


US 17/360 (Tappahannock Blvd/Church Ln) Corridor Study

Tappahannock, Virginia

DRAFT REPORT

March 2022

US 17/360 CORRIDOR STUDY

Tappahannock, Virginia

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Prepared for

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List of Acronyms

AADT: Average Annual Daily Traffic

AASHTO: American Association of State Highway and Transportation Officials

CLRP: Constrained Long-Range Transportation Plan

CMF: Crash Modification Factor

DGP: District Grants Program

EPDO: Equivalent Property Damage Only

HPPP: High-Priority Projects Program

HSIP: Highway Safety Improvement Program

LOS: Level of Service

MUTCD: Manual on Uniform Traffic Control Devices

PDO: Property Damage Only Crash

PSAP: Pedestrian Safety Action Plan

PSI: Potential for Safety Improvement

RCUT: Restricted Crossing U-Turn

SPS: Statewide Planning System

STARS: Strategically Targeted Affordable Roadway Solutions

TA: Transportation Alternatives

TOSAM: Traffic Operations and Safety Analysis Manual

VDOT: Virginia Department of Transportation

Table of Contents

1 Introduction 1
1.1 Background and Study Purpose 1
1.2 Study Work Group 1
1.3 Study Corridor Limits 1
1.4 Study Area Characteristics 2
2 Local and Regional Planning Context 3
2.1 Comprehensive Plans 3
2.2 Regional Long Range Transportation Plan 4
2.3 Arterial Preservation 4
2.4 Intersection Safety Review of US 17/360 (Church Lane) at Duke Street 4
2.5 Proposed Bicycle Routes 4
3 Data Collection and Inventory 6
3.1 Existing Roadway Geometry 6
3.2 Traffic Volume Data 6
3.2.1 Daily Traffic Volumes 6
3.2.2 Peak Hour Determination 6
3.2.3 Traffic Volume Calibration 9
3.2.4 Heavy Vehicle Percentages and Peak Hour Factors 9
3.2.5 Traffic Volume Balancing 9
3.3 Crash Data 11
3.4 Pedestrians and Bicyclists 11
3.5 Public Transportation 12
4 Existing Conditions Analysis 13
4.1 Peak Hour Traffic Operations Analysis 13
4.1.1 Measures of Effectiveness 13
4.1.2 Level of Service Criteria 13
4.1.3 Traffic Operations Analysis Results 13
4.2 Crash Analysis and Identified Deficiencies 16
4.2.1 Corridor-wide Crash Statistics 16
4.2.2 Locations with Potential for Safety Improvement 18
4.2.3 Fatal Crashes 23
4.2.4 Pedestrian and Bicyclist Crashes 24
4.2.5 Other Locations Examined for Safety Issues 24
4.3 Access Spacing 25
4.4 Conclusions from the Existing Conditions Analysis 25
4.5 Survey Results 26
4.5.1 What are the Issues? 26
4.5.2 Where are the Issues? 28
4.5.3 Survey Respondents 29
4.5.4 Key Themes from Survey Responses 30
5 Future Traffic Forecasting 31
5.1 Future Traffic Growth Rates 31
5.2 Future Development 31
5.3 Projected 2040 Traffic Volumes 31
6 Future No-Build Conditions Analysis 33
6.1 Background Improvements 33
6.2 Traffic Analysis Assumptions 33
6.3 Traffic Analysis Results 33
6.3.1 Control Delay and Level of Service Results 33
6.3.2 Queue Length Results 33
7 Developing and Refining the Potential Improvements 36
7.1 Developing the Potential Improvements 36
7.1.1 Downtown Tappahannock 36
7.1.2 South of Hoskins Creek 38
7.1.3 Brays Fork 39
7.2 Refining the Potential Improvements 40
7.2.1 Downtown Tappahannock 40
7.2.2 South of Hoskins Creek 46
7.2.3 Brays Fork 49
7.3 Public Meeting and Survey Results 50
7.3.1 Downtown Tappahannock Improvements 50
7.3.2 Brays Fork Improvements 50
7.3.3 South of Hoskins Creek Improvements 51
7.3.4 Ranking the Improvements 51
7.3.5 Survey Respondents 51
7.3.6 Is there another idea that should be considered? 52
8 Recommended Improvements 53
8.1 Recommended Projects 53
8.2 Safety Benefits 53
8.3 Improvements to Access Spacing 55
8.4 Policy Recommendations 56
8.5 Impacts to Traffic Operations 56
8.5.1 Control Delays and Levels of Service 56
8.5.2 Maximum Queue Lengths 56
9 Conceptual Design, Costs, and Schedules 61
9.1 Conceptual Design 61
9.2 Planning-Level Cost Estimates 61
9.3 Schedule Estimates 61
10 Project Advancement 62

List of Tables

Table 1: Annual Ridership for Bay Transit's The Rivah Ride Deviated Fixed Route Service 12
Table 2: Level of Service Criteria for Signalized and Unsignalized Intersections....13
Table 3: Corridor-wide Crashes by Crash Severity....17
Table 4: Corridor-wide Crashes by Crash Type 17
Table 5: Corridor-wide Crashes by Time of Day and Crash Type....17
Table 6: VDOT Access Spacing Standards for Principal Arterials 25
Table 7: Concepts Considered for Downtown Tappahannock 37
Table 8: Concepts Considered for Brays Fork....39
Table 9: Comparison of Downtown Alternatives....43
Table 10: Equivalent Property Damage Only Crash Value Scale....53
Table 11: Expected Crash Reductions....54
Table 12: Improvements to Access Spacing....55
Table 13: Planning-Level Cost Estimates 61
Table 14: Schedule Estimates 61

List of Figures

Figure 1: US 17/360 Study Corridor Limits....2
Figure 2: Town of Tappahannock Land Use Plan Map....3
Figure 3: Essex County Land Use Plan Map 3
Figure 4: Proposed Bicycle Routes in the Middle Peninsula Planning District 5
Figure 5: Existing Lane Configurations....7
Figure 6: Traffic Data Collection Locations 8
Figure 7: 2019 Bidirectional Average Annual Daily Traffic Volumes from VDOT Traffic Data....8
Figure 8: 24-hour Daily Traffic Volume Counts – 2-Day Average Collected March 30-31, 2021....9
Figure 9: Existing (2021) Intersection Turning Movement Volumes 10
Figure 10: The Rivah Ride Bus Stop Locations 12
Figure 11: 2021 Existing Peak Hour Traffic Operating Conditions – Control Delays (seconds per vehicle) and Levels of Service....14
Figure 12: 2021 Existing Peak Hour Traffic Operating Conditions –Queue Lengths (feet)....15
Figure 13: Crash Intensity Heat Map 16
Figure 14: Corridor-wide Crashes by Crash Severity....17
Figure 15: Corridor-wide Crashes by Crash Type....17
Figure 16: Corridor-wide Crashes by Time of Day 18
Figure 17: Collision Diagram – US 17 (Church Lane) at US 360 (Queen Street) 18
Figure 18: Collision Diagram – US 360 (Queen Street) at Cross Street....20
Figure 19: Collision Diagram – US 17/360 (Church Lane) at Duke Street....21
Figure 20: Collision Diagram – US 17/360 (Tappahannock Boulevard) at Winston Road 22
Figure 21: Collision Diagram – US 17/360 (Tappahannock Boulevard) at Ball Street 23
Figure 22: Collision Diagram – US 17 (Church Lane) at Marsh Street....24
Figure 23: Survey Results – Ranking of Issues 26
Figure 24: Survey Results – Safety Issues 26
Figure 25: Survey Results – Congestion Issues 27
Figure 26: Survey Results – Access Spacing Issues 27
Figure 27: Survey Results – Pedestrian, Bicycle, and Public Transit Issues 27
Figure 28: Survey Results – Location of All Map Comments 28
Figure 29: Survey Results – Map Comments by Type of Issue 28
Figure 30: Survey Responses – Location of Map Comments on Congestion....29
Figure 31: Survey Responses – Travel Behaviors and Demographics of Survey Respondents....29
Figure 32: Survey Responses – Example Written Comments....30
Figure 33: 2040 Future No-Build AM and PM Peak Hour Turning Movement Volumes....32
Figure 34: 2040 Future No-Build Peak Hour Traffic Operating Conditions – Control Delays (seconds per vehicle) and Levels of Service....34
Figure 35: 2040 Future No-Build Peak Hour Traffic Operating Conditions – Maximum Queue Lengths (feet) 35
Figure 36: Conflict Point Diagrams by Type of Median Opening....36
Figure 37: Restricted Crossing U-Turn (RCUT) 38
Figure 38: Conflict Points – Conventional Intersection and RCUT....38
Figure 39: One-Way Pairs Concept....40
Figure 40: Cross Street Partial Quadrant Concept....41
Figure 41: Water Lane Partial Quadrant Concept 42
Figure 42: Downtown Alternatives Travel Time Comparison....44
Figure 43: Short-Term Improvements Northern Area....45
Figure 44: Short-Term Improvements Southern Area....45
Figure 45: Commerce Drive Connection....46
Figure 46: South of Hoskins: White Oak to Teakwood Drive....47
Figure 47: South of Hoskins: Teakwood Drive to Richmond Beach Road 48
Figure 48: Brays Fork Continuous Green-T....49
Figure 49: Brays Fork Roundabout 49
Figure 50: Survey Results – Downtown Tappahannock Improvement Concepts....50
Figure 51: Survey Results – Brays Fork Improvement Concepts 50
Figure 52: Survey Results – South of Hoskins Creek Improvement Concepts....51
Figure 53: Survey Results – South of Hoskins Creek Improvement Concepts....51
Figure 54: Survey Responses –Demographics of Survey Respondents 51
Figure 55: Survey Responses – Is there another idea that should be considered?....52
Figure 56: Lane Configurations with Recommended Improvements....57
Figure 57: 2040 Future AM and PM Peak Hour Turning Movement Volumes with Recommended Improvements.....58
Figure 58: 2040 Future Peak Hour Traffic Operating Conditions with Recommended Improvements – Control Delays (seconds per vehicle) and Levels of Service....59
Figure 59: 2040 Future Peak Hour Traffic Operating Conditions with Recommended Improvements – Maximum Queue Lengths (feet) 60

APPENDICES

Appendix A: Turning Movement and Tube Count Raw Data

Appendix A-1: Intersection Turning Movement Count Data from 2021

Appendix A-2: 48-Hour Tube Count Data from 2021

Appendix A-3: Intersection Turning Movement Count Data from 2017

Appendix B: Peak Hour Determination Tables

Appendix C: Traffic Volume Calibration

Appendix D: Crash Maps

Appendix E: Synchro and SimTraffic Output Reports – 2021 Existing Conditions

Appendix F: Access Spacing Graphics

Appendix G: Synchro and SimTraffic Output Reports – 2040 Future No-Build Conditions

Appendix H: December 9, 2021 Study Work Group Presentation

Appendix I: Project Summary Sheets

Appendix J: Synchro, SimTraffic and SIDRA Output Reports – 2040 Future Build Conditions

Appendix K: Cost Estimates

1 INTRODUCTION

1.1 Background and Study Purpose

Through the Strategically Targeted Affordable Roadway Solutions (STARS) program, the Virginia Department of Transportation (VDOT) identifies corridors with safety and congestion challenges and develops solutions that can be programmed into VDOT's Six-Year Improvement Program or funded through other federal and state programs.

VDOT's STARS program seeks to develop comprehensive, innovative transportation solutions to resolve safety issues and relieve congestion bottlenecks. The goals of STARS studies include:

- Develop innovative, cost-effective solutions
- Evaluate potential solutions more thoroughly
- Identify potential project risks and costs
- Build stakeholder consensus
- Improve readiness for project implementation

VDOT identified portions of US 17 and US 360 in the Town of Tappahannock and Essex County as a STARS project corridor because of safety concerns, crash history, and statewide capacity preservation needs. Five intersections along the 3.5-mile long corridor are included in VDOT's list of intersections with Potential For Safety Improvements (PSIs), based on crash data from 2014 to 2018. VTrans, Virginia's statewide transportation plan, identifies nine intersections as having safety needs that need to be addressed in the next 10 years. VTrans also identifies the entire length of US 17 as having capacity preservation needs to varying degrees.

The US 17/360 Corridor Study ("the study") analyzed safety, traffic operations, and access spacing issues and developed recommendations to better manage access, improve safety, and address operational issues in the study area.

1.2 Study Work Group

A study work group guided the study and shaped the development of improvement concepts. The group provided input reflecting local and institutional knowledge through meetings throughout the study timeline. The group reviewed the analysis methodologies, assumptions, and results, and reviewed and approved the recommendations. Study work group members included representatives from multiple agencies with a variety of expertise areas, including traffic engineering, transit operations, regional and local multimodal transportation planning, roadway design, local land use, and community development.

Study work group members represented:

- Town of Tappahannock
- Essex County
- Essex County Economic Development Authority
- Tappahannock Main Street
- Bay Transit
- Middle Peninsula Planning District Commission
- VDOT Fredericksburg District
- VDOT Saluda Residency
- VDOT Central Office Transportation and Mobility Planning Division

A consultant team of EPR, P.C. and Kimley-Horn and Associates led the study and facilitated the study work group meetings.

1.3 Study Corridor Limits

US 17 is a north-south US highway spanning more than 1,200 miles of the southeastern coast from Winchester, VA to Punta Gorda, FL. US 360 is a 225-mile long spur of US 60 running from Danville, VA to Reedville, VA. US 17 is a principal arterial highway and a component of the Coastal Corridor – one of 12 corridors of statewide significance designated in VTrans that provides interregional travel within and outside the state. Through the Town of Tappahannock, US 17 is concurrent with US 360 between Brays Fork and Queen Street, where US 360 turns toward the Downing Bridge over the Rappahannock River.

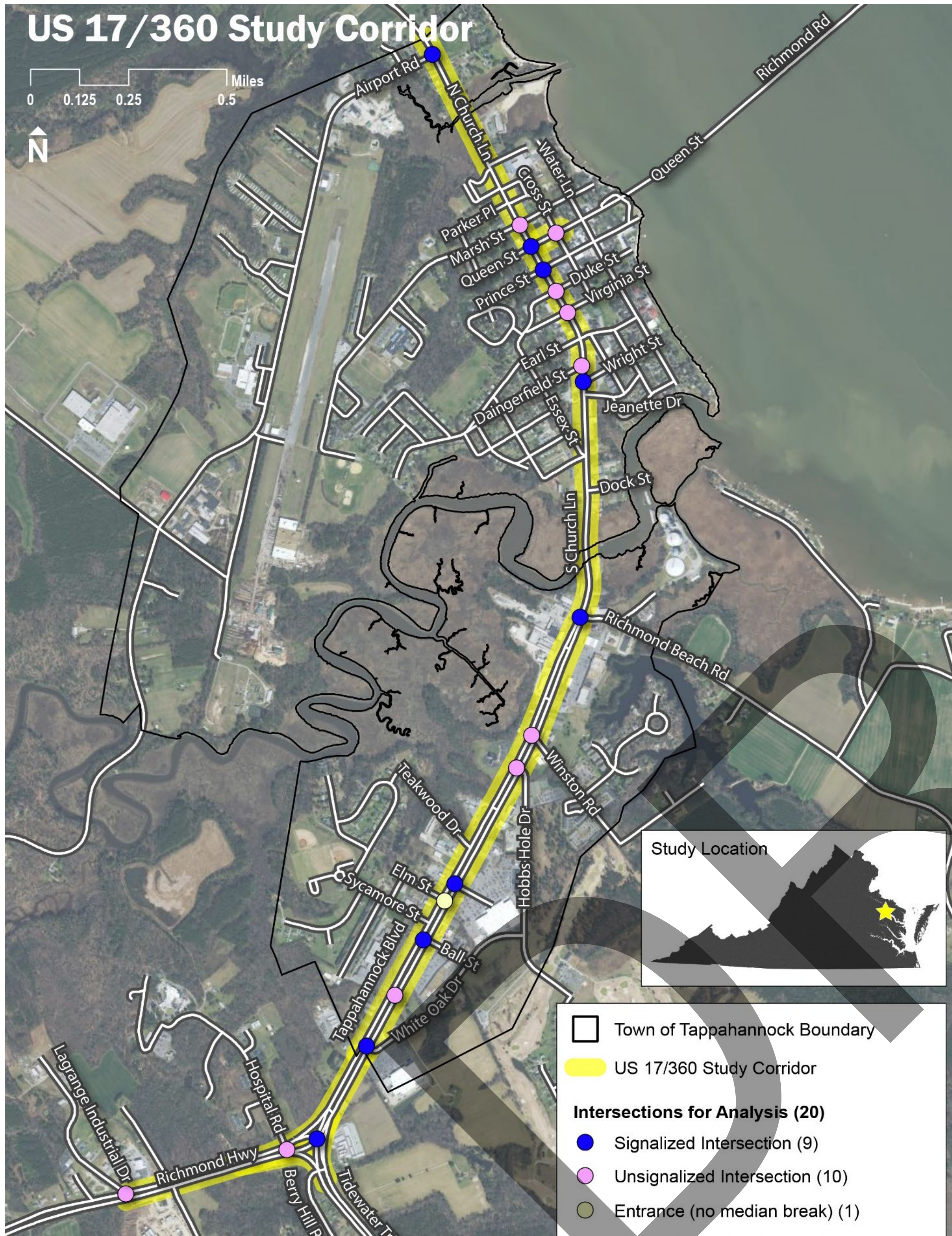
The segment of US 17 and US 360 that shares the same physical roadway in Tappahannock is the focus of this study, as it represents a key point of connection and bottleneck for both highways. Also included in this study are the portions of US 17 north to Airport Road and US 360 southeast to Lagrange Industrial Drive. **Figure 1** shows the limits of the 3.5-mile long study corridor.

The nine signalized intersections within the study corridor limits (listed below from north to south) are shown in **Figure 1**.

1. US 17 (Church Lane) at Airport Road
2. US 17 (Church Lane) at Queen Street (US 360)
3. US 17/360 (Church Lane) at Prince Street
4. US 17/360 (Church Lane) at Wright Street
5. US 17/360 (Tappahannock Boulevard) at Richmond Beach Road
6. US 17/360 (Tappahannock Boulevard) at Walmart entrance
7. US 17/360 (Tappahannock Boulevard) at Ball Street
8. US 17/360 (Tappahannock Boulevard) at White Oak Drive
9. US 17 (Tidewater Trail) at US 360 (Richmond Highway), Brays Fork

Figure 1 also shows the locations of 11 unsignalized intersections and/or median openings that were included in the analysis of the study corridor.

FIGURE 1: US 17/360 STUDY CORRIDOR LIMITS



1.4 Study Area Characteristics

US 17/360 is the main north-south road in the Town's historic district, which is listed in the National Register of Historic Places. The four travel lanes and sidewalks along the corridor are constrained within a narrow right-of-way, creating difficulty for the trucks that travel through the area.

The narrowest portion of the study corridor is between Marsh Street and Virginia Street, where the travel lanes are each nine feet wide, not including the width of the gutter pan. In this section, sidewalks have no buffer along the curb, and many buildings are located right against the sidewalk. There is a 500-ft long sidewalk gap on the east side of US 17 north of Queen Street. Commercial entrances in this section are frequent and closely-spaced, typically located no more than 100 feet apart. The posted speed limit is 25 miles per hour in this section, from Parker Place to just south of Jeannette Drive.

The typical section widens slightly south of Virginia Street to Wright Street, and transitions to include a two-way center turn lane south of Wright Street until the roadway meets the bridge over Hoskins Creek. Land use activity between Wright Street and the Hoskins Creek bridge is not as intense as further north, due to vacant and underutilized buildings, but commercial entrances and curb cuts are still frequent, and buildings are still located close to the back of sidewalk. The posted speed limit transitions from 25 mph to 35 mph south of Jeannette Drive.

South of Hoskins Creek, US 17/360 transitions to a more suburban character. In this southern section, US 17/360 has a wide median, provides access to big box shopping centers, and lacks sidewalks. Buildings are set further back from the road, many with parking lots between the road and the buildings. Commercial entrances are not as frequent, but still exist between median openings. The 35 mph posted speed limit increases to 45 mph at Winston Road.

Recent development activity consists of several businesses, including an O'Reilly Auto Parts, Dunkin Donuts, and Hampton Inn at the intersection of US 17/360 at Hobbs Hole Drive. A Wawa is currently under development near the intersection of US 17/360 and White Oak Drive. Major destinations along this stretch of the corridor include the Walmart, which has its own signalized entrance off of US 17/360, and the Food Lion and Walgreens in the Essex Square shopping center, with an entrance off of Ball Street.

VDOT classifies US 17 and US 360 in the study corridor as principal arterials.

2 Local and Regional Planning Context

The study team gathered and reviewed prior planning documents, including the currently adopted comprehensive plans from the Town of Tappahannock and Essex County, the Middle Peninsula Planning District Commission's current long range transportation plan, and other studies.

2.1 Comprehensive Plans

The Town of Tappahannock is the central focus of Essex County's land use activities as well as the anchor of the County's identity, according to Essex County's most recently adopted (2015) Comprehensive Plan. The Town is the designated growth center of Essex County. The Essex County Comprehensive Plan acknowledges the Town as the underpinning for the County's land use plan framework, which guides growth to the areas within and surrounding the Town limits where public facilities can be logically extended. The goal of guiding growth to these areas is to protect Essex County's rural character and reduce demand for County services in outlying rural areas.

The Land Use Plan maps from the Town and County Comprehensive Plans are provided in **Figures 2 and 3**. The Land Use Plan Map in the Town of Tappahannock's most recently adopted (2014) Comprehensive Plan shows a Central Business District along US 17/360 from Parker Place to Essex Street with town scale residential on either side. Land along US 17/360 in the southern portion is designated as general commercial, with mixed residential and residential on either side, as well as resource protection in areas alongside Hoskins Creek. The existing land uses are generally in line with the land use categories designated in the Town's comprehensive plan.

Figure 2: Town of Tappahannock Land Use Plan Map

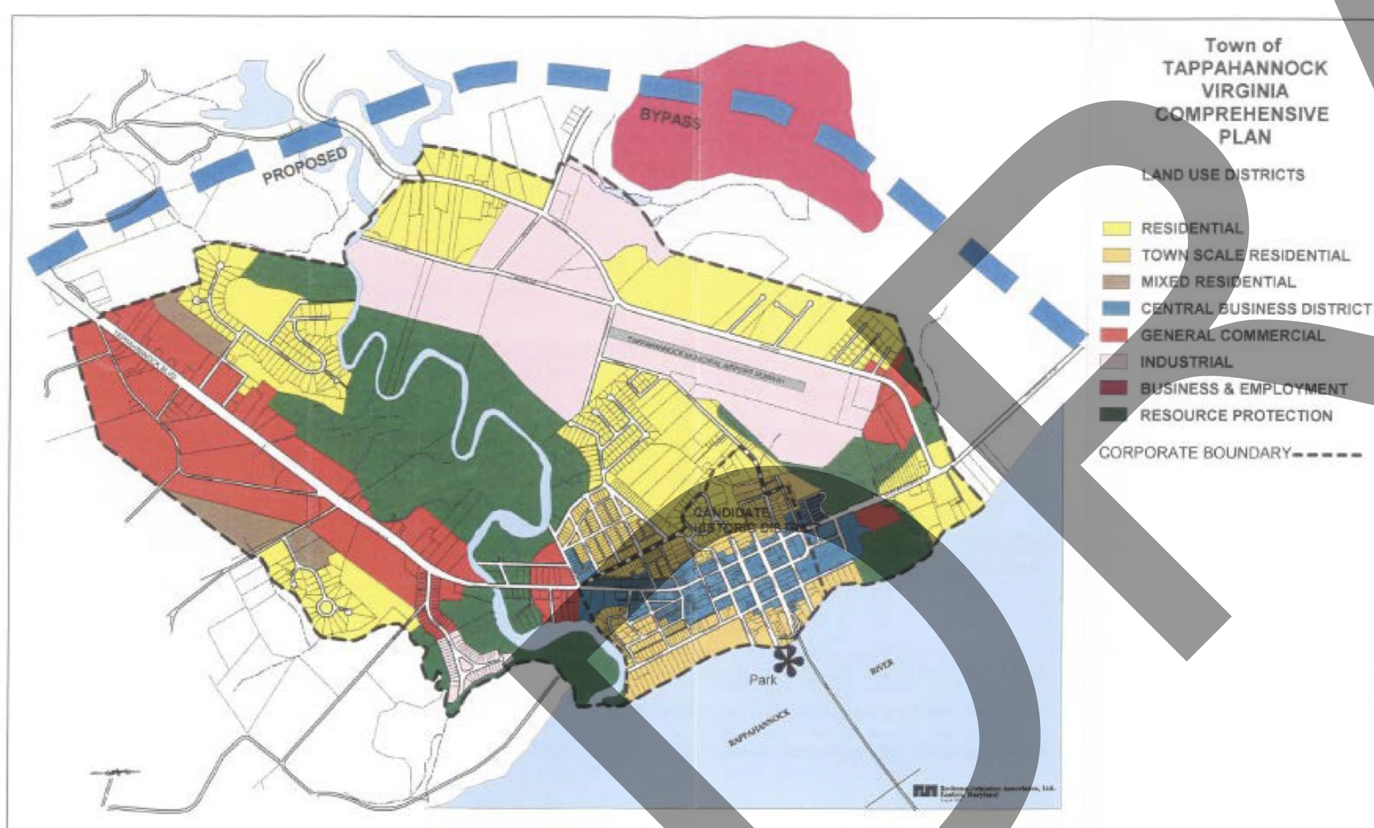
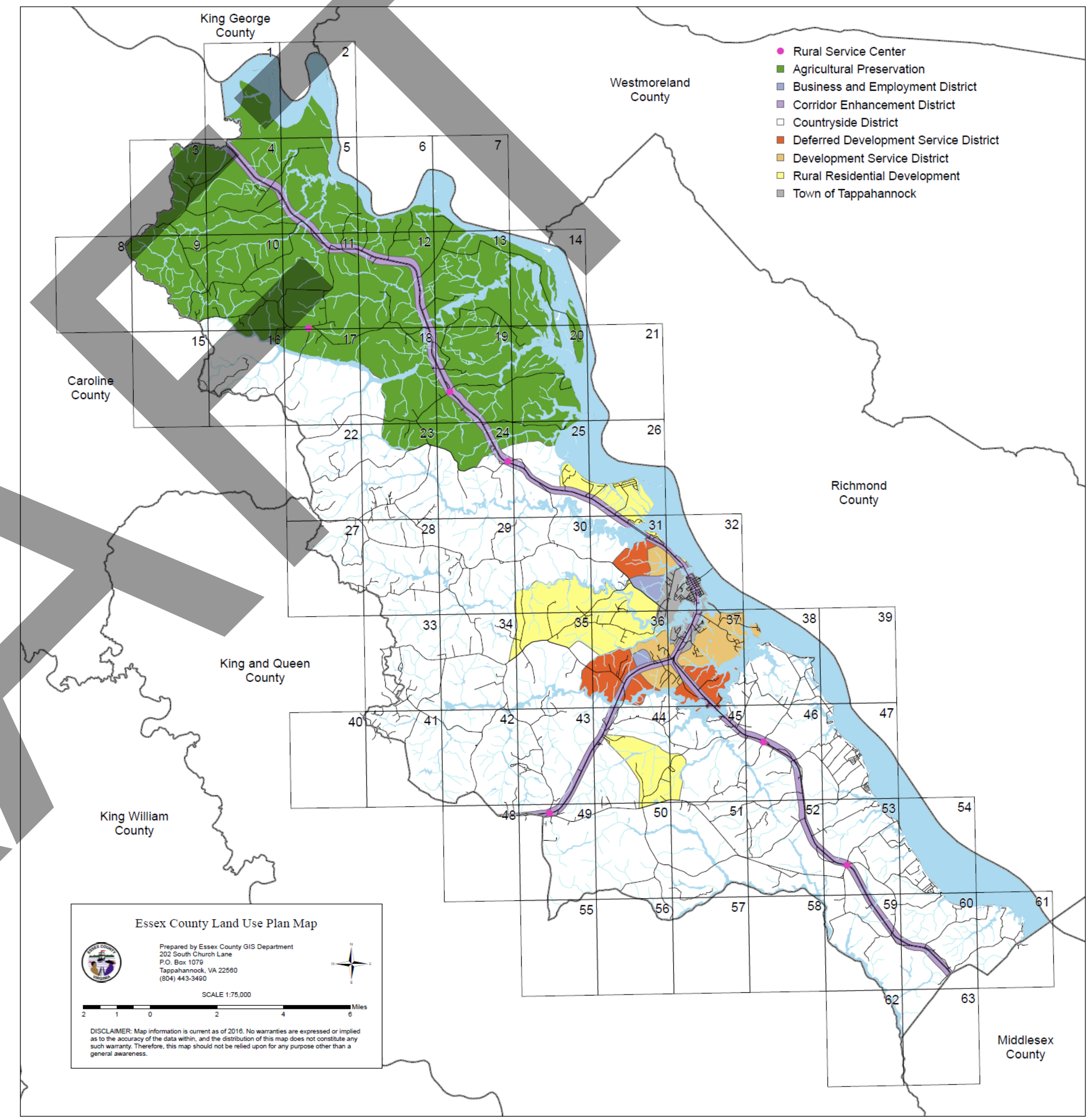


Figure 3: Essex County Land Use Plan Map



The Essex County land use plan map designates the areas immediately surrounding the Town of Tappahannock as Development Service Districts where new population, commercial, and industrial growth can most cost effectively be supported, however, expansion of higher density development into these areas is not expected until the residential development within the Town reaches the capacity outlined in the 2005 Tappahannock Buildout Plan.

Two areas surrounding the Town of Tappahannock are designated as Business and Employment Districts – the area near the former airport complex, and the area just west of the Lagrange Industrial Park development service district in Brays Fork. These specific areas are reserved for future business and employment park development.

The Essex County Land Use Plan also designates the areas within 500 feet of US 17 and US 360 as Highway Corridor Enhancement Districts. The purpose of these districts is "to protect and improve the quality of visual appearances along these linear corridors and to provide guidelines to ensure that buffering, landscaping, lighting, signage, and proposed structures are internally consistent and of a quality which contributes to County character." The Highway Corridor Enhancement District is also intended to be a zoning overlay with special access, buffering, signage, and setback requirements, as well as special consideration for the visual impact of development. However, the County's zoning map and zoning ordinance do not establish an overlay district for this purpose.

"Expand and enhance the US 17 Commercial District in the Town" is the first objective in the Land Use chapter of the Town's Comprehensive Plan. Other relevant objectives include:

- Developing and promoting downtown Tappahannock as a historic area
- Expanding residential further to the west and east of the Route 360/17 business corridor
- Protecting residential neighborhoods from encroachment by commercial and industrial activities and through traffic

Reducing through traffic on US 17/360 by creating alternate routes around the central business district, including a new truck bypass is a main focus of the Transportation Chapter of the Town's Comprehensive Plan.

2.2 Regional Long Range Transportation Plan

The Middle Peninsula PDC's current Regional Long-Range Transportation Plan (RLRTP) was adopted in June 2020. It outlines recommendations for intersections and roadway segments in each county. Recommendations in Essex County consist primarily of improvements at priority intersections, some of which align with the locations of focus for this US 17/360 Corridor Study, including (listed below from north to south) among others:

- US 17 at Marsh Street – Install turn lanes as needed to increase safety and capacity.
- US 17/360 at Duke Street – Recommendations for this intersection are the same as those listed in Intersection Safety Review of this intersection, as noted in ***Section 4.2.2*** of this report.
- US 17/360 at Ball Street – Explore possible solutions to safety concerns through a study of this commercial corridor.

The RLRTP recommendations also include construction of a roughly 3-mile long "Tappahannock Bypass" from the intersection of US 17 and US 360 south of Tappahannock to US 17 north of Tappahannock to allow vehicles using US 17 as a long-distance connecting route to bypass the congestion and intersections of concern within the Town of Tappahannock and decrease stress on the current US 17 segment through Tappahannock.

In addition to the recommendations, the RLRTP acknowledges that a majority of the economic opportunities in Essex County are located along US 17, along US 360, and in the Town of Tappahannock. It also acknowledges that the implementation cost of VDOT's access management standards is a significant obstacle preventing the economic development opportunities along these major roadways from coming to fruition.

2.3 Arterial Preservation

Both US 17 and US 360 are part of VDOT's Arterial Preservation Network – transportation highways for long-distance mobility of people and goods throughout Virginia that are critical to the current and future economy. VDOT's Arterial Preservation Program seeks to preserve and enhance the safety and capacity of these critical transportation highways through a variety of strategies including preparing Arterial Management Plans.

2.4 Intersection Safety Review of US 17/360 (Church Lane) at Duke Street

In 2019, VDOT conducted a safety evaluation of the unsignalized intersection of US 17/360 at Duke Street. The evaluation found that nine of the 16 crashes in the three-year period examined were caused by vehicles on Duke Street turning left or going straight across and failing to yield the right of way to oncoming traffic on US 17/360. Three additional crashes were caused by vehicles from nearby commercial entrances making similar maneuvers.

While the evaluation found that sight distances in both the eastbound and westbound directions are adequate and exceed the required stopping sight distance, the sight distance is often blocked by through traffic on US 17/360.

The evaluation suggested the following recommendations:

- Install a stop bar on both approaches of Duke Street to provide a visual stopping point for motorists on Duke Street.
- Eliminate left turns from Duke Street, such as by installing "No Left Turn" signs on both approaches.
- Eliminate crossing and left turn maneuvers by constructing a median along US 17/360, however, the evaluation acknowledged this may not be feasible due to limited lane widths and physical constraints.
- Close, consolidate, and/or relocate commercial entrances at the intersection, or restrict turning maneuvers at entrances to right-in/right-out movements.

As of the April 2021 field visit, none of the recommendations from the safety evaluation had been implemented.

2.5 Proposed Bicycle Routes

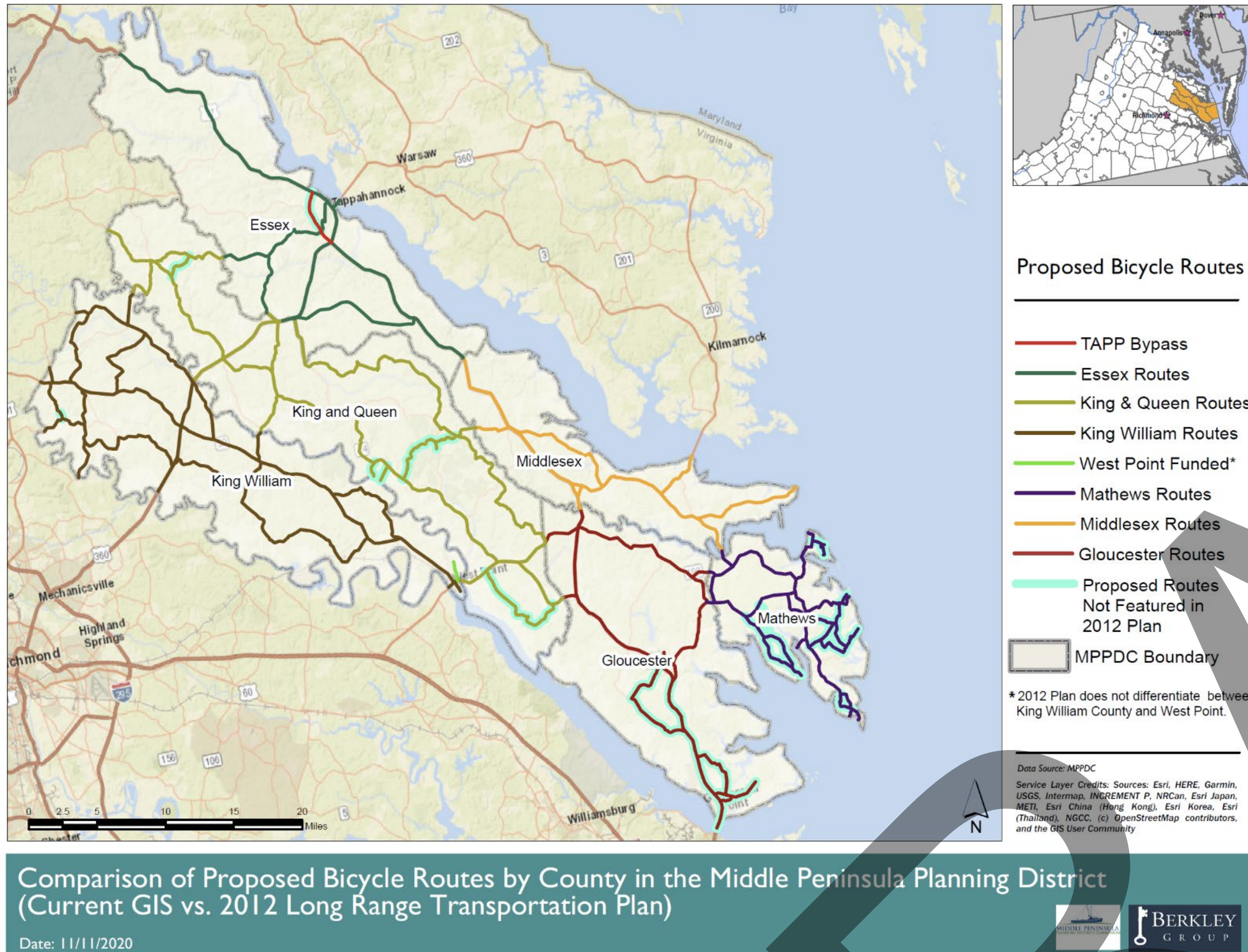
The Middle Peninsula PDC identified several proposed bicycle routes through the Middle Peninsula Regional Bike Plan, which was developed in 2004. **Figure 4** shows the proposed bicycle routes in the MPPDC area.

Proposed bicycle routes in the US 17/360 study corridor include:

- US 17
- US 360
- Airport Road

The map in **Figure 4** also shows a bypass.

FIGURE 4: PROPOSED BICYCLE ROUTES IN THE MIDDLE PENINSULA PLANNING DISTRICT



3 Data Collection and Inventory

The study team collected traffic volume data from a combination of peak hour intersection turning movement counts and 48-hour tube counts in March 2021 as well as turning movement counts from prior efforts that were collected in May 2017. The study team also collected historical traffic volume information, crash data, existing traffic signal timing plans, plans of future roadway improvement projects from VDOT and bus stop passenger counts from Bay Transit. The study team acquired GIS shapefiles of zoning districts, tax parcels, streams, wetlands, water bodies, and other information from the Essex County GIS department.

The study team conducted a field review on April 13-14, 2021 to gather additional geometric and operational data, observe traffic patterns, and identify areas with potential operational or safety issues.

The following sections summarize the collected data. Observations from the field review are presented with the discussion of safety deficiencies later in ***Section 4.2***. ***Section 3.2.3*** describes the methods the study team used to calibrate existing traffic volume data to reflect pre-pandemic conditions.

3.1 Existing Roadway Geometry

The horizontal and vertical alignment of US 17 and US 360 is generally straight and flat throughout the study corridor limits. One horizontal curve, just south of the bridge over Hoskins Creek is signed with a warning sign. The largest vertical curve in the study corridor is along US 360 west of Brays Fork between Hospital Drive and Lagrange Industrial Drive, where there is a hill. Other than these two curves, the terrain is generally flat, and the alignment of the study corridor is relatively straight.

Figure 5 shows the existing lane configurations, storage lengths for left- and right-turn storage bays and posted speed limits for the 25 at-grade intersections within the study area. The study team assumed a 25 mile per hour speed limit for roads without a posted speed limit.

The roadway width in the section of US 17 in the historic downtown district between Marsh Street and Wright Street is quite narrow. The study team measured nine-foot lane widths, not including the width of the gutter pans. There is no buffer between the back of curb and the sidewalk, which is 5-feet wide. Utility poles are placed in the sidewalk, reducing the effective width of the sidewalk to 2 to 3 feet. Buildings in this section are sometimes located right against the back of sidewalk. Overall, the roadway width in this section is very constrained.

3.2 Traffic Volume Data

The study team collected historical traffic volumes through Year 2019 (latest available at time of data collection) from VDOT's traffic data. The project team collected 48-hour tube counts at four locations as well as intersection turning movement counts at intersections within the study area, as shown in **Figure 6**. This data was collected March 30, 2021 through April 1, 2021 and is reported in 15-minute increments. **Appendix A** contains the traffic count data.

Because the 2021 traffic data was collected during the COVID-19 pandemic, the study team compared the collected traffic data with other existing turning movement counts and information from VDOT's COVID-19 Traffic Trend Tool. The calibration of traffic data is further explained in ***Section 3.2.3.***

3.2.1 Daily Traffic Volumes

Figure 7 shows the 2019 average annual daily traffic (AADT) volumes (vehicles per day) from VDOT's traffic data. The segment of US 17 that runs concurrent with US 360 through the Town of Tappahannock serves an average of 23,000 vehicles per day. This is the highest volume road segment in Essex County. Other notable daily traffic volumes include:

- 14,000 vehicles per day on US 360 (Queen Street) east of US 17 across the Downing Bridge over the Rappahannock River into Richmond County.
- 9,900 vehicles per day on US 360 (Richmond Highway) west of the US 17/360 interchange at Brays Fork.
- 7,500 vehicles per day on US 17 (Tidewater Trail) south of the US 17/360 interchange at Brays Fork.
- 7,400 vehicles per day on US 17 (Church Lane) north of US 360 (Queen Street).

Figure 8 shows the 24-hour daily traffic collected in March 2021 at the four tube count locations. The daily traffic shown in **Figure 8** is an average of the 48-hour raw counts. The daily traffic volumes from March 2021 are generally consistent with the 2019 VDOT AADTs.

- The location north of Winston Road had the highest average daily traffic counts, at 23,550 vehicles per day.
- The location between Hoskins Creek and Richmond Beach Road was slightly lower at 22,900 vehicles per day.
- Daily volumes drop slightly to 19,660 vehicles per day between White Oak Drive and the US 17/360 interchange at Brays Fork.
- To the north, daily volumes between Parker Place and the Elementary School drop to 10,180 vehicles per day, slightly higher than the 2019 AADT volumes from VDOT's annual traffic data.

3.2.2 Peak Hour Determination

Intersection turning movement counts from May 2017 were available at eight of the nine signalized intersections within the study corridor limits:

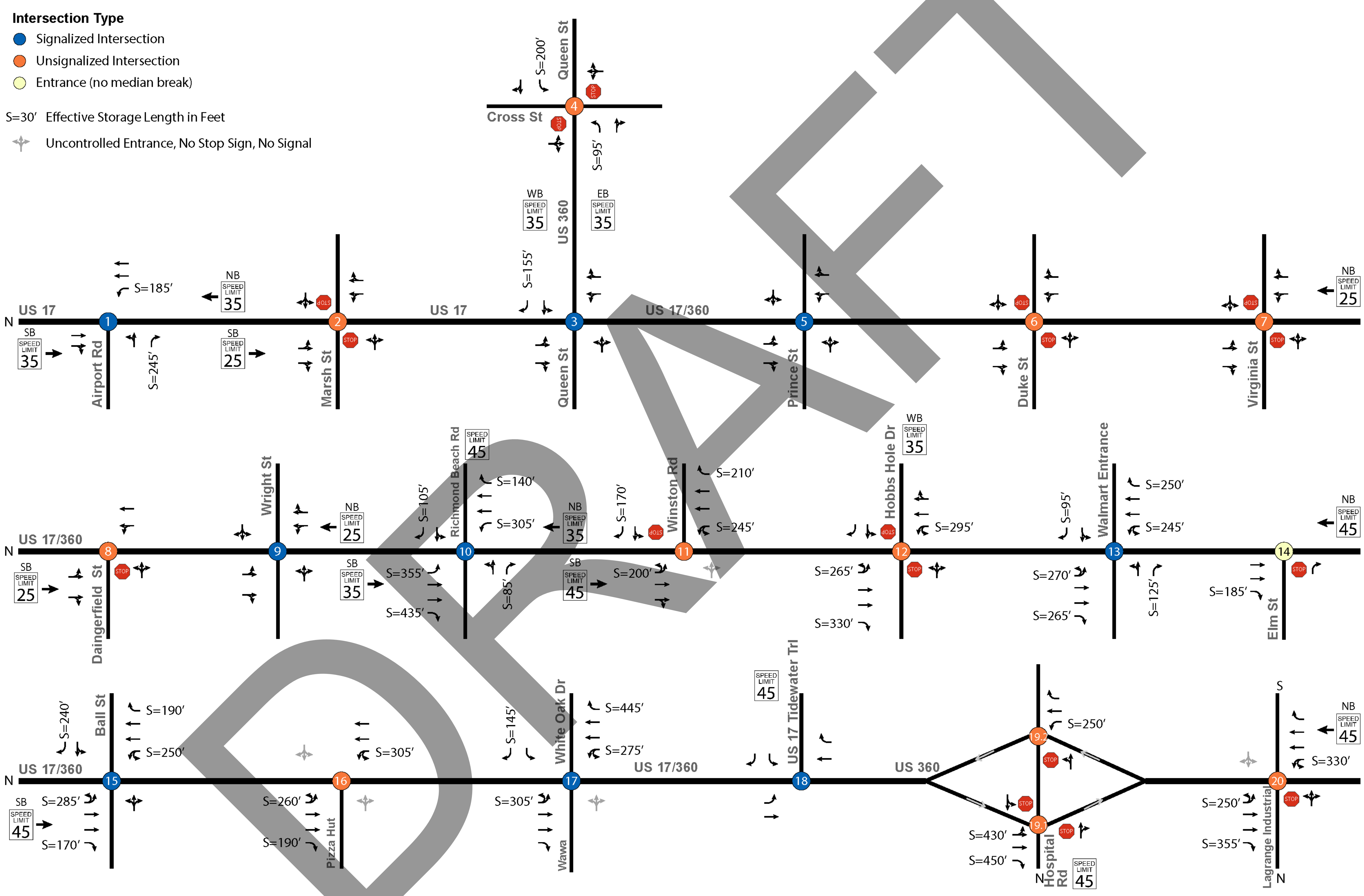
- US 17 (Church Lane) at US 360 (Queen Street)
- US 17/360 (Church Lane) at Prince Street
- US 17/360 (Church Lane) at Wright Street
- US 17/360 (Tappahannock Blvd) at Richmond Beach Road
- US 17/360 (Tappahannock Blvd) at Walmart entrance
- US 17/360 (Tappahannock Blvd) at Ball Street
- US 17/360 (Tappahannock Blvd) at White Oak Drive
- US 17/360 interchange at Brays Fork

The turning movement counts at these intersections from May 2017 included 15-minute count data from 7:00 AM to 7:00 PM. The study team examined the data from these 15-minute counts as well as the 15-minute count data from the 48-hour tube counts and the intersection turning movement counts collected in March 2021.

The study team identified 7:30 AM to 8:30 AM as the AM peak hour and 4:30 PM to 5:30 PM as the PM peak hour. Peak hour determination tables are provided in **Appendix B.** The intersection turning movement counts from both May 2017 and March 2021 indicated these hours as the AM and PM peak hours.

The tube counts collected in March 2021 showed a slightly different AM peak hour of 7:45 AM to 8:45 AM. This difference is due to several factors. Some of the intersections in the southern section showed a slightly later peaking in the AM than the intersections in the northern section. Also, as explained in the next section, the AM traffic patterns during the pandemic changed more dramatically than in the PM. Traffic volumes in the AM peak period during the pandemic are generally lower than in pre-pandemic conditions. For these reasons, the study team selected the pre-pandemic AM peak hour of 7:30 AM to 8:30 AM for the AM peak hour analysis for this study, which is also consistent with the March 2021 intersection turning movement counts.

Figure 5: Existing Lane Configurations



STARS
VDOT

FIGURE 6: TRAFFIC DATA COLLECTION LOCATIONS

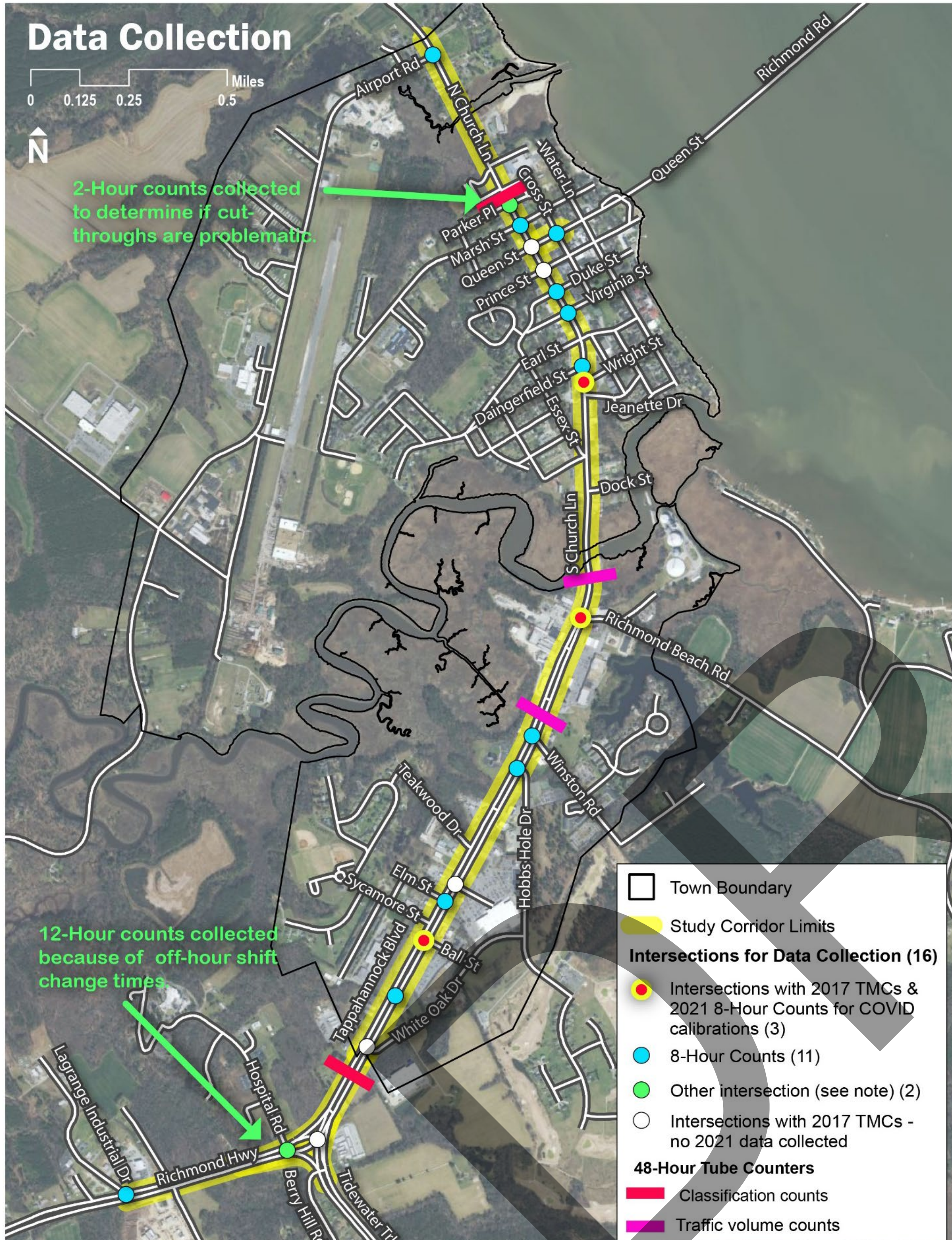


FIGURE 7: 2019 BIDIRECTIONAL AVERAGE ANNUAL DAILY TRAFFIC VOLUMES FROM VDOT TRAFFIC DATA

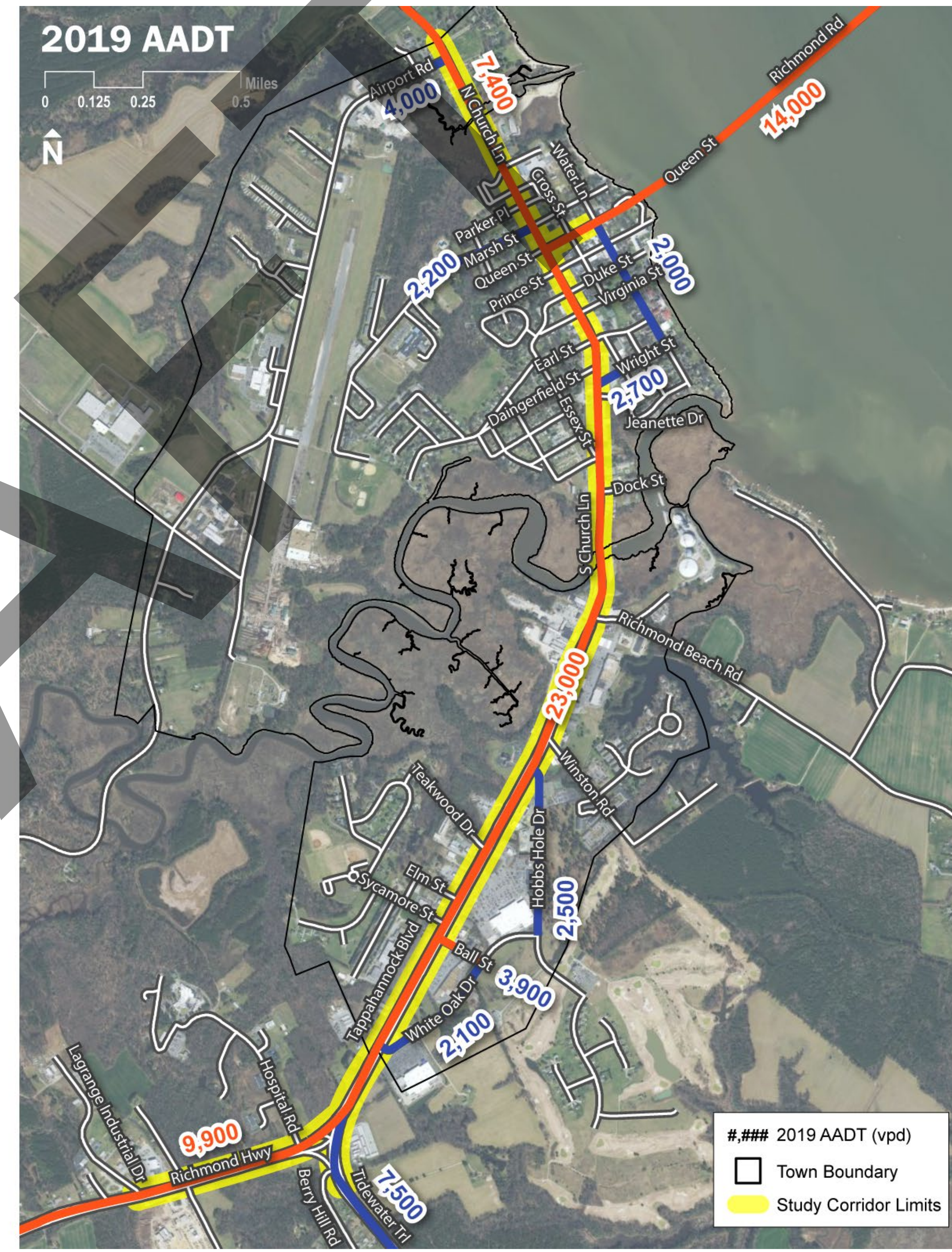
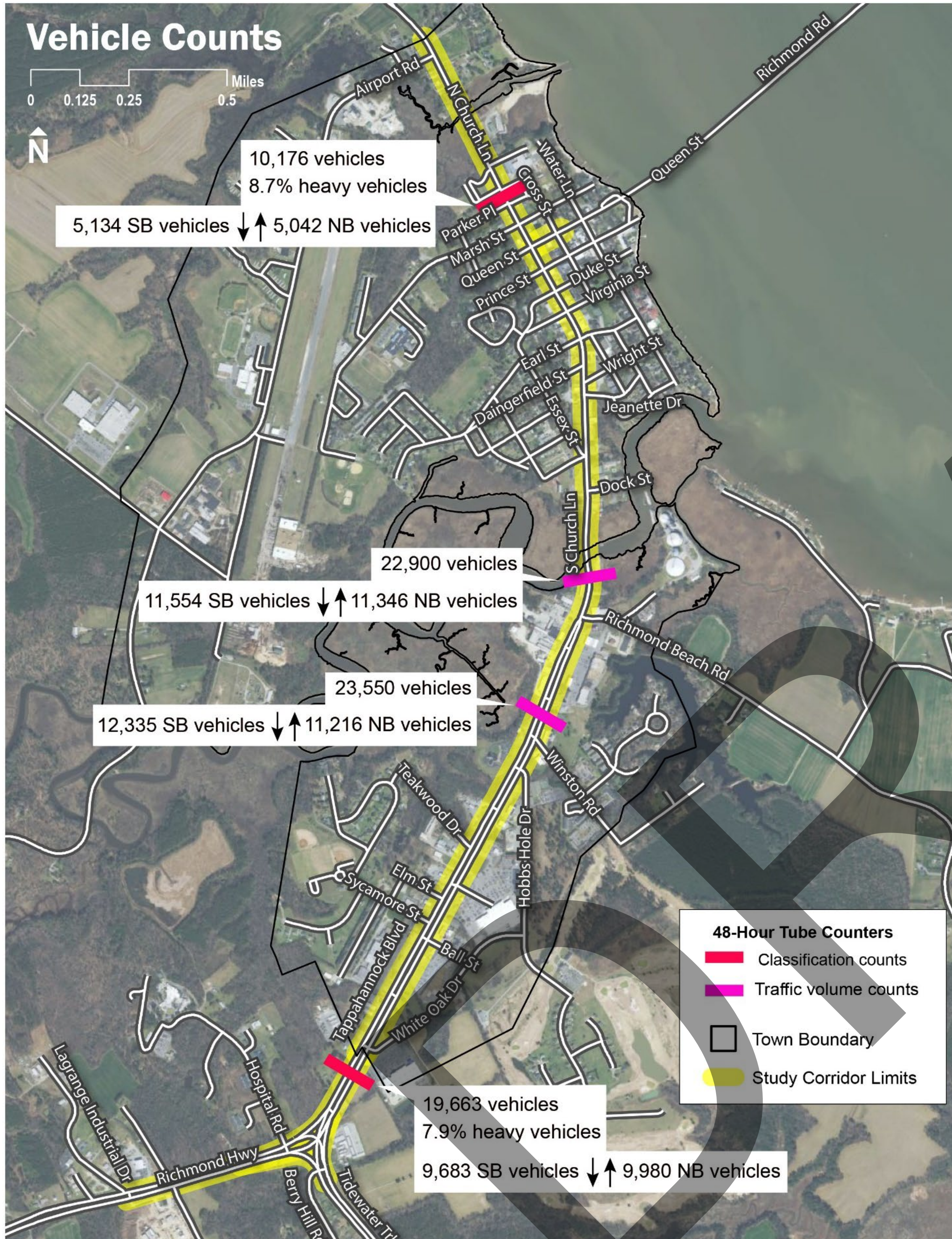


FIGURE 8: 24-HOUR DAILY TRAFFIC VOLUME COUNTS – 2-DAY AVERAGE COLLECTED MARCH 30-31, 2021



3.2.3 Traffic Volume Calibration

The study team examined all available traffic data to develop a set of network-wide turning movement volumes for the existing (year 2021) conditions analysis that reflected pre-pandemic traffic patterns. Data examined included:

- May 2017 intersection turning movement counts, available at eight intersections within the study corridor.
- March 2021 intersection turning movement counts, collected at all intersections not included in the May 2017 counts, as shown in **Figure 6**, as well as three intersections that had May 2017 counts for closer comparison.
- March 2021 48-hour tube counts, collected at four locations, as shown in **Figure 6**.
- Traffic volume data from VDOT's COVID-19 Traffic Trend Tool, including historical volumes showing variation by day of week and by month of year, for the segment of US 17 north of US 360 (Queen Street).
- VDOT historical traffic volume data to determine a future growth rate, which is further explained in ***Section 5.1.***

The comparison of May 2017 and March 2021 turning movement counts at the three intersections where both sets of counts are available reveals that AM peak hour volumes dropped by 9 to 16 percent. PM peak hour volumes changed by less than five percent at all three intersections. These changes are similar to changes in traffic patterns in other areas within the VDOT Fredericksburg District.

There is a natural fluctuation in traffic volumes that can occur on any given day. For example, the 24-hour traffic volumes collected over 48 hours by tube counts in March 2021 varied between 2 and 7 percent from the first 24 hours to the second. Historical traffic data from VDOT's COVID-19 Traffic Trend Tool incorporates factors for different days of the week and months of the year. The difference in daily traffic volumes between a typical Tuesday in March and a typical Thursday in May can vary from 16 to 33 percent. The daily traffic volumes collected during March 2021 were within 10 percent of daily historical traffic volumes.

The study team developed a set of existing intersection turning movement volumes that reflect pre-pandemic traffic patterns through the following methodology:

1. The study team grew the US 17 and US 360 mainline volumes at the eight intersections where 2017 turning movement counts were available by an agreed-upon 0.5 percent and 1.0 percent per year growth rates. These growth rates will be further discussed in ***Section 5.1.***
2. The study team adjusted the 2021 AM and PM peak hour turning movement counts for the remaining 12 intersections to balance with the 2017 volumes that were increased in Step 1.

More details on the traffic data comparison that informed the calibration of existing volumes is available in **Appendix C.**

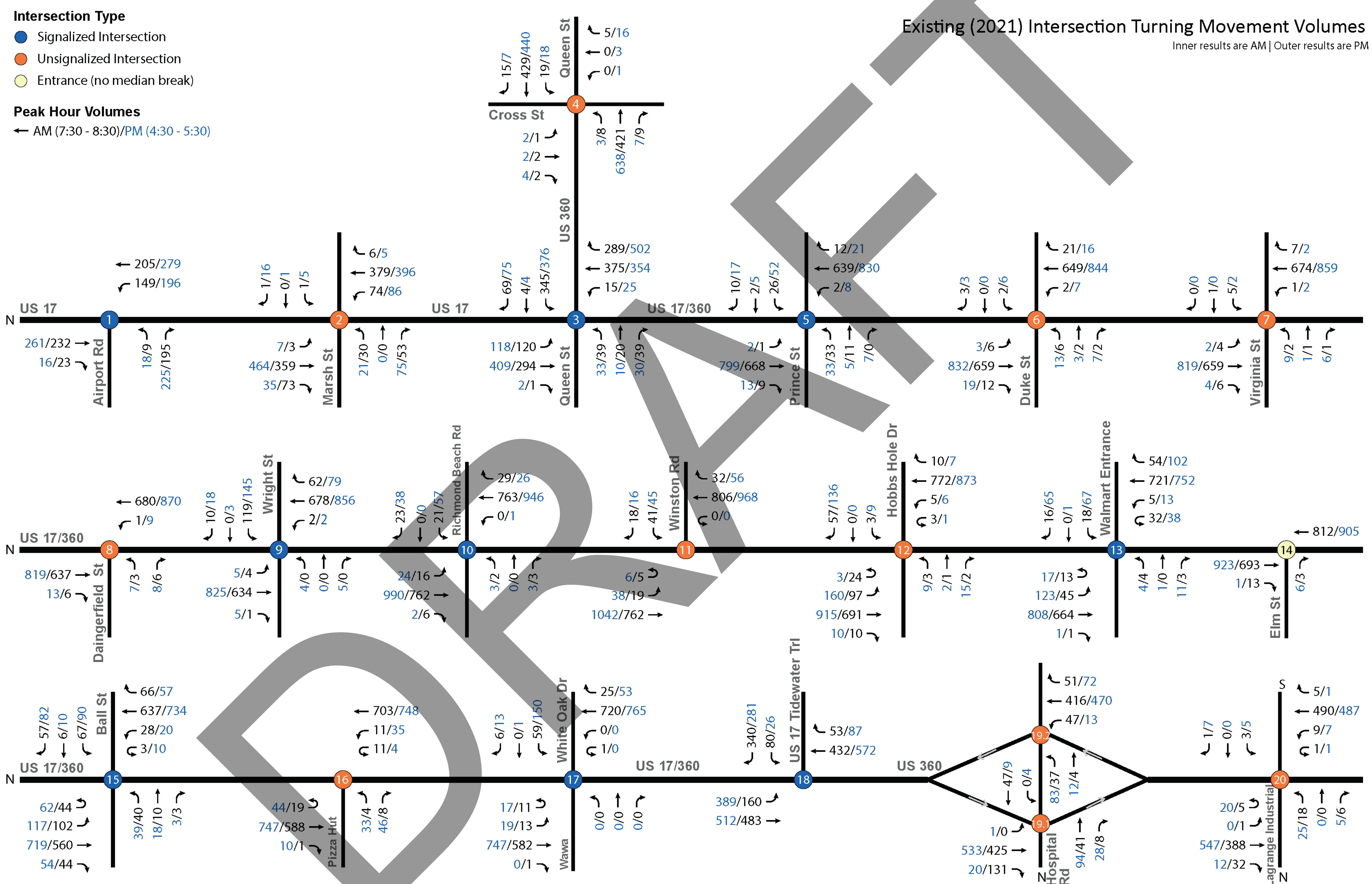
3.2.4 Heavy Vehicle Percentages and Peak Hour Factors

The study team calculated heavy vehicle percentages for each movement and intersection-wide peak hour factors at all study intersections during the AM and PM peak hours based on raw traffic data. These calculations were based on 2017 data, where available, and 2021 data at intersections where 2017 data was not available.

3.2.5 Traffic Volume Balancing

The study team examined the differences in turning movement volumes between intersections and balanced the volumes to reflect reasonable differences based on the number of driveways and adjacent land uses. **Figure 9** presents the balanced 2021 AM and PM peak hour turning movement volumes at all 20 intersections within the study corridor limits.

FIGURE 9: EXISTING (2021) INTERSECTION TURNING MOVEMENT VOLUMES



3.3 Crash Data

The study team collected crash data for the study corridor limits from VDOT's Crash Analysis Tool. At the time of the data download (March 29, 2021), the most recent five years of crash data available were from December 1, 2015 through November 30, 2020. Crash maps showing the location, crash type, and crash severity along the entire study corridor are provided in **Appendix D.**

The study team collected FR-300 reports for the crashes within the five year period at seven intersections:

- US 17 (Church Lane) at Marsh Street – location of a fatal crash in 2014
- US 17 (Church Lane) at US 360 (Queen Street) – location with potential for safety improvement (PSI)[1]
- US 360 (Queen Street) at Cross Street – location with PSI
- US 17/360 (Church Lane) at Duke Street - location with PSI
- US 17/360 (Church Lane) at Virginia Street – location of a fatal pedestrian crash in 2014
- US 17/360 (Tappahannock Blvd) at Winston Road - location with PSI
- US 17/360 (Tappahannock Blvd) at Ball Street - location with PSI

A closer examination of the crashes at each intersection and for the corridor overall is documented in ***Section 4.2.***

3.4 Pedestrians and Bicyclists

According to VDOT's statewide Policy for Integrating Bicycle and Pedestrian Accommodations adopted in 2004, VDOT is required to presume that all road projects will accommodate bicycling and walking. If a project will not include bicycle and pedestrian accommodations, there must be sufficient documentation and justification.

The study team observed some pedestrian and bicyclist activity during a preliminary site visit in March 2021 and during the formal field visit in April 2021. Most activity consisted of pedestrians walking along US 17/360 between Wright Street and Queen Street. In addition, one pedestrian was observed walking in the right turn lane for the entrance to the Food Lion shopping center along US 17/360 south of Ball Street, and another was observed walking along the bridge over Hoskins Creek. The crash history at Ball Street includes a crash where a driver hit a pedestrian trying to cross the street. The study work group noted there are occasional instances of pedestrians crossing the street at the Ball Street intersection.

The study team also observed three instances of people riding bicycles on the sidewalk adjacent to US 17/360 during the preliminary and formal field visits.

Five-foot wide sidewalks are provided along both sides of US 17/360 between Queen Street and Richmond Beach Road, including across the bridge over Hoskins Creek. However, commercial entrances frequently disrupt the sidewalks, and utility poles restrict the sidewalk width. Buffers between the back of curb and edge of sidewalk are limited to two feet in width, and there is no buffer between the back of curb and edge of sidewalk between Queen Street and Virginia Street.

Marked pedestrian crossings within the study corridor are limited to the following locations.

- The intersection of US 17/360 (Church Lane) at Wright Street has marked crosswalks and actuated pedestrian signals across two of the intersection approaches, including one crosswalk across US 17/360.
- The intersection of US 17/360 (Church Lane) at Prince Street has marked crosswalks and pedestrian signals. The pedestrian signals across US 17/360 are actuated. The pedestrian signals across Prince Street are automated.
- There is a midblock crosswalk across US 17 (Church Lane) between Marsh Street and Parker Place in front of the Essex County Public Library with a rectangular rapid flashing beacon.
- There is a midblock crosswalk across US 360 (Queen Street) between US 17 (Church Lane) and Cross Street in front of the Northern Neck Burger restaurant.

The northbound approach of the intersection of US 17/360 and Queen Street has a marked but faded crosswalk, and there is no pedestrian signal accompanying this crosswalk. The signal phasing at this intersection does not provide a phase for safe pedestrian crossing.

There are no pedestrian facilities south of Richmond Beach Road. There are no bicycle facilities along the entire study corridor limits.

The following photographs show instances of pedestrian and bicyclist activity as observed during the March 2021 preliminary field visit and the formal April 2021 field visit.

The five-foot wide sidewalk is located immediately behind the back of curb with no buffer. Utility poles frequently reduce the through width. Buildings are located within a few feet of the back of sidewalk.

A pedestrian walks in the right turn lane along US 17/360 in front of the White Oak Shopping Center.

A pedestrian crosses US 17 (Church Lane) north of Queen Street.

A bicyclist rides on the sidewalk going south on US 17/360 towards Dock Street.

[1] Potential for safety improvement is further described in **Section 4.2: Crash Analysis and Identified Deficiencies.**

3.5 Public Transportation

Bay Transit operates "The Rivah Ride" – a deviated fixed-route service in the Town of Tappahannock. The route runs every hour on a set schedule, but with an advanced reservation, the bus can deviate up to 0.75 miles off of the route. **Figure 10** shows the stop locations of the Rivah Ride route, which are located off of the US 17/360 corridor, primarily at store entrances and other front door locations. **Table 1** shows annual ridership data by stop for October 1, 2018 through September 30, 2019. This data was provided by Bay Transit.

Typical hours of operation are Monday through Friday from 9:00 AM to 2:00 PM, but during the COVID-19 pandemic have been extended to 7:00 AM to 3:00 PM with funding from the CARES Act. The extended hours will run through the end of the Federal 2021 Fiscal Year.

FIGURE 10: THE RIVAH RIDE BUS STOP LOCATIONS

TABLE 1: ANNUAL RIDERSHIP FOR BAY TRANSIT'S THE RIVAH RIDE DEVIATED FIXED ROUTE SERVICE

Bus Stop	10/1/2018 – 9/30/2019	
	Pick-Ups	Drop-Offs
1: Essex Co. School Board Office	113	76
2: Essex Trailer Park	323	256
3: Fox Chase Apartments	451	365
4: Derbyshire & Tanyard Apts.	120	45
5: Essex Square Shopping Center	140	278
6: Riverside Tappahannock Emergency Room	30	25
7: White Oak Shopping Center	128	176
8: Walmart	546	452
9: 900 Winston Road	244	244
10: Tappahannock Towne Center	79	74
11: Rappahannock Office Building	39	44
12: Post Office	77	53
13: Corner of Prince & Cross Street	100	41
Other stops	69	131
Total	**2,459**	**2,260**

4 Existing Conditions Analysis

Three types of analysis were conducted to assess the existing conditions of the US 17/360 corridor:

1. Peak Hour Traffic Operations Analysis: identifies locations where peak hour congestion is occurring and serves as a baseline for conducting an analysis of future conditions.
2. Crash Analysis: examines locations with potential for safety improvements, fatal crashes, or pedestrian or bicycle crashes, and identifies possible causal factors.
3. Access Spacing Analysis: identifies locations where the spacing of intersections, median openings, and commercial entrances do not meet VDOT's access spacing standards.

The results of the analyses reveal that safety issues are currently more pressing than congestion issues. The access spacing deficiencies may be one of several contributing factors to the safety issues.

The intersection of Queen Street at US 17 (Church Lane) is one of the most critical locations for both safety and congestion. Aside from this intersection, most of the US 17/360 corridor does not experience significant congestion (i.e. none of the other intersections operate at LOS E or D overall) during the peak hours. Crash clusters, including crashes resulting in injuries occur at various locations throughout the corridor.

The following sections describe the peak hour traffic operations, crash, and access spacing analyses and results in more detail.

4.1 Peak Hour Traffic Operations Analysis

The study team analyzed traffic operations during the AM and PM peak hours to understand where congestion is currently occurring and identify locations where demand is close to exceeding capacity. This analysis provides a baseline for conducting the analysis of future conditions. The operations analysis was conducted using Synchro Version 10, and in some instances SimTraffic, depending on the queue length as described below.

4.1.1 Measures of Effectiveness

The traffic operations analysis produced two measures of effectiveness for evaluating operating conditions in the peak hours:

1. Control Delay: the delay drivers experience at a traffic control device (e.g. traffic signal or stop sign) – reported for each individual turning or through movement and for each intersection overall.
2. Queue Lengths: the length of the queue for each turning or through movement.

Control Delay is an output from Synchro using the HCM 2000 reports, since the HCM 2010 methodology cannot report results for non NEMA phasing and U-turns.

The reported queue lengths are the 95th percentile queue lengths from the Synchro analysis. In some instances, the 95th percentile queue length extended to the upstream intersection. In these instances, the study team ran the operations analysis in SimTraffic for a grouping of intersections and report the maximum queue lengths from the SimTraffic runs. All outputs from Synchro and SimTraffic are provided in **Appendix E.**

Figures 11 and **12** provide the results of the analysis of existing peak hour traffic conditions. **Figure 11** shows the average control delays (in seconds per vehicle). The delays correspond to levels of service, represented with letter grades A through F, as further explained in the following section. **Figure 12** provides the queue lengths (in feet) for each intersection movement and indicates movements where the queue length extends to the upstream intersection or where the queue exceeds the effective (full-width plus half of the taper[2]) storage bay lengths.

4.1.2 Level of Service Criteria

Level of Service (LOS) is a concept that describes how well a transportation facility operates from the traveler's perspective. The *Highway Capacity Manual 6th Edition* defines six levels of service, ranging from A to F. LOS A represents the best operating conditions from the traveler's perspective, and LOS F the worst. For cost, environmental impact, and other reasons, roadways are typically designed not to provide LOS A conditions during peak periods, but instead to provide some lower LOS that balances individual travelers' desires against society's desires and financial resources.[3]

Control delay is the service measure that defines LOS for motorized vehicles at intersections. **Table 2** lists the LOS thresholds for motorized vehicles at signalized and unsignalized intersections.

Table 2: Level of Service Criteria for Signalized and Unsignalized Intersections

LOS	Control Delay (seconds per vehicle) at **Signalized Intersections**	Control Delay (seconds per vehicle) at **Unsignalized Intersections**
A	≤ 10	≤ 10
B	> 10 – 20	> 10 – 15
C	> 20 – 35	> 15 – 25
D	> 35 – 55	> 25 – 35
E	> 55 – 80	> 35 – 50
F*	> 80	> 50

*If the volume-to-capacity ratio is greater than 1.0, the LOS is F, even if delay is less than 80 seconds at signalized intersections or 50 seconds at unsignalized intersections.

4.1.3 Traffic Operations Analysis Results

4.1.3.1 Control Delay and Level of Service Results

The control delay and level of service results, shown in **Figure 11** indicate that all intersections are operating at overall LOS C or better in both AM and PM peak hours, with one exception. The intersection of US 17 (Church Lane) at US 360 (Queen Street) operates at LOS C in the AM peak hour and LOS D in the PM peak hour. The results indicate the overall average delay at this intersection is 39 seconds in the PM peak hour. Based on the field visit, this is the most congested intersection in the study corridor. The congestion and safety issues stemming from this intersection are discussed in more detail in later sections. The three-phase signal phasing keeps delays low, but as discussed in later sections, is not ideal from a crash standpoint. Only the southbound approach has a dedicated left turn arrow, and permissive left turns may be a causal factor to some of the crashes at this intersection.

[2] Existing and effective storage lengths on commercial entrances are equal (i.e. taper lengths on these types of approaches were assumed to be zero).

[3] Transportation Research Board, 2016. *Highway Capacity Manual, 6th Edition: A Guide for Multimodal Mobility Analysis*. Washington, D.C.

FIGURE 11: 2021 EXISTING PEAK HOUR TRAFFIC OPERATING CONDITIONS – CONTROL DELAYS (SECONDS PER VEHICLE) AND LEVELS OF SERVICE

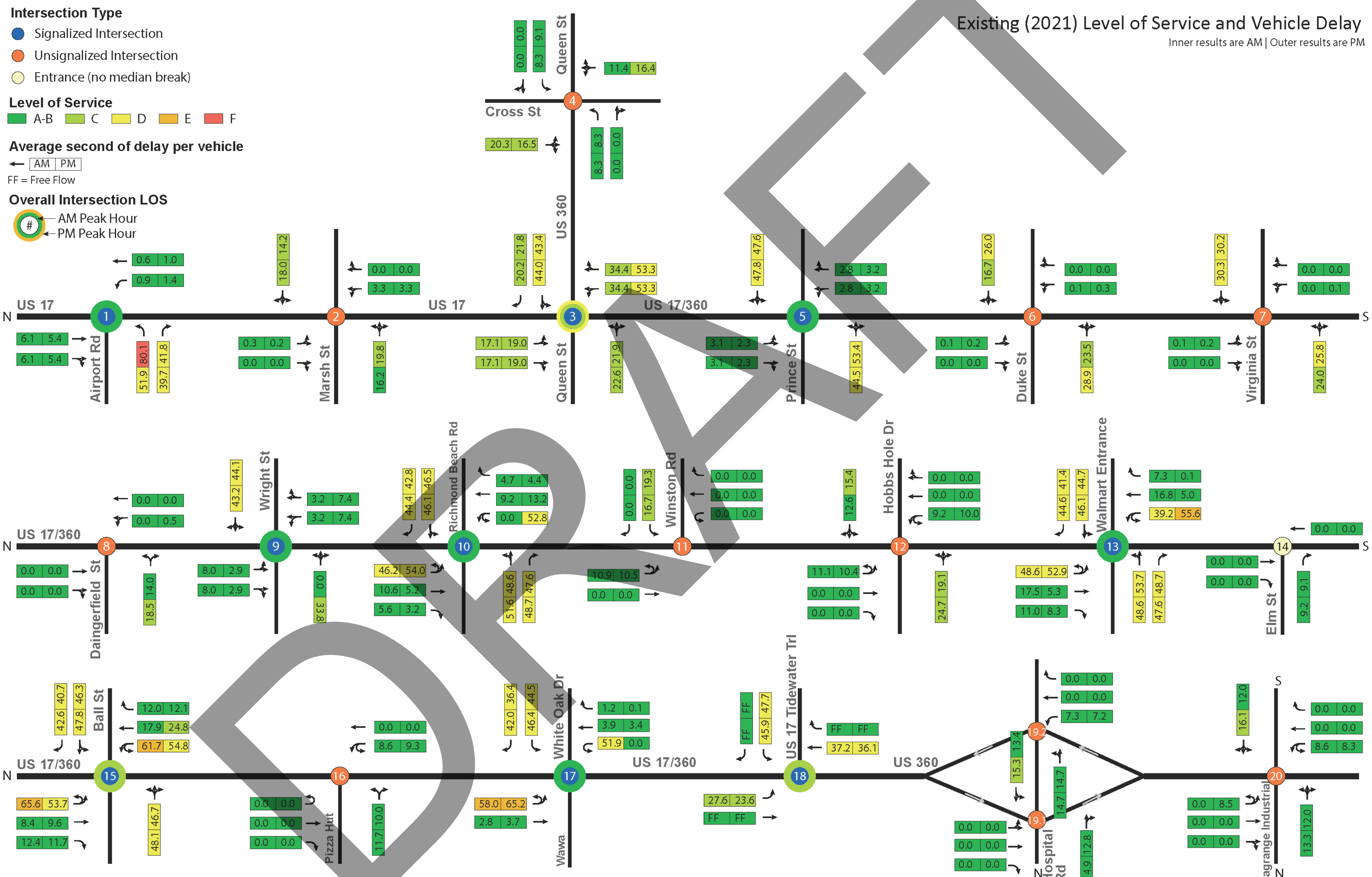
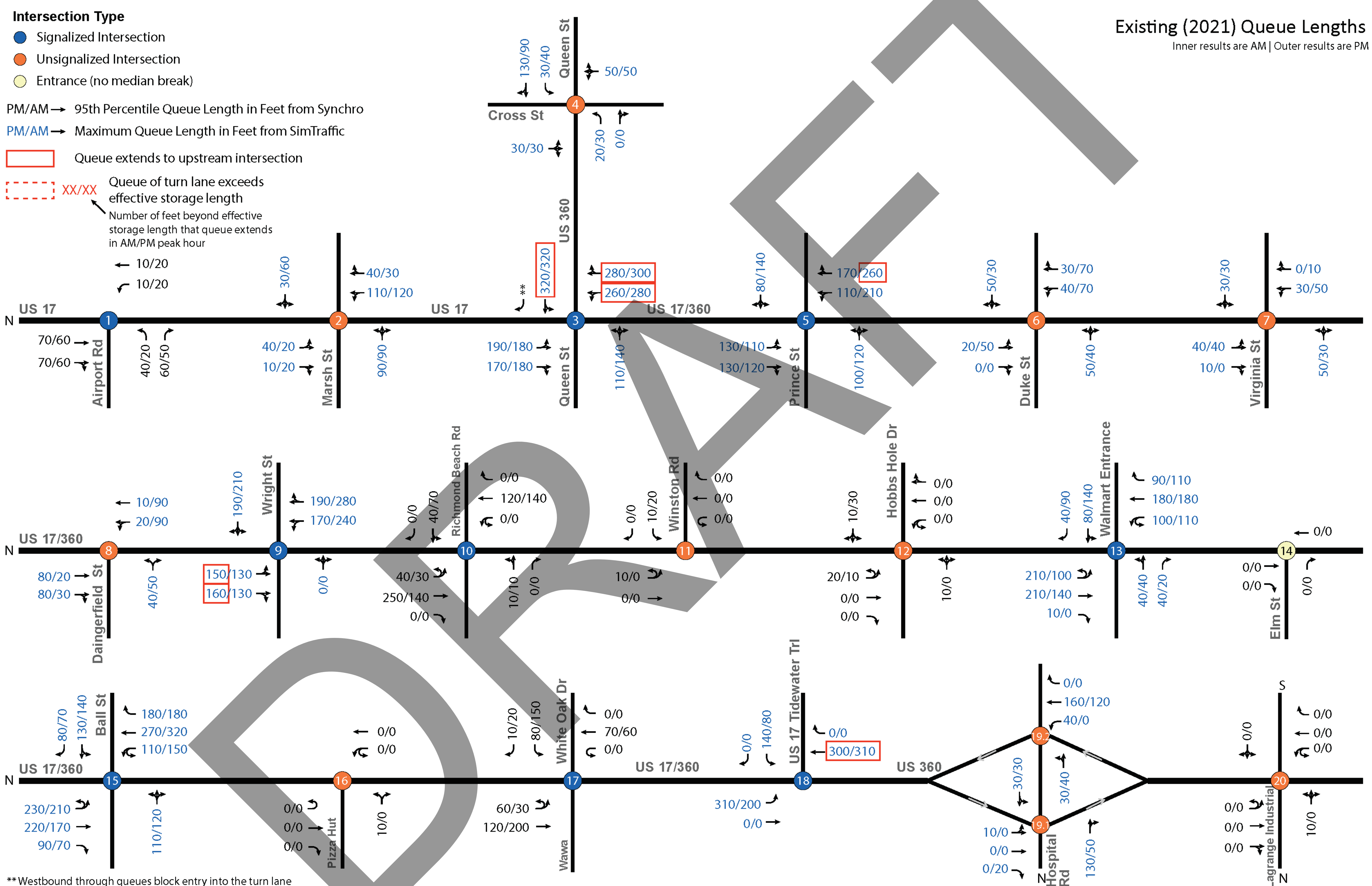


FIGURE 12: 2021 EXISTING PEAK HOUR TRAFFIC OPERATING CONDITIONS –QUEUE LENGTHS (FEET)



The results indicate several individual left turn and U-turn movements operate at LOS E or F in one or both peak hours. These movements include:

- At Airport Road, the eastbound left turn operates at LOS F in the AM peak hour. The volume of vehicles making this left turn is only nine vehicles in the AM peak hour, which can be considered a negligible effect.
- At the Walmart entrance, the northbound left turn (and U-turn) operates at LOS E in the PM peak hour.
- At Ball Street, both northbound and southbound left turns (and U-turns) operate at LOS E in the AM peak hour.
- At White Oak Drive, the southbound left turn (and U-turn) operates at LOS E in both AM and PM peak hours.

4.1.3.2 Queue Length Results

Queue lengths extend back to the prior intersection at a few locations:

- At the intersection of Queen Street and US 17, the westbound and northbound queues extend to the adjacent intersections in both the AM and PM peak hours. The study team confirmed during the field review that westbound queues coming from the Downing Bridge regularly extend back to and block the Cross Street intersection. Northbound queues also extend back to Prince Street, and in the height of the PM peak hour, can extend even further. SimTraffic's maximum queue reports the back of queue when vehicles have slowed to less than 6 mph. While the SimTraffic maximum queue results indicate the northbound queue in the PM peak hour stops between Prince Street and Duke Street, this does not account for the 'rolling' queue that the study team observed in the rightmost northbound lane that extends further back to Virginia Street and sometimes to Earl Street. The study team observed that vehicles in the rightmost northbound lane can be delayed for more than one signal cycle to make the northbound right turn at Queen Street.
- At the Wright Street intersection, the distance between Wright Street and Daingerfield Street is less than 150 feet. The SimTraffic results indicate the southbound queue at Wright Street extends back past Daingerfield Street. The study team did not observe this as problematic, as the southbound queue quickly cleared upon receiving a green light at the signal.
- At the US 17/360 interchange at Brays Fork (Intersection #18), the queue on the eastbound approach of US 360 continuing on to US 17/360 extends back to the intersection of Hospital Road.

The queuing issues described at Wright Street and the US 17/360 interchange at Brays Fork are due to inadequate access spacing, not congestion. The only location with congestion issues in the study corridor is the intersection of Queen Street and US 17.

4.2 Crash Analysis and Identified Deficiencies

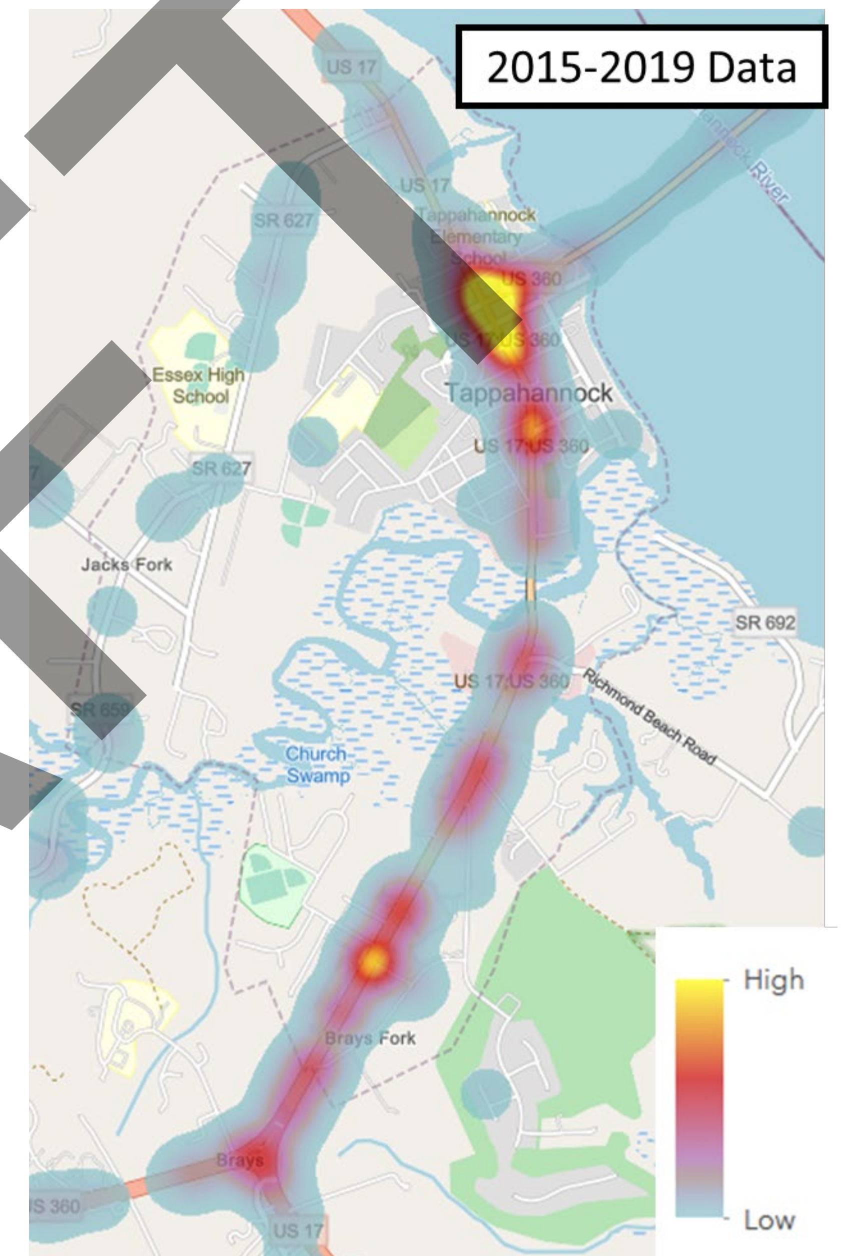
The project team prepared a series of crash maps showing the location, crash type (e.g. rear-end, angle, etc), and severity of crashes from December 1, 2015 through November 30, 2020[4] along the entire study corridor. These maps are provided in **Appendix D**.

4.2.1 Corridor-wide Crash Statistics

Over the 5-year crash analysis period, 377 crashes occurred along the study corridor. **Figure 13** shows a heat map displaying the intensity of crashes along the corridor. More detailed crash maps are available in **Appendix D**.

About one-third of crashes resulted in injury. There were no crashes resulting in a fatality in the 5-year analysis period. **Table 3** shows the number of crashes each year by the severity of the crash. **Figure 14** displays this information in a pie chart.

FIGURE 13: CRASH INTENSITY HEAT MAP



Crash severity is coded using the KABCO scale, which is defined using the following classifications:

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

[4] Crash data from VDOT's *Power BI* Crash Dataset, accessed on 3/29/2021.

TABLE 3: CORRIDOR-WIDE CRASHES BY CRASH SEVERITY

Year	Number of Crashes					
	K	A	B	C	PDO	Total
Year 1 (Dec 2015 - Nov 2016)	0	2	14	16	52	84
Year 2 (Dec 2016 - Nov 2017)	0	3	9	14	43	69
Year 3 (Dec 2017 - Nov 2018)	0	1	11	12	49	73
Year 4 (Dec 2018 - Nov 2019)	0	1	16	10	59	86
Year 5 (Dec 2019 - Nov 2020)	0	1	10	17	37	65
Total	**0**	**8**	**60**	**69**	**240**	**377**

FIGURE 14: CORRIDOR-WIDE CRASHES BY CRASH SEVERITY

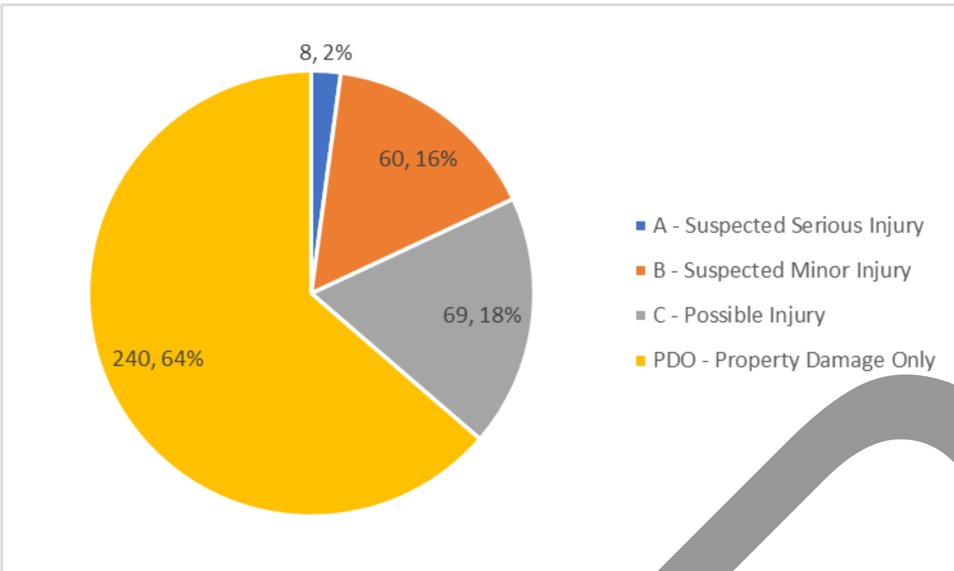


Table 4 shows the types of crashes by year over the study corridor. Angle crashes were the most prevalent crash type (45 percent), followed by rear-ends (30 percent), and sideswipes (12 percent). About three-quarters of the side-swipe crashes occur in the constrained portion of the study corridor north of Hoskins Creek. **Figure 15** displays this information in a pie chart.

TABLE 4: CORRIDOR-WIDE CRASHES BY CRASH TYPE

Year	Number of Crashes							
	Rear End	Angle	Head On	Side-swipe	Fixed Object	Deer	Other	Total
Year 1 (Dec 2015 - Nov 2016)	29	41	1	7	3	3	0	84
Year 2 (Dec 2016 - Nov 2017)	22	28	0	10	5	2	2	69
Year 3 (Dec 2017 - Nov 2018)	20	32	2	9	4	5	1	73
Year 4 (Dec 2018 - Nov 2019)	25	38	4	12	4	2	1	86
Year 5 (Dec 2019 - Nov 2020)	17	29	3	8	4	1	3	65
Total	**113**	**168**	**10**	**46**	**20**	**13**	**7**	**377**

FIGURE 15: CORRIDOR-WIDE CRASHES BY CRASH TYPE

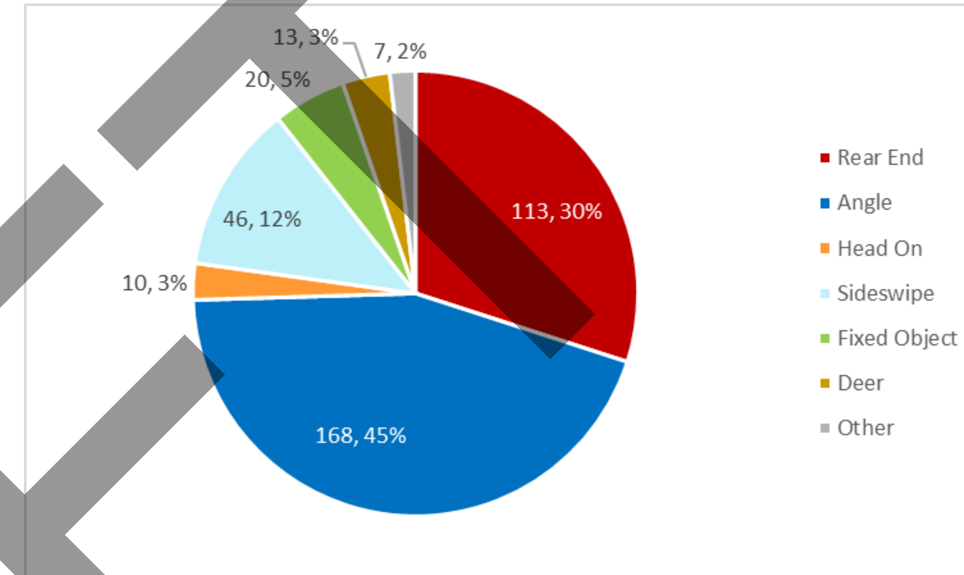


Table 5 shows the number of crashes by time of day and by severity. This information is also displayed in a pie chart in **Figure 16**. Over half of the crashes in the study corridor occurred between 10 AM and 4 PM, outside of the AM and PM peak periods. Seven of the eight severe injury crashes occurred between 10 AM and 4 PM.

TABLE 5: CORRIDOR-WIDE CRASHES BY TIME OF DAY AND CRASH TYPE

Time of Day	Number of Crashes					
	K	A	B	C	PDO	Total
Early morning (midnight to 7AM)	0	1	4	2	12	19
AM Peak (7 AM to 10 AM)	0	0	6	8	37	51
Mid-day (10 AM to 4 PM)	0	7	31	31	124	193
PM Peak (4 PM to 7 PM)	0	0	13	26	47	86
Nighttime (7 PM to midnight)	0	0	6	2	20	28
Total	**0**	**8**	**60**	**69**	**240**	**377**

FIGURE 16: CORRIDOR-WIDE CRASHES BY TIME OF DAY

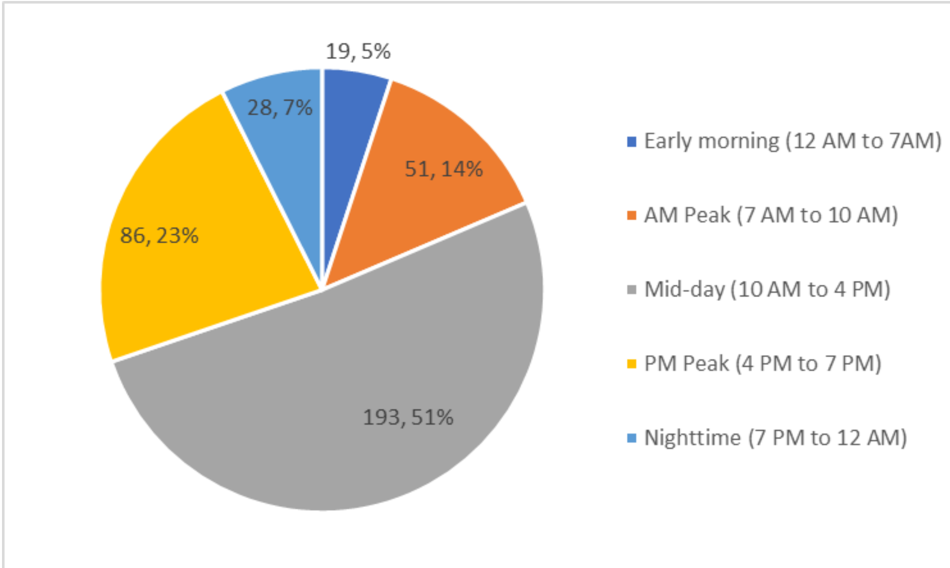
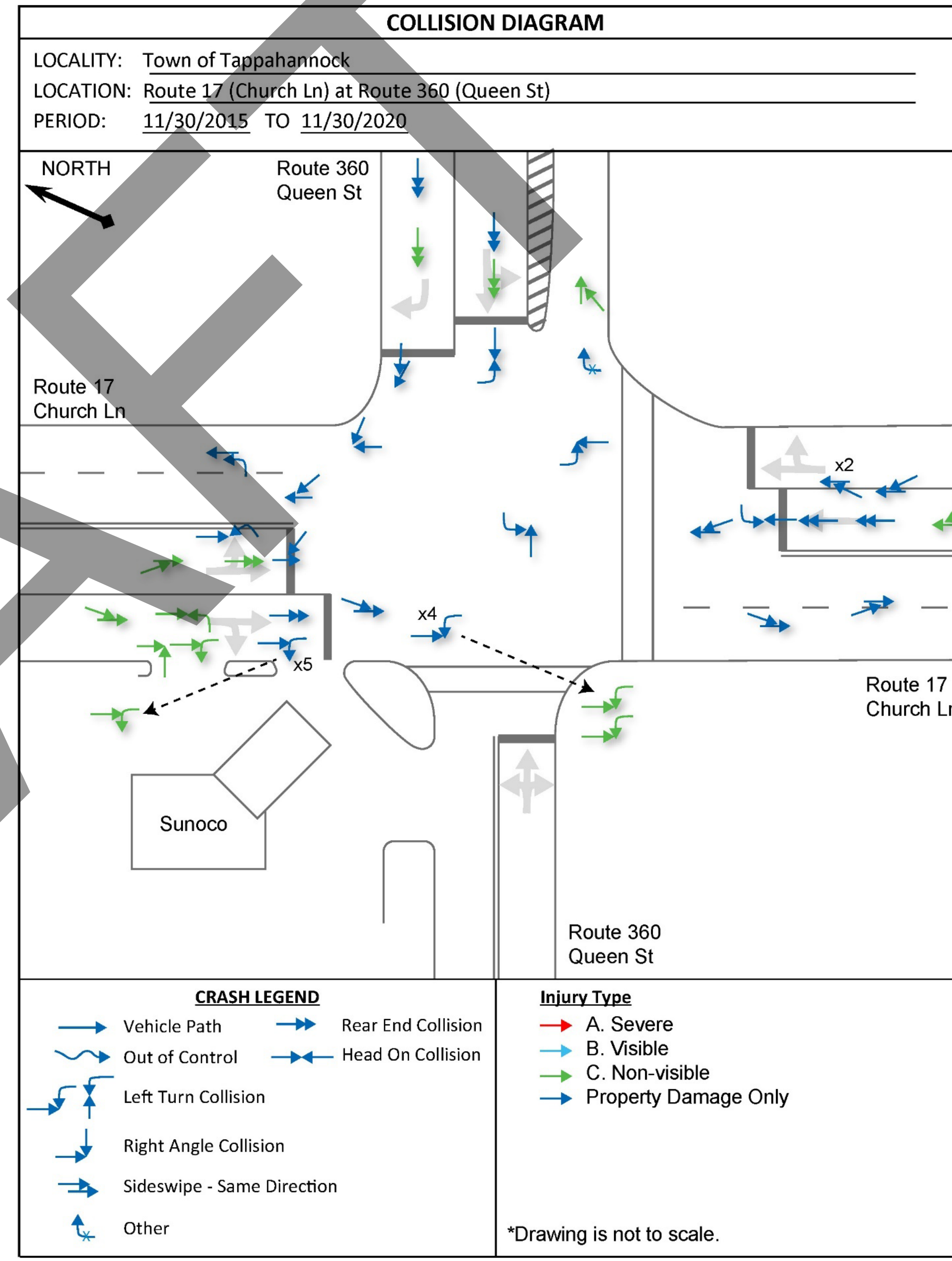


FIGURE 17: COLLISION DIAGRAM – US 17 (CHURCH LANE) AT US 360 (QUEEN STREET)



The crash analysis for this study focused closely on locations identified as having "potential for safety improvement" (PSI), locations where a fatal crash occurred, and locations where a pedestrian or bicyclist crash occurred. Corridor-wide crash statistics are provided at the end of this section.

4.2.2 Locations with Potential for Safety Improvement

PSI is a calculation that determines if the observed crash frequency exceeds the frequency that would typically be expected on a road with similar characteristics and traffic volumes. PSI is the best measure available for understanding whether crashes at an intersection are lower or higher than expected. VDOT publishes a ranking of intersections and road segments with PSI for each VDOT District. The latest available PSI rankings use 2014-2018 crash data. The lower the ranking, the higher the PSI. For example, the #1 ranked intersection with PSI has the highest potential for safety improvement, meaning the observed crash frequency is higher than the crash frequency that would be expected for an intersection with similar traffic volumes and characteristics.

Five intersections in the study corridor have PSI according to the 2014-2018 VDOT Fredericksburg District PSI rankings:

- US 17 (Church Lane) at US 360 (Queen Street) – Ranked #24, the highest PSI in the study corridor,
- US 360 (Queen Street) at Cross Street – Ranked #77,
- US 17/360 (Church Lane) at Duke Street – Ranked #82,
- US 17/360 (Tappahannock Blvd) at Winston Road – Ranked #107, and
- US 17/360 (Tappahannock Blvd) at Ball Street – Ranked #32, the second highest PSI in the study corridor.

The following sections describe the results of the crash analysis at these locations.

4.2.2.1 US 17 (Church Lane) at US 360 (Queen Street)

This intersection has the highest PSI in the study corridor. VTrans identifies "very high" priority needs for both safety and capacity preservation at this intersection. Forty-two crashes occurred at this intersection within the 5 year crash analysis period. **Figure 17** shows the collision diagram at this intersection.

The crash analysis reveals several findings and possible causal factors at this location:

- Nine crashes involved vehicles turning into or out of the two Sunoco entrances on Church Lane. These entrances are located within 100 feet of the intersection. Vehicles turning left out of the Sunoco have a limited view of oncoming northbound traffic. Additionally, vehicles accessing the Sunoco in the northbound direction face a 'multiple threat' situation, where a southbound vehicle queued on the inner lane may leave a space for the northbound vehicle to turn left, but the turning vehicle cannot see southbound vehicles approaching in the outer lane. The crash reports indicate this multiple threat situation was the cause of at least two crashes at this location.
- Several crashes involved vehicles attempting to pass vehicles waiting to make a northbound left turn or southbound left turn onto Queen Street. Both northbound and southbound approaches lack a dedicated left turn lane. The left turn in both directions shares a lane with through vehicles. The northbound approach lacks a dedicated left turn phase, and the southbound left turn and through green phase is only 8 seconds long. When a vehicle is turning left from either of these approaches, drivers behind the vehicle will try to maneuver around the left turning vehicle, sometimes colliding with a vehicle in the adjacent lane.
- Several crashes at this intersection and at the intersection of US 360 (Queen Street) at Cross Street involved westbound rear-ends occurring as one westbound vehicle is slowing down in the queue at the traffic signal. The study team observed the queue for the westbound approach consistently backing up beyond Cross Street, sometimes back to the Downing Bridge in the peak hours, and vehicles do not clear in one cycle.
- The narrow nine-foot wide lanes at this intersection give little margin for error. Many crash reports mentioned vehicles changing lanes, which caused several sideswipe, angle, and rear-end crashes.
- Four crashes resulted from northbound vehicles attempting to turn left onto Queen Street and colliding with oncoming southbound through vehicles. The lack of a dedicated northbound left turn phase makes it difficult for northbound vehicles turning left to find a gap in oncoming southbound traffic.
- The study team observed confusion when a vehicle was present at the low-volume eastbound Queen Street approach. The westbound left turn is a permissive only phase but is very high volume, and it can be confusing which vehicles have the right-of-way, as both eastbound and westbound approaches see a green ball. One crash in the 5-year crash history resulted from a vehicle proceeding through the intersection from the eastbound Queen Street approach and colliding with a westbound vehicle turning left. The crash report indicated both vehicles had a green light. There is no sign that indicates westbound left turning vehicles must yield to oncoming through vehicles.

The westbound approach of Queen Street at US 17 lacks a dedicated left turn phase and signage indicating turning vehicles must yield to oncoming eastbound vehicles.

Lanes on US 17 between Marsh Street and Wright Street are nine-feet wide, providing little margin for error for vehicles changing lanes. Trucks and other heavy vehicles comprise 9 percent of daily traffic volumes.

There is currently an intersection improvement project under construction at this intersection that will modify the westbound Queen Street approach. The new configuration, shown in the graphic to the right, will:

- Remove the existing painted median and eastbound left turn lane at Cross Street
- Extend the length of the westbound right turn lane
- Increase the westbound right turn radius
- Reconstruct entrances to the parking lot on the north side of Queen Street
- Install a sidewalk on the north side of Queen Street
- Relocate and rebuild the existing pedestrian crossing with ADA compliant curb ramps

Improvements currently under construction on the westbound approach of Queen Street at US 17.

While this project will provide improvements to the westbound approach, it will not address all of the issues present at this intersection, described previously.

4.2.2.2 US 360 (Queen Street) at Cross Street

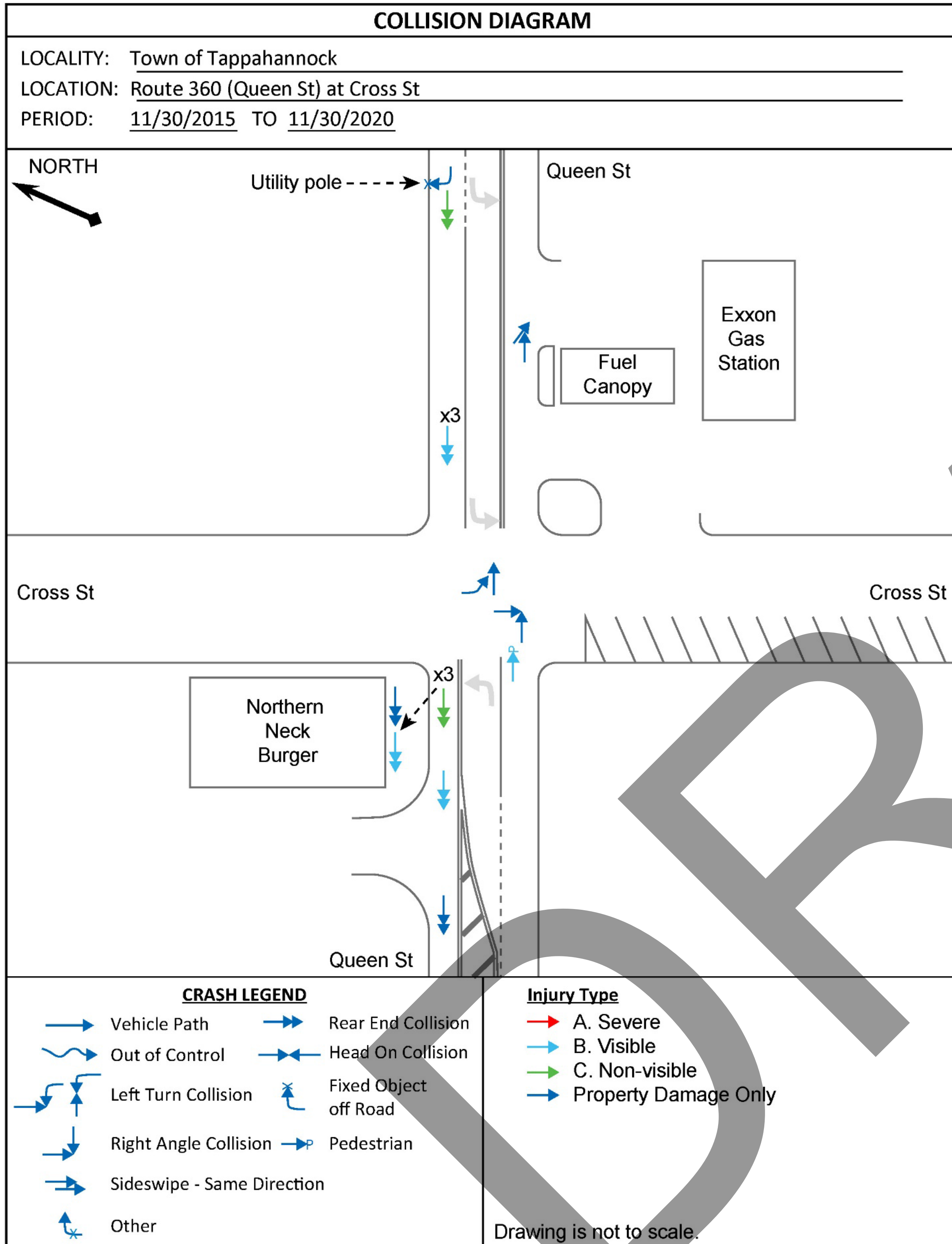
Figure 18 shows the collision diagram at this intersection. Eight of the 14 crashes that occurred at this intersection over the 5 year period were westbound rear-end crashes resulting from queue spillback from the traffic signal at Church Lane. The study team observed the westbound queue spilling back beyond Cross Street and failing to clear within one cycle. The study team observed heavy truck traffic on the westbound approach, which adds to start-up lost time.

The westbound Queen Street queue from the traffic signal at US 17 (Church Lane) consistently queues back beyond Cross Street in the AM peak hour.

One pedestrian crash occurred at this intersection. This crash occurred at 1:30 PM on Sunday October 22, 2017, when a pedestrian crossing Queen Street at Cross Street was hit by an eastbound vehicle.

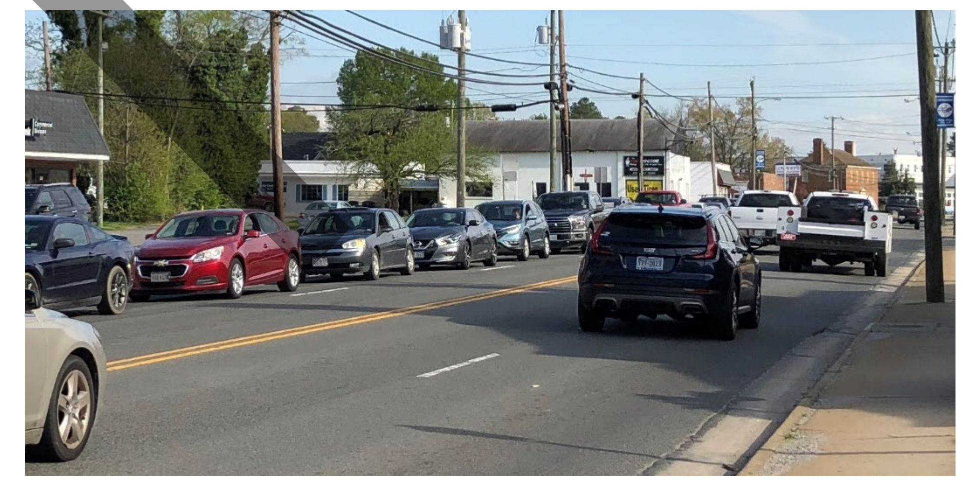
Two crashes at this intersection resulted from vehicles at the southbound approach of Cross Street colliding with eastbound vehicles on Queen Street. With vehicles queued back from the traffic signal at Church Lane, vehicles on Cross Street likely have trouble finding a gap in oncoming traffic.

Figure 18: Collision Diagram – US 360 (Queen Street) at Cross Street



4.2.2.3 US 17/360 (Church Lane) at Duke Street

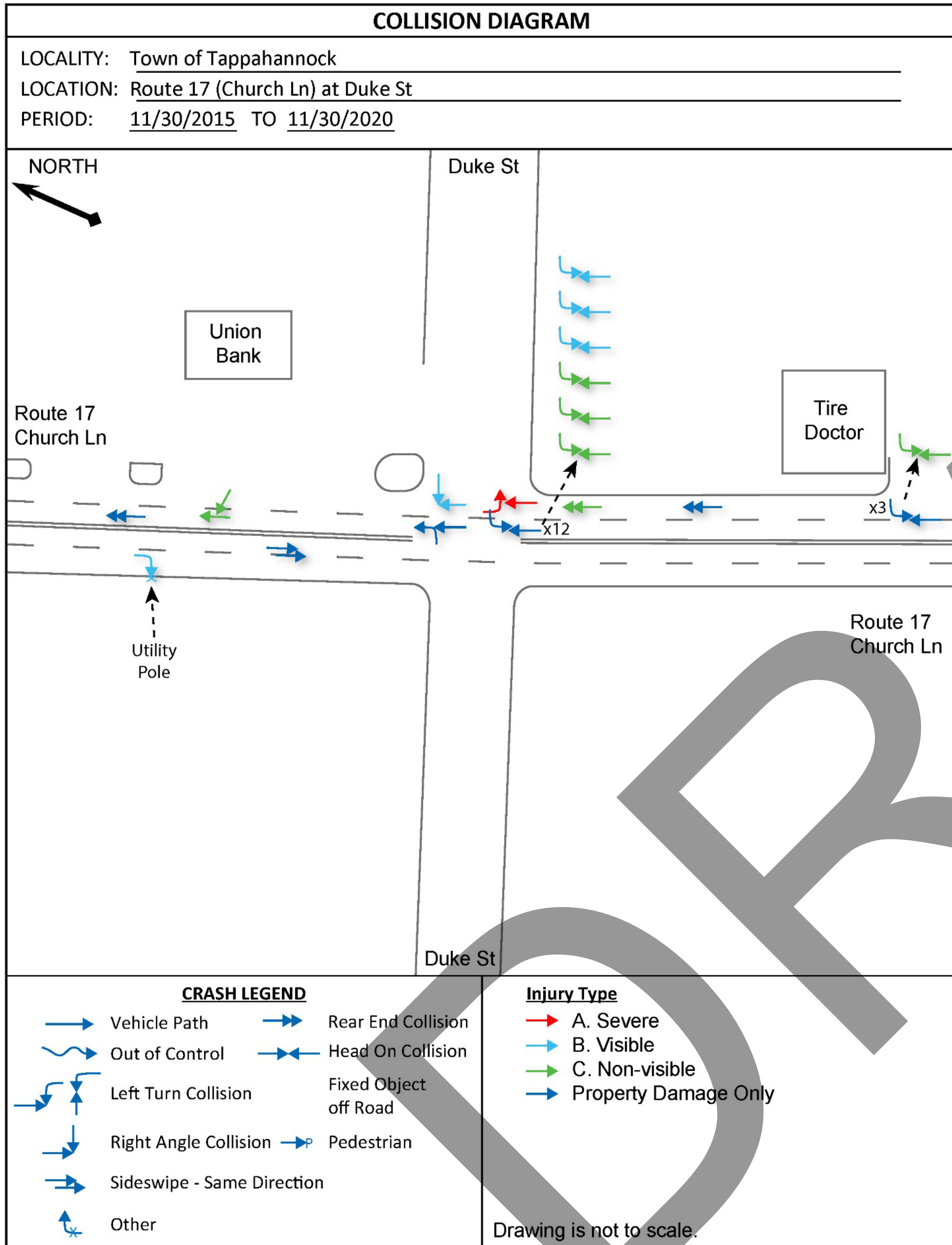
Figure 19 shows the collision diagram at this unsignalized intersection. Fourteen of the 24 crashes (58 percent) that occurred at this intersection are angle crashes where a vehicle on the stop-controlled westbound approach collided with a northbound vehicle in the left lane. Another four crashes involved westbound vehicles entering US 17 from adjacent commercial entrances.



The northbound queue on US 17/360 from Queen Street extends back to Duke Street, blocking the westbound approach of Duke Street.

Nearly all of these crashes occurred from a 'multiple threat' situation, where a stopped vehicle in the right northbound lane, likely from the queue of vehicles extending back from the upstream Queen Street intersection, obstructing the view of the westbound vehicle turning left. In many instances, the crash reports indicate the driver of the stopped northbound vehicle in the right lane waved the westbound vehicle through, but the westbound vehicle then collided with a northbound vehicle in the left lane.

FIGURE 19: COLLISION DIAGRAM – US 17/360 (CHURCH LANE) AT DUKE STREET



In 2019, VDOT conducted a safety evaluation at this intersection, which revealed similar findings, that the majority of crashes at this intersection are the result of westbound vehicles from either Duke Street or the adjacent commercial entrances pulling out onto US 17, at locations where the sight distance is often blocked by northbound queued traffic. The safety evaluation suggested several recommendations, none of which have been implemented at the time of this report.

1. Install a stop bar on both approaches of SR-1003 (Duke St.). This will provide visual stopping points to motorists on SR-1003 (Duke St.) as they approach the stop sign.
2. Eliminate left turns from SR-1003 (Duke St.). This can be done by the installation of "No Left Turn" signs on both approaches.
3. Eliminate crossing and left turn maneuvers by constructing a median along US-360 (Church Ln.) in order to minimize the number vehicle conflict points. This may not be a feasible option due to the limited lane widths and physical constraints of the intersection.
4. Close, consolidate, and/or relocate driveways at the intersection. This will reduce roadside friction by removing the number of locations where vehicle to vehicle conflicts occur. If driveways cannot be closed, consolidated, or relocated, it may be appropriate to restrict turning maneuvers at the driveway to right-in/right-out movements. For example, left turns at the Union Bank and plant nursery driveway can be restricted / limited to right turns in and right turns out. The median proposed above would further reduce the number of conflict points at these driveways.

LEFT TURNS FROM THE WESTBOUND APPROACH OF DUKE STREET COMPRISE OVER HALF OF THE CRASHES AT DUKE STREET.

These recommendations were considered, and several were incorporated in the development of alternatives discussed later in this report.

4.2.2.4 US 17/360 (Tappahannock Blvd) at Winston Road

Figure 20 shows the collision diagram at this intersection. Most crashes (8 of 15) at this intersection resulted from vehicles attempting to turn left from Winston Road. In all eight of these crashes, the westbound vehicle from Winston Road collided with a northbound vehicle. There were no instances of a westbound vehicle colliding with a southbound vehicle.

The posted speed limit on US 17/360 at Winston Road is 45 mph. The northbound and southbound through volumes at this intersection are the highest in the study corridor – around 800 vehicles each direction in the AM peak hour and around 1,000 vehicles each direction in the PM peak hour. While only 40 to 45 vehicles want to make a left turn in the peak hours, the heavy through volumes make it difficult to find a gap in traffic.

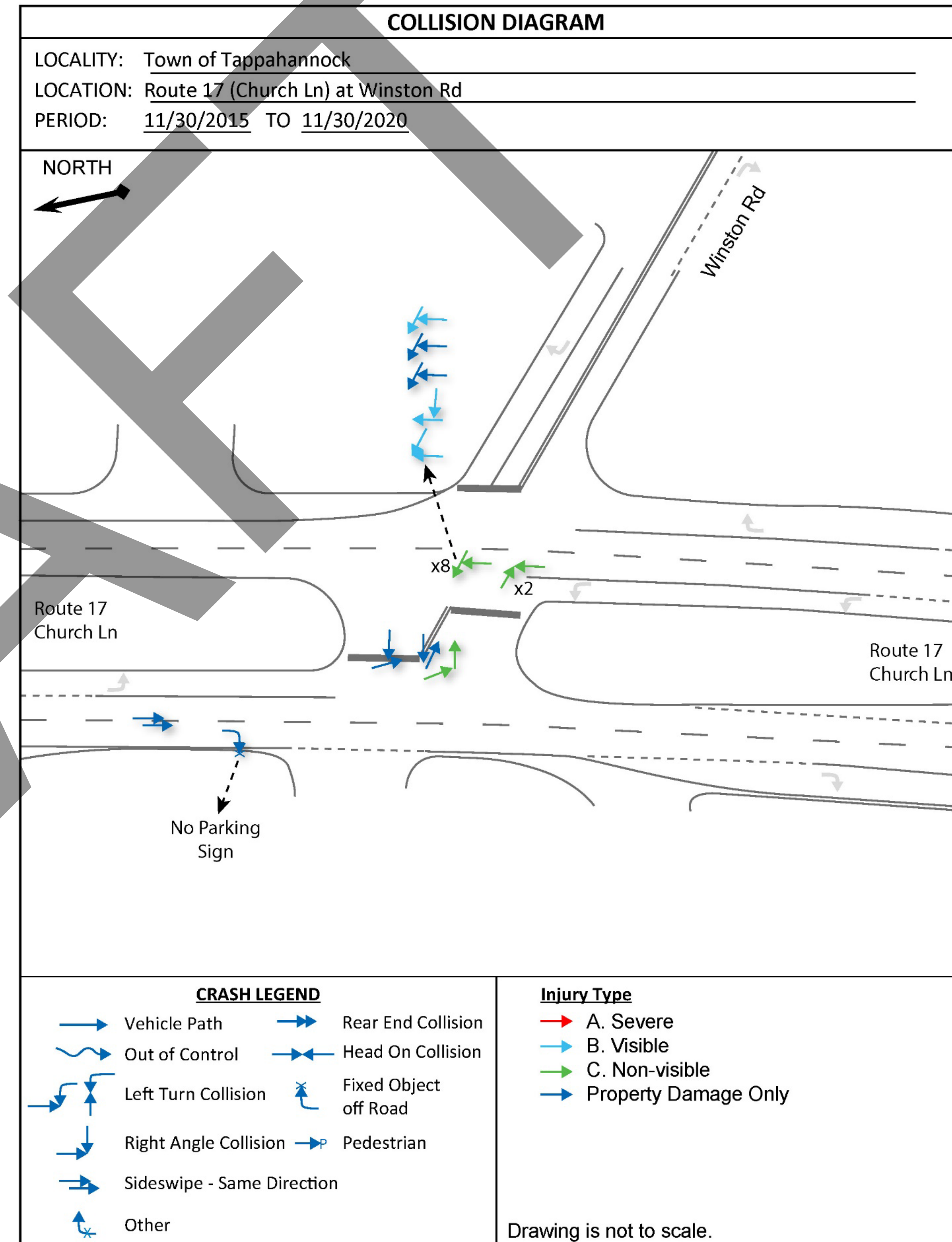
EXAMPLE OF DOUBLE-STACKING IN THE MEDIAN AT WINSTON ROAD AND IMPROPER VEHICLE POSITIONING.

Additionally, three crashes at this intersection occurred in the median due to improper positioning in the median, one of which clearly resulted from a driver failing to pull forward to the far end of the median. Another crash in the median resulted from double-stacking, where a vehicle was waiting in the median to complete a left turn or a U-turn, and another vehicle going in the same direction pulled into the median beside it.

The intersection at Winston Road is currently under construction to be converted to a Restricted Crossing U-Turn (RCUT) configuration as part of the Route 17 Corridor Improvements that are being funded through the first round of SMART SCALE funds. The RCUT configuration will place an island in the median to permit left turns from US 17 onto Winston Road and prohibit vehicles on Winston Road from entering the median. Vehicles wishing to make a left turn from Winston Road will make a right turn, proceed to the next median opening, and make a U-turn.

THE INTERSECTION OF WINSTON ROAD IS CURRENTLY BEING CONVERTED TO A RESTRICTED CROSSING U-TURN CONFIGURATION.

FIGURE 20: COLLISION DIAGRAM – US 17/360 (TAPPAHANNOCK BOULEVARD) AT WINSTON ROAD



4.2.2.5 US 17/360 (Tappahannock Blvd) at Ball Street

This intersection has the second highest PSI in the study corridor. VTrans identifies "very high" priority needs for both safety and capacity preservation at this intersection. 32 crashes occurred at this intersection within the 5 year crash analysis period. **Figure 21** shows the collision diagram at this intersection.

The crashes at this intersection are primarily a mix of angle and rear-end crashes. The crash history reveals several patterns of crashes.

- US 17/360 mainline collisions with side-street traffic. Over the 5 year period, four crashes occurred where northbound mainline through movements collided with eastbound side-street traffic, and another four crashes occurred where southbound mainline through movements collided with westbound side-street traffic. Several of the crash reports indicated drivers were running a red light, that the red light phase seemed short, or that both drivers thought they had a green light.
- Four crashes occurred when a vehicle turning left from the northbound left turn lane into the McDonald's parking lot collided with the southbound through traffic. Three similar crashes occurred in the opposite direction – where the southbound left/U-turns collided with northbound through traffic.
- Northbound and southbound rear-ends are also occurring in a pattern at this location. Six northbound rear-ends and four southbound rear-ends occurred in the 5 year crash analysis period.

The study team noted several possible influencing factors at the intersection of US 17/360 and Ball Street.

- The yellow phase for northbound and southbound through vehicles is 4.8 seconds long, and the all-red phase is 1.0 seconds long. While these timings are consistent with VDOT's Yellow Change Intervals and Red Clearance Intervals (TE-306.1), the effect of a long yellow paired with a short red could contribute to the instances of red-light running seen in the crash reports. A long yellow phase may encourage drivers to speed up to pass through the intersection, while the short all-red phase gives little time to clear the intersection before the side-street phases go.
- The study team observed queues in the southbound left/U-turn lane that did not clear in one cycle in the AM peak hour. Southbound left and U-turning vehicles may be inclined to continue speeding up through the yellow phase to avoid waiting another cycle.
- Sycamore Drive serves several residential developments and recreational sports fields. It is located less than 200 feet from the Ball Street intersection and may be a significant source of southbound U-turns. Vehicles originating from Sycamore Drive and wanting to head north must make a southbound U-turn at Ball Street.
- There is a slight grade difference between the northbound and southbound US 17/360 lanes.
- The Burger King has two entrances on Ball Street. The entrance nearest to US 17 is only about 50 feet from the intersection.

4.2.3 Fatal Crashes

Although no fatal crashes occurred in the study corridor between December 1, 2015 and November 30, 2020, there was one fatal crash that occurred in 2014 at the intersection of US 17 (Church Lane) and Marsh Street. Because of this fatal crash, the intersection of US 17 and Marsh Street was included for closer examination in the crash analysis. The collision diagram for this intersection is shown in **Figure 22**.

The fatal crash at Marsh Street occurred on Friday August 22, 2014 at 5:55 AM. A driver going eastbound on Marsh Street disregarded the stop sign and proceeded to cross US 17 at a high rate of speed, colliding with a northbound vehicle. Both vehicles were totaled after striking trees and a building. The driver of the northbound vehicle was not wearing a safety belt, ejected from the vehicle, and killed. Despite the fatal crash, this intersection is not identified as having potential for safety improvement, nor a VTrans safety need.

Figure 21: Collision Diagram – US 17/360 (Tappahannock Boulevard) at Ball Street

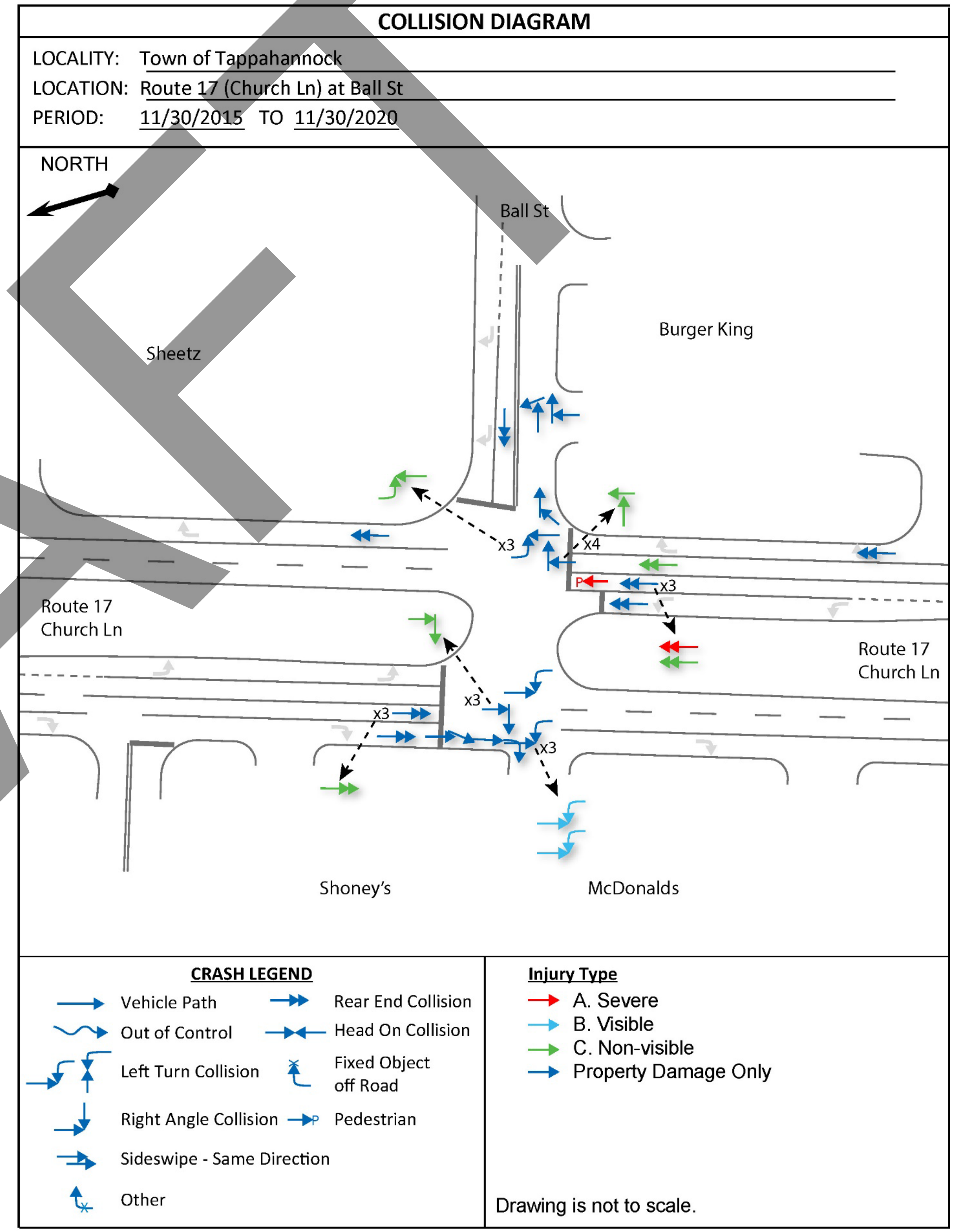
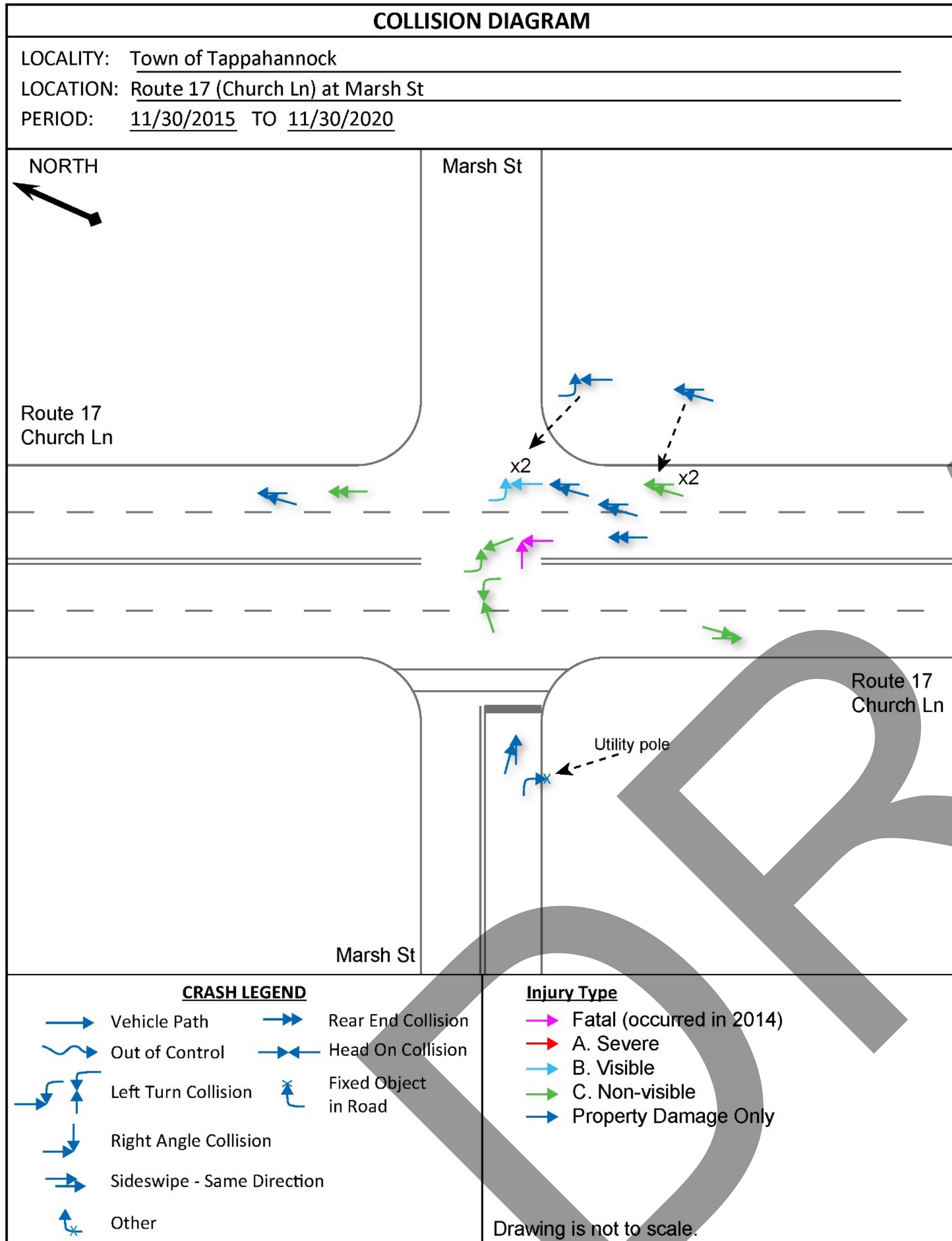


FIGURE 22: COLLISION DIAGRAM – US 17 (CHURCH LANE) AT MARSH STREET



Seven of the 14 crashes that occurred at the Marsh Street intersection in the 5 year period resulted from vehicles changing lanes and hitting a vehicle in the adjacent lane. Several of these crashes occurred because a vehicle in the left lane attempted to change into the right lane to avoid a vehicle waiting in the left lane through lane to make a left turn. The lack of left turn lanes can be considered a potential causal factor in these crashes. This situation occurred several times in the northbound direction approaching Marsh Street and once in the southbound direction approaching Queen Street. The lack of left turn lanes may also have been a causal factor in a rear-end crash where a northbound vehicle collided with the vehicle in front of it that had stopped to make a left turn onto Marsh Street.

4.2.4 Pedestrian and Bicyclist Crashes

Two pedestrian crashes occurred in the study corridor between December 1, 2015 and November 30, 2020.

- One pedestrian crash occurred in 2016 at the intersection of US 17/360 and Ball Street. A pedestrian attempted to cross US 17/360 from the Burger King parking lot and was struck by a northbound vehicle. There are no marked crosswalks or pedestrian signals at the Ball Street intersection.
- Another pedestrian crash occurred in 2017 at the intersection of US 360 (Queen Street) and Cross Street. A pedestrian was crossing Queen Street at Cross Street and was struck by an eastbound vehicle. There are no crosswalks at the intersection of Queen Street and Cross Street, but there is a mid-block crossing on Queen Street between Cross Street and US 17 (Church Lane).

THE INTERSECTION OF BALL STREET AND US 17, LIKE THE OTHER INTERSECTIONS SOUTH OF HOSKINS CREEK, LACK PEDESTRIAN FACILITIES, INCLUDING CROSSWALKS AND PEDESTRIAN SIGNALS. A PEDESTRIAN CRASH OCCURRED AT THE BALL STREET INTERSECTION IN 2016.

Another pedestrian crash occurred in 2014 at the intersection of US 17/360 and Virginia Street. A pedestrian was attempting to cross US 17/360 just south of Virginia Street. A vehicle on the eastbound approach of Virginia Street turned right onto US 17/360, striking the pedestrian. The driver would have been looking to the left to find a gap in oncoming traffic, and the pedestrian was on the right side of the vehicle. This intersection is not identified as having potential for safety improvement nor a VTrans safety need.

4.2.5 Other Locations Examined for Safety Issues

During the kickoff meeting, the study work group noted several issues at the US 17/360 interchange at Brays Fork, as well as concerns at the intersection of US 360 and Lagrange Industrial Drive.

4.2.5.1 US 17/360 Interchange at Brays Fork

While the crash mapping and PSI calculations do not indicate a higher crash frequency than would be expected at the US 17/360 interchange at Brays Fork, the study work group noted several safety concerns due to the geometric configuration and access spacing.

- Vehicles coming from the south on US 17 that wish to access Hospital Road do not have enough distance after the traffic signal to merge with westbound traffic and get over to make the right turn onto Hospital Road.
- The point where vehicles on the ramp from eastbound US 360 to southbound US 17 merge with vehicles coming from the north continuing south on US 17 is located at the intersection of Berry Hill Road.

These concerns were noted, confirmed during the field visit, and considered in the development of alternative concepts, as explained in later sections.

4.2.5.2 US 360 at Lagrange Industrial Drive

This unsignalized intersections serves a lumber yard to the south and an industrial park to the north. The traffic counts indicate over the 8-hour count period, 91 trucks turned into or out of this intersection, accounting for 19 percent of the side-street traffic volumes at this intersection.

This intersection is located in the segment with a 45 mph posted speed limit. The speed limit changes to 60 mph to the west. Westbound traffic approaching the intersection is coming over a hillcrest. The study team did not observe any sight distance obstructions at this intersection. While driving the corridor during the site visit, the study team noticed westbound traffic approaching this intersection was consistently traveling over the 45 mph speed limit. Large trucks that cannot pull into the median will experience longer delays waiting for a gap in both directions. The crash data does not indicate that crash frequencies here are higher than would be expected. However, Essex County representatives have indicated the County would like to see more intense industrial development occur here in the future.

TRUCKS CONSIST OF 19 PERCENT OF SIDE-STREET TRAFFIC AT LAGRANGE INDUSTRIAL DRIVE.

4.3 Access Spacing

The VDOT Road Design Manual provides spacing standards for different types of intersections and access points, which ensure an appropriate balance between providing access to adjacent land uses and maintaining the flow of traffic, based on a roadway's functional classification and posted speed limit. By managing the location, spacing, and design of entrances and intersections, planners and designers can reduce the number of conflict points, traffic congestion, and crashes. Businesses benefit from access management because more efficient traffic flow expands their market area.

VDOT classifies US 17 and US 360 as *Other Principal Arterials* throughout the study area. In the northern section of the study corridor, the posted speed limit is 25 mph. The posted speed limit increases to 35 mph south of Wright Street and 45 mph south of Richmond Beach Road. VDOT's Access Management Design Standards indicate Principal and Minor Arterials should have "limited or partial" access control because the functional purpose of these roads is "high mobility, low to moderate access."[5]

The access management standards applicable to US 17/360 are listed in **Table 6**. The study team documented the existing access spacing throughout the study area and identified areas where the current access spacing does not meet the standards outlined in **Table 6**. These figures are provided in **Appendix F**.

The spacing of commercial entrances is most deficient in the northern historic section of the US 17/360 corridor. The access spacing standards require a minimum distance of 440 feet between the centerlines of each full-access commercial entrance on principal arterials with a 25 mph speed limit. Many commercial entrances in the northern section have less than 100 feet between adjacent entrances. Block lengths in the historic downtown area are less than 400 feet, which is optimal for pedestrian walkability, if crosswalks were to be provided at each intersection, but this does not meet VDOT's access spacing standards.

TABLE 6: VDOT ACCESS SPACING STANDARDS FOR PRINCIPAL ARTERIALS

Description of Type of Access Points				Minimum Spacing Distance (feet) Posted Speed Limit: 25 to 30 mph	Minimum Spacing Distance (feet) Posted Speed Limit: 35 to 45 mph
From	**Signalized Intersections**	To	**Other Signalized Intersections**	**1,050**	**1,320**
From	**Unsignalized Intersections & Full Median Crossovers**	To	**Signalized or Unsignalized Intersections & Full Median Crossovers**	**880**	**1,050**
From	**Full Access Entrances or Directional Median Crossovers**	To	**Other Full Access Entrances and Any Intersection or Median Crossover**	**440**	**565**
From	**Partial Access One- or Two-Way Entrances**	To	**Any Type of Entrance, Intersection, or Median Crossover**	**250**	**305**
From	**Start/End of Ramp Terminal**	To	**Any Intersection, Full Access Entrance, or Full Median Crossover**	**1,320**	**1,320**
From	**Start/End of Ramp Terminal**	To	**Directional Median Crossover**	**990**	**990**
From	**Start/End of Ramp Terminal**	To	**Right-in/Right-Out Partial Access Entrance**	**750**	**750**

Source: VDOT Road Design Manual, Appendix F: Access Management Design Standards for Entrances and Intersections, Table 2.2: Minimum Spacing Standards for Commercial Entrances, Intersections, and Median Crossovers, and Table 2-3: Minimum Spacing Standards for Intersections and Commercial Entrances Near Interchange Areas on Multilane Crossroads.

Access spacing is also deficient in the southern portion of the study corridor. Median openings and commercial entrances do not meet VDOT's access spacing standards in this section.

4.4 Conclusions from the Existing Conditions Analysis

The following items summarize the most pressing issues in the study corridor.

- The section of the study corridor in the historic downtown district is the most severely constrained. The four-lane configuration with narrow nine-foot wide travel lanes presents several issues including increased potential for side-swipe crashes and a lack of left turn lanes, which increases potential for rear-end, angle, and side-swipe crashes.
- The intersection of US 17 (Church Lane) at US 360 (Queen Street) is the most critical intersection in the study corridor. It has the highest PSI in the corridor and "very high" VTrans needs for safety and capacity preservation. Northbound queue spillback from this intersection creates safety issues at the unsignalized Duke Street intersection, notably a 'multiple threat' situation for westbound left turns. The northbound spillback is exacerbated when a through vehicle stops in the shared

[5] VDOT Road Design Manual Appendix F. Pg. F-11.

northbound through and right turn lane, preventing right turning vehicles from proceeding during the westbound through phase.

- The lack of dedicated left turn lanes and left turn phases at the US 17 (Church Lane) and US 360 (Queen Street) creates confusion, especially when a vehicle is present at the low volume eastbound approach.
- The entrances to the Sunoco gas station on the northwest corner of Queen Street and Church Lane are located very close to the intersection and have resulted in several crashes.
- Marked pedestrian crossings on US 17/360 are limited to a handful of locations, encouraging pedestrians to cross at unmarked locations. The section of US 17/360 south of Hoskins Creek lacks sidewalks and crosswalks completely.
- The intersection of Ball Street and US 17 has the second highest PSI in the corridor and has "very high" VTrans needs for safety and capacity preservation. Many of the crash reports at this location report instances of red light running or drivers reporting having green lights in conflicting movements. The yellow and all-red clearance intervals are 4.8 and 1.0 seconds respectively, which may be encouraging motorists to speed up during the yellow phase without enough time to clear during the all-red phase.
- The current configuration of the US 17/360 interchange at Brays Fork makes it difficult for motorists coming from the south on US 17 to access the VCU Health Tappahannock Hospital on Hospital Drive.
- The spacing of unsignalized intersections and commercial entrances does not meet VDOT's access spacing standards.

These and the other issues noted previously in this chapter were considered during the development of alternatives.

4.5 Survey Results

The study team solicited input from the public on issues and concerns through an online survey from May 6, 2021 through June 4, 2021. Over 1,100 people responded to the survey. This section summarizes the survey results, which generally confirm the issues and deficiencies identified in the existing conditions analysis.

4.5.1 What are the Issues?

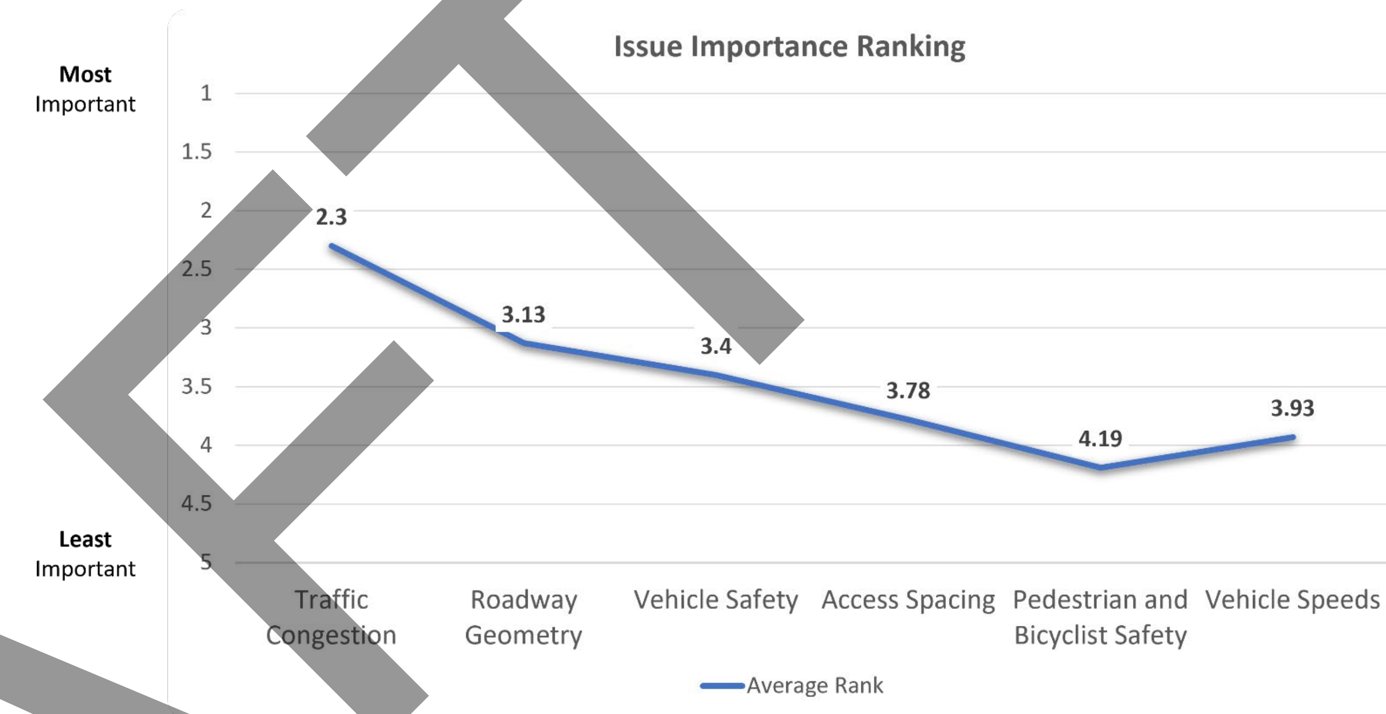
The survey asked respondents to rank six issues on US 17/360 in Tappahannock in order from most important (1) to least important (6). The issues were defined as follows:

- **Traffic Congestion** – Long back-ups of traffic, frequently having to sit in traffic when driving on US 17/360.
- **Roadway Geometry -** Roadway geometry issues could include lanes that are too narrow, curves that are hard to see around, intersections or entrances that aren't clearly visible, and confusing intersections.
- **Vehicle Safety** – Several intersections on US 17 have high crashes.
- **Access Spacing** – Driveways, entrances, and intersections on US 17/360 that are spaced too close together.
- **Pedestrian and Bicyclist Safety -** Lack of sidewalks, crosswalks, curb ramps, pedestrian signals, bicycle lanes, shared use paths, or other facilities for walking or bicycling.
- **Vehicle Speeds** - Cars or trucks traveling too fast.

Figure 23 shows the results of the issues ranking. Respondents ranked traffic congestion as the most important, with roadway geometry and vehicle safety as second and third.

The survey asked multiple choice questions about these issues to gather additional information. The responses to the multiple choice questions are summarized in the following sections.

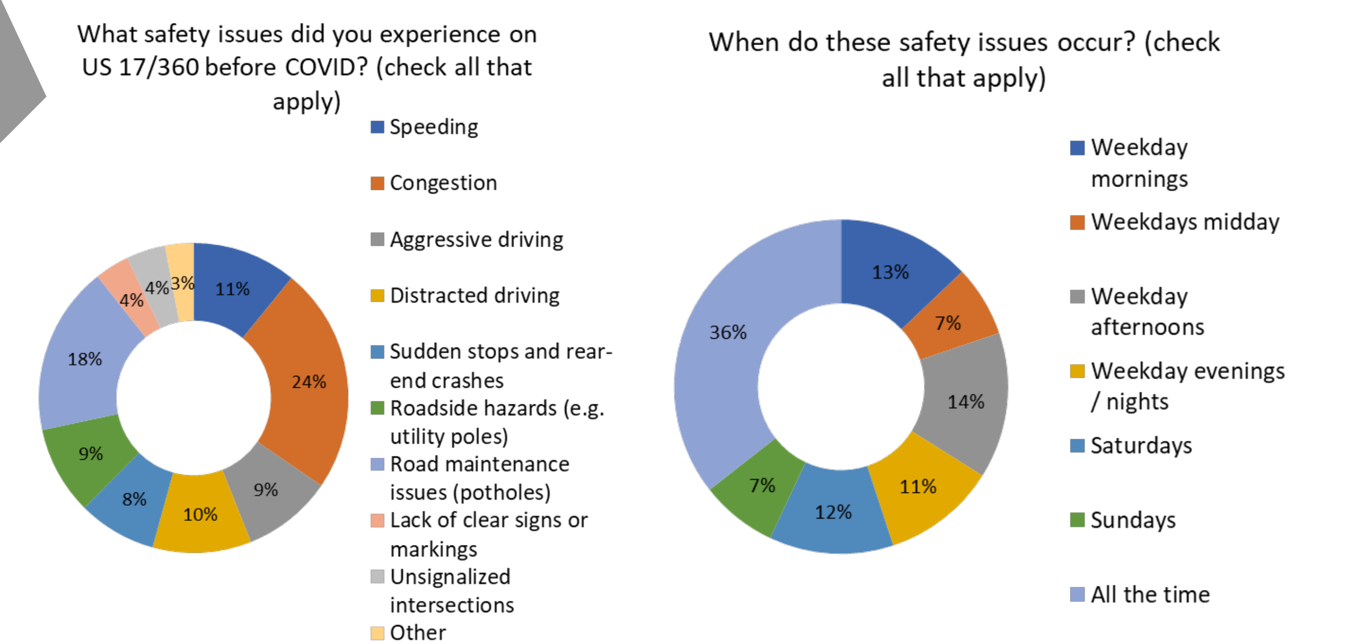
FIGURE 23: SURVEY RESULTS – RANKING OF ISSUES



4.5.1.1 Safety Issues

Respondents confirmed a range of safety issues exist on US 17/360, including congestion, road maintenance issues, and speeding, as well as others shown in **Figure 24**. A large portion of respondents indicated these safety issues occur all the time.

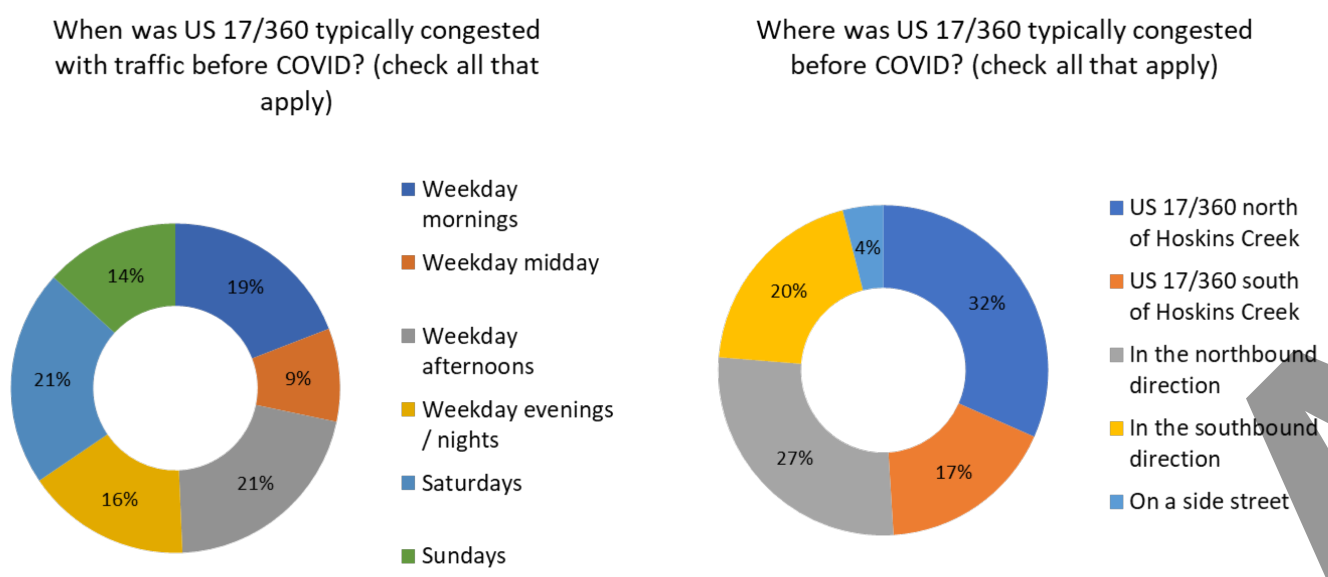
FIGURE 24: SURVEY RESULTS – SAFETY ISSUES



4.5.1.2 Congestion Issues

Respondents indicated US 17/360 is typically congested throughout the weekday and on weekends, with the most popular responses being on weekday afternoons and Saturdays. More respondents indicated US 17/360 is typically congested north of Hoskins Creek and in the northbound direction. Responses related to congestion issues are shown in **Figure 25**.

FIGURE 25: SURVEY RESULTS – CONGESTION ISSUES



4.5.1.3 Access Spacing Issues

Respondents most often indicated that slowing down to turn off of US 17/360 and turning left onto US 17/360 are issues present on US 17/360 in Tappahannock. Most respondents indicated these issues are typically experienced all the time, as shown in **Figure 26**.

4.5.1.4 Pedestrian, Bicycle, and Public Transit Issues

Respondents most often selected sidewalk, crosswalks, and pedestrian signals as needed improvements on US 16/360. Respondents most often selected bus and park-and-ride as needed modes of transit, as shown in **Figure 27**.

FIGURE 26: SURVEY RESULTS – ACCESS SPACING ISSUES

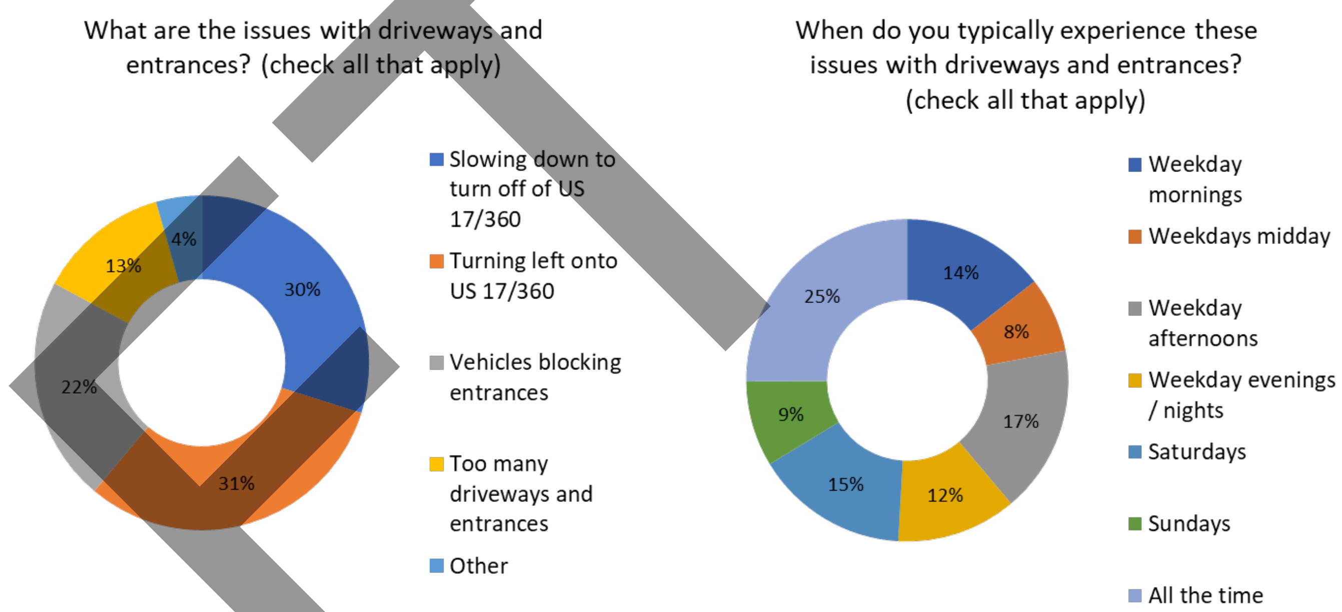
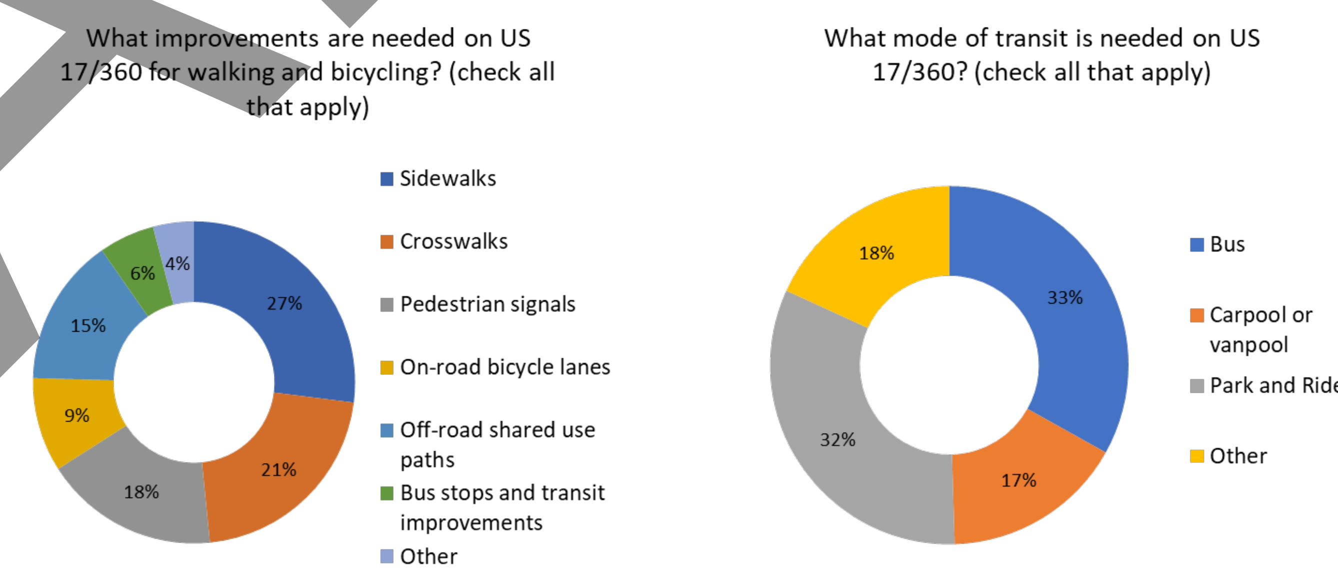


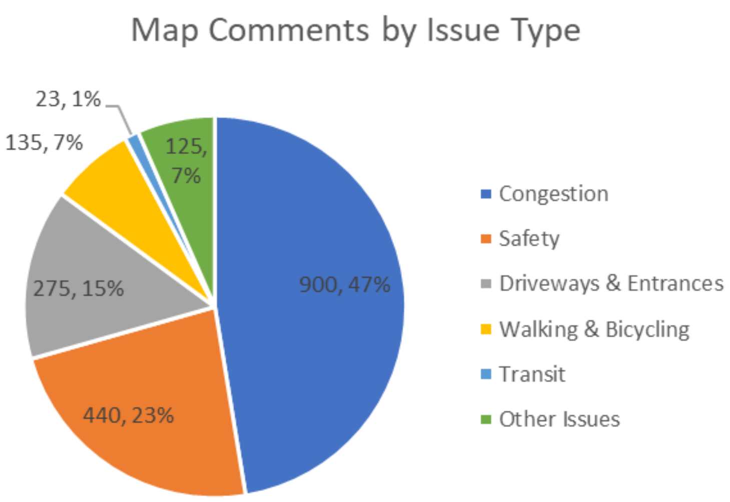
FIGURE 27: SURVEY RESULTS – PEDESTRIAN, BICYCLE, AND PUBLIC TRANSIT ISSUES



4.5.2 Where are the Issues?

The survey asked respondents to identify the locations of issues on a map. Respondents submitted 1,898 comments on the map. **Figure 28** shows the percentages of comments received for each type of issue. **Figure 29** shows the location of all 1,898 comments received.

FIGURE 29: SURVEY RESULTS – MAP COMMENTS BY TYPE OF ISSUE



Almost half of the comments respondents provided on the map were related to congestion. **Figure 30** shows the location of the congestion-related comments. Of the 900 congestion related comments, three-quarters were located in the historic downtown section. Nearly 60 percent of congestion-related comments were focused on the intersection of Queen Street and Church Lane.

Safety related comments were also concentrated in the historic downtown section. Comments related to driveways and entrances, walking and bicycling, and transit were generally distributed throughout the study corridor.

FIGURE 28: SURVEY RESULTS – LOCATION OF ALL MAP COMMENTS

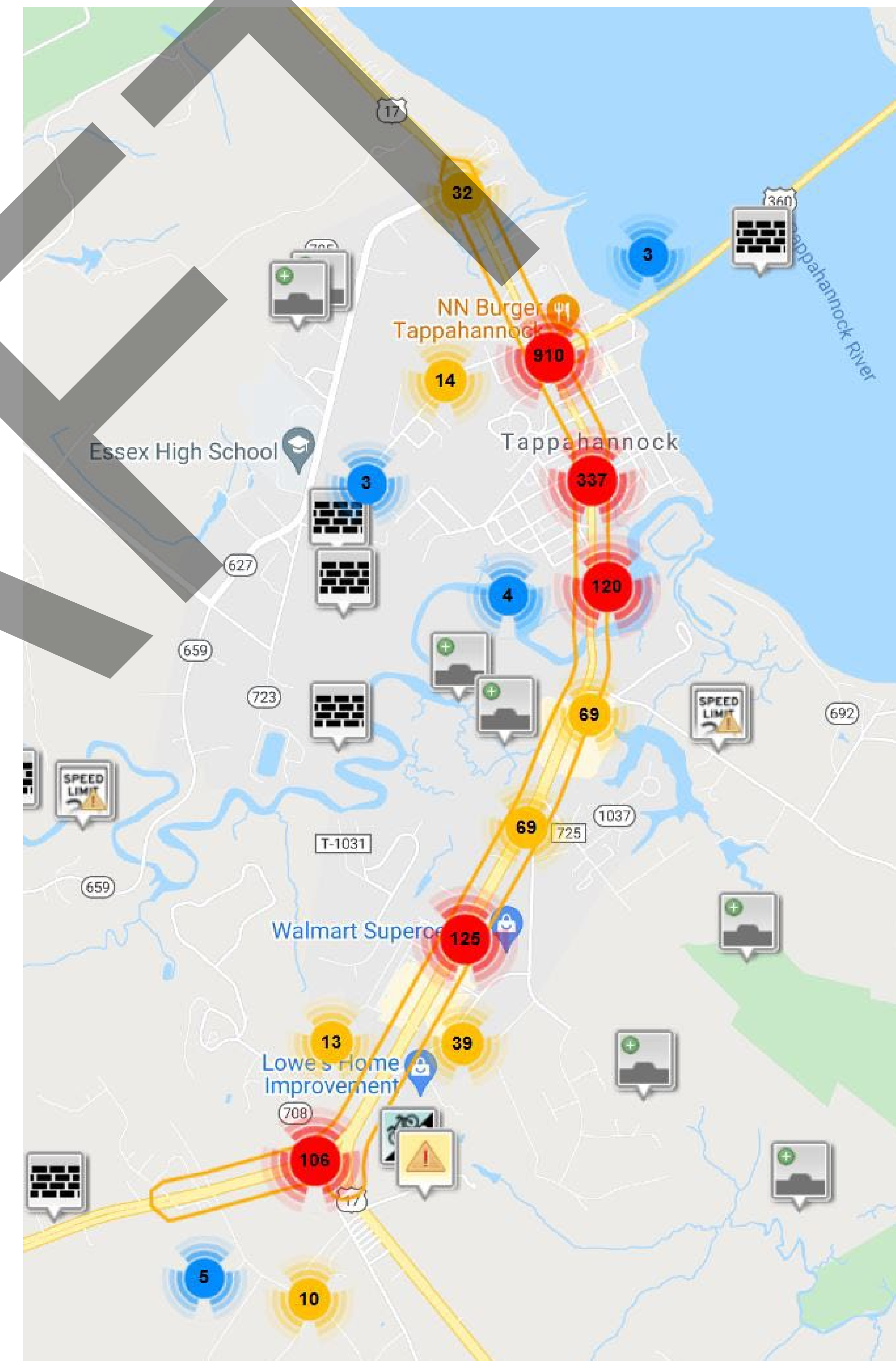
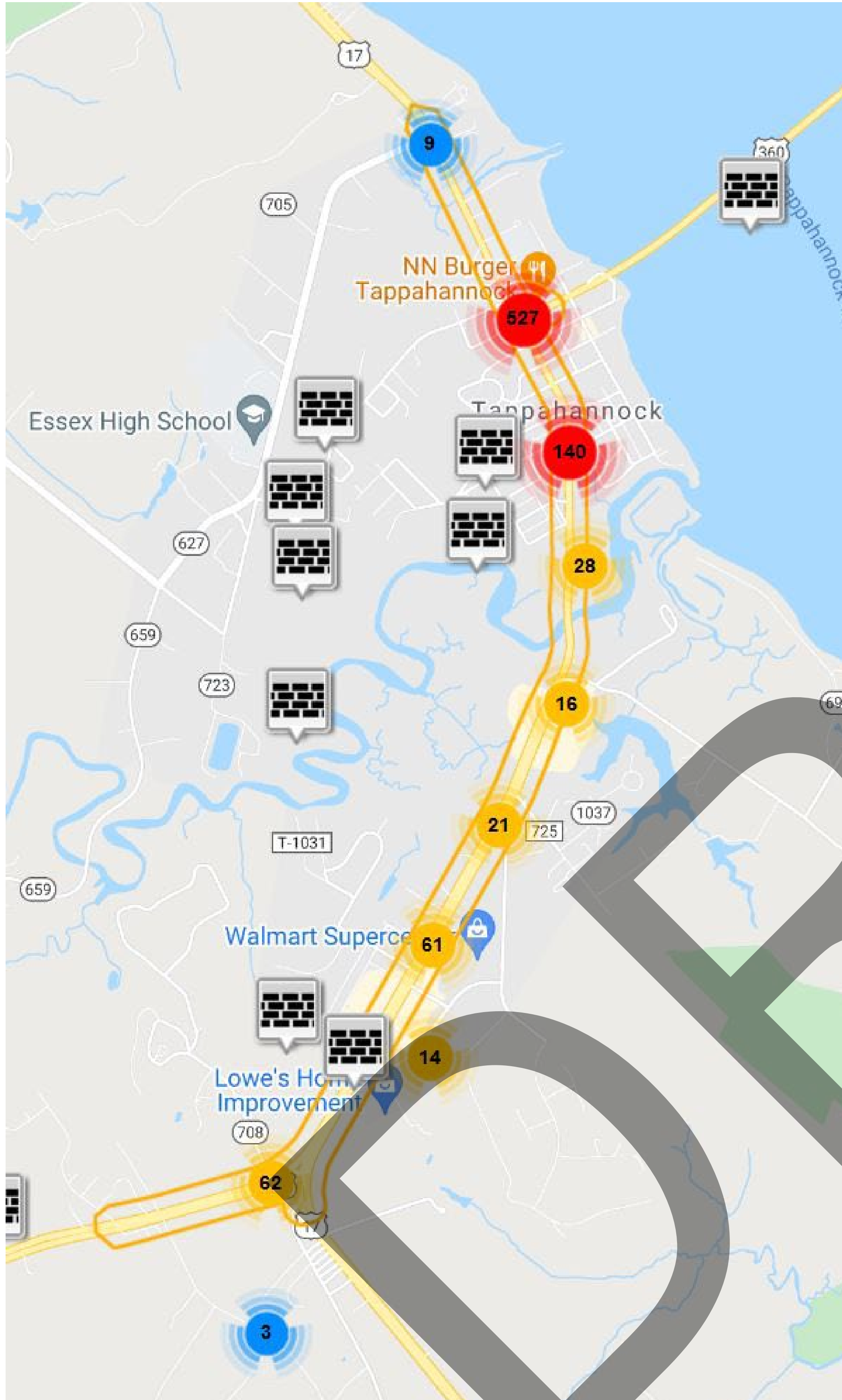


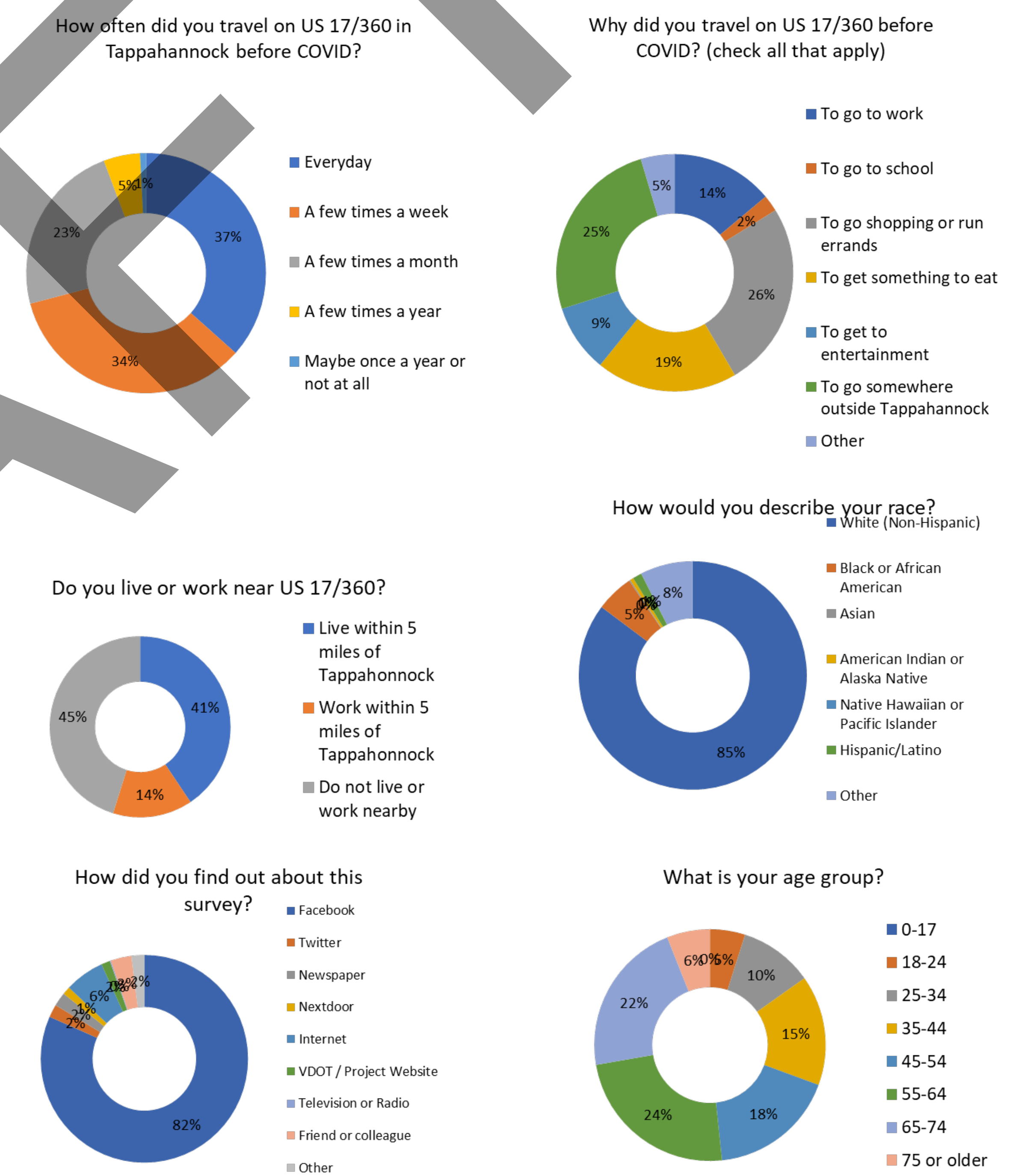
FIGURE 30: SURVEY RESPONSES – LOCATION OF MAP COMMENTS ON CONGESTION



4.5.3 Survey Respondents

Over 70 percent of survey respondents indicated they typically travel on US 17/360 in Tappahannock everyday or a few times a week. When asked why you travel on US 17/360, the most popular responses were to go shopping or run errands and to go somewhere outside Tappahannock. **Figure 31** shows the responses from survey respondents on how often and why they travel on US 17/360 as well as other demographic information.

FIGURE 31: SURVEY RESPONSES – TRAVEL BEHAVIORS AND DEMOGRAPHICS OF SURVEY RESPONDENTS



4.5.4 Key Themes from Survey Responses

Narrow lanes, trucks and large vehicles, lack of sidewalks, and maintenance issues were key themes throughout the written survey comments. **Figure 32** shows examples of comments submitted.

FIGURE 32: SURVEY RESPONSES – EXAMPLE WRITTEN COMMENTS

5 Future Traffic Forecasting

To understand future traffic conditions in the study area and assess the long-term benefits of proposed improvements, traffic volumes were forecasted for 2040 traffic conditions. The following sections describe the methodology for developing traffic growth rates and projecting future traffic volumes for the study area.

5.1 Future Traffic Growth Rates

Average annual daily traffic (AADT) volumes have remained constant or decreased slightly on the corridor since 2002. It is uncertain if the historically flat trend will continue or if the region will experience economic growth which could fuel traffic volume growth. The project team reviewed several sources of historical and projected traffic growth:

- VDOT's historical average annual traffic volumes (2002 through 2019)
- VDOT's Statewide Planning System (SPS) existing (2019) and future (2035) traffic volume projections

The historical AADT volumes show negative or very small (less than 0.5 percent per year) growth rates. The VDOT SPS projections show annual rates of change of 0.51 percent or less for the segments of the study corridor between Brays Fork and US 360 (Queen Street) and 0.52 percent for the Queen Street (US 360) bridge. The SPS projections show an annual rate of change of 1.07 percent for US 360 (Richmond Highway).

Based on the information listed above, the study work group agreed the following linear growth rates are acceptable:

- 0.5 percent per year for the study corridor between Brays Fork and the northern limits
- 1.0 percent per year for US 360 (Richmond Highway)
- 0.5 percent per year for all other intersecting streets

5.2 Future Development

Three specific projects are currently in the development pipeline and will increase traffic volumes on the corridor: a Wawa gas station and convenience market, a Hampton Inn, and Riverstone Apartments.

The proposed Wawa fuel station will have 16 fuel pumps and a 6,049 square foot convenience market. The proposed development will be located on an undeveloped parcel and is bounded by residential developments west of the intersection of US 17/360 (Tappahannock Boulevard) and White Oak Drive. The primary access point to/from the site will be via a proposed full-access entrance on the western leg of the intersection of Church Lane and White Oak Drive. The trip generation and distribution were based on the assumptions provided in the traffic study along with a 75 percent pass-by rate.

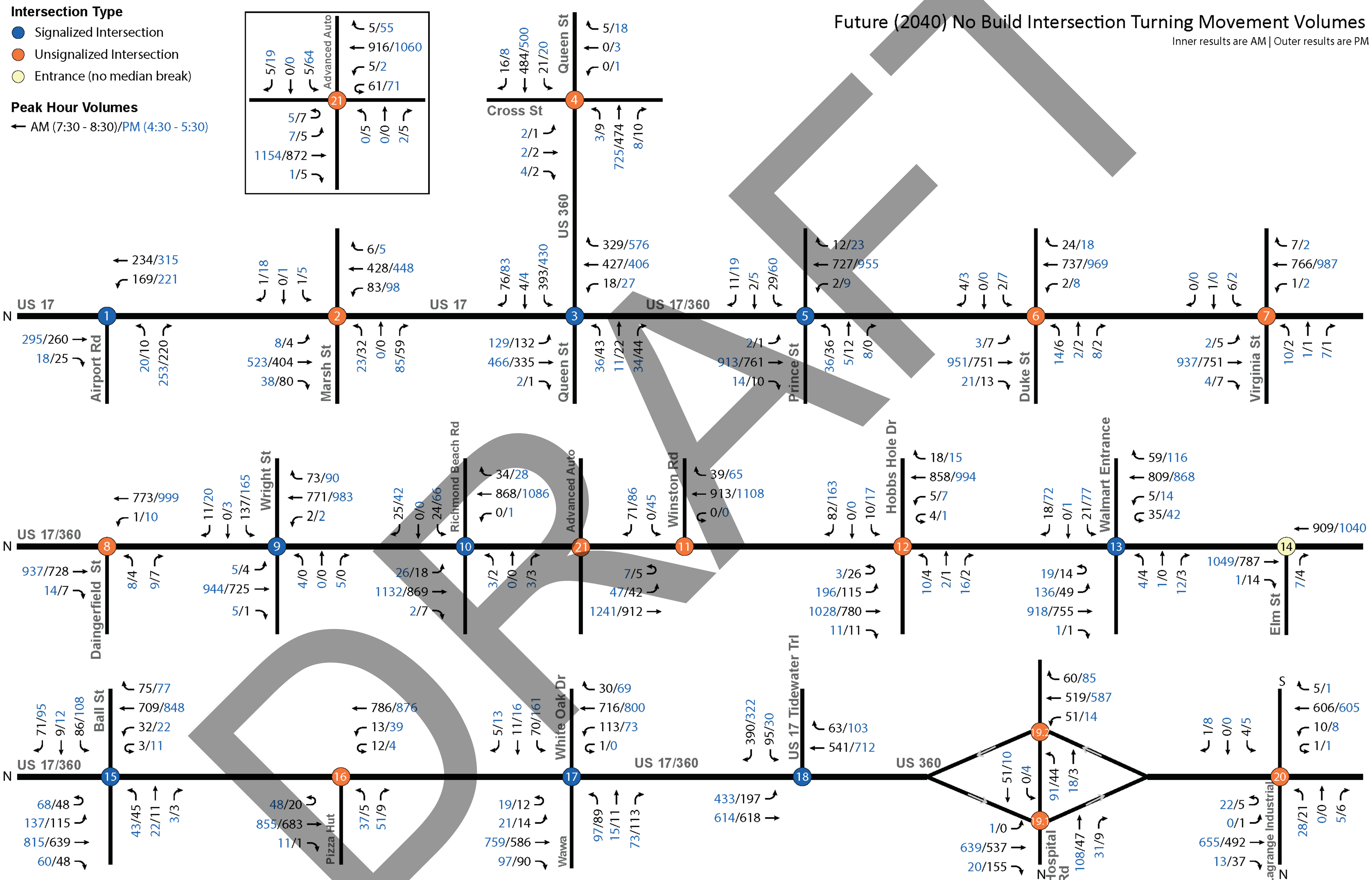
The Hampton Inn will have 87 rooms and be located on the west side of US 17/360 (Tappahannock Boulevard) between Hobbs Hole Drive and Winston Road. Full access entrances to the site will be provided on both Hobbs Hole Drive and Winston Road. The trip generation for this project was based on the *Institute of Transportation Engineers Trip Generation Manual, 10th Edition* for land use code 310, hotel. The distribution was based on existing traffic patterns.

Riverstone Apartments will have 144 units and be located on the east side of Hobbs Hole Drive, opposite and to the north of White Oak Drive. Two full access entrances to the site will be provided on Hobbs Hole Drive. The trip generation for this project was based on the *Institute of Transportation Engineers Trip Generation Manual, 10th Edition* for land use code 220, apartment. The distribution was based on existing traffic patterns.

5.3 Projected 2040 Traffic Volumes

The project team applied the linear traffic growth rates to the 2021 existing AM and PM peak hour turning movement volumes and added the trips from the three developments to generate projected 2040 traffic volumes. **Figure 33** shows the 2040 peak hour turning movement volumes for the Future No-Build analysis.

Figure 33: 2040 Future No-Build AM and PM Peak Hour Turning Movement Volumes



6 Future No-Build Conditions Analysis

Traffic operational analyses were conducted to evaluate the overall performance of the study corridor under No-Build (2040) AM and PM peak hour conditions and to identify any significant differences from the existing conditions. The No-Build conditions analyses provide a general understanding of baseline future traffic conditions as a starting point for comparing against future improvement strategies. No-Build traffic conditions were modeled using Synchro and SimTraffic, Version 10. The safety issues identified in the existing conditions analysis are anticipated to remain, except for crashes at the locations identified in ***Section 6.1***. Generally, as traffic volumes increase, safety issues at locations with no background improvements may be exacerbated.

6.1 Background Improvements

VDOT has plans to make improvements at two intersections in the study area and modifications are planned at the intersection of White Oak Drive in conjunction with the new Wawa gas station. The following improvements have been or are projected to be completed before 2040 and were included in the 2040 No-Build Synchro models.

- Winston Road: Modification of the existing median opening to an RCUT
- Queen Street: Restriping of the westbound approach extending turn lanes, an increase to the right turn radius, reconstruction of entrances to the parking lot on the north side, relocation and reconstruction of pedestrian amenities on the north side with ADA compliant curb ramps
- White Oak Drive: Modification of the traffic signal to include signal heads and phasing adjustments for the new Wawa gas station entrance (eastbound approach)
- Corridorwide: Signal timings and offsets were optimized to reflect the planned ATSPM implementation

As a result of the RCUT at Winston Road, the full median opening immediately to the north that aligns with the Advanced Auto Parts entrance was added to the models in order to analyze the shift in traffic volumes resulting from the restricted movements at the Winston Road RCUT.

6.2 Traffic Analysis Assumptions

The existing conditions Synchro models were used as a basis to develop the No-Build models for the AM and PM peak hour conditions. The geometric and traffic signal timing changes listed in ***Section 6.1*** were incorporated and the models were updated with projected 2040 No-Build traffic volumes. Inputs, analysis methodologies, and calibration approaches were consistent with the TOSAM.

6.3 Traffic Analysis Results

Figures 34 and 35 provide the results of the analysis of future No-Build peak hour traffic conditions. **Figure 34** shows the average control delays and corresponding levels of service. **Figure 35** provides the queue lengths and indicates movements where the queue length exceeds the existing and effective storage bay lengths. Where the 95th percentile queue lengths found in Synchro indicated a queuing concern the maximum queue lengths from SimTraffic are reported. All outputs from Synchro and SimTraffic are provided in **Appendix G.**

Similar to the existing conditions analysis, the future No-Build analysis reveals significant congestion issues at the intersection of Queen Street and Church Lane only. Minor delays are expected for a number of left turn and side street movements and some queues are expected to extend beyond the provided storage areas, but largely the study area intersections are expected to operate well in 2040.

6.3.1 Control Delay and Level of Service Results

The control delay and level of service results, shown in **Figure 34**, indicate that all intersections are projected to operate at overall LOS C or better in both the AM and PM peak hours.

The following approaches and movements were projected to operate at LOS E or F in the AM or PM peak hour. Approaches that operated at or better than LOS E in existing conditions are italicized. Additionally, several left-turn movements on US 17/360 are expected to operate at LOS F.

- *At Airport Road the eastbound left turn movement is expected to operate at LOS F in the PM peak hour.* The volume of vehicles making this left turn is only 20 vehicles in the PM peak hour, which can be considered a negligible effect.
- *At Queen Street the westbound left turn movement is expected to operate at LOS E in the AM and PM peak hours.*
- *At Prince Street the eastbound and westbound approaches are expected to operate at LOS E in the AM and PM peak hours.*
- *At Wright Street the westbound approach is expected to operate at LOS E in the PM peak hour.*
- *At Richmond Beach Road the southbound left turn (and U-turn) movement is expected to operate at LOS F in the AM peak hour.*
- *At Hobbs Hole Drive the eastbound approach is expected to operate at LOS E in the PM peak hour.*
- At Ball Street the *eastbound approach* is expected to operate at LOS E in the PM peak hour, the *westbound shared left turn and through movement* is expected to operate at LOS E in the AM peak hour, and the northbound left turn (and U-turn) movement is expected to operate at LOS E in the AM peak hour.
- At White Oak Drive, the southbound left turn (and U-turn) is expected to operate at LOS E in the PM peak hour.

6.3.2 Queue Length Results

Also similar to existing conditions, queue lengths extend back to the prior intersection at the locations listed below. Movements that did not have significant queue lengths in existing conditions are italicized.

- At the intersection of Queen Street and US 17, the westbound, northbound, and *southbound* queues are expected to extend to the adjacent intersections in both the AM and PM peak hours.
- *At the intersection of Prince Street and US 17 the northbound queue from Queen Street is expected to extend through the intersection and cause the northbound queue at Prince Street to extend through Duke Street in both the AM and PM peak hours.*
- At the Wright Street intersection, the distance between Wright Street and Daingerfield Street is less than 150 feet. The SimTraffic results indicate the southbound queue at Wright Street is expected to extend back past Daingerfield Street.
- At the US 17/360 interchange at Brays Fork (Intersection #18), the queue on the eastbound approach of US 360 continuing on to US 17/360 is expected to extend back to the intersection of Hospital Road.
- The queuing issues described at Wright Street and the US 17/360 interchange at Brays Fork are due to inadequate access spacing, not congestion. The only location with expected congestion issues in the study corridor is the intersection of Queen Street and US 17.

FIGURE 34: 2040 FUTURE NO-BUILD PEAK HOUR TRAFFIC OPERATING CONDITIONS – CONTROL DELAYS (SECONDS PER VEHICLE) AND LEVELS OF SERVICE

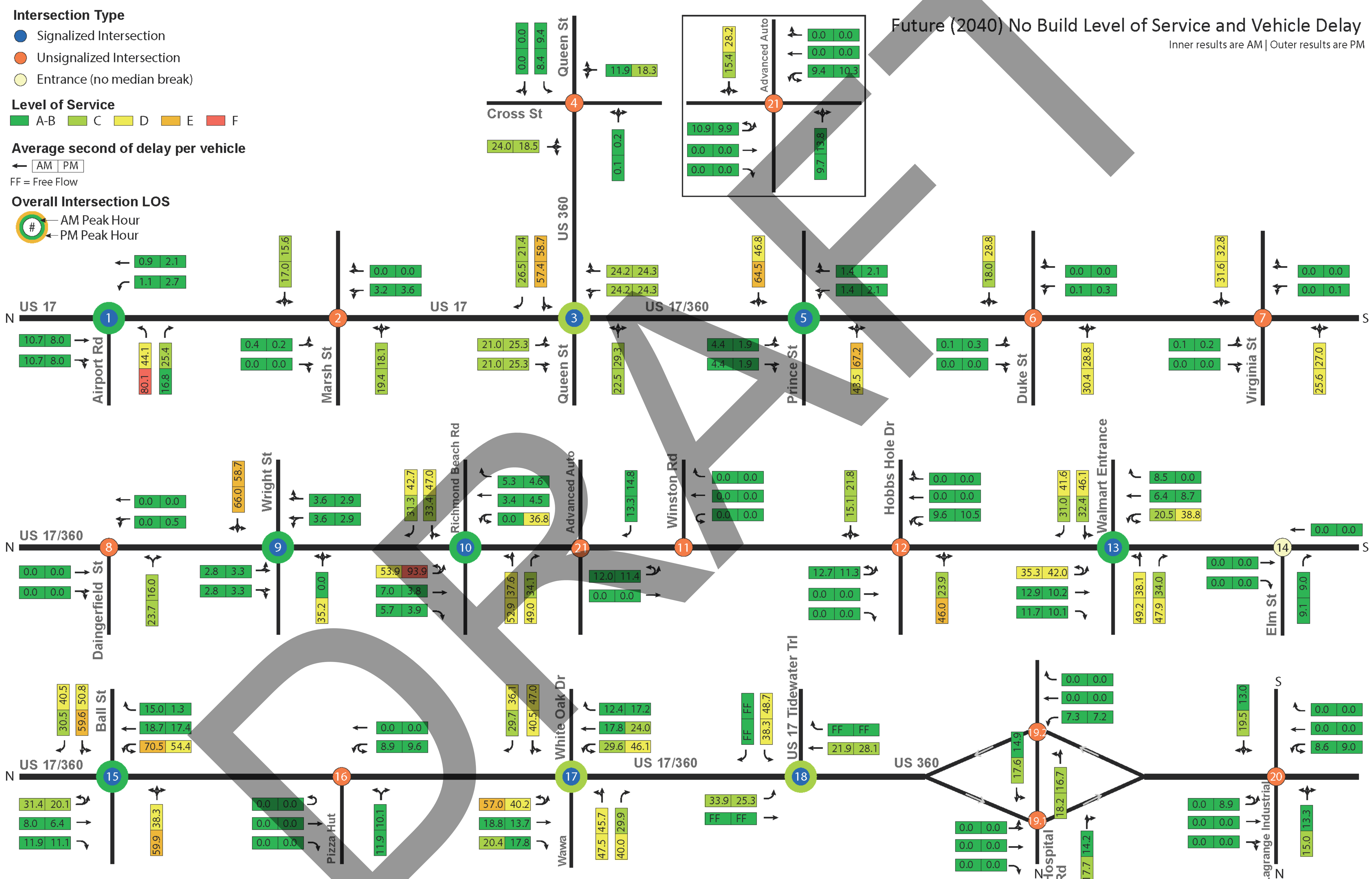
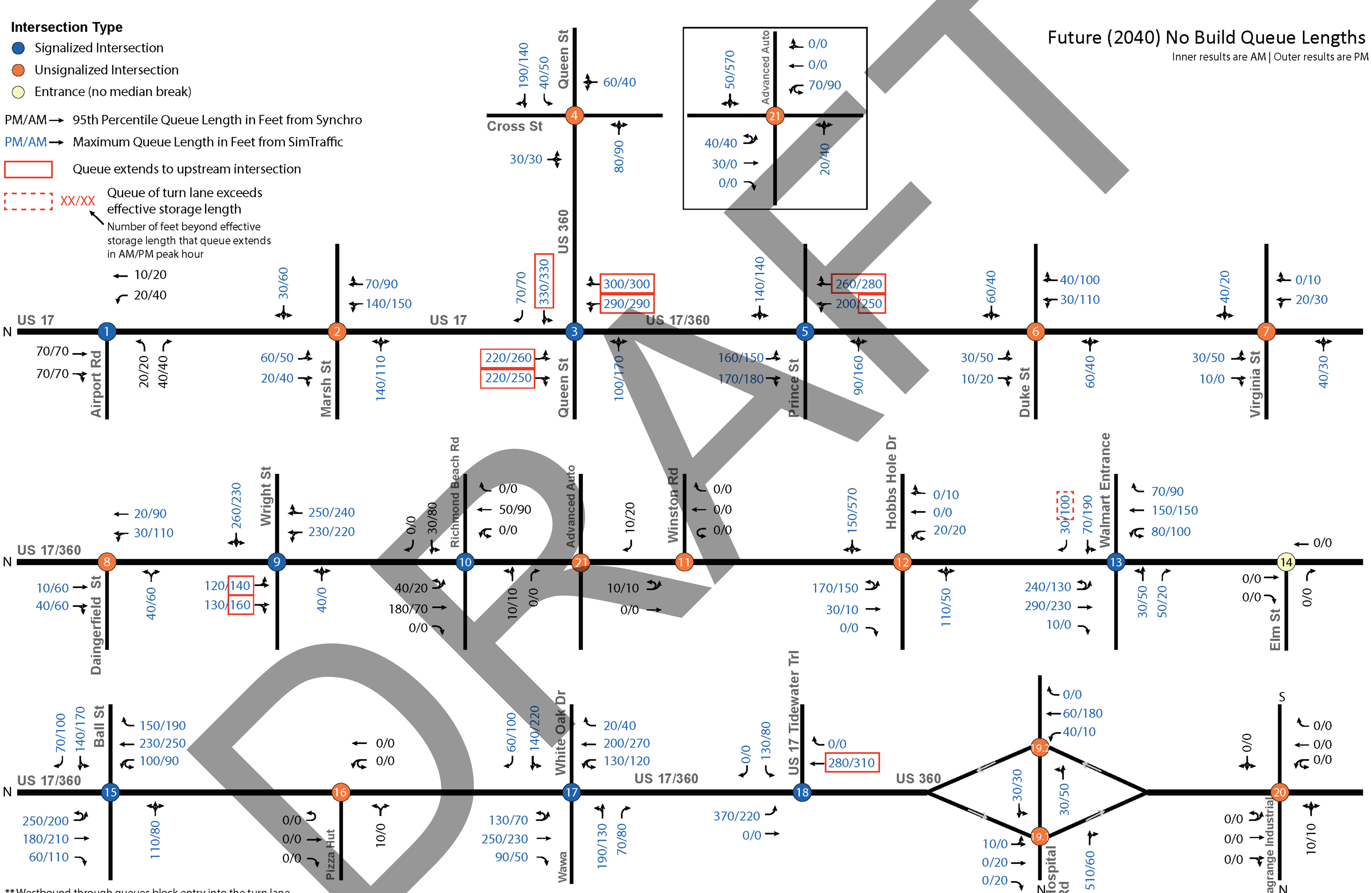


FIGURE 35: 2040 FUTURE NO-BUILD PEAK HOUR TRAFFIC OPERATING CONDITIONS – MAXIMUM QUEUE LENGTHS (FEET)



** Westbound through queues block entry into the turn lane

7 Developing and Refining the Potential Improvements

After identifying the safety and congestion issues, the study team developed, tested, and refined a range of potential improvements to address the issues. This chapter describes the process to develop and refine the potential improvements.

7.1 Developing the Potential Improvements

When considering potential improvements, the study corridor was broken into three distinct areas, each with its unique characteristics and needs:

1. Downtown Tappahannock
2. South of Hoskins Creek
3. Brays Fork

The project team and study work group developed a range of potential improvements to improve deficiencies based on four major themes:

1. Improve safety
2. Reduce congestion
3. Improve access spacing
4. Accommodate pedestrian and bicyclist activity

These four major themes are interrelated so many of the potential improvements address more than one theme. For example, reconfiguring a signalized intersection to reduce the number and severity of conflict points would both improve safety by reducing crash potential and decrease congestion by allocating more green time to fewer signal phases. Similarly, constructing sidewalks and installing crosswalks and pedestrian countdown signals would both accommodate pedestrian activity and improve pedestrian safety.

Several of the potential improvements involve limiting the number and type of turning movements to reduce conflict points and decrease crash potential. **Figure 36** illustrates how converting a typical full access intersection to a directional median opening or to a right-in/right-out only entrance reduces the number and severity of conflict points.

7.1.1 Downtown Tappahannock

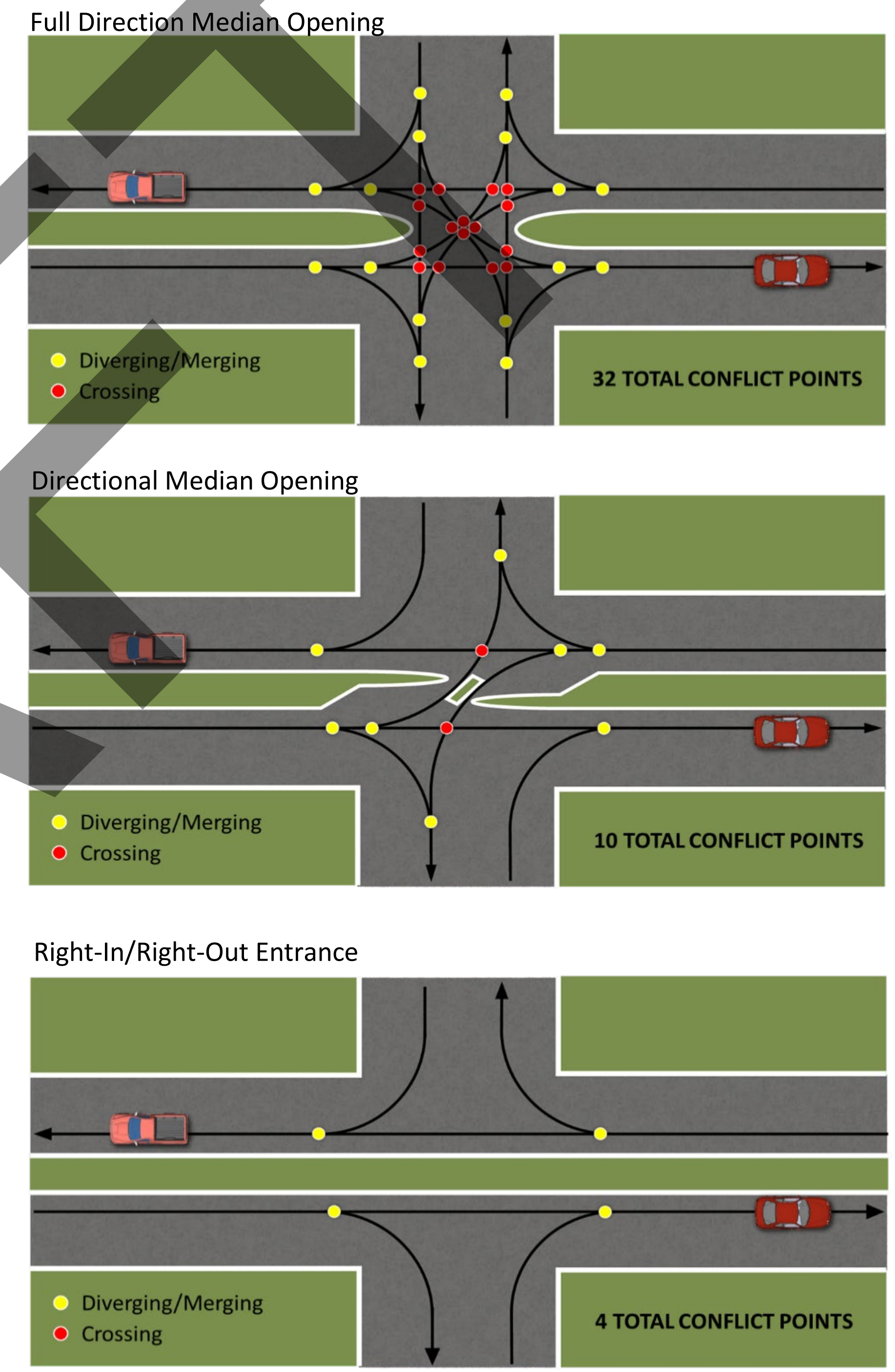
Table 7 describes the potential improvements identified and considered in Downtown Tappahannock. In general, the potential improvements included:

- Changing intersection lane configurations
- Rerouting select turning movements to reduce the number of conflict points, minimize crash potential, increase signal efficiency, and reduce the queues
- Reducing the number of lanes on constrained Church Lane from four lanes to three lanes to give more width to narrow lanes and provide more space between the sidewalk and travel lanes

The study team also considered several additional variations of the concepts in **Table 7** with slight differences in signal phasing, intersection lane configuration, and traffic control.

The study team tested these concepts using Synchro and SimTraffic 10 to examine intersection level of service, control delay, and queue lengths compared to future No-Build conditions. **Table 7** summarizes the results from this preliminary testing. The initial concepts and preliminary test results were shared with the study work group. The presentation slides from that meeting are provided in **Appendix H** and contain graphics and additional information on the potential improvements.

Figure 36: Conflict Point Diagrams by Type of Median Opening



Based on the preliminary test results, two concepts for the Downtown Tappahannock area were advanced for further testing and refinement—the Quadrant Roadway 2 and the One-Way Grid. ***Section 7.2*** describes how these concepts were refined.

TABLE 7: CONCEPTS CONSIDERED FOR DOWNTOWN TAPPAHANNOCK

	Conventional Turn Lane Improvements	Road Diet 1: One Lane Each Way	Road Diet 2: Two Northbound Lanes	Quadrant Roadway 1	Quadrant Roadway 2	Quadrant Roadway 3	One-Way Grid
Concept Description	• Church Lane remains 2 lanes in each direction. • Two left lanes for westbound left turns from Queen Street to southbound Church Lane. • Eastbound Queen Street approach is converted to a right-in/right-out only configuration.	• One through lane in each direction on Church Lane with turn lanes at intersections between Marsh Street and Virginia Street. • More width for pedestrian accommodations. • Remove traffic signal at Prince Street.	• Church Lane northbound remains two through lanes. • Southbound Church Lane has one travel lane between Marsh Street and Virginia Street. • More width for pedestrian accommodations. • Remove traffic signal at Prince Street.	• Northbound and southbound vehicles on Church Lane use Duke Street and Cross Street to access the Downing Bridge. • Prohibit northbound and southbound turns from Church Lane onto eastbound Queen Street. • Relocate traffic signal at Prince Street to Duke Street. • Modify roadway at Cross Street and Duke Street to a curve to accommodate large trucks. • Convert eastbound Queen Street approach to right-in/right-out only.	• Northbound vehicles on Church Lane use Duke Street and Cross Street to access the Downing Bridge. • Prohibit northbound turns from Church Lane onto Queen Street. • Southbound approach of Church Lane at Queen Street remains unchanged. • Relocate traffic signal at Prince Street to Duke Street. • Modify roadway at Cross Street and Duke Street to a curve to accommodate large trucks. • Convert eastbound Queen Street approach to right-in/right-out only.	• Northbound vehicles on Church Lane use Duke Street and Cross Street to access the Downing Bridge. • Vehicles coming from the bridge and going south use Cross Street and Duke Street. • Prohibit northbound turns from Church Lane onto Queen Street. • Prohibit westbound left turns from Queen Street at Church Lane. • Southbound approach of Church Lane at Queen Street remains unchanged. • Relocate traffic signal at Prince Street to Duke Street. • Relocate traffic signal at Queen Street and Church Lane to Queen Street at Cross Street. • Modify roadway at Cross Street and Duke Street to a curve to accommodate large trucks. • Convert eastbound Queen Street approach to right-in/right-out only.	• Convert three blocks of downtown to a series of one-way streets. • Southbound Church Lane becomes one-way between Queen Street and Virginia Street. • Northbound Cross Street becomes one-way between Queen Street and Virginia Street. • Westbound Queen Street and Duke Street become one-way between Church Lane and Cross Street. • Eastbound Prince Street and Virginia Street become one-way between Church Lane and Cross Street. • Relocate traffic signal at Prince Street to the intersection of Queen Street and Cross Street.
Issues Addressed	• Westbound Queen Street queue does not back up to Cross Street. • Simplifies confusing eastbound Queen Street approach.	• Provides more width for narrow travel lanes on Church Lane. • Provides space for buffer to separate pedestrians from traffic on Church Lane. • Eliminates 'multiple threat' situation that causes side-street left turn crashes.	• Provides more width for narrow travel lanes on Church Lane. • Provides space for buffer to separate pedestrians from traffic on Church Lane.	• Reduces the number of conflict points and crash potential at the intersection of Church Lane and Queen Street. • Simplifies signal phasing at the Church Lane and Queen Street intersection, reducing congestion and queue lengths. • Provides space for buffer to separate pedestrians from traffic on Church Lane between Queen Street and Duke Street.	• Reduces conflict points and crash potential at the intersection of Church Lane and Queen Street. • Simplifies signal phasing at the Church Lane and Queen Street intersection, reducing congestion and queue lengths. • Provides space for buffer to separate pedestrians from traffic on Church Lane between Queen Street and Duke Street.	• Reduces the number of conflict points and crash potential at the intersection of Church Lane and Queen Street. • Simplifies signal phasing at the Church Lane and Queen Street intersection, reducing congestion and queue lengths. • Provides space for buffer to separate pedestrians from traffic on Church Lane between Queen Street and Duke Street.	• Reduces the number of conflict points and crash potential at the intersection of Church Lane and Queen Street. • Simplifies signal phasing at the Church Lane and Queen Street intersection, reducing congestion and queue lengths. • Provides space for buffer to separate pedestrians from traffic on Church Lane between Queen Street and Duke Street.
Preliminary Results	• Dual westbound left turn lanes cannot accommodate simultaneous truck turns. • Westbound Queen Street queue decreases, no longer blocking the Cross Street intersection. • Does not reduce queues on northbound and southbound Church Lane. Northbound Church Lane queue still extends beyond Duke Street.	• Queue lengths on all approaches increase, blocking upstream intersections. • Northbound queue on Church Lane doubles in length, extending past Virginia Street.	• Northbound Church Lane queue decreases, but still blocks the Prince Street intersection. • Westbound Queen Street queue length increases to Water Lane. • Southbound Church Lane queue length increases past Marsh Street.	• Queue lengths on all approaches at the intersection of Church Lane and Queen Street decrease by about half. • Circuitous route for southbound vehicles heading to the Downing Bridge. • Requires right-of-way acquisition at the intersection of Cross Street and Duke Street. • Significant increase in traffic (11-15 times greater than No Build) and large trucks on Cross Street.	• Queue lengths on all approaches at the intersection of Church Lane and Queen Street decrease by about half. • Requires right-of-way acquisition at the intersection of Cross Street and Duke Street. • Significant increase in traffic (8-13 times greater than No Build) and large trucks on Cross Street.	• Queue lengths on all approaches at the intersection of Church Lane and Queen Street decrease by more than half. • Requires right-of-way acquisition at the intersection of Cross Street and Duke Street. • Significant increase in traffic (19-23 times greater than No Build) and large trucks on Cross Street.	• Decreases queue lengths on all approaches to avoid backing up to adjacent intersections.
Advanced for Further Testing?	No	No	No	No	Yes	No	Yes

7.1.2 South of Hoskins Creek

As described in previous sections, the existing and future No-Build analysis results revealed safety deficiencies at two intersections in the section of US 17/360 from Richmond Beach Road to White Oak Drive:

- US 17/360 (Tappahannock Boulevard) at Ball Street
- US 17/360 (Tappahannock Boulevard) at Winston Road

Additionally, the lack of sidewalks or paths and crosswalks for pedestrians in this section was identified as a deficiency in the existing conditions analysis. The responses to the online survey reiterated safety issues at the intersection of US 17/360 at Ball Street, as well as congestion, access spacing, and pedestrian and bicycle issues in this section.

7.1.2.1 US 17/360 at Ball Street

The study team considered several potential improvements to address safety deficiencies at the Ball Street intersection:

- Converting the intersection to a Median U-Turn (MUT)
- Converting the intersection to a Restricted Crossing U-Turn (RCUT)
- Conventional turn lane improvements
- Signal phasing and timing changes
- Crosswalks and pedestrian signals

The MUT configuration would eliminate the left turn lanes, reduce conflict points, and greatly reduce the potential for angle crashes at the Ball Street intersection. It would also lessen crash potential at the Sycamore Drive intersection, as vehicles coming from Sycamore Drive would not try to access the southbound left turn lane. However, it would reroute left turns to U-turns at downstream intersections. The heavy southbound left turn and U-turn traffic volumes at Ball Street would be rerouted to the unsignalized median opening to the south at the Pizza Hut. Adding the rerouted left turns and U-turns to this median opening would likely require installing a new traffic signal. For this reason, the Median U-Turn concept was not advanced for further consideration.

The RCUT configuration, illustrated conceptually in **Figure 37**, would place a barrier in the median opening to allow left turns from US 17/360 and direct all side-street traffic to make a right turn. Vehicles on the side-streets wanting to turn left or go straight through would turn right and make a U-turn at the next median opening. This is the same configuration recently constructed at the intersection of US 17/360 and Winston Road. The RCUT configuration reduces the number of conflict points from 32 to 18, including conflict points at the downstream U-turn locations, shown in **Figure 38**. As a result, the RCUT concept was advanced for further consideration.

Conventional turn lane improvements and signal phasing and timing changes alone provide limited benefits at the Ball Street intersection. These types of improvements were considered and incorporated into the RCUT concept, along with additional entrance configuration improvements. Crosswalks and pedestrian signals were considered at this intersection and advanced to the RCUT concept.

As a result of the analyses and intersection configurations considered above, an additional concept evolved for consideration. This concept included modifying the eastbound McDonald's approach for ingress only with signal phasing and timing changes and pedestrian improvements. This concept was also advanced for further consideration.

7.1.2.2 US 17/360 at Winston Road

As mentioned previously in ***Section 4.2.2.4***, most crashes at the intersection of US 17/360 and Winston Road resulted from vehicles attempting to turn left from Winston Road to head south on US 17/360. This intersection was recently converted to an RCUT configuration to reroute left turns from Winston Road to instead make a right turn and then a U-turn. This configuration, while requiring a slightly longer travel path, reduces crash potential. The RCUT configuration addresses the most prominent safety issue at this intersection.

FIGURE 37: RESTRICTED CROSSING U-TURN (RCUT)

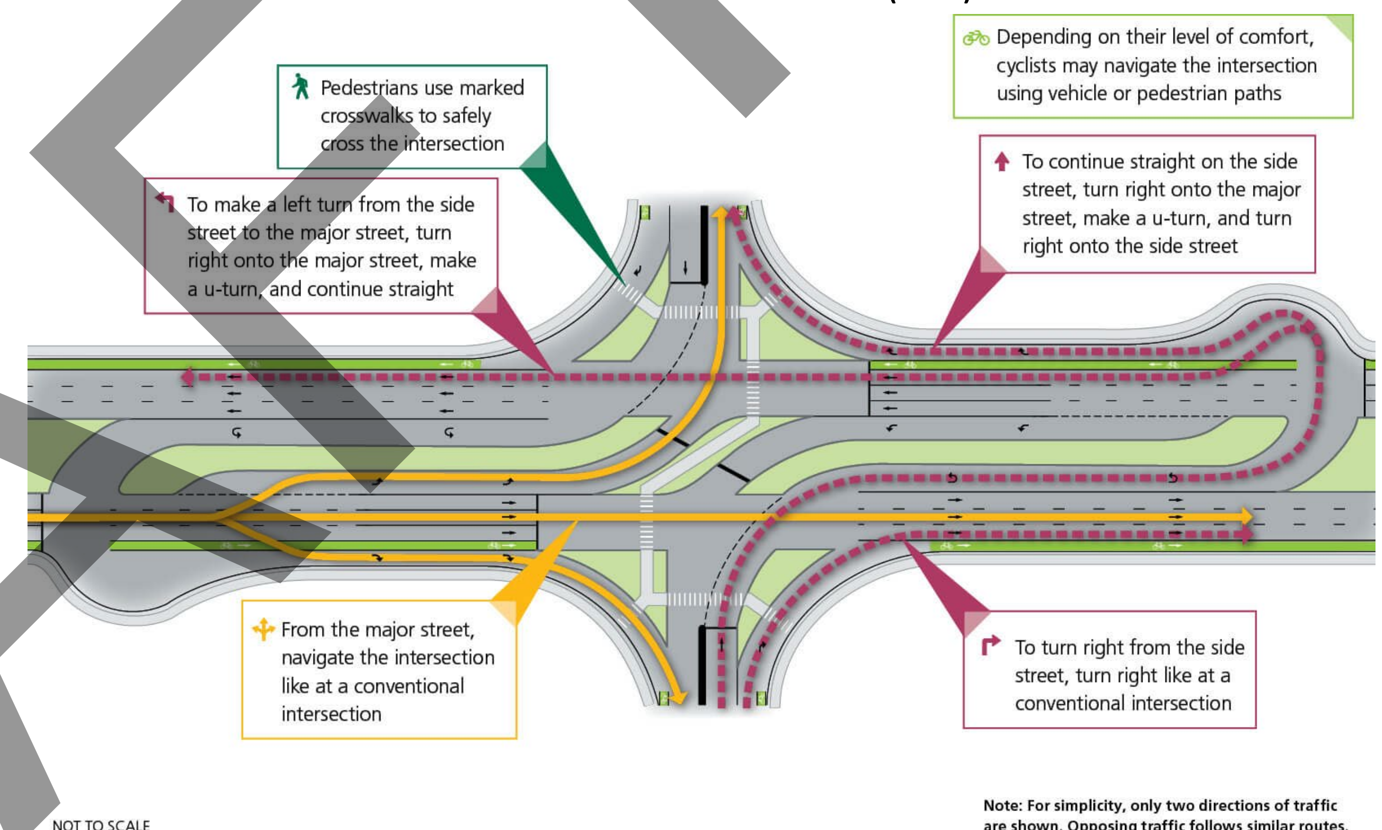
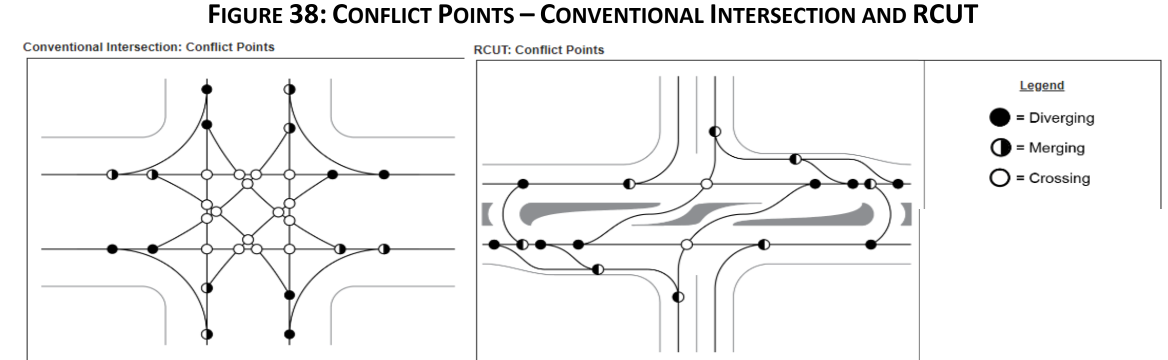


FIGURE 38: CONFLICT POINTS – CONVENTIONAL INTERSECTION AND RCUT



Conflict Type	Count
Crossing	16
Merging	8
Diverging	8
Total:	
32 Conflicts	

Conflict Type	Count
Crossing	2
Merging	8
Diverging	8
Total:	
18 Conflicts	

7.1.2.3 Other Intersections

If an RCUT were to be implemented at the intersection of US 17/360 and Ball Street, the side street left turns and through movements would be re-routed to adjacent intersections.

As shown in **Appendix F**, the spacing between full-access median openings on US 17/360 between Richmond Beach Road and White Oak Drive generally does not meet the required distances. The study team considered applying the RCUT directional median configuration to other intersections throughout this section of US 17/360, which would bring the spacing of the median openings closer to compliance with the required distances. A consistent series of RCUTs and directional median openings would also improve driver expectation, and better accommodate the rerouted movements from the Ball Street intersection.

The concept of a series of RCUTs and directional median openings was advanced for further testing and refinement, as explained further in ***Section 7.2.2***.

7.1.3 Brays Fork

Four potential improvements were identified and considered for the intersection at Brays Fork, just south of the Town of Tappahannock limits, where US 17 (Tidewater Trail) intersects with US 360 (Richmond Highway), as outlined in **Table 8**.

Two of the four concepts were advanced for further testing and refinement—the three-leg roundabout and the continuous green-T. ***Section 7.2.3*** describes how these concepts were refined.

TABLE 8: CONCEPTS CONSIDERED FOR BRAYS FORK

	Four-Leg Roundabout	Three-Leg Roundabout	Continuous Green-T	Access Modifications
Concept Description	• Signalized intersection is replaced with a roundabout located closer to Hospital Drive. • The intersection of Hospital Drive and US 360 is included in the roundabout as its fourth leg. • The four legs of the roundabout are: 1. US 17/360 (Tappahannock Boulevard) from the east 2. US 17 (Tidewater Trail) from the south 3. US 360 (Richmond Highway) from the west 4. Hospital Drive from the north • The first three approaches listed above have free-flow right turn lanes.	• Signalized intersection is replaced with a roundabout at the location of the current traffic signal. • Hospital Drive remains a separate intersection to the west on its current alignment. • The roundabout has three legs: 1. US 17/360 (Tappahannock Boulevard) from the east 2. US 17 (Tidewater Trail) from the south 3. US 360 (Richmond Highway) from the west • The first two approaches listed above have free-flow right turn lanes.	• Existing signalized intersection is reconfigured to a more conventional T intersection alignment. • The intersection remains signalized. • Northbound US 17 vehicles continuing to northbound US 17/360 into Tappahannock remain a free-flow movement. • The existing free-flow ramp for westbound US 17/360 vehicles continuing to westbound US 360 is eliminated. These vehicles proceed through the signalized intersection as a right turn. • The existing free-flow ramp for vehicles from US 360 continuing to southbound US 17 is relocated closer to the signalized intersection.	• Retain existing signalized intersection. • Close median opening on US 17/360 to the north. • Close median opening at Berry Hill Road and close off Berry Hill Road as a cul-de-sac. • Install new signs to direct northbound vehicles going to the hospital to proceed north on US 17/360 and U-turn at White Oak Drive.
Issues Addressed	• Improves safety and access to Hospital Drive for northbound vehicles. • Eliminates traffic signal.	• Improves safety and access to Hospital Drive for northbound vehicles. • Eliminates traffic signal. • Moves the merge point near Berry Hill Road further away, reducing crash potential.	• Improves safety and access to Hospital Drive for southbound vehicles. • Moves the merge point near Berry Hill Road further away, reducing crash potential.	• Improves access spacing. • Directs hospital-bound traffic from the south away from substandard merge.
Preliminary Results	• Operates with no significant delay nor queuing issues. All movements operate at LOS B or better. Queues are 300 feet or shorter. • Realignment of Hospital Drive would require right-of-way acquisition from adjacent property.	• Operates with no significant delay nor queuing issues. All movements operate at LOS C or better. Queues are 250 feet or shorter. • Retains more alignment with existing roadway than the four-leg roundabout.	• Operates with no significant delay nor queuing issues. All movements operate at LOS B or better. • Retains more alignment with existing roadway than the four-leg roundabout.	• Berry Hill Road does not connect to another access point to US 17. • Traffic operations are same as future No-Build conditions.
Advanced for Further Testing?	No	Yes	Yes	No

7.2 Refining the Potential Improvements

The study team further refined the potential improvements advanced from the preliminary testing and shared the refined potential improvements with the public. This section describes the refined potential improvements shared with the public. ***Section 7.3*** describes the public feedback.

Like the previous section, the potential improvements are organized into the three distinct areas:

1. Downtown Tappahannock
2. South of Hoskins Creek
3. Brays Fork

7.2.1 Downtown Tappahannock

Two concepts were refined and presented to the public:

1. One-Way Grid (e.g., One-Way Pairs)
2. Quadrant Roadway 2 (e.g., Partial Quadrant)

Both concepts convert the two-block section of Church Lane between Queen Street and Duke Street from four travel lanes to three travel lanes. These two blocks of Church Lane are extremely constrained by adjacent land development and narrow lanes. Reducing the number of travel lanes from four to three would allow for wider travel lanes to better accommodate large trucks and other wide vehicles. It also provides an opportunity to provide buffer space between the sidewalks and travel lanes.

Both concepts redirect traffic coming from the south and heading toward the Downing Bridge to turn right onto Duke Street and use Cross Street. This strategy removes some traffic from the constrained intersection at Church Lane and Queen Street and diverts them to other adjacent streets. Both concepts accommodate the future 2040 traffic volumes such that queues do not block upstream intersections on any approaches.

7.2.1.1 One-Way Pairs

The One-Way Pairs concept, shown in **Figure 39**, routes all northbound traffic away from Church Lane onto Cross Street between Queen Street and Duke Street. Vehicles coming from the south on Church Lane would turn right onto Duke Street, and then turn left onto Cross Street. Vehicles heading toward the Downing Bridge would turn right from Cross Street onto Queen Street. Vehicles continuing north on US 17 would turn left from Cross Street onto Queen Street and then turn right onto Church Lane.

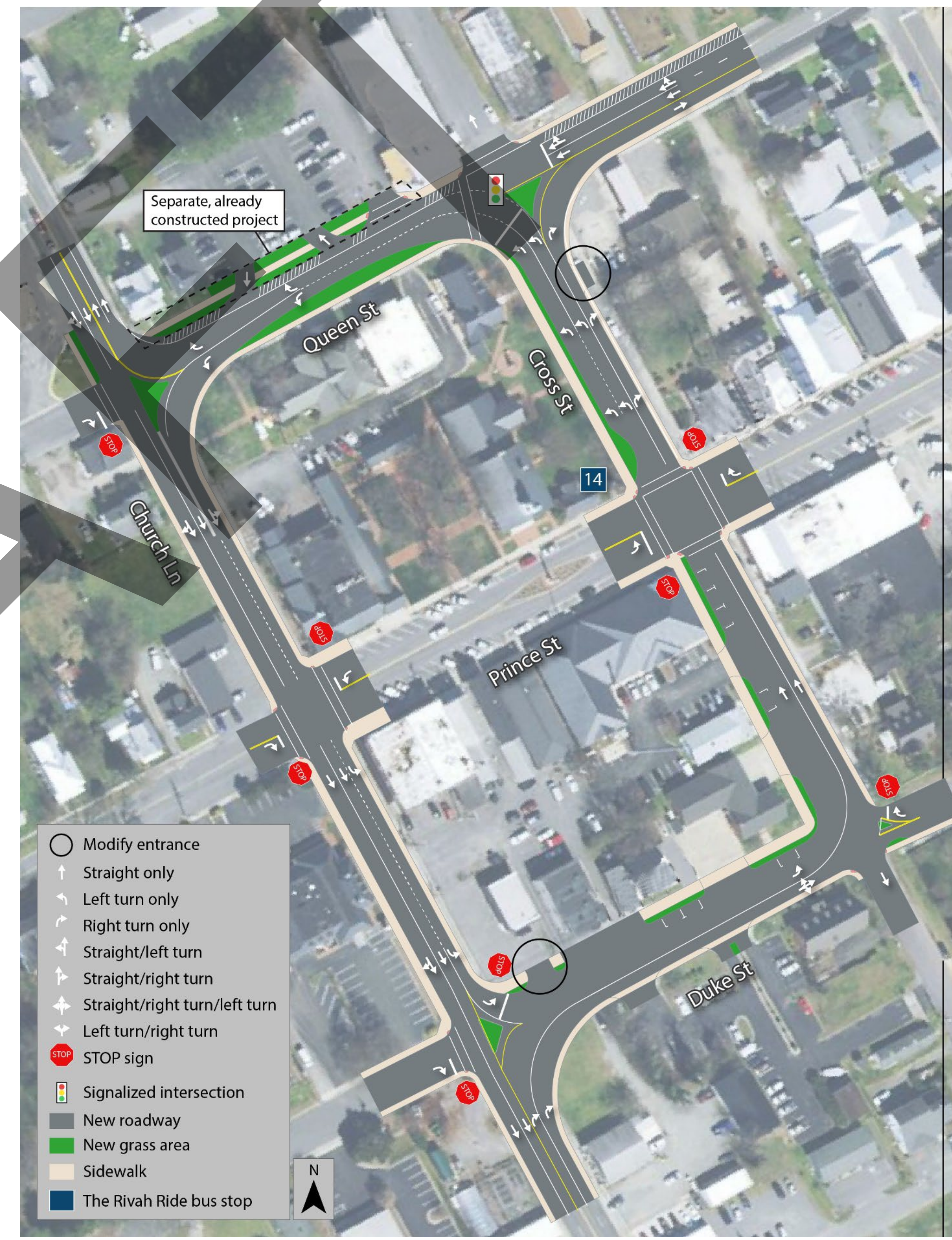
The One-Way Pairs concept would convert several streets in the two-block downtown core area to one-way:

- Church Lane becomes southbound only for two blocks between Queen Street and Duke Street
- Cross Street becomes northbound only for two blocks between Queen Street and Duke Street
- Queen Street becomes westbound only for one block between Church Lane and Cross Street
- Duke Street becomes eastbound only for one block between Church Lane and Cross Street
- Prince Street remains two-way

Church Lane would consist of three southbound lanes between Queen Street and Duke Street. This configuration would eliminate the substandard narrow lanes in this two-block section and provide adequately wide travel lanes to more safely accommodate large trucks and other wide vehicles. This configuration would also provide buffer space between the sidewalk and travel lanes.

The traffic signal at the intersection of Church Lane and Queen Street would be moved to the intersection of Queen Street and Cross Street. The traffic signal at Church Lane and Prince Street would be removed. Most of the existing on-street parking on Cross Street would be removed.

FIGURE 39: ONE-WAY PAIRS CONCEPT



7.2.1.2 Partial Quadrant

7.2.1.2.1 CROSS STREET PARTIAL QUADRANT

The Partial Quadrant concept, shown in **Figure 40**, routes traffic from the south and heading east on the Downing Bridge to turn right onto Duke Street, and then turn left onto Cross Street. Northbound right turns from Church Lane onto Queen Street would be prohibited. Vehicles continuing north on US 17 would stay on Church Lane.

By rerouting the vehicles coming from the south and heading over the bridge to Cross Street, northbound traffic on Church Lane can be accommodated with one travel lane. Church Lane would become three travel lanes in the two-block section between Queen Street and Duke Street, with two southbound lanes and one northbound lane.

Like the One-Way Pairs concept, the three-lane configuration on Church Lane in the Partial Quadrant concept would eliminate the substandard narrow lanes in this two-block section and provide travel lanes meeting design standards to more safely accommodate large trucks and other wide vehicles. This configuration would also provide buffer space between the sidewalk and travel lanes.

In the Partial Quadrant concept, the traffic signal at the intersection of Church Lane and Queen Street would remain. The traffic signal at the intersection of Church Lane and Prince Street would be moved to the intersection of Church Lane and Duke Street. Eastbound and westbound Prince Street approaches would be converted to right-in/right-out only operations.

Figure 40: Cross Street Partial Quadrant Concept

7.2.1.2.2 WATER LANE PARTIAL QUADRANT

An additional Partial Quadrant concept was developed based on input from Town of Tappahannock representatives. This concept, shown in **Figure 41**, uses Water Lane rather than Cross Street in an attempt to route as little additional traffic through the historic Downtown Tappahannock area as possible.

Like the Cross Street concept, the Water Lane concept routes traffic from the south heading east on the Downing Bridge to turn right onto Duke Street, and then turn left onto Water Street. As for the Cross Street Partial Quadrant concept, northbound right turns from Church Lane onto Queen Street would be prohibited. Vehicles continuing north on US 17 would stay on Church Lane.

Like the Cross Street concept, by rerouting vehicles from the south heading over the bridge to Cross Street, northbound traffic on Church Lane can be accommodated with one travel lane. Church Lane would become three travel lanes in the two-block section between Queen Street and Duke Street, with two southbound lanes and one northbound lane.

Like the One-Way Pairs concept, the three-lane configuration on Church Lane in the Partial Quadrant concept would eliminate the substandard narrow lanes in this two-block section and provide adequately wide travel lanes to more safely accommodate large trucks and other wide vehicles. This configuration would also provide buffer space between the sidewalk and travel lanes.

Like the Cross Street concept, the traffic signal at the intersection of Church Lane and Queen Street would remain. The traffic signal at the intersection of Church Lane and Prince Street would be moved to the intersection of Church Lane and Duke Street. Eastbound and westbound Prince Street approaches would be converted to right-in/right-out only operations.

Varying from the Cross Street concept, a new traffic signal would be added at the intersection of Queen Street and Water Lane. Also, this concept does not route westbound truck traffic traveling from the Downing Bridge to the south on Church Lane. This truck traffic would remain on Queen Street and turn left on Church Lane as it does today. The area needed for trucks to make the turning movements onto Water Lane and Duke Street would have significant right-of-way impacts.

FIGURE 41: WATER LANE PARTIAL QUADRANT CONCEPT

7.2.1.3 Downtown Alternatives Comparison

The study team compared a variety of factors for the three downtown alternatives. **Table 9** summarizes the comparison.

Each of the alternatives provides an improvement to safety, queuing, and pedestrian access. These improvements come at the expense of community cohesion, on-street parking, and control delay at Marsh Street. Each alternative is also expected to have right-of-way impacts on four parcels.

In addition to queue lengths and control delay, travel time was analyzed for the alternatives. Given the complex nature of the alternatives, travel time was determined to be a comprehensive measure of the effectiveness to compare the alternatives. **Figure 42** provides the results of the travel time analysis for the three alternatives. Generally, the alternatives reduce travel time except for movements where a circuitous route is required and for northbound traffic coming from the Downing Bridge.

TABLE 9: COMPARISON OF DOWNTOWN ALTERNATIVES

Alternative	Safety			Traffic Operations					Pedestrian Access		Community Impacts		
	Conflict Points			Queues		Control Delay (AM/PM) (expressed in seconds/vehicle)							
	Queen Street/ Church Lane	Queen Street/ Cross Street	Duke Street/ Church Lane	Through Adjacent Intersections	Northbound Queue from Queen Street	Overall Queen Street/ Church Lane	Westbound Queen Street at Church Lane Left and Thru	Eastbound Marsh Street	Sidewalks	Crosswalks	Parcels with ROW Impacts	Cohesion	On-Street Parking
No-Build	32	32	32	Yes	800’ (extends beyond Duke Street)	32/30	57/59	18/19	Narrow sidewalks with obstructions and sidewalk gaps remain same as today	No marked crosswalks or pedestrian signals crossing Church Lane	0	No change	No change
One-Way Pairs	3	2	4	No	240’ (on Cross Street)	NA	3/4	31/46	Provides more space for widening sidewalks and/or buffer between sidewalk and vehicle travel lane	No marked crosswalks or pedestrian signals crossing Church Lane	4	Cross Street will accommodate more through traffic, including large trucks	Some parking spaces on Cross Street and Duke Street will be removed
Cross Street Partial Quadrant	11	32	32	No	<190’	17/14	38/26	42/51	Provides more space for widening sidewalks and/or buffer between sidewalk and vehicle travel lane	Marked crosswalks and pedestrian signals for crossing at all 4 intersection legs	4	Cross Street will accommodate more through traffic, including large trucks	All parking spaces on Cross Street and some on Duke Street will be removed
Water Lane Partial Quadrant	11	7	32	No	<190’	14/14	25/19	43/61	Provides more space for widening sidewalks and/or buffer between sidewalk and vehicle travel lane	Marked crosswalks and pedestrian signals for crossing at all 4 intersection legs	4	Water Lane will accommodate more through traffic, including large trucks	All parking spaces on Water Lane and some on Duke Street will be removed

NA – not available

FIGURE 42: DOWNTOWN ALTERNATIVES TRAVEL TIME COMPARISON

7.2.1.4 Short-Term Improvements and Commerce Drive Connection

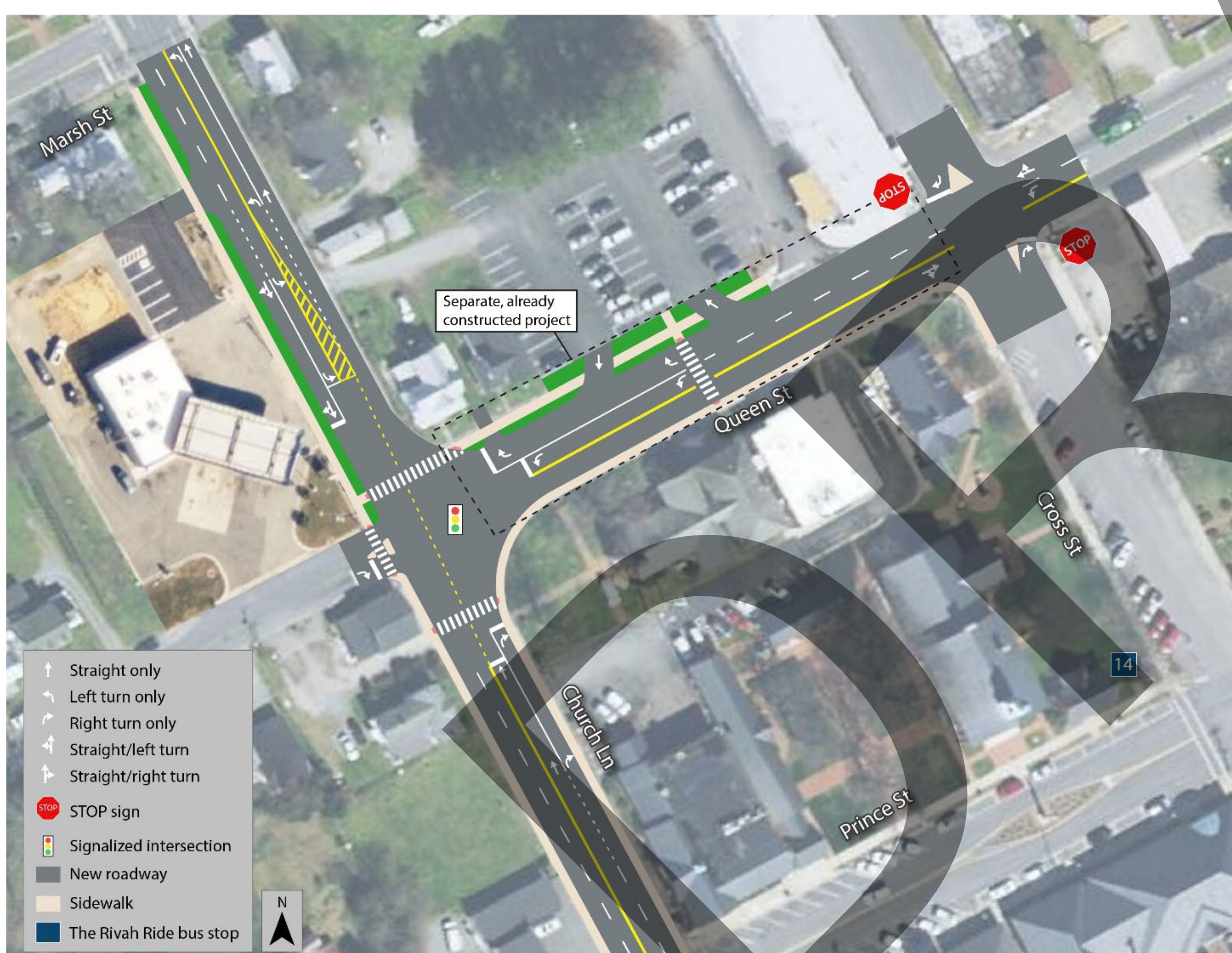
Upon consideration of the survey responses and public meeting discussion, the study team recognized that the Downtown Tappahannock concepts presented were not likely to be pursued further based on the significant impacts to the historic area of Downtown Tappahannock. To improve safety and traffic operations an additional concept was developed.

The Short-Term Improvements concept, shown in **Figure 43** and **Figure 44**, focuses on changing lane configurations to improve operations, adding channelizing islands to improve safety, installing improved pedestrian features, modifying access, and connecting Marsh Street to Airport Road.

The locations where modified lane uses are recommended include:

- Northbound Church Lane at Marsh Street: northbound shared through/left-turn lane becomes an exclusive left-turn lane
- Southbound Church Lane at Queen Street: southbound shared through/left-turn lane becomes an exclusive left-turn lane
- Northbound Church Lane at Queen Street: northbound shared through/right-turn lane becomes an exclusive right-turn lane

FIGURE 43: SHORT-TERM IMPROVEMENTS NORTHERN AREA



Channelizing islands are recommended to reduce conflict points at the following locations:

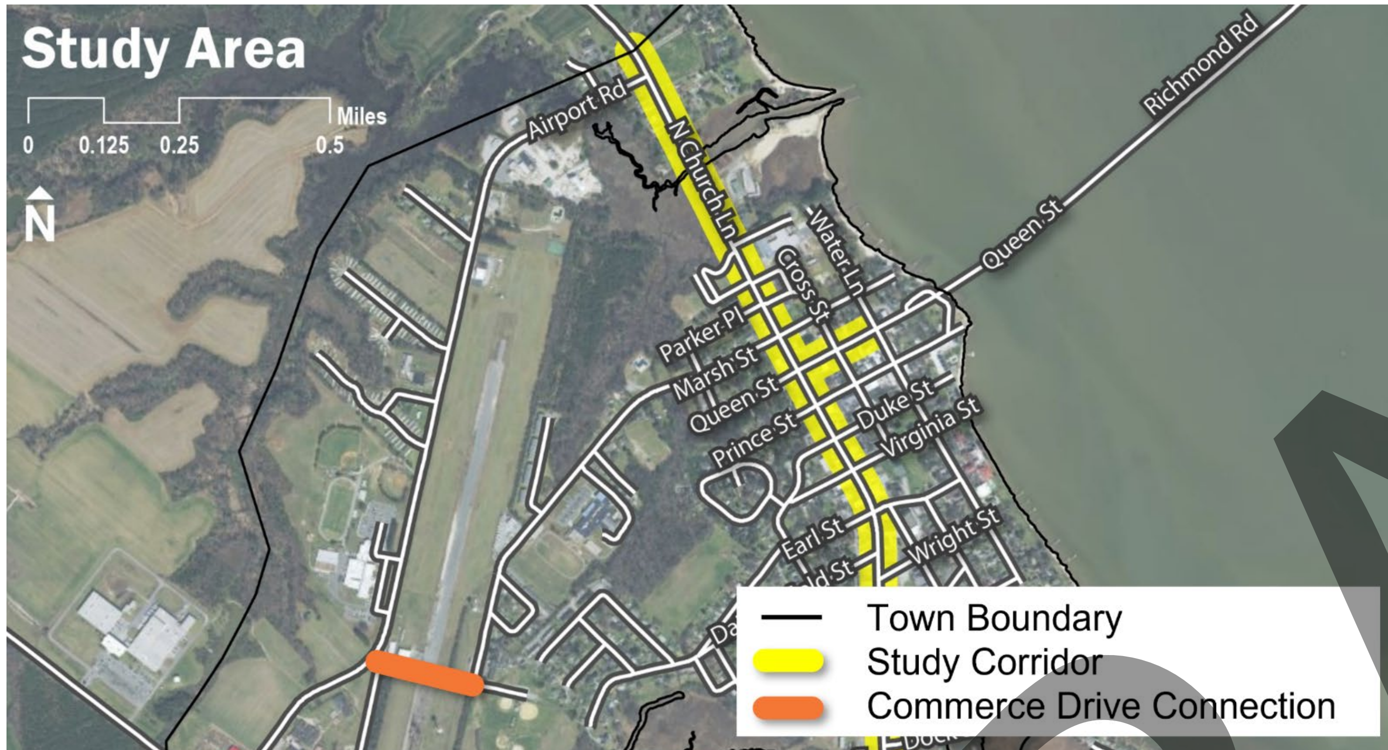
- Church Lane and Queen Street intersection: eastbound approach right-in/right-out only
- Queen Street and Cross Street intersection: northbound approach right-in/right-out/left-in only and southbound approach right-in/right-out only
- Church Lane and Duke Street intersection: eastbound and westbound approaches right-in/right-out only
- Church Lane and Virginia Street intersection: eastbound and westbound approaches (markings only) right-in/right-out only

In addition to these traffic operations improvements, pedestrian crosswalks, curb ramps, and traffic signals are recommended at the intersection of Church Lane and Queen Street. Access modifications to the gas station on the northwest corner of the intersection allow for an improved sidewalk providing better pedestrian access.

FIGURE 44: SHORT-TERM IMPROVEMENTS SOUTHERN AREA

The Commerce Drive connection between Marsh Road and Airport Drive, shown in **Figure 45**, enhances the current Downtown Tappahannock roadway network by offering another route from Marsh Street. Today access to Marsh Street is provided solely via Church Lane. This connection also provides a connection between Essex Intermediate School and Essex High School allowing buses to move between the schools more efficiently.

FIGURE 45: COMMERCE DRIVE CONNECTION



7.2.2 South of Hoskins Creek

The study team refined the concept of a series of RCUTs and directional median openings for this section, illustrated in **Figure 46** and **Figure 47**. **Figure 46** shows the potential improvements from White Oak Drive to Teakwood Drive. **Figure 47** shows the potential improvements from Teakwood Drive to Richmond Beach Road.

In this concept, the intersections of US 17/360 at Richmond Beach Road, US 17/360 at Ball Street, and US 17/360 at White Oak Drive remain as conventional signalized intersections with no turn restrictions. All other intersections and median openings on US 17/360 between Richmond Beach Road and White Oak Drive are converted to RCUTs. This concept includes a new RCUT median opening at Teakwood Drive to better accommodate U-turns north of the Walmart intersection.

The series of RCUTs and directional median openings reduces conflict points, decreases crash potential, and provides consistency for improved driver expectation throughout this section of US 17/360.

This concept adds sidewalk on the west side of US 17/360 and a paved multi-use path for pedestrians and bicyclists on the east side of US 17/360. It also adds crosswalks and pedestrian signals at the signalized intersections.

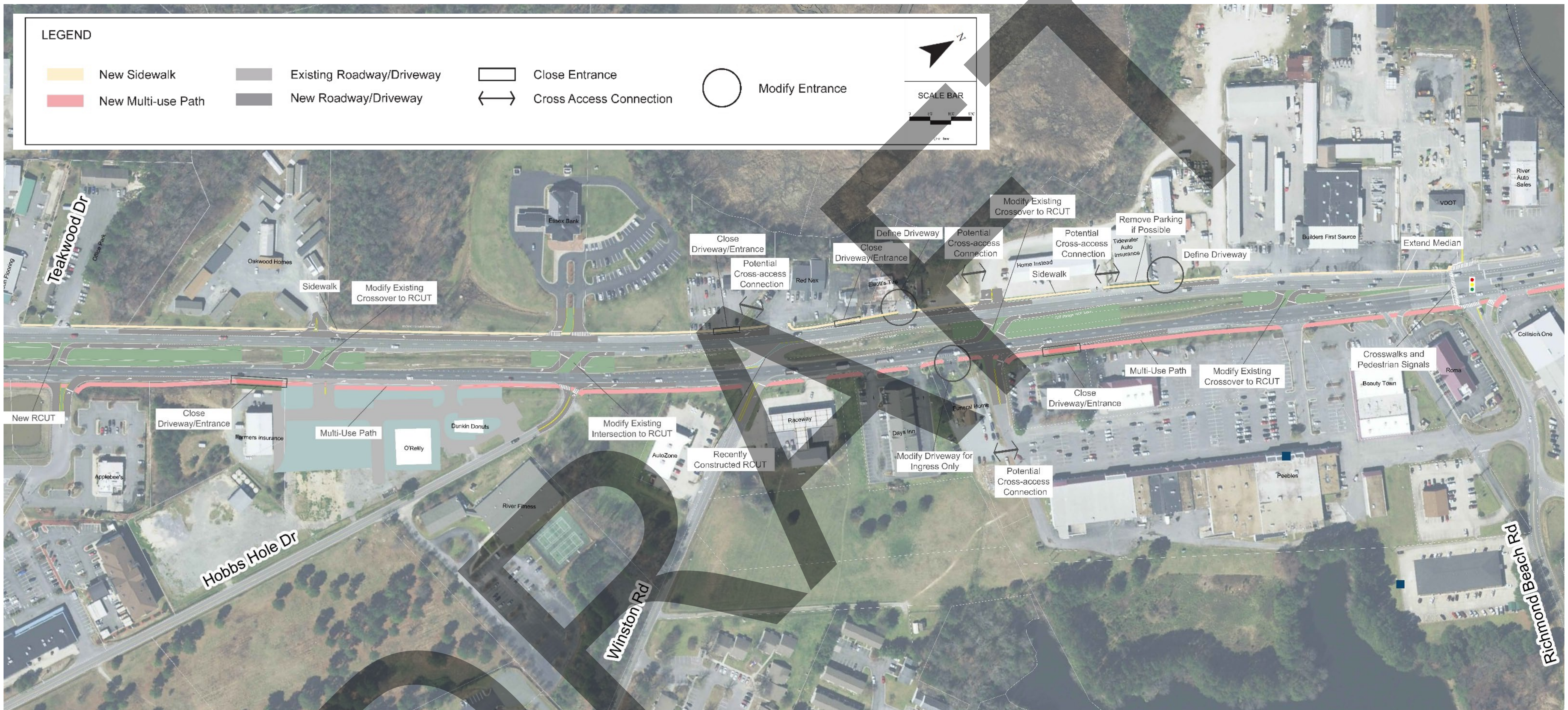
Opportunities for consolidating driveways and commercial entrances are identified in **Figure 46** and **Figure 47** in an attempt to bring the entrance spacing closer to compliance with the VDOT access spacing requirements.

The presentations from these meetings incorporated the initial improvement sketches, safety benefits, and other information, and are provided in **Appendix H**.

Improving traffic operations was not a key focus of the potential improvements. The project team analyzed the potential improvements in Synchro and SimTraffic to determine the operational impacts of the potential improvements and made adjustments, if necessary, so that the potential improvements would not result in operational issues. The analysis of traffic operations is described in more detail in ***Section 8.5***.

FIGURE 46: SOUTH OF HOSKINS: WHITE OAK TO TEAKWOOD DRIVE

FIGURE 47: SOUTH OF HOSKINS: TEAKWOOD DRIVE TO RICHMOND BEACH ROAD



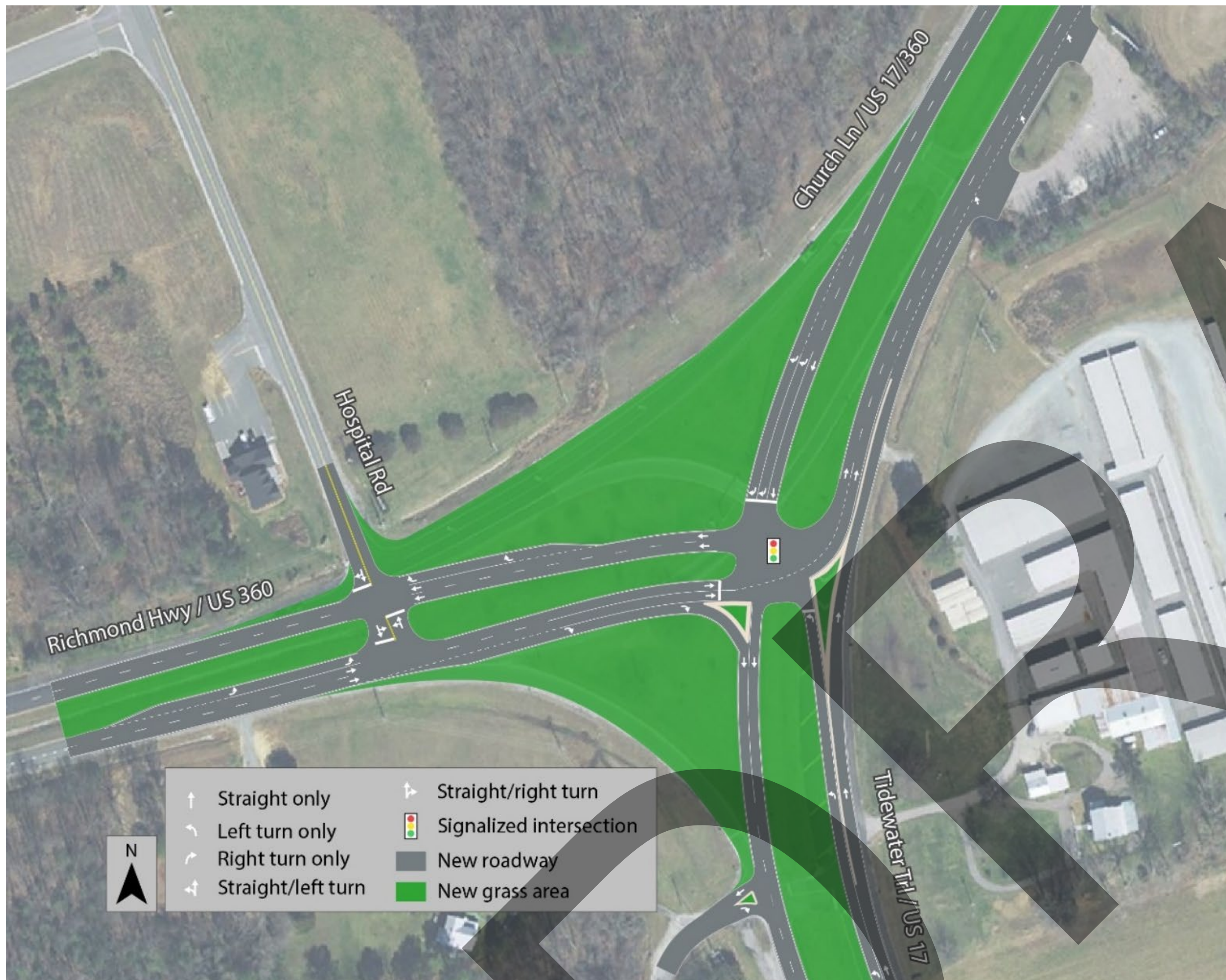
7.2.3 Brays Fork

The study team refined the continuous green-T and three leg roundabout concepts and presented them to the public. Both options reduce conflict points, decrease crash potential, improve access to Hospital Drive, and close the median opening at Berry Hill Drive, a location repeatedly mentioned as confusing and unsafe by both the public and study work group members.

7.2.3.1 Continuous Green-T

The continuous green-T concept, shown in **Figure 48**, converts the existing signalized intersection to a signalized continuous green-T configuration.

FIGURE 48: BRAYS FORK CONTINUOUS GREEN-T



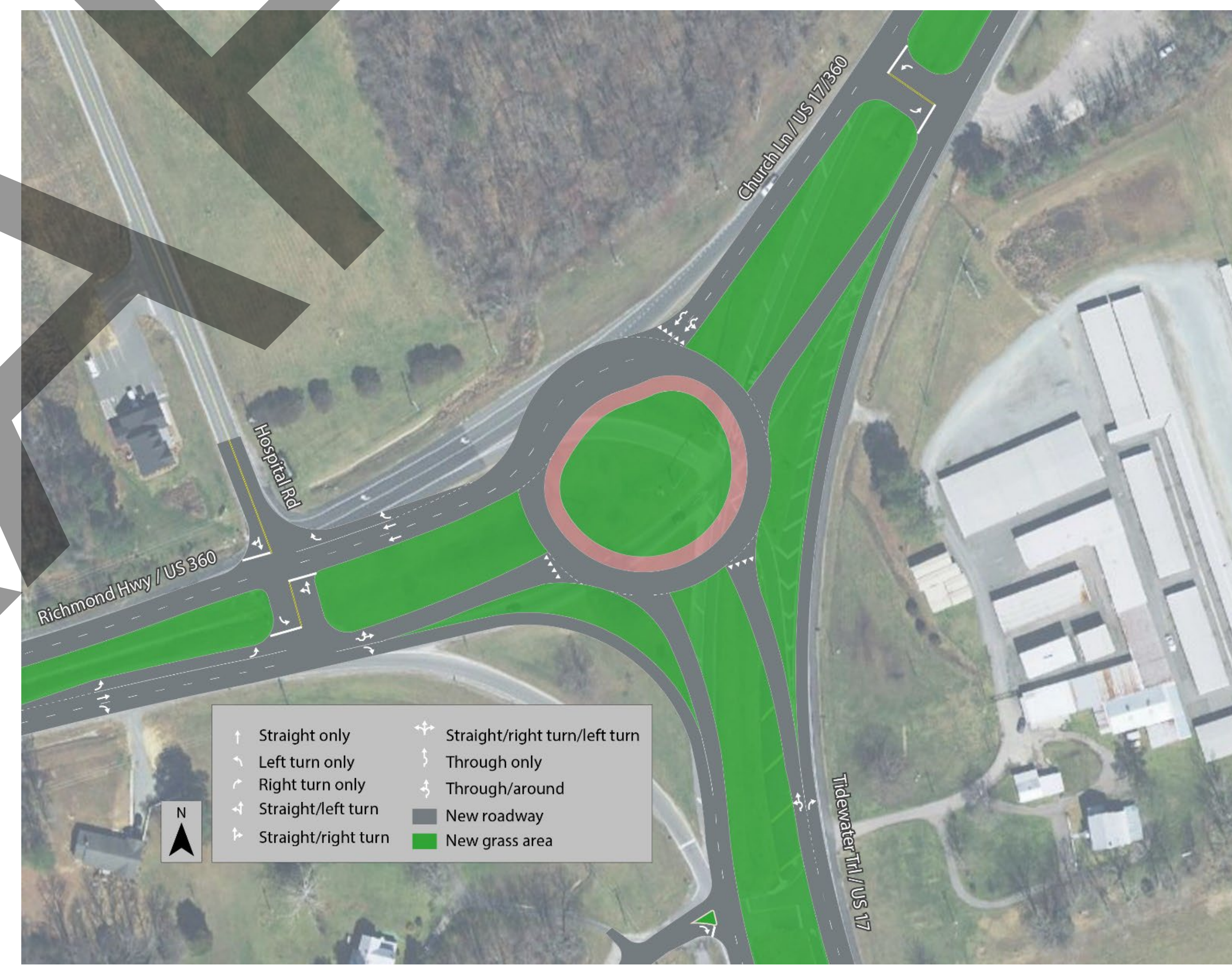
In this concept, the existing signalized intersection is reconfigured to a more conventional T intersection alignment. Northbound US 17 vehicles continuing to northbound US 17/360 toward Tappahannock remains a free-flow operation. The existing free-flow lane for westbound US 17/360 vehicles continuing to westbound US 360 is eliminated. These vehicles proceed through the signalized intersection as a right-turn movement. Due to the high number of vehicles completing this movement, two right turn lanes are provided. The existing free-flow ramp for vehicles coming from US 360 continuing to southbound US 17 is pulled closer to the signalized intersection. In addition to the Berry Hill Drive median closure, the median opening north of the intersection would also be closed in this concept.

The project team analyzed the potential improvements in Synchro and SimTraffic to determine their operational impacts and made adjustments, as necessary, so that the potential improvements would not result in operational issues. The traffic operations analysis is described in more detail in ***Section 8.5***.

7.2.3.2 Roundabout

The roundabout concept, shown in **Figure 49**, converts the existing signalized intersection into a roundabout at its current location. Both the northbound and eastbound approaches have free-flow right turn lanes. The southbound approach does not have a free-flow lane, rather two lanes are provided in the roundabout as shown in **Figure 49**.

FIGURE 49: BRAYS FORK ROUNDABOUT



The project team analyzed the potential improvements in Synchro and SimTraffic to determine their operational impacts and made adjustments, as necessary, so that the potential improvements would not result in operational issues. The analysis of traffic operations is described in more detail in ***Section 8.5***.

7.3 Public Meeting and Survey Results

The study team solicited input from the public on the potential improvements through an online survey from October 8, 2021 through November 5, 2021, and a virtual public meeting held on October 14, 2021. Over 600 people responded to the survey and 15 people attended the meeting. This section summarizes the survey results and public meeting input.

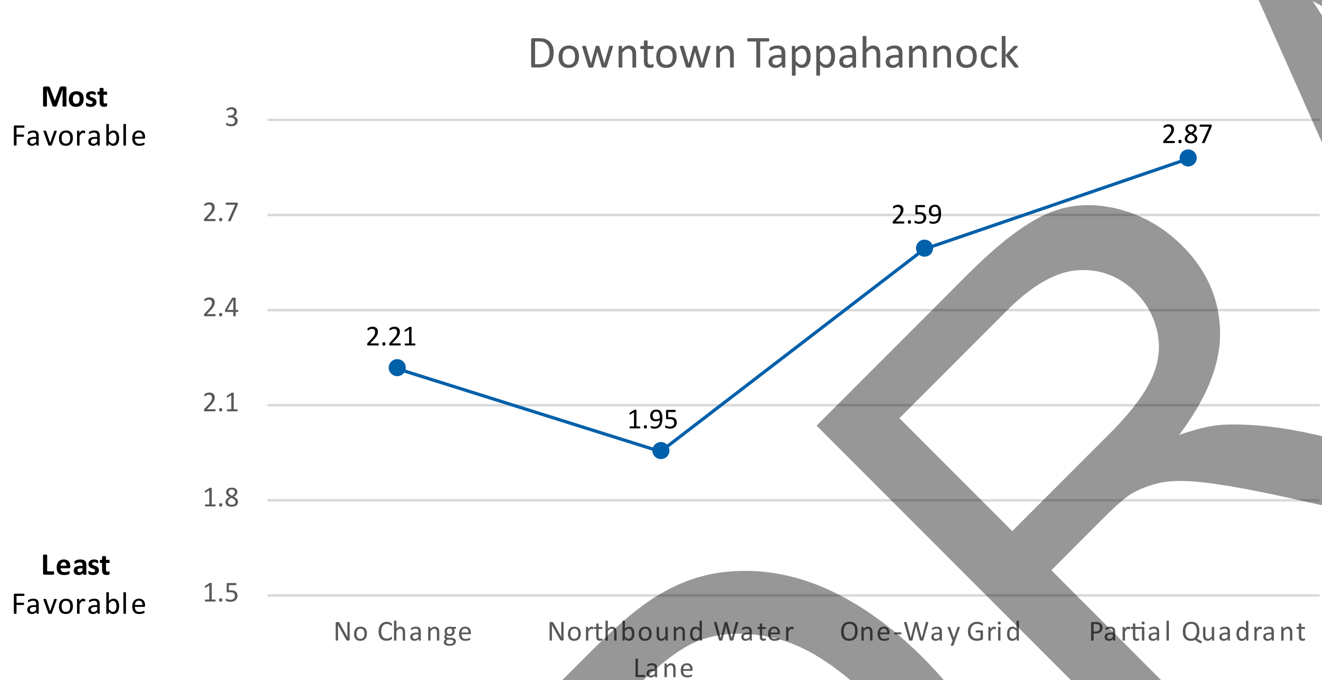
7.3.1 Downtown Tappahannock Improvements

The survey asked respondents to rate four improvement alternatives in Downtown Tappahannock from least preferred (one star) to most preferred (five stars). The following alternatives were presented:

- No Change
- One-Way Grid
- Partial Quadrant
- Northbound Water Lane

Figure 50 shows the results of the improvement concepts rating. Respondents rated the Partial Quadrant concept as the most favorable, followed by the One-Way Grid concept, No Change, and Northbound Water Lane concept.

FIGURE 50: SURVEY RESULTS – DOWNTOWN TAPPAHANNOCK IMPROVEMENT CONCEPTS



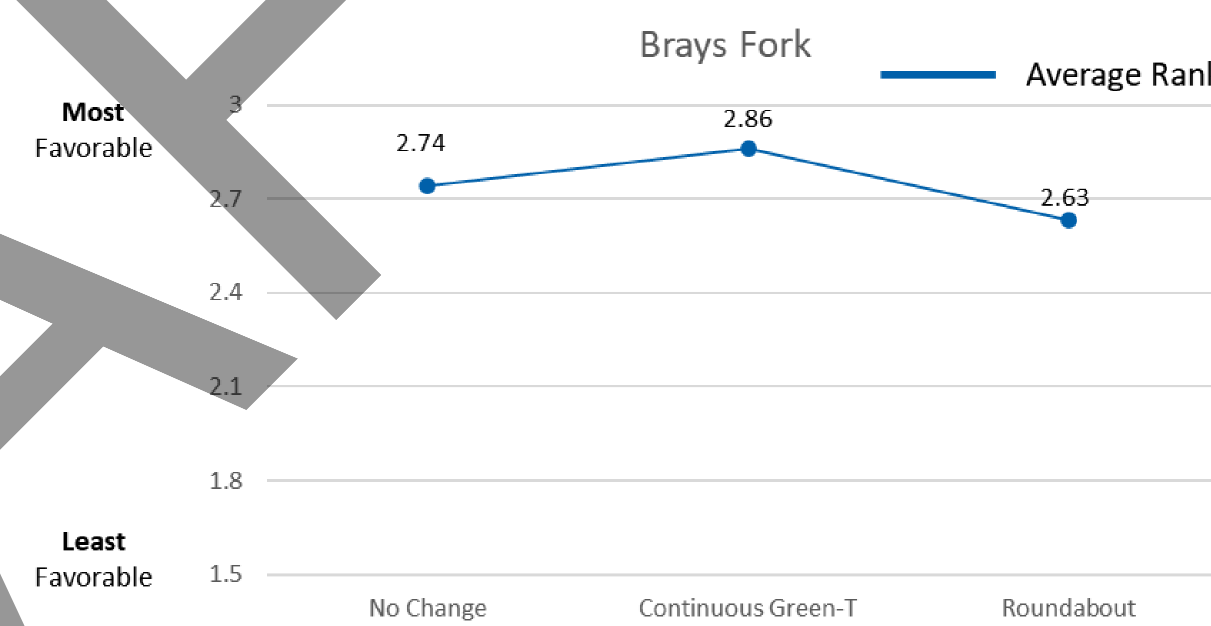
7.3.2 Brays Fork Improvements

The survey asked respondents to rate three improvement alternatives at Brays Fork from least preferred (one star) to most preferred (five stars). The following alternatives were presented:

- No Change
- Continuous Green-T
- Roundabout

Figure 51 shows the results of the improvement concepts rating. Respondents rated the Continuous Green-T concept as the most favorable, followed by the No Change and Roundabout concepts. It is worth noting that the ratings for the three concepts are all very similar only varying by 0.23 "stars."

FIGURE 51: SURVEY RESULTS – BRAYS FORK IMPROVEMENT CONCEPTS



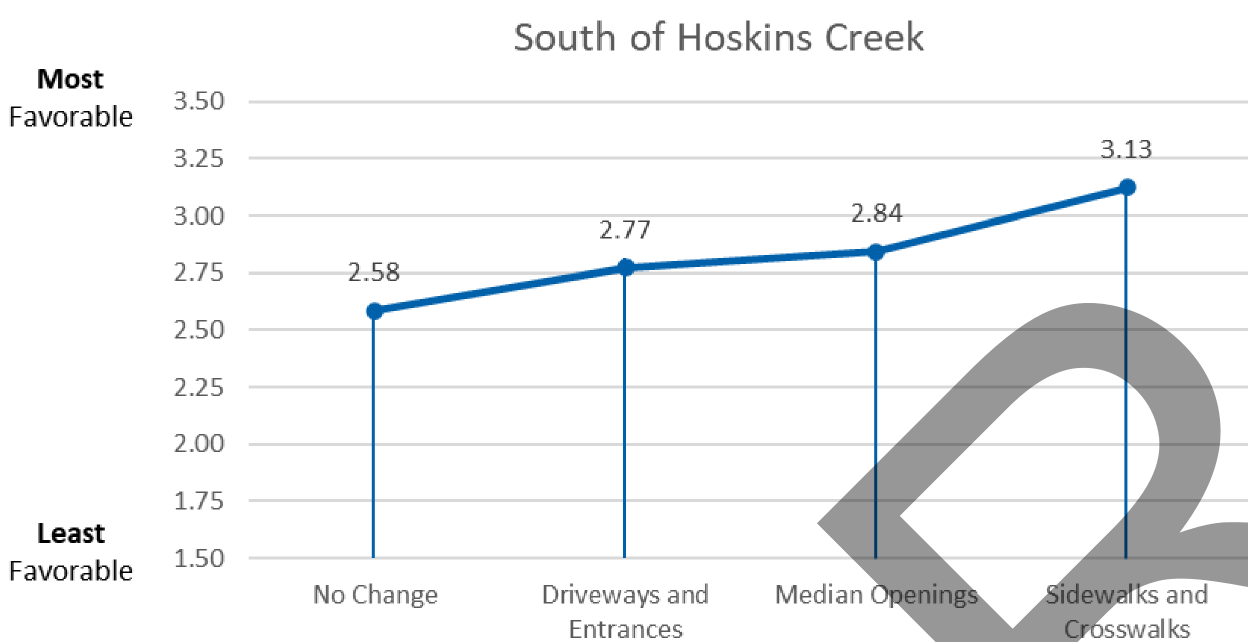
7.3.3 South of Hoskins Creek Improvements

The survey asked respondents to rate four improvement alternatives south of Hoskins Creek from least preferred (one star) to most preferred (five stars). This section of the study corridor was broken into four sections due to its length, however, the results are presented for the entire area between White Oak Drive and Richmond Beach Road. The following alternatives were presented:

- No Change
- Median Openings
- Sidewalks and Crosswalks
- Driveways and Entrances

Figure 52 shows the results of the improvement concepts rating. Respondents rated the Sidewalks and Crosswalks concept as the most favorable, followed by the Median Openings, Driveways and Entrances, and No Change concepts.

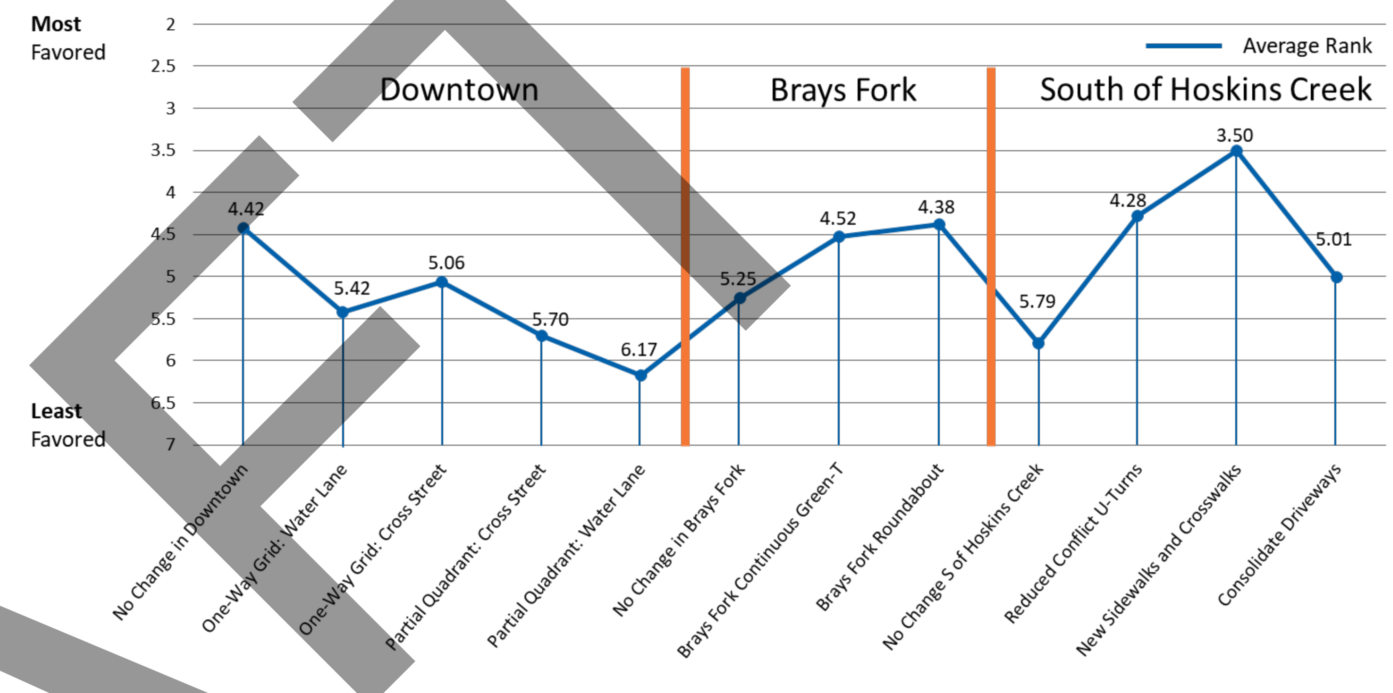
FIGURE 52: SURVEY RESULTS – SOUTH OF HOSKINS CREEK IMPROVEMENT CONCEPTS



7.3.4 Ranking the Improvements

The survey asked respondents to rank each of the alternative improvement concepts for all three areas of the study against one another, from 1 to 9. **Figure 53** shows the results of the improvement concepts ranking. Respondents ranked New Sidewalks and Crosswalks South of Hoskins Creek the highest and the Partial Quadrant: Water Lane concept the lowest with all other concepts between.

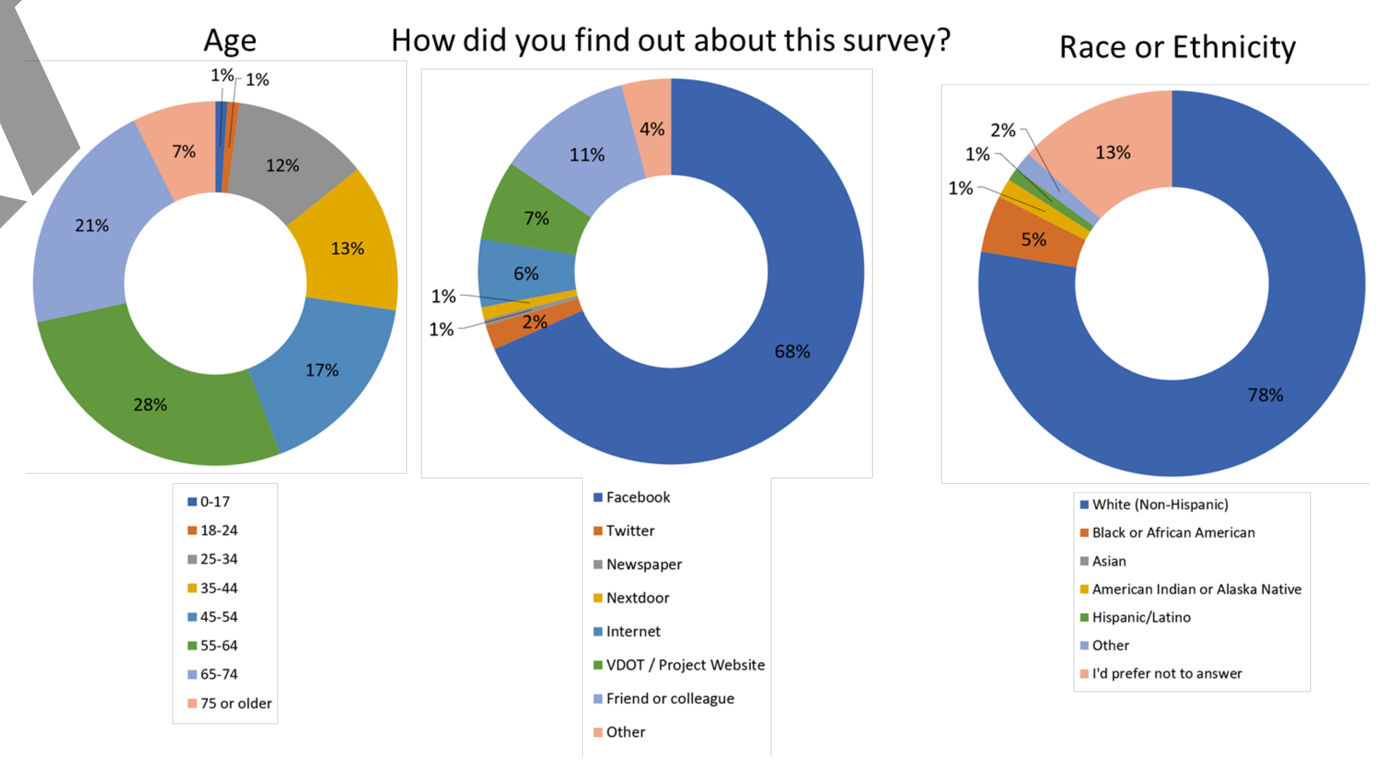
FIGURE 53: SURVEY RESULTS – SOUTH OF HOSKINS CREEK IMPROVEMENT CONCEPTS



7.3.5 Survey Respondents

Figure 54 shows demographic information for survey respondents.

FIGURE 54: SURVEY RESPONSES –DEMOGRAPHICS OF SURVEY RESPONDENTS



7.3.6 Is there another idea that should be considered?

When asked if there was another idea that should be considered, the responses shown in **Figure 55** were the most frequent. Of these responses, the most common was a bypass.

FIGURE 55: SURVEY RESPONSES – IS THERE ANOTHER IDEA THAT SHOULD BE CONSIDERED?

8 Recommended Improvements

The study work group determined which improvements should be included in the study recommendations to best improve safety, improve access spacing, and accommodate pedestrian and bicycle activity, as described in the previous sections. The project team developed more detailed drawings and conducted additional analyses to finalize the recommendations, quantify the benefits, and develop planning-level cost estimates.

8.1 Recommended Projects

The project team grouped the recommended improvements into nine projects that can be implemented alone or in combination with others. The projects are ranked in a recommended order for implementation based on general consideration of the intersection and segment PSI rankings, crash severities, crash types, location of pedestrian crashes, and adjacent land uses.

1. Downtown Tappahannock: Short-Term Improvements and Commerce Drive Connection
2. South of Hoskins Creek: White Oak Drive to Teakwood Drive: Sidewalks and Crosswalks
3. South of Hoskins Creek: Teakwood Drive to Richmond Beach Road: Sidewalks and Crosswalks
4. South of Hoskins Creek: White Oak Drive to Teakwood Drive: RCUTs and Access Modifications
5. South of Hoskins Creek: Teakwood Drive to Richmond Beach Road: RCUTs and Access Modifications
6. Brays Fork: Roundabout - Preferred
7. Brays Fork: Continuous Green-T
8. South of Hoskins Creek: White Oak Drive to Teakwood Drive: Multi-use Path
9. South of Hoskins Creek: Teakwood Drive to Richmond Beach Road: Multi-use Path

The improvements within each of the nine projects are described and illustrated in the project summary sheets in Appendix I. Subsequent sections describe the safety and access spacing benefits and the impacts to traffic operations.

8.2 Safety Benefits

One way to quantify the safety benefits of an improvement is to calculate the expected reduction in the number of crashes once the improvement is implemented. The Highway Safety Manual defines a method for calculating the expected reduction in crashes using crash modification factors (CMFs). Crash modification factors are ratios that estimate the degree to which a particular treatment (i.e., countermeasure or treatment) would reduce the number of crashes. The CMF ratio compares the expected average crash frequencies before and after a treatment is implemented. CMFs less than 1.0 indicate a treatment would reduce the crash frequency. CMFs more than 1.0 indicate a treatment would increase the crash frequency. A CMF of 1.0 indicates a treatment would have no change in the expected crash frequency.

$$CMF = \frac{\text{Expected Average Crash Frequency } \textit{after} \text{ treatment is implemented}}{\text{Expected Average Crash Frequency } \textit{before} \text{ treatment is implemented}}$$

VDOT maintains a list of planning level CMFs for SMART SCALE project scoring. The planning level CMFs indicate the expected reduction in the number of fatality (F) and injury (I) crashes, weighted by the equivalent property damage only (EPDO) crash value scale, shown in **Table 10**.

As noted in ***Section 4.2.1***, the crash analysis for this study focused closely on PSI locations, locations where a fatal crash occurred, and locations where a pedestrian or bicyclist crash occurred. For the PSI intersections, the project team conducted the planning level CMF analysis in accordance with the SMART SCALE scoring methodology. The project team used five years of crash data from November 30, 2015, through November 30, 2020. Crashes involving alcohol were excluded from the analysis. Only one CMF per intersection was selected, even though the recommendations include multiple improvements with CMFs at many of the intersections. **Table 11** shows the results from the planning level CMF analysis. Intersections and locations are listed from north to south.

As further described in ***Sections 4.3***, ***7.2.2***, and ***7.2.3***, the consolidation of median openings and entrances is needed to bring the US 17/360 corridor closer to meeting access spacing standards. Each access point creates conflict points, which represent the potential for crashes to occur. Addressing the access spacing deficiencies will reduce the number of conflict points, thereby reducing crash potential. The sidewalks, crosswalks, pedestrian countdown signals, and multi-use path will improve pedestrian safety, providing much needed designated paths for walking along and crossing US 17/360. Although these safety improvements are not quantified in terms of crash reductions, they will address the identified deficiencies.

Table 10: Equivalent Property Damage Only Crash Value Scale

Crash Severity	Crash Value
K (Fatality)	160
A (Severe Injury)	160
B (Moderate Injury)	20
C (Minor Injury)	10

Source: Draft SMART SCALE Technical Guide, Revised February 2022

Table 11: Expected Crash Reductions

Intersection/Location	2015-2020 EPDO (FI)	CMF Description	CMF	EPDO (FI) Reduction
US 17 at Marsh Street	80	New turn lane (none present)	0.85	12
US 17 at Queen Street (US 360)	110	Close driveway	0.70	33
Queen Street (US 360) at Cross Street	120	Add median or close median opening (convert to right-in/right-out)	0.40	70
US 17 at Duke Street	320	Add median or close median opening (convert to right-in/right-out)	0.40	192
US 17 at Virginia Street	60	Add median or close median opening (convert to right-in/right-out)	0.40	36
Southbound segment between Richmond Beach Road and Teakwood Drive	90	Pedestrian and Bicycle: Add new sidewalk	0.12	79
Northbound segment between Richmond Beach Road and Teakwood Drive	230	Pedestrian and Bicycle: Add new sidewalk	0.12	202
Southbound segment between Teakwood Drive and White Oak Drive	500	Pedestrian and Bicycle: Add new sidewalk	0.12	440
Northbound segment between Teakwood Drive and White Oak Drive	470	Pedestrian and Bicycle: Add new sidewalk	0.12	414
Median opening at Tappahannock Town Center	10	Convert two-way stop control to unsignalized RCUT	0.40	6
Median opening at Advanced Auto	40	Convert two-way stop control to unsignalized RCUT	0.40	24
Hobbs Hole Drive	60	Convert two-way stop control to unsignalized RCUT	0.40	36
Median opening at Oakwood Homes	0	Convert two-way stop control to unsignalized RCUT	0.40	0
Walmart Entrance	410	Convert signal control to signalized RCUT	0.65	144
US 17/360 at Ball Street	430	Non-Freeway Access Management - Close driveway	0.70	129
Median opening at Shopping Center Entrance north of White Oak Drive	60	Convert two-way stop control to unsignalized RCUT	0.40	36
US 17/360 (Tidewater Trail) median opening north of US 17/360 intersection	20	Add median or close median opening (convert to right-in/right-out)	0.40	12
US 17 (Tidewater Trail) at US 360 (Richmond Highway)	180	Convert signal to roundabout	0.40	108
US 17 (Tidewater Trail) at US 360 (Richmond Highway)	180	Convert signal control to continuous green-T signal	0.85	27
US 17 (Tidewater Trail) at Berry Hill Road	80	Add median or close median opening (convert to right-in/right-out)	0.40	48
Median opening at Shopping Center Entrance north of White Oak Drive	60	Convert two-way stop control to unsignalized RCUT	0.40	36

8.3 Improvements to Access Spacing

As explained in ***Section 4.3*** and shown in the access spacing maps in **Appendix F**, the median opening and entrance spacing does not meet the VDOT access spacing standards over most of the study corridor. The recommendations improve the spacing of driveways and entrances and bring the study corridor closer to meeting VDOT's standards. These recommendations are focused primarily in the South of Hoskins Creek portion of the study corridor between White Oak Drive and Richmond Beach Road.

Table 12 shows how the recommendations improve access spacing in the corridor along with the existing spacing, the existing spacing standard based on the existing entrances and median openings, and the proposed spacing and relevant spacing standard. The distances shown in bold indicate locations where the spacing standards are not met today but will be met with the proposed recommendations. While not all locations are expected to meet the spacing standards with the proposed recommendations, the distances all increase and thus move closer to the standards. Entrance consolidation will involve conversations with property owners to better understand site circulation patterns and determine the best arrangement of entrance locations.

The VDOT access spacing standards do not clearly explain whether the minimum spacing between a signalized RCUT and another signalized intersection is different from the minimum spacing between two typical signalized intersections where no movements are restricted.

Table 12: Improvements to Access Spacing

From	To	Access Spacing				Improvement	Concept
		VDOT Standard for Existing Control	Existing Spacing	VDOT Standard for Proposed Control	Proposed Spacing		
Brays Fork	White Oak Drive	1,050	450	**NA**	**NA**	Close median crossover north of Brays Fork	Roundabout or CGT
White Oak Drive	Ball Street	1,050	780-860	**565**	**780-860**	Convert full median opening at shopping center to RCUT	RCUTs and Access Modifications
		305	250-260	**305**	**510**	Close one entrance northbound	
		305	180-250	**305**	**660**	Close two entrances southbound	
Ball Street	Walmart Entrance	1,320	820	1,320	820	Signalized RCUT at Walmart entrance	RCUTs and Access Modifications
		305	180-260	**305**	**440**	Close one entrance northbound	
		305	60-230	305	220-**370**	Close two entrances southbound	
Walmart Entrance	Hobbs Hole Drive	1,050	610	**565**	**610**	Convert full median opening at Oakwood Homes to RCUT	RCUTs and Access Modifications
		305	150	**305**	**310**	Close Farmers Insurance entrance	
		1,050	610-1,010	**565**	**610-1,010**	Convert full median opening at Hobbs Hole Drive to RCUT	
Hobbs Hole Drive	Richmond Beach Road	305	120 110-170	305	290 280	Close two entrances southbound	RCUTs and Access Modifications
		1,050	730-1,101	**565**	**730-1,101**	Convert full median opening at Advance Auto to RCUT	
		1.050	440-730	565	440-**730**	Convert full median opening at Tappahannock Town Center to RCUT	
Church Lane	Marsh Street	250	80-120	250	200	Consolidate two entrances southbound to one	Downtown Short-Term

8.4 Policy Recommendations

While the previous sections describe physical improvements to modify and close existing median openings and entrances, it is important to ensure that the County approve new entrances and access points in conformance with the VDOT access spacing standards. This study recommends the County adopt a policy to follow VDOT access spacing standards and access management design standards when considering and approving new entrances and access points during rezoning and site plan review processes.

8.5 Impacts to Traffic Operations

The project team analyzed the recommended improvements in Synchro and SIDRA to ensure they would not produce any major operational issues. The lane configurations of the recommended improvements are shown in **Figure 56**. **Figure 57** shows the peak hour turning movement volumes at each intersection, including rerouted volumes from the modified intersection configurations.

The analysis confirmed that **most of the recommended improvements are not projected to adversely impact traffic operations**. Overall traffic operating conditions are expected to improve after the recommended improvements are implemented, with a few exceptions. The delays and LOS for the future Build scenario are shown in **Figure 58**. The maximum queue lengths are shown in **Figure 59**. Cycle lengths and phase splits were optimized throughout the corridor. The analysis results are provided in **Appendix J**.

8.5.1 Control Delays and Levels of Service

The traffic analysis indicates there is minimal change in the traffic operating conditions between the future No-Build scenario and the scenario with the recommended improvements (i.e., the future Build scenario). Like the future No-Build scenario, all the signalized intersections are projected to operate at LOS C or better in both peak hours in the future Build scenario.

The analysis indicates that the levels of service for individual turning movements are expected to stay the same or improve, with few exceptions. The following movements could degrade with the recommended improvements.

- At the intersection of Marsh Street and Church Lane, the eastbound approach level of service degrades from LOS C to LOS F. The recommended change to the northbound lane configuration from a shared through/left turn lane and shared through/right turn lane to a left turn only and shared through/right turn lane makes it more difficult for the eastbound Marsh Road vehicles to enter Church Lane. It should be noted that if the Commerce Drive connection is constructed, traffic volumes will likely decrease on this approach. This traffic shift was not assumed when the future traffic volumes were developed.
- At the intersection of Queen Street and Church Lane, the northbound right turn movement level of service degrades from LOS C to LOS E during the PM peak hour, however the queue length decreases and the overall level of service for the intersection remains LOS C.
- At the intersection of the Walmart entrance with Tappahannock Boulevard, the northbound shared left/u-turn movement level of service degrades from LOS D to LOS E during the PM peak due to the additional u-turn volumes.
- At the intersection of White Oak Drive with Tappahannock Boulevard, the southbound shared left/u-turn movement level of service degrades from LOS D to LOS E during the AM peak due to the additional u-turn volumes.

8.5.2 Maximum Queue Lengths

The recommendations generally improve queue lengths on approaches where geometric changes are proposed and queue lengths on approaches without geometric recommendations are generally similar to the queue lengths in the future No-Build scenario.

The previously described impacts to traffic operations are relatively minor compared to the safety benefits of reducing the number of conflict points and reducing the expected crashes. Despite the minor impacts to the traffic operations, the proposed changes described in previous sections and illustrated in the project summary sheets in **Appendix I** are recommended because of the safety improvements.

Figure 56: Lane Configurations with Recommended Improvements

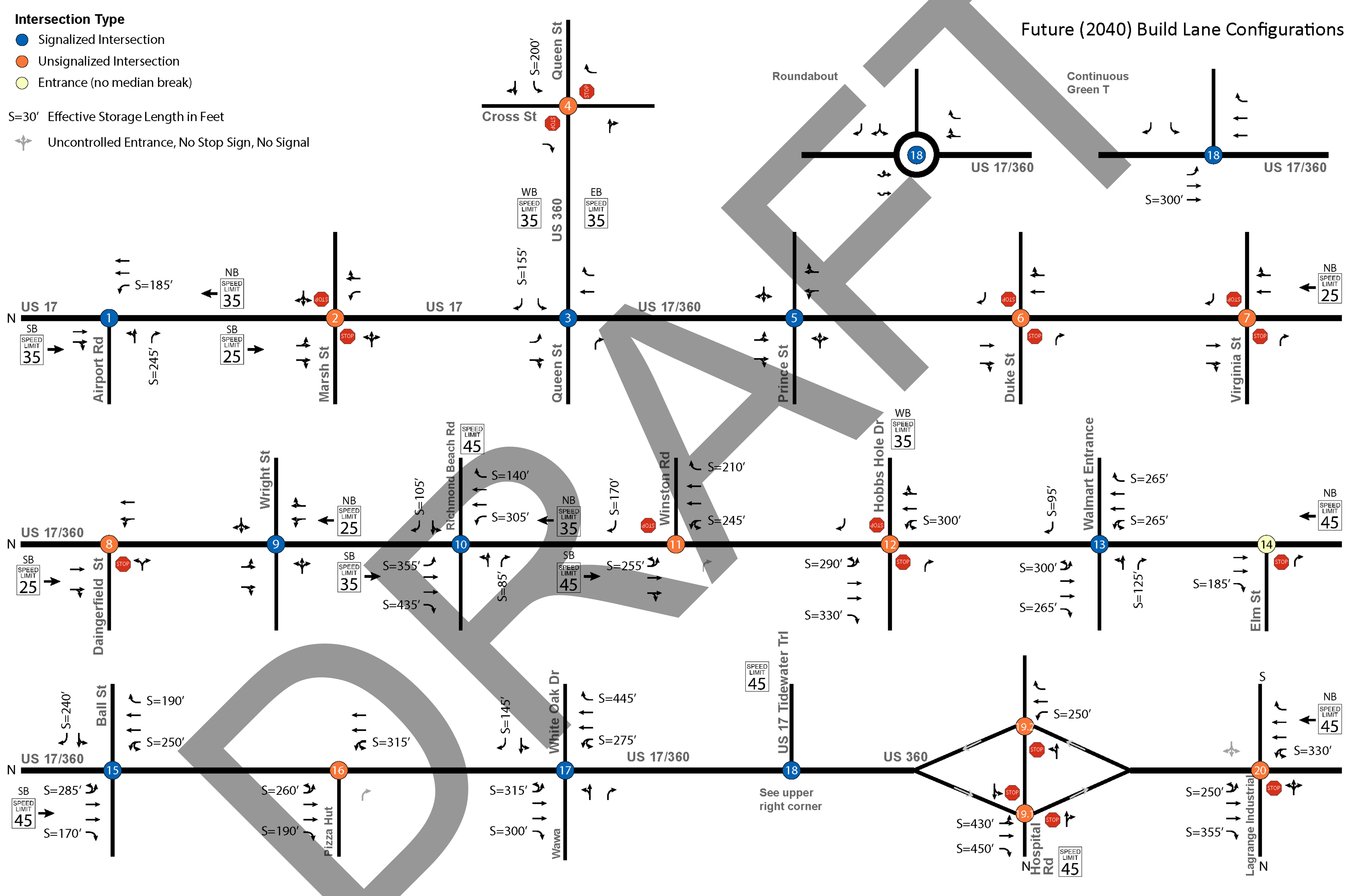


Figure 57: 2040 Future AM and PM Peak Hour Turning Movement Volumes with Recommended Improvements

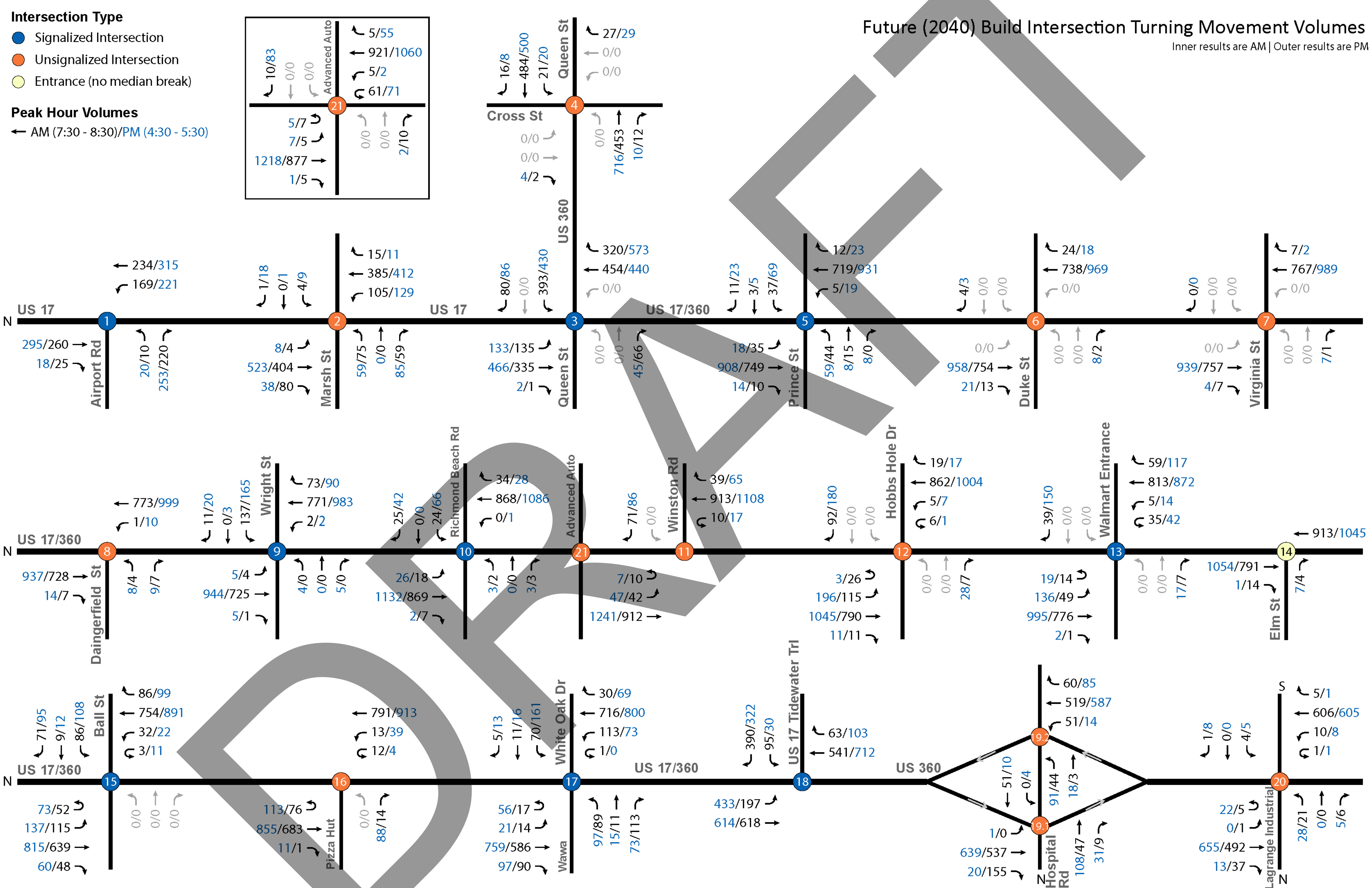


Figure 58: 2040 Future Peak Hour Traffic Operating Conditions with Recommended Improvements – Control Delays (seconds per vehicle) and Levels of Service

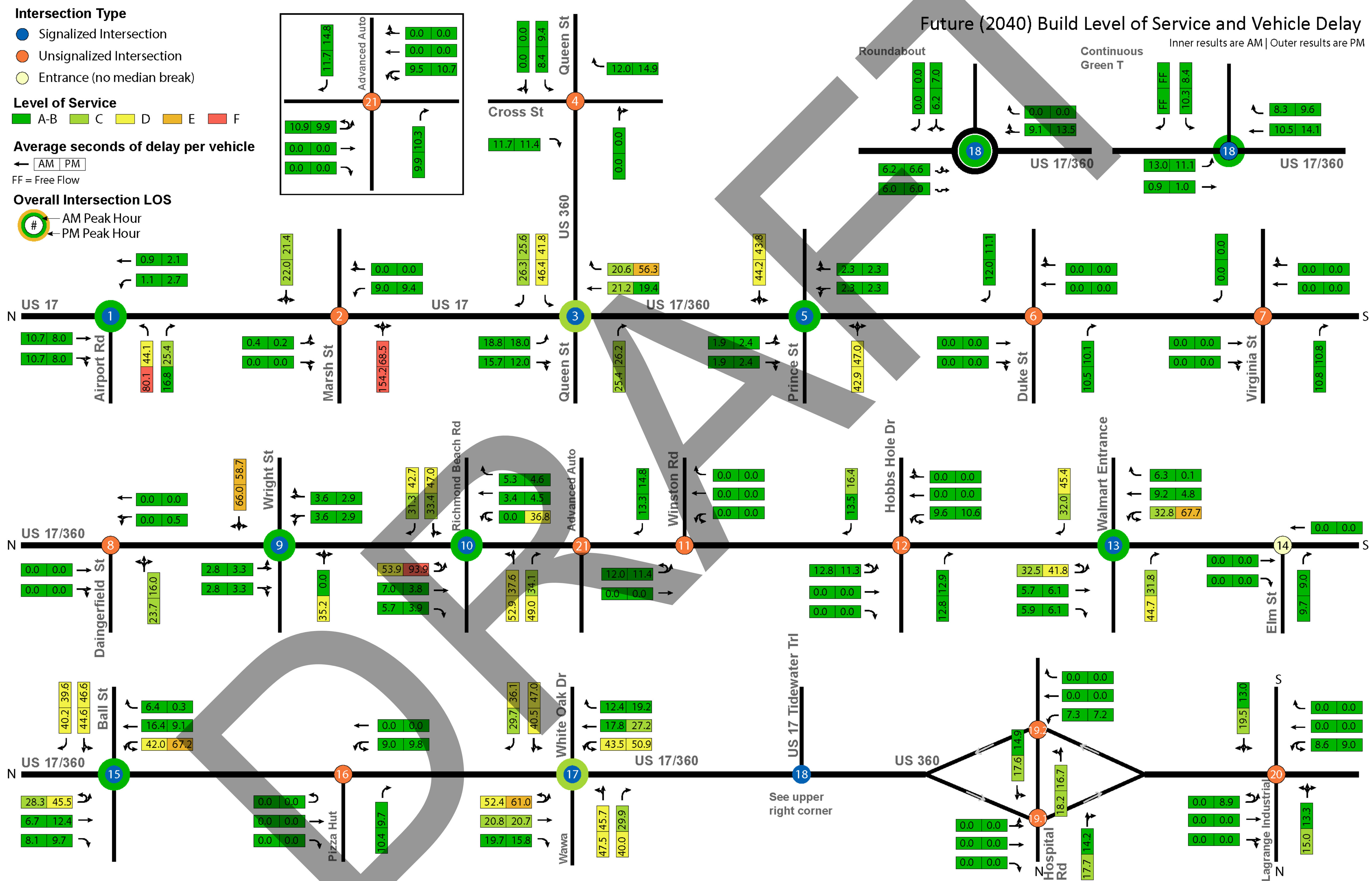
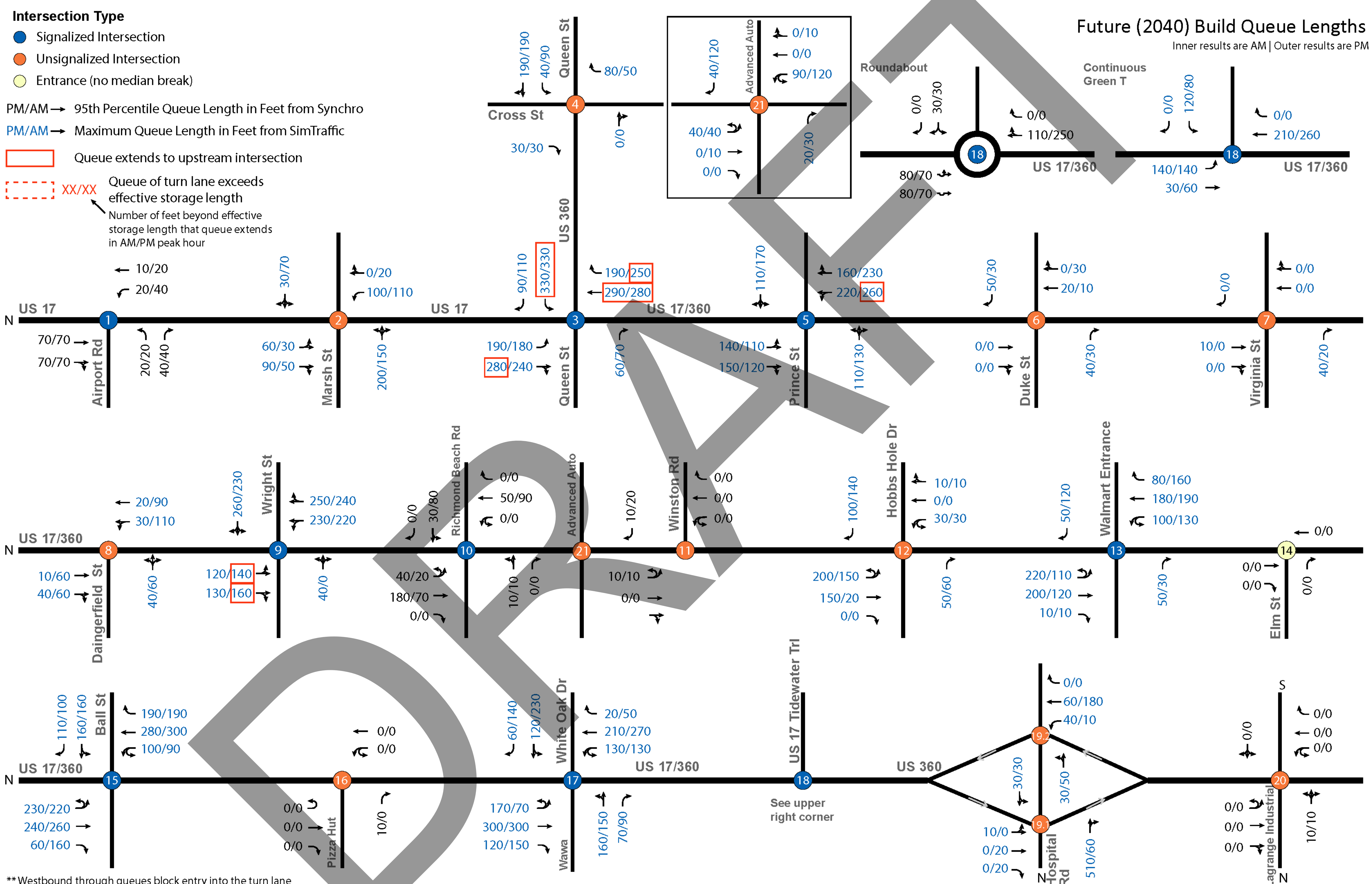


FIGURE 59: 2040 FUTURE PEAK HOUR TRAFFIC OPERATING CONDITIONS WITH RECOMMENDED IMPROVEMENTS – MAXIMUM QUEUE LENGTHS (FEET)



9 Conceptual Design, Costs, and Schedules

The project team developed conceptual designs, planning-level cost estimates, and schedule estimates for the nine projects listed in ***Section 8.1***. The project summary sheets in **Appendix I** provide this information for each project, as well as a description of the recommended improvements, a conceptual illustration, a location map, summaries of the safety benefits, and traffic operations results.

9.1 Conceptual Design

The project team developed the conceptual designs in accordance with the following applicable guidelines:

- A Policy on Geometric Design of Highways and Streets (AASHTO 2018)
- VDOT Road Design Manual (Issued January 2005, Revised July 2016)
- VDOT Road and Bridge Standards (VDOT 2016, latest revisions)
- Manual on Uniform Traffic Control Devices (MUTCD 2009)
- 2011 Virginia Supplement to the MUTCD

9.2 Planning-Level Cost Estimates

A refined planning-level cost estimate was developed for all selected improvement projects. The following assumptions were made in the development of the costs estimates:

- The estimated preliminary engineering cost was estimated based on the complexity of the project.
- The preliminary engineering estimate was completed using 2022 dollars escalated to 2024 dollars.
- For projects with anticipated right-of-way and/or utility impacts, those costs were estimated on a project-by-project basis based on the size and complexity of the project, as well as per inspection of the existing right-of-way limits as shown in the GIS parcel layer.
- The right-of-way and utility cost estimates are based on 2028 dollars.
- Construction costs were estimated using VDOT Transportation and Mobility Planning Division's Statewide Planning Level Cost Estimate Spreadsheet v2.54.
- The construction cost estimates include an additional 30 percent for unidentified project risks plus 30 percent for construction engineering and inspection.
- The construction costs estimates are based on 2030 dollars.

Table 13 summarizes the preliminary engineering, right-of-way and utility relocation, construction, and total planning level cost estimates for each improvement project. A more detailed breakdown of the planning-level cost estimates is provided in **Appendix K**.

While neither the One-Way Pairs, Cross Street Partial Quadrant, nor Water Street Partial Quadrant concepts were selected for implementation, planning-level cost estimates were developed for these concepts for future reference. The estimated cost for these concepts is between $4 and $8 million including preliminary engineering, right-of-way and utility relocation, and construction.

Table 13: Planning-Level Cost Estimates

Project	Cost Estimate (Construction Year 2030)			
	Preliminary Engineering	Right-of-Way and Utilities	Construction	Total
1: Downtown Tappahannock: Short-Term	$438,000	$248,000	$1,096,000	$1,782,000
1: Commerce Drive Connection	$438,000	$450,000	$2,114,000	$3,002,000
2: White Oak Drive to Teakwood Drive: Sidewalks and Crosswalks	$655,000	$923,000	$3,578,000	$5,156,000
3: Teakwood Drive to Richmond Beach Road: Sidewalks and Crosswalks	$655,000	$676,000	$2,729,000	$4,060,000
4: White Oak Drive to Teakwood Drive: RCUTs and Access Modifications	$655,000	$586,000	$3,297,000	$4,538,000
5: Teakwood Drive to Richmond Beach Road: RCUTs and Access Modifications	$645,000	$529,000	$2,015,000	$3,189,000
6: White Oak to Teakwood Drive: Multi-use Path	$655,000	$1,126,000	$3,423,000	$5,204,000
7: Teakwood Drive to Richmond Beach Road: Multi-use Path	$676,000	$1,306,000	$3,931,000	$5,913,000
8: Brays Fork: Roundabout	$1,082,000	$56,000	$10,725,000	$11,863,000
9: Brays Fork: Continuous Green-T	$843,000	$56,000	$9,286,000	$10,185,000

9.3 Schedule Estimates

The project team developed schedule estimates for each project. **Table 14** summarized the projected timeframes for the Preliminary Engineering, Right-of-Way and Utilities, and Construction phases of each project.

Table 14: Schedule Estimates

Project	Schedule Estimate (months)			
	Preliminary Engineering	Right-of-Way and Utilities	Construction	Total
1: Downtown Tappahannock: Short-Term and Commerce Drive Connection	30	18	24	54
2: White Oak Drive to Teakwood Drive: Sidewalks and Crosswalks	30	36	18	66
3: Teakwood Drive to Richmond Beach Road: Sidewalks and Crosswalks	30	30	18	72
4: White Oak Drive to Teakwood Drive: RCUTs and Access Modifications	30	36	18	84
5: Teakwood Drive to Richmond Beach Road: RCUTs and Access Modifications	30	30	18	78
6: Brays Fork: Roundabout	30	30	18	84
7: Brays Fork: Continuous Green-T	30	30	18	78
8: White Oak to Teakwood Drive: Multi-use Path	36	12	30	78
9: Teakwood Drive to Richmond Beach Road: Multi-use Path	36	12	30	78

10 Project Advancement

This study should be used as a planning tool to achieve the next steps of planning, programming, designing, and constructing the identified safety and operational improvements in the study corridor. To build on the efforts of this study, Essex County should continue to coordinate with the Town of Tappahannock, Middle Peninsula Planning District Commission (MPPDC), VDOT, and other stakeholders. To advance these projects beyond the planning stage, members of the study work group should use the following steps.

Prepare Projects for Advancement

The County should conduct outreach meetings to further vet the proposed projects. These outreach meetings should include additional stakeholders that were not in the study work group. Other stakeholders may include business owners on the corridor and Essex County residents.

Improvement projects should be prioritized on a local and regional level. Prior to submitting funding applications, applicants must have one of the following:

1. Inclusion or proven consistency with the Constrained Long-Range Transportation Plan (CLRP)
2. Resolution of support from a governing body

Apply for Funding

The following funding sources should be considered for improvement projects identified in this study.

- Revenue Sharing: a program that provides a dollar-for-dollar state match to local funds for transportation projects. Projects eligible for Revenue Sharing funds include construction, reconstruction, improvement, and maintenance projects. All improvement projects are candidate projects for Revenue Sharing.
- Highway Safety Improvement Program (HSIP): a program that provides funding for improvements that correct or improve safety on a section of roadway or intersection with a high crash frequency.
- SMART SCALE: a program that allocates funding from the construction District Grants Program (DGP) and High-Priority Projects Program (HPPP) to transportation projects. SMART SCALE uses a scoring process that evaluates, scores, and ranks project applications based on six measures: congestion mitigation, economic development, accessibility, safety, environmental quality, and land use. All proposed projects included in this study are eligible for SMART SCALE funding.
- Transportation Alternatives (TA): a program that federal funding for creative projects that integrate transportation into our communities and environment. Funding is applicable for projects that improve non-motorized transportation, enhance the public's traveling experience, revitalize communities, and improve quality of life. Seven of the nine improvement projects are candidate projects for TA funding. Neither of the Brays Fork projects would be eligible for this funding source.