republic Road	WBL	37.0	D	21.5	C
				WBT	21.3	C		
				WBR	9.6	A		
			South Main Street	SBL	74.7	E	53.7	D
				SBT	35.7	D		
				SBR	39.0	D		
			South Main Street	NBL	60.7	E	35.4	D
				NBT	43.9	D		
NBR	17.0	B						
Intersection					39.4	D	39.4	D
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBL	13.5	B	13.3	B
				EBT	13.3	B		
				EBR	31.1	D		
			Port Republic Road	WBL	10.0	A	1.3	A
				WBT	1.2	A		
				WBR	1.7	A		
			Hillcrest Drive	SBL	34.2	D	22.8	C
				SBR	9.4	A		
			Hillcrest Drive	NBL	0.0	A	36.9	E
				NBR	36.9	E		
			Intersection					8.2
3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBL	0.0	A	83.7	F
				NBR	83.7	F		
			Port Republic Road	EBT	22.7	C	22.7	C
				EBR	0.0	A		
			Port Republic Road	WBL	72.7	F	7.9	A
				WBT	7.0	A		
			Intersection					16.7
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal	Hillside Avenue	NBL	64.5	E	31.8	C
				NBT	58.3	E		
				NBR	15.7	B		
			Bluestone Drive	SBL	98.0	F	101.5	F
				SBT	122.1	F		
				SBR	105.6	F		
			Port Republic Road	EBL	92.4	F	44.4	D
				EBT	38.7	D		
				EBR	29.9	C		
			Port Republic Road	WBL	24.7	C	23.1	C
				WBT	24.6	C		
WBR	17.1	B						
Intersection					45.2	D	45.2	D
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	75.8	E	78.4	E
				SBR	80.7	F		
			Port Republic Road	EBT	7.9	A	6.9	A
				EBR	2.2	A		
			Port Republic Road	WBL	26.7	C	34.3	C
				WBT	36.1	D		
			Intersection					25.2

Table 2.8 2030 PM No Build Level of Service (Cont)

Node No.	Intersection	Traffic Control	Approach	Movement	No Build MOEs			
					Movement Delay (sec/veh)	Estimated Movement LOS	Approach Delay (sec/veh)	Estimated Approach LOS
6	Port Republic Road at NB I-81 On-Ramp	Signal	Port Republic Road	EBL	38.8	D	19.2	B
				EBT	15.2	B		
			Port Republic Road	WBT	10.7	B	9.8	A
				WBR	4.5	A		
			Intersection				14.7	B
7	Port Republic Road at NB I-81 Off-Ramp / Forest Hill Road	Signal	NB I-81 Off-Ramp	NBL	73.0	E	49.3	D
				NBT	53.3	D		
				NBR	15.5	B		
			Forest Hill Road	SBL	67.3	E	48.0	D
				SBR	33.5	C		
			Port Republic Road	EBL	35.2	D	13.9	B
				EBT	11.5	B		
			Port Republic Road	WBT	65.8	E	69.0	E
				WBR	86.9	F		
			Intersection				42.1	D
8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBL	371.5	F	358.5	F
				NBR	324.4	F		
			Port Republic Road	EBT	3.7	A	3.8	A
				EBR	5.0	A		
			Port Republic Road	WBL	57.0	F	78.1	F
				WBT	78.8	F		
			Intersection				42.7	E
9	Port Republic Road at Bradley Drive	Two-Way Stop	Bradley Drive	NBL	386.2	F	387.9	F
				NBR	392.7	F		
			Port Republic Road	EBT	5.9	A	5.8	A
				EBT	4.3	A		
			Port Republic Road	WBL	59.9	F	61.2	F
				WBT	61.2	F		
			Intersection				42.2	E
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	219.3	F	201.5	F
				NBT	177.9	F		
				NBR	99.6	F		
			Devon Lane	SBL	55.3	E	52.3	D
				SBT	58.6	E		
				SBR	49.7	D		
			Port Republic Road	EBL	69.1	E	37.9	D
				EBT	33.1	C		
			Port Republic Road	EBR	32.5	C	86.6	F
				WBL	52.2	D		
				WBT	88.5	F		
Port Republic Road	WBR	79.7	E	65.4	E			
	Intersection					65.4	F	65.4

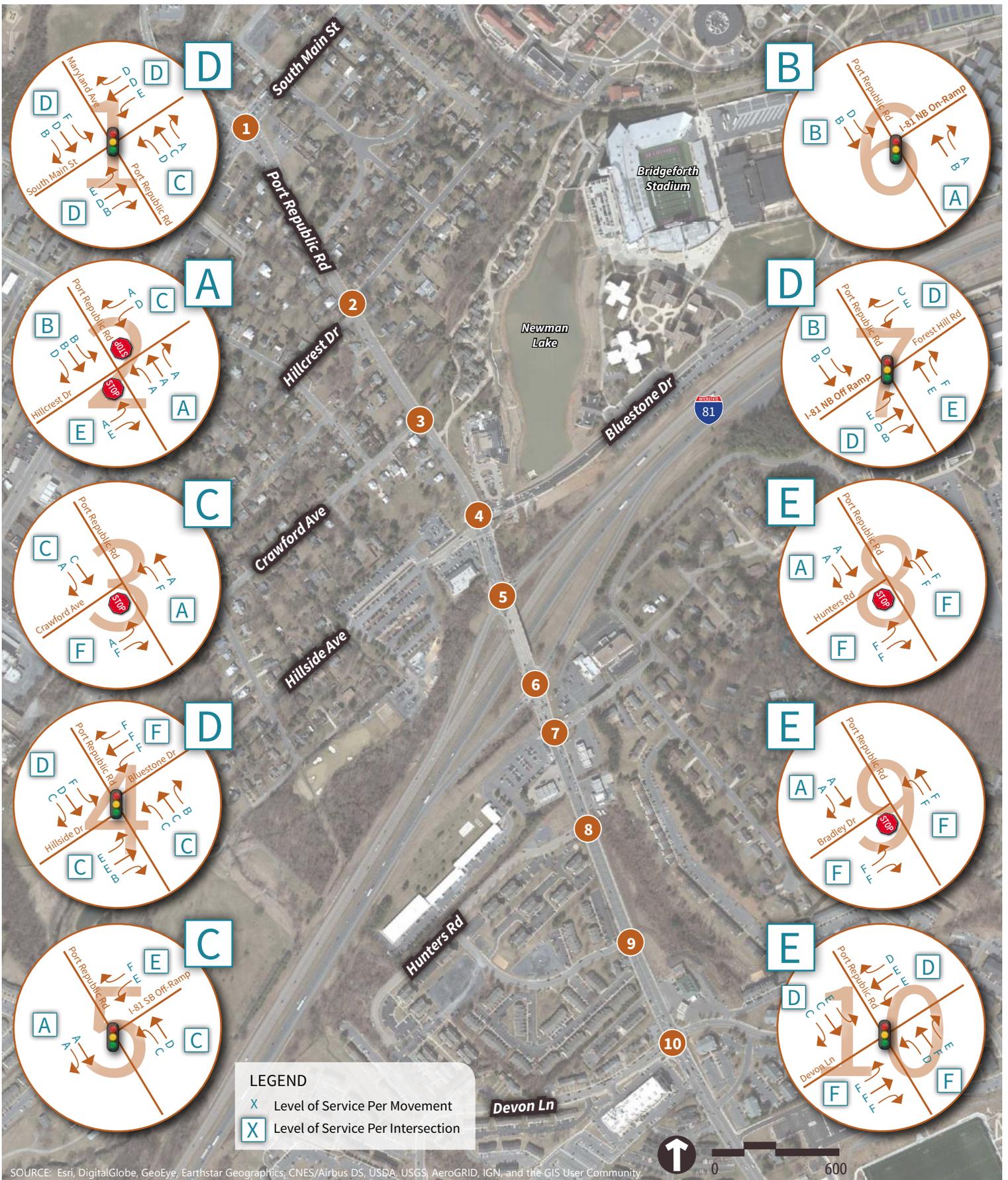


SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 2.10
2030 AM NO BUILD LEVEL OF SERVICE

Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia



SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 2.11
2030 PM NO BUILD LEVEL OF SERVICE

Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

Queue Analysis

In the 2030 no build analysis model there are several locations where downstream signals (particularly around the I-81 interchange) impact upstream flow in both directions based on the VISSIM model. Tables 2.9 and 2.10 show the 2030 no build simulated average and maximum queue lengths for all movements. Locations where average or maximum queue lengths extend beyond the available storage are shown in red.

There were several through movements, particularly in the PM peak period, where queueing is anticipated to back up to a level where vehicles intending to turn onto Port Republic Road are unable to do so due to excessive congestion. These locations were carefully monitored during the 2030 build model to ensure the queues are managed to allow these movements to enter the system. These critical locations are:

- Port Republic Road and Southbound I-81 off-ramp;
- Port Republic Road and northbound Bradley Drive;
- Port Republic Road and northbound Devon Lane; and,
- Westbound on Port Republic Road east of Devon Lane.

The majority of the no build turn lanes are unable to contain the anticipated maximum queues as shown in Tables 2.9 and 2.10. Additionally, there are several turn lanes that are unable to handle the average queues. These locations are described below.

The auxiliary lanes that are unable to accommodate the expected average queue lengths are:

- Port Republic Road and South Main Street:
 - westbound right; and,
 - southbound left.
- Port Republic Road and Bluestone Drive/Hillside Avenue:
 - eastbound left.
- Port Republic Road and I-81 southbound ramps:
 - southbound left; and,
 - southbound right.

The auxiliary lanes that are unable to accommodate the simulated maximum queue lengths are:

- Port Republic Road and South Main Street:
 - westbound left;
 - westbound right;
 - eastbound left;
 - southbound left;
 - northbound left; and,
 - northbound right.
- Port Republic Road and Bluestone Drive/Hillside Avenue:
 - southbound left;
 - eastbound left; and,
 - westbound right.
- Port Republic Road and I-81 southbound ramps:
 - westbound left;
 - southbound left; and,
 - Southbound right.
- Port Republic Road and I-81 northbound on-ramp:
 - eastbound left; and,
 - westbound right.
- Port Republic Road and I-81 northbound off-ramp and Forest Hill Road:
 - northbound left; and
 - eastbound left.
- Port Republic Road and Devon Lane:
 - southbound right; and
 - eastbound left.

It is important to point out that the southbound queues at the I-81 southbound off-ramp during the 2030 no build AM peak hour are approaching a length that could back up onto the I-81 southbound main line. This is a critical concern. The improvements included in the 2030 build model manage the queues so there is not spillback onto I-81 southbound. These improvements include lengthening the signal cycle length to 150 seconds; installing a flashing yellow arrow signal head to allow for lagging lefts at this intersection in the AM peak hour; lengthening the length of the left turn lane and right turn lane on the ramp to 500 feet; and installing a pedestrian overpass at Bluestone Drive that allows for more green time on Port Republic Road. To reduce potential queuing in the short term, installation of the flashing yellow arrow and optimization of the signal timing and phasing are recommended.

Table 2.9 2030 No Build AM Simulated Queue Lengths

Node No.	Intersection	Traffic Control	Approach	Movement	No Build MOEs			
					Average Queue Length (ft)	Max Queue Length (ft)	Link Distance (ft)	Storage Length (ft)
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	29	200		150
				EBT	56	318	225	
				EBR	1	67		100
			Port Republic Road	WBL	21	144		250
				WBT	52	787	525	
				WBR	263	900		150
			South Main Street	SBL	39	148		200
				SBT	28	177	300	
				SBR	26	179	300	
			South Main Street	NBL	26	167		150
				NBT	52	381	350	
NBR	2	135			150			
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBL	1	55	275	
				EBT	0	21	275	
				EBR	0	21	275	
			Port Republic Road	WBL	10	209	525	
				WBT	17	289	525	
				WBR	14	249	525	
			Hillcrest Drive	SBL	2	66	525	
				SBR	1	67	525	
			Hillcrest Drive	NBL	0	41	375	
				NBR	0	42	375	
			3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBL	1
NBR	2	109					275	
Port Republic Road	EBT	0				3	525	
	EBR	0				3	525	
Port Republic Road	WBL	3				212	450	
	WBT	2				163	450	
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal	Hillside Avenue	NBL	20	172	200	
				NBT	20	172	200	
				NBR	1	55		100
			Bluestone Drive	SBL	18	96		600
				SBT	18	96	600	
				SBR	20	101	600	
			Port Republic Road	EBL	42	371		100
				EBT	67	461	475	
				EBR	3	253	475	
			Port Republic Road	WBL	14	123		200
				WBT	170	367	225	
WBR	35	367			50			
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	940	1672		100
				SBR	1137	1775		100
			Port Republic Road	EBT	19	313	250	
				EBR	0	56		100
			Port Republic Road	WBL	12	358		125
				WBT	77	467	350	

Table 2.9 2030 No Build AM Simulated Queue Lengths (Cont)

Node No.	Intersection	Traffic Control	Approach	Movement	No Build MOEs			
					Average Queue Length (ft)	Max Queue Length (ft)	Link Distance (ft)	Storage Length (ft)
6	Port Republic Road at NB I-81 On-Ramp	Signal	Port Republic Road	EBL	46	326		125
				EBT	0	24	325	
			Port Republic Road	WBT	15	302	150	
				WBR	0	46		50
7	Port Republic Road at NB I-81 Off-Ramp / Forest Hill Road	Signal	NB I-81 Off-Ramp	NBL	110	510		275
				NBT	44	227	900	
				NBR	6	118	900	
			Forest Hill Road	SBL	41	197		500
				SBR	41	197		500
			Port Republic Road	EBL	9	120		175
				EBT	38	237	125	
			Port Republic Road	WBT	2025	2293	375	
				WBR	2025	2293	375	
			8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBL	115
NBR	113	496					725	
Port Republic Road	EBT	2				182	375	
	EBR	3				225	375	
Port Republic Road	WBL	219				1863	525	
	WBT	201				1863	525	
9	Port Republic Road at Bradley Drive	Two-Way Stop	Bradley Drive	NBL	17	178	900	
				NBR	16	179	900	
			Port Republic Road	EBT	0	7	525	
				EBT	0	10	525	
			Port Republic Road	WBL	71	1263	425	
				WBT	62	1263	425	
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	89	435	4250	
				NBT	89	435	4250	
				NBR	0	32		150
			Devon Lane	SBL	7	87	300	
				SBT	7	87	300	
				SBR	11	181		150
			Port Republic Road	EBL	5	77		150
				EBT	43	342	425	
				EBR	41	344	425	
			Port Republic Road	WBL	3	65		150
				WBT	180	688	800	
				WBR	179	687	800	

Table 2.10 2030 No Build PM Simulated Queue Lengths

Node No.	Intersection	Traffic Control	Approach	Movement	No Build MOEs			
					Average Queue Length (ft)	Max Queue Length (ft)	Link Distance (ft)	Storage Length (ft)
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	9	70		150
				EBT	62	302	225	
				EBR	1	74		100
			Port Republic Road	WBL	43	419		250
				WBT	56	482	525	
				WBR	14	350		150
			South Main Street	SBL	347	1301		200
				SBT	192	1254	300	
				SBR	192	1255	300	
			South Main Street	NBL	37	174		150
				NBT	110	588	350	
NBR	24	418		150				
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBL	84	687	275	
				EBT	75	641	275	
				EBR	75	641	275	
			Port Republic Road	WBL	1	153	525	
				WBT	1	111	525	
				WBR	1	77	525	
			Hillcrest Drive	SBL	2	61	525	
				SBR	1	62	525	
			Hillcrest Drive	NBL	0	37	375	
				NBR	0	38	375	
			3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBL	5
NBR	14	129					275	
Port Republic Road	EBT	170				681	525	
	EBR	170				681	525	
Port Republic Road	WBL	46				544	450	
	WBT	37				502	450	
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal				Hillside Avenue	NBL	19
			NBT	19	183		200	
			NBR	2	82			100
			Bluestone Drive	SBL	387	1136		600
				SBT	387	1136	600	
				SBR	404	1157	600	
			Port Republic Road	EBL	136	2336		100
				EBT	0	3630	475	
				EBR	17	3630	475	
			Port Republic Road	WBL	5	85		200
				WBT	167	359	225	
WBR	30	349		50				
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	122	633		100
				SBR	160	685		100
			Port Republic Road	EBT	47	405	250	
				EBR	1	68		100
			Port Republic Road	WBL	31	372		125
				WBT	103	454	350	

Table 2.10 2030 No Build PM Simulated Queue Lengths (Cont)

Node No.	Intersection	Traffic Control	Approach	Movement	No Build MOEs			
					Average Queue Length (ft)	Max Queue Length (ft)	Link Distance (ft)	Storage Length (ft)
6	Port Republic Road at NB I-81 On-Ramp	Signal	Port Republic Road	EBL	77	451		125
				EBT	23	393	325	
			Port Republic Road	WBT	54	337	150	
				WBR	3	279		50
7	Port Republic Road at NB I-81 Off-Ramp / Forest Hill Road	Signal	NB I-81 Off-Ramp	NBL	101	505		275
				NBT	37	197	900	
				NBR	10	133	900	
			Forest Hill Road	SBL	116	393		500
				SBR	116	393		500
			Port Republic Road	EBL	29	240		175
				EBT	92	354	125	
			Port Republic Road	WBT	1682	2238	375	
				WBR	1682	2238	375	
			8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBL	216
NBR	216	584					725	
Port Republic Road	EBT	8				327	375	
	EBR	9				362	375	
Port Republic Road	WBL	494				1808	525	
	WBT	463				1808	525	
9	Port Republic Road at Bradley Drive	Two-Way Stop	Bradley Drive	NBL	334	486	900	
				NBR	334	487	900	
			Port Republic Road	EBT	22	1216	525	
				EBT	26	1216	525	
			Port Republic Road	WBL	277	1208	425	
				WBT	252	1208	425	
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	273	472	4250	
				NBT	273	472	4250	
				NBR	0	22		150
			Devon Lane	SBL	31	240	300	
				SBT	31	240	300	
			Port Republic Road	SBR	46	342		100
				EBL	78	479		150
			Port Republic Road	EBT	154	1721	425	
				EBR	155	1721	425	
			Port Republic Road	WBL	4	66		150
WBT	340	720		800				
WBR	339	720		800				

Travel Time Analysis

Travel times to traverse the corridor were calculated using the same method used in the 2018 existing model. The travel time results are displayed in Table 2.11. Speed maps for the 2030 no build AM and PM peak hours are shown in Figures 2.12 and 2.13. The dark green color represents expected vehicle speeds near the speed limit of the corridor, which is 35 mph, and the red and pink colors denote areas of slower speed vehicles traveling through the model, with pink representing the highest level of congestion.

Table 2.11 2030 No Build Summary of Travel Time

Peak Hour	Travel Time Run	Simulated Travel Time (sec)	Simulated Travel Time (M:SS)
	Segment		
AM Peak Hour	Port Republic Road Eastbound	260.88	04:20.9
	Port Republic Road Westbound	274.93	04:34.9
	Port Republic Road EB to I-81 NB Ramps	171.43	02:51.4
	Port Republic Road WB to I-81 SB Ramps	181.24	03:01.2
PM Peak Hour	Port Republic Road Eastbound	334.32	05:34.3
	Port Republic Road Westbound	478.6	07:58.6
	Port Republic Road EB to I-81 NB Ramps	228.51	03:48.5
	Port Republic Road WB to I-81 SB Ramps	385.08	06:25.1

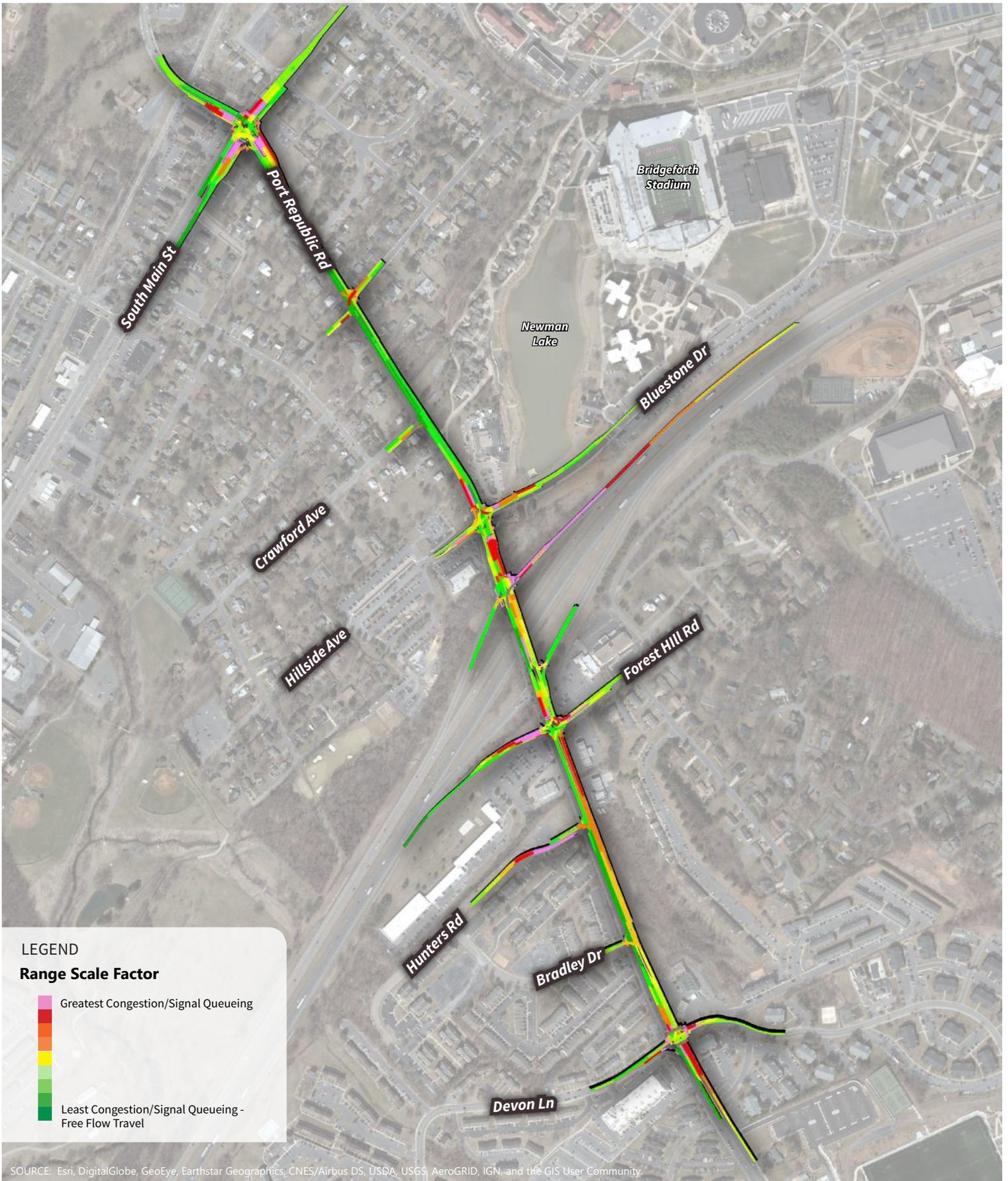


FIGURE 2.12
2030 AM NO BUILD SPEED MAP
 Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

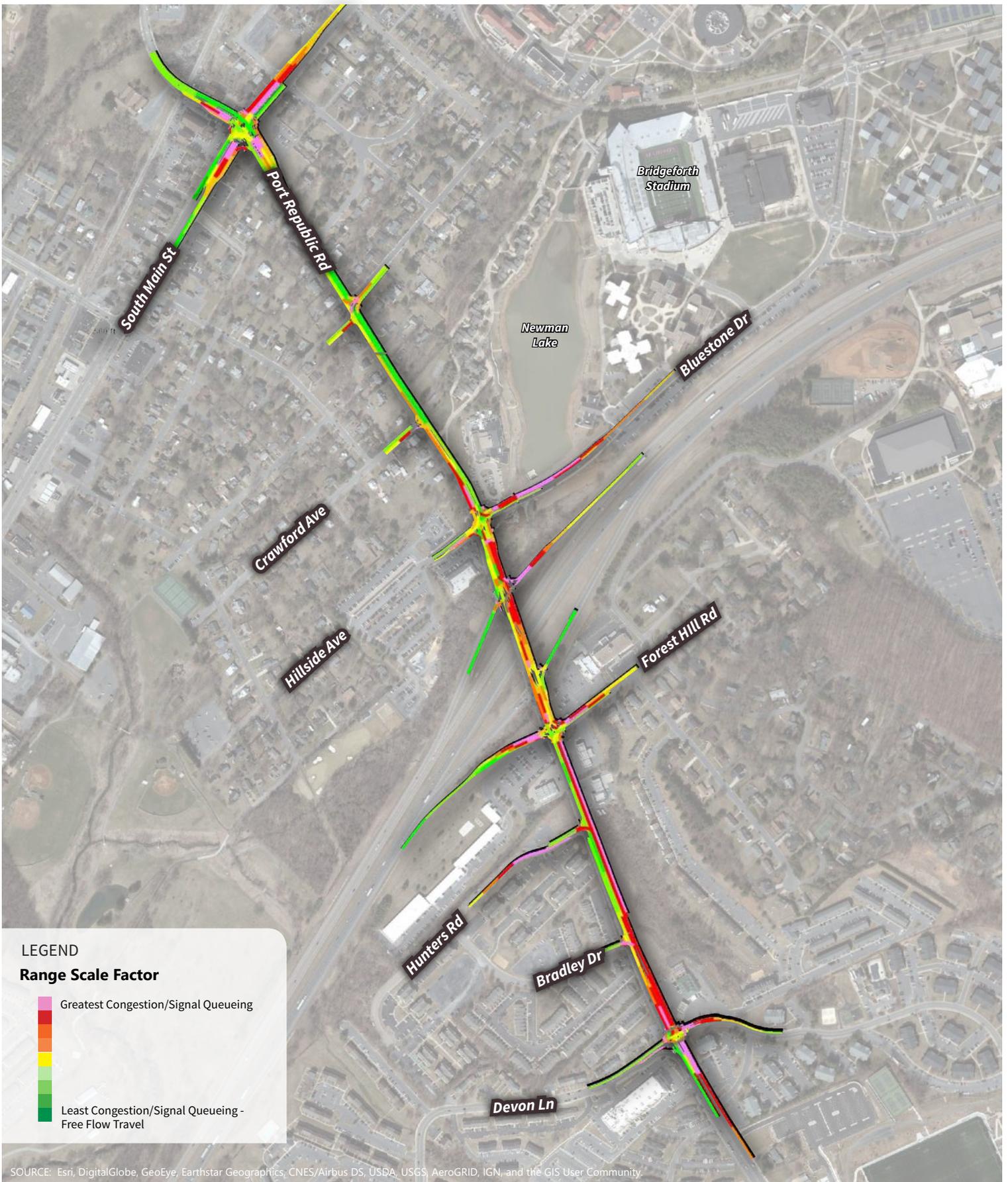


FIGURE 2.13
2030 PM NO BUILD SPEED MAP
 Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

2030 Build Conditions Analysis

Through the operational analysis of the 2018 existing conditions, the 2030 no build conditions, and the safety analysis potential shortfalls were identified along the corridor and a set of recommendations was developed to mitigate these shortfalls. The main objective of these recommended improvements is to manage queues and maximize throughput to prevent queue spillback and resultant congestion.

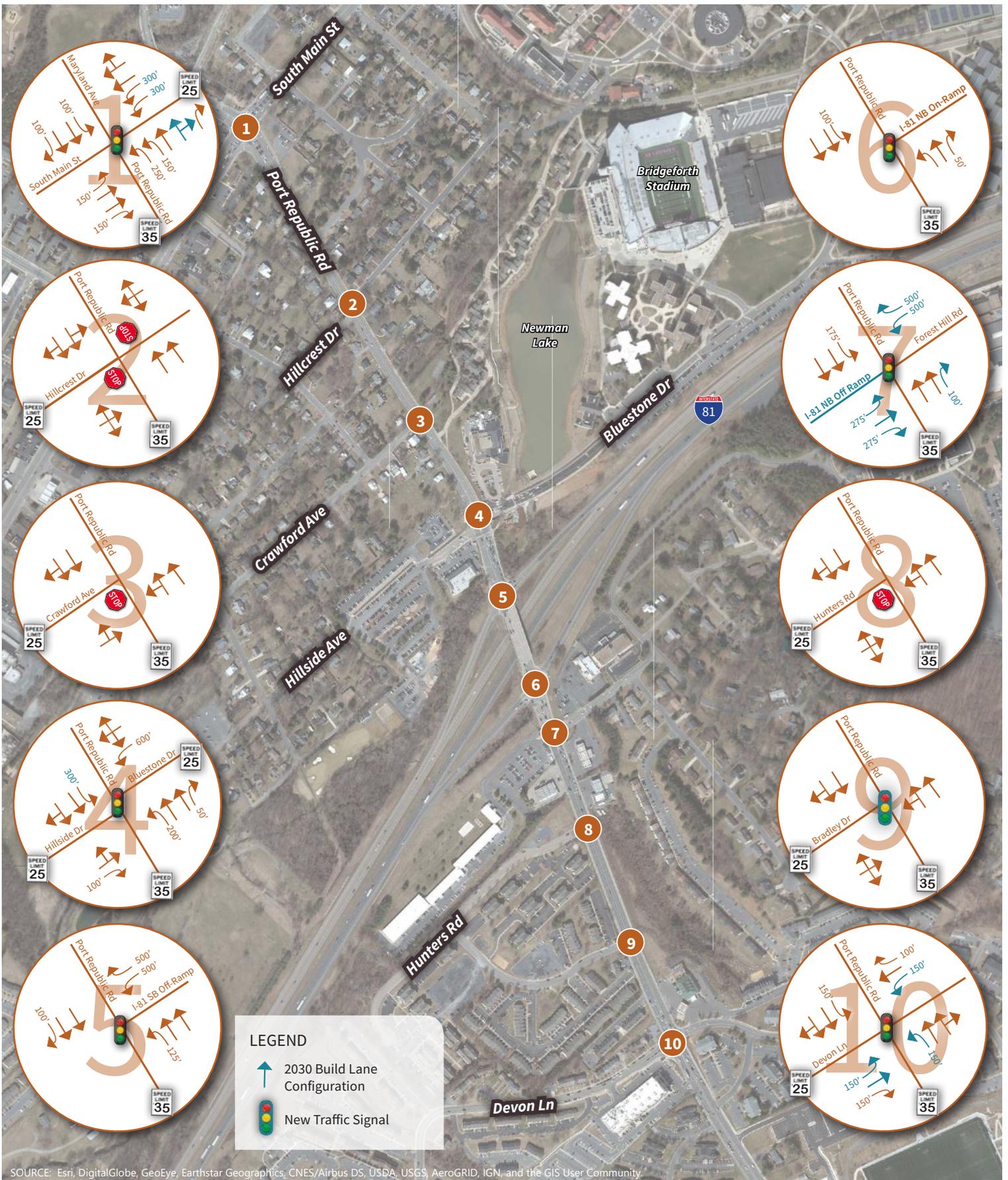
The calibrated and validated 2018 existing conditions AM and PM VISSIM models was utilized as the foundation for the build models. The coded VISSIM geometry was modified to reflect the upcoming roadway projects that were included in the 2030 no build model as well as the improvements listed below. The 2030 build lane geometry is shown in Figure 2.14. The methodology and model development for the 2030 build model is documented in Appendix F.

Geometric Changes

Turn lanes were included, or extended, by reconfiguring the lane configurations within the existing roadway footprint or widening of the existing roadway at the intersections of Port Republic Road with Forest Hill Bluestone Drive, South Main Street, I-81 southbound off ramp, and Devon Lane. These lanes provide storage for queued vehicles and allow for strategic changes to signal phasing.

An alternative intersections analysis was performed for the intersection of Port Republic Road and South Main Street using VDOT's VJUST tool. This analysis included the feasibility of alternative intersection configurations to improve operations at this intersection. The intersection types that were evaluated included a conventional signalized intersection, a full displaced left turn intersection, a partial displaced left turn intersection, a roundabout, and a stop control intersection. The results show that three of these intersection types have the capacity to facilitate the 2030 projected traffic volumes. These include the conventional signalized intersection, and the full and partial displaced left turns. The intersection types that were not evaluated require significant financial, right-of-way, or were not applicable for this facility type. This report is included in Appendix G.

The most favorable, in terms of congestion, are the conventional signalized intersection and the partial displaced left turn. The partial displacement intersection configuration does reduce some of the conflict points, resulting in an anticipated safety benefit for vehicles but was less accommodating to pedestrians. For this reason, it is recommended this intersection remains a conventional signalized intersection. For the build model a focus on access management strategies, lane configurations and signal operations were considered to improve operations at this intersection.



SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 2.14
2030 BUILD LANE GEOMETRICS
 Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

Additional geometric changes include a grade separated pedestrian overpass to facilitate the northbound and southbound pedestrian movements at the intersection of Port Republic Road and Bluestone Drive/Hillside Avenue. This improvement is further discussed in the traffic signal optimization section.

Geometric Improvements that were included in the 2030 Build Model are summarized below:

- Include a westbound right turn lane with 100 feet of storage on Port Republic Road at the intersection of Port Republic Road and Forest Hill Road;
- Increase the eastbound left turn lane storage length on Port Republic Road and Bluestone Drive from 100 feet to 300 feet;
- Increase the southbound left turn lane and right turn lane storage length on the south I-81 off ramp from 100 feet to 500 feet;
- Reconfigure westbound Port Republic Road approach at South Main Street to include two (2) left turn lanes, one (1) through lane and one (1) through/right and one (1) right turn lane;
- Reconfigure the westbound approach of Devon Lane at Port Republic Road to include one (1) left turn lane, one (1) through lane and one (1) right turn lane and widen the southbound approach to include one (1) left turn lane, one (1) through lane and one (1) right turn-lane; and,
- Pedestrian overpass over Port Republic at Bluestone Drive/Hillside Avenue.

Access Management Strategies

Safety and operations at some intersections may be enhanced by restricting left turning maneuvers during specific times of the day using signage or by prohibiting the turning movement all together by installing a median or channelizing device. Restricting these movements increases the operational capacity of the roadway and should practically eliminate crashes related to the affected turning maneuver due to the removal of conflict points. Additionally, a non-traversable median separates opposing directions of travel, significantly reducing the potential for head-on crashes.

Peak hour turn restrictions are recommended at three (3) of the four (4) currently unsignalized study intersections. While these restrictions should improve operations on Port Republic Road, and provide a safety benefit, it is important to understand the impact to the system.

Restricting eastbound left turns onto Hillcrest Drive should result in a minimal detour as traffic can access Fairview Avenue or Maplehurst Avenue from South Main Street. The westbound left turn restriction at Hillcrest Drive and Crawford Avenue will be a more significant detour as traffic will need to make a left onto South Main Street and then a left onto Weaver Avenue or Monument Avenue. While these movements will see some delay, there is an overall safety benefit of making these left turns within a dedicated left turning space on South Main Street in addition to the operational benefit on Port Republic Road.

Restricting access at both Hunters Road and Bradley Drive is more difficult as these roadways are the only access points to the apartments. Prohibiting these left turns at both locations will re-route traffic patterns which may involve risky U-turn maneuvers at adjacent traffic signals, or at gas station drives and may negatively impact transit operations. Therefore, it is recommended that one of these access points remain open. The addition of a traffic signal at Bradley Drive, which would require a waiver due to its proximity to the signalized intersection of Port Republic Road and Devon Lane, should be the best option for safety and access. Since a left turn lane at this location is not considered to be an option at this time due to right of way constraints, the proposed signal will include a westbound leading left with concurrent through phase to accommodate the westbound left turns onto Bradley Drive.

Traffic counts used for Bradley Drive were peak hour counts obtained from a 2016 Traffic Impact Analysis report, performed by DRW Consultants, LLS. Therefore, a preliminary signal warrant analysis was based on ADT values, as outlined in Table 4C-V1 of the Virginia Supplement to the 2009 MUTCD was performed. The 2017 ADT counts provided by VDOT were used for Port Republic and an assumption that the design peak hour volumes on Bradley Drive represent roughly 10% of the daily AADT. Based on these counts and assumptions, a signal is warranted at the intersection of Port Republic Road and Bradley Drive as shown in Table 2.12. A full signal justification report will need to be performed before a signal is installed at this location.

Table 2.12 Planning Level Signal Warrant Analysis

Port Republic Street and Bradley Drive				Major		Minor		Meet Warrant?
	Major AADT (2017 VDOT)	Minor Street VPH	Minor AADT*	Cond. A	Cond. B	Cond. A	Cond. B	
AM	27,000	180	1,800	Yes	Yes	No	Yes	Yes
PM	27,000	198	1,980	Yes	Yes	No	Yes	Yes

* Assumption That Peak Hour Traffic Volumes are Equal to 10% of Daily AADT

Additionally, there were five angled collisions in 2017 that involved a northbound vehicle on Bradley Lane attempting to turn left onto Port Republic Road. These crashes would be considered to be correctable with the installation of a traffic signal and would satisfy condition B of Warrant 7, Crash Experience, found within the MUTCD.

A restriction of northbound and southbound through movements at the intersection of Port Republic Road and Devon Lane was discussed with stakeholders. The through movements during the AM and PM peak hours are low: 17 northbound vehicles in the AM and PM peak, and six (6) southbound vehicles in the AM peak, and 24 in the PM peak. Restricting these through movements would remove the need to provide a split phase at the signal and would allow for additional time to be provided to the eastbound and westbound movements on Port Republic Road.

Using Synchro 9.1 software, a model was created that compared existing lane configuration and signal phasing at Devon Lane and Port Republic Road to eliminating the northbound and southbound through movements and changing the lane configurations, both of which allow for the removal of the split phase which was found to benefit operations at the intersection. These results are shown below in Table 2.13.

While this analysis shows significant advantages to the overall operations of the intersection by restricting the through movement, there is a concern that transit vehicles currently performing a through movement at this intersection would endure significant delay that might necessitate re-routing. Additionally, while it was assumed this restriction could be made using an electronic R3-27 sign installed on the mast arm, compliance would be difficult to enforce. Due to these concerns, the 2030 build model includes the lane change option with no turn restrictions.

Table 2.13 Devon Lane Alternatives

Peak Hour	Approach	Delay			Queue		
		Base Build	Thru Restrict	Lane Change	Base Build	Thru Restrict	Lane Change
AM Peak	Intersection	37 (D)	22 (C)	31 (C)	N/A		
	NB Devon Lane	81 (F)	66 (E)	67 (E)	450	360	320
	SB Devon Lane	37 (D)	18 (B)	36 (D)	70	45	114
	WB Port Republic Road	31 (C)	17 (B)	27 (C)	540	411	500
	EB Port Republic Road	28 (C)	12 (B)	21 (C)	411	200	320
PM Peak	Intersection	30 (C)	16 (B)	24 (C)	N/A		
	NB Devon Lane	66 (E)	56 (E)	44 (D)	320	285	230
	SB Devon Lane	35 (D)	22 (C)	31 (C)	140	100	100
	WB Port Republic Road	30 (C)	17 (B)	27 (C)	400	300	390
	EB Port Republic Road	21 (C)	5 (A)	16 (B)	580	180	500

Access management improvements that were included in the 2030 Build Model are summarized below:

- Peak hour left turn restrictions onto and off Hillcrest Drive, Crawford Avenue, and Hunters Road;
- Install a median to restrict left turning movements within the proximity of all signalized intersections; and,
- Close the gas station entrance nearest the intersection of Port Republic Road and Forest Hills Road on the northeast corner.

The left turning restrictions on Port Republic Road at Hillcrest Drive, Crawford Avenue and Hunters Road is anticipated to be during the peak traffic hours in the morning and evening. The exact time of the restriction is estimated to be from 7AM to 9AM and 4 PM and 6PM. This can be accomplished through the use of a flashing sign, that will flash during the time of the restriction, and police enforcement. It is important for the city to monitor compliance and install a physical barrier on the side street approaches, making the restriction full time if necessary.

Traffic Control Measures

Signal timing parameters including cycle length, splits, and offsets were optimized for the 2030 no build geometry and volumes utilizing the Synchro software. These parameters are discussed in greater detail below.

Traffic signal operations throughout the study area were analyzed and optimized in the 2030 build model. Signal optimization strategies include split reallocation, cycle length increase from 134 seconds to 150 seconds, and phase sequence modifications to increase the bandwidth and progress vehicles through the corridor.

The signalized intersections that currently operate with a split phase were analyzed to allow simultaneous opposing through and left turn movements when applicable. To facilitate these movements a change in the lane configuration, or the addition of turn lanes was considered.

Using flashing yellow arrow signal indications allows for left turn phases to be leading or lagging without the safety concern of yellow trap. In addition to allowing for better two-way progression, the sequence of the left turns can benefit locations with limited left turn storage. Leading lefts are beneficial in areas where the left turn volume exceeds its available storage while lagging lefts are more appropriate if the through lane typically backs up past the end of the left turn storage bay. Optimizing the left turn sequence is particularly beneficial in coordinated systems with closely spaced signals such as the study corridor. Note that the optimization includes the use of a lagging westbound left during the AM peak hour and a leading left turn during the PM peak hour at the intersection of Port Republic Road and southbound I-81 ramps.

The reconfiguration of the westbound approach at South Main Street to include two (2) left turn lanes, one (1) through lane and (1) through/right and one (1) right turn lane was first modeled in Synchro to determine the potential benefits before including the reconfiguration in the VISSIM model. Based on the results of the Synchro the reconfiguration was anticipated to produce significant improvements in delay and queueing during both the AM and PM

peak hours. The results of the VISSIM Build AM peak model show an anticipated reduction of the maximum queue by 127 feet and a reduction of the queue for the westbound right movement by 240 feet. The build AM peak model also projects improvements to the level of service and overall intersection delay improvement by 1.5 seconds. However, in the PM peak hour the proposed reconfiguration is not expected to have a positive impact. While eight (8) of the 12 movements are expected to have a maximum queue length less than what is predicted in the no build model, the westbound right queue increases by 135 feet. This anticipated result is counterintuitive. One theory is that due to the congestion in the no build model the westbound traffic was essentially metered. The expected improvement between the no build and build model in westbound travel time by almost three (3) minutes and an expected reduction in stops from 4.5 seconds per vehicle to 2.68 stops per vehicle would suggest this may be the case. Additionally, there were some unprocessed vehicles in the no build model that are able to enter in the build model.

One of the improvements included in the 2030 build model is the addition of a grade separated pedestrian overpass at Port Republic and Hillside Drive/Bluestone Drive to facilitate pedestrians and cyclists coming from the Bluestone Trail into the JMU campus. A significant volume of pedestrians cross Port Republic Road at Bluestone Drive/Hillside. Seventy-nine (79) pedestrians cross northbound or southbound across Port Republic in the AM peak hour and 69 pedestrians cross in the PM peak hour with a total of 932 a day. In addition to increasing the mobility, comfort, and safety to the pedestrian, removing the northbound and southbound pedestrian phase should have a significant benefit to the throughput capacity along Port Republic Road because network coordination is more efficient and more green time is available to westbound and eastbound movements.

The minimum signal green time programmed for the vehicular north and southbound movements are less than the necessary pedestrian clearance time. The northbound and southbound pedestrian phase is served by suspending coordination, requiring the controller to transition back into the coordination pattern after the pedestrian phase is served resulting in a less than optimal timing plan.

The projected conditions based on the 2030 build model show a slight increase in the PM queue for the I-81 southbound ramp. This projected increase in queue is a result of the improved travel conditions on Port Republic Road. The projected maximum PM queue length of 742 feet contains the queue within the ramp length and is not projected to back onto the interstate. The projected average queues should be contained within the proposed 500' turn lane. Increasing green time for the southbound ramp does not

alleviate the potential increase in queue since the ramp traffic is constrained from turning onto Port Republic Road by the queued traffic on Port Republic Road as well as the adjacent traffic signals at Bluestone Drive and the I-81 northbound ramp. Queues should be monitored in the future to see if the queues increase as projected.

Traffic control improvements that were included in the 2030 Build Model are summarized below:

- Optimize signal timings including cycle lengths, splits, offsets, and phasing sequences;
- Eliminate the northbound and southbound split phase operation at the relocated northbound I-81 off-ramp and Forest Hills Road and allowing simultaneously protected and permissive left turns in the northbound and southbound directions;
- Eliminate the northbound and southbound split phase operation at Port Republic Road and Devon Lane by providing exclusive left turn lanes on the north and south legs, allowing for simultaneous protected and permissive southbound and northbound left turns;
- Eliminate the northbound and southbound pedestrian crossing at Port Republic Road and Bluestone Drive by installing a pedestrian overpass;
- Signalize Port Republic Road and Bradley Lane; and,
- Installing flashing yellow signals where protected/permissive left turns are used. This allows for lead/leg left turn phasing which will assist in bi-directional coordination.

The same projected 2030 volumes that were computed and coded in 2030 no build VISSIM model were used for the build scenario; however, they were redistributed to reflect the change in access and turn restrictions. The 2030 build traffic volumes are depicted in Figure 2.15.



FIGURE 2.15
2030 BUILD NETWORK BALANCED TRAFFIC VOLUMES

Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia



SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

Measures of Effectiveness

As described above, the build condition measures of effectiveness include several strategies to improve operations. With these improvements coded into the build model, the analysis demonstrated a significant improvement in delay and queueing in comparison to the 2030 no build model. A comparison of the measures of effectiveness between the models is detailed later in this report.

Delay and Level of Service Analysis

Based on the 2030 build conditions analysis, all intersections in the study area are expected to operate at acceptable levels of service C or better during the AM peak hour. There are no movements in the 2030 build AM peak hour that are expected to operate at a LOS F, which is an improvement from the 2030 no build model where four (4) movements are expected to operate at a LOS of F. There are several movements, however, that are expected to operate at LOS E which will be listed below and shown in Table 2.14 and Table 2.15 and in Figures 2.16 and 2.17.

Movements that are expected to operate at a LOS of E in the 2030 build AM peak hour are:

- Port Republic Road and Main Street:
 - eastbound left;
 - westbound left;
 - southbound left; and,
 - northbound left.
- Port Republic Road and Bluestone Drive/Hillside Avenue:
 - northbound through
- Port Republic Road and Bradley Drive:
 - northbound left.
- Port Republic Road and Devon Lane:
 - southbound through.

During the 2030 build PM peak period, all intersections in the study area are expected to operate at an acceptable LOS D, which is an improvement from the 2030 no build model where three (3) intersections operated at an overall LOS of E. There are 14 movements that are expected to operate at a LOS E and three (3) movements that are expected to operate at LOS F 2030 PM peak period as shown in Table 2.14. This is a significant improvement from the 2030 no build model, where 21 movements are expected to operate at a LOS of F.

Movements that are expected to operate at a LOS of E in the 2030 build PM peak hour are:

- Port Republic Road and South Main Street:
 - eastbound left;
 - southbound left; and,
 - northbound left.
- Port Republic Road and Crawford Avenue
 - northbound right
- Port Republic Road and Bluestone Drive/Hillside Avenue:
 - northbound left;
 - northbound through;
 - southbound left;
 - southbound through; and
 - southbound right
- Port Republic and I-81 southbound ramps:
 - southbound left.
- Port Republic Road and I-81 northbound off-ramp and Forest Hill Road:
 - northbound through
- Port Republic and Bradley Drive:
 - northbound left.
- Port Republic Road and Devon Lane:
 - northbound through; and
 - southbound through.

Movements that operate at a LOS of F in the 2030 build PM peak hour are:

- Port Republic Road and South Main Street:
 - westbound left.
- Port Republic Road and Bluestone Drive/Hillside Avenue:
 - eastbound left.
- Port Republic Road and I-81 southbound ramps:
 - southbound right.

Table 2.14 2030 AM Build Level of Service

Node No.	Intersection	Traffic Control	Approach	Movement	Build MOEs							
					Movement Delay (sec/veh)	Estimated Movement LOS	Stops per Vehicle	Approach Delay (sec/veh)	Estimated Approach LOS			
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	57.6	E	1.0	31.5	C			
				EBT	36.0	D	0.7					
				EBR	7.2	A	1.0					
			Port Republic Road	WBL	59.8	E	1.0	32.1	C			
				WBT	37.1	D	0.9					
				WBR	22.8	C	1.2					
			South Main Street	SBL	57.3	E	0.9	36.8	D			
				SBT	25.2	C	0.7					
				SBR	17.4	B	0.7					
			South Main Street	NBL	57.6	E	0.9	23.8	C			
				NBT	29.2	C	0.7					
				NBR	4.4	A	0.2					
			Intersection					30.3	C	0.8	30.3	C
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBT	0.3	A	0.0	0.3	A			
				EBR	0.0	A	0.0					
			Port Republic Road	WBT	1.7	A	0.0	1.7	A			
				WBR	2.6	A	0.1					
			Hillcrest Drive	SBR	11.7	B	1.5	11.7	B			
				NBR	9.3	A	1.3	9.3	A			
			Intersection					1.2	A	0.0	1.2	A
			3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBR	9.8	A	1.2	9.8	A
Port Republic Road	EBT	0.3				A	0.0	0.3	A			
	EBR	0.0				A	0.0					
Port Republic Road	WBT	0.4				A	0.0	0.4	A			
Intersection						0.5	A	0.0	0.5	A		
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal	Hillside Avenue	NBL	54.5	D	0.9	37.2	D			
				NBT	63.9	E	1.0					
				NBR	10.5	B	1.1					
			Bluestone Drive	SBL	53.5	D	0.9	43.0	D			
				SBT	48.0	D	1.0					
				SBR	28.2	C	1.2					
			Port Republic Road	EBL	34.8	C	1.4	17.2	B			
				EBT	13.5	B	0.4					
				EBR	11.3	B	0.4					
			Port Republic Road	WBL	12.3	B	0.6	8.4	A			
				WBT	8.3	A	0.2					
				WBR	7.3	A	0.4					
Intersection					14.3	B	0.4	14.3	B			
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	49.4	D	0.9	32.4	C			
				SBR	18.1	B	1.9					
			Port Republic Road	EBT	5.8	A	0.2	5.3	A			
				EBR	2.3	A	0.2					
			Port Republic Road	WBL	6.9	A	0.4	8.8	A			
				WBT	9.0	A	0.4					
			Intersection					11.3	B	0.5	11.3	B

Table 2.14 2030 AM Build Level of Service (Cont)

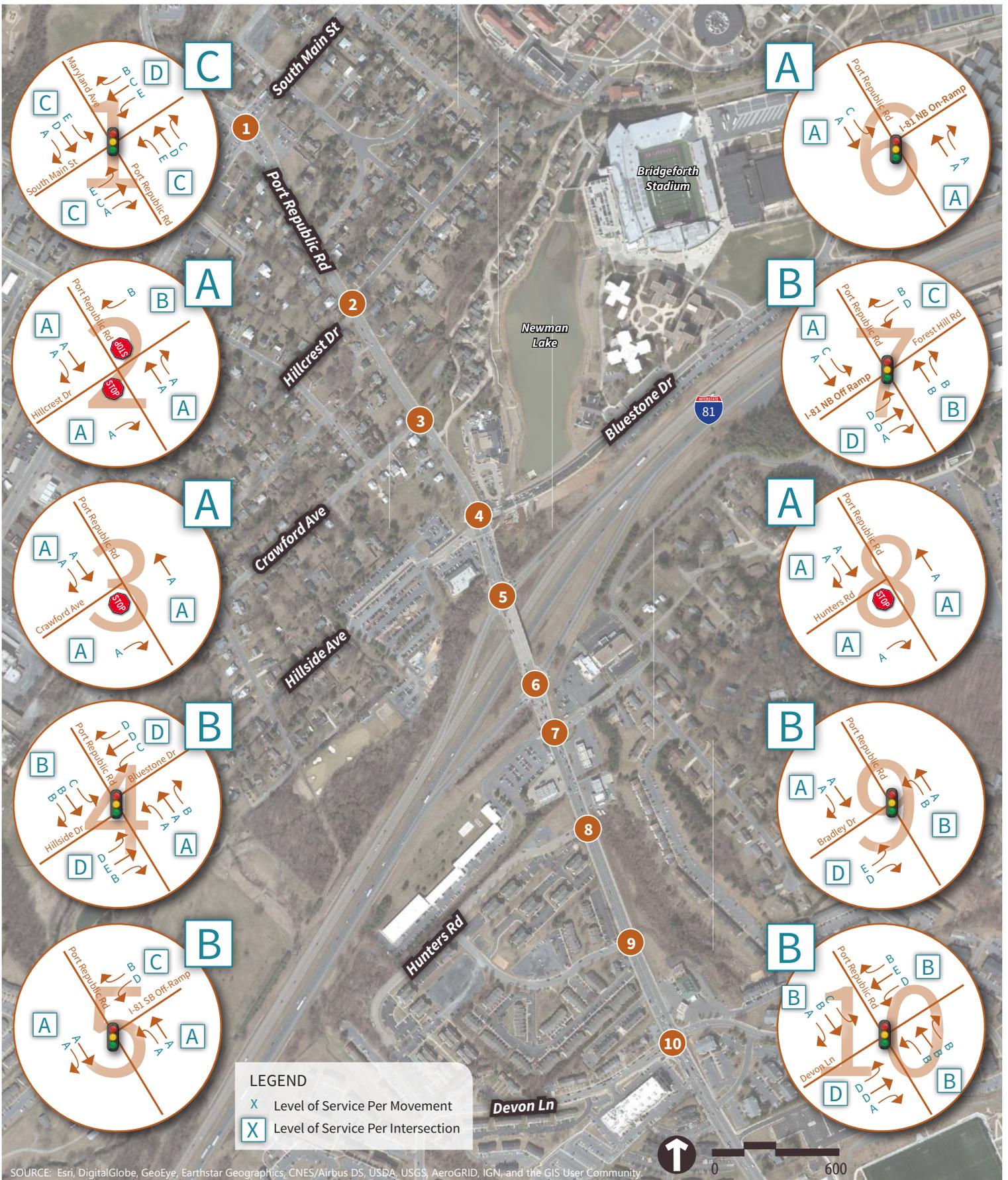
Node No.	Intersection	Traffic Control	Approach	Movement	Build MOEs				
					Movement Delay (sec/veh)	Estimated Movement LOS	Stops per Vehicle	Approach Delay (sec/veh)	Estimated Approach LOS
6	Port Republic Road at NB I-81 On-Ramp	Signal	Port Republic Road	EBL	21.5	C	1.3	4.4	A
EBT				0.8	A	0.0			
Port Republic Road			WBT	2.0	A	0.1	1.8	A	
			WBR	0.6	A	0.0			
Intersection					2.7	A	0.1	2.7	A
7	Port Republic Road at NB I-81 Off-Ramp / Forest Hill Road	Signal	NB I-81 Off-Ramp	NBL	41.3	D	0.9	35.5	D
NBT				50.8	D	0.9			
NBR				8.3	A	1.3			
Forest Hill Road			SBL	54.1	D	0.9	25.6	C	
			SBR	11.4	B	1.6			
Port Republic Road			EBL	26.5	C	1.2	7.1	A	
			EBT	5.1	A	0.2			
Port Republic Road			WBT	12.9	B	0.4	13.9	B	
			WBR	18.9	B	0.7			
Intersection					17.2	B	0.6	17.2	B
8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBR	5.9	A	1.1	5.9	A
EBT				0.7	A	0.0			
Port Republic Road			EBR	1.6	A	0.0	0.8	A	
			WBT	4.5	A	0.2			
Intersection					3.2	A	0.1	3.2	A
9	Port Republic Road at Bradley Drive	Signal	Bradley Drive	NBL	56.0	E	1.0	51.5	D
NBR				39.3	D	1.1			
Port Republic Road			EBT	7.1	A	0.2	7.1	A	
			EBT	6.2	A	0.3			
Port Republic Road			WBL	11.2	B	0.7	7.6	A	
			WBT	7.5	A	0.3			
Intersection					11.0	B	0.4	11.0	B
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	47.9	D	0.9	45.0	D
NBT				43.1	D	0.9			
NBR				7.4	A	0.3			
Devon Lane			SBL	44.7	D	0.8	17.7	B	
			SBT	63.5	E	1.0			
SBR			SBR	12.6	B	2.3			
			Port Republic Road	EBL	20.2	C	1.0	10.8	B
EBT				10.1	B	0.3			
EBR				9.0	A	2.3			
Port Republic Road			WBL	16.9	B	0.9	14.6	B	
	WBT	14.5	B	0.5					
	WBR	14.5	B	0.5					
Intersection					17.8	C	0.7	17.8	B

Table 2.15 2030 PM Build Level of Service

Node No.	Intersection	Traffic Control	Approach	Movement	Build MOEs				
					Movement Delay (sec/veh)	Estimated Movement LOS	Stops per Vehicle	Approach Delay (sec/veh)	Estimated Approach LOS
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	62.8	E	1.1	37.2	D
				EBT	46.5	D	0.8		
				EBR	10.0	A	1.2		
			Port Republic Road	WBL	100.3	F	1.1	48.6	D
				WBT	40.3	D	0.6		
				WBR	12.9	B	0.5		
			South Main Street	SBL	65.3	E	1.0	45.6	D
				SBT	28.6	C	0.7		
				SBR	31.2	C	0.7		
			South Main Street	NBL	62.2	E	1.0	31.2	C
				NBT	37.7	D	0.8		
				NBR	13.9	B	0.6		
			Intersection					41.8	D
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBT	2.0	A	0.1	2.0	A
				EBR	0.8	A	0.0		
			Port Republic Road	WBT	1.5	A	0.0	1.5	A
				WBR	1.8	A	0.0		
			Hillcrest Drive	SBR	7.0	A	1.0	7.0	A
			Hillcrest Drive	NBR	21.8	C	1.7	21.8	C
			Intersection					1.8	A
3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBR	35.9	E	2.2	35.9	E
				EBT	9.9	A	0.3		
			Port Republic Road	EBR	0.0	A	0.0	9.9	A
				WBT	0.8	A	0.0		
			Intersection					5.9	A
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal	Hillside Avenue	NBL	59.4	E	0.9	31.1	C
				NBT	56.0	E	0.9		
				NBR	16.8	B	1.7		
			Bluestone Drive	SBL	68.2	E	1.5	68.7	E
				SBT	79.5	E	1.8		
				SBR	68.6	E	2.0		
			Port Republic Road	EBL	89.6	F	2.4	35.5	D
				EBT	29.1	C	0.7		
				EBR	24.7	C	0.6		
			Port Republic Road	WBL	40.9	D	1.4	22.3	C
				WBT	22.7	C	0.3		
				WBR	16.8	B	0.7		
Intersection					35.4	D	0.9	35.4	D
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	57.2	E	0.9	85.0	F
				SBR	110.1	F	4.3		
			Port Republic Road	EBT	7.0	A	0.2	6.3	A
				EBR	2.8	A	0.2		
			Port Republic Road	WBL	34.8	C	1.5	24.6	C
				WBT	22.2	C	0.7		
			Intersection					22.3	C

Table 2.15 2030 PM Build Level of Service (Cont)

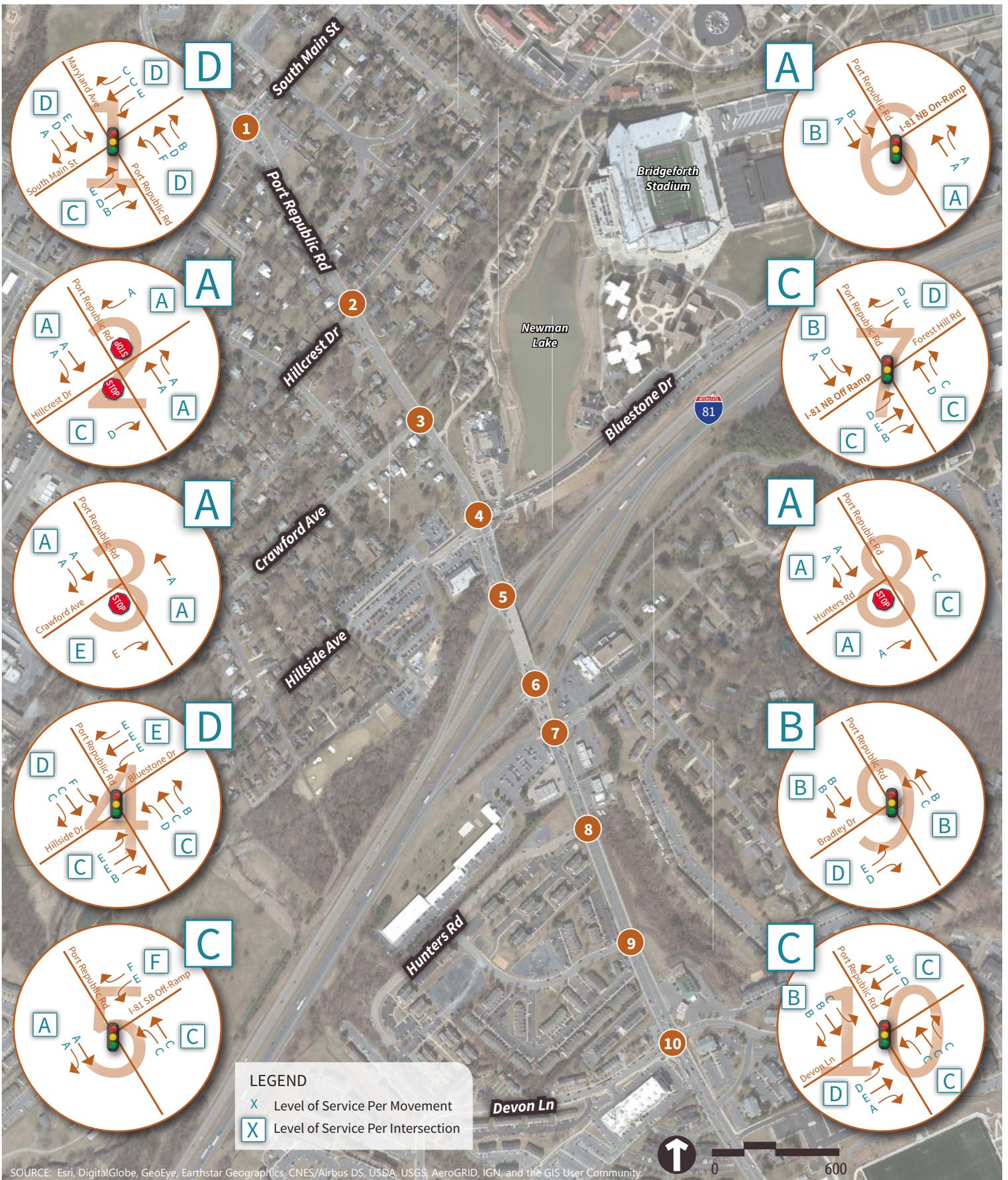
Node No.	Intersection	Traffic Control	Approach	Movement	Build MOEs							
					Movement Delay (sec/veh)	Estimated Movement LOS	Stops per Vehicle	Approach Delay (sec/veh)	Estimated Approach LOS			
6	Port Republic Road at NB I-81 On-Ramp	Signal	Port Republic Road	EBL	18.0	B	1.2	7.8	A			
				EBT	5.8	A	0.2					
			Port Republic Road	WBT	8.8	A	0.3	8.2	A			
				WBR	4.9	A	0.3					
			Intersection					8.0	A	0.3	8.0	A
7	Port Republic Road at NB I-81 Off-Ramp / Forest Hill Road	Signal	NB I-81 Off-Ramp	NBL	37.7	D	1.1	34.5	C			
				NBT	57.8	E	0.9					
				NBR	11.8	B	1.3					
			Forest Hill Road	SBL	53.2	D	1.0	35.1	D			
				SBR	21.9	C	1.8					
			Port Republic Road	EBL	44.5	D	1.5	13.3	B			
				EBT	9.9	A	0.2					
			Port Republic Road	WBT	36.2	D	0.9	34.3	C			
				WBR	23.5	C	1.3					
			Intersection					26.9	C	0.8	26.9	C
			8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBR	8.5	A	1.5	8.5	A
Port Republic Road	EBT	1.9				A	0.0	2.0	A			
	EBR	2.7				A	0.0					
Port Republic Road	WBT	19.1				C	0.6	19.1	C			
Intersection						10.0	A	0.3	10.0	A		
9	Port Republic Road at Bradley Drive	Signal	Bradley Drive	NBL	56.7	E	1.0	54.7	D			
				NBR	45.2	D	1.1					
			Port Republic Road	EBT	11.2	B	0.3	11.1	B			
				EBR	10.4	B	0.4					
			Port Republic Road	WBL	32.3	C	1.3	11.7	B			
				WBT	10.7	B	0.4					
			Intersection					14.5	B	0.4	14.5	B
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	54.2	D	1.0	49.5	D			
				NBT	78.0	E	1.3					
				NBR	6.3	A	0.3					
			Devon Lane	SBL	38.0	D	0.8	28.9	C			
				SBT	61.6	E	1.0					
				SBR	19.0	B	1.9					
			Port Republic Road	EBL	29.3	C	1.1	17.4	B			
				EBT	15.6	B	0.4					
				EBR	14.9	B	0.6					
			Port Republic Road	WBL	30.2	C	1.0	24.2	C			
				WBT	24.0	C	0.6					
				WBR	23.4	C	0.7					
			Intersection					24.1	C	0.7	24.1	C



SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 2.16
2030 AM BUILD LEVEL OF SERVICE
 Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia



SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 2.17
2030 PM BUILD LEVEL OF SERVICE
 Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

Queue Analysis

Tables 2.16 and 2.17 show the 2030 build simulated average and maximum queue lengths for all movements. Locations where average or maximum queue lengths extend beyond the available storage are shown in red.

The auxiliary lanes that are unable to accommodate the expected average queue lengths are:

- Port Republic Road and South Main Street:
 - southbound left.
- Port Republic Road and I-81 southbound ramps:
 - southbound right.
- Port Republic Road and I-81 northbound off-ramp and Forest Hill Road:
 - westbound right.

The auxiliary lanes that unable to accommodate the simulated maximum queue lengths are:

- Port Republic Road and Main Street:
 - westbound left;
 - westbound right;
 - southbound left;
 - northbound left; and,
 - northbound right.
- Port Republic Road and Bluestone Drive/Hillside Avenue:
 - southbound left;
 - eastbound left; and,
 - westbound right.
- Port Republic Road and I-81 southbound ramps:
 - westbound left;
 - southbound left; and,
 - southbound right.
- Port Republic Road and I-81 northbound on-ramp:
 - eastbound left; and,
 - westbound right.
- Port Republic Road and I-81 northbound off-ramp and Forest Hill Road:
 - westbound right
 - northbound left; and
 - eastbound left.
- Port Republic Road and Devon Lane:
 - southbound left
 - southbound right; and
 - eastbound left.

Table 2.16 2030 Build AM Simulated Queue Lengths

Node No.	Intersection	Traffic Control	Approach	Movement	Build MOEs			
					Average Queue Length (ft)	Max Queue Length (ft)	Link Distance (ft)	Storage Length (ft)
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	17	119		150
				EBT	40	247	225	
				EBR	1	68		100
			Port Republic Road	WBL	41	190		250
				WBT	99	660	525	
				WBR	99	660		150
			South Main Street	SBL	41	159		200
				SBT	28	172	300	
				SBR	25	174	300	
			South Main Street	NBL	24	155		150
NBT	57	323		350				
			NBR	2	119		150	
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBT	0	0	0	
				EBR	0	0	0	
			Port Republic Road	WBT	4	0	0	
				WBR	5	0	2	
			Hillcrest Drive	SBR	0	0	44	
			Hillcrest Drive	NBR	0	0	42	
3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBR	1	109	275	
			Port Republic Road	EBT	0	0	525	
				EBR	0	0	525	
			Port Republic Road	WBT	0	0	450	
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal	Hillside Avenue	NBL	41	207	200	
				NBT	42	208	200	
				NBR	1	60		100
			Bluestone Drive	SBL	20	95		600
				SBT	20	95	600	
				SBR	22	118	600	
			Port Republic Road	EBL	21	174		300
				EBT	29	263	475	
				EBR	3	187	475	
			Port Republic Road	WBL	5	104		200
WBT	56	346		225				
WBR	4	232			50			
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	53	262		500
				SBR	18	186		500
			Port Republic Road	EBT	13	249	250	
				EBR	0	56		100
			Port Republic Road	WBL	3	204		125
				WBT	36	429	350	

Table 2.16 2030 Build AM Simulated Queue Lengths (Cont)

Node No.	Node No.	Node No.	Node No.	Node No.	Node No.	Node No.	Node No.	Node No.
6	Port Republic Road at NB I-81 On-Ramp	Signal	Port Republic Road	EBL	10	176		125
				EBT	0	4	325	
			Port Republic Road	WBT	6	255	150	
				WBR	0	33		50
7	Port Republic Road at NB I-81 Off-Ramp / Forest Hill Road	Signal	NB I-81 Off-Ramp	NBL	69	354		275
				NBT	41	216	900	
				NBR	5	110	900	
			Forest Hill Road	SBL	28	193		500
				SBR	28	193		500
			Port Republic Road	EBL	5	93		175
				EBT	10	166	125	
			Port Republic Road	WBT	208	992	375	
				WBR	208	992		100
			8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBR	1
Port Republic Road	EBT	0				0	375	
	EBR	0				8	375	
Port Republic Road	WBT	20				562	525	
9	Port Republic Road at Bradley Drive	Signal	Bradley Drive	NBL	62	334	900	
				NBR	66	341	900	
			Port Republic Road	EBT	18	192	525	
				EBT	22	225	525	
			Port Republic Road	WBL	36	484	425	
				WBT	36	484	425	
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	95	537	4250	
				NBT	5	55	4250	
				NBR	0	33		150
			Devon Lane	SBL	7	77		100
				SBT	3	38	300	
				SBR	12	167		100
			Port Republic Road	EBL	4	77		150
				EBT	23	211	425	
				EBR	23	212	425	
				WBL	2	57		150
Port Republic Road	WBT	50	458	800				
	WBR	49	458	800				

Table 2.17 2030 Build PM Simulated Queue Lengths

Node No.	Intersection	Traffic Control	Approach	Movement	Build MOEs			
					Average Queue Length (ft)	Max Queue Length (ft)	Link Distance (ft)	Storage Length (ft)
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	6	63		150
				EBT	55	237	225	
				EBR	1	72		100
			Port Republic Road	WBL	131	492		250
				WBT	74	485	525	
				WBR	74	485		150
			South Main Street	SBL	295	1,178		200
				SBT	145	1,099	300	
				SBR	145	1,101	300	
			South Main Street	NBL	39	191		150
NBT	90	500		350				
			NBR	18	306		150	
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBT	3	110	275	
				EBR	3	110	275	
			Port Republic Road	WBT	0	18	525	
				WBR	0	0	525	
			Hillcrest Drive	SBR	0	47	525	
				NBR	0	38	375	
3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBR	5	115	275	
				Port Republic Road	EBT	58	546	525
			EBR		58	546	525	
			Port Republic Road	WBT	0	0	450	
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal	Hillside Avenue	NBL	19	171	200	
				NBT	19	171	200	
				NBR	2	78		100
			Bluestone Drive	SBL	183	1129		600
				SBT	183	1129	600	
				SBR	196	1150	600	
			Port Republic Road	EBL	92	0		300
				EBT	431	1295	475	
				EBR	6	1295	475	
			Port Republic Road	WBL	7	85		200
WBT	179	352		225				
WBR	44	366			50			
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	67	311		100
				SBR	190	742		100
			Port Republic Road	EBT	43	409	250	
				EBR	1	98		100
			Port Republic Road	WBL	54	411		125
				WBT	72	463	350	

Table 2.17 2030 Build PM Simulated Queue Lengths (Cont)

Node No.	Intersection	Traffic Control	Approach	Movement	No Build MOEs			
					Average Queue Length (ft)	Max Queue Length (ft)	Link Distance (ft)	Storage Length (ft)
6	Port Republic Road at NB I-81 On-Ramp	Signal	Port Republic Road	EBL	21	378		125
				EBT	4	163	325	
			Port Republic Road	WBT	54	312	150	
				WBR	5	263		50
7	Port Republic Road at NB I-81 Off-Ramp / Forest Hill Road	Signal	NB I-81 Off-Ramp	NBL	45	273		275
				NBT	41	206	900	
				NBR	7	122	900	
			Forest Hill Road	SBL	81	363		500
				SBR	81	363		500
			Port Republic Road	EBL	38	261		175
				EBT	54	328	125	
			Port Republic Road	WBT	431	1295	375	
				WBR	431	1295		100
			8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBR	1
Port Republic Road	EBT	1				116	375	
	EBR	1				129	375	
Port Republic Road	WBT	104				865	525	
9	Port Republic Road at Bradley Drive	Signal	Bradley Drive	NBL	73	354	900	
				NBR	78	362	900	
			Port Republic Road	EBT	53	453	525	
				EBT	65	484	525	
			Port Republic Road	WBL	47	265	425	
				WBT	47	265	425	
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	93	469	4250	
				NBT	8	74	4250	
				NBR	0	45		150
			Devon Lane	SBL	16	183		100
				SBT	9	81	300	
			Port Republic Road	SBR	14	224		100
				EBL	30	281		150
			Port Republic Road	EBT	63	511	425	
				EBR	63	512	425	
			Port Republic Road	WBL	4	79		150
WBT	74	459		800				
			WBR	73	459	800		

Travel Time Analysis

Travel times to traverse the corridor were calculated using the same method used in the 2018 existing and 2030 no build models. The travel time results are displayed in Table 2.18. Speed maps for the 2030 build AM and PM peak hours are shown in Figures 2.18 and 2.19. The dark green color represents expected vehicle speeds near the speed limit of the corridor, which is 35 mph, and the red and pink colors denote areas of slower speed vehicles traveling through the model, with pink representing the highest level of congestion. This is a projected improvement in the westbound direction of one (1) minute and 3.9 seconds in the AM peak hour and two (2) minutes and 59.6 seconds in the PM peak hour and 56.2 seconds in the AM peak hour and one (1) minute and 20.5 seconds in the PM peak hour in the eastbound direction.

Table 2.18 2030 Build Summary of Travel Time

Peak Hour	Travel Time Run	Simulated Travel Time (sec)	Simulated Travel Time (M:SS)
	Segment		
AM Peak Hour	Port Republic Road Eastbound	208.04	03:28.0
	Port Republic Road Westbound	207.65	03:27.6
	Port Republic Road EB to I-81 NB Ramps	131.55	02:11.5
	Port Republic Road WB to I-81 SB Ramps	93.99	01:34.0
PM Peak Hour	Port Republic Road Eastbound	258.00	04:18.0
	Port Republic Road Westbound	302.26	05:02.3
	Port Republic Road EB to I-81 NB Ramps	165.28	02:45.3
	Port Republic Road WB to I-81 SB Ramps	167.10	02:47.1

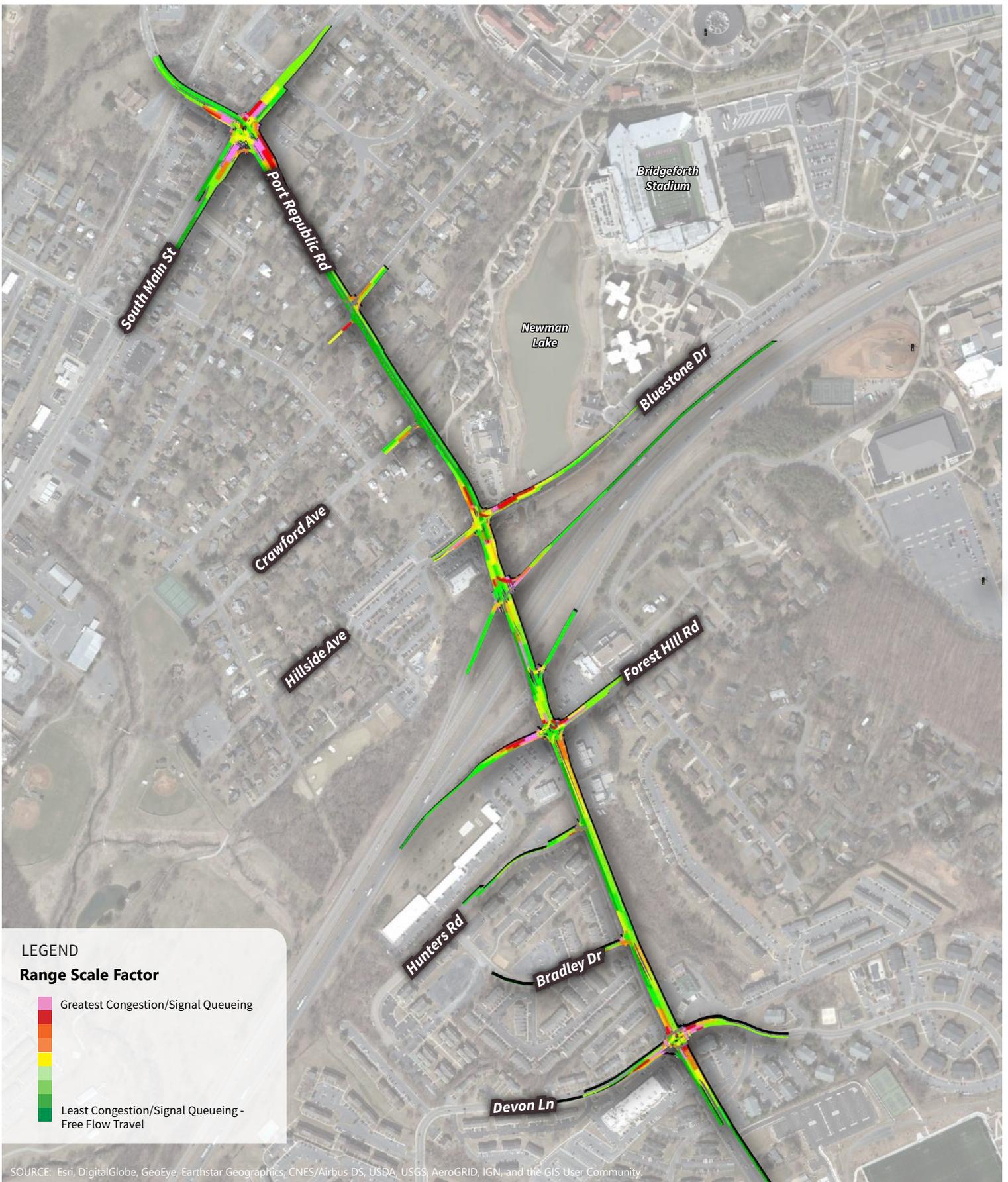


FIGURE 2.18
2030 AM BUILD SPEED MAP

Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

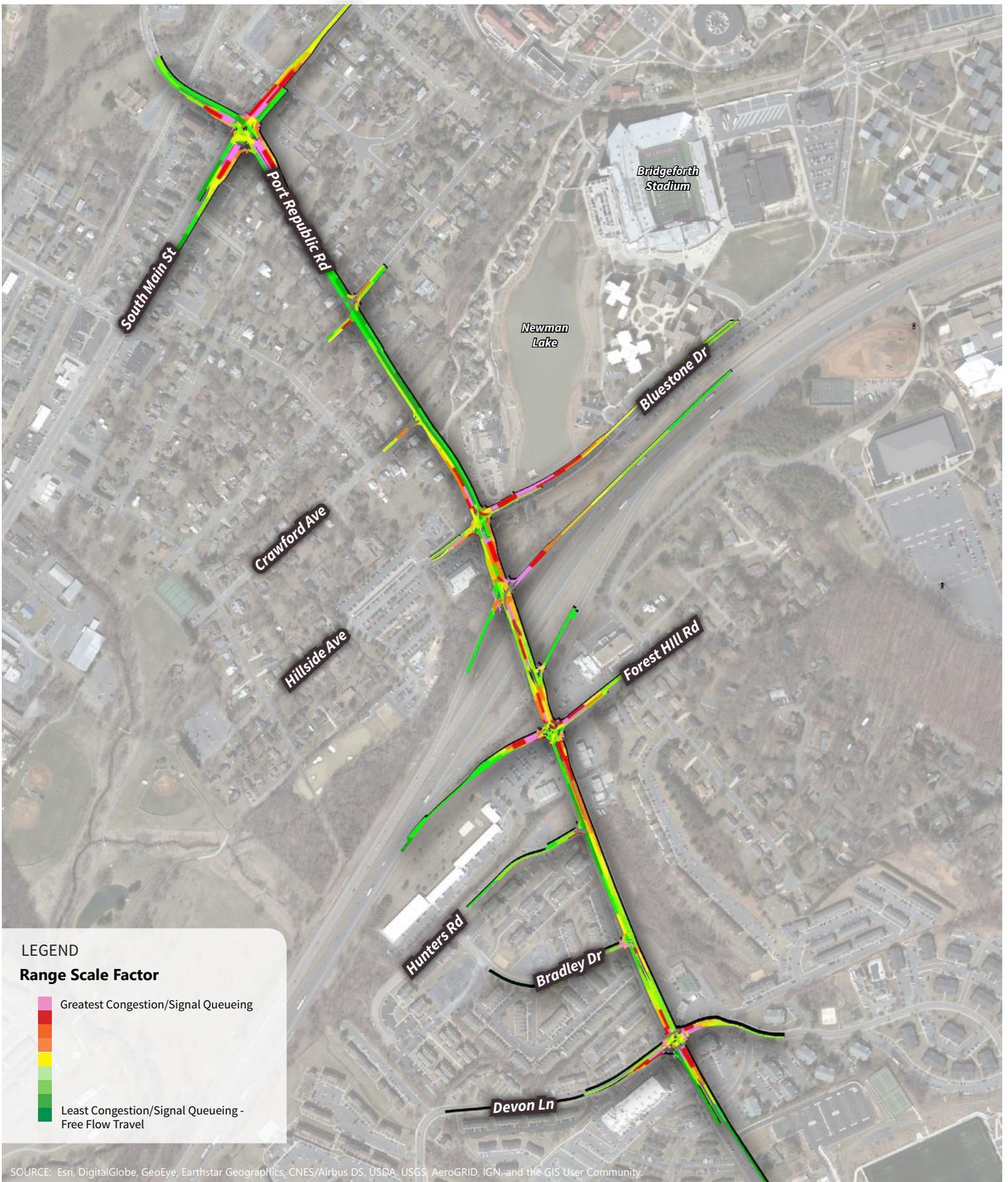


FIGURE 2.19
2030 PM BUILD SPEED MAP

Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

2018 Existing, No Build 2030, and Build 2030 Model Comparisons

The MOEs obtained from the VISSIM models include length of the average queue and maximum queues, control delay (and corresponding level of service), travel time and average and total number of stops. Side-by-side comparison of these metrics is shown in Tables 2.19, 2.20, 2.21, 2.22, 2.23, and 2.24 below.

Table 2.19 Travel Time and Total Stops

Travel Time	Eastbound	Westbound
	VISSIM Travel Time (M:SS)	VISSIM Travel Time (M:SS)
AM Peak Hour		
Existing	03:37.5	03:52.7
No Build (2030)	04:20.9	04:34.9
Build (2030)	03:28.0	03:27.6
PM Peak Hour		
Existing	04:21.9	04:16.0
No Build (2030)	05:34.3	07:58.6
Build (2030)	04:18.0	05:02.3

Table 2.20 Average and Total Vehicle Stops

Stops	Average Stops per Vehicle within Network	Total Number of Stops in Peak Hour
AM Peak Hour		
Existing	2.26	10,524
No Build (2030)	4.29	22,543
Build (2030)	1.87	9,643
PM Peak Hour		
Existing	2.51	15,550
No Build (2030)	4.50	30,423
Build (2030)	2.68	18,417

Change in delay between scenarios does not correspond to the change in travel time because the travel time measurement is from one end of Port Republic Road to the other, which only a small subset of network vehicles travel, while average delay represents every vehicle in the network. Since many of these vehicles are only traversing a portion of the network, they don't experience as high a delay value as does a vehicle traversing Port Republic Road from end to end.

Table 2.21 Average and Total Vehicle Delay Time

Delay	Average Delay [sec] per Vehicle	Total Vehicle Delay [min] in Peak Hour
AM Peak Hour		
Existing	69.3	5,380
No Build (2030)	122.3	10,711
Build (2030)	58.4	5,029
PM Peak Hour		
Existing	92.3	9,525
No Build (2030)	171.2	19,277
Build (2030)	101.1	11,594

Table 2.22 AM LOS Comparison

Node No.	Intersection	Traffic Control	Approach	Movement	2018 Existing		2030 No Build		2030 Build	
					Approach Delay (sec/veh)	Estimated Approach LOS	Approach Delay (sec/veh)	Estimated Approach LOS	Approach Delay (sec/veh)	Estimated Approach LOS
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	42.3	D	45.1	D	31.5	C
				EBT						
				EBR						
			Port Republic Road	WBL	38.5	D	32.1	C	32.1	C
				WBT						
				WBR						
			South Main Street	SBL	37.4	D	36.9	D	36.8	D
				SBT						
				SBR						
			South Main Street	NBL	25.1	C	22.4	C	23.8	C
				NBT						
NBR										
Intersection					34.8	C	31.8	C	30.3	C
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBL	0.4	A	0.4	A	0.3	A
				EBT						
				EBR						
			Port Republic Road	WBL	1.9	A	3.9	A	1.7	A
				WBT						
				WBR						
			Hillcrest Drive	SBL	15.5	C	17.1	C	11.7	A
				SBT						
				SBR						
			Hillcrest Drive	NBL	8.5	A	8.8	A	9.3	A
				NBT						
NBR										
Intersection					1.5	A	2.7	A	1.2	A
3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBL	9.9	A	9.5	A	9.8	A
				NBR						
			Port Republic Road	EBT	0.3	A	0.3	A	0.3	A
				EBR						
			Port Republic Road	WBL	1.9	A	2.4	A	0.4	A
				WBT						
Intersection					1.4	A	1.7	A	0.5	A
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal	Hillside Avenue	NBL	32.2	C	34.1	C	37.2	D
				NBT						
				NBR						
			Bluestone Drive	SBL	44.7	D	42.9	D	43.0	D
				SBT						
				SBR						
			Port Republic Road	EBL	31.8	C	33.4	C	17.2	B
				EBT						
				EBR						
			Port Republic Road	WBL	18.0	B	20.1	C	8.4	A
				WBT						
WBR										
Intersection					24.3	C	26.1	C	14.3	B
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	49.5	D	148.7	F	32.4	C
				SBR						
			Port Republic Road	EBT	1.1	A	7.1	A	5.3	A
				EBR						
			Port Republic Road	WBL	19.0	B	17.5	B	8.8	A
				WBT						
Intersection					18.3	B	31.3	C	11.3	B

Table 2.22 AM LOS comparison (Cont)

Node No.	Intersection	Traffic Control	Approach	Movement	2018 Existing		2030 No Build		2030 Build	
					Approach Delay (sec/veh)	Estimated Approach LOS	Approach Delay (sec/veh)	Estimated Approach LOS	Approach Delay (sec/veh)	Estimated Approach LOS
6	Port Republic Road at NB I-81 On-Ramp	Signal	NB I-81 Off-Ramp (2018 existing model only)	NBL	46.0	D				
				NBR						
			Port Republic Road	EBL	9.3	A	12.6	B	4.4	A
				EBT						
				WBT						
Port Republic Road	WBR	4.6	A	4.1	A	1.8	A			
Intersection					13.9	B	6.9	A	2.7	A
7	Port Republic Road at NB I-81 Off-Ramp / Forest Hill Road	Signal	JMU Parking Lot (2018) NB I-81 Off-Ramp (2030)	NBL	58.1	E	47.1	D	35.5	D
				NBT						
				NBR						
			Forest Hill Road	SBL	27.6	C	33.6	C	25.6	C
				SBT (Existing Only)						
			Port Republic Road	SBR	5.5	A	16.8	B	7.1	A
				EBL						
			Port Republic Road	EBT	16.2	B	33.3	C	13.9	B
				WBT						
				WBR						
Intersection					13.7	B	32.2	C	17.2	B
8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBL	14.9	B	135.5	F	5.9	A
				NBR						
			Port Republic Road	EBT	1.0	A	2.1	A	0.8	A
				EBR						
			Port Republic Road	WBL	2.7	A	26.3	D	4.5	A
WBT										
Intersection					2.7	A	22.8	C	3.2	A
9	Port Republic Road at Bradley Drive	Unsignalized/Signal	Bradley Drive	NBL	11.7	B	28.3	D	51.5	D
				NBR						
			Port Republic Road	EBT	0.4	A	0.5	A	7.1	A
				EBR						
			Port Republic Road	WBL	0.5	A	12.8	B	7.6	A
WBT										
Intersection					1.0	A	9.7	A	11.0	B
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	34.2	C	41.7	D	45.0	D
				NBT						
				NBR						
			Devon Lane	SBL	14.8	B	17.4	B	17.7	B
				SBT						
			Port Republic Road	SBR	13.9	B	18.5	B	10.8	B
				EBL						
				EBT						
			Port Republic Road	EBR	16.4	B	38.3	D	14.6	B
				WBL						
WBT										
Port Republic Road	WBR									
Intersection					17.9	B	30.5	C	17.8	B

Table 2.23 PM LOS Comparison

Node No.	Intersection	Traffic Control	Approach	Movement	2018 Existing		2030 No Build		2030 Build	
					Approach Delay (sec/veh)	Estimated Approach LOS	Approach Delay (sec/veh)	Estimated Approach LOS	Approach Delay (sec/veh)	Estimated Approach LOS
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	49.1	D	43.3	D	37.2	D
				EBT						
				EBR						
			Port Republic Road	WBL	35.0	D	21.5	C	48.6	D
				WBT						
				WBR						
			South Main Street	SBL	50.6	D	53.7	D	45.6	D
				SBT						
				SBR						
			South Main Street	NBL	34.1	C	35.4	D	31.2	C
NBT										
NBR										
Intersection					41.8	D	39.4	D	41.8	D
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBL	1.0	A	13.3	B	2.0	A
				EBT						
				EBR						
			Port Republic Road	WBL	1.3	A	1.3	A	1.5	A
				WBT						
				WBR						
			Hillcrest Drive	SBL	13.9	B	22.8	C	7.0	A
				SBR						
			Hillcrest Drive	NBL	10.4	B	36.9	E	21.8	C
				NBR						
Intersection					1.2	A	8.2	A	1.8	A
3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBL	26.6	D	83.7	F	35.9	E
				NBR						
			Port Republic Road	EBT	9.5	A	22.7	C	9.9	A
				EBR						
			Port Republic Road	WBL	4.3		7.9	A	0.8	A
				WBT						
Intersection					7.3		16.7	C	5.9	A
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal	Hillside Avenue	NBL	30.0	C	31.8	C	31.1	C
				NBT						
				NBR						
			Bluestone Drive	SBL	76.4	E	101.5	F	68.7	E
				SBT						
				SBR						
			Port Republic Road	EBL	41.9	D	44.4	D	35.5	D
				EBT						
				EBR						
			Port Republic Road	WBL	20.9	C	23.1	C	22.3	C
WBT										
WBR										
Intersection					38.7	D	45.2	D	35.4	D
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	54.4	D	78.4	E	85.0	F
				SBR						
			Port Republic Road	EBT	3.7	A	6.9	A	6.3	A
				EBR						
			Port Republic Road	WBL	21.0	C	34.3	C	24.6	C
				WBT						
Intersection					16.4	B	25.2	C	22.3	C

Table 2.23 PM LOS Comparison (Cont)

Node No.	Intersection	Traffic Control	Approach	Movement	2018 Existing		2030 No Build		2030 Build	
					Approach Delay (sec/veh)	Estimated Approach LOS	Approach Delay (sec/veh)	Estimated Approach LOS	Approach Delay (sec/veh)	Estimated Approach LOS
6	Port Republic Road at NB I-81 On-Ramp	Signal	NB I-81 Off-Ramp (2018 existing model only)	NBL	70.7	E				
				NBR						
			Port Republic Road	EBL	11.5	B	19.2	B	7.8	B
				EBT						
			Port Republic Road	WBL	5.7	A	9.8	A	8.2	A
				WBT						
Intersection					16.9	B	14.7	B	8.0	A
7	Port Republic Road at NB I-81 Off-Ramp / Forest Hill Road	Signal	JMU Parking Lot (2018)	NBL	58.5	E	49.3	D	34.5	C
				NBT						
			NB I-81 Off-Ramp (2030)	NBR	31.1	C	48.0	D	35.1	D
				SBL (Existing Only)						
			Forest Hill Road	SBR	9.8	A	13.9	B	13.3	B
				EBL						
			Port Republic Road	EBT	36.5	D	69.0	E	34.3	D
				WBL						
			Port Republic Road	WBT	24.2	C	42.1	D	26.9	C
				WBR						
Intersection					24.2	C	42.1	D	26.9	C
8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBL	21.6	C	358.5	F	8.5	A
				NBR						
			Port Republic Road	EBT	1.8	A	3.8	A	2.0	A
				EBR						
			Port Republic Road	WBL	7.9	A	78.1	F	19.1	C
				WBT						
Intersection					5.0	A	42.7	E	10.0	A
9	Port Republic Road at Bradley Drive	Unsignalized/Signal	Bradley Drive	NBL	14.2	B	387.9	F	54.7	D
				NBR						
			Port Republic Road	EBT	1.5	A	5.8	A	11.1	B
				EBT						
			Port Republic Road	WBL	0.8	A	61.2	F	11.7	B
				WBT						
Intersection					1.5	A	42.2	E	14.5	B
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	35.8	D	201.5	F	49.5	D
				NBT						
			Devon Lane	NBR	22.7	C	52.3	D	28.9	C
				SBL						
			Port Republic Road	SBT	17.1	B	37.9	D	17.4	B
				SBR						
			Port Republic Road	EBL	22.0	C	86.6	F	24.2	C
				EBT						
			Port Republic Road	EBR	21.7	C	65.4	E	24.1	C
				WBL						
Port Republic Road	WBT	21.7	C	65.4	E	24.1	C			
	WBR									
Intersection					21.7	C	65.4	E	24.1	C

Table 2.24 AM Queue Comparison

Node No.	Intersection	Traffic Control	Approach	Movement	2018 Existing		2030 No Build		2030 Build	
					Average Queue Length (ft)	Max Queue Length (ft)	Average Queue Length (ft)	Max Queue Length (ft)	Average Queue Length (ft)	Max Queue Length (ft)
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	19	146	29	200	17	119
				EBT	49	217	56	318	40	247
				EBR	0	55	1	67	1	68
			Port Republic Road	WBL	29	137	21	144	41	190
				WBT	72	742	52	787	99	660
				WBR	197	813	263	900	99	660
			South Main Street	SBL	34	153	39	148	41	159
				SBT	26	185	28	177	28	172
				SBR	24	188	26	179	25	174
			South Main Street	NBL	22	153	26	167	24	155
				NBT	54	328	52	381	57	323
			NBR	1	111	2	135	2	119	
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBL	0	25	1	55		
				EBT	0	7	0	21	0	0
				EBR	0	7	0	21	0	0
			Port Republic Road	WBL	0	54	10	209		
				WBT	1	98	17	289	0	0
				WBR	0	80	14	249	0	2
			Hillcrest Drive	SBL	2	64	2	66		
				SBR	1	65	1	67	0	44
			Hillcrest Drive	NBL	0	41	0	41		
				NBR	0	42	0	42	0	42
			3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBL	1	88	1
NBR	2	113					2	109	1	109
Port Republic Road	EBT	0				0	0	3	0	0
	EBR	0				0	0	3	0	0
	WBL	1				137	3	212		
Port Republic Road	WBT	1				97	2	163	0	0
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal				Hillside Avenue	NBL	17	151	20
			NBT	17	151		20	172	42	208
			NBR	1	63		1	55	1	60
			Bluestone Drive	SBL	18	120	18	96	20	95
				SBT	18	120	18	96	20	95
				SBR	18	143	20	101	22	118
			Port Republic Road	EBL	24	260	42	371	21	174
				EBT	63	353	67	461	29	263
				EBR	5	245	3	253	3	187
			Port Republic Road	WBL	10	121	14	123	5	104
				WBT	139	354	170	367	56	346
				WBR	14	311	35	367	4	232
			5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	53	351	940
SBR	40	302					1137	1775	18	186
Port Republic Road	EBT	2				75	19	313	13	249
	EBR	0				34	0	56	0	56
Port Republic Road	WBL	5				186	12	358	3	204
	WBT	61				454	77	467	36	429

Table 2.24 AM Queue Comparison (Cont)

Node No.	Intersection	Traffic Control	Approach	Movement	2018 Existing		2030 No Build		2030 Build	
					Average Queue Length (ft)	Max Queue Length (ft)	Average Queue Length (ft)	Max Queue Length (ft)	Average Queue Length (ft)	Max Queue Length (ft)
6	Port Republic Road at NB I-81 On-Ramp	Signal	NB I-81 Off-Ramp (2018 existing model only)	NBL	144	699				
				NBR	29	455				
			Port Republic Road	EBL	6	151	46	326	10	176
				EBT	16	173	0	24	0	4
			Port Republic Road	WBT	20	301	15	302	6	255
				WBR	1	178	0	46	0	33
7	Port Republic Road at NB I-81 Off-Ramp / Forest Hill Road	Signal	JMU Parking Lot (2018) NB I-81 Off-Ramp (2030)	NBL	4	56	110	510	69	354
				NBT	4	56	44	227	41	216
				NBR	1	68	6	118	5	110
			Forest Hill Road	SBL	29	167	41	197	28	193
				SBT (2018)	29	167				
			Forest Hill Road	SBR	29	167	41	197	28	193
				EBL	13	171	9	120	5	93
			Port Republic Road	EBT	4	117	38	237	10	166
				EBR (2018)	2	134				
			Port Republic Road	WBT	362	1262	2025	2293	208	992
				WBR	362	1262	2025	2293	208	992
			8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBL	8	105	115
NBR	6	106					113	496	1	67
Port Republic Road	EBT	0				35	2	182	0	0
	EBR	1				85	3	225	0	8
Port Republic Road	WBL	8				832	219	1863		
	WBT	6				832	201	1863	20	562
9	Port Republic Road at Bradley Drive	Unsignalized/Signal	Bradley Drive	NBL	5	101	17	178	62	334
				NBR	5	101	16	179	66	341
			Port Republic Road	EBT	0	21	0	7	18	192
				EBT	0	51	0	10	22	225
			Port Republic Road	WBL	0	232	71	1263	36	484
				WBT	0	232	62	1263	36	484
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	63	371	89	435	95	537
				NBT	63	371	89	435	5	55
				NBR	0	21	0	32	0	33
			Devon Lane	SBL	7	109	7	87	7	77
				SBT	7	109	7	87	3	38
				SBR	8	167	11	181	12	167
			Port Republic Road	EBL	3	76	5	77	4	77
				EBT	29	260	43	342	23	211
				EBR	27	262	41	344	23	212
			Port Republic Road	WBL	2	58	3	65	2	57
				WBT	50	382	180	688	50	458
				WBR	49	382	179	687	49	458

Table 2.25 PM Queue Comparison

Node No.	Intersection	Traffic Control	Approach	Movement	2018 Existing		2030 No Build		2030 Build	
					Average Queue Length (ft)	Max Queue Length (ft)	Average Queue Length (ft)	Max Queue Length (ft)	Average Queue Length (ft)	Max Queue Length (ft)
1	Port Republic Road / Maryland Avenue at South Main Street	Signal	Maryland Avenue	EBL	9	65	9	70	6	63
				EBT	63	287	62	302	55	237
				EBR	1	73	1	74	1	72
			Port Republic Road	WBL	60	382	43	419	131	492
				WBT	101	593	56	482	74	485
				WBR	30	413	14	350	74	485
			South Main Street	SBL	272	1266	347	1301	295	1,178
				SBT	210	1271	192	1254	145	1099
				SBR	210	1272	192	1255	145	1101
			South Main Street	NBL	35	183	37	174	39	191
				NBT	93	536	110	588	90	500
				NBR	13	317	24	418	18	306
2	Port Republic Road at Hillcrest Drive	Two-Way Stop	Port Republic Road	EBL	1	84	84	687		
				EBT	0	61	75	641	3	110
				EBR	0	61	75	641	3	110
			Port Republic Road	WBL	1	155	1	153		
				WBT	0	36	1	111	0	18
				WBR	0	7	1	77	0	0
			Hillcrest Drive	SBL	1	61	2	61		
				SBR	1	61	1	62	0	47
				NBL	0	37	0	37		
			Hillcrest Drive	NBR	0	38	0	38	0	38
3	Port Republic Road at Crawford Avenue	Two-Way Stop	Crawford Avenue	NBL	2	92	5	105		
				NBR	4	116	14	129	5	115
			Port Republic Road	EBT	38	506	170	681	58	546
				EBR	38	506	170	681	58	546
			Port Republic Road	WBL	20	376	46	544		
				WBT	15	334	37	502	0	0
4	Port Republic Road at Hillside Avenue / Bluestone Drive	Signal	Hillside Avenue	NBL	16	119	19	183	19	171
				NBT	16	119	19	183	19	171
				NBR	2	77	2	82	2	78
			Bluestone Drive	SBL	139	838	387	1136	183	1129
				SBT	139	838	387	1136	183	1129
				SBR	153	859	404	1157	196	1150
			Port Republic Road	EBL	99	777	136	2336	92	0
				EBT	885	1572	3358	3630	0	0
				EBR	7	1572	17	3630	6	0
			Port Republic Road	WBL	5	80	5	85	7	85
				WBT	140	345	167	359	179	352
				WBR	16	314	30	349	44	366
5	Port Republic Road at SB I-81 Ramps	Signal	SB I-81 Off-Ramp	SBL	62	416	122	633	67	311
				SBR	64	429	160	685	190	742
			Port Republic Road	EBT	19	333	47	405	43	409
				EBR	1	71	1	68	1	98
			Port Republic Road	WBL	44	357	31	372	54	411
				WBT	41	426	103	454	72	463

Table 2.25 PM Queue Comparison (Cont)

Node No.	Intersection	Traffic Control	Approach	Movement	2018 Existing		2030 No Build		2030 Build	
					Average Queue Length (ft)	Max Queue Length (ft)	Average Queue Length (ft)	Max Queue Length (ft)	Average Queue Length (ft)	Max Queue Length (ft)
6	Port Republic Road at NB I-81 On-Ramp	Signal	NB I-81 Off-Ramp (2018 existing model only)	NBL	171	789				
				NBR	198	793				
			Port Republic Road	EBL	37	318	77	451	21	378
				EBT	21	250	23	393	4	163
			Port Republic Road	WBT	24	301	54	337	54	312
				WBR	1	112	3	279	5	263
7	Port Republic Road at NB I-81 Off-Ramp / Forest Hill Road	Signal	JMU Parking Lot (2018) NB I-81 Off-Ramp (2030)	NBL	28	217	101	505	45	273
				NBT	28	217	37	197	41	206
				NBR	27	231	10	133	7	122
			Forest Hill Road	SBL	72	321	116	393	81	363
				SBT (2018)	72	321				
			Port Republic Road	SBR	72	321	116	393	81	363
				EBL	55	275	29	240	38	261
			Port Republic Road	EBT	46	273	92	354	54	328
				EBR (2018)	27	319				
			Port Republic Road	WBT	227	801	1682	2238	431	1295
				WBR	227	801	1682	2238	431	1295
8	Port Republic Road at Hunters Road	Two-Way Stop	Hunters Road	NBL	8	103	216	583		
				NBR	6	103	216	584	1	67
			Port Republic Road	EBT	1	162	8	327	1	116
				EBR	3	208	9	362	1	129
			Port Republic Road	WBL	26	371	494	1808		
				WBT	21	371	463	1808	104	865
9	Port Republic Road at Bradley Drive	Unsignalized/Signal	Bradley Drive	NBL	5	97	334	486	73	354
				NBR	4	97	334	487	78	362
			Port Republic Road	EBT	1	260	22	1216	53	453
				EBT	2	260	26	1216	65	484
			Port Republic Road	WBL	1	0	277	1208	47	265
				WBT	1	0	252	1208	47	265
10	Port Republic Road at Devon Lane	Signal	Devon Lane	NBL	63	382	273	472	93	469
				NBT	63	382	273	472	8	74
				NBR	0	31	0	22	0	45
			Devon Lane	SBL	22	171	31	240	16	183
				SBT	22	171	31	240	9	81
			Port Republic Road	SBR	5	123	46	342	14	224
				EBL	15	201	78	479	30	281
			Port Republic Road	EBT	68	765	154	1721	63	511
				EBR	68	765	155	1721	63	512
			Port Republic Road	WBL	2	57	4	66	4	79
				WBT	59	355	340	720	74	459
Port Republic Road	WBR	58	355	339	720	73	459			

3 Safety Analysis

Methodology

Five (5) years and six months (January 2013–June 2018) of crash data was used to measure current crash trends and develop site specific improvements to achieve a reduction in the number of crashes or the severity of crashes. VHB took a hybrid approach to evaluating the corridor using a process that combines systemic and site-specific approaches at locations with high crash frequency and severity to comprehensively review the Port Republic Road corridor.

The objectives in comprehensively assessing the safety of the corridors are as follows:

- Conduct a field review, inventory, and evaluation of existing conditions.
- Identify roadway characteristics and key issues affecting travel along the corridor.
- Synthesize crash data.
- Develop recommendations that address safety concerns and operational issues.
- Provide planning level cost estimates for associated study recommendation

This report provides the documentation of the study, results, and recommendations. It is generally organized by existing corridor conditions, site specific location evaluations, and recommendations.

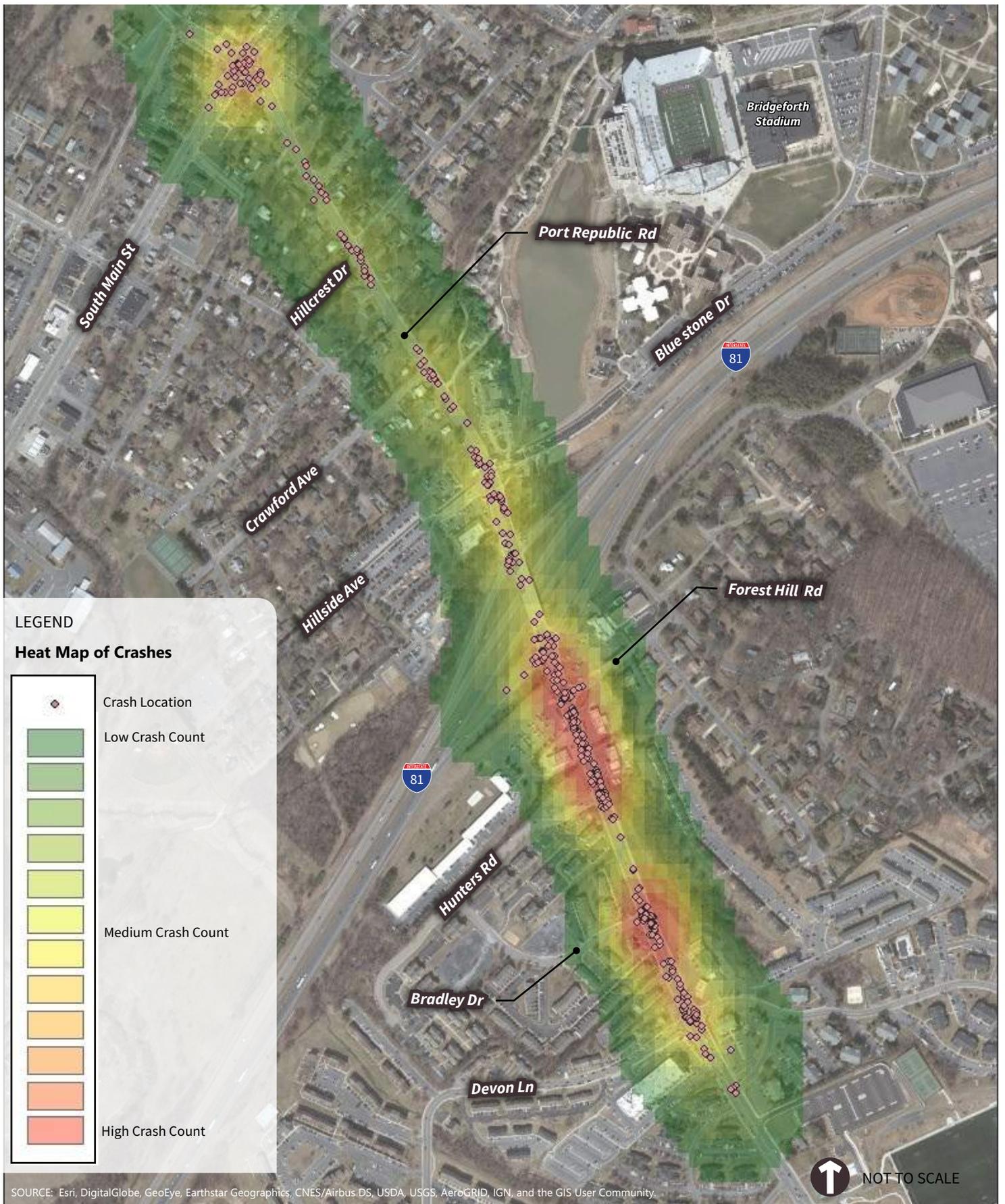
GIS mapping tools and crash data analysis for a five-and-a-half-year period were used to identify specific areas of concern, or locations that have a potential for safety improvement. Heat maps were created by crash location and severe crash locations. These maps are shown in Figures 3.1 and 3.2. Crash location and crash type, by study intersection, are shown in Appendix H. A more in-depth review was conducted at two (2) site specific locations, which are described in detail later in this report and are shown in Figures 3.3 and 3.4.

Crash Modification Factors

A crash modification factor (CMF) is a factor, based on documented safety research studies, used to compute the expected number of crashes after implementing a given countermeasure at a specific site. CMFs provide some indication of the potential benefit, or lack thereof, associated with specific countermeasures. The Federal Highway Administration (FHWA) compiles CMF data from published safety studies and posts them in the CMF Clearinghouse (<http://www.cmfclearinghouse.org/index.cfm>) to help practitioners select the most effective safety treatments. While CMF data is not available for all potential countermeasures, the CMF Clearinghouse provides a useful and consolidated source of data to help engineers, planners, and project owners make informed decisions. CMFs for the specific countermeasures are shown in Table 3.1.

Table 3.1 Proposed Countermeasures for the Study Area

	Countermeasure Measures	CMF	Notes	Source
1	Reducing number of driveways/consolidating driveways	0.93	All crashes - all severities	Clearinghouse
2	Eliminating certain movements (right in/right out street intersections and drives)	0.129-0.456	Angle,Fixed object,Left turn,Rear end,Vehicle/bicycle,Vehicle/pedestrian/all severities	Clearinghouse
3	Adding medians in the intersection functional area	0.77	All crashes - all severities	Clearinghouse
4	High friction surface course (at approaches)	0.207	All crashes	Clearinghouse
5	Enhanced transit stations	0.88	All crashes - all severities	Clearinghouse
6	Increase intersection sight distance	0.44-0.53	All crashes - KABC severities	Clearinghouse
7	Adding left turn lanes	0.85	All crashes - all severities	Smart Scale CMF
8	High visibility back plates	0.85	All crashes - all severities	Clearinghouse
9	Red light running cameras	0.8	All crashes - all severities	Clearinghouse
10	Change from Protected/Permissive Left-Turn to Flashing Yellow Arrow	0.935	All crashes- all severities	Clearinghouse



SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 3.1
HEAT MAP OF CRASH LOCATIONS

Port Republic Road Safety and Operations Study
Harrisonburg, Virginia

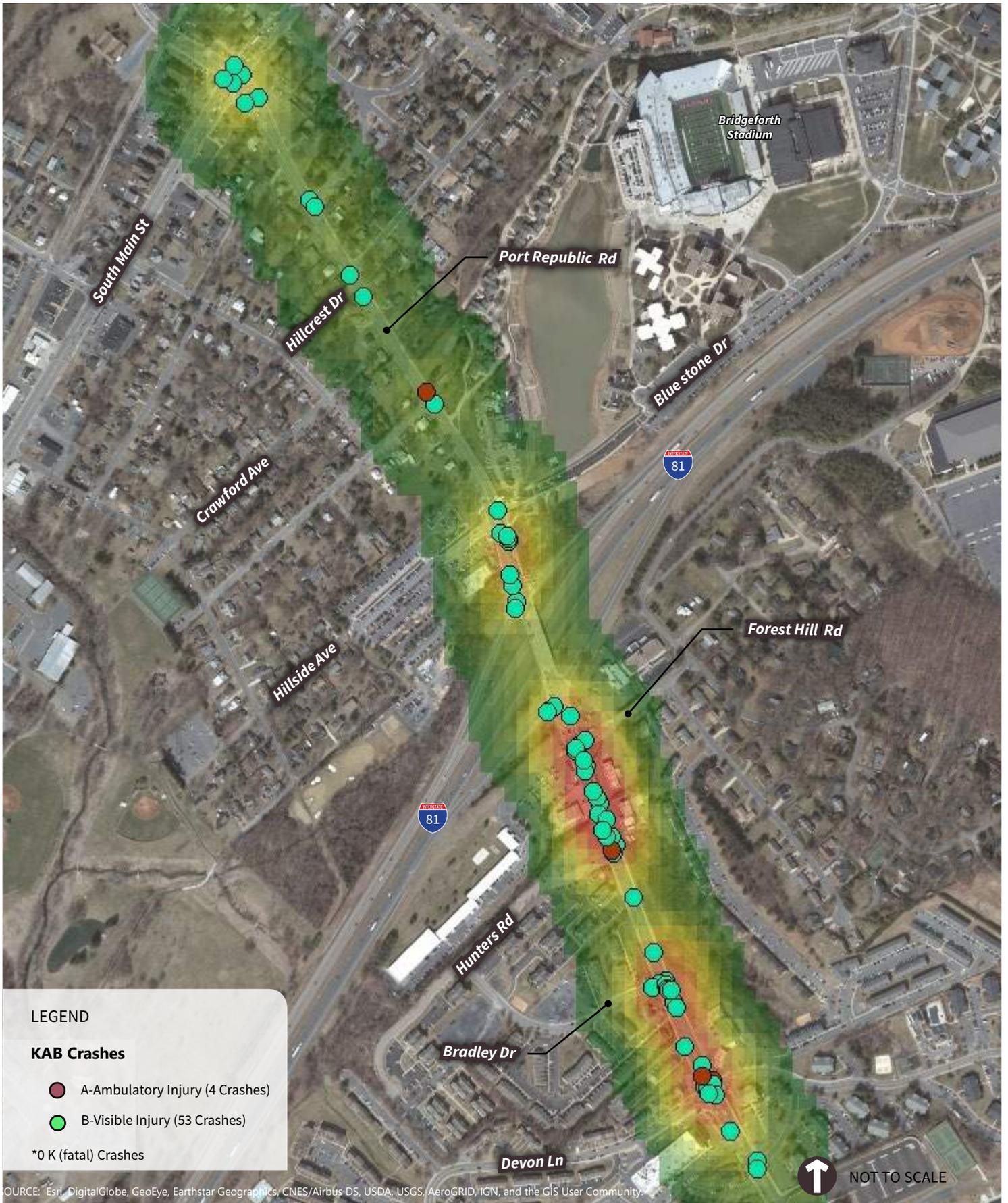
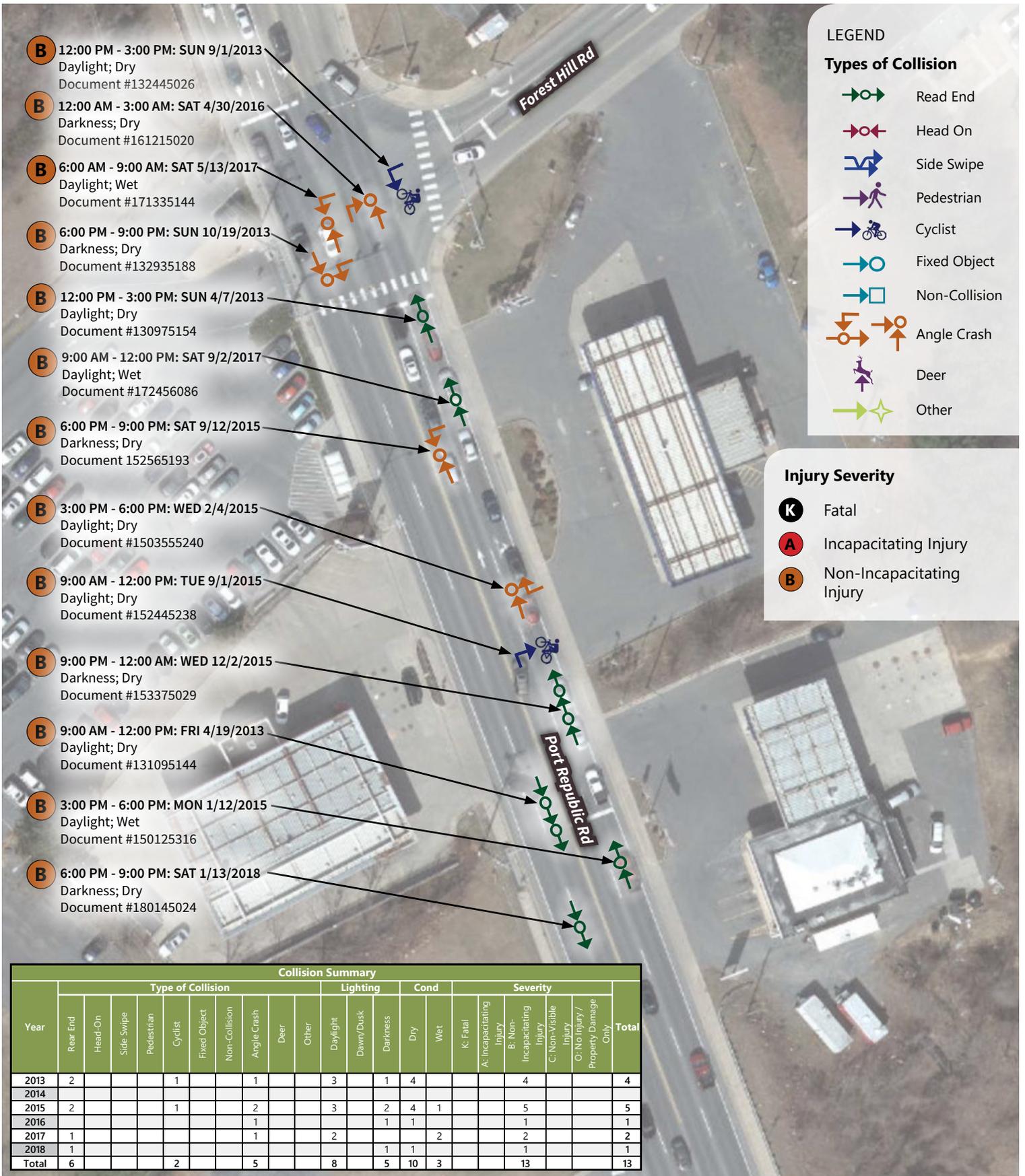


FIGURE 3.2
HEAT MAP OF CRASH LOCATIONS AND SEVERITY

Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

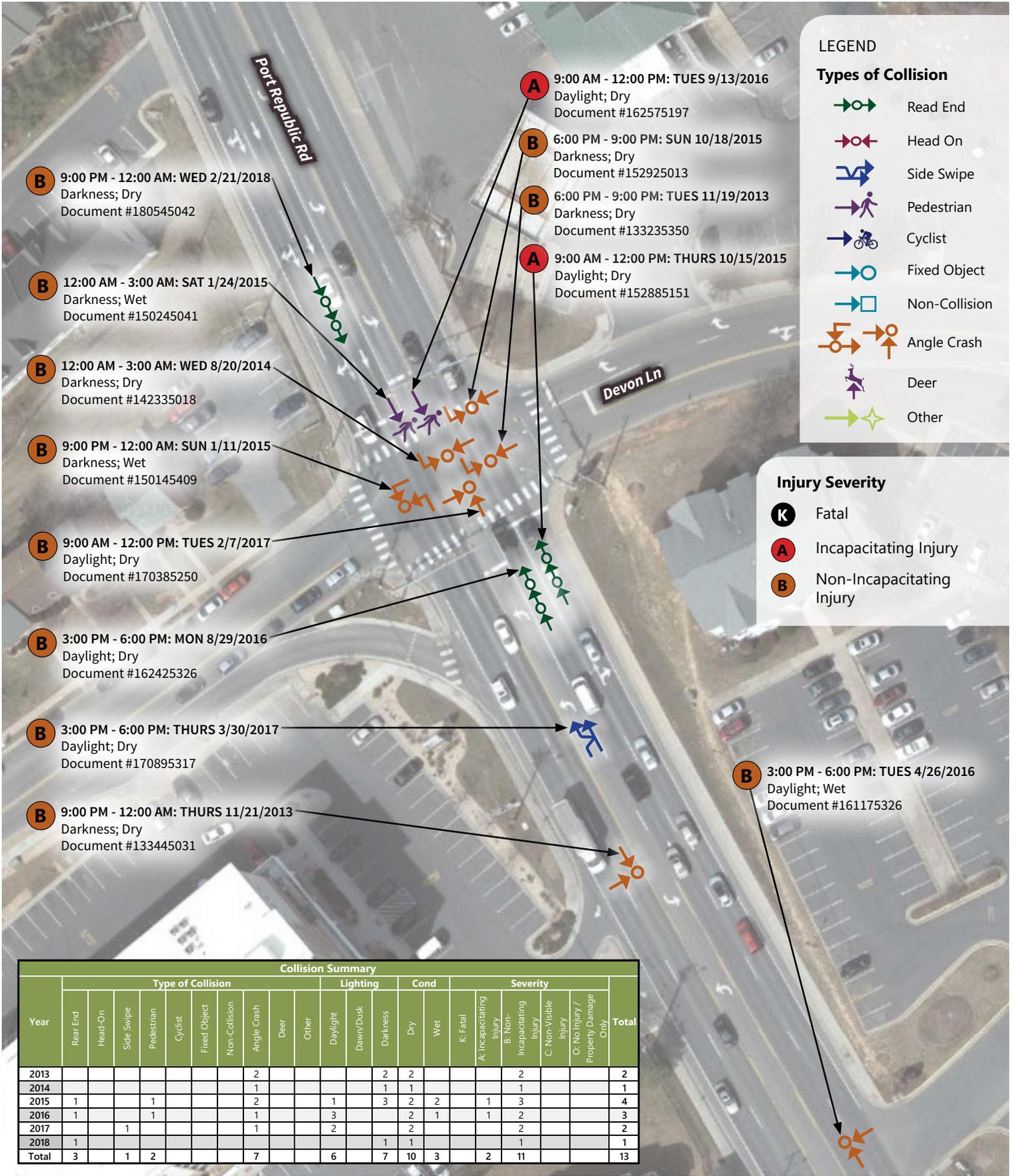




SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 3.3
CRASH DIAGRAM
 FOREST HILL ROAD AND PORT REPUBLIC ROAD
 Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia



Year	Type of Collision									Lighting			Cond		Severity					Total		
	Rear End	Head-On	Side Swipe	Pedestrian	Cyclist	Fixed Object	Non-Collision	Angle Crash	Deer	Other	Daylight	Dawn/Dusk	Darkness	Dry	Wet	K: Fatal	A: Incapacitating Injury	B: Non-Incapacitating Injury	C: Non-Visible Injury		O: No Injury / Property Damage Only	
2013							2					2	2					2				2
2014							1					1	1					1				1
2015	1			1			2			1		3	2	2		1	3					4
2016	1			1			1			3		2	2	1		1	2					3
2017			1				1			2			2				2					2
2018	1											1	1				1					1
Total	3	1	2	2	1	1	7	1	1	6	3	7	10	3	2	11	11	1	1	1	1	13

SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.

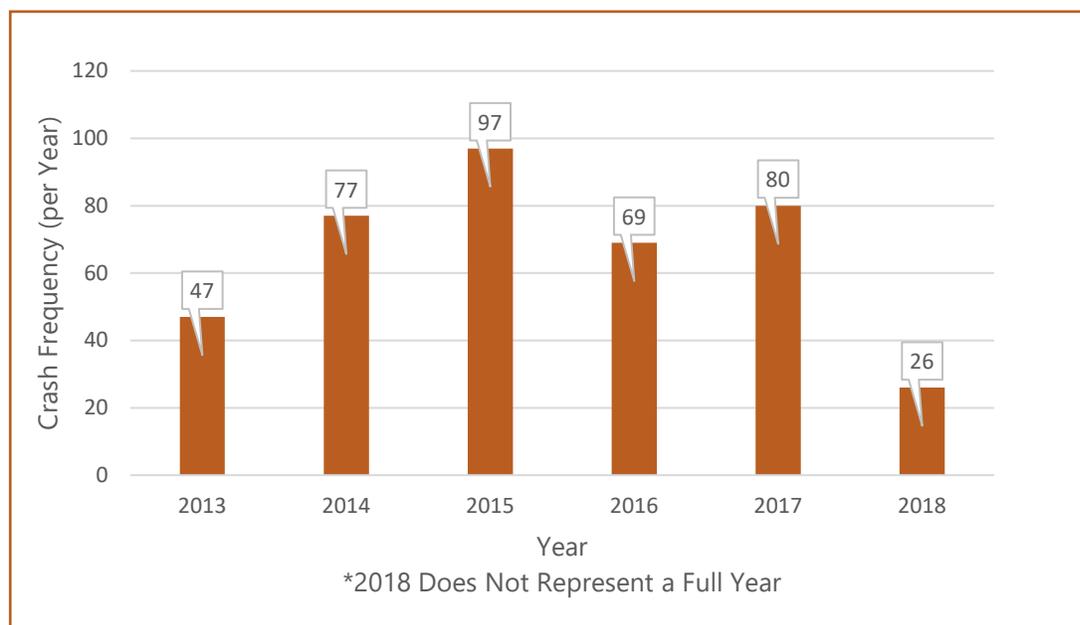


FIGURE 3.4
CRASH DIAGRAM
 DEVON LANE AND PORT REPUBLIC ROAD
 Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

Systemic Risk Factor Analysis

The following analysis involves the identification of focus areas and the associated risk factors. The data set used in the analysis includes 396 crashes for the five-and-a-half-year period from January 2013 to June 2018 over approximately one (1) mile, equivalent to an average of 72 crashes a year. Table 3.2 illustrates the trend of yearly crash frequencies in the study area.

Table 3.2 Crash Frequency



In order to analyze crash frequencies and patterns for each study intersection on Port Republic Road, the corridor crashes were assigned to individual intersections based on proximity to the intersection and engineering judgement. VDOT guidelines recommend crashes be linked to the intersection when the first harmful event occurs within 250 feet of the center of an intersection and be used for network level screenings. For project level analysis, like this project, the engineer determines the most appropriate intersection influence area. The signalized intersection area included the entire taper and storage length of dedicated turn bays under the assumption that crashes within that area were attributable to the corresponding intersection. For unsignalized intersections the 250-foot radius was used. Sixteen (16) crashes were considered corridor crashes, meaning they occurred with the study area, but were not close enough to assign to a specific intersection. A graphical representation of the areas used for the analysis are shown in Figure 3.5 below. The corresponding summary of crashes per intersection on Port Republic Road are shown in Figure 3.6.

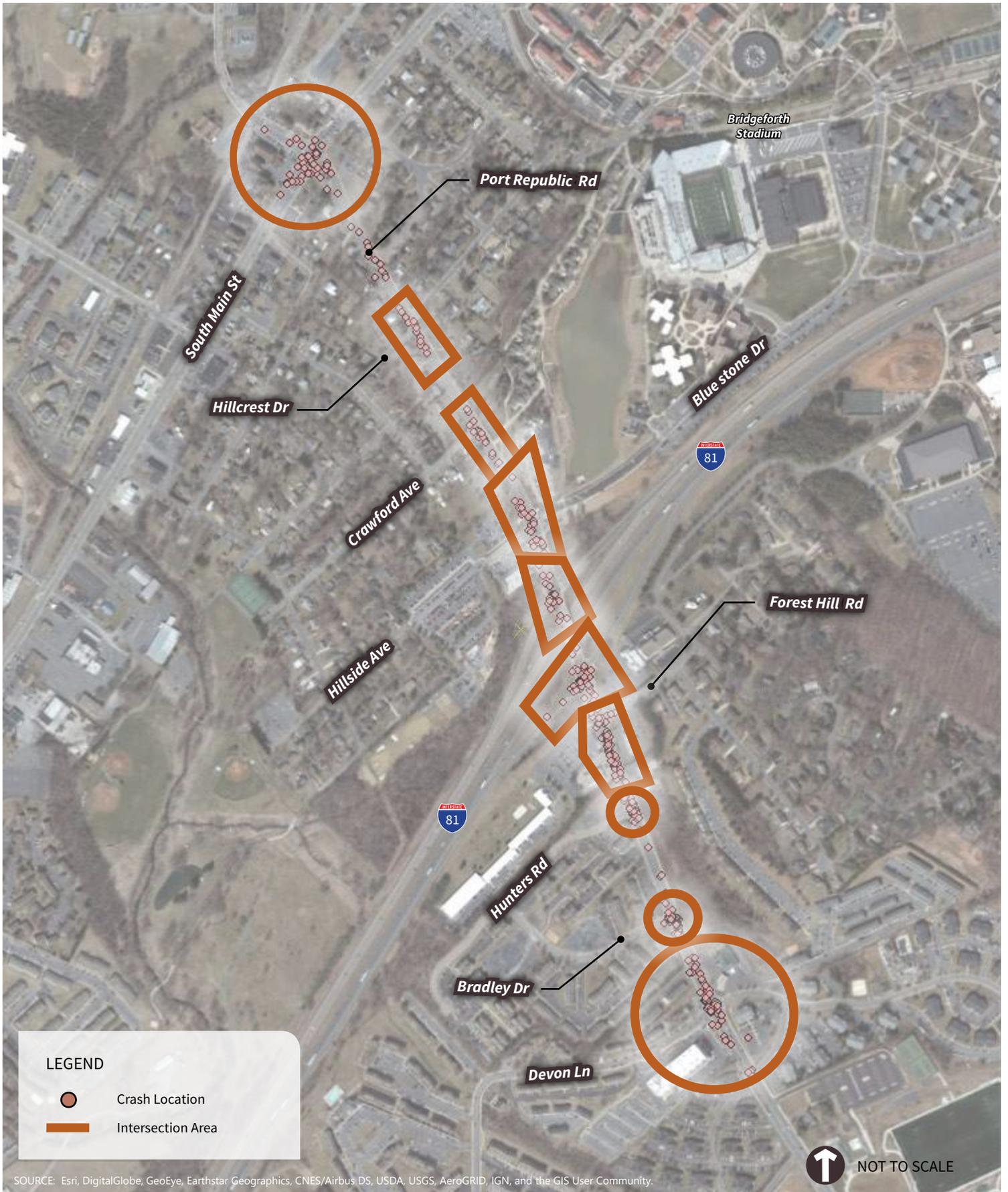
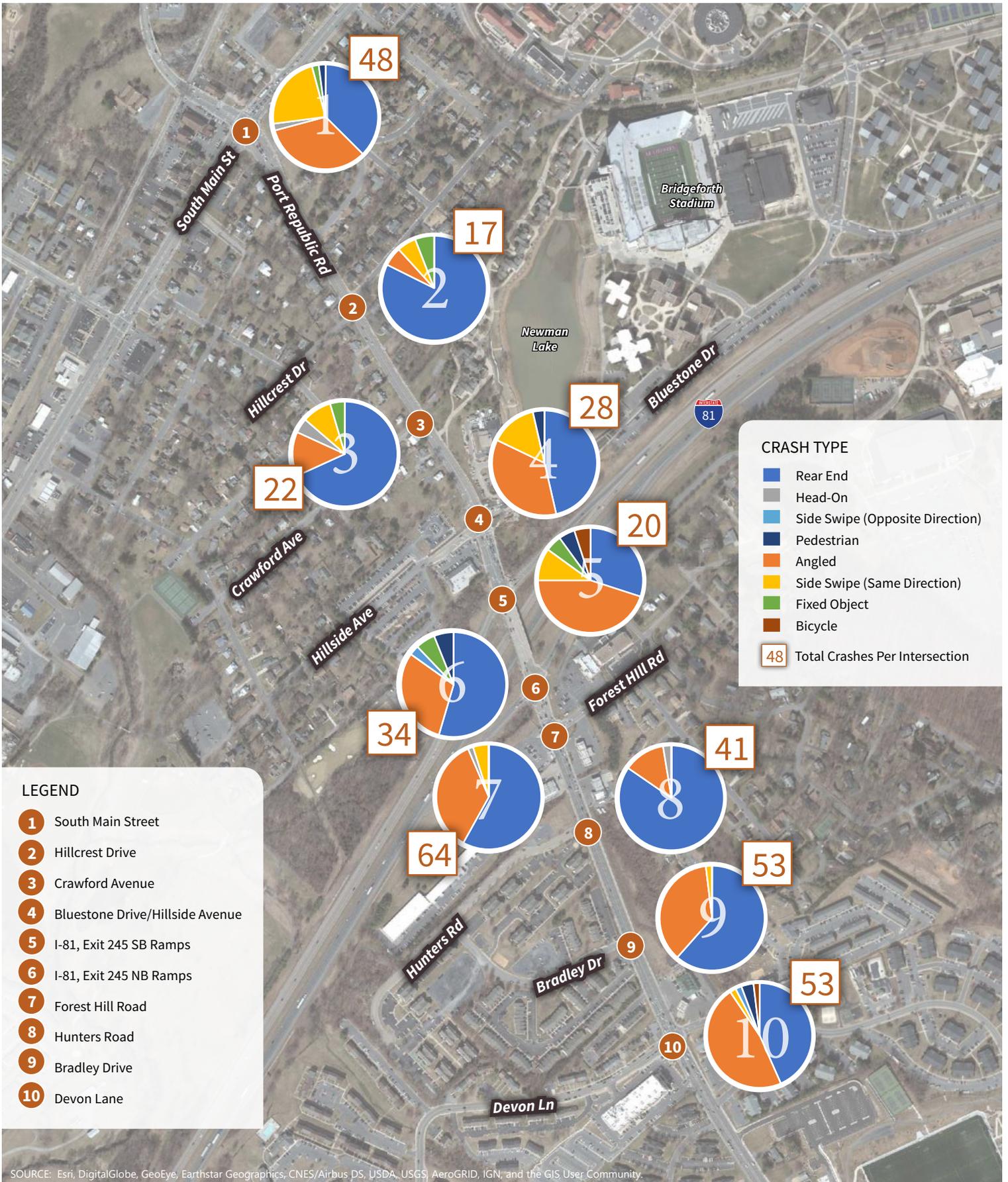


FIGURE 3.5
INTERSECTION CRASH AREA
 Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia



SOURCE: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community.



FIGURE 3.6
CRASH TYPE BY INTERSECTION
 Port Republic Road Safety and Operations Study
 Harrisonburg, Virginia

Primary Focus Areas

There are two (2) primary approaches to addressing safety, using a site-specific approach to address locations with a history of high or severe crashes, and using a systemic approach to proactively address safety by identifying and targeting specific risk factors. The following analysis involves the identification of focus areas and the associated risk factors. The data set used in the analysis includes 396 crashes for the five-and-a-half-year period.

There are two (2) possible types of focus areas in systemic data analysis: focus crash types and focus facility types. With the available robust crash dataset, the analysis was guided by the focus crash types. The highest proportion of crashes are rear-end followed by angle crash types as shown in Figure 3.7. Together these two (2) crash types comprised 88 percent of the total crashes and 85 percent of the severe crashes within the study area as shown in Table 3.3. Figure 3.8 and Table 3.4 show the number and percentage of injury crashes by severity type. KAB crashes are fatal and severe crashes as noted by the KABCO scale: K = fatal crash, A = incapacitating injury, B = non-incapacitating injury, C = possible injury, and O = no injury.

Crash Frequency Analysis

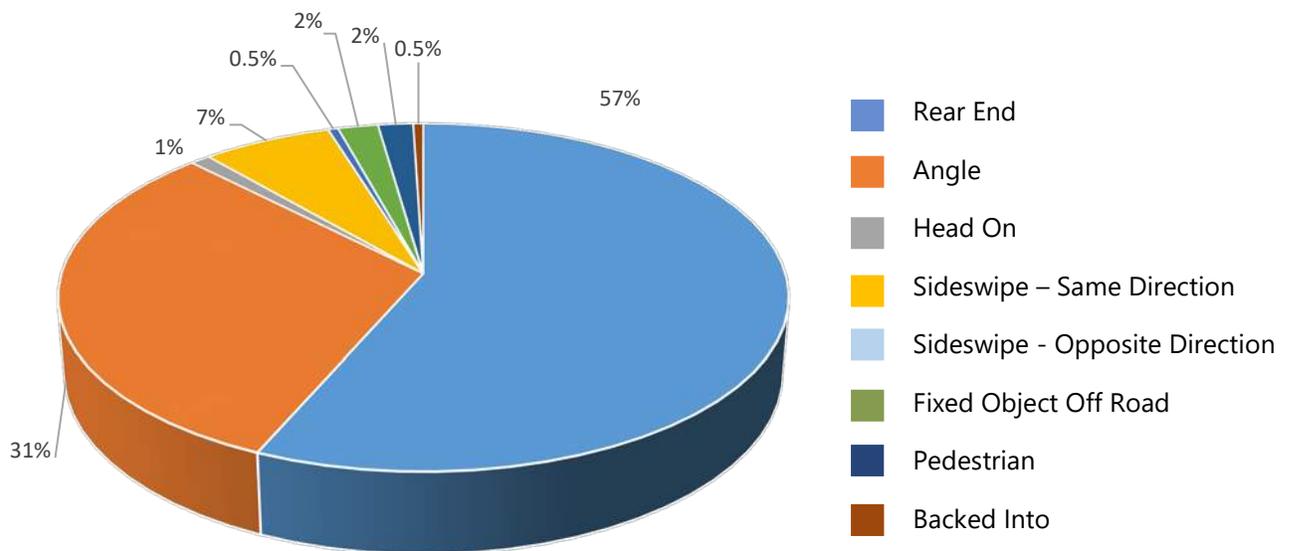


Figure 3.7 Percent of Total Crashes

Table 3.3 Percentage of Total Crashes by Type

Crash Types	All Crashes	% of Total Crashes (n=396)	Fatal and Severe Crashes (K, A, B codes)	% of Total Fatal and Severe Crashes (n=68)
Rear End	224	57%	33	49%
Angle	123	31%	24	36%
Head On	4	1%	2	3%
Sideswipe- Same Direction	26	7%	1	1%
Sideswipe- Opposite Direction	2	0.5%	0	0%
Fixed Object Off Road	8	2%	1	1%
Pedestrian	7	2%	6	9%
Backed Into	2	0.5%	0	0%
Total	396	100%	67	100%

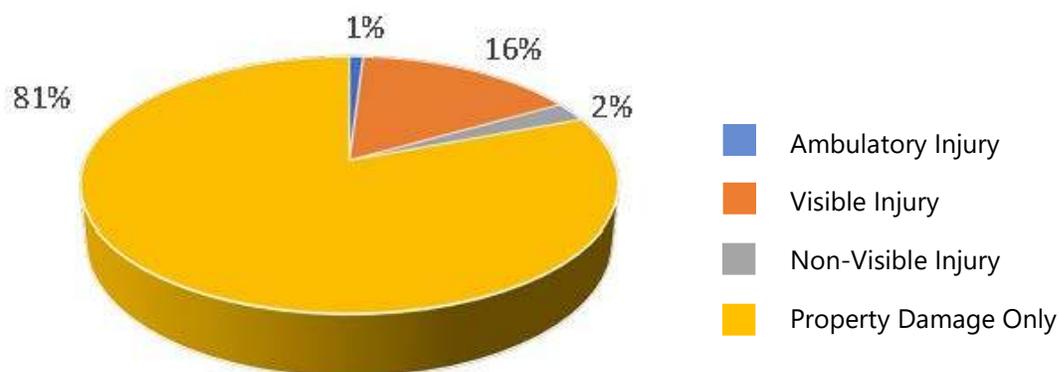


Figure 3.8 Crash Severity

Table 3.4 Crash Severity

Crash Severity	Number of Crashes	Percentage of Total Crashes (n=396)
A. Ambulatory Injury	4	1%
B. Visible Injury	63	16%
C. Non-Visible Injury	10	2%
PDO. Property Damage Only	319	81%
Total Crashes	396	100%

Crash Rates

VDOT has moved away from traditional crash rate comparisons to a Potential for Safety Improvement (PSI) philosophy which is a data-driven, strategic approach based on expected performance outcomes. VDOT's program involves the identification of intersections and roadway segments with above average total and injury crashes for existing traffic, analysis of crash trends and existing conditions, and economic and/or risk evaluation of proposed safety project benefits.

Nearly all the Port Republic Road study area has been identified within the top 100 miles of segments in the Staunton District with the largest potential for safety improvements for 2013 through 2017. Locations that have been identified for safety improvements along Port Republic Road include the section between I-81 southbound ramp and Hillside Avenue, Forest Hills Road to approximately 300 feet east of the intersection, and 200 feet west of Devon Lane to beyond the study area to the east.

The intersection of Port Republic Road with I-81 southbound ramps was also identified, but not targeted for safety improvements. No other study intersections were identified.

At the City of Harrisonburg's request, the overall crash rates for the corridor, and corridor segments, were compared to the statewide average rates for all primary roads and urban minor arterials. The crash rates were calculated based on the published average annual daily traffic volumes (AADT) and traffic counts provided by the City. When sufficient volume information was not available, assumptions between the peak hour volumes and AADT was calculated using a K factor of .1046, which represents the average K value for the corridor in the published AADT and classification data from 2017. An average of 2013-2017 AADTs was used for the statewide average crash rate and an average of the crashes was used for the total crashes. A growth factor of 1% was used to reduce existing volumes to calculate past year volumes, if the information was not available. The crashes were analyzed by entire corridor and corridor segment in units of crashes per 100 million vehicle miles traveled (VMT).

While the average statewide corridor rates were available on the Tableau website statewide intersection crash rates are not available as VDOT has moved away from this type of comparison. The individual intersection crash rates were calculated in crashes per million entering vehicles (MEV) and are used as a comparison between the study intersections only. This information is shown in Table 3.5 and Table 3.6.

Table 3.5 Segment Crash Analysis

Road Segment	Total Crashes (January 2013-June)	Segment Crash Rate per 100 VMT	Statewide Average Crash Rate per 100 VMT	Percent Difference
Port Republic Road S. Main St. to Devon Ln.	396	790.6	126.3 (All Primary Roads)	526.0%
			181.1 (Urban Minor Arterial)	336.6%
Port Republic Road S. Main St. to I-81 SB Ramp	146	513.1	126.3 (All Primary Roads)	306.3%
			181.1 (Urban Minor Arterial)	183.3%
Port Republic Road I-81 SB Ramp to Devon Ln.	250	1151.6	126.3 (All Primary Roads)	815.0%
			181.1 (Urban Minor Arterial)	538.1%

Road Segment	Total Injury Crashes (January 2013-June)	Segment Injury Crash Rate per 100 VMT	Statewide Average Crash Rate per 100 VMT	Percent Difference
Port Republic Road S. Main St. to Devon Ln.	67	133.8	43.1 (All Primary Roads)	210.4%
			59.1 (Urban Minor Arterial)	126.4%
Port Republic Road S. Main St. to I-81 SB Ramp	21	73.8	43.1 (All Primary Roads)	71.2%
			59.1 (Urban Minor Arterial)	24.9%
Port Republic Road I-81 SB Ramp to Devon Ln.	46	212.6	43.1 (All Primary Roads)	393.3%
			59.1 (Urban Minor Arterial)	259.7%

Table 3.6 Intersection Crash Rate Analysis

Intersection	Total crashes (January 2013-June)	Intersection Crash Rate per MEV	Study Area Ranking	Total Injury Crashes (January 2013-June)	Intersection Injury Crash Rate	Study Area Ranking
Port Republic Road S. Main St.	48	0.54	6	6	0.06	8
Port Republic Road Hillcrest Dr.	17	0.45	7	2	0.05	9
Port Republic Road Crawford Ave.	22	0.42	9	2	0.04	10
Port Republic Road Bluestone Dr. / Hillside Ave.	28	0.45	8	5	0.08	5
Port Republic Road I-81 SB Ramp	20	0.34	10	4	0.07	7
Port Republic Road I-81 NB Ramp	34	0.58	5	4	0.07	6
Port Republic Road Forest Hills Rd.	64	1.06	1	12	0.2	2
Port Republic Road Hunters Rd.	41	0.79	4	6	0.12	4
Port Republic Road Bradley Dr.	53	1.02	3	9	0.17	3
Port Republic Road Devon Ln.	53	1.04	2	13	0.25	1

Risk Factor Determination

The following is a description and overview of the risk factor determination for the focus crash types: rear-end and angle crashes. Included is an analysis related to each focus area within the corridor.

Rear-end crashes were the most prevalent crash type with 57 percent of the total crashes and 49 percent of the severe crashes. There were 224 total rear-end crashes reported of which 33 were reported as severe. Over half (52 percent) of the total rear-end crashes and the majority of severe crashes (52 percent), occurred at signalized intersection locations. Rear-end collisions within the vicinity of the unsignalized, residential entrances represent 43 percent of the total rear-end crashes and 39 percent of severe rear-end crashes. Five (5) percent of all rear-end crashes were not intersection related. Table 3.7 presents rear-end crashes with respect to the intersection type (signalized, unsignalized, or non-intersection).

Table 3.7 Rear-End Crashes

All Crash Types	Rear-End Crashes	Percentage of Rear-End Crashes (n=224)	Rear-End KAB Crashes	Percentage of Rear-End KAB Crashes (n=33)
Unsignalized Intersection-Related	96	43%	13	39%
Signalized Intersection-Related	116	52%	17	52%
Not Intersection-Related	12	5%	3	9%
Total	224	100%	33	100%

Rear-end and severe rear-end crashes along the corridor typically occurred during the PM peak hour, between 3 PM to 6 PM. Thirty-two (32) percent of total rear-end crashes and 30 percent of severe rear-end crashes occurred in this time frame as shown in Table 3.8.

Table 3.8 Rear-End Crashes by Time

Time of Day	Rear-End Crashes	% of Rear-End Crashes (n=224)	Rear-End KAB Crashes	% of Rear-End KAB Crashes (n=33)
0 AM TO 3 AM	7	3%	1	3%
3 AM TO 6 AM	0	0%	0	0%
6 AM TO 9 AM	19	8%	2	6%
9 AM TO 12 PM	24	11%	6	18%
12 PM TO 3 PM	41	18%	5	15%
3 PM TO 6 PM	71	32%	10	30%
6 PM TO 9 PM	49	22%	6	18%
9 PM TO 12 AM	13	6%	3	9%
Total	224	100%	33	100%

Congestion, excessive access points, an absence of turn lanes, in-lane transit bus stops, and closely spaced signalized intersections are probable causes for vehicles to be stopped in the flow of traffic. Motorists who are distracted or following too closely fail to stop in time to avoid colliding with the car in front of it. It is not anticipated that excessive speeding is a factor contributing to most or the rear-end collisions, as the time of the crashes corresponds to a period of congestion where free flow speed is slower than the posted speed limit. Roadway surfaces in areas steep grades and intersection approaches can become polished, reducing friction between the pavement and the tires, contributing to crashes. In some cases, the rear-end crash pattern could also reflect geometric conditions, such as the grade of the roadway causing a reduction in sight distance, and an increase in stopping sight distance.

Rear-End Crashes at Signalized Intersections

Port Republic Road and South Main Street

There were 18 rear-end crashes at the intersection of Port Republic and South Main Street. Six (6) of the rear-end crashes involved eastbound vehicles, and five (5) included westbound vehicles. Two (2) of the eastbound crashes occurred within, or just past, the northbound channelized right turn onto Port Republic Road. The MUTCD requires yield signs to be installed on the near side of the intersection on the right-hand side of the intersection. The existing yield sign in the median, to the left of the channelized roadway should be used as a supplement only.

The remaining rear-end crashes involve a vehicle that was stopped, but it is unclear if it is due to the signal or the driveways located near the intersection. Medians are recommended on all legs of the signalized intersections within the functional area of the intersection, which will prohibit

left turns onto Port Republic Road and South Main Street which will mitigate the crashes that originate from these driveways.

Port Republic Road and Bluestone Drive

Thirteen (13) rear-end collisions occurred at the intersection of Port Republic Road and Bluestone Drive. Six (6) of the collisions involved westbound vehicles, six (6) involved eastbound vehicles and only one (1) involved southbound vehicles. All collision descriptions indicate that vehicles were stopped due to the signal and were following too closely to stop in time. No improvements are warranted at this time.

Port Republic Road and Southbound I-81

Six (6) rear-end crashes occurred at the intersection of Port Republic Road and the southbound I-81 ramps. Five (5) of the incidents involved at the southbound ramps were eastbound vehicles, while only one (1) was a westbound vehicle. All rear-end crashes were due to vehicles stopped at the traffic signal and following too closely. No changes are being suggested at this time.

Port Republic Road and Northbound I-81

There were 18 rear-end collisions that occurred at the intersection of Port Republic Road and the northbound I-81 ramps. Eight (8) of the rear-end collisions involved westbound traffic, five (5) involved eastbound vehicles and five (5) involved northbound vehicles. Like the southbound ramps, all rear-end crashes were due to vehicles stopped due to the traffic signal and following too closely. No changes are being suggested at this time. The relocation of the northbound off-ramp configuration that is currently being designed should have a positive impact on this area.

Port Republic Road and Forest Hill Road

The majority (38) of total rear-end crashes occurred at the intersection of Port Republic Road and Forest Hill Road. This intersection is analyzed further in the site-specific portion of the report.

Port Republic Road and Devon Lane

Twenty-three (23) rear-end crashes occurred at the intersection of Port Republic Road and Devon Lane. This intersection was identified as a hot spot for total crashes and severe crashes and is analyzed further in the site-specific portion of the report.

Rear-End Crashes at Unsignalized Intersections

Port Republic Road and Hillcrest Drive

Fourteen (14) rear-end crashes occurred at the intersection of Port Republic Road and Hillcrest Drive. Nine (9) of those collisions involved westbound vehicles and five (5) involved eastbound vehicles. Four (4) of the crash descriptions note the driver was attempting to turn left onto Hillcrest Drive (two in the westbound direction and two in the eastbound direction). The crest of the hill causes a reduction in sight distance of stopped vehicles and was specifically mentioned in one (1) of the eastbound collisions. The length and angle of curvature of Port Republic Road, as well as the existing retaining structures in this area, should be evaluated and improved on future roadway projects, if necessary. All other collisions are related to stopped vehicles due to congestion from the upstream and downstream signalized intersections. As previously recommended in the operational analysis it a peak hour left turn restriction is recommended at this intersection. Restricting left turn movements during the peak periods will assist flow and prevent rear-end collisions in this area.

Port Republic Road and Crawford Drive

There were 15 rear-end collisions at the intersection of Port Republic Road and Crawford Drive. Thirteen (13) of those crashes involve westbound vehicles. Of the 13 crashes involving westbound vehicles, eight (8) specifically mention the vehicle was struck while being stopped in traffic attempting a left turn onto Crawford Avenue. The vertical grade in the area, combined with following too closely or being distracted, is the likely reason that westbound vehicles did not see the vehicle stopped in traffic. As previously recommended in the operational analysis it a peak hour left turn restriction is recommended at this intersection. Restricting left turn movements during the peak periods will assist flow and prevent rear-end collisions in this area.

Port Republic Road and Hunters Road

Thirty-three (34) rear-end crashes occurred at the intersection of Port Republic Road and Hunters Road. A significant number of the rear-end crashes were westbound vehicles. This is likely due to the westbound downhill grade of the intersection and the queuing from Forest Hill Road. While these crashes are coded at the intersection of Port Republic Road and Hunters Road, the configuration of the crashes and the crash descriptions describe rear-end crash origins being backed up from the signal at Forest Hill, and vehicles stopped to turn into the gas station located on the north side of Port Republic across Hunters Road, in addition to vehicles turning onto Hunters Road. High-friction surface course is recommended for the locations with significant downhill grade, such as this location. This will decrease braking distance at this location and may reduce the rear-end collisions at this location. A peak hour left turn restriction is recommended at this intersection. Restricting left turn movements during the peak periods so that vehicle may only perform a right turn movement in and a right turn movement out will assist flow and prevent rear-end collisions in this area.

Port Republic Road and Bradley Drive

There were 34 rear-end collisions at the intersection of Port Republic Road and Bradley Drive. The rear-end collisions at the intersection of Port Republic Road and Bradley Drive have a concentrated pattern within the inside westbound lane, just east of Bradley Drive. This suggests that these crashes involve a stopped vehicle waiting to make a left-hand turn onto Bradley Drive. The topography of the area in the vicinity of Bradley Drive limits a westbound vehicle's view of a stopped car until it is too close to safely come to a stop. A left turn restriction into Bradley Drive during peak hour traffic was investigated in the preliminary draft report; however, after considering the effect to the system this recommendation has been removed. Bradley Drive and Hunters Lane are the sole access points to the apartments located on the south side of Port Republic Road and turn restrictions will likely move the problem elsewhere. A signal is recommended in this location to assist the turning movements. In the long term, a left turn pocket on Port Republic Road to facilitate these left turns by removing them from the vehicle flow should greatly improve safety and operations at this intersection.

Angle Crashes

Angle crashes were the second most prevalent crash type in the study area. There was a total of 123 total angle crashes, of which 24 were severe angle crashes. Relative to all other crash types, angle crashes comprised 31% of total crashes, and 36% of severe crashes. As shown in Table 3.9, approximately 76% (83% of severe) occurred at signalized intersections. This comparison appears counterintuitive, as you would anticipate angle crashes to occur at a lower rate at signalized intersections when compared with unsignalized intersections. It is important to note that traffic volumes making turning movements occur at a significantly higher rate at the signalized intersections. Additionally, more crashes are attributed to the signalized intersections because there is a much larger influence area as shown previously in Figure 3.5.

Table 3.9 Angle Crashes

All Crash Types	Angle Crashes	Percentage of Angle Crashes (n=123)	Angle KAB Crashes	Percentage of Angle KAB Crashes (n=24)
Unsignalized Intersection-Related	29	24%	3	13%
Signalized Intersection-Related	93	76%	20	83%
Not Intersection-Related	1	1%	1	4%
Total	123	100%	24	100%

Total and severe angle crashes most often occurred during 12:00 PM to 3:00 PM, however it is almost evenly spaced between 12:00 PM to 9:00 PM, as shown in Table 3.10.

Table 3.10 Angle Crashes by Time

Time of Day	Angle Crashes	% of Angle Crashes (n=123)	Angle KAB Crashes	% of Angle KAB Crashes (n=24)
0 AM TO 3 AM	8	7%	2	8%
3 AM TO 6 AM	3	2%	1	4%
6 AM TO 9 AM	8	7%	2	8%
9 AM TO 12 PM	19	15%	2	8%
12 PM TO 3 PM	27	22%	4	17%
3 PM TO 6 PM	25	20%	3	13%
6 PM TO 9 PM	22	18%	7	29%
9 PM TO 12 AM	11	9%	3	13%
Total	123	100%	24	100%

Angled crashes occur when a vehicle makes a turning maneuver and does not yield right of way to opposing traffic. For those crashes at signalized intersections there are several elements that may have contributed to the improper maneuver such as speed, heavy traffic volumes, driver impatience, large vehicles obscuring the view of other on-coming vehicles, lack of adequate sight distance, lack of sufficient protected turn phasing, or not being able to clearly see the signal indications.

Angle Crashes at Signalized Intersections

Port Republic Road and South Main Street

There were 16 angle crashes at the intersection of Port Republic Road and South Main Street. The angle crashes are nearly evenly distributed between directions of travel. The angle crashes at the intersection were the result of traffic violating the traffic signal control and running a red light or turning on a permissive green phase without yielding to through traffic. Three (3) of the angle crashes involved turns from private driveways in the influence area of the intersection. Median treatments are recommended at all signalized intersections within the functional area of the intersection, which should mitigate the crashes that originate from these driveways.

Port Republic Road and Bluestone Drive

There were 10 angle collisions that occurred at the intersection of Port Republic Road and Bluestone Drive. Six (6) of the collisions were westbound vehicles. There is no visible reason that would cause westbound vehicles to misjudge the signal indication. No other improvements are warranted at this time.

Port Republic Road and Southbound I-81

There were nine (9) angle collisions that occurred at the intersection of Port Republic Road and southbound I-81 ramps. Over half (5 total) of these angle collisions involve an eastbound vehicle running a red light. This could indicate that eastbound vehicles are seeing a green light at the intersection with the northbound I-81 ramps and mistakenly enter the intersection illegally.

Guidance suggests that programable signals, or louvered signals, should be used when intersections are spaced 300 feet or less apart. Since programable or louvered signals come with some drawbacks -- they can be difficult to position properly, and these signals are 450 feet apart, this countermeasure is not suggested at this time; however, this countermeasure should be considered in the future if there is an increase in this type of crashes at this location.

Port Republic Road and Northbound I-81

Eleven (11) angle crashes occurred at the intersection of Port Republic Road and Northbound I-81 ramps. Two (2) of the crashes involved running a red light in the eastbound direction, and two (2) involved running the red light in the westbound direction. Two (2) of the crashes involved a right turn on red from the off-ramp who were unable to see the eastbound traffic properly. Additionally, it is assumed that some of the crashes were attributed to the weaving movement of left bound from I-81 northbound ramps. This should no longer be an issue when the ramp is moved to meet Forest Hills Drive in the near future. No countermeasures are recommended at this time.

Port Republic Road and Forest Hill Road

Twenty-two (22) angle crashes occurred at the intersection of Port Republic Road and Forest Hill Road. This intersection was identified as a hot spot for total crashes and severe crashes and is analyzed further in the site-specific portion of the report.

Port Republic Road and Devon Lane

The intersections with the highest frequency of angled crashes occur at the intersection of Port Republic Road with Devon Lane. This intersection was identified as a hot spot for total crashes and severe crashes and is analyzed further in the site-specific portion of the report.

Angle Crashes at Unsignalized Intersections

At unsignalized intersections turns are not facilitated through signal phasing. As a result, a driver's gap acceptance behavior is typically a factor in angle crashes. Factors that influence gap acceptance are the presence of a queue behind a driver, driver wait time, and number of gaps rejected. When a driver feels pressure or grows impatient, they may accept shorter gaps, sacrificing a degree of safety, to execute their turn. Studies have also indicated that younger drivers often exhibit riskier behavior when evaluating gaps.

Port Republic Road and Hillcrest Drive

Only one (1) angle crash was reported at the intersection of Hillcrest Drive and Port Republic Road. This is particularly surprising given the limited sight distance due to the topography and the retaining wall structures located on the corners of both the north and south legs. The crash reported originated from a residential driveway on the south side of Port Republic Road west of Hillcrest Drive. A possible explanation is sincere care is taken when vehicles are making turns due to the discomfort created by the reduction in sight distance. Another explanation is local traffic is choosing alternative access points during congested periods of the day. No improvements are recommended at this time.

Port Republic Road and Crawford Drive

There were three (3) angle collisions at the intersection of Port Republic Road and Crawford Drive. With an average crash rate of less than one (1) crash per year, no recommendations are being proposed at this time beyond the time of day turning restriction already recommended for operational capacity and reduction in rear-end collisions.

Port Republic Road and Hunters Drive

Six (6) angle crashes occurred at the intersection of Port Republic Road and Hunters Road. Of these six (6) crashes, only two (2) specifically reference turning into (1 crash) or turning out of (1 crash) Hunters Road. No recommendations beyond the time of day turning restriction already recommended for operational capacity and reduction in rear-end collisions are proposed at this time.

Port Republic Road and Bradley Drive

Nineteen (19) angled crashes, representing almost 15% of the total angle crashes, occurred at the intersection of Port Republic Road and Bradley Drive. After reviewing AM and PM peak hour turning movements, there is less traffic entering and exiting Bradley Drive when compared to Hunters Road; but it has almost four (4) times the number of angle crashes. Ten (10) of the 19 angled crashes at this location involved a northbound vehicle and an eastbound vehicle. Some of the crash descriptions discuss traffic in the outside eastbound lane queuing and leaving a gap/waving in for the northbound traffic on Bradley Drive to turn. When the driver made the turn, he or she was hit by an eastbound vehicle in the inside eastbound lane, that the drivers could not see. Other reports simply state the driver could not see the eastbound vehicles with no further explanation. There are trees and a fence present on the south side of Port Republic Road, west of the intersection with Bradley Drive, that may hinder the ability of a northbound vehicle to see eastbound traffic. It is recommended that the City of Harrisonburg investigate this further during leaf out to ensure standard sight distance can be achieved.

Due to the lack of alternative access locations into the apartment complex served by Hunters Road and Bradley Drive, a turn restriction at both Hunters Road and Bradley Lane was not feasible. There were five angled collisions in 2017 that involved a northbound vehicle on

Bradley Lane attempting to turn left onto Port Republic Road. These crashes are considered to be correctable with the installation of a traffic signal and would satisfy condition B of Warrant 7, Crash Experience, found within the MUTCD. To provide access and address the safety of northbound and westbound left turning vehicles into and out of Bradley safely, a signal is being recommended at this location.

Pedestrian Crashes

Crashes between motor vehicles and people walking only represent two (2) percent of the total crashes, but account for the third highest of severe crashes. There was a total of seven (7) crashes involving a pedestrian, accounting for nine (9%) of the total severe crashes. All of the pedestrian crashes occurred at signalized intersections. The pedestrian crashes were evenly dispersed and did not concentrate at one (1) intersection. One (1) pedestrian crash each occurred at the intersections of Port Republic Road and South Main Street, Bluestone Drive, Southbound I-81 ramps. One (1) pedestrian crash also occurred outside of an intersection area. Two (2) pedestrian crashes occurred at the Northbound I-81 ramps and at Devon Lane.

Two (2) of the collisions with a pedestrian ended with the pedestrian receiving the citation. While this means the pedestrian is considered to be at fault because they did not yield right-of-way, the signal cycle length should be researched as pedestrians are very sensitive to delay and may perform risky maneuvers.

A total of three (3) pedestrian crashes occurred within the interchange with Port Republic Road and the I-81 ramps. Two (2) of the pedestrian crashes involved vehicles exiting NB I-81 and attempting to turn right onto Port Republic Road. Both were turning right on red. In one (1) crash the pedestrian was eastbound, the second is unknown. In both accidents the pedestrians were in the crosswalk. The fenced portion and bridge may be creating a sight distance issue with someone on the sidewalk. This should not be a concern once the northbound I-81 off-ramp is moved to align with Forest Hills Road. However, before the relocation of the northbound I-81 ramp is constructed the City of Harrisonburg should evaluate this further. The pedestrian crash located at the southbound I-81 ramp involved a driver who was westbound on Port Republic Road and turned left to enter the southbound direction of I-81. The driver had a green light but did not yield right-of-way to the pedestrian lawfully crossing the intersection. The crash occurred at 7:46 AM, during morning rush hour. The driver was on her cell phone.

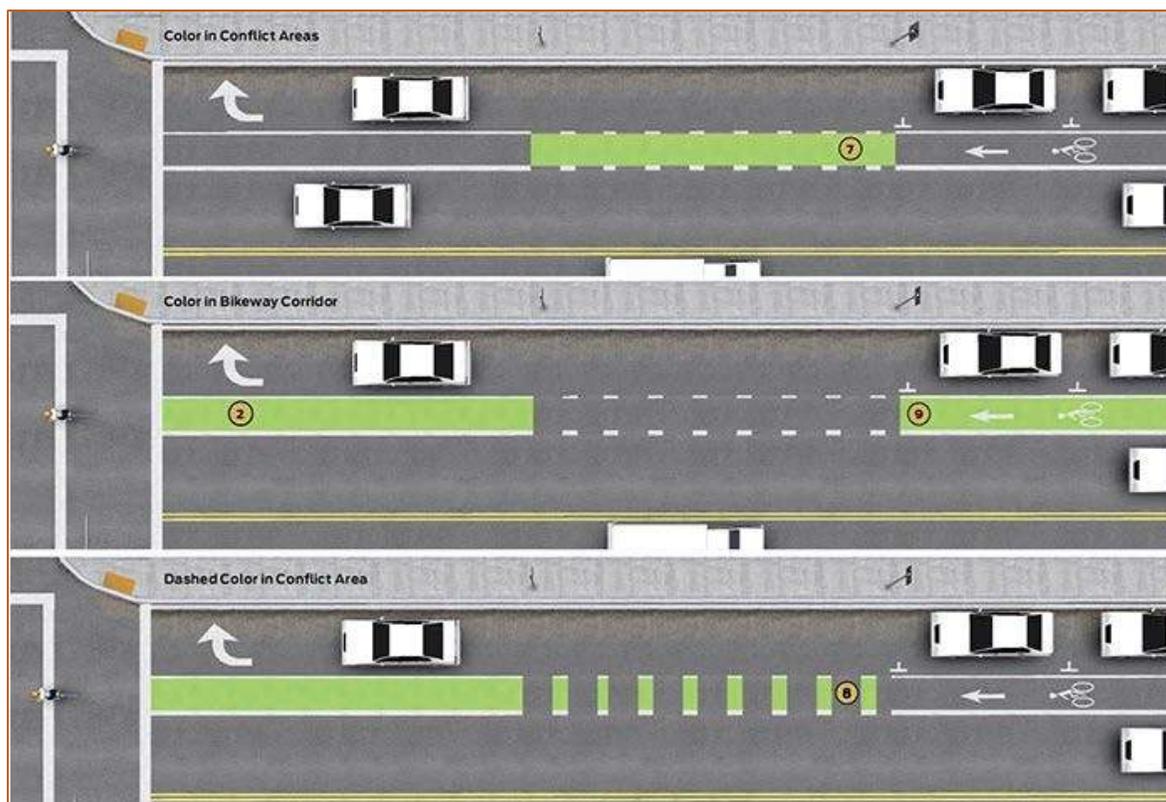
During the site observation, vehicles queueing up to adjacent intersections was frequently witnessed. While the vehicles did not block the downstream intersection, they queued up close enough to the intersection to obscure the view of pedestrians in the crosswalk from a left turning vehicle. This would be especially concerning if the vehicle at the back of this queue was a large vehicle as shown in the following photograph. Fortunately, this observation is not represented in the crash data; however, to prevent a crash in the future "Do Not Block the Box" intersection markings should be considered. Additionally, these markings would prevent queued vehicles from blocking the crosswalk.



Large Vehicle Queueing Example

Bicycle Crashes

Four (4) of the angled crashes and one (1) of the rear-end crashes involved a bicycle. Two (2) of these collisions occurred due to turning vehicles not yielding to a bicycle in the bike lane. In one (1) instance the vehicle was traveling westbound and turned left onto Bradley Drive and struck the person riding a bike. In the other instance, a westbound vehicle was making a right turn into the gas station on the northeast corner and hit the person riding a bike, who was going too fast to stop. A countermeasure that should be considered is the use of green colored markings in the conflict areas to highlight the potential presence of people riding bikes as shown in the following photograph.



Green Colored Conflict Markings

Site Specific Analysis

The second approach to addressing safety in the corridor is through a site-specific analysis. Heat maps created by crash frequency, and crash severity of the five-and-a-half-year period (2013-2018) of crash data led to the identification of two (2) site specific locations due to the crash frequency, and crash severity that is occurring at these locations. These heat maps are shown in Figure 3.1 and Figure 3.2.

The site-specific locations were chosen based on their potential to show reduced average crash frequency or severity. Once the locations were identified, collision diagrams were created of the injury crashes to get a more detailed view into the cause of the collisions. Key safety concerns, recommended counter-measures, and implementation for short-term and long-term conditions are described in this section of the report.

Site Specific Location #1 – Port Republic and Forest Hill Road

This location is a signalized, four-legged intersection of Port Republic Road and Forest Hill Road. Surrounding areas include a parking lot for JMU to the south, a gas station to the east, a hotel and single-family neighborhood is located to the north. The bus stop located near this intersection picks up 15-20 people per hour.

On the western leg of the intersection, there is a 150-foot left turn lane that continues through the I-81 northbound on-ramp interchange, without a taper. The eastern leg of the intersection does not have dedicated turn lanes, and left turns into the parking lot are restricted. The north leg of the intersection has a 500-foot right turn lane, that terminates at the intersection with Oak Hill Drive, without a taper. The eastbound lefts are facilitated with a protected/permissive left turn phase. A five-section, dog house style signal head was installed until recently when a four-section with flashing yellow signal was installed. The southern leg is the exit of JMU parking lot and does not have dedicated left turn lanes. The north and southbound traffic is split-phased to allow for protected lefts, in the absence of dedicated left turn lanes.

There are sidewalks on both sides of Port Republic Road through the intersection with Forest Hill Road, and crosswalks are present across the east leg and the north leg of the intersection. There is a bike lane east of the intersection on Port Republic Road. This bike lane ends abruptly at Forest Hill Road. It is assumed that people riding bikes to the JMU main campus likely use the sidewalk once the bike lane ends.

A construction project to relocate the northbound I-81 on-ramp to align with Forest Hill Road is currently under design. This exit serves as the primary access for the JMU east campus, as well as access to employment and activity centers in the City. This realignment will provide direct access to JMU east campus, including the convention center. This realignment is anticipated to have a positive impact on safety as motorists entering the corridor from I-81 north who intend to travel north on Forest Hills Road will no longer be required to weave across two (2) lanes of traffic in a short distance in order to turn left onto Forest Hills Drive.

Crash Summary

Between January of 2013 and June of 2018, 64 crashes occurred at Port Republic Road and Forest Hill Road. This represents just over 16% of the total crashes within the study corridor. Nineteen (19) % (12 crashes) resulted in an injury (crash type A or B) and 81% (52 crashes) resulted in a property damage only (crash type O). There were 36 total rear-end crashes, with six (6) of them resulting in an injury. There was a total of 22 angle crashes, with seven (7) of them resulting in an injury. Collision diagrams of the injury crashes are shown in Figure 3.3.

Westbound vehicles are involved in 61 percent of rear-end crashes, and 68 percent of angle crashes. This is not surprising given the steep downhill grade of westbound Port Republic Road in this vicinity. While the grade is not something that can be changed without a significant investment and adjacent property impacts, the use of a high friction surface treatment in the

downhill direction should mitigate the increase in stopping sight distance resulting from the grade.

A westbound right turn lane is recommended at this intersection in the operational analysis section of the report. The addition of a right turn lane will provide a safety benefit as right turning vehicles will have space outside of the through travel lane to decelerate before making their turn or stop to yield to a pedestrian within the crosswalk.

Four (4) of the angled collisions involved turning movements into or out of the gas station located on the northeast corner. The proximity of the entrances to the gas station to the intersection is undesirable as it relates to safety and operations. Closing the driveway nearest to the intersection is recommended. In addition, reduction of conflict points through the use of a median through the functional area of the intersection is recommended. If the roadway does not provide sufficient space for a concrete barrier median, the use of flexible curbing and flex tubes can be a low-cost method to provide a physical barrier to prevent left turns in the functional area of the intersection. An example of this improvement is shown in the following photograph.



Flex Tubes

Traffic Signal Timing and Operations

Three (3) angled collisions involved an eastbound vehicle running a red light, while one (1) included a westbound vehicle running a red light. Four (4) involved an eastbound left turn movement on a permissive phase and not yielding the right-of-way to westbound vehicles. The use of high visibility back plates could assist motorists in recognizing the signal at a further distance, and at night.

A check of the pedestrian clearance interval and the yellow and all red change intervals show that the total time appears to be within current standards, and no changes are recommended.

The distance between the westbound signal indications for Forest Hill Road is located only 285 feet from the signal indications for northbound I-81. A standard industry practice is referenced in the Caltrans traffic manual which provides some guidance relating to countermeasures to avoid motorist confusion when two (2) intersections are located less than 300 feet apart. It is suggested that programmable traffic signals, or louvers be installed so that only certain lanes of traffic get a clear indication and other lanes controlled by a second signal do not see that indication. Only one (1) angled crash was attributed to a westbound vehicle running a red light, which would indicate that is not a problem at this time; however, this condition should be monitored and potentially considered in the future if warranted.

Transit

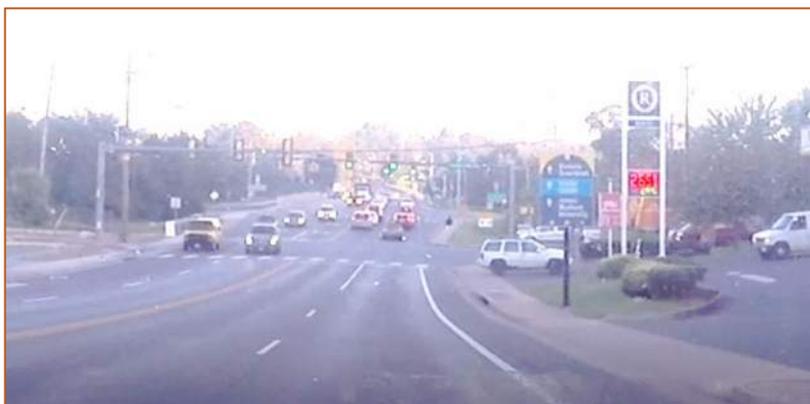
A near side, in-lane transit stop is located at the bottom of the hill, which may contribute to the frequency of rear-end collisions. For safety reasons, it would be beneficial to provide a bus pull out at this location, which can be accommodated if the gas station entrance nearest Forest Hills Drive is removed. For transit operations, this is not ideal as the bus will be required to find a gap to get back into the flow of traffic. Another countermeasure could be the installation of a more robust rear flashers to alert on-coming traffic that the bus is stopped in the lane.



Rear Flasher on Bus

Suggested Countermeasures

- Reflective back plates
- Better rear warning lights for the transit vehicles
- Eliminate the gas station entrance that is closest to Forest Hill Road
- Provide a bus pull out at bottom of hill
- Install a median within the functional area of the intersection
- High friction surface treatment on the downgrade lanes
- Construct westbound right turn lane.



Northbound I-81 Signals Visible at the Forest Hill Road Intersection



High Friction Surface Treatment

Site Specific Location #2 – Port Republic Road and Devon Lane

This location is a signalized, four-legged intersection of Port Republic Drive and Devon Lane. Surrounding areas include a gas station and restaurant on the northwest corner, multi-family apartment complex on the northeast corner, multi-use commercial/residential on the southeast corner, and dense student housing to the south on both sides of the intersection.

The start of the left turn lane on the eastern leg is not well defined as it transitions from a two-way left turn lane (TWLTL) to a left turn only lane. The western leg of the intersection has a 175-foot left turn lane and 250-foot taper. The right turn lane on the north leg is 85 feet with no taper. The south leg has a channelized right turn lane (yield condition) with 135 feet of storage and a 75-foot taper. The striping for the westbound turn bay should be re-striped to clarify the extents of the dedicated left turn lane in compliance with VDOT standard PM-5. The eastbound and westbound directions have a protected/permissive left turn phase with a five-section, dog house style. The southern leg does not have a dedicated left turn lane. The north and southbound traffic is split phased to allow for protected lefts in both directions.

There are curb ramps on all legs of the intersection of Port Republic through the intersection with Devon Lane, and crosswalks are present across all legs of the intersection. There is continuous sidewalk on all approaches, except the western side of the north leg on Devon Lane.

Crash Summary

Between 2013 and 2018, 53 crashes occurred at Port Republic Road and Devon Lane. This represents just over 13% of the total crashes within the study corridor. Twenty-five (25) percent (13 crashes) resulted in a visible, or non-visible injury (crash type A or B) and 75 percent (40 crashes) resulted in a property damage only crash (crash type O). Collision diagrams of the injury crashes are shown in Figure 3.2. There were total 36 rear-end crashes, with three (3) of them

resulting in an injury. There was a total of 25 angled crashes, with six (6) of them resulting in an injury. This intersection also experienced two (2) pedestrian crashes, both which resulted in an injury.

Thirteen (13) of the rear-end collisions involved a westbound vehicle, while seven (7) involved an eastbound vehicle. Two (2) of the rear-end collisions specifically mention a stopped transit vehicle being the reason a vehicle was stopped in the roadway. Three (3) mentioned site congestion being the reason for the stopped vehicle, although it is anticipated that this number is much higher. One (1) westbound crash contributes the sun to being unable to see the vehicles in front of them before the collision. Given that the orientation of Port Republic Road is not true east and west facing, it is not believed this is a significant factor. The location of the transit stop should be evaluated for sight distance and relocated if the bus is stopped in a location where sufficient stopping sight distance is not provided. Additionally, the increase in warning lights for stopped transit vehicles could help alert drivers to the presence of a stopped transit vehicle.

Five (5) of the angled crashes involved a westbound vehicle which ran a red light, while three (3) involved an eastbound vehicle which ran red light. High visibility back plates should be installed to help draw attention to the signal, which should reduce the frequency of this type of collision. There is a possibility that vehicles are intentionally running the red light just after it turns red in an attempt to avoid waiting through another cycle. In this case the installation of red light running cameras should be investigated to discourage this behavior.

Traffic Signal Timing and Operations

Four (4) angled collisions were the result of an eastbound vehicle turning left during a permissive phase and failing to yield to a westbound vehicle. Two (2) angles crashes were the result of a westbound vehicle performing a permissive left and failing to yield to an eastbound vehicle. The location of the intersection on a crest makes it difficult for westbound and eastbound vehicles to see vehicles turning; however, the frequency of these crashes does not warrant the use of protected only left turn phasing at this time. The installation of a flashing yellow arrow signal head to replace the existing five-section dog house should reduce these types of collisions. The yellow and red change intervals appear to be within current standards and no changes are recommended at this time.

Six (6) of the angled crashes involved a vehicle exiting from a roadway or driveway near the intersection. A median should be installed within the functional area of the intersection to prevent these movements.

Two (2) of the collisions with a pedestrian were the result of the pedestrian crossing Port Republic against a no walk indication. While this means the pedestrian is "at fault," the signal cycle length could be reviewed if there is a high frequency of pedestrian travel as pedestrians are sensitive to long wait times, which results in risky crossing behaviors.

No pedestrian crashes occurred within the northbound channelized right turn lane. However, the FHWA suggests that crosswalks should be located more towards the middle of the channelized turn. This is because turners are generally fully committed to their turn at the location where the crosswalk is located and are generally looking towards their right for conflicting vehicles, instead of pedestrians, as shown in the adjacent photograph. This would require the reconfiguration of the wheel chair ramps.

Suggested Countermeasures

- Reflective back plates.
- Striping of westbound turn lane to clearly define the left turn lane bay area and improve guidance to the motorists.
- Relocation of crosswalk at channelized right.
- Install a median within the functional area of the intersection
- Flashing yellow arrow for the east and west bound movements.



Turn Lane Striping

Recommendations

The goal of the study was to provide a set of recommendations to improve safety within the Port Republic Road corridor. To achieve that goal, this safety analysis provided a comprehensive evaluation the corridor with the purpose of understanding the safety conditions. The outcome of these evaluations is a series of recommended treatments which have proven safety benefits and address existing, short-term, and long-term corridor needs.

Safety Recommendations

The safety portion of the study incorporated intersection evaluation and site-specific assessment toward the development of the recommendations. The safety improvements are comprised of a set of tiered recommendations of access management, traffic control techniques, and other improvements to enhance safety and operations of the Port Republic Road corridor. The recommendations were determined through an evaluation of crash history and proactively applying Crash Modification Factors modifications with proven safety results.

During the five-and-a-half-year period between January 2013 and June 2018, there were 396 crashes. Through the approach presented in this report, the most prevalent and most severe crash types have been comprehensively considered and addressed.

Congestion Mitigation

Congestion mitigation is a key recommendation that is anticipated to reduce the risk of both rear-end collisions, and angled collisions. Less congestion correlates to fewer stopped vehicles in the travel lane, which will lessen the exposure a car has to being rear-ended. Reduced congestion is expected to reduce risky turning maneuvers and gap acceptance behavior, leading to fewer angled crashes. Additionally, increasing traffic flow should reduce the desire to quickly change lanes to avoid stopping for queued cars, which can lead to a collision.

Rear-end collisions are one of the most common accidents that occur in heavy traffic, especially stop and go traffic. In congested situations vehicles may follow the vehicle in front of them too closely and become eager to accelerate when traffic starts moving. Additionally, being stuck in congestion can be stressful, causing a driver to become distracted, or drive aggressively. When a driver brakes suddenly in dense traffic, discontinuities in the traffic stream in the form of shock waves can occur. This transition zone between the stopped vehicle and the faster moving upstream vehicle travels varies according to the density and speed of traffic. As the speed of the shock wave increases, the potential for rear end collisions increases.

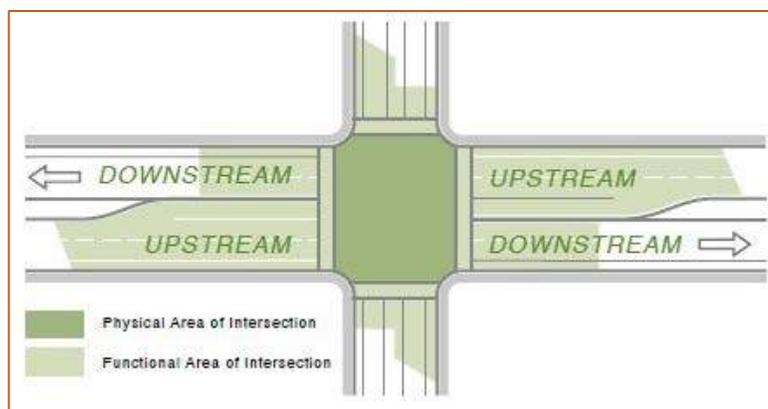
A key element in reducing the frequency of rear-end collisions along a corridor is reduce the number of stops that occur on the roadway. This is done through a series of strategies aimed at reducing the number of vehicles stopped in the traffic flow through the use of access management strategies, providing turn lanes and increasing the throughput capacity through signal timing and phasing optimization.

Recommendations that are intended to increase the operational capacity of the corridor, and thus reducing stops, have been identified in the operational analysis. As displayed above in Tables 2.18 and 2.19 these improvements have shown the potential to decrease the average number of stops along the study corridor. While the modeled corridor volumes increased over the 12-year analysis due to anticipated growth, the average stops per vehicle within the network was anticipated to drop by 11.5% when compared to existing conditions in the AM peak hour, and a modest increase of 9.16% in the PM peak hour. While the number of stops is expected to increase in the PM peak hour when compared to existing conditions, it is anticipated to be significantly better than the no build scenarios, which is anticipated to increase by 79.28% in 2030 if the proposed recommendations are not in place.

Access Management

Access management provides a safety improvement by both reducing conflict points, and by facilitating traffic flow, reducing speed differential and exposure to crashes. As discussed previously in the document, medians should be provided within the functional area of the signalized intersections to prohibit left turns. See following figure as an illustration.

Additionally, peak hour turning restrictions have been recommended at three (3) of the four (4) unsignalized study intersections and it is recommended the gas station access along the south side of Port Republic Road nearest Forest Hill Road be removed.



Median Intersections

Signal Optimization

The signals in the corridor are currently coordinated to provide progression through the corridor; however, the green bands appear to break down during the most congested times of the AM and PM peak hour. There are a few reasons this might be happening. One (1) reason may be that the offsets do not account for the reduction in speed due to the congestion/queueing and are not appropriate during the peak volume times.

Another reason might be attributed to the high number of pedestrian calls. Pedestrian walk and clearance times to cross Port Republic Road often exceed the maximum green time for the vehicular movements. To accommodate this movement, the controller will suspend coordination. The transition back to the coordination pattern after the pedestrian phase has been served can take some time.

The addition of flashing yellow arrows at all locations where left turns are protected and permitted will provide additional safety against angled crashes while allowing more flexibility for coordination due to the ability to lead lag left turns without the concern of yellow trap.

Conclusion

Safety plays an important role in improving mobility along the Port Republic Road corridor. This study has identified several low-cost improvements that can be implemented along the corridor to provide a safer travel experience to road users.

4 Conclusion and Cost Estimate

The goal of this study was to provide a set of recommendations for operational and safety improvements to the Port Republic Road study corridor. In order to achieve this goal, this report provides a comprehensive evaluation of the corridor with the purpose of understanding the operational and safety concerns. The outcome of these evaluations is a series of recommended treatments which have proven operational and safety benefits. Graphical representation of these improvements by intersection are shown in Appendix I. These recommendations have been prioritized as short term, mid term and long term improvements as shown in Tables 4.1, 4.2 and 4.3.

The recommendations can be organized into four (4) categories: traffic control measures, geometric changes, access management strategies and miscellaneous.

Traffic Control Measures

- Optimize corridor signal timings including cycle lengths, splits, offsets, and phasing sequences;
- Eliminate the split phase operation at the relocated NB I-81 off-ramp and Forest Hills once left turn lanes are added to the northbound and southbound directions and allowing protected left turn movements to occur simultaneously;
- Eliminate the split phase operation at Port Republic Road and Devon Lane by including left turn lanes in the northbound and southbound direction, and allowing these protected/permissive left turn movements to occur simultaneously;
- Eliminate the northbound and southbound pedestrian signal crossing at Port Republic Road and Bluestone Drive by providing a pedestrian overpass;
- Signalize Port Republic Road and Bradley Lane;
- Install flashing yellow arrows (FYAs) where protected/permissive left turns are used. This allows for lead/leg left turn phasing which will assist in bi-directional coordination.
- Install High Visibility Backplates;
- Install yield sign on the right side of the roadway for the northbound channelized right turn at Port Republic Road and South Main Street;
- Relocate the crosswalk within the channelized northbound right turn lane at Port Republic Road and Devon Road;
- Install green markings in the bike lane across driveways and intersections; and,
- Restripe the westbound left turn lane at the intersection of Port Republic Road and Devon Road to clearly designate the transition from a two-way-left-turn-lane to a dedicated left turn lane.

Geometric Changes

- Construct a westbound right turn lane with 100 feet of storage and a 100 foot taper on Port Republic Road at the intersection of Port Republic Road and Forest Hill Road;
- Increase the eastbound left turn lane storage length on Port Republic Road and Bluestone Drive from 100 feet to 300 feet;
- Reconfigure the westbound Port Republic Road approach at South Main Street to include two left turn lanes, one through lane, one through/right and one right turn lane;
- Reconfigure the westbound approach of Devon Lane at Port Republic Road to include one left turn lane, one through lane and one right turn lane. Widen the southbound approach to include one left turn lane, one through lane and one right turn lane; and,
- Construct a pedestrian overpass over Port Republic at Bluestone Drive/Hillside Avenue in order to improve pedestrian mobility and safety while eliminating the northbound and southbound pedestrian crossings that are facilitated by the existing traffic signals.

Access Management Strategies

- Implement peak hour turning restrictions at Hillcrest Drive, Crawford Avenue, and Hunters Road;
- Install a median to restrict turning movements within the proximity of all signalized intersections; and,
- Close gas station driveway located on the northside of Port Republic Road just east of Forest Hill Road.

Miscellaneous Recommendations

- Install high friction surface course at downhill approaches to increase skid resistance and reduce stopping distances.

Future Considerations

Below are considerations that are expected to involve significant financial investment, or will require more study, and should be considered in the future.

- Transit stop enhancements;
- Evaluate intersection sight distance;
- Install left turn lanes at the unsignalized intersections;
- Evaluate the need to use louvered or programmable signal indications where the signals are closely spaced;
- Evaluate the implementation of red-light running cameras;

- Evaluate the design of the vertical curves to current geometric design standards to provide adequate sight distance; and,
- Investigate a bus pull-out for transit vehicles in the westbound direction on Port Republic Road just east of Forest Hill Road.

Probable Estimate of Cost

Safety and operations play an important role in improving mobility along Port Republic Road. This study has identified varying tiers of improvements that can be implemented along the corridor to provide a safer travel experience to road users. A cost estimate for these improvements is shown in Table 4.1. These cost estimates are intended to be planning level costs for budgeting purposes only.

The cost estimate does not include an estimate for right-of-way costs or utility relocations that may be required to construct the recommendations that include:

- Pedestrian overpass;
- Permanent four-foot-wide median installation within intersection influence area;
- Proposed turn lanes that require widening of the roadway;
- Flashing beacon sign during peak hour restrictions;
- Traffic signal installation at Bradley Drive; and
- Relocation of one mast arm at Devon Lane and Port Republic Road.



Flashing Beacon Sign

Several of the recommendations are considered to be low-cost and can be done utilizing City staff and are not included in the cost estimate. These include:

- Median separation using flexible tubes and curbing;
- Lane configuration changes that include removal of existing striping and re-striping in the new configuration;
- Traffic signal optimization; and
- Installing left turn prohibition signage on side streets.

Funding has been identified to install FYA signal heads and high visibility back plates at the signalized locations proposed in this report and are therefore not reflected in the cost estimate.

Short Term Projects

These projects are assumed to include city crews or an on-call contract and produce improvements to the safety and operations along the Port Republic Corridor. These items are not anticipated to require right-of-way or utility relocation.

Table 4.1 Short Term Projects

Intersection	Pay Item	Quantity	Unit Cost	Total Cost
Port Republic Road S. Main St.	Yield Sign - Installed	1	\$150	\$150
	Pavement Marking Arrows	3	\$750	\$2,250
Port Republic Road Hillcrest Dr.	Solar Flashing Beacon	2	\$10,000	\$20,000
Port Republic Road Crawford Ave.	Solar Flashing Beacon	2	\$10,000	\$20,000
Port Republic Road Hunters Rd.	Solar Flashing Beacon	2	\$10,000	\$20,000
Corridor	Temporary Median (flex Tubes)	1,545 LF	\$75	\$115,875
Corridor	High Friction Surface Coarse	2,445 SF	\$29	\$70,891
Corridor	Green Paint (Bike Lane)	70 rectangles	\$200	\$14,000
Total				\$263,166

Mid Term Projects

These projects are anticipated to increase safety and produce benefit operations along the Port Republic Corridor in the midterm as they will require detailed engineering design and identified funding source to construct. These improvements are anticipated to require some right-of-way acquisition and utility relocations, that are not included in the cost estimate. The estimated build year for inflation is 2024.

Table 4.2 Mid Term Projects

Intersection	Pay Item	A*	B*	C*	D*	Total Cost	Total Cost (With Inflation)
Port Republic Road I-81 SB Ramp	Widen ramp to lengthen turn lanes	\$315,024	\$110,258	\$42,528	\$191,802	\$659,613	\$764,672
Port Republic Road Forest Hills Road	Right turn lane and relocated ped pole (widened only to the north)	\$180,983	\$63,344	\$24,433	\$110,191	\$378,951	\$439,308
Port Republic Road Bradley Drive	Install Traffic Signal	\$225,000	\$78,750	\$30,375	\$136,991	\$471,116	\$546,153
Total							\$1,750,133

The columns in table 4.2 are described below:

- A* Includes base bid estimate for work. This includes an estimate for relocated drainage pipes and structures and stormwater management (where applicable).
- B* cost includes erosion and sediment control (estimated at 5% of base bid 'A'), maintenance of traffic (estimated at 5% of base bid 'A') and miscellaneous items (estimated at 25% of base bid 'A').
- C* cost includes mobilization (estimated at 10% of subtotal A* and B*)
- D* cost includes preliminary engineering (estimated at 14% of subtotal A* and B* and C*), construction engineering (estimated at 17% of subtotal A* and B* and C*), and a construction contingency (estimated at 10% of subtotal A* and B* and C*)
- The Grand Total Cost is the combination of A*, B*, C* and D*.
- The Grand Total Cost with Inflation - An annual inflation rate of 3% is was applied to construction year 2024. This was applied to projects that are considered to be long term.

Long Term Projects

These projects are anticipated to increase safety and produce benefit operations along the Port Republic Corridor in the long term as they will require substantial funding sources to construct. These improvements are anticipated to require some right-of-way acquisition and utility relocations, that are not included in the cost estimate. The estimated build year for inflation is 2029.

Table 4.3 Long Term Projects

Intersection	Pay Item	A*	B*	C*	D*	Total Cost	Total Cost (With Inflation)
Port Republic Road Bluestone Drive / Hillside Avenue	Lengthen EB Left Turn Lane	\$234,640	\$82,124	\$31,676	\$142,861	\$491,301	\$660,267
	Pedestrian Overpass	\$1,500,000	\$525,000	\$202,500	\$913,275	\$3,140,775	\$4,220,939
Port Republic Road Devon Lane	Installing Left Turn Lane on North Leg and Re-Striping on South Leg	\$238,959	\$83,636	\$32,259	\$145,490	\$500,344	\$672,421
Corridor	Permanant 4' concrete median and widening	\$1,529,951	\$535,483	\$206,543	\$931,511	\$3,203,488	\$4,305,220
Total							\$9,858,847

The columns in table 4.3 are described below:

- A* Includes base bid estimate for work. This includes an estimate for relocated drainage pies and structures and stormwater management (where applicable).
- B* cost includes erosion and sediment control (estimated at 5% of base bid 'A'), maintenance of traffic (estimated at 5% of base bid 'A') and miscellaneous items (estimated at 25% of base bid 'A').
- C* cost includes mobilization (estimated at 10% of subtotal A* and B*)
- D* cost includes preliminary engineering (estimated at 14% of subtotal A* and B* and C*), construction engineering (estimated at 17% of subtotal A* and B* and C*), and a construction contingency (estimated at 10% of subtotal A* and B* and C*)
- The Grand Total Cost is the combination of A*, B*, C* and D*.
- The Grand Total Cost with Inflation - An annual inflation rate of 3% is was applied to construction year 2029. This was applied to projects that are considered to be long term.