Earlysville Road with Reas Ford Rd/Earlysville Forest Dr Intersection Traffic Study
Earlysville, Albemarle County

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EXECUTIVE SUMMARY

This report summarizes evaluation of potential intersection improvement alternatives at the intersection of Earlysville Road with Reas Ford Road and Earlysville Forest Drive in Earlysville, Albemarle County. This study includes review of previous investigations, assessment of physical conditions, traffic volume collection, evaluation of crash data, discussion of alternatives, alternatives evaluation, signal warrant analysis, capacity analysis, queuing analysis, safety analysis, and investigative conclusions.

Albemarle County and The Virginia Department of Transportation (VDOT) previously identified safety concerns at the intersection of Earlysville Road with Reas Ford Road and Earlysville Forest Drive. As a result of a pattern of right angle crashes at the intersection, two traffic studies have been prepared evaluating the intersection.

Previous Studies

An internal intersection traffic study was completed by ***VDOT Culpepper District in 2018***. This study was prompted from a request from a state legislator based upon citizen concerns regarding intersection safety. This study included evaluation of crash data, sight distance, signal warrant analysis, auxiliary lane analysis, and signing and marking considerations. Recommendations from this report are separated by Short Term, Intermediate, and Long Term timeframes. Short term improvements consisted of low cost traffic control device installation, intermediate recommendations included a right turn lane on Reas Ford Road eastbound and driveway channelization, and the long term recommendation was to evaluate and construct a roundabout.

A subsequent intersection traffic study was completed by a ***consultant employed by VDOT in 2019***. This study was again prompted by concerns from elected officials and local residents. This study included evaluation of existing conditions, traffic volume collection, crash analysis, intersection capacity analysis, alternative development, evaluation of alternatives, signal warrant analysis, conceptual cost estimates, alternative comparison, and recommendations. The recommendations of this report were separated as short term low cost improvements (traffic control device installation) and a long term recommendation to convert the intersection to a mini roundabout.

Physical Conditions

The intersection of Earlysville Road with Reas Ford Road and Earlysville Forest Drive is a four legged crossroad intersection that is two way stop controlled with free flow on Earlysville Road. The Earlysville Business Park is located just over one mile west of the intersection along the south side of Reas Ford Road. This facility is a multi-tenant industrial park that generates truck traffic that utilizes the study intersection. The Charlottesville-Albemarle Airport is located two miles south of the intersection along the north side of Earlysville Road. The majority of airport traffic enters from US 29 and the roadway network south of the intersection.

Traffic Volume

A 12-hour turning movement count was collected at the intersection of Earlysville Road with Reas Ford Road and Earlysville Forest Drive on Thursday September 23, 2021 between the hours of 7 AM to 7 PM. The overall peak hour was found to occur between the hours of 4 PM to 5 PM when 996 vehicles entered the intersection. This includes 543 vehicles on the Earlysville Road northbound approach, 307 vehicles on the Earlysville southbound approach, 95 vehicles on the Reas Ford Road eastbound approach, and 51

vehicles on the Earlysville Forest Drive westbound approach. Pedestrian volumes are low throughout all hours of the collected data, with less than five pedestrians in total traversing the intersection in all hours. Overall, trucks and heavy vehicles constitute 1.2% of all vehicles entering the intersection. Ten large trucks entered the intersection in the AM peak hour and 12 entered during the PM peak hour. The heaviest truck movement is the Reas Ford Road eastbound right turn movement, which is approximately 7% of all traffic on that approach.

Crash Data

Crash data was obtained from VDOT sources for the most recent five year period available from July 1, 2016 to June 30, 2021. Crash data was utilized to quantify the recent safety performance of the intersection and to compare the potential benefit of potential alternatives understanding constrained funding for potential safety improvement projects. Over the five year period, 15 crashes were reported within the intersection and its influence area. Right angle crashes account for 53% of intersection crashes and is the most common crash type reported to occur. Angle crashes are the type of crash potentially prevented by the installation of a traffic signal or roundabout. Six of the intersection angle crashes involved a motorist from Reas Ford colliding with a northbound motorist on Earlysville Road. Right angle crashes are concerning since this is the type of intersection crash that tends to result in injuries. The right angle crashes at this intersection accounted for 12 of the 16 documented injuries. The data shows that the majority of the angle crashes occurred from 2016 to 2018, with only one angle crash each reported in 2019 and 2020, with zero in the first half of 2020.

Alternative Evaluation

Preliminary intersection alternatives have been developed as the basis for evaluation within this study founded upon the results of previous studies and screening for appropriate countermeasures for similar locations. Preliminary design and cost estimation was performed for each alternative utilizing aerial survey data obtained from VDOT. Potential alternatives include No Build, widening Earlysville Road to construct left turn lanes in both directions and widening Reas Ford Road to construct an eastbound right turn lane (Alternative 1), installing a traffic signal along with the Alternative 1 improvements (Alternative 2), and converting the intersection to a single lane roundabout (Alternative 3). An additional short-term alternative is also briefly discussed, which is simple installation of All Way Stop Control (AWSC) as an interim measure (Alternative 4). One of the previous studies indicated that a mini roundabout should be considered for the intersection. Mini roundabouts are typically constructed in low speed residential areas and the study intersection is not appropriate for this type of design, especially considering the regular occurrence of large trucks arriving and departing the Earlysville Industrial Park via Reas Ford Road and prevailing speed of each roadway.

The **No Build Alternative** is detailed by existing traffic analysis and recent crash data. The No Build alternative is viable if existing intersection operation is acceptable in terms of level of service and crash history, or if the cost of improvement is excessive compared to the anticipated benefit. No major intersection modification or widening occurs in the **No Build Alternative**.

Alternative 1 includes construction of exclusive left turn lanes on both Earlysville Road approaches and construction of an exclusive right turn lane on the Reas Ford Road eastbound approach without any modification to intersection control (i.e. no need for signalization or a roundabout). **Alternative 2** includes the installation of a traffic signal along with construction of exclusive left turn lanes on both Earlysville Road approaches and construction of an exclusive right turn lane on the Reas Ford Road eastbound

approach without any modification to intersection control. **Alternative 3** includes construction of a single lane roundabout with an inscribed circle diameter of 170 feet. Due to the truck percentage and location of the Earlysville Business Park, the roundabout is a traditional design to accommodate a WB-62 design vehicle (tractor trailer).

Alternative 3B includes construction of a mini roundabout. This alternative was included based upon feedback from review of the preliminary report. This alternative is a modified version of **Alternative 3** utilizing significantly smaller dimensions. The mini roundabout uses a total inscribed circle diameter of 80 feet to minimize right of way impact and cost. **Alternative 3B** is assumed to provide similar operational and safety impact compared to a traditional roundabout. Therefore; LOS, queuing, and safety analysis is assumed to be identical for the purpose of this study. The key difference with a mini roundabout is that the dimension do not accommodate large vehicles to traverse the circle the same as passenger cars. With a mini roundabout, large vehicles and trucks are able to travel through and over the center island, which can be mountable curb, painted, or a modular device. With the skewed angle of the Reas Ford approach to Earlysville Road, the mini roundabout would still necessitate modification of this approach to align near 90 degrees opposite Earlysville Forest Road.

Previous studies suggested construction of a mini roundabout at the intersection, which are typically utilized for intersections where all approaching roadways have prevailing speed of less than 30 mph and truck traffic is low. With the volume of truck traffic generated by the Earlysville Business Park west of the intersection on Reas Ford Road and the prevailing speed of traffic, a mini roundabout is likely not appropriate for this location.

Alternative 4 is simply the installation of All Way Stop Control (AWSC) as a short-term (*interim only*) potential option to address the occurrence of angle crashes at the intersection. This alternative includes installation of stop signs at the intersection with advance warning signs on Earlysville Road. The engineering construction estimate for the **Alternative 4** improvements is of negligible cost. Costs to implement AWSC would be minimal if implemented by VDOT forces.

A summary table listing the potential alternatives and estimated construction cost is shown below:

Alternative Number	Description	Construction Estimate
No Build	No Build	$0
Alt 1	Turn Lanes Only	$1,903,495
Alt 2	Traffic Signal and Turn Lanes	$2,330,995
Alt 3	Traditional Roundabout	$4,267,066
Alt 3B	Mini Roundabout	$2,430,144
Alt 4	All Way Stop	Less than $5,000

Traffic Signal Warrant Analysis

The Manual on Uniform Traffic Control Devices (MUTCD) contains nine warrants for investigating the need for a traffic signal at a particular intersection. The satisfaction of a signal warrant or warrants may indicate

the need for the installation of a traffic signal. Three of the warrants deal directly with traffic volumes; two warrants focus on pedestrian issues; one focuses on safety; one on grade crossings; one on traffic signal progression; and one on a Planning level (non-data-based) analysis. None of the nine MUTCD warrants are satisfied for the intersection of Earlysville Road with Reas Ford Road and Earlysville Forest Drive. The heaviest side street movement at the intersection is the right turn movement from Reas Ford Road, and right turning traffic is generally only impeded by the queue of left turning traffic. Based upon review of the actual intersection conditions, the MUTCD traffic signal warranting criteria is not satisfied for the study intersection.

Turn Lane Analysis

Auxiliary turn lane analysis was performed for the intersection using the VDOT *Access Management Design Standards for Entrances and Intersections,* Revised January of 2021. These standards are based upon the AASHTO publication *A Policy on Geometric Design of Highways and Streets.* Based upon evaluation of actual intersection conditions, the Earlysville Road northbound approach meets the criteria for a left turn lane during the PM peak hour. In addition, the Reas Ford Road eastbound approach meets the criteria for a right turn lane during the AM peak hour.

Capacity Analysis

The procedures outlined in the Highway Capacity Manual; 6th Edition were used as guidelines for the analysis of the intersection alternatives. This manual provides procedures for the analysis of both signalized and unsignalized intersections. Level of Service (LOS) categories range from LOS "A" (best) to "F" (worst). LOS analysis was completed through the use of Synchro, version 10.3 and Sidra, version 9.0. These software packages categorize the LOS based on HCM methodology and criteria.

Evaluation of the collected data shows that the intersection currently (**No Build Alternative**) operates at an acceptable LOS, with LOS A on Earlysville Road with modest delay on the side streets. Reas Ford Road operates at LOS C and Earlysville Forest Drive operates at LOS D. Construction of auxiliary lanes including left turn lanes on Earlysville Road in both directions and a right turn lane on the Reas Ford Road eastbound approach (**Alternative 1**) provides minimal improvement only with LOS remaining unchanged. Installation of a traffic signal with auxiliary lanes (**Alternative 2**) improves all movements to LOS B or better. Installation of a roundabout (**Alternative 3**) improves all movements to LOS A or better. For the purpose of analysis, a traditional roundabout and a mini roundabout are assumed to provide the same LOS. The installation of All Way Stop Control (**Alternative 4**) as an interim measure improves LOS on the side roads to LOS B or better but deteriorates the Earlysville Road southbound approach to LOS D in the AM peak hour the northbound approach to LOS D in the PM peak hour. Alternative 4 is a considered a short term safety measure only.

Queuing Analysis

Queuing refers to the back up of vehicles on a particular approach to an intersection. Analysis was performed at the study intersection during the weekday AM and PM peak hours using the SimTraffic micro-simulation model, which is a simulation complement to the Synchro traffic analysis models utilized for the capacity analysis.

Queuing analysis indicates that no existing (**No Build Alternative**) turning movements currently exceed the available storage length or impede other traffic movements during the peak periods analyzed. Queuing analysis indicates that all conditions described in the Existing Conditions are expected to continue

with similar queuing following construction of exclusive left turn lanes on Earlysville Road and a right turn lane on the Reas Ford (**Alternative 1**) northbound approach. Queue lengths are minimally reduced in comparison to Existing Conditions. With the installation of a traffic signal (**Alternative 2**), short queues are created on the Earlysville northbound and southbound approaches. The queues are not substantial and are not anticipated to inhibit access to proposed exclusive left turn lanes. Queuing on the side road approaches is similar to existing conditions. Queuing analysis indicates that queuing is anticipated to be minimal with the construction of a roundabout (**Alternative 3**). For the purpose of analysis, a traditional roundabout and a mini roundabout are assumed to provide the same queuing results. Queuing analysis indicates that queuing is anticipated to be a more significant issue with All Way Stop Control (**Alternative 4**). The most significant queue is the Earlysville Road southbound approach during AM peak hour and Earlysville northbound approach during PM peak hour.

Safety Analysis

For purposes of comparing benefit vs cost for potential intersection improvement alternatives, evaluation of economic cost of safety performance resulting from motor vehicle crashes at the intersection was performed utilizing accepted Federal Highway Administration (FHWA) safety analysis procedures.

Applying approved Crash Modification Factors (CMF's), Alternative 3 (Roundabout) would be anticipated to result in the largest reduction in overall crashes at the intersection. Alternative 3, however, also is the most expensive and the most impactful to adjacent property owners and the community. Alternative 3B was is a mini roundabout option intended to be less costly. For the purpose of this study, crash reduction is assumed to be the same for the traditional roundabout and mini roundabout. Further evaluation of anticipated monetized annual safety performance over a 20 year service life was compared to the estimated cost of construction for each alternative. The 20 year performance assumes annual inflation of 4% for cost of each crash type. By comparison of the forecast crash reduction with estimated cost, ***Alternative 3B (mini roundabout)*** was found to achieve the highest benefit/cost ratio of all alternatives evaluated.

Conclusions:

This report summarizes evaluation of potential intersection improvement alternatives at the intersection of Earlysville Road (Route 743) with Reas Ford Road (Route 660) and Earlysville Forest Drive (Route 660) in Earlysville, Albemarle County. Albemarle County and The Virginia Department of Transportation (VDOT) previously identified safety concerns at the intersection evidenced by crash data, and subsequently previously evaluated various options for modification of the intersection.

Based upon evaluation of the collected data and Alternatives evaluation, the following recommendations are made in regard to the intersection of Earlysville Road with Reas Ford Road and Earlysville Forest Drive:

- *Based upon assessment of the entirety of the collected data, major intersection reconfiguration is not necessary at this time, and the **No Build Alternative** is appropriate. The intersection currently operates at adequate Level of Service (LOS) and the occurrence of crashes at the intersection has declined in the most recent 30 month period of the study.*

- *Due to the identified pattern of right angle crashes from 2016 to 2018, the intersection should continue to be monitored closely to determine if the recent reduction of intersection crashes following implementation of low cost safety improvements endures.*

- *If right angle crashes persist or increase where five or more occur in a 12 month period, a traffic signal can be installed in accordance with MUTCD Warrant Seven (Crash Safety). If safety performance or future traffic volume indicate that intersection control needs to be enhanced, a traffic signal or a roundabout both would provide adequate Level of Service.*

- *A mini roundabout appears to be inappropriate at this intersection due to volume, truck traffic, and prevailing speed. If a roundabout is considered in the future, a traditional roundabout is more appropriate for the conditions at this location.*

- *Ideally, construct auxiliary lanes including left turn lanes in both directions of Earlysville Road and a right turn lane on Reas Ford Road. VDOT warranting criteria based upon AASHTO is satisfied for these approaches. These auxiliary lanes, however, do not address the right angle crash pattern at the intersection or appreciably improve Level of Service.*

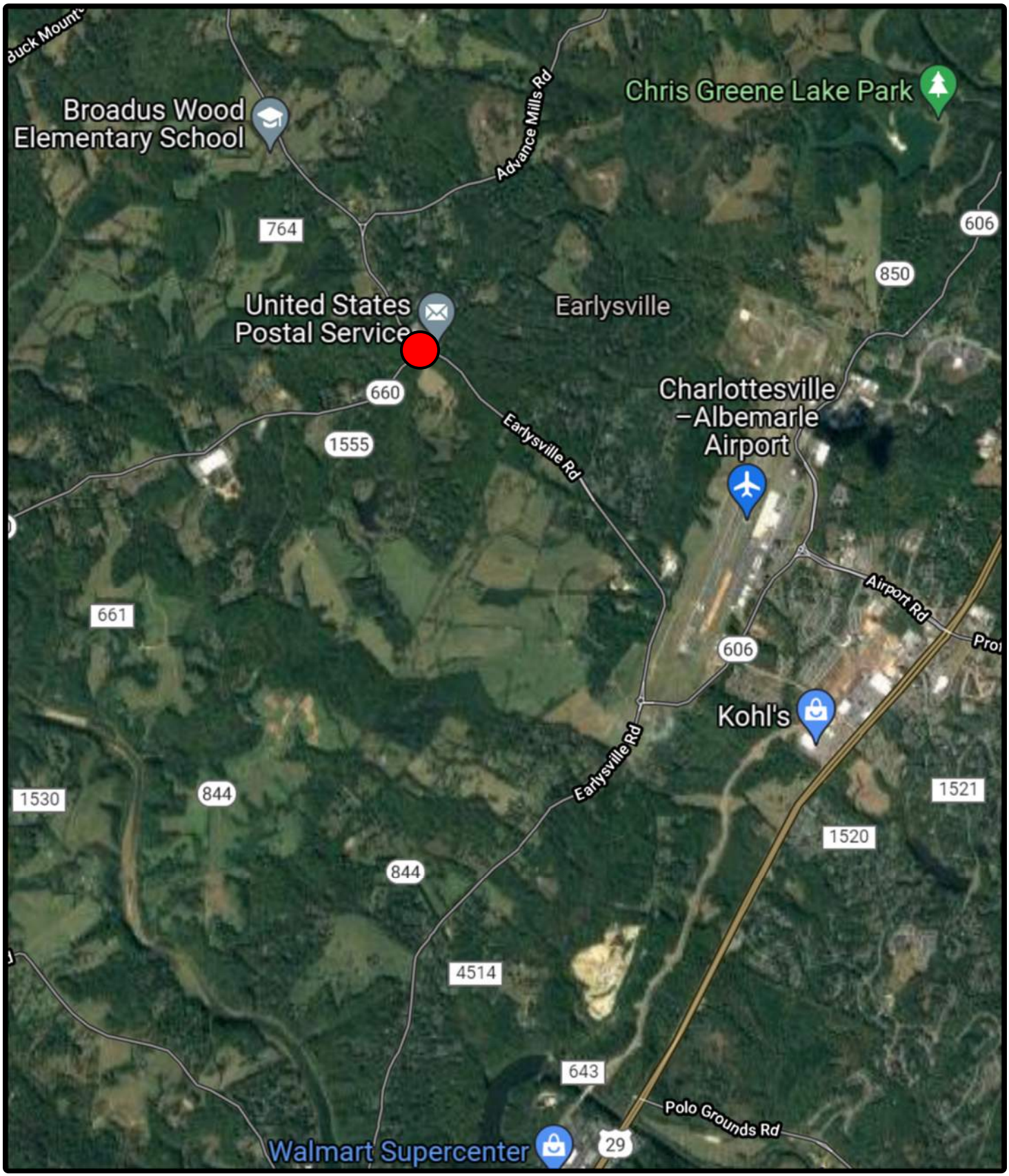
INTRODUCTION

This report summarizes evaluation of potential intersection improvement alternatives at the intersection of Earlysville Road (Route 743) with Reas Ford Road (Route 660) and Earlysville Forest Drive (Route 660) in Earlysville, Albemarle County. Albemarle County and The Virginia Department of Transportation (VDOT) previously identified safety concerns at the intersection of Earlysville Road and Reas Ford Road evidenced by crash data, and subsequently evaluated various options for modification of the intersection. This study includes review of previous investigations, assessment of physical conditions, traffic volume collection, evaluation of crash data, discussion of alternatives, alternatives evaluation, signal warrant analysis, capacity analysis, queuing analysis, safety analysis, and investigative conclusions.

The specific purpose of this study is to review and expand the effort from previous studies, determine if the roundabout alternative is appropriate, consider alternatives to a roundabout, evaluate the intersection operation to define any deficiency, provide cost and benefit analysis for improvements, evaluate and compare operation of alternatives, determine appropriate size of a potential roundabout, prepare cost estimates for recommended improvements, and identify the pros and cons associated with the proposed recommendation including impact of construction on neighboring businesses and the community of Earlysville.

Traffic analyses will consider No Build Conditions utilizing 2021 date along with evaluation of four separate alternatives. Forecast or Design Year analysis was not part of the scope of work for this investigation. Alternatives evaluated include widening to construct left turn lanes on Earlysville Road and right turn lane on Reas Ford Road without installation of a traffic signal (**Alternative 1**), Installation of a Traffic Signal with left turn lanes on Earlysville Road and a right turn lane on Reas Ford Road (**Alternative 2**), conversion to a roundabout (**Alternative 3 and Alternative 3B**), and installation of All-way Stop Control (**Alternative 4).** The **No Build Alternative** is evaluated for comparison as shown in the existing configuration. Crash data is reviewed in detail to document the extent of the existing safety issue and as related to performance of potential mitigation strategies.

The study area and project location is shown on **Figure 1**.



LEGEND

= Study Intersection

AMT

N

NOT TO SCALE

Earlysville and Reas Ford Road

Site Location Map

DATE: March 2022

FIGURE 1

PREVIOUS STUDIES

Albemarle County and The Virginia Department of Transportation (VDOT) previously identified safety concerns at the intersection of Earlysville Road with Reas Ford Road and Earlysville Forest Drive. The primary issues that resulted in the previous intersection studies were right angle crashes that occurred at the intersection. The principal conclusion of previous intersection studies was that the intersection should be reconfigured as a roundabout. Copies of previous traffic study documents are included in **Appendix I**.

An internal intersection traffic study was completed by ***VDOT Culpepper District in 2018***. This study was prompted from a request from a state legislator based upon citizen concerns regarding intersection safety. This study included evaluation of crash data, sight distance, signal warrant analysis, auxiliary lane analysis, and signing and marking considerations. Recommendations from this report are separated by Short Term, Intermediate, and Long Term timeframes and are shown below:

- Short Term Recommendations:
  - *Refresh Stop Ahead pavement markings on Reas Ford Road*
  - *Refresh Stop Bar on the Reas Ford Road approach*
  - *Refresh and relocate Stop Bart forward on the Earlysville Forest Drive approach*
- Intermediate Recommendations:
  - *Introduce driveway channelization for uncontrolled approaches in the northwest quadrant*
  - *Construct an exclusive right-turn lane on the Reas Ford Road approach*
- Long Term Recommendations:
  - *Evaluate and install a roundabout as the preferred intersection alternative*

A subsequent intersection traffic study was completed by a ***consultant employed by VDOT in 2019***. This study was again prompted by concerns from elected officials and local residents. This study included evaluation of existing conditions, traffic volume collection, crash analysis, intersection capacity analysis, alternative development, evaluation of alternatives, signal warrant analysis, conceptual cost estimates, alternative comparison, and recommendations. The recommendations of this report were separated as short term low cost improvements and a long term recommendation to convert the intersection to a mini roundabout. Recommendations are detailed below:

- Short Term (Low Cost) Recommendations:
  - *Dual installation of oversized W2-1 (Crossroad Warning) signs with street name plaques*
  - *Enhanced pavement markings to delineate through lanes through the intersection*
  - *Dual installation of W3-1 (Stop Ahead) signs on side streets*
  - *Dual installation of R1-1 (STOP) signs on side streets*
  - *Install retroreflective sign post inserts*
  - *Removal of vegetation or obstructions to improve sight distance*
- Long Term Recommendation:
  - *Construct a mini roundabout*

Additional traffic control devices have been installed at the intersection following the most recent traffic study. The additional traffic control devices include:

- Radar feedback sign on Earlysville Road NB – Installed May 2020
- Flashing LED STOP sign on Reas Ford Road – installed June 2020

ROADWAY CONDITIONS

Below is a detailed description of the existing study area roadway network. AADT (Annual Average Daily Traffic) volume information was estimated based on the collected turning movement counts (TMC) using a K factor of 10%.

Earlysville Road (Route 743) is a two lane Urban Collector roadway with an exclusive right turn lane in the northbound direction. The roadway is undivided with shoulders of varying width from 0-10 feet wide. Earlysville Road is oriented north-south operating as free-flow traveling unimpeded through the intersection. The speed limit on Earlysville Road is 35 mph (miles per hour) and the AADT is 8,500 vpd (vehicles per day).

Reas Ford Road (Route 660) is a two lane Rural Major Collector roadway. Reas Ford Road is oriented east-west operating under stop control. The roadway is undivided without paved shoulders and has an open ditch on the east side of the road. The speed limit on Reas Ford Road is 35 mph and the AADT is 5,700 vpd.

Earlysville Forest Drive (Route 660) is a two lane undivided Urban Local Collector without paved shoulders. Earlysville Forest Drive is oriented east-west opposite Reas Ford Road operating under stop control. The speed limit on Earlysville Forest Drive is 35 mph and the AADT is 1,110 vpd.

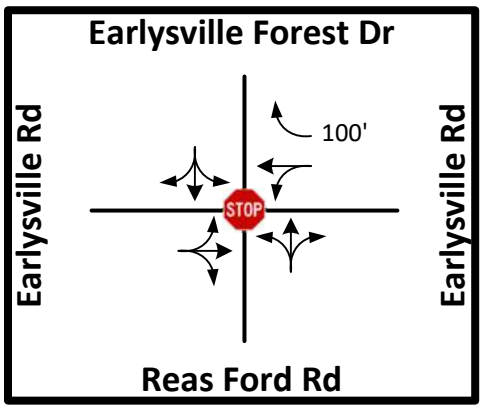
The Rivanna Community Church is located in the northeast quadrant of the intersection. A new sanctuary was recently completed that relocated the building closer to the roadway. The parking area with access to Earlysville Forest Drive has also been expanded. The Earlysville Exchange Thrift Store is located in the northwest quadrant of the intersection with an uncontrolled driveway frontage along the west side of Earlysville Road. VIP Customs is located north of and adjacent to the Earlysville Exchange and utilizes the same uncontrolled connected roadway frontage. The Earlysville Auto Center is located 0.07 mile north of the intersection along the east side of Earlysville Road. The Earlysville Post Office is located in the southeast quadrant of the intersection with access to Earlysville Forest Drive via Bent Oaks Drive.

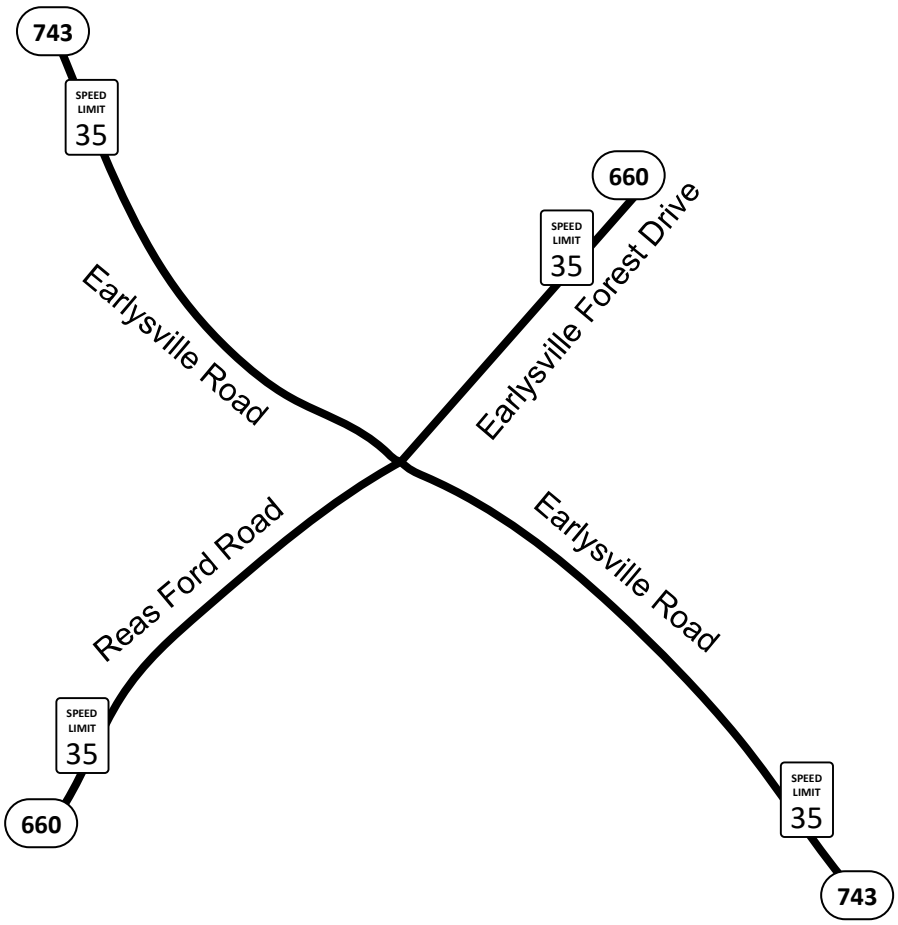
The Earlysville Business Park is located just over one mile west of the intersection along the south side of Reas Ford Road. This facility is a multi-tenant industrial park that generates truck traffic that utilizes the study intersection. The Charlottesville-Albemarle Airport is located two miles south of the intersection along the north side of Earlysville Road. The majority of airport traffic enters from US 29 and the roadway network south of the intersection.

Table 1 below provides a detailed description of the existing study area roadway network. The 2021 existing intersection lane configuration and intersection control are shown on **Figure 2**.

Table 1: Roadway Facility Summary

Name	Code	State Functional Classification	Area	Direction	Speed Limit	AADT	Year	Description
Earlysville Road	743	Urban Collector	Earlysville	N-S	35	8,500	2021	N-S Urban Collector that connects with Route 606 to the southeast and Route 629 to the northwest
Reas Ford Road	660	Rural Major Collector	Earlysville	E-W	35	5,700	2021	E-W Rural Major Collector that connects to Route 676 to the south and Route 743 to the north
Earlysville Forest Drive	660	Urban Local Collector	Earlysville	E-W	35	1,110	2021	E-W Urban Local Collector that intersects with Route 743 to the north and south





LEGEND

- STOP — Existing Traffic Control
- Existing Roadway
- Existing Lane Configuration
- XXX' Storage Bay Length
- SPEED LIMIT XX — Existing Posted Speed

N

NOT TO SCALE

Earlysville and Reas Ford Road

2021 Existing Lane Configuration

DATE: March 2022

FIGURE 2

TRAFFIC VOLUME

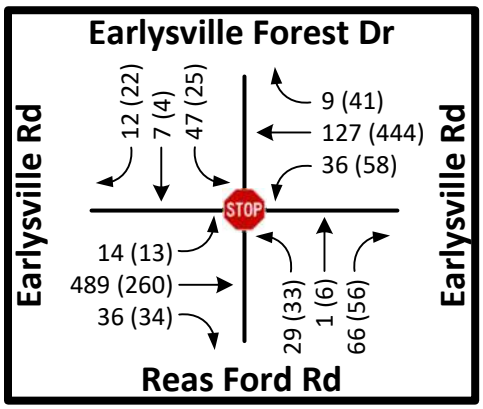
A 12-hour turning movement count was collected at the intersection of Earlysville Road with Reas Ford Road and Earlysville Forest Drive on Thursday September 23, 2021 between the hours of 7 AM to 7 PM. On this date, Albemarle County Schools were fully operational with in classroom instruction for all students.

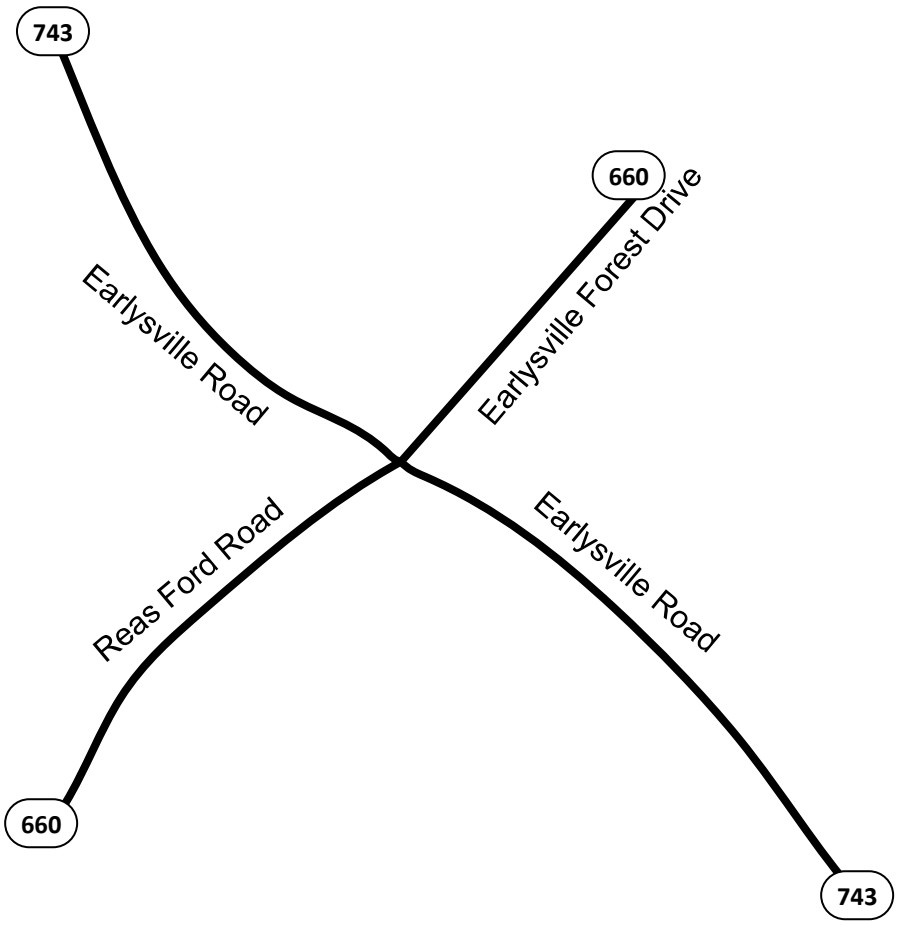
The overall peak hour was found to occur between the hours of 4 PM to 5 PM when 996 vehicles entered the intersection. This includes 543 vehicles on the Earlysville Road northbound approach, 307 vehicles on the Earlysville southbound approach, 95 vehicles on the Reas Ford Road eastbound approach, and 51 vehicles on the Earlysville Forest Drive westbound approach.

Overall, trucks and heavy vehicles constitute 1.2% of all vehicles entering the intersection. Ten large trucks entered the intersection in the AM peak hour and 12 entered during the PM peak hour. The most significant truck movements occur on the Reas Ford Road approach right turn movement (7% in the PM peak hour), the Earlysville Road northbound left turn movement (5% in the PM peak hour), and the Earlysville Road southbound right turn movement (6% in the PM peak hour).

Pedestrian and bicycle data was collected as part of the turning movement counts. Pedestrian volumes are low throughout all hours of the collected data, with less than five pedestrians traversing the intersection in all hours.

The turning movement count (including truck and pedestrian data) is located in **Appendix B** and the 2021 Existing Traffic Volumes for the weekday AM and PM peak hour volumes are shown in **Figure 3**.





LEGEND

- STOP Existing Traffic Control
- Existing Roadway
- → Existing Lane Configuration
- XX AM Peak Hour Voluems
- (XX) PM Peak Hour Volumes

N

NOT TO SCALE

Earlysville and Reas Ford Road

2021 Existing Volumes

DATE: March 2022

FIGURE 3

CRASH DATA

Crash data was obtained from VDOT sources for the most recent five year period available from July 1, 2016 to June 30, 2021. Crash data was utilized to quantify the recent safety performance of the intersection and to compare the potential benefit of potential alternatives understanding constrained funding for potential safety improvement projects.

Over the five year period, 15 crashes were reported within the intersection and its influence area. The influence area of the intersection was assumed to be within 300 feet on all approaches. Of the 15 crashes, one occurred during hours of darkness and two occurred on wet and/or snow covered pavement. The 15 total reported crashes include eight angle crashes, two rear end crashes, two sideswipe (opposite direction) crashes, one head-on crash, one roadway departure (right) crash, and one crash involving a bicycle rider being struck by a vehicle. Right angle crashes account for 53% of intersection crashes and is the most common crash type reported to occur. Angle crashes are the type of crash potentially prevented by the installation of a traffic signal or roundabout. **Table 2** below provides a summary of the crash type along with the percentage of total crashes at the intersection during the five-year period.

Table 2: Crash Type Summary

Crash Type	Number of Crashes	Percent of Total
Angle	8	53%
Head On	1	7%
Bicycle Hit by Vehicle	1	7%
Ran Off Road (Right)	1	7%
Rear End	2	13%
Sideswipe, Opposite Direction	2	13%

No fatal crashes occurred at the intersection during the study period. The 15 total reported crashes resulted in 16 total reported injuries from eight injury crashes. Of the 16 total injuries, two were Type A injuries, 11 were Type B injuries, and three were Type C injuries. Type A injuries are severe incapacitating injuries, Type B injuries are non-incapacitating visible injuries, and Type C injuries are non-visible injuries where the occupant complains of pain. Twelve of the injuries resulted from the right angle crashes and two injuries occurred during the collision involving a bicycle. **Table 3** provides a summary of number of injuries by crash severity.

Table 3: Injuries by Severity

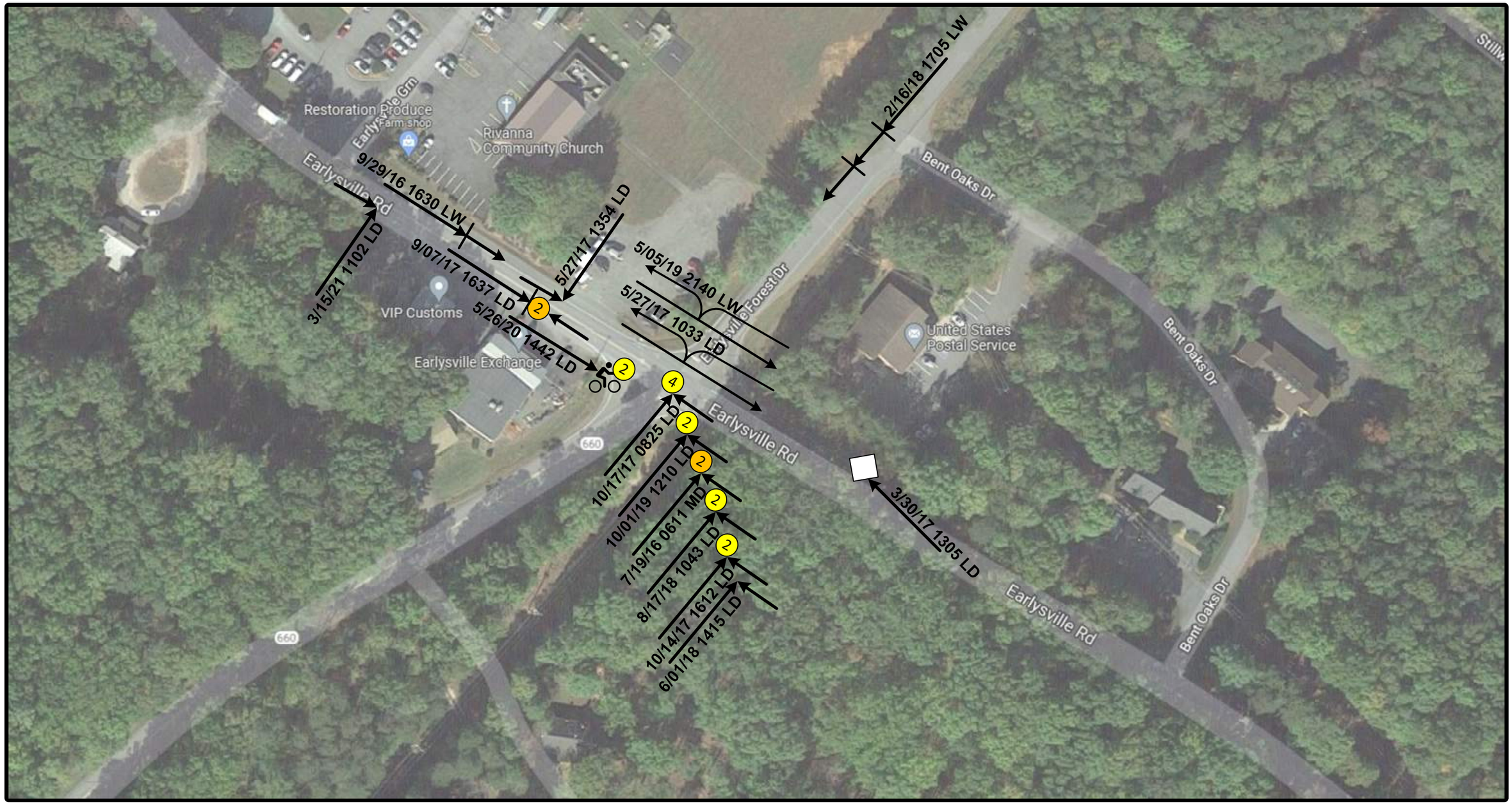
Injury Type	Number of Injuries	Percent of Total
Fatal Injuries	0	0%
Class A Injuries	2	13%
Class B Injuries	11	69%
Class C Injuries	3	19%
Total Non-Fatal Injuries	16	100%
Total Injuries	16	100%

The intersection crash rate was determined to be 0.83 crashes per million entering vehicles. The intersection severity rate is 0.11 injuries per million entering vehicles, with serious injuries being correlated with Type A injuries. **Table 4** provides a summary of the intersection crash rates.

Table 4: Intersection Crash Rate Summary

Intersection	DHV	ADT	Crashes	Years	Crash Rate (CPMEV)	Total Injuries	Injury Rate	Severe (Type A + Fatal)	Severity Rate
Earlysville Road with Reas Ford Road	996	9960	15	5	0.83	16	0.88	2	0.11

The most concerning crash pattern at the intersection is the occurrence of right angle crashes involving entering motorists from the Reas Ford approach. Six of the intersection right angle crashes involved a motorist from Reas Ford colliding with a northbound motorist on Earlysville Road. A single angle crash also occurred from the Thrift Store open frontage approach and another from the Ravenna Community Church approach. Right angle crashes are concerning since this is the type of intersection crash that tends to result in injuries. The right angle crashes at this intersection accounted for 12 of the 16 documented injuries. The data shows that the majority of the angle crashes occurred from 2016 to 2018, with only one reported in 2019 and none in 2020 or the first half of 2021.



SYMBOLS	TYPES OF CRASHES	EVENT CODES
Moving Vehicle Backing Vehicle Overturned Out of Control Fixed Object Fatal Crash Injury Crash Debris Bike DUI Parked Vehicle Type A Injury Type B Injury Type C Injury	Rear End Head On Sideswipe Same Sideswipe Opposite Left Turn Right Angle	L=Daylight N=Nighttime M=Dusk/Dawn D=Dry W=Wet S=Snow I=Ice 01/01/15=Date 2000=8:00 PM (Military)

N

NOT TO SCALE

Earlysville Road with Reas Ford Road

Collision Diagram

DATE: March 2022

FIGURE 4

ALTERNATIVES DISCUSSION

Preliminary intersection alternatives have been developed as the basis for evaluation within this study founded upon the results of previous studies and screening for appropriate countermeasures for similar locations. Preliminary design was performed for each alternative utilizing aerial survey data obtained from VDOT. Initial cross sections were developed for each site specific improvement for the purpose of preparing accurate cost estimates.

Potential alternatives include widening Earlysville Road to construct left turn lanes in both directions and widening Reas Ford Road to provide an eastbound right turn lane (**Alternative 1**), Installing a traffic signal along with the Alternative 1 improvements (**Alternative 2**), and converting the intersection to a single lane roundabout (**Alternative 3**). A mini roundabout option (**Alternative 3B**) is also included as a variation of Alternative 3. An additional short-term alternative is also briefly discussed, which is simple installation of All Way Stop Control (AWSC) as an interim measure (**Alternative 4**).

Intersection Alternatives

Intersection Alternative improvements Include:

- No Build Alternative
- Alternative 1: Left-Turn Lanes Earlysville Road NB and SB & Right-Turn Lane Reas Ford Road EB
- Alternative 2: Installation of a Traffic Signal along with Left-Turn Lanes Earlysville Road & Right-Turn Lane Reas Ford Road
- Alternative 3: Single Lane Roundabout
- Alternative 3B: Mini Roundabout
- Alternative 4: Interim AWSC

No Build Alternative

The Traffic Operations Study details analysis of Existing Condition, which equates as the **No Build Condition** for the intersection. The **No Build Alternative** is detailed by existing traffic analysis and current crash data. The No Build alternative is viable if existing intersection operation is acceptable in terms of level of service analysis and crash history, or if the cost of improvement is excessive compared to the anticipated benefit. **Table 5** presents Pros and Cons for the **No Build Alternative**.

Table 5: No Build Pros & Cons

Pros	Cons
No Cost	No Substantial Safety Enhancement
No Property Impacts	Potential Stakeholder Dissatisfaction
Earlysville Road Remains Free Flow	
Allows further Monitoring	
Intersection Operation is Already Acceptable	

Alternative 1 (Turn Lanes Only)

Alternative 1 include construction of exclusive left turn lanes on both Earlysville Road approaches and construction of an exclusive right turn lane on the eastbound Reas Ford Road approach without any modification to intersection control. The engineering construction estimate for the **Alternative 1** improvements is **$1,903,495.** A breakdown of costs for the estimate can be found **Appendix E**.

Widening will require right of way acquisition but is not anticipated to adversely impact any adjacent property owners. Utility relocations are minimal or not necessary with this alternative. All driveway and property access is left intact as well. **Table 6** presents Pros and Cons for **Alternative 1**.

Table 6: Alternative 1 Pros & Cons

Pros	Cons
Less Costly Compared with other Alternatives	Does Not Address Right Angle Crashes
Reduces Potential for Rear End Crashes	Potential Stakeholder Dissatisfaction
Earlysville Road Remains Free Flow	Property Impacts are Moderate
Improves Operation of Side Streets	

A detailed exhibit of **Alternative 1** is illustrated in **Figure 5**.

Alternative 2 (Traffic Signal Plus Turn Lanes)

Alternative 2 include the installation of a traffic signal along with construction of exclusive left-turn lanes on both Earlysville Road approaches and construction of an exclusive right-turn lane on the eastbound Reas Ford Road approach without any modification to intersection control. The engineering construction estimate for the **Alternative 2** improvements is **$2,330,995.** A breakdown of costs for the estimate can be found **Appendix E**.

The same as Alternative 1, widening will require right of way acquisition but is not anticipated to adversely impact any adjacent property owners. Utility relocations are minimal or not necessary with this alternative. All driveway and property access is left intact as well. Installation of the signal improves ingress and egress from the Rivanna Church, Earlysville Business Park, and Earlysville Post Office. Due to proximity, the queuing from the traffic signal creates some interference with the open driveway to the Earlysville Exchange and VIP Customs. **Table 7** presents Pros and Cons for **Alternative 2**.

Table 7: Alternative 2 Pros & Cons

Pros	Cons
Less Costly than Roundabout Alternative	Long Term Maintenance
Reduces Potential for Angle Crashes	Increases Delay on Earlysville Road
Improves Operation of Side Streets	Property Impacts are Moderate
Gateway to Business Park	Potential for Increased Rear End Crashes
Less Property Impacts than Roundabout	Marginal Need for Signal in terms of Volume

A detailed exhibit of **Alternative 2** is illustrated in **Figure 6**.

Alternative 3 (Single Lane Roundabout)

Alternative 3 includes construction of a single lane roundabout with an inscribed circle diameter of 170 feet. Due to the truck percentage and location of the Earlysville Business Park, the roundabout is designed to accommodate a WB-62 design vehicle. The engineering construction estimate for the **Alternative 3** improvements is **$4,267,066.** A breakdown of costs for the estimate can be found **Appendix E**.

Construction of the single lane roundabout will have major impacts on right of way acquisition. The roundabout creates significant takes from the Rivanna Community Church, Earlysville Post Office, and likely total takes for the Earlysville Exchange on the northwest corner. One utility pole will be relocated. This alternative will require a complex Temporary Traffic Control (TTC) plan that adds significant cost. **Table 8** presents Pros and Cons for **Alternative 3**.

Table 8: Alternative 3 Pros & Cons

Pros	Cons
Greatest Reduction in Crashes Predicted	Most Costly Alternative
Traffic Calming Impact	Major Property Impacts
Better LOS Compared with Traffic Signal	Benefit vs Cost
Improves Operation of Side Streets	Constructability and MOT
Gateway to Business Park	

A detailed exhibit of **Alternative 3** is illustrated in **Figure 7**.

Alternative 3B (Mini Roundabout)

Alternative 3B includes construction of a single lane *mini* roundabout with an inscribed circle diameter of 80 feet. Trucks would traverse a mountable circular median built within existing right of way. Due to the skewed angle of approach, the Reas Ford approach necessitates realignment for proper operation. The engineering construction estimate for the **Alternative 3B** improvements is **$2,430,144.** A breakdown of costs for the estimate can be found **Appendix E**.

Previous studies suggested construction of a mini roundabout. Typically, mini roundabouts should only be considered in areas where all approaching roadways have prevailing speed of less than 30 mph. Mini roundabouts are not well suited for high volumes of trucks, as trucks will occupy most of the intersection when turning. Mini roundabouts are most often employed in residential areas with lower volumes of traffic. With the volume of truck traffic generated by the Earlysville Industrial Park west of the intersection on Reas Ford Road and the prevailing speed of traffic, a mini roundabout may not be appropriate for this location.

Construction of the mini roundabout will have modest impacts on right of way acquisition for the realignment of the Reas Ford Road approach. **Table 9** presents Pros and Cons for **Alternative 3B**.

Table 9: Alternative 3B Pros & Cons

Pros	Cons
Greatest Reduction in Crashes Predicted	Impacts to Truck Traffic
Traffic Calming Impact	Not Appropriate with Industrial Park
Better LOS Compared with Traffic Signal	May be perceived as a Nuissance
Highest B/C safety Ratio	Constructability and MOT
Less Expensive than a Traditional Roundabout	

A detailed exhibit of **Alternative 3B** is illustrated in **Figure 8**.

Alternative 4 (Interim AWSC)

Alternative 4 is simply the installation of All Way Stop Control (AWSC) as a short-term interim potential option to address the occurrence of angle crashes at the intersection. This alternative includes installation of stop signs at the intersection with advance warning signs on Earlysville Road. The engineering construction estimate for the **Alternative 4** improvements is of negligible cost. Costs to implement AWSC would be under **$5,000** if implemented by VDOT forces.

There are no impacts with the installation of the AWSC aside from traffic operations, which is detailed in the capacity section of this report. AWSC is not a long term intersection control strategy and should be considered an interim measure only if determined to be viable to address angle crashes. No design schematic is provided for this interim alternative. **Table 10** presents Pros and Cons for **Alternative 4**.

Table 10: Alternative 4 Pros & Cons

Pros	Cons
Minimal Cost	Disruptive to Earlysville Road LOS
Easily Implemented	Potential for Rear End Crashes on Earlysville Road
Addresses Right Angle Crash Problem	Stakeholder Dissatisfaction
Improves Operation of Side Streets	Interim Solution Only
	No Gateway Effect for Industrial Park

001
600 EARLYSILLE GREEN LLC
DB 4569 PG 661
2.1300 AC.
TAX MAP= 31

002
HOOD,STEVE & KATHY HOOD ET ALS TRUSTEES RIVANNA COMMUNITY CHURCH
DB 4389 PG 746
4.1200 AC.
TAX MAP= 31

RECENTLY CONSTRUCTED CHURCH

RECONFIGURED PARKING LOT

007D
TST INVESTMENTS LLC
DB 4454 PG 551
1.1.83 AC.
TAX MAP= 31

EARLYSVILLE ROAD

EARLYSVILLE FOREST ROAD

003
APHF - VIRGINIA LLC
DB 5163 PG 625
0.8780 AC.
TAX MAP= 31

007C
TST INVESTMENTS LLC
DB 4454 PG 551
0.40 AC.
TAX MAP= 31

007A
TST INVESTMENTS LLC
DB 4454 PG 551
0.50 AC.
TAX MAP= 31

004
EARLYSVILLE COMMONS LAND TRUST+GEO
PARCEL ID 031B0-00-00-000C3
0.5980 AC.
TAX MAP= 31

007B
TST INVESTMENTS LLC
DB 4454 PG 551
0.03 AC.
TAX MAP= 31

REAS FORD ROAD

006
HEYWARD,JAMES H OR CANDACE L
DB 3878 PG 222
95.5950 AC.
TAX MAP= 31

EARLYSVILLE ROAD

005
ASHLYNN LLC
DB 3442 PG 032
0.6540 AC.

LEGEND

PROP. PAVE. (FULL-DEPTH OR OVERLAY)

EXISTING PROPERTY LINES

PROPOSED RIGHT-OF-WAY

A. Morton Thomas and Associates, Inc.
Consulting Engineers

SCALE
0 25' 50'

EARLYSVILLE-REAS FORD INTERSECTION IMPROVEMENT UNSIGNALIZED OPTION

FIGURE 5

MARCH 2022

001
600 EARLYSILLE GREEN LLC
DB 4569 PG 661
2.1300 AC.
TAX MAP= 31

002
HOOD,STEVE & KATHY HOOD ET ALS TRUSTEES RIVANNA COMMUNITY CHURCH
DB 4389 PG 746
4.1200 AC.
TAX MAP= 31

RECENTLY CONSTRUCTED CHURCH

RECONFIGURED PARKING LOT

007D
TST INVESTMENTS LLC
DB 4454 PG 551
1.1.83 AC.
TAX MAP= 31

007C
TST INVESTMENTS LLC
DB 4454 PG 551
0.40 AC.
TAX MAP= 31

007A
TST INVESTMENTS LLC
DB 4454 PG 551
0.50 AC.
TAX MAP= 31

007B
TST INVESTMENTS LLC
DB 4454 PG 551
0.03 AC.
TAX MAP= 31

006
HEYWARD,JAMES H OR CANDACE L
DB 3878 PG 222
95.5950 AC.
TAX MAP= 31

003
APHF - VIRGINIA LLC
DB 5163 PG 625
0.8780 AC.
TAX MAP= 31

004
EARLYSVILLE COMMONS LAND TRUST,GEO
PARCEL ID 031B0-00-00-000C3
0.6980 AC.
TAX MAP= 31

005
ASHLYNN LLC
DB 3442 PG 032
0.6540 AC.

EARLYSVILLE ROAD

EARLYSVILLE FOREST ROAD

REAS FORD ROAD

EARLYSVILLE ROAD

LEGEND

- PROP. PAVE. (FULL-DEPTH OR OVERLAY)
- EXISTING PROPERTY LINES
- PROPOSED RIGHT-OF-WAY
- PROPOSED TRAFFIC SIGNAL

A. Morton Thomas and Associates, Inc.
Consulting Engineers

SCALE
0 25' 50'

EARLYSVILLE-REAS FORD INTERSECTION IMPROVEMENT SIGNALIZED OPTION

FIGURE 6

MARCH 2022

001
600 EARLYSILLE GREEN LLC
DB 4569 PG 661
2.1300 AC.
TAX MAP° 31

002
HOOD, STEVE & KATHY HOOD ET ALS
TRUSTEES RIVANNA COMMUNITY CHURCH
DB 4389 PG 746
4.1200 AC.
TAX MAP° 31

RECENTLY CONSTRUCTED CHURCH

RECONFIGURED PARKING LOT

EARLYSVILLE FOREST ROAD

007D
TST INVESTMENTS LLC
DB 4454 PG 551
11.83 AC.
TAX MAP° 31

EARLYSVILLE ROAD

003
APIF - VIRGINIA LLC
DB 5163 PG 625
0.8780 AC.
TAX MAP° 31

007C
TST INVESTMENTS LLC
DB 4454 PG 551
0.40 AC.
TAX MAP° 31

007A
TST INVESTMENTS LLC
DB 4454 PG 551
0.50 AC.
TAX MAP° 31

004
EARLYSVILLE COMMONS LAND TRUST: GEO
PARCEL ID 031B0-00-00-000C3
0.6980 AC.
TAX MAP° 31

DEMOLISH PAVEMENT

007B
TST INVESTMENTS LLC
DB 4454 PG 551
0.03 AC.
TAX MAP° 31

REAS FORD ROAD

006
HEYWARD, JAMES H OR CANDACE L
DB 3878 PG 222
95.5950 AC.
TAX MAP° 31

005
ASHLYNN LLC
DB 3442 PG 032
0.6540 AC.

EARLYSVILLE ROAD

LEGEND

- PROP. PAVE. (FULL-DEPTH OR OVERLAY)
- PROPOSED TRUCK APRON
- PROPOSED LANDSCAPING
- PROPOSED CONCRETE SPLITTER ISLAND
- EXISTING PROPERTY LINES
- PROPOSED RIGHT-OF-WAY
- PAVEMENT DEMOLITION

A. Morton Thomas and Associates, Inc.
Consulting Engineers

SCALE
0 25' 50'

EARLYSVILLE-REAS FORD INTERSECTION IMPROVEMENT ROUNDABOUT OPTION

FIGURE 7

MARCH 2022

001
600 EARLYSILLE GREEN LLC
DB 4569 PG 661
2.1300 AC.
TAX MAP° 31

002
HOOD, STEVE & KATHY HOOD ET ALS
TRUSTEES RIVANNA COMMUNITY CHURCH
DB 4389 PG 746
4.1200 AC.
TAX MAP° 31

RECENTLY CONSTRUCTED CHURCH

RECONFIGURED PARKING LOT

EARLYSVILLE FOREST ROAD

007D
TST INVESTMENTS LLC
DB 4454 PG 551
11.83 AC.
TAX MAP° 31

EARLYSVILLE ROAD

003
APIF - VIRGINIA LLC
DB 5163 PG 625
0.8780 AC.
TAX MAP° 31

007C
TST INVESTMENTS LLC
DB 4454 PG 551
0.40 AC.
TAX MAP° 31

007A
TST INVESTMENTS LLC
DB 4454 PG 551
0.50 AC.
TAX MAP° 31

004
EARLYSVILLE COMMONS
LAND TRUST: GEO
PARCEL ID 031B0-00-00-000C3
0.6980 AC.
TAX MAP° 31

007B
TST INVESTMENTS LLC
DB 4454 PG 551
0.03 AC.
TAX MAP° 31

REAS FORD ROAD

006
HEYWARD, JAMES H OR
CANDACE L
DB 3878 PG 222
95.5950 AC.
TAX MAP° 31

005
ASHLYNN LLC
DB 3442 PG 032
0.6540 AC.

EARLYSVILLE ROAD

LEGEND

- PROP. PAVE. (FULL-DEPTH OR OVERLAY)
- PROPOSED TRUCK APRON
- PROPOSED CONCRETE SPLITTER ISLAND
- EXISTING PROPERTY LINES
- PROPOSED RIGHT-OF-WAY
- CHEVRON MARKINGS

A. Morton Thomas and Associates, Inc.
Consulting Engineers

SCALE
0 25' 50'

EARLYSVILLE-REAS FORD INTERSECTION IMPROVEMENT MINI-ROUNDABOUT OPTION

FIGURE 8

MARCH 2022

SIGNAL WARRANT ANALYSIS

The Manual on Uniform Traffic Control Devices (MUTCD) contains nine warrants for investigating the need for a traffic signal at a particular intersection. The satisfaction of a signal warrant or warrants may indicate the need for the installation of a traffic signal. Three of the warrants deal directly with traffic volumes; two warrants focus on pedestrian issues; one focuses on safety; one on grade crossings; one on traffic signal progression; and one on a Planning level (non-data-based) analysis.

In accordance with MUTCD procedures, the impact of right turning traffic from the side street approaches was assessed to determine appropriate consideration as a component of the signal warrant analysis. Left turning motorists or those crossing the intersection are those most benefiting from a traffic signal, as right turning maneuvers typically can be made easily without a signal. Therefore, *Pagones Theorem* was utilized to reduce the number of right turns included in the minor street approach volume. A detailed report containing the hourly volumes at the intersection is located in **Appendix D**.

Warrant 1 – Eight-Hour Vehicular Volume

This warrant is intended for application at locations where there is a large volume of intersection traffic. To meet Warrant 1, the major street traffic (total of both approaches) must meet or exceed 350 vehicles per hour while the minor street traffic (one direction only) must meet or exceed 105 vehicles per hour for any eight hours of the day (Condition A – Minimum Vehicular Volume), or the major street traffic (total of both approaches) must meet or exceed 525 vehicles per hour while the minor street traffic (one direction only) must meet or exceed 53 vehicles per hour for any 8 hours of the day (Condition B – Interruption of Continuous Traffic). Warranting criteria have been reduced by 30% to utilize the 70% column to reflect the isolated location of the intersection. Adjustment of side street right turn volume was made using Pagones Theorem.

The minimum thresholds and conditions for this warrant as listed in the MUTCD are located on **Table 11.**

It is intended that warrant 1 be treated as a single warrant. If condition A is satisfied, then the criteria for warrant 1 is satisfied and condition B and the combination of condition A and B are not needed. Also, if condition B is satisfied, then the criteria for warrant 1 is satisfied and the combination of conditions A and B is not needed. Warrant 1 is considered the primary warrant for the installation of a signal and is often considered as singular standalone criteria.

Table 11: MUTCD Table 4C-1, Warrant 1 Eight-Hour Vehicular Volume

Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume

Condition A—Minimum Vehicular Volume

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112

Condition B—Interruption of Continuous Traffic

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

[a] Basic minimum hourly volume
[b] Used for combination of Conditions A and B after adequate trial of other remedial measures
[c] May be used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000
[d] May be used for combination of Conditions A and B after adequate trial of other remedial measures when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000

After applying the warrant criteria for Existing Conditions, zero of the twelve hours meet the criteria set for Warrant 1A, five hours meet the criteria for Warrant 1B, and zero hours meet the criteria for combination of Warrant 1A & 1B of the Major and Minor street volumes set in the "70%" conditions. Criteria 1B is three hours short of meeting the warranting criteria.

Warrant 1 is **NOT MET**.

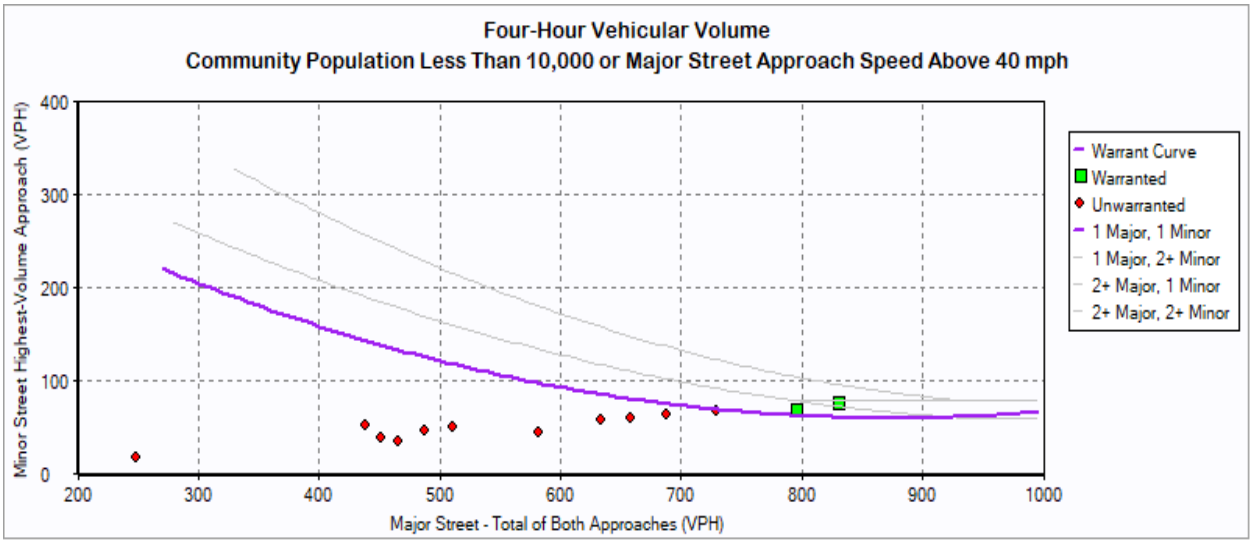
Warrant 2 – Four Hour Vehicular Volumes

The warrant is intended for locations where, for a brief period of the day, minor road traffic experiences excessive delays in attempting to enter or cross the major street. Warrant 2 requires that the combination of the major street traffic (total of both approaches) and minor street traffic (one direction only) reaches a designated minimum volume during any four hours of any average day.

Only two hours meet the guideline criteria, short of the four required in evaluation of Existing Conditions. Evaluation of Warrant 2 is illustrated in **Figure 9**.

Warrant 2 is **NOT MET**.

Figure 9: Warrant 2 – Four-Hour Vehicular Volume

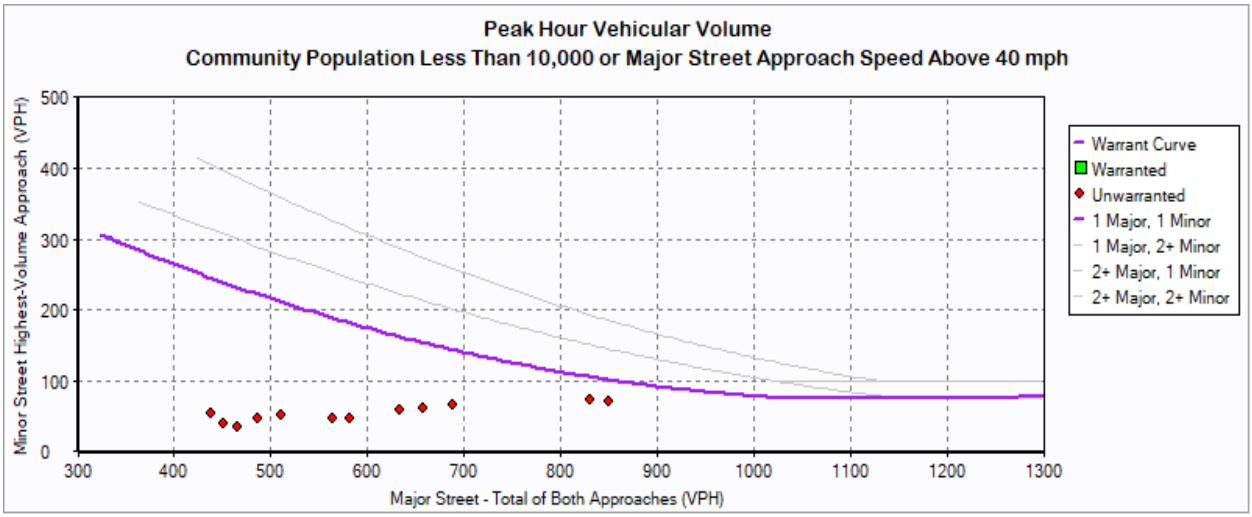


Warrant 3 – Peak Hour Vehicular Volumes

This warrant is intended to be used where large numbers of vehicles are attracted or discharged for brief periods and minor street traffic suffers excessive delay when entering or crossing the major street. Warrant 3 requires that the combination of the major street traffic (total of both approaches) and the minor street traffic (one approach only) reaches a designated minimum volume during any one hour of an average day.

For Existing Conditions, none of the twelve hours evaluated meet the criteria established for Warrant 3. Evaluation of Warrant 3 is illustrated in **Figure 10**.

Figure 10: Warrant 3 – Peak Hour Vehicular Volume



Warrant 3 is **NOT MET.**

Warrant 4 – Pedestrian Volume

The pedestrian volume signal warrant is intended for locations where traffic volumes on the major street are such that pedestrians experience excessive delay in crossing the major street. Warrant 4 requires a minimum of 75 pedestrians for each of any four hours or 93 pedestrians during the peak hour.

The volume of pedestrians at the intersection is far below the threshold required by the MUTCD.

Warrant 4 is **NOT MET.**

Warrant 5 – School Crossing

This warrant is intended for application where school children must cross the major street is the principle reason to consider the installation of a traffic control signal.

A signal at the subject intersection does not serve to create a controlled school crossing.

Warrant 5 is **NOT MET.**

Warrant 6 – Coordinated Signal System

This warrant is intended for intersections that fall within an existing coordinated signal system in order to maintain proper vehicle progression.

The subject intersection is isolated from any potential coordination with adjacent traffic signals.

Warrant 6 is **NOT APPLICABLE.**

Warrant 7 – Crash Experience

This warrant is intended for application where the severity and frequency of crashes are the principle reasons to consider installing a traffic control signal. Warrant 7 is applicable where five or more crashes that are potentially preventable by the installation of a traffic signal have occurred a 12-month period and the intersection traffic volumes meet the 56% column from MUTCD Table 4C-1.

Based upon an evaluation of the intersection crash data, there was not a period where five correctable right angle crashes occurred within a one year period. Four right angle crashes occurred between 10/14/17 and 8/17/18, one short of the initial threshold. An additional angle crash occurred on 5/27/17, constituting five crashes in a fifteen month period. Since August of 2018, there was one reported crash that occurred at the intersection that is potentially correctable by the installation of a traffic signal. Within the five year study period, eight potentially correctable right angle crashes have occurred at the intersection. *If the initial correctable crash threshold were satisfied, the subsequent 56% volume criteria would be met and Warrant 7 would be met.*

Warrant 7 is **NOT MET**.

Warrant 8 – Roadway Network

A signal may be justified to encourage concentration and organization of traffic flow on a roadway network. According to the MUTCD, Warrant 8 can be considered when two or more major routes intersect and a minimum total entering volume of at least 1,000 vehicles during the peak hour of a typical weekday and has 5-year projected traffic volumes that meet one or more of Warrants 1, 2, and 3.

The subject intersection does not involve the crossing of two major routes.

Warrant 8 is **NOT APPLICABLE**.

Warrant 9 – Intersection Near a Grade Crossing

This warrant is intended for use at a location where the proximity to the intersection of a grade crossing on an intersection approach controlled by a stop or yield sign is the principal reason to consider installing a traffic control signal.

There is not a railroad crossing near the intersection that impacts traffic flow.

Warrant 9 is **NOT APPLICABLE.**

None of the nine MUTCD warrants are satisfied for the intersection of Earlysville Road with Reas Ford Road and Earlysville Forest Drive. The heaviest side street movement at the intersection is the right turn from Reas Ford Road, and right turning traffic is generally only impeded by the queue of left turning traffic. Based upon review of the actual intersection conditions, the MUTCD traffic signal warranting criteria is not satisfied for the study intersection. As noted, If the initial correctable crash threshold were satisfied, Warrant 7 could be utilized to justify the installation of a traffic signal.

Copies of signal warrant analysis are included in **Appendix D**.

AUXILIARY LANE ANALYSIS

Auxiliary turn lane analysis was performed for the intersection using the VDOT *Access Management Design Standards for Entrances and Intersections,* Revised January of 2021. These standards are based upon the AASHTO publication *A Policy on Geometric Design of Highways and Streets.*

Intersection traffic volume and design speed are the primary variables evaluated to determine the need for auxiliary lanes. Left turn lane warranting criteria is outlined in Figure 3-4 through Figure 3-9 from VDOT Access Management Manual and are shown in **Appendix G**.

Based upon evaluation of actual intersection conditions, the Earlysville Road northbound approach meets the criteria shown in Figure 3-5 during the PM peak hour with 10% left turns. The left turn warranting criteria is not met northbound in the AM peak hour and not for the southbound approach in either the AM or PM peak hour. In addition, a right turn taper is warranted on the Reas Ford Road eastbound approach during the AM peak hour. **Table 12** provides a summary of the various potential turn lanes evaluated and whether VDOT warranting criteria is satisfied.

Table 12: Auxiliary Lane Analysis Summary

Approach	Turn Lane Analyzed	Analysis Results	
		AM Peak Hour	PM Peak Hour
EB Approach (Reas Ford Road)	Right-Turn Lane	MET	NOT MET
WB Approach (Earlysville Forest Drive)	Right-Turn Lane	NOT MET	NOT MET
NB Approach (Earlysville Road)	Left-Turn Lane	NOT MET	MET
	Right-Turn Lane	NOT MET	NOT MET
SB Approach (Earlysville Road)	Left-Turn Lane	NOT MET	NOT MET
	Right-Turn Lane	NOT MET	NOT MET

CAPACITY ANALYSIS

The Highway Capacity Manual defines capacity as the maximum suitable flow rate at which vehicles reasonably can be expected to traverse a point during a specified time period. Capacity uses the measure of efficiency, Level-of-Service (LOS), to describe the traffic performance at intersections. LOS is defined for the overall intersection delay for signalized intersections. An acceptable LOS for a signalized intersection is considered to be LOS D or better (i.e. A, B, C or D).

At unsignalized intersections, the LOS is defined by the control delay for the movement that must yield right-of-way. It may be typical for stop-controlled minor streets to experience long delays during peak periods, while the majority of the traffic flows through the intersection on the major street travel unimpeded.

The procedures outlined in the Highway Capacity Manual; 6th Edition were used as guidelines for the analysis of the study area intersections. This manual provides procedures for the analysis of both signalized and unsignalized intersections. LOS categories range from LOS "A" (best) to "F" (worst) as shown in **Table 13**.

Table 13: Level of Service Criteria

Level of Service	SIGNALIZED Intersection Control Delay (sec/veh)	UNSIGNALIZED Intersection Control Delay (sec/veh)	Intersection LOS Description
A	≤ 10.0	≤ 10.0	Free flow, insignificant delays.
B	10.1-20.0	10.1-15.0	Stable operation, minimal delays.
C	20.1-35.0	15.1-25.0	Stable operation, acceptable delays.
D	35.1-55.0	25.1-35.0	Restricted flow, common delays.
E	55.1-80.0	35.1-50.0	Maximum capacity, extended delays. Volumes at or near capacity. Long queues form upstream from intersection.
F	> 80.0	> 50.0	Forced flow, excessive delays. Represents jammed conditions. Intersection operates below capacity with low volumes. Queues may block upstream intersections.

LOS analysis was completed through the use of Synchro, version 10.3 and Sidra, version 9.0. These software packages categorize the LOS based on HCM methodology and criteria. According to industry standards, any signalized intersection or any approach of an unsignalized intersection is considered acceptable if the average delay is at LOS D or better with LOS A representing little or no delay. Any signalized intersection or approach with a LOS of E or F is considered substandard and may need solutions to improve the operational performance. Copies of the Synchro and Sidra reports are included in **Appendix F.**

No Build Conditions (Existing Configuration)

Analysis was performed of the existing intersection configuration with two way stop control on the Reas Ford Road and Earlysville Forest Drive approaches. Analysis shows that the left turn movements on both Earlysville Road approaches operate at LOS A during both the AM and PM peak hours, which control operation on each mainline approach in the absence of exclusive turn lanes. The Reas Ford Road eastbound approach currently operates at LOS C during both the AM and PM peak hours while the Earlysville Forest Drive westbound approach currently operates at LOS D during the AM peak hour and LOS C during the PM peak hour under two way stop control.

Alternative 1 - TWSC with Turn Lanes

Improvements included in **Alternative 1** include construction of exclusive left turn lanes on both Earlysville Road approaches and construction of an exclusive right turn lane on the eastbound Reas Ford Road approach.

Following construction of the proposed exclusive auxiliary lanes, analysis indicates that the left turn movement on each Earlysville Road approach continues to operate at LOS A during both the AM and PM peak hours. The shared thru/right lane in each direction operates free flow traveling unimpeded through the intersection. The Reas Ford Road eastbound approach will continue to operate at LOS C during both the AM and PM peak hours with two way stop control. The Earlysville Forest Drive westbound approach will continue to operate at LOS D during the AM peak hour and LOS C during the PM peak hour with two way stop control.

Alternative 2 - Traffic Signal Plus Turn Lanes

Improvements included in **Alternative 2** include installation of a traffic signal and construction of exclusive left turn lanes on both Earlysville Road approaches as well as a right turn lane on the Reas Ford eastbound approach.

Following installation of a traffic signal and auxiliary lanes at the intersection, analysis indicates that the Earlysville Road southbound approach is expected to operate at LOS B during the AM peak hour and LOS A during the PM peak hour. The Earlysville Road northbound approach is expected to operate at LOS A during both the AM and PM peak hours. The Reas Ford Road eastbound approach to Earlysville Road is expected to improve to LOS B during both the AM and PM peak hours. The Earlysville Forest Drive westbound approach to improve to LOS B during both the AM and PM peak hours. The overall signalized intersection is expected to operate at LOS B during the AM peak hour and LOS A during the PM peak hour.

Alternative 3 - Roundabout Conditions

Improvements included in **Alternative 3** consist of conversion of the intersection to a single lane roundabout without any auxiliary or slip lanes. This analysis is assumed to be the same for a traditional roundabout or a mini roundabout.

Following construction of a single lane roundabout, analysis indicates that the Earlysville Road southbound approach is expected to operate at LOS A during both the AM and PM peak hours under

roundabout yield control. The Earlysville Road northbound approach is expected to operate at LOS A during both the AM and PM peak hours. The Reas Ford Road eastbound approach is expected to operate at LOS A during both the AM and PM peak hours. The Earlysville Forest Drive westbound approach is expected to operate at LOS A during both the AM and PM peak hours. The overall roundabout intersection is expected to operate at LOS A during both the AM and PM peak hours.

Alternative 4 – Short-Term AWSC

Alternative 4 should be considered as a short-term interim option to address the angle crash pattern and is not evaluated as a long term intersection control option. Level of Service (LOS) analysis is shown as a measure of the anticipated operation of the intersection.

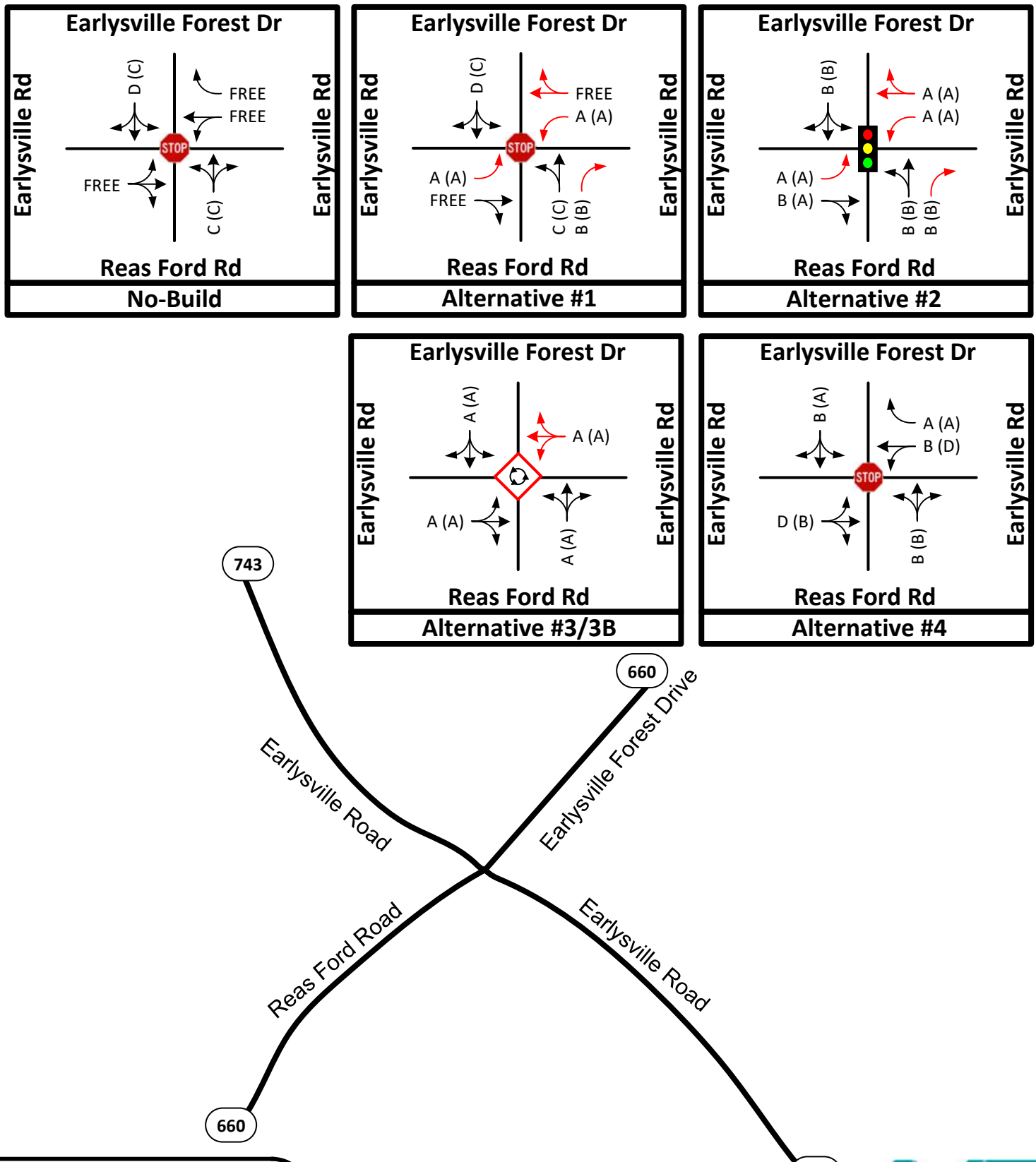
Following installation of All Way Stop Control (AWSC), analysis indicates that the Earlysville Road southbound approach would be expected to deteriorate to LOS D during the AM peak hour and LOS B during the PM peak hour. The Earlysville Road northbound approach would be expected to deteriorate to LOS B during the AM peak hour and LOS C during the PM peak hour. The Reas Ford Road eastbound approach is expected to improve to LOS B during both the AM and PM peak hours. The Earlysville Forest Drive westbound approach is expected to improve to LOS B during the AM peak hour and LOS A during the PM peak hour. The overall AWSC intersection is expected to operate at LOS C during both the AM and PM peak hours.

Table 14 provides a summary of the LOS results during the weekday AM and PM peak hours for Existing Conditions, Alternative 1 (Turn Lanes Only), Alternative 2 (Traffic Signal Plus Turn Lanes), and Alternative 3 (Single Lane Roundabout).

Figure 11 shows the LOS during the weekday AM and PM peak hours for the various alternatives evaluated study intersection.

Table 14: Level of Service Analysis Summary

Intersection	Movement	No-Build Conditions				Alternative 1 (Turn Lanes Only)				Alternative 2 (Signal with Turn Lanes)				Alternative 3/3B (Roundabouts)				Alternative 4 (AWSC)			
		AM Peak		PM Peak		AM Peak		PM Peak		AM Peak		PM Peak		AM Peak		PM Peak		AM Peak		PM Peak	
		LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay	LOS	Delay
Intersection 1 - Earlysville Road (Route 743) with Reas Ford Road /Earlysville Forest Drive (Route 660)	**EB Left/Thru/Right**	C	18.4	C	17.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	A	6.6	A	4.6	B	10.1	B	10.1
	EB Left/Thru	N/A	N/A	N/A	N/A	C	21.6	C	23.9	B	15.3	B	12.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	EB Right-Turn	N/A	N/A	N/A	N/A	B	13.5	B	10.3	B	14.6	B	11.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	EB Approach	C	18.4	C	17.7	C	16.0	C	15.9	B	14.8	B	11.9	A	6.6	A	4.6	B	10.1	B	10.1
	WB Left/Thru/Right	**D**	**25.5**	C	19.5	**D**	**25.5**	C	19.8	B	16.0	B	12.9	A	3.9	A	4.9	B	10.3	A	9.8
	WB Approach	**D**	**25.5**	C	19.5	**D**	**25.5**	C	19.8	B	16.0	B	12.9	A	3.9	A	4.9	B	10.3	A	9.8
	NB Left-Turn	A	8.9	A	8.0	A	8.9	A	8.0	A	6.8	A	6.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	NB Thru/Right	N/A	N/A	N/A	N/A	N/A	FREE	N/A	FREE	A	6.1	A	9.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	NB Left/Thru	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	B	11.3	D	25.2
	NB Right-Turn	N/A	FREE	N/A	FREE	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	A	7.9	A	7.6
	NB Left/Thru/Right	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	A	4.2	A	7.1	N/A	N/A	N/A	N/A
	NB Approach	N/A	1.9	N/A	0.9	N/A	1.9	N/A	0.9	A	6.2	A	9.1	A	4.2	A	7.1	B	11.1	C	23.9
	SB Left-Turn	A	7.5	A	8.5	A	7.5	A	8.5	A	5.7	A	7.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	SB Thru/Right	N/A	N/A	N/A	N/A	N/A	FREE	N/A	FREE	B	10.3	A	8.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Existing Four legged unsignalized intersection with stop control on Reas Ford Road & Earlysville Forest Drive	**SB Left/Thru/Right**	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	A	8.5	A	5.2	D	29.0	B	12.9
	SB Approach	N/A	0.2	N/A	0.4	N/A	0.2	N/A	0.4	B	10.2	A	8.8	A	8.5	A	5.2	D	29.0	B	12.9
	Overall	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	B	10.4	A	9.5	A	7.1	A	6.2	C	22.0	C	18.5


Earlysville Forest Dr
Earlysville Rd
Earlysville Rd
Reas Ford Rd
D (C)
FREE
FREE
FREE
C (C)
STOP
No-Build
Earlysville Forest Dr
Earlysville Rd
Earlysville Rd
Reas Ford Rd
D (C)
FREE
A (A)
A (A)
FREE
C (C)
B (B)
STOP
Alternative #1
Earlysville Forest Dr
Earlysville Rd
Earlysville Rd
Reas Ford Rd
B (B)
A (A)
A (A)
A (A)
B (A)
B (B)
B (B)
Alternative #2
Earlysville Forest Dr
Earlysville Rd
Earlysville Rd
Reas Ford Rd
A (A)
A (A)
A (A)
A (A)
Alternative #3/3B
Earlysville Forest Dr
Earlysville Rd
Earlysville Rd
Reas Ford Rd
B (A)
A (A)
B (D)
D (B)
B (B)
STOP
Alternative #4
743
660
Earlysville Road
Earlysville Forest Drive
Reas Ford Road
Earlysville Road
660
743
LEGEND
STOP
Proposed Traffic Control
Existing Roadway
Existing Lane Configuration
Proposed Lane Configuration
A
AM Level of Service
(A)
PM Level of Service
N
NOT TO SCALE
Earlysville and Reas Ford Road
2021 Level of Service Analysis
DATE: March 2022
FIGURE 11

QUEUING ANALYSIS

Queuing analysis was performed at the study intersection during the weekday AM and PM peak hours using the SimTraffic micro-simulation model, which is a simulation complement to the Synchro traffic analysis models utilized for the capacity analysis. The queuing calculations produced by SimTraffic are acknowledged within the industry to be a realistic replication of actual conditions. Each simulation model was seeded for 10 minutes and recorded for 60 minutes. The simulation was run five times and then averaged to estimate the 95th percentile queuing for all scenarios. Queuing analysis was performed for roundabout analysis during the weekday AM and PM peak hours using Sidra modeling. The queuing calculations produced by Sidra are acknowledged within the industry to be a realistic replication of actual conditions for roundabout intersections.

No Build Conditions (Existing Configuration)

The queuing analysis indicates that no existing turning movements currently exceed the available storage length or impeded other traffic movements during the peak periods analyzed.

Alternative 1 - TWSC with Turn Lanes

Queuing analysis indicates that all conditions described in the No Build Conditions are expected to continue with similar queuing following construction of exclusive left turn lanes on Earlysville Road and a right turn lane on the Reas Ford eastbound approach. Queue lengths are reduced in comparison to No Build Conditions.

Alternative 2 - Traffic Signal Plus Turn Lanes

With the installation of a traffic signal, short queues are created on the Earlysville southbound and northbound approaches with the installation of a traffic signal. The queues are not substantial and are not anticipated to inhibit access to proposed exclusive left turn lanes. The projected queue is 129 feet northbound during the PM peak hour and 140 feet southbound during the AM peak hour. Queuing on the side road approaches is similar to No Build Conditions.

Alternative 3 - Roundabout

Queuing analysis indicates that queuing is anticipated to be minimal with roundabout operation. This analysis is assumed to be the same for a traditional roundabout and a mini roundabout. The most significant queue is the Earlysville southbound approach during AM peak hour and Earlysville northbound approach during PM peak hour. The projected queue is 110 feet southbound during the AM peak hour and 91 feet northbound during the PM peak hour.

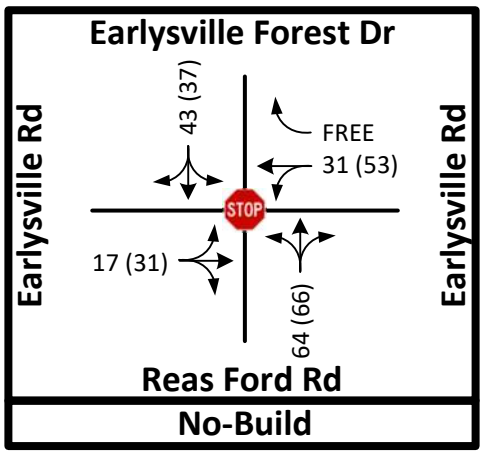
Alternative 4 – Short-Term AWSC

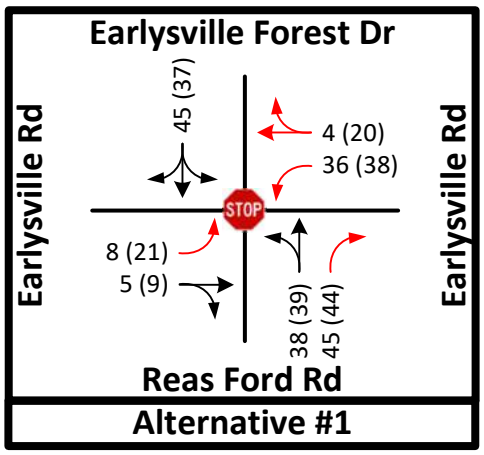
Queuing analysis indicates that queuing is anticipated to be a more significant issue with AWSC. The most significant queue is the Earlysville southbound approach during AM peak hour and Earlysville northbound approach during PM peak hour. The projected queue is 129 feet northbound during the PM peak hour and 163 feet southbound during the AM peak hour.

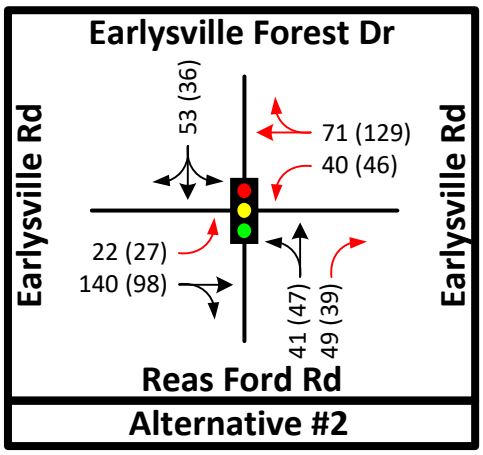
Table 15 presents the 95% queuing results and **Figure 12** provides an illustration of anticipated queuing for the weekday AM and PM peak periods for the alternatives evaluated. Copies of the SimTraffic and Sidra analyses outputs are included in **Appendix F**.

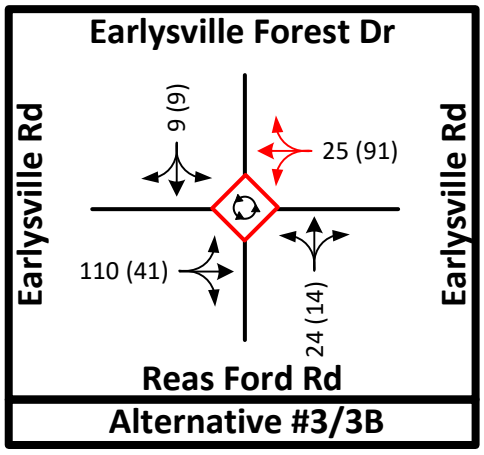
Table 15: Queueing Analysis Summary

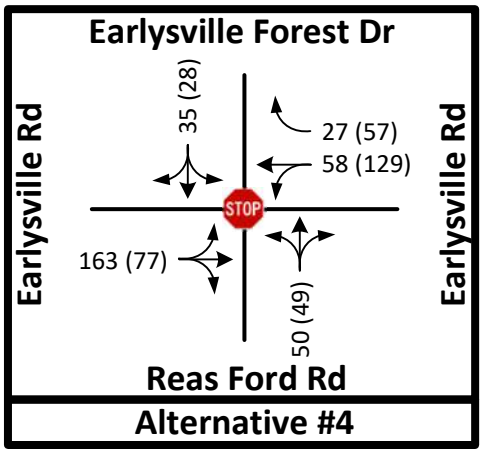
Intersection	Movement	Existing Storage Length (ft)	No-Build		Proposed Storage Length (ft)	Alternative 1		Proposed Storage Length (ft)	Alternative 2		Proposed Storage Length (ft)	Alternative 3/3B		Existing Storage Length (ft)	Alternative 4	
			AM	PM		AM	PM		AM	PM		AM	PM		AM	PM
Intersection 1 - Earlysville Road (Route 743) with Reas Ford Road (Route 660)/Earlysville Forest Drive	EB Left/Thru/Right	--	64	66	N/A	N/A	N/A	N/A	N/A	N/A	--	24	14	--	50	49
	EB Left/Thru	N/A	N/A	N/A	--	38	39	--	41	47	N/A	N/A	N/A	N/A	N/A	N/A
	EB Right-Turn	N/A	N/A	N/A	125	45	44	125	49	39	N/A	N/A	N/A	N/A	N/A	N/A
	WB Left/Thru/Right	--	43	37	--	45	37	--	53	36	--	9	9	--	35	28
	NB Left/Thru	--	31	53	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	--	58	129
	NB Right-Turn	100	0	0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	100	27	57
	NB Left-Turn	N/A	N/A	N/A	125	36	38	125	40	46	N/A	N/A	N/A	N/A	N/A	N/A
	NB Thru/Right	N/A	N/A	N/A	--	4	20	--	71	129	N/A	N/A	N/A	N/A	N/A	N/A
	NB Left/Thru/Right	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	--	25	91	N/A	N/A	N/A
	SB Left/Thru/Right	--	17	31	N/A	N/A	N/A	N/A	N/A	N/A	--	110	41	--	163	77
	SB Left-Turn	N/A	N/A	N/A	125	8	21	125	22	27	N/A	N/A	N/A	N/A	N/A	N/A
	SB Thru/Right	N/A	N/A	N/A	--	5	9	--	140	98	N/A	N/A	N/A	N/A	N/A	N/A

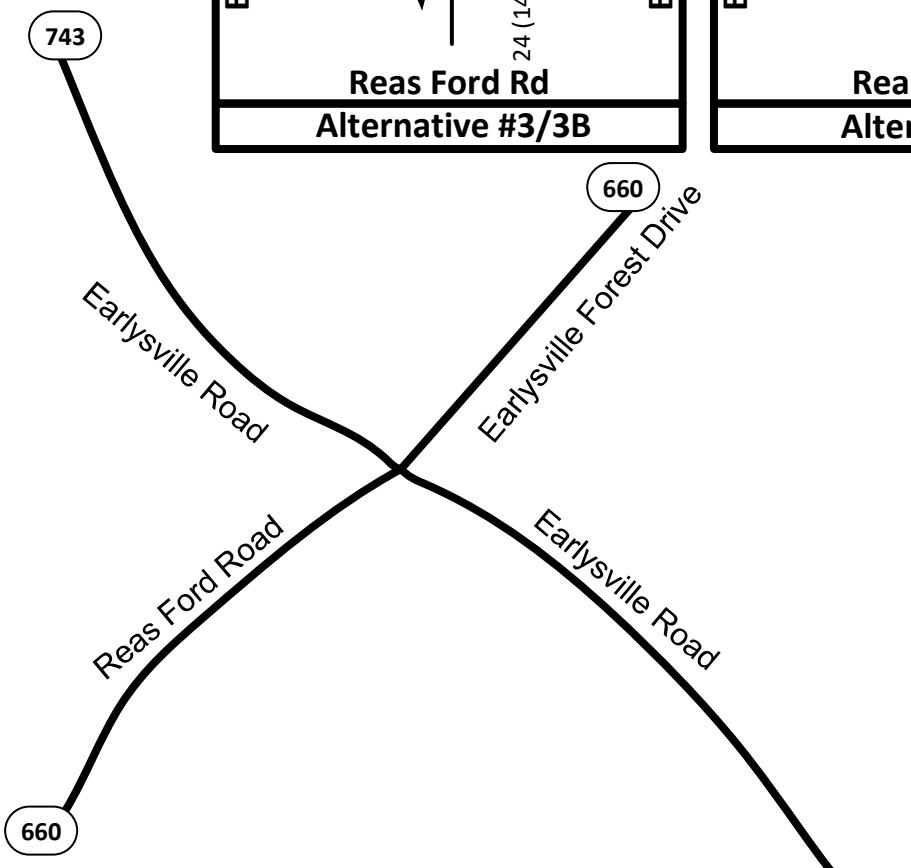












LEGEND

- Proposed Traffic Control
- Existing Roadway
- Existing Lane Configuration
- Proposed Lane Configuration
- XX — AM Queue Length (ft)
- (XX) — PM Queue Length (ft)

N

NOT TO SCALE

Earlysville and Reas Ford Road

2021 Queue Analysis

DATE: March 2022

FIGURE 12

SAFETY ANALYSIS

For purposes of comparing benefit vs cost for potential intersection improvement alternatives, evaluation of economic cost of safety performance resulting from motor vehicle crashes at the intersection was performed utilizing accepted FHWA safety analysis procedures. Crash Modification Factors (CMF's) depicting the proposed alternatives were selected from the *VDOT Preferred CMF List*, which is provided in **Appendix H** for reference. A summary of the CMF's utilized is illustrated in **Table 16**.

Table 16: Utilized CMF Summary

Countermeasure	CMF #	Crash Type	K	A	BC	O	Service Life	Reference
Add Left-Turn Lane to Major Approach of 3-Leg Stop Controlled Intersection	1	ALL	0.56	0.56	0.56	0.56	20 YRS	HSM Table 11-22
Convert Stop-Controlled Intersection to Signalized Intersection	2	ALL	0.642	0.642	0.642	0.639	20 YRS	CMF ID: 7983, 7986
Convert Stop-Controlled Intersection to Roundabout	3	ALL	0.56	0.18	0.18	0.56	20 YRS	CMF ID: 227, 228
Convert Minor Stop-Control to All-Way Stop Control	4	ALL	0.23	0.23	0.23	0.319	20 YRS	CMF ID: 3127, 3128

The selected CMF's were utilized to forecast the safety performance of each alternative as a means to estimate the anticipated benefit in terms of reduction of injury crashes. The CMF's shown in **Table 16** are applied to recent crash data to predict the expected crash reduction from each alternative by severity. Safety performance is a key factor of this study, as all alternatives including No Build operate at acceptable level of service (LOS). For that reason, Benefit/Cost (B/C) is expressed simply in terms of safety performance based upon economic cost based upon injury severity over 20 years compared with cost of construction. **Table 17** shows the annualized crash performance of the intersection based upon recent data and application of the CMF's. Each value reflects the number of crashes expected by severity annually following construction of each alternative.

Table 17: Annualized CMF Application

Crash Severity	Number of Crashes	Annualized Crashes	CMF 1 - ALT 1	CMF 2/CMF 1 ALT 2	CMF 3 -ALT 3/3B	CMF 4 - ALWSC
Fatal Crashes	0	0	0.00	0.00	0.00	
Class A Crashes	2	0.40	0.22	0.14	0.07	0.09
Class B Crashes	6	1.20	0.67	0.43	0.22	0.28
Class C Crashes	0	0.00	0.00	0.00	0.00	0.00
Property Damage Only Crashes	7	1.40	0.78	0.57	0.78	0.45
Total	15	3.00	1.68	1.15	1.07	0.81

Utilizing the forecast annual crashes by severity along with the monetized crash value by severity established by FHWA, total safety performance was calculated from a baseline of No Build based upon recent crash history. Safety performance is monetized as a way to measure the effectiveness of constrained financial resources to achieve the most benefit. **Table 18** illustrates the total forecast 20 year cost of motor vehicle crashes for each alternative. Since Alternative 4 (All Way Stop Control) is shown as a potential interim or short-term solution only, it is not applicable to present a 20 year service life for this scenario.

Table 18: Forecast Monetized Safety Performance by Alternative

Crash Severity	Monetized Crash Value (2021)	NO BUILD	CMF 1 - ALT 1	CMF 1/2 - ALT 2	CMF 3 - ALT 3	CMF 4 - ALT 4
Fatal Crashes	$5,861,850.00	$0.00	$0.00	$0.00	$0.00	$0.00
Class A Crashes	$315,837.00	$126,334.80	$70,747.49	$45,419.89	$22,740.26	$29,057.00
Class B Crashes	$115,515.00	$138,618.00	$77,626.08	$49,835.94	$24,951.24	$31,882.14
Class C Crashes	$65,653.00	$0.00	$0.00	$0.00	$0.00	$0.00
Property Damage Only Crashes	$10,820.00	$15,148.00	$8,482.88	$6,214.29	$8,482.88	$29,320.63
Total		$280,100.80	$156,856.45	$101,470.12	$56,174.38	$90,259.77
20 Year Safety Cost		***$8,340,869.63***	***$4,670,886.99***	***$3,021,587.26***	***$1,672,766.42***	***n/a***

As shown through the application of the CMF's, Alternative 3 (Roundabout) would be anticipated to result in the largest reduction in overall crashes at the intersection. Alternative 3, however, also is the most expensive and the most impactful to adjacent property owners and the community. Further evaluation of anticipated monetized annual safety performance over a 20 year service life was compared to the estimated cost of construction for each alternative. The 20 year performance assumes annual inflation of 4% for cost of each crash type. By comparison of the forecast crash reduction with estimated cost, ***Alternative 3B (Mini Roundabout)*** was found to achieve the highest benefit/cost ratio of 2.7. A summary of B/C analysis is illustrated in **Table 19**.

Table 19: Benefit/Cost Comparison

Scenario	20 YR safety cost	ALT Cost	Crash Savings	B/C
NO Build	$8,340,870	$0	$0	0
ALT 1	$4,670,887	$1,903,345	$3,669,983	1.9
ALT 2	$3,021,587	$2,330,995	$5,319,282	2.3
ALT 3	$1,672,766	$4,267,066	$6,668,103	1.6
ALT 3B	$1,672,766	$2,430,144	$6,668,103	***2.7***
ALT 4	n/a	n/a	n/a	n/a

Safety analysis was performed on the total number of crashes reported to occur for the five year period available from July 1, 2016 to June 30, 2021. Of the 15 crashes reported to occur, 11 occurred from July of 2016 to through 2018. Four crashes were reported to occur from January of 2019 through June of 2021. The safety analysis assumes crashes are linear for the reported time period. The data shows that fewer crashes have occurred in the most recent 30 month portion of the study, including only one crash after additional traffic control devices were installed.

CONCLUSIONS

This report summarizes evaluation of potential intersection improvement alternatives at the intersection of Earlysville Road (Route 743) with Reas Ford Road (Route 660) and Earlysville Forest Drive (Route 660) in Earlysville, Albemarle County. Albemarle County and The Virginia Department of Transportation (VDOT) previously identified safety concerns at the intersection of Earlysville Road and Reas Ford Road evidenced by crash data, and subsequently evaluated various options for modification of the intersection.

This study was initiated to evaluate the potential for intersection modification based upon previously identified safety concerns at the intersection. Evaluation of the collected data shows that the intersection currently operates at an acceptable Level of Service (LOS), with modest delay quantified on the side street approaches to the intersection. The intersection currently operates at acceptable LOS.

The most important operational issue at the intersection is the occurrence of right angle crashes at the intersection. Eight angle crashes were reported to occur at the intersection in the five year period evaluated, which resulted in 16 injuries including two serious injuries (Type A) and 11 significant injuries (Type B). All four alternatives evaluated are anticipated to reduce the occurrence of crashes, with the Roundabout and Traffic Signal options anticipated to address the angle crash pattern most significantly. The traditional roundabout, however, is the most expensive alternative and would have significant impacts in terms of right of way, utilities, and temporary traffic control. While the mini roundabout results in the highest benefit vs cost ratio in terms of safety impact, it is likely inappropriate for the intersection.

Based upon evaluation of the collected data and Alternatives evaluation, the following recommendations are made in regard to the intersection of Earlysville Road with Reas Ford Road and Earlysville Forest Drive:

- *Based upon assessment of the entirety of the collected data, major intersection reconfiguration is not necessary at this time, and the **No Build Alternative** is appropriate. The intersection currently operates at adequate Level of Service (LOS) and the occurrence of crashes at the intersection has declined in the most recent 30 month period of the study.*

- *Due to the identified pattern of right angle crashes from 2016 to 2018, the intersection should continue to be monitored closely to determine if the recent reduction of intersection crashes following implementation of low cost safety improvements endures.*

- *If right angle crashes persist or increase where five or more occur in a 12 month period, a traffic signal can be installed in accordance with MUTCD Warrant Seven (Crash Safety). If safety performance or future traffic volume indicate that intersection control needs to be enhanced, a traffic signal or a roundabout both would provide adequate Level of Service.*

- *A mini roundabout appears to be inappropriate at this intersection due to volume, truck traffic, and prevailing speed. If a roundabout is considered in the future, a traditional roundabout is more appropriate for the conditions at this location.*

- *Ideally, construct auxiliary lanes including left turn lanes in both directions of Earlysville Road and a right turn lane on Reas Ford Road. VDOT warranting criteria based upon AASHTO is satisfied for these approaches. These auxiliary lanes, however, do not address the right angle crash pattern at the intersection or appreciably improve Level of Service.*

Appendix A

Study Area Photos

Reas Ford Road Eastbound Approach to Earlysville Road

Earlysville Forest Drive Westbound Approach to Earlysville Road

Earlysville Road Northbound Approach to Reas Ford Road/Earlysville Forest Drive

Earlysville Road Southbound Approach to Reas Ford Road/Earlysville Forest Drive

Looking North from Reas Ford Road

Looking South from Reas Ford Road

Looking North from Earlysville Forest Drive

Looking South from Earlysville Forest Drive

Appendix B

Traffic Data

Appendix B-1

Turning Movement Counts

VEHICLE AND PEDESTRIAN VOLUME SUMMARY

COUNT LOCATION	
CITY	**Earlysville**
STATE	**VA**
DATE	**9/23/2021**
INTERSECTION	**Int 1: Earlysville Road (CR 743) @ Reas Ford Road (SR 660)/Earlysville Forest Drive**
COUNT BY	**AMT**

All Vehicles
Thursday - 12 Hour Count

STREET	**Earlysville Forest Dr**				**SR 660**				**CR 743**				**CR 743**				**Total**			**PEAK HR**
	From North				**From South**				**From East**				**From West**							
TIME	**L**	**T**	**R**	**TOT**	**L**	**T**	**R**	**TOT**	**L**	**T**	**R**	**TOT**	**L**	**T**	**R**	**TOT**	**N-S**	**E-W**	**ALL**	
0700 - 0715	1	1	0	2	1	0	4	5	7	17	1	25	0	103	8	111	7	136	143	143
0715 - 0730	9	0	1	10	2	1	18	21	4	17	3	24	2	107	6	115	31	139	170	313
0730 - 0745	**8**	**0**	**5**	**13**	**11**	**0**	**17**	**28**	**7**	**39**	**2**	**48**	**4**	**114**	**7**	**125**	**41**	**173**	**214**	527
0745 - 0800	**10**	**4**	**1**	**15**	**11**	**1**	**18**	**30**	**11**	**41**	**2**	**54**	**3**	**138**	**15**	**156**	**45**	**210**	**255**	782
0800 - 0815	**13**	**3**	**4**	**20**	**6**	**0**	**18**	**24**	**10**	**26**	**2**	**38**	**2**	**111**	**9**	**122**	**44**	**160**	**204**	843
0815 - 0830	**16**	**0**	**2**	**18**	**1**	**0**	**13**	**14**	**8**	**21**	**3**	**32**	**5**	**126**	**5**	**136**	**32**	**168**	**200**	***873***
0830 - 0845	11	0	1	12	7	1	15	23	10	35	3	48	4	106	0	110	35	158	193	852
0845 - 0900	11	0	1	12	5	2	15	22	9	45	5	59	3	79	6	88	34	147	181	778
0900 - 0915	14	0	0	14	3	0	9	12	14	41	5	60	3	63	7	73	26	133	159	733
0915 - 0930	8	0	1	9	5	0	6	11	6	40	4	50	2	47	3	52	20	102	122	655
0930 - 0945	6	0	2	8	1	2	8	11	10	36	2	48	1	54	6	61	19	109	128	590
0945 - 1000	8	1	1	10	5	1	7	13	7	34	0	41	2	57	7	66	23	107	130	539
1000 - 1015	2	2	2	6	5	0	7	12	6	42	4	52	1	50	4	55	18	107	125	505
1015 - 1030	7	2	3	12	4	0	5	9	11	52	3	66	3	55	3	61	21	127	148	531
1030 - 1045	8	0	1	9	4	1	8	13	7	52	2	61	1	57	5	63	22	124	146	549
1045 - 1100	4	1	3	8	3	1	8	12	5	39	8	52	1	52	3	56	20	108	128	547
1100 - 1115	9	1	4	14	0	4	8	12	10	34	7	51	0	37	6	43	26	94	120	542
1115 - 1130	8	1	3	12	0	0	6	6	7	43	3	53	3	42	5	50	18	103	121	515
1130 - 1145	12	1	1	14	6	0	12	18	3	47	4	54	6	65	6	77	32	131	163	532
1145 - 1200	9	3	6	18	8	1	12	21	10	34	10	54	3	48	5	56	39	110	149	553
1200 - 1215	8	0	6	14	6	1	11	18	14	46	4	64	1	39	3	43	32	107	139	572
1215 - 1230	5	0	3	8	3	0	11	14	8	67	4	79	1	55	3	59	22	138	160	611
1230 - 1245	6	0	2	8	3	2	13	18	10	47	4	61	4	58	3	65	26	126	152	600
1245 - 1300	6	1	7	14	5	1	8	14	9	41	6	56	3	50	7	60	28	116	144	595
1300 - 1315	9	1	3	13	2	4	13	19	6	52	2	60	5	46	3	54	32	114	146	602
1315 - 1330	5	0	2	7	5	1	10	16	10	52	6	68	1	65	3	69	23	137	160	602
1330 - 1345	4	2	4	10	0	1	16	17	7	54	8	69	5	55	1	61	27	130	157	607
1345 - 1400	10	0	11	21	3	2	15	20	11	53	6	70	6	52	2	60	41	130	171	634
1400 - 1415	12	1	2	15	6	2	12	20	10	54	6	70	2	42	5	49	35	119	154	642
1415 - 1430	6	1	3	10	7	0	10	17	18	68	12	98	3	63	1	67	27	165	192	674
1430 - 1445	6	2	2	10	3	2	6	11	4	53	6	63	2	56	11	69	21	132	153	670
1445 - 1500	6	0	5	11	3	0	10	13	16	48	10	74	5	79	8	92	24	166	190	689
1500 - 1515	6	1	4	11	4	2	7	13	18	77	7	102	1	75	3	79	24	181	205	740
1515 - 1530	8	1	4	13	8	1	14	23	8	64	9	81	1	60	4	65	36	146	182	730
1530 - 1545	5	2	2	9	8	1	17	26	13	57	6	76	3	87	5	95	35	171	206	783
1545 - 1600	11	0	1	12	12	0	11	23	13	79	10	102	1	80	7	88	35	190	225	818
1600 - 1615	**3**	**2**	**5**	**10**	**6**	**2**	**7**	**15**	**14**	**105**	**12**	**131**	**2**	**90**	**9**	**101**	**25**	**232**	**257**	870
1615 - 1630	**9**	**1**	**8**	**18**	**9**	**1**	**13**	**23**	**14**	**101**	**11**	**126**	**5**	**67**	**5**	**77**	**41**	**203**	**244**	932
1630 - 1645	**9**	**0**	**4**	**13**	**8**	**1**	**19**	**28**	**15**	**112**	**17**	**144**	**2**	**53**	**11**	**66**	**41**	**210**	**251**	977
1645 - 1700	**4**	**1**	**5**	**10**	**10**	**2**	**17**	**29**	**15**	**126**	**1**	**142**	**4**	**50**	**9**	**63**	**39**	**205**	**244**	***996***
1700 - 1715	9	0	5	14	8	1	14	23	14	116	15	145	2	48	5	55	37	200	237	976
1715 - 1730	7	1	3	11	9	0	13	22	25	118	19	162	0	47	7	54	33	216	249	981
1730 - 1745	4	2	1	7	11	2	16	29	16	141	12	169	0	50	3	53	36	222	258	988
1745 - 1800	6	1	1	8	8	1	11	20	15	115	9	139	1	49	3	53	28	192	220	964
1800 - 1815	2	0	1	3	8	0	12	20	11	87	13	111	3	45	7	55	23	166	189	916
1815 - 1830	4	0	2	6	7	1	11	19	12	87	4	103	0	44	2	46	25	149	174	841
1830 - 1845	8	1	0	9	4	1	10	15	9	70	7	86	0	51	3	54	24	140	164	747
1845 - 1900	2	1	1	4	3	0	6	9	13	42	12	67	2	40	0	42	13	109	122	649
Peak HR AM																				
0730 - 0830	***47***	***7***	***12***	***66***	***29***	***1***	***66***	***96***	***36***	***127***	***9***	***172***	***14***	***489***	***36***	***539***	***162***	***711***	***873***	
Peak HR PM																				
1600 - 1700	***25***	***4***	***22***	***51***	***33***	***6***	***56***	***95***	***58***	***444***	***41***	***543***	***13***	***260***	***34***	***307***	***146***	***850***	***996***	
AM PHF	**0.825**				**0.800**				**0.796**				**0.864**				**0.856**			
PM PHF	**0.708**				**0.819**				**0.943**				**0.760**				**0.969**			

VEHICLE AND PEDESTRIAN VOLUME SUMMARY

COUNT LOCATION	
CITY	**Earlysville**
STATE	**VA**
DATE	**9/23/2021**
INTERSECTION	**Int 1: Earlysville Road (CR 743) @ Reas Ford Road (SR 660)/Earlysville Forest Drive**
COUNT BY	**AMT**

Trucks Only
Thursday - 12 Hour Count

STREET	**Earlysville Forest Dr**				**SR 660**				**CR 743**				**CR 743**				**Total**			**PEAK HR**
	From North				**From South**				**From East**				**From West**							
TIME	**L**	**T**	**R**	**TOT**	**L**	**T**	**R**	**TOT**	**L**	**T**	**R**	**TOT**	**L**	**T**	**R**	**TOT**	**N-S**	**E-W**	**ALL**	
0700 - 0715	0	0	0	0	0	0	0	0	1	1	0	2	0	0	0	0	0	2	2	2
0715 - 0730	0	0	0	0	0	0	0	0	0	3	0	3	0	1	0	1	0	4	4	6
0730 - 0745	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**0**	**1**	**0**	**1**	**1**	**2**	**3**	9
0745 - 0800	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**0**	**1**	**0**	**1**	**0**	**0**	**0**	**0**	**2**	**1**	**3**	12
0800 - 0815	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**2**	**0**	**1**	**0**	**1**	**0**	**3**	**3**	13
0815 - 0830	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	***10***
0830 - 0845	0	0	0	0	0	0	1	1	2	1	0	3	0	1	0	1	1	4	5	12
0845 - 0900	0	0	0	0	0	0	1	1	0	2	0	2	0	1	0	1	1	3	4	13
0900 - 0915	0	0	0	0	2	0	0	2	1	3	0	4	0	2	0	2	2	6	8	18
0915 - 0930	0	0	0	0	1	0	0	1	0	2	0	2	0	0	0	0	1	2	3	20
0930 - 0945	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	1	1	16
0945 - 1000	0	0	0	0	0	0	0	0	0	1	0	1	0	0	1	1	0	2	2	14
1000 - 1015	0	0	0	0	0	0	1	1	1	2	0	3	0	0	0	0	1	3	4	10
1015 - 1030	0	0	0	0	0	0	0	0	2	1	0	3	0	3	0	3	0	6	6	13
1030 - 1045	0	0	0	0	0	0	0	0	0	1	0	1	0	2	1	3	0	4	4	16
1045 - 1100	0	0	0	0	0	0	3	3	1	0	0	1	0	0	1	1	3	2	5	19
1100 - 1115	0	0	0	0	0	0	1	1	4	1	0	5	0	2	0	2	1	7	8	23
1115 - 1130	0	0	0	0	0	0	1	1	0	2	0	2	0	3	1	4	1	6	7	24
1130 - 1145	0	0	0	0	0	0	0	0	1	1	0	2	0	2	0	2	0	4	4	24
1145 - 1200	0	0	0	0	0	0	0	0	1	1	0	2	0	2	0	2	0	4	4	23
1200 - 1215	0	0	0	0	1	0	0	1	1	0	0	1	0	0	1	1	1	2	3	18
1215 - 1230	0	0	0	0	0	0	1	1	0	0	0	0	0	1	0	1	1	1	2	13
1230 - 1245	0	0	0	0	0	0	2	2	2	2	0	4	0	1	0	1	2	5	7	16
1245 - 1300	0	0	0	0	0	0	0	0	2	1	0	3	0	1	1	2	0	5	5	17
1300 - 1315	0	0	0	0	0	0	2	2	1	1	0	2	0	3	0	3	2	5	7	21
1315 - 1330	0	0	0	0	0	0	1	1	1	2	0	3	0	2	0	2	1	5	6	25
1330 - 1345	0	0	0	0	0	0	1	1	1	0	0	1	0	0	0	0	1	1	2	20
1345 - 1400	0	0	0	0	0	0	0	0	0	2	0	2	0	0	1	1	0	3	3	18
1400 - 1415	0	0	0	0	0	0	2	2	0	0	0	0	0	1	0	1	2	1	3	14
1415 - 1430	0	0	0	0	0	0	2	2	5	2	0	7	0	3	0	3	2	10	12	20
1430 - 1445	0	0	0	0	0	0	2	2	1	1	0	2	0	0	0	0	2	2	4	22
1445 - 1500	0	0	0	0	0	0	2	2	0	0	0	0	0	4	0	4	2	4	6	25
1500 - 1515	0	0	0	0	0	0	0	0	3	0	0	3	0	2	0	2	0	5	5	27
1515 - 1530	0	0	0	0	0	0	0	0	1	0	0	1	0	1	0	1	0	2	2	17
1530 - 1545	0	0	0	0	0	0	1	1	1	0	0	1	0	2	0	2	1	3	4	17
1545 - 1600	0	0	0	0	0	0	2	2	1	0	0	1	0	1	0	1	2	2	4	15
1600 - 1615	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**1**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**1**	**2**	12
1615 - 1630	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	10
1630 - 1645	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**2**	**1**	**0**	**3**	**0**	**1**	**1**	**2**	**1**	**5**	**6**	12
1645 - 1700	**0**	**0**	**0**	**0**	**0**	**0**	**2**	**2**	**0**	**0**	**0**	**0**	**1**	**0**	**1**	**2**	**2**	**2**	**4**	***12***
1700 - 1715	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	11
1715 - 1730	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11
1730 - 1745	0	0	0	0	0	0	0	0	2	0	0	2	0	0	0	0	0	2	2	7
1745 - 1800	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	1	0	1	4
1800 - 1815	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	4
1815 - 1830	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	1	0	1	5
1830 - 1845	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	1	0	1	1	4
1845 - 1900	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3
Peak HR AM																				
0730 - 0830	***0***	***0***	***1***	***1***	***0***	***0***	***3***	***3***	***1***	***3***	***0***	***4***	***0***	***2***	***0***	***2***	***4***	***6***	***10***	
Peak HR PM																				
1600 - 1700	***0***	***0***	***0***	***0***	***0***	***0***	***4***	***4***	***3***	***1***	***0***	***4***	***1***	***1***	***2***	***4***	***4***	***8***	***12***	
AM Truck %	**0.0%**	**0.0%**	**8.3%**	**1.5%**	**0.0%**	**0.0%**	**4.5%**	**3.1%**	**2.8%**	**2.4%**	**0.0%**	**2.3%**	**0.0%**	**0.4%**	**0.0%**	**0.4%**	**2.5%**	**0.8%**	**1.1%**	
PM Truck %	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**0.0%**	**7.1%**	**4.2%**	**5.2%**	**0.2%**	**0.0%**	**0.7%**	**7.7%**	**0.4%**	**5.9%**	**1.3%**	**2.7%**	**0.9%**	**1.2%**	

VEHICLE AND PEDESTRIAN VOLUME SUMMARY

COUNT LOCATION	
CITY	**Earlysville**
STATE	**VA**
DATE	**9/23/2021**
INTERSECTION	**Int 1: Earlysville Road (CR 743) @ Reas Ford Road (SR 660)/Earlysville Forest Drive**
COUNT BY	**AMT**

Non-Vehicle Traffic
Thursday - 12 Hour Count

STREET	**Earlysville Forest Dr**			**SR 660**			**CR 743**			**CR 743**		
	From North			**From South**			**From East**			**From West**		
TIME	**School Children**	**Pedestrians**	**Bicycles**	**School Children**	**Pedestrians**	**Bicycles**	**School Children**	**Pedestrians**	**Bicycles**	**School Children**	**Pedestrians**	**Bicycles**
0700 - 0715	0	0	0	0	0	0	1	1	0	0	0	0
0715 - 0730	0	0	0	0	0	0	0	3	0	0	1	0
0730 - 0745	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**1**	**0**
0745 - 0800	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**1**	**0**	**0**	**0**	**0**
0800 - 0815	**0**	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**1**	**0**
0815 - 0830	**0**	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**
0830 - 0845	0	0	0	0	0	1	2	1	0	0	1	0
0845 - 0900	0	0	0	0	0	1	0	2	0	0	1	0
0900 - 0915	0	0	0	2	0	0	1	3	0	0	2	0
0915 - 0930	0	0	0	1	0	0	0	2	0	0	0	0
0930 - 0945	0	0	0	0	0	0	1	0	0	0	0	0
0945 - 1000	0	0	0	0	0	0	0	1	0	0	0	1
1000 - 1015	0	0	0	0	0	1	1	2	0	0	0	0
1015 - 1030	0	0	0	0	0	0	2	1	0	0	3	0
1030 - 1045	0	0	0	0	0	0	0	1	0	0	2	1
1045 - 1100	0	0	0	0	0	3	1	0	0	0	0	1
1100 - 1115	0	0	0	0	0	1	4	1	0	0	2	0
1115 - 1130	0	0	0	0	0	1	0	2	0	0	3	1
1130 - 1145	0	0	0	0	0	0	1	1	0	0	2	0
1145 - 1200	0	0	0	0	0	0	1	1	0	0	2	0
1200 - 1215	0	0	0	1	0	0	1	0	0	0	0	1
1215 - 1230	0	0	0	0	0	1	0	0	0	0	1	0
1230 - 1245	0	0	0	0	0	2	2	2	0	0	1	0
1245 - 1300	0	0	0	0	0	0	2	1	0	0	1	1
1300 - 1315	0	0	0	0	0	2	1	1	0	0	3	0
1315 - 1330	0	0	0	0	0	1	1	2	0	0	2	0
1330 - 1345	0	0	0	0	0	1	1	0	0	0	0	0
1345 - 1400	0	0	0	0	0	0	0	2	0	0	0	1
1400 - 1415	0	0	0	0	0	2	0	0	0	0	1	0
1415 - 1430	0	0	0	0	0	2	5	2	0	0	3	0
1430 - 1445	0	0	0	0	0	2	1	1	0	0	0	0
1445 - 1500	0	0	0	0	0	2	0	0	0	0	4	0
1500 - 1515	0	0	0	0	0	0	3	0	0	0	2	0
1515 - 1530	0	0	0	0	0	0	1	0	0	0	1	0
1530 - 1545	0	0	0	0	0	1	1	0	0	0	2	0
1545 - 1600	0	0	0	0	0	2	1	0	0	0	1	0
1600 - 1615	**0**	**0**	**0**	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**
1615 - 1630	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
1630 - 1645	**0**	**0**	**0**	**0**	**0**	**1**	**2**	**1**	**0**	**0**	**1**	**1**
1645 - 1700	**0**	**0**	**0**	**0**	**0**	**2**	**0**	**0**	**0**	**1**	**0**	**1**
1700 - 1715	0	0	0	0	0	0	0	0	0	0	1	0
1715 - 1730	0	0	0	0	0	0	0	0	0	0	0	0
1730 - 1745	0	0	0	0	0	0	2	0	0	0	0	0
1745 - 1800	0	0	0	1	0	0	0	0	0	0	0	0
1800 - 1815	0	0	0	0	0	1	0	0	0	0	0	0
1815 - 1830	0	0	0	0	0	1	0	0	0	0	0	0
1830 - 1845	0	0	0	0	0	0	0	0	0	0	1	0
1845 - 1900	0	0	0	0	0	0	0	0	0	0	0	0
Peak HR AM												
0730 - 0830	***0***	***0***	***1***	***0***	***0***	***3***	***1***	***3***	***0***	***0***	***2***	***0***
Peak HR PM												
1600 - 1700	***0***	***0***	***0***	***0***	***0***	***4***	***3***	***1***	***0***	***1***	***1***	***2***

Appendix C

Crash Data

Accident Number	Date	Time	Accident Type	Injury Type	No. of Injuries	Lighting Conditions	Road Surface Condition
1	3/30/2017	13:05	Single Vehicle (Ran Off-Road Right)	PDO	0	Day	Dry
2	6/1/2018	14:15	Angle	PDO	0	Day	Dry
3	10/14/2017	16:12	Angle	B	2	Day	Dry
4	5/27/2017	10:33	Sideswipe (Opposite Direction)	PDO	0	Day	Dry
5	5/26/2020	14:42	Other	B	2	Day	Dry
6	8/17/2018	10:43	Angle	B	1	Day	Dry
7	7/19/2016	6:11	Angle	A	2	Dawn	Dry
8	9/7/2017	16:37	Head-On	A	2	Day	Dry
9	5/5/2019	21:40	Sideswipe (Opposite Direction)	PDO	0	Night	Wet
10	10/1/2019	12:10	Angle	B	2	Day	Dry
11	10/17/2019	8:25	Angle	B	4	Day	Dry
12	5/27/2017	13:54	Angle	PDO	0	Day	Dry
13	9/29/2016	16:30	Rear-End	B	1	Day	Wet
14	3/15/2021	11:02	Angle	PDO	0	Day	Dry
15	2/16/2018	17:05	Rear-End	PDO	0	Day	Dry

Appendix D

Signal Warrant Analysis

Appendix D-1

Warrant 1: Eight-Hour Warrant
2021 Existing Conditions

VEHICLE AND PEDESTRIAN VOLUME SUMMARY

COUNT LOCATION	
CITY	Earlysville
STATE	VA
DATE	9/23/2021
INTERSECTION	Int 1: Earlysville Road (CR 743) @ Reas Ford Road (SR 660)/Earlysville Forest Drive
COUNT BY	AMT

All Vehicles
Thursday - 12 Hour Count

STREET	Earlysville Forest Dr					SR 660					CR 743				CR 743			
	From North					From South					From East				From West			
TIME	L	T	R	R*	TOT	L	T	R	R*	TOT	L	T	R	TOT	L	T	R	TOT
0700 - 0715	1	1	0	0	2	1	0	4	2	3	7	17	1	25	0	103	8	111
0715 - 0730	9	0	1	1	10	2	1	18	11	14	4	17	3	24	2	107	6	115
0730 - 0745	**8**	**0**	**5**	**3**	**11**	**11**	**0**	**17**	**10**	**21**	**7**	**39**	**2**	**48**	**4**	**114**	**7**	**125**
0745 - 0800	**10**	**4**	**1**	**1**	**15**	**11**	**1**	**18**	**11**	**23**	**11**	**41**	**2**	**54**	**3**	**138**	**15**	**156**
0800 - 0815	**13**	**3**	**4**	**2**	**18**	**6**	**0**	**18**	**11**	**17**	**10**	**26**	**2**	**38**	**2**	**111**	**9**	**122**
0815 - 0830	**16**	**0**	**2**	**1**	**17**	**1**	**0**	**13**	**8**	**9**	**8**	**21**	**3**	**32**	**5**	**126**	**5**	**136**
0830 - 0845	11	0	1	1	12	7	1	15	9	17	10	35	3	48	4	106	0	110
0845 - 0900	11	0	1	1	12	5	2	15	9	16	9	45	5	59	3	79	6	88
0900 - 0915	14	0	0	0	14	3	0	9	5	8	14	41	5	60	3	63	7	73
0915 - 0930	8	0	1	1	9	5	0	6	4	9	6	40	4	50	2	47	3	52
0930 - 0945	6	0	2	1	7	1	2	8	5	8	10	36	2	48	1	54	6	61
0945 - 1000	8	1	1	1	10	5	1	7	4	10	7	34	0	41	2	57	7	66
1000 - 1015	2	2	2	1	5	5	0	7	4	9	6	42	4	52	1	50	4	55
1015 - 1030	7	2	3	2	11	4	0	5	3	7	11	52	3	66	3	55	3	61
1030 - 1045	8	0	1	1	9	4	1	8	5	10	7	52	2	61	1	57	5	63
1045 - 1100	4	1	3	2	7	3	1	8	5	9	5	39	8	52	1	52	3	56
1100 - 1115	9	1	4	2	12	0	4	8	5	9	10	34	7	51	0	37	6	43
1115 - 1130	8	1	3	2	11	0	0	6	4	4	7	43	3	53	3	42	5	50
1130 - 1145	12	1	1	1	14	6	0	12	7	13	3	47	4	54	6	65	6	77
1145 - 1200	9	3	6	4	16	8	1	12	7	16	10	34	10	54	3	48	5	56
1200 - 1215	8	0	6	4	12	6	1	11	7	14	14	46	4	64	1	39	3	43
1215 - 1230	5	0	3	2	7	3	0	11	7	10	8	67	4	79	1	55	3	59
1230 - 1245	6	0	2	1	7	3	2	13	8	13	10	47	4	61	4	58	3	65
1245 - 1300	6	1	7	4	11	5	1	8	5	11	9	41	6	56	3	50	7	60
1300 - 1315	9	1	3	2	12	2	4	13	8	14	6	52	2	60	5	46	3	54
1315 - 1330	5	0	2	1	6	5	1	10	6	12	10	52	6	68	1	65	3	69
1330 - 1345	4	2	4	2	8	0	1	16	10	11	7	54	8	69	5	55	1	61
1345 - 1400	10	0	11	7	17	3	2	15	9	14	11	53	6	70	6	52	2	60
1400 - 1415	12	1	2	1	14	6	2	12	7	15	10	54	6	70	2	42	5	49
1415 - 1430	6	1	3	2	9	7	0	10	6	13	18	68	12	98	3	63	1	67
1430 - 1445	6	2	2	1	9	3	2	6	4	9	4	53	6	63	2	56	11	69
1445 - 1500	6	0	5	3	9	3	0	10	6	9	16	48	10	74	5	79	8	92
1500 - 1515	6	1	4	2	9	4	2	7	4	10	18	77	7	102	1	75	3	79
1515 - 1530	8	1	4	2	11	8	1	14	8	17	8	64	9	81	1	60	4	65
1530 - 1545	5	2	2	1	8	8	1	17	10	19	13	57	6	76	3	87	5	95
1545 - 1600	11	0	1	1	12	12	0	11	7	19	13	79	10	102	1	80	7	88
1600 - 1615	**3**	**2**	**5**	**3**	**8**	**6**	**2**	**7**	**4**	**12**	**14**	**105**	**12**	**131**	**2**	**90**	**9**	**101**
1615 - 1630	**9**	**1**	**8**	**5**	**15**	**9**	**1**	**13**	**8**	**18**	**14**	**101**	**11**	**126**	**5**	**67**	**5**	**77**
1630 - 1645	**9**	**0**	**4**	**2**	**11**	**8**	**1**	**19**	**11**	**20**	**15**	**112**	**17**	**144**	**2**	**53**	**11**	**66**
1645 - 1700	**4**	**1**	**5**	**3**	**8**	**10**	**2**	**17**	**10**	**22**	**15**	**126**	**1**	**142**	**4**	**50**	**9**	**63**
1700 - 1715	9	0	5	3	12	8	1	14	8	17	14	116	15	145	2	48	5	55
1715 - 1730	7	1	3	2	10	9	0	13	8	17	25	118	19	162	0	47	7	54
1730 - 1745	4	2	1	1	7	11	2	16	10	23	16	141	12	169	0	50	3	53
1745 - 1800	6	1	1	1	8	8	1	11	7	16	15	115	9	139	1	49	3	53
1800 - 1815	2	0	1	1	3	8	0	12	7	15	11	87	13	111	3	45	7	55
1815 - 1830	4	0	2	1	5	7	1	11	7	15	12	87	4	103	0	44	2	46
1830 - 1845	8	1	0	0	9	4	1	10	6	11	9	70	7	86	0	51	3	54
1845 - 1900	2	1	1	1	4	3	0	6	4	7	13	42	12	67	2	40	0	42

R* = Reduced Right-Turn Volume utilizing Pagones Theorem

WARRANT 1 -- EIGHT-HOUR VEHICULAR VOLUME

2021 Existing Year

Major Street	**Ealysville Road**
Minor Street	**Reas Ford Road**
Jurisdiction	**Earlysville**
85% Speed > 40 mph	**NO**
Population < 10K	**YES**
# of Lanes on Major Street	**1**
# of Lanes on Minor Street	**1**
Minor St. Right Turns Discounted	**YES**
Have five (5) correctable crashes occurred in 1 year?	**NO**

HOUR	MAJOR ST VOLUME	MINOR ST VOLUME
7-8 AM	**658**	**61**
8-9 AM	**633**	**59**
9-10 AM	**451**	**35**
10-11 AM	**466**	**35**
11-12 PM	**438**	**42**
12-1 PM	**487**	**47**
1-2 PM	**511**	**50**
2-3 PM	**582**	**46**
3-4 PM	**688**	**65**
4-5 PM	**850**	**73**
5-6 PM	**830**	**72**
6-7 PM	**564**	**47**

FINDINGS:

Condition 'A' Satisfied	**NO**
Condition 'B' Satisfied	**NO**
Combination 'A' & 'B' Satisfied	**NO**
WARRANT 1 Satisfied?	**NO**

COMMENTS:

Minor Street volume was reduced 40% utilizing Pagones Theorem

WARRANT 1 -- EIGHT-HOUR VEHICULAR VOLUME

CONDITION 'A' -- MINIMUM VEHICULAR VOLUME

Major Street	**Ealysville Road**
Minor Street	**Reas Ford Road**
Jurisdiction	**Earlysville**
85% Speed > 40 mph	**NO**
Population < 10K	**YES**
# of Lanes on Major Street	**1**
# of Lanes on Minor Street	**1**
Minor St. Right Turns Discounted	**YES**
Major St. Warranting Volume	**500**
Minor St. Warranting Volume	**150**
30% Warrant Volume Reduction	**YES**

HOUR	MAJOR STREET VOLUME	MINOR STREET VOLUME	MAJOR ST WARRANT VOLUME	MINOR ST WARRANT VOLUME	HOUR MET
7-8 AM	**658**	**61**	**350**	**105**	**NO**
8-9 AM	**633**	**59**	**350**	**105**	**NO**
9-10 AM	**451**	**35**	**350**	**105**	**NO**
10-11 AM	**466**	**35**	**350**	**105**	**NO**
11-12 PM	**438**	**42**	**350**	**105**	**NO**
12-1 PM	**487**	**47**	**350**	**105**	**NO**
1-2 PM	**511**	**50**	**350**	**105**	**NO**
2-3 PM	**582**	**46**	**350**	**105**	**NO**
3-4 PM	**688**	**65**	**350**	**105**	**NO**
4-5 PM	**850**	**73**	**350**	**105**	**NO**
5-6 PM	**830**	**72**	**350**	**105**	**NO**
6-7 PM	**564**	**47**	**350**	**105**	**NO**

FINDINGS:

Number of Hours Condition 'A' Met	**0**
Condition 'A' Satisfied?	**NO**

COMMENTS:

Minor Street volume was reduced 40% utilizing Pagones Theorem

WARRANT 1 -- EIGHT-HOUR VEHICULAR VOLUME
CONDITION 'B' -- INTERRUPTION OF CONTINUOUS TRAFFIC

Major Street	**Ealysville Road**
Minor Street	**Reas Ford Road**
Jurisdiction	**Earlysville**
85% Speed > 40 mph	**NO**
Population < 10K	**YES**
# of Lanes on Major Street	**1**
# of Lanes on Minor Street	**1**
Minor St. Right Turns Discounted	**YES**
Major St. Warranting Volume	**750**
Minor St. Warranting Volume	**75**
30% Warrant Volume Reduction	**YES**

HOUR	MAJOR STREET VOLUME	MINOR STREET VOLUME	MAJOR ST WARRANT VOLUME	MINOR ST WARRANT VOLUME	HOUR MET
7-8 AM	**658**	**61**	**525**	**53**	**YES**
8-9 AM	**633**	**59**	**525**	**53**	**YES**
9-10 AM	**451**	**35**	**525**	**53**	**NO**
10-11 AM	**466**	**35**	**525**	**53**	**NO**
11-12 PM	**438**	**42**	**525**	**53**	**NO**
12-1 PM	**487**	**47**	**525**	**53**	**NO**
1-2 PM	**511**	**50**	**525**	**53**	**NO**
2-3 PM	**582**	**46**	**525**	**53**	**NO**
3-4 PM	**688**	**65**	**525**	**53**	**YES**
4-5 PM	**850**	**73**	**525**	**53**	**YES**
5-6 PM	**830**	**72**	**525**	**53**	**YES**
6-7 PM	**564**	**47**	**525**	**53**	**NO**

FINDINGS:

Number of Hours Condition 'B' Met	**5**
Condition 'B' Satisfied?	**NO**

COMMENTS:

Minor Street volume was reduced 40% utilizing Pagones Theorem

WARRANT 1 -- EIGHT-HOUR VEHICULAR VOLUME
COMBINATION OF CONDITION 'A' & 'B' (80% VOLUME)

Major Street	Ealysville Road
Minor Street	Reas Ford Road
Jurisdiction	Earlysville

CONDITION 'A'

HOUR	MAJOR STREET VOLUME	MINOR STREET VOLUME	MAJOR ST WARRANT VOLUME	MINOR ST WARRANT VOLUME	HOUR MET
7-8 AM	658	61	280	84	NO
8-9 AM	633	59	280	84	NO
9-10 AM	451	35	280	84	NO
10-11 AM	466	35	280	84	NO
11-12 PM	438	42	280	84	NO
12-1 PM	487	47	280	84	NO
1-2 PM	511	50	280	84	NO
2-3 PM	582	46	280	84	NO
3-4 PM	688	65	280	84	NO
4-5 PM	850	73	280	84	NO
5-6 PM	830	72	280	84	NO
6-7 PM	564	47	280	84	NO

CONDITION 'B'

HOUR	MAJOR STREET VOLUME	MINOR STREET VOLUME	MAJOR ST WARRANT VOLUME	MINOR ST WARRANT VOLUME	HOUR MET
7-8 AM	658	61	420	42	YES
8-9 AM	633	59	420	42	YES
9-10 AM	451	35	420	42	NO
10-11 AM	466	35	420	42	NO
11-12 PM	438	42	420	42	YES
12-1 PM	487	47	420	42	YES
1-2 PM	511	50	420	42	YES
2-3 PM	582	46	420	42	YES
3-4 PM	688	65	420	42	YES
4-5 PM	850	73	420	42	YES
5-6 PM	830	72	420	42	YES
6-7 PM	564	47	420	42	YES

FINDINGS:

Number of Hours Combination A&B Met	0
Combination of A&B Satisfied?	**NO**

COMMENTS:

Minor Street volume was reduced 40% utilizing Pagones Theorem

Appendix D-2

Warrant 2: 4-Hour Signal Warrant
2021 Existing Conditions

Warrant 2: Four-hour Vehicular Volume

1: Earlysville Rd @ Reas Ford Road/Earlysville Forest Drive

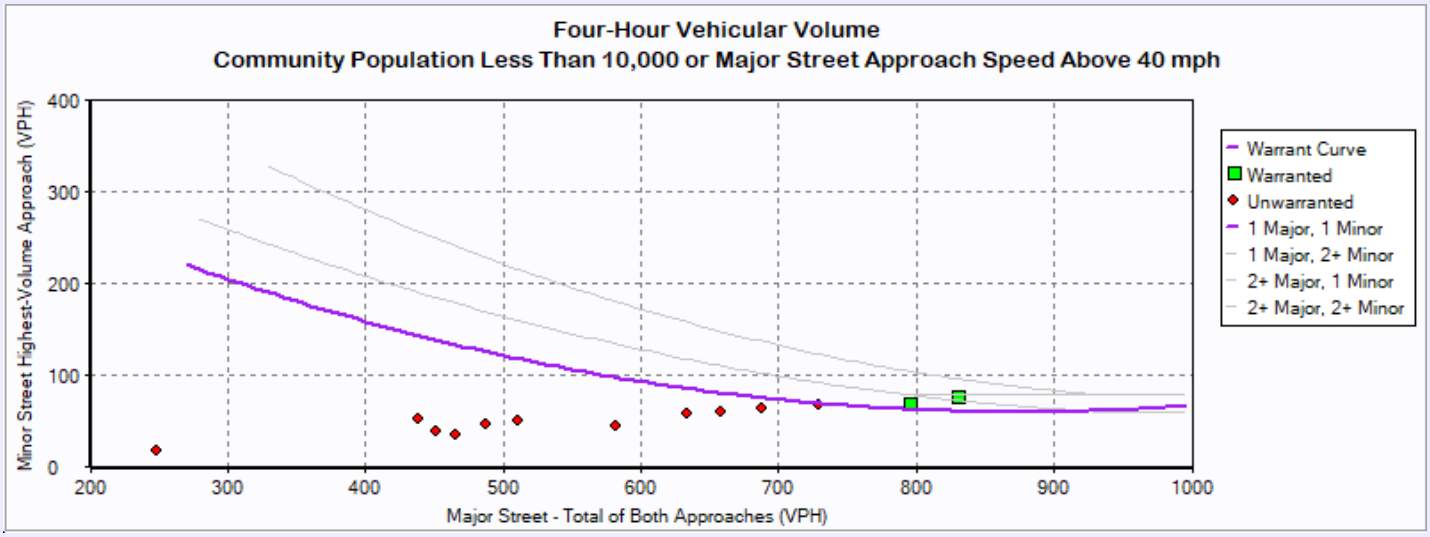
Intersection Information

	Major Street	Minor Street
Street Name	Earlysville Rd	Earlysville Forest Dr
Direction	EB/WB	NB/SB
Number of Lanes	1	1
Approch Speed	35	35

Warrant 2 Met? **No**

Details:

Notes	2 Hours met (4 required)
Low population	Yes



Warrant 2: Four-hour Vehicular Volume

1: Earlysville Rd @ Reas Ford Road/Earlysville Forest Drive

Hourly Volumes

Hour	Major Street Total All Approaches (vph)	Minor Street Highest Volume Approach (vph)
00:00:00 - 01:00:00	0	0
01:00:00 - 02:00:00	0	0
02:00:00 - 03:00:00	0	0
03:00:00 - 04:00:00	0	0
04:00:00 - 05:00:00	0	0
05:00:00 - 06:00:00	0	0
06:00:00 - 07:00:00	0	0
07:00:00 - 08:00:00	658	61
08:00:00 - 09:00:00	633	59
09:00:00 - 10:00:00	451	40
10:00:00 - 11:00:00	466	35
11:00:00 - 12:00:00	438	53
12:00:00 - 13:00:00	487	48
13:00:00 - 14:00:00	511	51
14:00:00 - 15:00:00	582	46
15:00:00 - 16:00:00	688	65
16:00:00 - 17:00:00	850	72
17:00:00 - 18:00:00	830	73
18:00:00 - 19:00:00	564	48
19:00:00 - 20:00:00	0	0
20:00:00 - 21:00:00	0	0
21:00:00 - 22:00:00	0	0
22:00:00 - 23:00:00	0	0

23:00:00 - 00:00:00	0	0

Warranted Hours

Hour	Major Street Total All Approaches (vph)	Minor Street Highest Volume Approach (vph)
15:30:00 - 16:30:00	796.00	68.00
16:30:00 - 17:30:00	831.00	76.00

Note: Only data of hours warranted is represented in the above table.

Appendix D-3

Warrant 3: Peak Hour Signal Warrant
2021 Existing Conditions

Warrant 3: Peak Hour

1: Earlysville Rd @ Reas Ford Road/Earlysville Forest Drive

Intersection Information

	Major Street	Minor Street
Street Name	Earlysville Rd	Earlysville Forest Dr
Direction	EB/WB	NB/SB
Number of Lanes	1	1
Approch Speed	35	35

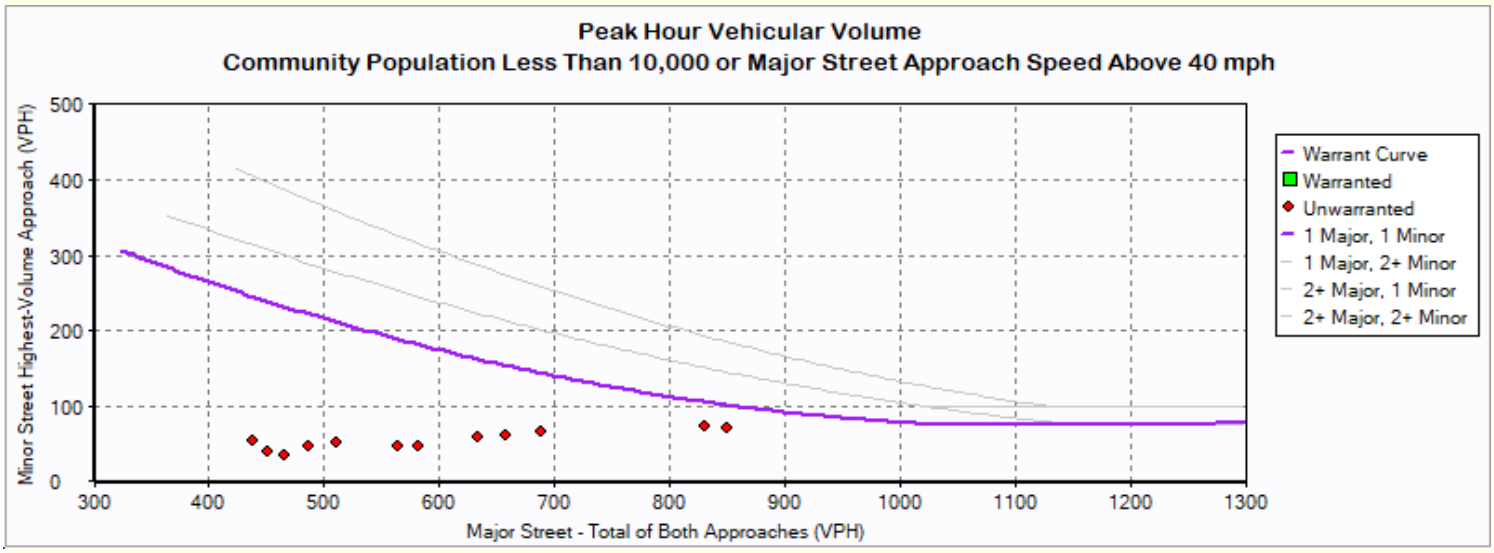
Warrant 3 Met? No

Details

Low Population? Yes

Condition A Met	No	**Condition B Met**	No
Notes	0 Hours met (1 required)	**Notes**	0 Hours met (1 required)

Minor Approach Time Delay Condition Met?	Not Met
Minor Approach Volume Condition Met?	Not Met
Total Entering Intersection Volume Condition Met?	Not Met



Warrant 3: Peak Hour

1: Earlysville Rd @ Reas Ford Road/Earlysville Forest Drive

Hour	Major Street Total All Approaches (vph)	Minor Street Highest Volume Approach (vph)
7:00	658	61
8:00	633	59
9:00	451	40
10:00	466	35
11:00	438	53
12:00	487	48
13:00	511	51
14:00	582	46
15:00	688	65
16:00	850	72
17:00	830	73
18:00	564	48

Appendix D-4

Warrant 7: Crash Experience
2021 Existing Conditions

WARRANT 7 -- CRASH EXPERIENCE

Major Street	Ealysville Road
Minor Street	Reas Ford Road
Jurisdiction	Earlysville
Have five (5) correctable crashes occurred in 1 year?	NO

CONDITION 'A'

HOUR	MAJOR STREET VOLUME	MINOR STREET VOLUME	MAJOR ST WARRANT VOLUME	MINOR ST WARRANT VOLUME	HOUR MET
6-7 AM	658	61	350	105	NO
7-8 AM	633	59	350	105	NO
8-9 AM	451	35	350	105	NO
9-10 AM	466	35	350	105	NO
10-11 AM	438	42	350	105	NO
11-12 PM	487	47	350	105	NO
12-1 PM	511	50	350	105	NO
1-2 PM	582	46	350	105	NO
2-3 PM	688	65	350	105	NO
3-4 PM	850	73	350	105	NO
4-5 PM	830	72	350	105	NO
5-6 PM	564	47	350	105	NO
6-7 PM	0	0	350	105	NO

CONDITION 'B'

HOUR	MAJOR STREET VOLUME	MINOR STREET VOLUME	MAJOR ST WARRANT VOLUME	MINOR ST WARRANT VOLUME	HOUR MET
6-7 AM	658	61	525	53	YES
7-8 AM	633	59	525	53	YES
8-9 AM	451	35	525	53	NO
9-10 AM	466	35	525	53	NO
10-11 AM	438	42	525	53	NO
11-12 PM	487	47	525	53	NO
12-1 PM	511	50	525	53	NO
1-2 PM	582	46	525	53	NO
2-3 PM	688	65	525	53	YES
3-4 PM	850	73	525	53	YES
4-5 PM	830	72	525	53	YES
5-6 PM	564	47	525	53	NO
6-7 PM	0	0	525	53	NO

FINDINGS:

Condition A Satisfied?	0
Condition B Satisfied?	5
WARRANT 7 Satisfied?	**NO**

COMMENTS:

Minor Street volume was reduced 40% utilizing Pagones Theorem

Warrant 7: Crash Experience

1: Earlysville Rd @ Reas Ford Road/Earlysville Forest Drive

Intersection Information

Major Street Name	Earlysville Rd
Major Street Direction	EB/WB
Minor Street Direction	NB/SB

WARRANT 7 MET? **No**

Details:

Low Population?	Yes	Traffic Volume Condition Met?	Yes
Major Street Speed Limit	35		10 Hours Met (8 Required)
Major Street 85th-% tile Speed	0.00	Ped Volume Condition Met?	No
			0 Hours Met (8 Required)

Qualifying Crashes **7**

Adequate Alternative Trials? No

Hour	Traffic Volumes				Pedestrian Volumes			
	Major Street Vehicles	Minor Street Vehicles	80% Standard Met? A or B		Northbound Ped Volumes		Southbound Ped Volumes	
			Condition A	Condition B	Peds	> 80?	Peds	> 80?
07:00 to 08:00	658	0	No	No	0	No	0	No
07:15 to 08:15	682	0	No	No	0	No	0	No
07:30 to 08:30	711	0	No	No	0	No	0	No
07:45 to 08:45	696	0	No	No	0	No	0	No
08:00 to 09:00	633	0	No	No	0	No	0	No
08:15 to 09:15	606	0	No	No	0	No	0	No

08:30 to 09:30	540	0	No	No	0	No	0	No
08:45 to 09:45	491	0	No	No	0	No	0	No
09:00 to 10:00	451	0	No	No	0	No	0	No
09:15 to 10:15	425	0	No	No	0	No	0	No
09:30 to 10:30	450	0	No	No	0	No	0	No
09:45 to 10:45	465	0	No	No	0	No	0	No
10:00 to 11:00	466	0	No	No	0	No	0	No
10:15 to 11:15	453	0	No	No	0	No	0	No
10:30 to 11:30	429	0	No	No	0	No	0	No
10:45 to 11:45	436	0	No	No	0	No	0	No
11:00 to 12:00	438	0	No	No	0	No	0	No
11:15 to 12:15	451	0	No	No	0	No	0	No
11:30 to 12:30	486	0	No	No	0	No	0	No
11:45 to 12:45	481	0	No	No	0	No	0	No
12:00 to 13:00	487	0	No	No	0	No	0	No
12:15 to 13:15	494	0	No	No	0	No	0	No

12:30 to 13:30	493	0	No	No	0	No	0	No
12:45 to 13:45	497	0	No	No	0	No	0	No
13:00 to 14:00	511	0	No	No	0	No	0	No
13:15 to 14:15	516	0	No	No	0	No	0	No
13:30 to 14:30	544	0	No	No	0	No	0	No
13:45 to 14:45	546	0	No	No	0	No	0	No
14:00 to 15:00	582	0	No	No	0	No	0	No
14:15 to 15:15	644	0	No	No	0	No	0	No
14:30 to 15:30	625	0	No	No	0	No	0	No
14:45 to 15:45	664	0	No	No	0	No	0	No
15:00 to 16:00	688	0	No	No	0	No	0	No
15:15 to 16:15	739	0	No	No	0	No	0	No
15:30 to 16:30	796	0	No	No	0	No	0	No
15:45 to 16:45	835	0	No	No	0	No	0	No
16:00 to 17:00	850	0	No	No	0	No	0	No
16:15 to 17:15	818	0	No	No	0	No	0	No

16:30 to 17:30	831	0	No	No	0	No	0	No
16:45 to 17:45	843	0	No	No	0	No	0	No
17:00 to 18:00	830	0	No	No	0	No	0	No
17:15 to 18:15	796	0	No	No	0	No	0	No
17:30 to 18:30	729	0	No	No	0	No	0	No
17:45 to 18:45	647	0	No	No	0	No	0	No
18:00 to 19:00	564	0	No	No	0	No	0	No
18:15 to 19:15	398	0	No	No	0	No	0	No
18:30 to 19:30	249	0	No	No	0	No	0	No
18:45 to 19:45	109	0	No	No	0	No	0	No

Appendix E

Alternative Cost Analysis

Appendix E-1

Alternative 1: Cost Analysis

Albemarle County
Earlysville Road / Reas Ford Road Turn Lanes
November 16, 2021
Preliminary Cost Estimate

ITEM CODE	SPEC	ITEM DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL PRICE
00100	513	MOBILIZATION	LS	1	$ 59,000	$ 59,000
00101	105	CONSTRUCTION SURVEYING (CONSTRUCTION)	LS	1	$ 7,000	$ 7,000
00110	301	CLEARING AND GRUBBING	ACRE	1.0	$ 15,000	$ 15,000
		EARTHWORK				
00120	303	REGULAR EXCAVATION	CY	1,000	$ 18	$ 18,000
00140	303, 305	BORROW EXCAVATION	CY	500	$ 23	$ 11,500
		INCIDENTALS				
68576	315, 412	SAW CUT	LF	2,976	$ 10	$ 29,760
		PAVEMENT				
16350	315	ASPHALT CONC. TYPE SM-12.5A (NEW SECTION)	TON	180	$ 115	$ 20,700
10610	315	ASPHALT CONC. TYPE IM-19.0A (NEW SECTION)	TON	224	$ 115	$ 25,760
16390	315	ASPH. CONC. BASE COURSE TY. BM-25.0A (NEW SECTION)	TON	359	$ 105	$ 37,695
10128	308, 309	AGGR. BASE MATL. TY. I NO. 21B (NEW SECTION)	TON	725	$ 40	$ 29,000
10628	515	FLEXIBLE PAVEMENT PLANNING 0" - 2"	SY	4,828	$ 6	$ 28,968
16350	315	ASPHALT CONC. TYPE SM-12.5A (OVERLAY)	TON	531	$ 100	$ 53,100
24430	508	DEMOLITION OF PAVEMENT (FLEXIBLE)	SY	50	$ 20	$ 1,000
		DRAINAGE & BASINS				
NS		DRAINAGE ITEMS	LS	1	$ 150,000	$ 150,000
		EROSION AND SEDIMENT CONTROL				
NS		E&S ITEMS	LS	1	$ 30,000	$ 30,000
		TRAFFIC				
NS		SIGNING & PAVEMENT MARKING	LS	1	$ 30,000	$ 30,000
		ROADSIDE DEVELOPMENT				
NS		ROADSIDE DEVELOPMENT ITEMS	LS	1	$ 25,000	$ 25,000
		MAINTENANCE OF TRAFFIC				
NS	-	MOT	LS	1	$ 200,000	$ 200,000

Estimated Construction Cost		**$ 771,483**
CONTINGENCY	**50%**	**$ 385,742**
CEI	**18%**	**$ 190,964**
TOTAL CONSTRUCTION		**$ 1,348,189**
PE & Permitting (25% of Construction Cost excluding CEI)		**$ 289,306**
Preliminary Right of Way and Easements		**$ 266,000**
Utility Easements and Relocation Cost		**$ -**
R/W & UTILITIES (2020)		**$ 266,000**
Environmental Mitigation (2020)		**$ -**
PROJECT GRAND TOTAL (FY 2020)		**$ 1,903,495**

Appendix E-2

Alternative 2: Cost Analysis

Albemarle County
Earlysville Road / Reas Ford Road Turn Lanes
November 16, 2021
Preliminary Cost Estimate

ITEM CODE	SPEC	ITEM DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL PRICE
00100	513	MOBILIZATION	LS	1	$ 59,000	$ 59,000
00101	105	CONSTRUCTION SURVEYING (CONSTRUCTION)	LS	1	$ 7,000	$ 7,000
00110	301	CLEARING AND GRUBBING	ACRE	1.0	$ 15,000	$ 15,000
		EARTHWORK				
00120	303	REGULAR EXCAVATION	CY	1,000	$ 18	$ 18,000
00140	303, 305	BORROW EXCAVATION	CY	500	$ 23	$ 11,500
		INCIDENTALS				
68576	315, 412	SAW CUT	LF	2,976	$ 10	$ 29,760
		PAVEMENT				
16350	315	ASPHALT CONC. TYPE SM-12.5A (NEW SECTION)	TON	180	$ 115	$ 20,700
10610	315	ASPHALT CONC. TYPE IM-19.0A (NEW SECTION)	TON	224	$ 115	$ 25,760
16390	315	ASPH. CONC. BASE COURSE TY. BM-25.0A (NEW SECTION)	TON	359	$ 105	$ 37,695
10128	308, 309	AGGR. BASE MATL. TY. I NO. 21B (NEW SECTION)	TON	725	$ 40	$ 29,000
10628	515	FLEXIBLE PAVEMENT PLANNING 0" - 2"	SY	4,828	$ 6	$ 28,968
16350	315	ASPHALT CONC. TYPE SM-12.5A (OVERLAY)	TON	531	$ 100	$ 53,100
24430	508	DEMOLITION OF PAVEMENT (FLEXIBLE)	SY	50	$ 20	$ 1,000
		DRAINAGE & BASINS				
NS		DRAINAGE ITEMS	LS	1	$ 150,000	$ 150,000
		EROSION AND SEDIMENT CONTROL				
NS		E&S ITEMS	LS	1	$ 30,000	$ 30,000
		TRAFFIC				
NS		SIGNING & PAVEMENT MARKING	LS	1	$ 30,000	$ 30,000
		ROADSIDE DEVELOPMENT				
NS		ROADSIDE DEVELOPMENT ITEMS	LS	1	$ 25,000	$ 25,000
		MAINTENANCE OF TRAFFIC				
NS	-	MOT	LS	1	$ 200,000	$ 200,000
		SIGNALIZATION				
NS	-	TRAFFIC SIGNAL	LS	1	$ 200,000	$ 200,000

Estimated Construction Cost		**$ 971,483**
CONTINGENCY	**50%**	**$ 485,742**
CEI	**18%**	**$ 243,464**
TOTAL CONSTRUCTION		**$ 1,700,689**
PE & Permitting (25% of Construction Cost excluding CEI)		**$ 364,306**
Preliminary Right of Way and Easements		**$ 266,000**
Utility Easements and Relocation Cost		**$ -**
R/W & UTILITIES (2020)		**$ 266,000**
Environmental Mitigation (2020)		**$ -**
PROJECT GRAND TOTAL (FY 2020)		**$ 2,330,995**

Appendix E-3

Alternative 3: Cost Analysis

Albemarle County
Earlysville Road / Reas Ford Road Roundabout
November 16, 2021
Preliminary Cost Estimate

ITEM CODE	SPEC	ITEM DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL PRICE
00100	513	MOBILIZATION	LS	1	$ 93,368	$ 93,368
00101	105	CONSTRUCTION SURVEYING (CONSTRUCTION)	LS	1	$ 12,674	$ 12,674
00110	301	CLEARING AND GRUBBING	ACRE	1.6	$ 15,000	$ 24,000
		EARTHWORK				
00120	303	REGULAR EXCAVATION	CY	2,891	$ 18	$ 52,038
00140	303, 305	BORROW EXCAVATION	CY	1,789	$ 23	$ 41,147
00128	ATTD	UNSUITABLE EXCAVATION	CY	320	$ 20	$ 6,400
		INCIDENTALS				
12600	502	STD. COMB. CURB & GUTTER CG-6	LF	210	$ 34	$ 7,140
12610	502	RADIAL COMB. CURB & GUTTER CG-6	LF	310	$ 35	$ 10,850
12032	502	RADIAL CURB CG-3	LF	420	$ 32	$ 13,440
21020	502	MEDIAN STRIP MS-1	SY	299	$ 115	$ 34,385
68576	315, 412	SAW CUT	LF	6,000	$ 10	$ 60,000
		PAVEMENT				
16350	315	ASPHALT CONC. TYPE SM-12.5A (NEW SECTION)	TON	219	$ 115	$ 25,185
10610	315	ASPHALT CONC. TYPE IM-19.0A (NEW SECTION)	TON	273	$ 115	$ 31,395
16390	315	ASPH. CONC. BASE COURSE TY. BM-25.0A (NEW SECTION)	TON	437	$ 105	$ 45,885
10128	308, 309	AGGR. BASE MATL. TY. I NO. 21B (NEW SECTION)	TON	884	$ 40	$ 35,360
10628	515	FLEXIBLE PAVEMENT PLANNING 0" - 2"	SY	1,290	$ 6	$ 7,740
16350	315	ASPHALT CONC. TYPE SM-12.5A (OVERLAY)	TON	142	$ 100	$ 14,200
24430	508	DEMOLITION OF PAVEMENT (FLEXIBLE)	SY	52	$ 20	$ 1,040
10011	504	7" HYDRAULIC CEMENT STAMPED CONCRETE (TRUCK APRON)	SY	659	$ 155	$ 102,145
		DRAINAGE & BASINS				
NS		DRAINAGE ITEMS	LS	1	$ 300,000	$ 300,000
		EROSION AND SEDIMENT CONTROL				
NS		E&S ITEMS	LS	1	$ 30,000	$ 30,000
		TRAFFIC				
NS		SIGNING & PAVEMENT MARKING	LS	1	$ 30,000	$ 30,000
NS		ROUNDABOUT LIGHTING	LS	1	$ 60,000	$ 60,000
		ROADSIDE DEVELOPMENT				
NS		ROADSIDE DEVELOPMENT ITEMS	LS	1	$ 25,000	$ 25,000
NS		LANDSCAPING	LS	1	$ 60,000	$ 60,000
		MAINTENANCE OF TRAFFIC				
NS	-	MOT	LS	1	$ 250,000	$ 250,000

Estimated Construction Cost		**$ 1,373,391**
CONTINGENCY	**50%**	**$ 686,696**
CEI	**18%**	**$ 341,958**
TOTAL CONSTRUCTION		**$ 2,402,044**
PE & Permitting (25% of Construction Cost excluding CEI)		**$ 515,022**
Preliminary Right of Way and Easements		**$ 1,250,000**
Utility Easements and Relocation Cost		**$ 100,000**
R/W & UTILITIES (2022)		**$ 1,350,000**
Environmental Mitigation (2022)		**$ -**
PROJECT GRAND TOTAL (FY 2022)		**$ 4,267,066**

Appendix E-3B

Alternative 3B: Cost Analysis

Albemarle County
Earlysville Road / Reas Ford Road Roundabout
February 18, 2022
Preliminary Cost Estimate

ITEM CODE	SPEC	ITEM DESCRIPTION	UNITS	QUANTITY	UNIT PRICE	TOTAL PRICE
00100	513	MOBILIZATION	LS	1	$ 66,160	$ 66,160
00101	105	CONSTRUCTION SURVEYING (CONSTRUCTION)	LS	1	$ 7,232	$ 7,232
00110	301	CLEARING AND GRUBBING	ACRE	0.8	$ 15,000	$ 12,000
		EARTHWORK				
00120	303	REGULAR EXCAVATION	CY	1,051	$ 18	$ 18,918
00140	303, 305	BORROW EXCAVATION	CY	597	$ 23	$ 13,731
00128	ATTD	UNSUITABLE EXCAVATION	CY	105	$ 20	$ 2,100
		INCIDENTALS				
12600	502	STD. COMB. CURB & GUTTER CG-6	LF	0	$ 34	$ -
12610	502	RADIAL COMB. CURB & GUTTER CG-6	LF	189	$ 35	$ 6,615
12032	502	RADIAL CURB CG-3	LF	12	$ 32	$ 384
21020	502	MEDIAN STRIP MS-1	SY	32	$ 115	$ 3,680
68576	315, 412	SAW CUT	LF	3,000	$ 10	$ 30,000
		PAVEMENT				
16350	315	ASPHALT CONC. TYPE SM-12.5A (NEW SECTION)	TON	139	$ 115	$ 15,985
10610	315	ASPHALT CONC. TYPE IM-19.0A (NEW SECTION)	TON	173	$ 115	$ 19,895
16390	315	ASPH. CONC. BASE COURSE TY. BM-25.0A (NEW SECTION)	TON	278	$ 105	$ 29,190
10128	308, 309	AGGR. BASE MATL. TY. I NO. 21B (NEW SECTION)	TON	561	$ 40	$ 22,440
10628	515	FLEXIBLE PAVEMENT PLANNING 0" - 2"	SY	927	$ 6	$ 5,562
16350	315	ASPHALT CONC. TYPE SM-12.5A (OVERLAY)	TON	102	$ 100	$ 10,200
24430	508	DEMOLITION OF PAVEMENT (FLEXIBLE)	SY	0	$ 20	$ -
10011	504	7" HYDRAULIC CEMENT STAMPED CONCRETE (TRUCK APRON)	SY	0	$ 155	$ -
		DRAINAGE & BASINS				
NS		DRAINAGE ITEMS	LS	1	$ 150,000	$ 150,000
		EROSION AND SEDIMENT CONTROL				
NS		E&S ITEMS	LS	1	$ 15,000	$ 15,000
		TRAFFIC				
NS		SIGNING & PAVEMENT MARKING	LS	1	$ 45,000	$ 45,000
NS		ROUNDABOUT LIGHTING	LS	1	$ 60,000	$ 60,000
		ROADSIDE DEVELOPMENT				
NS		ROADSIDE DEVELOPMENT ITEMS	LS	1	$ 12,500	$ 12,500
		MAINTENANCE OF TRAFFIC				
NS	-	MOT	LS	1	$ 250,000	$ 250,000

Estimated Construction Cost		**$ 796,592**
CONTINGENCY	**50%**	**$ 398,296**
CEI	**18%**	**$ 196,262**
TOTAL CONSTRUCTION		**$ 1,391,150**
PE & Permitting (25% of Construction Cost excluding CEI)		**$ 298,722**
Preliminary Right of Way and Easements		**$ 640,272**
Utility Easements and Relocation Cost		**$ 100,000**
R/W & UTILITIES (2022)		**$ 740,272**
Environmental Mitigation (2022)		**$ -**
PROJECT GRAND TOTAL (FY 2022)		**$ 2,430,144**

Appendix F

Traffic Analysis

Appendix F-1

2021 Existing Conditions
AM Peak

Intersection	
Int Delay, s/veh	4.4

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		↕			↰	↗		↕			↕	
Traffic Vol, veh/h	14	489	36	36	127	9	29	1	66	47	7	12
Future Vol, veh/h	14	489	36	36	127	9	29	1	66	47	7	12
Conflicting Peds, #/hr	0	0	0	0	0	0	2	0	3	3	0	2
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	100	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	86	86	86	86	86	86	86	86	86	86	86	86
Heavy Vehicles, %	0	1	0	3	3	0	0	0	5	0	0	8
Mvmt Flow	16	569	42	42	148	10	34	1	77	55	8	14

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	158	0	0	611	0	0	872	864	593	896	875	150
Stage 1	-	-	-	-	-	-	622	622	-	232	232	-
Stage 2	-	-	-	-	-	-	250	242	-	664	643	-
Critical Hdwy	4.1	-	-	4.13	-	-	7.1	6.5	6.25	7.1	6.5	6.28
Critical Hdwy Stg 1	-	-	-	-	-	-	6.1	5.5	-	6.1	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.1	5.5	-	6.1	5.5	-
Follow-up Hdwy	2.2	-	-	2.227	-	-	3.5	4	3.345	3.5	4	3.372
Pot Cap-1 Maneuver	1434	-	-	963	-	-	273	294	500	263	290	881
Stage 1	-	-	-	-	-	-	478	482	-	775	716	-
Stage 2	-	-	-	-	-	-	759	709	-	453	472	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	1434	-	-	963	-	-	249	275	499	210	271	879
Mov Cap-2 Maneuver	-	-	-	-	-	-	249	275	-	210	271	-
Stage 1	-	-	-	-	-	-	470	474	-	762	682	-
Stage 2	-	-	-	-	-	-	701	675	-	375	464	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.2	1.9	18.4	25.5
HCM LOS			C	D

Minor Lane/Major Mvmt	NBLn1	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	380	1434	-	-	963	-	-	251
HCM Lane V/C Ratio	0.294	0.011	-	-	0.043	-	-	0.306
HCM Control Delay (s)	18.4	7.5	0	-	8.9	0	-	25.5
HCM Lane LOS	C	A	A	-	A	A	-	D
HCM 95th %tile Q(veh)	1.2	0	-	-	0.1	-	-	1.2

Intersection: 1: Reas Ford Rd/Earlysville Forest Drive & Earlysville Road

Movement	EB	WB	NB	SB
Directions Served	LTR	LT	LTR	LTR
Maximum Queue (ft)	39	47	83	62
Average Queue (ft)	3	10	33	21
95th Queue (ft)	17	31	64	43
Link Distance (ft)	906	1105	1198	748
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				
Storage Blk Time (%)				
Queuing Penalty (veh)				

Network Summary

Network wide Queuing Penalty: 0

Appendix F-2

2021 Existing Conditions
PM Peak

Intersection	
Int Delay, s/veh	3.3

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		⇕			⇃	↱		⇕			⇕	
Traffic Vol, veh/h	13	260	34	58	444	41	33	6	56	25	4	22
Future Vol, veh/h	13	260	34	58	444	41	33	6	56	25	4	22
Conflicting Peds, #/hr	0	0	0	0	0	0	2	0	4	2	0	4
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	100	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	97	97	97	97	97	97	97	97	97	97	97	97
Heavy Vehicles, %	8	1	6	5	1	0	0	0	7	0	0	0
Mvmt Flow	13	268	35	60	458	42	34	6	58	26	4	23

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	500	0	0	303	0	0	929	932	290	926	907	462
Stage 1	-	-	-	-	-	-	312	312	-	578	578	-
Stage 2	-	-	-	-	-	-	617	620	-	348	329	-
Critical Hdwy	4.18	-	-	4.15	-	-	7.1	6.5	6.27	7.1	6.5	6.2
Critical Hdwy Stg 1	-	-	-	-	-	-	6.1	5.5	-	6.1	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.1	5.5	-	6.1	5.5	-
Follow-up Hdwy	2.272	-	-	2.245	-	-	3.5	4	3.363	3.5	4	3.3
Pot Cap-1 Maneuver	1034	-	-	1241	-	-	250	269	737	251	278	604
Stage 1	-	-	-	-	-	-	703	661	-	505	504	-
Stage 2	-	-	-	-	-	-	481	483	-	672	650	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	1034	-	-	1241	-	-	222	247	734	212	255	602
Mov Cap-2 Maneuver	-	-	-	-	-	-	222	247	-	212	255	-
Stage 1	-	-	-	-	-	-	692	651	-	497	470	-
Stage 2	-	-	-	-	-	-	426	451	-	602	640	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.4	0.9	17.7	19.5
HCM LOS			C	C

Minor Lane/Major Mvmt	NBLn1	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	381	1034	-	-	1241	-	-	300
HCM Lane V/C Ratio	0.257	0.013	-	-	0.048	-	-	0.175
HCM Control Delay (s)	17.7	8.5	0	-	8	0	-	19.5
HCM Lane LOS	C	A	A	-	A	A	-	C
HCM 95th %tile Q(veh)	1	0	-	-	0.2	-	-	0.6

Intersection: 1: Reas Ford Rd/Earlysville Forest Drive & Earlysville Road

Movement	EB	WB	NB	SB
Directions Served	LTR	LT	LTR	LTR
Maximum Queue (ft)	57	83	88	42
Average Queue (ft)	5	15	32	18
95th Queue (ft)	31	53	66	37
Link Distance (ft)	906	1105	1198	748
Upstream Blk Time (%)				
Queuing Penalty (veh)				
Storage Bay Dist (ft)				
Storage Blk Time (%)		0		
Queuing Penalty (veh)		0		

Network Summary

Network wide Queuing Penalty: 0

Appendix F-3

Alternative 1: TWSC w/ Turn Lanes
Conditions
AM Peak

Intersection	
Int Delay, s/veh	4.2

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	14	489	36	36	127	9	29	1	66	47	7	12
Future Vol, veh/h	14	489	36	36	127	9	29	1	66	47	7	12
Conflicting Peds, #/hr	0	0	0	0	0	0	2	0	3	3	0	2
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	125	-	-	125	-	-	-	-	125	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	86	86	86	86	86	86	86	86	86	86	86	86
Heavy Vehicles, %	0	1	0	3	3	0	0	0	5	0	0	8
Mvmt Flow	16	569	42	42	148	10	34	1	77	55	8	14

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	158	0	0	611	0	0	872	864	593	901	880	155
Stage 1	-	-	-	-	-	-	622	622	-	237	237	-
Stage 2	-	-	-	-	-	-	250	242	-	664	643	-
Critical Hdwy	4.1	-	-	4.13	-	-	7.1	6.5	6.25	7.1	6.5	6.28
Critical Hdwy Stg 1	-	-	-	-	-	-	6.1	5.5	-	6.1	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.1	5.5	-	6.1	5.5	-
Follow-up Hdwy	2.2	-	-	2.227	-	-	3.5	4	3.345	3.5	4	3.372
Pot Cap-1 Maneuver	1434	-	-	963	-	-	273	294	500	261	288	875
Stage 1	-	-	-	-	-	-	478	482	-	771	713	-
Stage 2	-	-	-	-	-	-	759	709	-	453	472	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	1434	-	-	963	-	-	251	278	499	210	272	873
Mov Cap-2 Maneuver	-	-	-	-	-	-	251	278	-	210	272	-
Stage 1	-	-	-	-	-	-	473	477	-	763	682	-
Stage 2	-	-	-	-	-	-	704	678	-	377	467	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.2	1.9	16	25.5
HCM LOS			C	D

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	252	499	1434	-	-	963	-	-	251
HCM Lane V/C Ratio	0.138	0.154	0.011	-	-	0.043	-	-	0.306
HCM Control Delay (s)	21.6	13.5	7.5	-	-	8.9	-	-	25.5
HCM Lane LOS	C	B	A	-	-	A	-	-	D
HCM 95th %tile Q(veh)	0.5	0.5	0	-	-	0.1	-	-	1.2

Intersection: 1: Reas Ford Rd/Earlysville Forest Drive & Earlysville Road

Movement	EB	EB	WB	WB	NB	NB	SB
Directions Served	L	TR	L	TR	LT	R	LTR
Maximum Queue (ft)	18	9	39	6	54	66	49
Average Queue (ft)	1	0	13	0	16	20	23
95th Queue (ft)	8	5	36	4	38	45	45
Link Distance (ft)		905		1109	1192		755
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (ft)	125		125			125	
Storage Blk Time (%)							
Queuing Penalty (veh)							

Network Summary

Network wide Queuing Penalty: 0

Appendix F-4

Alternative 1: TWSC w/ Turn Lanes
Conditions
PM Peak

Intersection	
Int Delay, s/veh	3.1

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	13	260	34	58	444	41	33	6	56	25	4	22
Future Vol, veh/h	13	260	34	58	444	41	33	6	56	25	4	22
Conflicting Peds, #/hr	0	0	0	0	0	0	2	0	4	2	0	4
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	125	-	-	125	-	-	-	-	125	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	97	97	97	97	97	97	97	97	97	97	97	97
Heavy Vehicles, %	8	1	6	5	1	0	0	0	7	0	0	0
Mvmt Flow	13	268	35	60	458	42	34	6	58	26	4	23

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	500	0	0	303	0	0	929	932	290	947	928	483
Stage 1	-	-	-	-	-	-	312	312	-	599	599	-
Stage 2	-	-	-	-	-	-	617	620	-	348	329	-
Critical Hdwy	4.18	-	-	4.15	-	-	7.1	6.5	6.27	7.1	6.5	6.2
Critical Hdwy Stg 1	-	-	-	-	-	-	6.1	5.5	-	6.1	5.5	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.1	5.5	-	6.1	5.5	-
Follow-up Hdwy	2.272	-	-	2.245	-	-	3.5	4	3.363	3.5	4	3.3
Pot Cap-1 Maneuver	1034	-	-	1241	-	-	250	269	737	243	270	588
Stage 1	-	-	-	-	-	-	703	661	-	492	494	-
Stage 2	-	-	-	-	-	-	481	483	-	672	650	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	1034	-	-	1241	-	-	226	253	734	209	254	586
Mov Cap-2 Maneuver	-	-	-	-	-	-	226	253	-	209	254	-
Stage 1	-	-	-	-	-	-	694	652	-	486	470	-
Stage 2	-	-	-	-	-	-	435	460	-	603	642	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.4	0.9	15.9	19.8
HCM LOS			C	C

Minor Lane/Major Mvmt	NBLn1	NBLn2	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	230	734	1034	-	-	1241	-	-	295
HCM Lane V/C Ratio	0.175	0.079	0.013	-	-	0.048	-	-	0.178
HCM Control Delay (s)	23.9	10.3	8.5	-	-	8	-	-	19.8
HCM Lane LOS	C	B	A	-	-	A	-	-	C
HCM 95th %tile Q(veh)	0.6	0.3	0	-	-	0.2	-	-	0.6

Intersection: 1: Reas Ford Rd/Earlysville Forest Drive & Earlysville Road

Movement	EB	EB	WB	WB	NB	NB	SB
Directions Served	L	TR	L	TR	LT	R	LTR
Maximum Queue (ft)	32	17	44	43	42	53	42
Average Queue (ft)	5	1	13	3	19	19	20
95th Queue (ft)	21	9	38	20	39	44	37
Link Distance (ft)		905		1109	1192		755
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (ft)	125		125			125	
Storage Blk Time (%)							
Queuing Penalty (veh)							

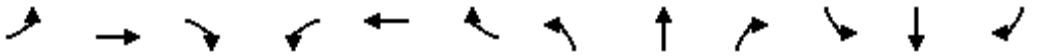
Network Summary

Network wide Queuing Penalty: 0

Appendix F-5

Alternative 2: Traffic Signal Conditions
AM Peak

HCM 6th Signalized Intersection Summary Earlysville Rd with Reas Ford Rd Intersection Study 1: Reas Ford Rd/Earlysville Forest Drive & Earlysville Road



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	14	489	36	36	127	9	29	1	66	47	7	12
Future Volume (veh/h)	14	489	36	36	127	9	29	1	66	47	7	12
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		0.98	1.00		0.98	0.99		0.99	0.99		0.99
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1900	1885	1900	1856	1856	1900	1900	1900	1826	1900	1900	1781
Adj Flow Rate, veh/h	16	569	42	42	148	10	34	1	77	55	8	14
Peak Hour Factor	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Percent Heavy Veh, %	0	1	0	3	3	0	0	0	5	0	0	8
Cap, veh/h	745	765	56	405	804	54	368	8	262	267	38	32
Arrive On Green	0.02	0.44	0.44	0.05	0.47	0.47	0.12	0.12	0.12	0.12	0.12	0.12
Sat Flow, veh/h	1810	1731	128	1767	1716	116	1494	67	1529	869	308	262
Grp Volume(v), veh/h	16	0	611	42	0	158	35	0	77	77	0	0
Grp Sat Flow(s),veh/h/ln	1810	0	1859	1767	0	1832	1561	0	1529	1439	0	0
Q Serve(g_s), s	0.2	0.0	10.6	0.5	0.0	1.9	0.0	0.0	1.7	1.2	0.0	0.0
Cycle Q Clear(g_c), s	0.2	0.0	10.6	0.5	0.0	1.9	0.7	0.0	1.7	1.9	0.0	0.0
Prop In Lane	1.00		0.07	1.00		0.06	0.97		1.00	0.71		0.18
Lane Grp Cap(c), veh/h	745	0	822	405	0	858	376	0	262	337	0	0
V/C Ratio(X)	0.02	0.00	0.74	0.10	0.00	0.18	0.09	0.00	0.29	0.23	0.00	0.00
Avail Cap(c_a), veh/h	942	0	2400	550	0	2366	930	0	863	893	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	5.7	0.0	9.0	6.7	0.0	6.0	15.2	0.0	14.0	15.6	0.0	0.0
Incr Delay (d2), s/veh	0.0	0.0	1.4	0.1	0.0	0.1	0.1	0.0	0.6	0.3	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	3.0	0.1	0.0	0.5	0.2	0.0	0.5	0.5	0.0	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	5.7	0.0	10.3	6.8	0.0	6.1	15.3	0.0	14.6	16.0	0.0	0.0
LnGrp LOS	A	A	B	A	A	A	B	A	B	B	A	A
Approach Vol, veh/h		627			200			112			77	
Approach Delay, s/veh		10.2			6.2			14.8			16.0	
Approach LOS		B			A			B			B	

Timer - Assigned Phs	1	2		4	5	6		8				
Phs Duration (G+Y+Rc), s	6.8	22.1		9.8	5.8	23.1		9.8				
Change Period (Y+Rc), s	5.0	5.0		5.0	5.0	5.0		5.0				
Max Green Setting (Gmax), s	5.0	50.0		20.0	5.0	50.0		20.0				
Max Q Clear Time (g_c+I1), s	2.5	12.6		3.7	2.2	3.9		3.9				
Green Ext Time (p_c), s	0.0	4.5		0.3	0.0	0.9		0.3				

Intersection Summary												
HCM 6th Ctrl Delay			10.4									
HCM 6th LOS			B									

Intersection: 1: Reas Ford Rd/Earlysville Forest Drive & Earlysville Road

Movement	EB	EB	WB	WB	NB	NB	SB
Directions Served	L	TR	L	TR	LT	R	LTR
Maximum Queue (ft)	25	179	54	106	54	68	64
Average Queue (ft)	5	73	16	25	15	20	25
95th Queue (ft)	22	140	40	71	41	49	53
Link Distance (ft)		905		1109	1192		755
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (ft)	125		125			125	
Storage Blk Time (%)		1		0			
Queuing Penalty (veh)		0		0			

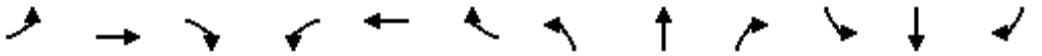
Network Summary

Network wide Queuing Penalty: 0

Appendix F-6

Alternative 2: Traffic Signal Conditions
PM Peak

HCM 6th Signalized Intersection Summary Earlysville Rd with Reas Ford Rd Intersection Study 1: Reas Ford Rd/Earlysville Forest Drive & Earlysville Road



Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Volume (veh/h)	13	260	34	58	444	41	33	6	56	25	4	22
Future Volume (veh/h)	13	260	34	58	444	41	33	6	56	25	4	22
Initial Q (Qb), veh	0	0	0	0	0	0	0	0	0	0	0	0
Ped-Bike Adj(A_pbT)	1.00		1.00	1.00		0.98	0.99		0.99	0.99		0.96
Parking Bus, Adj	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Work Zone On Approach		No			No			No			No	
Adj Sat Flow, veh/h/ln	1781	1885	1811	1826	1885	1900	1900	1900	1796	1900	1900	1900
Adj Flow Rate, veh/h	13	268	35	60	458	42	34	6	58	26	4	23
Peak Hour Factor	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Percent Heavy Veh, %	8	1	6	5	1	0	0	0	7	0	0	0
Cap, veh/h	394	564	74	560	666	61	356	47	293	236	41	86
Arrive On Green	0.02	0.35	0.35	0.06	0.39	0.39	0.13	0.13	0.13	0.13	0.13	0.13
Sat Flow, veh/h	1697	1633	213	1739	1697	156	1167	361	1502	547	315	661
Grp Volume(v), veh/h	13	0	303	60	0	500	40	0	58	53	0	0
Grp Sat Flow(s),veh/h/ln	1697	0	1847	1739	0	1853	1529	0	1502	1523	0	0
Q Serve(g_s), s	0.2	0.0	4.2	0.7	0.0	7.3	0.0	0.0	1.1	0.0	0.0	0.0
Cycle Q Clear(g_c), s	0.2	0.0	4.2	0.7	0.0	7.3	0.6	0.0	1.1	0.9	0.0	0.0
Prop In Lane	1.00		0.12	1.00		0.08	0.85		1.00	0.49		0.43
Lane Grp Cap(c), veh/h	394	0	638	560	0	727	403	0	293	363	0	0
V/C Ratio(X)	0.03	0.00	0.48	0.11	0.00	0.69	0.10	0.00	0.20	0.15	0.00	0.00
Avail Cap(c_a), veh/h	677	0	2663	822	0	2729	1146	0	1066	1113	0	0
HCM Platoon Ratio	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Upstream Filter(I)	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	1.00	1.00	0.00	0.00
Uniform Delay (d), s/veh	7.2	0.0	8.4	6.2	0.0	8.2	12.6	0.0	11.0	12.7	0.0	0.0
Incr Delay (d2), s/veh	0.0	0.0	0.6	0.1	0.0	1.2	0.1	0.0	0.3	0.2	0.0	0.0
Initial Q Delay(d3),s/veh	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
%ile BackOfQ(50%),veh/ln	0.0	0.0	1.1	0.1	0.0	1.9	0.2	0.0	0.3	0.3	0.0	0.0
Unsig. Movement Delay, s/veh												
LnGrp Delay(d),s/veh	7.2	0.0	8.9	6.3	0.0	9.4	12.7	0.0	11.3	12.9	0.0	0.0
LnGrp LOS	A	A	A	A	A	A	B	A	B	B	A	A
Approach Vol, veh/h		316			560			98			53	
Approach Delay, s/veh		8.8			9.1			11.9			12.9	
Approach LOS		A			A			B			B	

Timer - Assigned Phs	1	2		4	5	6		8				
Phs Duration (G+Y+Rc), s	7.1	16.3		9.2	5.6	17.8		9.2				
Change Period (Y+Rc), s	5.0	5.0		5.0	5.0	5.0		5.0				
Max Green Setting (Gmax), s	7.0	47.0		21.0	6.0	48.0		21.0				
Max Q Clear Time (g_c+I1), s	2.7	6.2		3.1	2.2	9.3		2.9				
Green Ext Time (p_c), s	0.0	1.9		0.3	0.0	3.5		0.2				

Intersection Summary			
HCM 6th Ctrl Delay		9.5	
HCM 6th LOS		A	

Intersection: 1: Reas Ford Rd/Earlysville Forest Drive & Earlysville Road

Movement	EB	EB	WB	WB	NB	NB	SB
Directions Served	L	TR	L	TR	LT	R	LTR
Maximum Queue (ft)	37	126	55	162	59	52	39
Average Queue (ft)	7	51	21	64	20	17	17
95th Queue (ft)	27	98	46	129	47	39	36
Link Distance (ft)		905		1109	1192		755
Upstream Blk Time (%)							
Queuing Penalty (veh)							
Storage Bay Dist (ft)	125		125			125	
Storage Blk Time (%)		0		1			
Queuing Penalty (veh)		0		0			

Network Summary

Network wide Queuing Penalty: 0

Appendix F-7

Alternative 3: Roundabout Conditions
AM Peak

LANE SUMMARY

Site: 1 [2021 AM Peak (Site Folder: Earlysville Rd with Reas Ford Rd)]

Proposed Single-Lane Roundabout
Site Category: Proposed Design 1
Roundabout

Lane Use and Performance

	DEMAND FLOWS [Total veh/h	HV] %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh	Dist] ft	Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
South: Reas Ford Road													
Lane 1[d]	112	3.4	729	0.153	100	6.6	LOS A	0.9	24.1	Full	1600	0.0	0.0
Approach	112	3.4		0.153		6.6	LOS A	0.9	24.1				
East: Earlysville Road													
Lane 1[d]	200	2.8	1267	0.158	100	4.2	LOS A	1.0	25.0	Full	1000	0.0	0.0
Approach	200	2.8		0.158		4.2	LOS A	1.0	25.0				
North: Earlysville Forest Drive													
Lane 1[d]	77	1.5	1098	0.070	100	3.9	LOS A	0.4	9.3	Full	1600	0.0	0.0
Approach	77	1.5		0.070		3.9	LOS A	0.4	9.3				
West: Earlysville Road													
Lane 1[d]	627	0.9	1230	0.509	100	8.5	LOS A	4.4	109.7	Full	1600	0.0	0.0
Approach	627	0.9		0.509		8.5	LOS A	4.4	109.7				
Intersection	1015	1.6		0.509		7.1	LOS A	4.4	109.7				

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).
Roundabout Capacity Model: SIDRA Standard.
Delay Model: HCM Delay Formula (Geometric Delay is not included).
Queue Model: HCM Queue Formula.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

Approach Lane Flows (veh/h)

South: Reas Ford Road

Mov. From S To Exit:	L2 W	T1 N	R2 E	Total	%HV	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Prob. SL Ov. %	Ov. Lane No.
Lane 1	34	1	77	112	3.4	729	0.153	100	NA	NA
Approach	34	1	77	112	3.4		0.153			

East: Earlysville Road

Mov. From E To Exit:	L2 S	T1 W	R2 N	Total	%HV	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Prob. SL Ov. %	Ov. Lane No.
Lane 1	42	148	10	200	2.8	1267	0.158	100	NA	NA

Approach	42	148	10	200	2.8		0.158			
North: Earlysville Forest Drive										
Mov. From N To Exit:	L2 E	T1 S	R2 W	Total	%HV	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Prob. SL Ov. %	Ov. Lane No.
Lane 1	55	8	14	77	1.5	1098	0.070	100	NA	NA
Approach	55	8	14	77	1.5		0.070			
West: Earlysville Road										
Mov. From W To Exit:	L2 N	T1 E	R2 S	Total	%HV	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Prob. SL Ov. %	Ov. Lane No.
Lane 1	16	569	42	627	0.9	1230	0.509	100	NA	NA
Approach	16	569	42	627	0.9		0.509			
	Total	%HV	Deg.Satn (v/c)							
Intersection	1015	1.6		0.509						

Lane flow rates given in this report are based on the arrival flow rates subject to upstream capacity constraint where applicable.

Merge Analysis

	Exit Lane Number	Short Lane Length ft	Percent Opng in Lane %	Opposing Flow Rate veh/h	Opposing Flow Rate pcu/h	Critical Gap sec	Follow-up Headway sec	Lane Flow Rate veh/h	Capacity veh/h	Deg. Satn v/c	Min. Delay sec	Merge Delay sec
South Exit: Reas Ford Road Merge Type: **Not Applied**												
Full Length Lane	1	Merge Analysis not applied.										
East Exit: Earlysville Road Merge Type: **Not Applied**												
Full Length Lane	1	Merge Analysis not applied.										
North Exit: Earlysville Forest Drive Merge Type: **Not Applied**												
Full Length Lane	1	Merge Analysis not applied.										
West Exit: Earlysville Road Merge Type: **Not Applied**												
Full Length Lane	1	Merge Analysis not applied.										

Appendix F-8

Alternative 3: Roundabout Conditions PM Peak

LANE SUMMARY

Site: 1 [2021 PM Peak (Site Folder: Earlysville Rd with Reas Ford Rd)]

Proposed Single-Lane Roundabout
Site Category: Proposed Design 1
Roundabout

Lane Use and Performance

	DEMAND FLOWS [Total veh/h	HV] %	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Aver. Delay sec	Level of Service	95% BACK OF QUEUE [Veh	Dist] ft	Lane Config	Lane Length ft	Cap. Adj. %	Prob. Block. %
South: Reas Ford Road													
Lane 1[d]	98	4.1	987	0.099	100	4.6	LOS A	0.5	14.1	Full	1600	0.0	0.0
Approach	98	4.1		0.099		4.6	LOS A	0.5	14.1				
East: Earlysville Road													
Lane 1[d]	560	1.4	1285	0.436	100	7.1	LOS A	3.6	91.1	Full	1000	0.0	0.0
Approach	560	1.4		0.436		7.1	LOS A	3.6	91.1				
North: Earlysville Forest Drive													
Lane 1[d]	53	0.0	848	0.062	100	4.9	LOS A	0.4	8.8	Full	1600	0.0	0.0
Approach	53	0.0		0.062		4.9	LOS A	0.4	8.8				
West: Earlysville Road													
Lane 1[d]	316	1.9	1235	0.256	100	5.2	LOS A	1.6	40.9	Full	1600	0.0	0.0
Approach	316	1.9		0.256		5.2	LOS A	1.6	40.9				
Intersection	1027	1.7		0.436		6.2	LOS A	3.6	91.1				

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Lane LOS values are based on average delay and v/c ratio (degree of saturation) per lane.
LOS F will result if v/c > 1 irrespective of lane delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all lanes (v/c not used as specified in HCM 6).
Roundabout Capacity Model: SIDRA Standard.
Delay Model: HCM Delay Formula (Geometric Delay is not included).
Queue Model: HCM Queue Formula.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

d Dominant lane on roundabout approach

Approach Lane Flows (veh/h)

South: Reas Ford Road

Mov. From S To Exit:	L2 W	T1 N	R2 E	Total	%HV	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Prob. SL Ov. %	Ov. Lane No.
Lane 1	34	6	58	98	4.1	987	0.099	100	NA	NA
Approach	34	6	58	98	4.1		0.099			

East: Earlysville Road

Mov. From E To Exit:	L2 S	T1 W	R2 N	Total	%HV	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Prob. SL Ov. %	Ov. Lane No.
Lane 1	60	458	42	560	1.4	1285	0.436	100	NA	NA

Approach	60	458	42	560	1.4		0.436			
North: Earlysville Forest Drive										
Mov. From N To Exit:	L2 E	T1 S	R2 W	Total	%HV	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Prob. SL Ov. %	Ov. Lane No.
Lane 1	26	4	23	53	0.0	848	0.062	100	NA	NA
Approach	26	4	23	53	0.0		0.062			
West: Earlysville Road										
Mov. From W To Exit:	L2 N	T1 E	R2 S	Total	%HV	Cap. veh/h	Deg. Satn v/c	Lane Util. %	Prob. SL Ov. %	Ov. Lane No.
Lane 1	13	268	35	316	1.9	1235	0.256	100	NA	NA
Approach	13	268	35	316	1.9		0.256			
	Total	%HV	Deg.Satn (v/c)							
Intersection	1027	1.7		0.436						

Lane flow rates given in this report are based on the arrival flow rates subject to upstream capacity constraint where applicable.

Merge Analysis

	Exit Lane Number	Short Lane Length ft	Percent Opng in Lane %	Opposing Flow Rate veh/h	Opposing Flow Rate pcu/h	Critical Gap sec	Follow-up Headway sec	Lane Flow Rate veh/h	Capacity veh/h	Deg. Satn v/c	Min. Delay sec	Merge Delay sec
South Exit: Reas Ford Road Merge Type: **Not Applied**												
Full Length Lane	1	Merge Analysis not applied.										
East Exit: Earlysville Road Merge Type: **Not Applied**												
Full Length Lane	1	Merge Analysis not applied.										
North Exit: Earlysville Forest Drive Merge Type: **Not Applied**												
Full Length Lane	1	Merge Analysis not applied.										
West Exit: Earlysville Road Merge Type: **Not Applied**												
Full Length Lane	1	Merge Analysis not applied.										

Appendix F-9

Alternative 4: AWSC Conditions
AM Peak

Intersection	
Intersection Delay, s/veh	22
Intersection LOS	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	14	489	36	36	127	9	29	1	66	47	7	12
Future Vol, veh/h	14	489	36	36	127	9	29	1	66	47	7	12
Peak Hour Factor	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86	0.86
Heavy Vehicles, %	0	1	0	3	3	0	0	0	5	0	0	8
Mvmt Flow	16	569	42	42	148	10	34	1	77	55	8	14
Number of Lanes	0	1	0	0	1	1	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	2	1
HCM Control Delay	29	11.1	10.1	10.3
HCM LOS	D	B	B	B

Lane	NBLn1	EBLn1	WBLn1	WBLn2	SBLn1
Vol Left, %	30%	3%	22%	0%	71%
Vol Thru, %	1%	91%	78%	0%	11%
Vol Right, %	69%	7%	0%	100%	18%
Sign Control	Stop	Stop	Stop	Stop	Stop
Traffic Vol by Lane	96	539	163	9	66
LT Vol	29	14	36	0	47
Through Vol	1	489	127	0	7
RT Vol	66	36	0	9	12
Lane Flow Rate	112	627	190	10	77
Geometry Grp	2	5	7	7	2
Degree of Util (X)	0.18	0.85	0.31	0.015	0.133
Departure Headway (Hd)	5.793	4.882	5.886	5.064	6.258
Convergence, Y/N	Yes	Yes	Yes	Yes	Yes
Cap	617	746	610	706	571
Service Time	3.846	2.882	3.621	2.799	4.316
HCM Lane V/C Ratio	0.182	0.84	0.311	0.014	0.135
HCM Control Delay	10.1	29	11.3	7.9	10.3
HCM Lane LOS	B	D	B	A	B
HCM 95th-tile Q	0.7	9.9	1.3	0	0.5

Intersection: 1: Reas Ford Rd/Earlysville Forest Drive & Earlysville Road

Movement	EB	WB	WB	NB	SB
Directions Served	LTR	LT	R	LTR	LTR
Maximum Queue (ft)	190	74	28	60	46
Average Queue (ft)	94	33	8	28	18
95th Queue (ft)	163	58	27	50	35
Link Distance (ft)	906	1105		1198	748
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (ft)			100		
Storage Blk Time (%)		0			
Queuing Penalty (veh)		0			

Network Summary

Network wide Queuing Penalty: 0

Appendix F-10

Alternative 4: AWSC Conditions
PM Peak

Intersection	
Intersection Delay, s/veh	18.5
Intersection LOS	C

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations												
Traffic Vol, veh/h	13	260	34	58	444	41	33	6	56	25	4	22
Future Vol, veh/h	13	260	34	58	444	41	33	6	56	25	4	22
Peak Hour Factor	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
Heavy Vehicles, %	8	1	6	5	1	0	0	0	7	0	0	0
Mvmt Flow	13	268	35	60	458	42	34	6	58	26	4	23
Number of Lanes	0	1	0	0	1	1	0	1	0	0	1	0

Approach	EB	WB	NB	SB
Opposing Approach	WB	EB	SB	NB
Opposing Lanes	2	1	1	1
Conflicting Approach Left	SB	NB	EB	WB
Conflicting Lanes Left	1	1	1	2
Conflicting Approach Right	NB	SB	WB	EB
Conflicting Lanes Right	1	1	2	1
HCM Control Delay	12.9	23.9	10.1	9.8
HCM LOS	B	C	B	A

Lane	NBLn1	EBLn1	WBLn1	WBLn2	SBLn1
Vol Left, %	35%	4%	12%	0%	49%
Vol Thru, %	6%	85%	88%	0%	8%
Vol Right, %	59%	11%	0%	100%	43%
Sign Control	Stop	Stop	Stop	Stop	Stop
Traffic Vol by Lane	95	307	502	41	51
LT Vol	33	13	58	0	25
Through Vol	6	260	444	0	4
RT Vol	56	34	0	41	22
Lane Flow Rate	98	316	518	42	53
Geometry Grp	2	5	7	7	2
Degree of Util (X)	0.161	0.465	0.786	0.054	0.09
Departure Headway (Hd)	5.929	5.292	5.466	4.633	6.174
Convergence, Y/N	Yes	Yes	Yes	Yes	Yes
Cap	604	680	668	778	579
Service Time	3.973	3.32	3.166	2.333	4.223
HCM Lane V/C Ratio	0.162	0.465	0.775	0.054	0.092
HCM Control Delay	10.1	12.9	25.2	7.6	9.8
HCM Lane LOS	B	B	D	A	A
HCM 95th-tile Q	0.6	2.5	7.7	0.2	0.3

Intersection: 1: Reas Ford Rd/Earlysville Forest Drive & Earlysville Road

Movement	EB	WB	WB	NB	SB
Directions Served	LTR	LT	R	LTR	LTR
Maximum Queue (ft)	92	172	77	60	33
Average Queue (ft)	53	72	22	27	15
95th Queue (ft)	77	129	57	49	28
Link Distance (ft)	906	1105		1198	748
Upstream Blk Time (%)					
Queuing Penalty (veh)					
Storage Bay Dist (ft)			100		
Storage Blk Time (%)		3			
Queuing Penalty (veh)		1			

Network Summary

Network wide Queuing Penalty: 1

Appendix G

Auxiliary Lane Analysis

Appendix G-1

Earlysville Road Northbound
2021 Existing Conditions

Earlysville Road Northbound - 2021 AM Peak

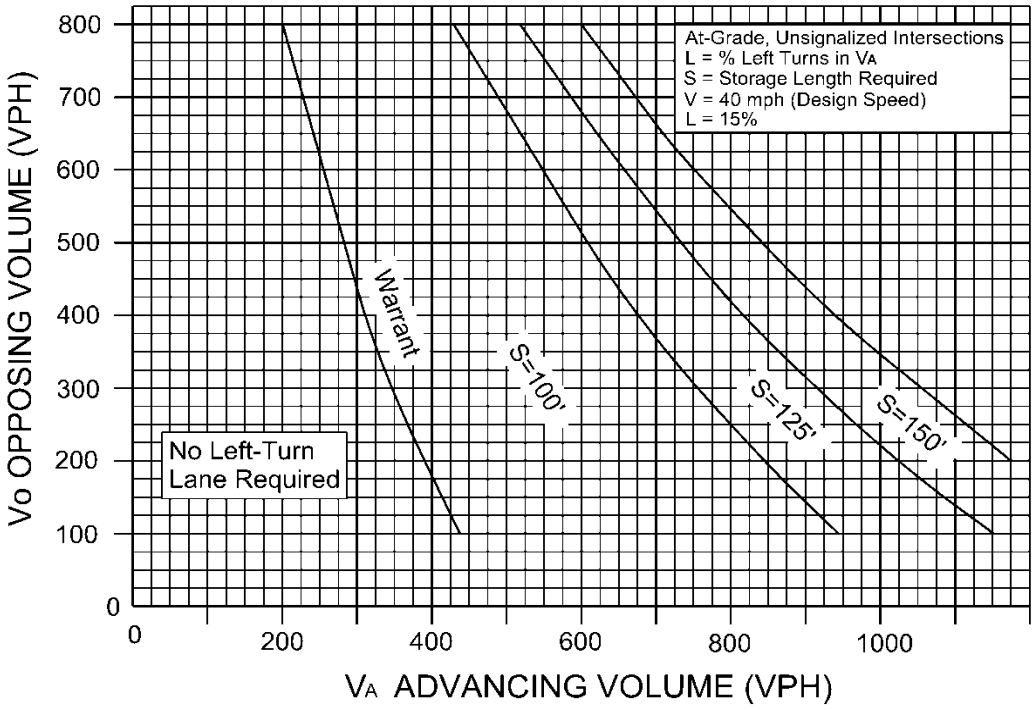
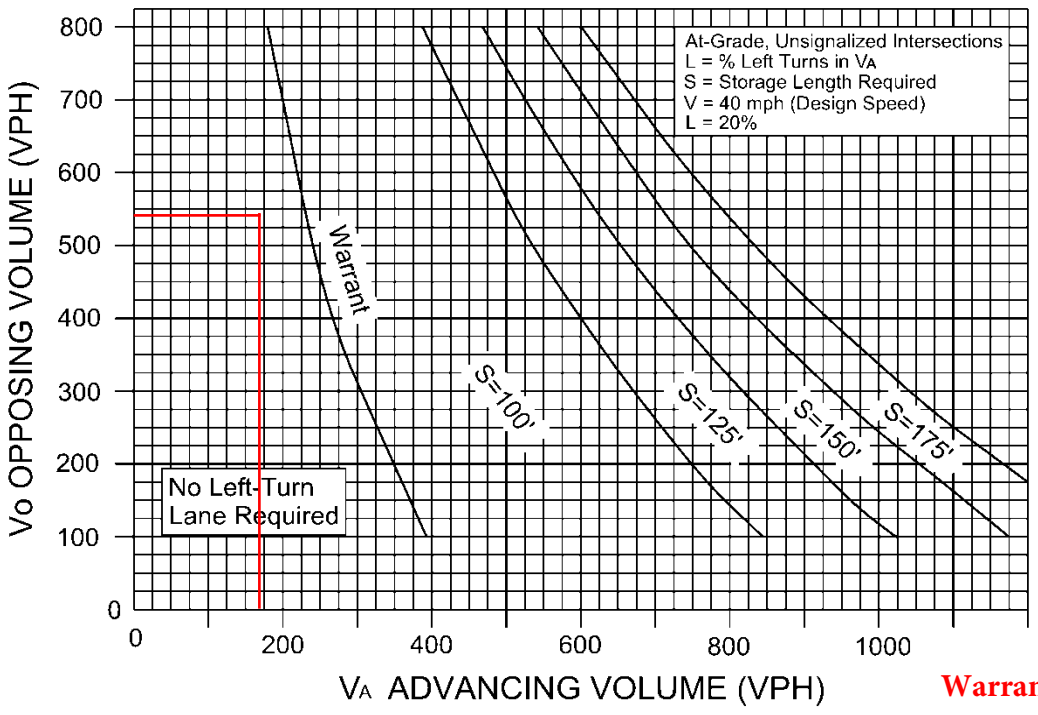


FIGURE 3-6 WARRANT FOR LEFT TURN STORAGE LANES ON TWO LANE HIGHWAY



Adv Vol = 172
LT % = 20.0%
Opp Vol = 539

Warrant NOT MET

FIGURE 3-7 WARRANT FOR LEFT TURN STORAGE LANES ON TWO LANE HIGHWAY

Earlysville Road Northbound - 2021 AM Peak

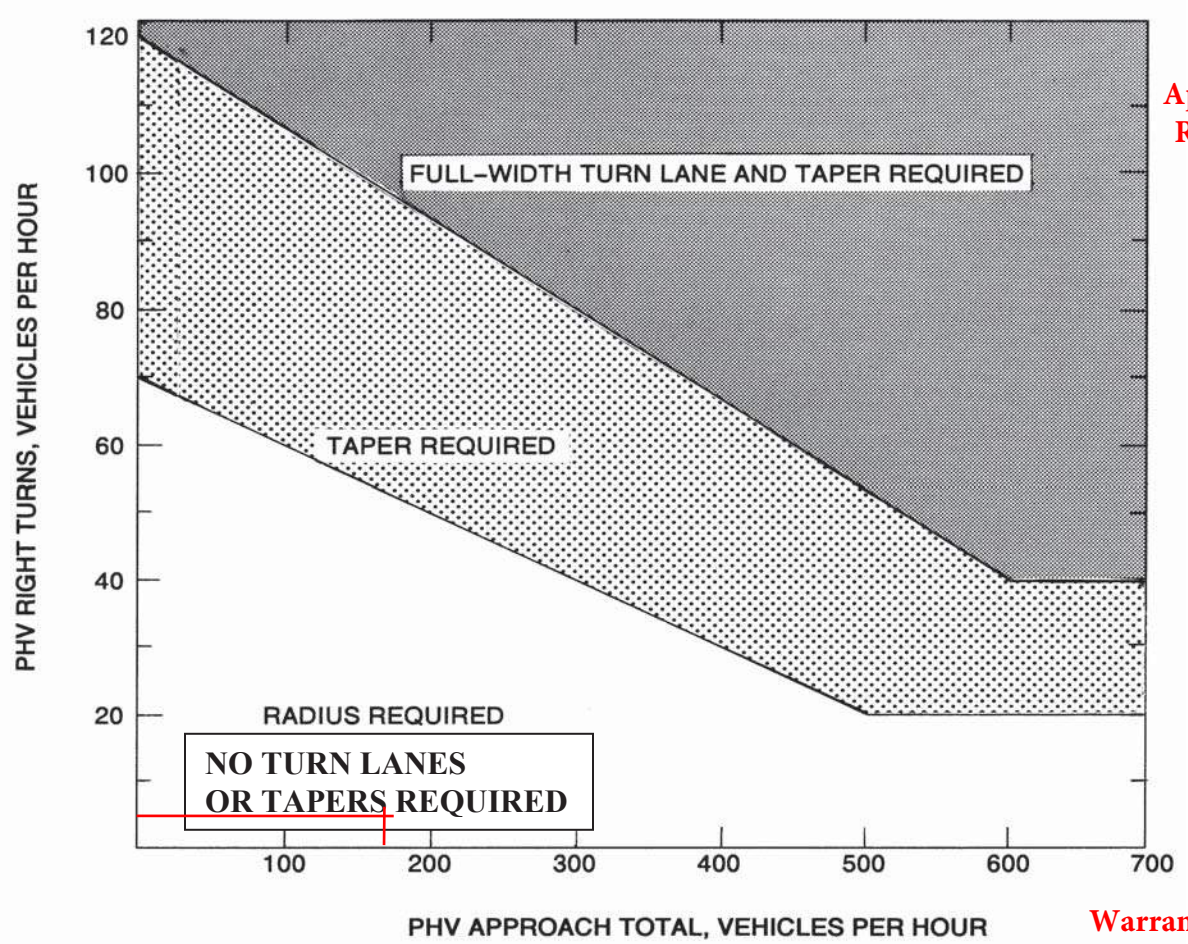


FIGURE 3-26 WARRANTS FOR RIGHT TURN TREATMENT (2-LANE HIGHWAY)

Appropriate Radius required at all Intersections and Entrances (Commercial or Private).

LEGEND

PHV - Peak Hour Volume (also Design Hourly Volume equivalent)

Adjustment for Right Turns

For posted speeds at or under 45 mph, PHV right turns > 40, and PHV total < 300.
Adjusted right turns = PHV Right Turns - 20
If PHV is not known use formula: PHV = ADT x K x D

K = the percent of AADT occurring in the peak hour
D = the percent of traffic in the peak direction of flow

Note: An average of 11% for K x D will suffice.

When right turn facilities are warranted, see Figure 3-1 for design criteria.*

* Rev. 1/15

Earlysville Road Northbound - 2021 PM Peak

WARRANT FOR LEFT-TURN STORAGE LANES ON TWO-LANE HIGHWAY

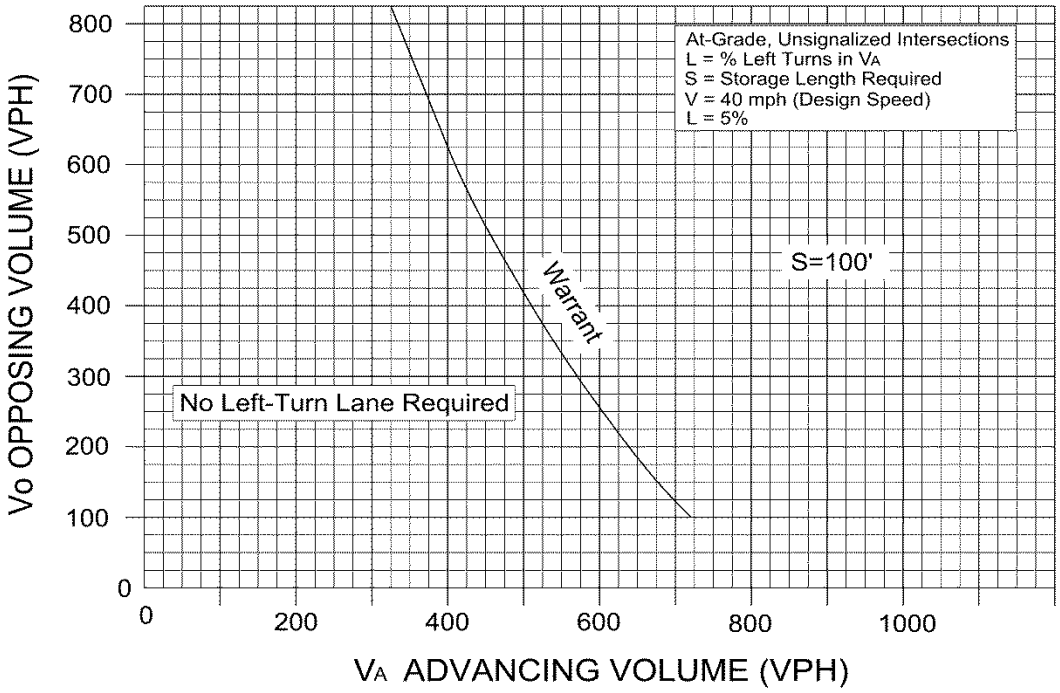
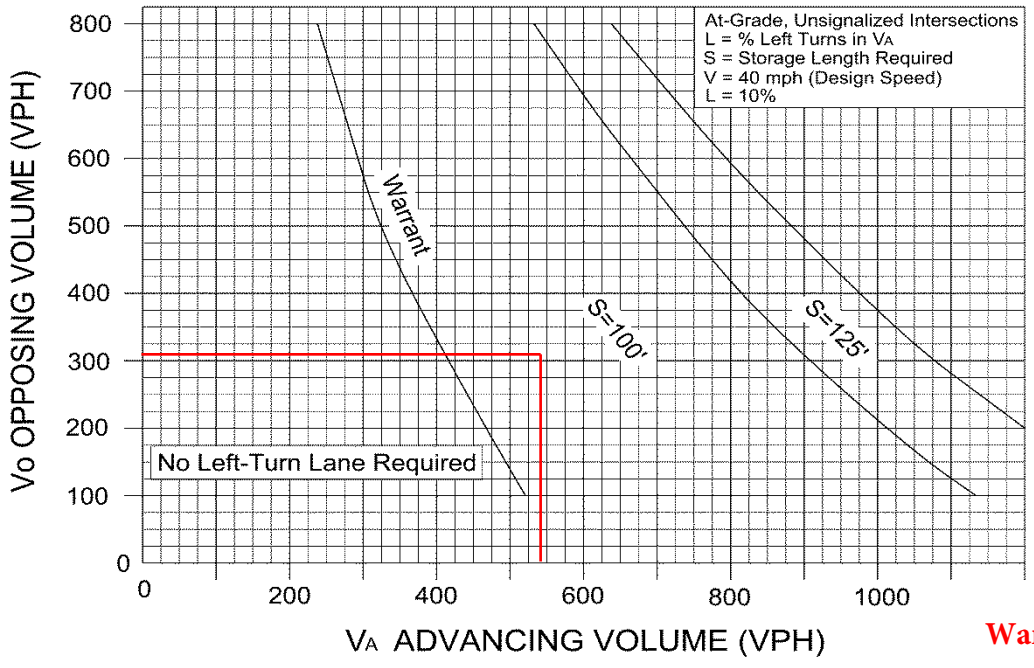


FIGURE 3-4 WARRANT FOR LEFT TURN STORAGE LANES ON TWO LANE HIGHWAY



Adv Vol = 543
LT % = 10.0%
Opp Vol = 307

Warrant MET

FIGURE 3-5 WARRANT FOR LEFT TURN STORAGE LANES ON TWO LANE HIGHWAY

Earlysville Road Northbound - 2021 PM Peak

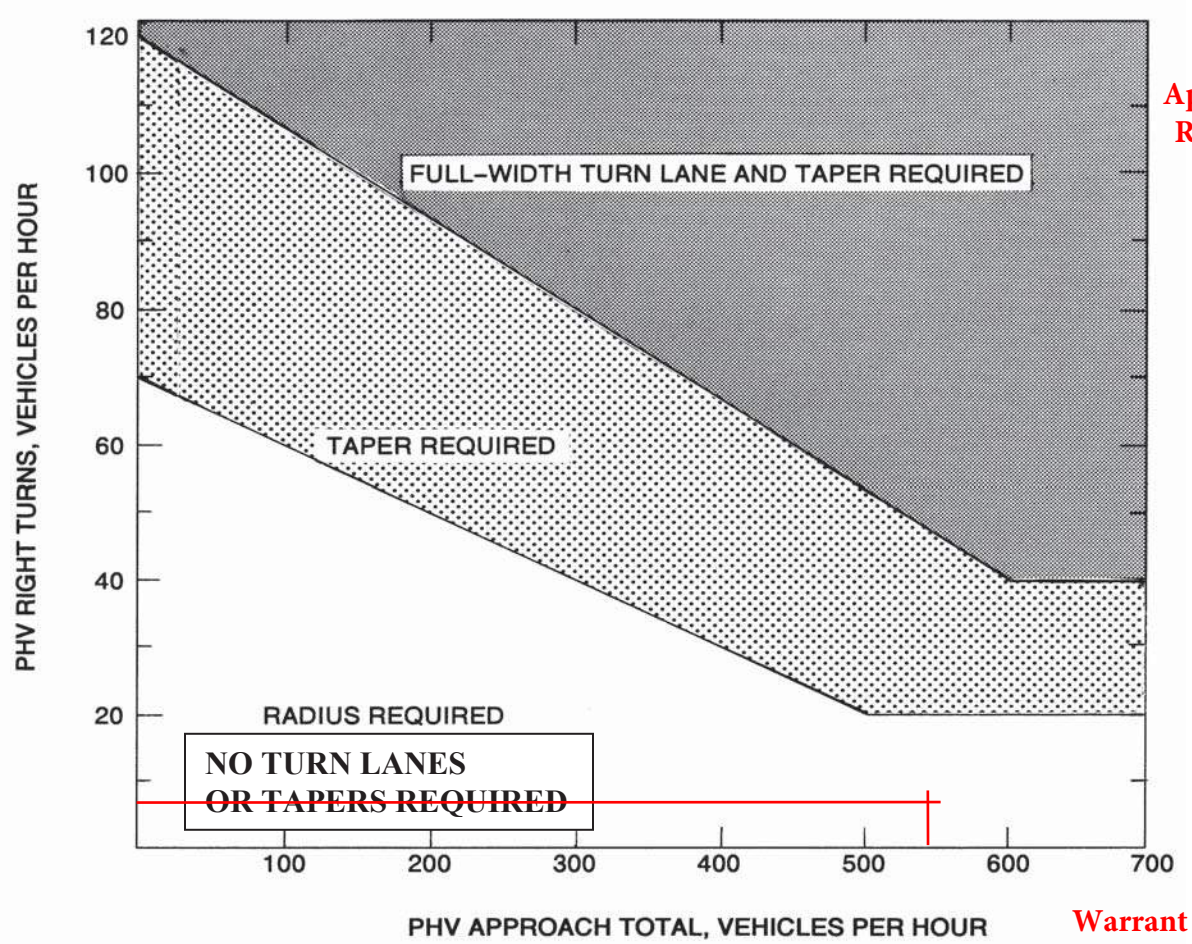


FIGURE 3-26 WARRANTS FOR RIGHT TURN TREATMENT (2-LANE HIGHWAY)

Appropriate Radius required at all Intersections and Entrances (Commercial or Private).

LEGEND

PHV - Peak Hour Volume (also Design Hourly Volume equivalent)

Adjustment for Right Turns

For posted speeds at or under 45 mph, PHV right turns > 40, and
PHV total < 300.
Adjusted right turns = PHV Right Turns - 20
If PHV is not known use formula: PHV = ADT x K x D

K = the percent of AADT occurring in the peak hour
D = the percent of traffic in the peak direction of flow

Note: An average of 11% for K x D will suffice.

When right turn facilities are warranted, see Figure 3-1 for design criteria.*

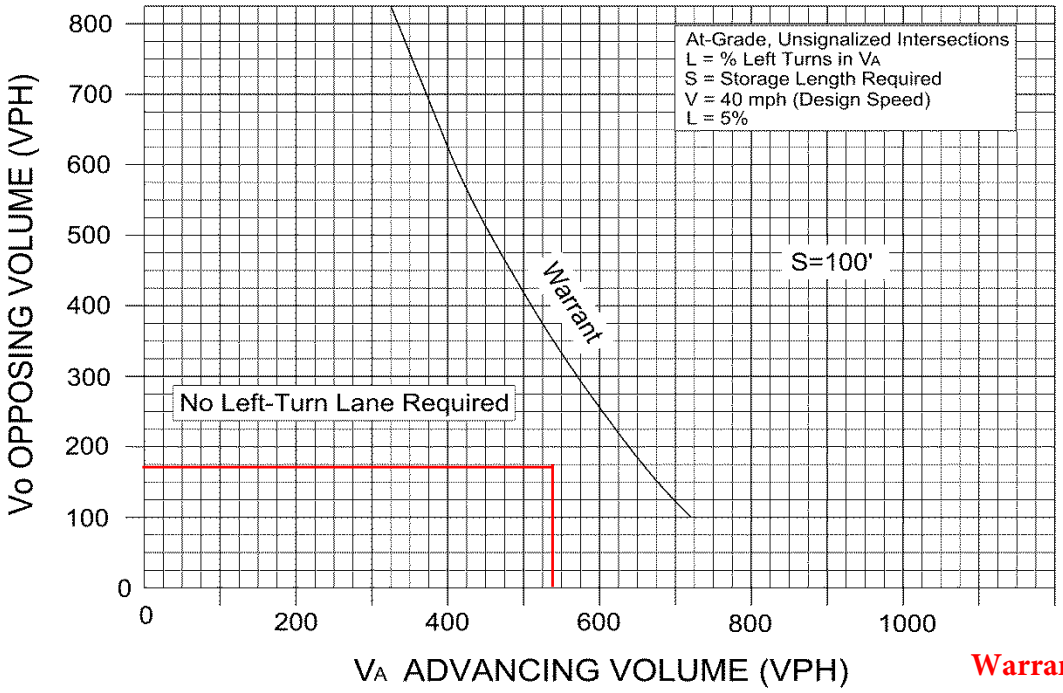
* Rev. 1/15

Appendix G-2

Earlysville Road Southbound
2021 Existing Conditions

Earlysville Road Southbound - 2021 AM Peak

WARRANT FOR LEFT-TURN STORAGE LANES ON TWO-LANE HIGHWAY



Adv Vol = 539
LT % = 2.5%
Opp Vol = 172

Warrant NOT MET

FIGURE 3-4 WARRANT FOR LEFT TURN STORAGE LANES ON TWO LANE HIGHWAY

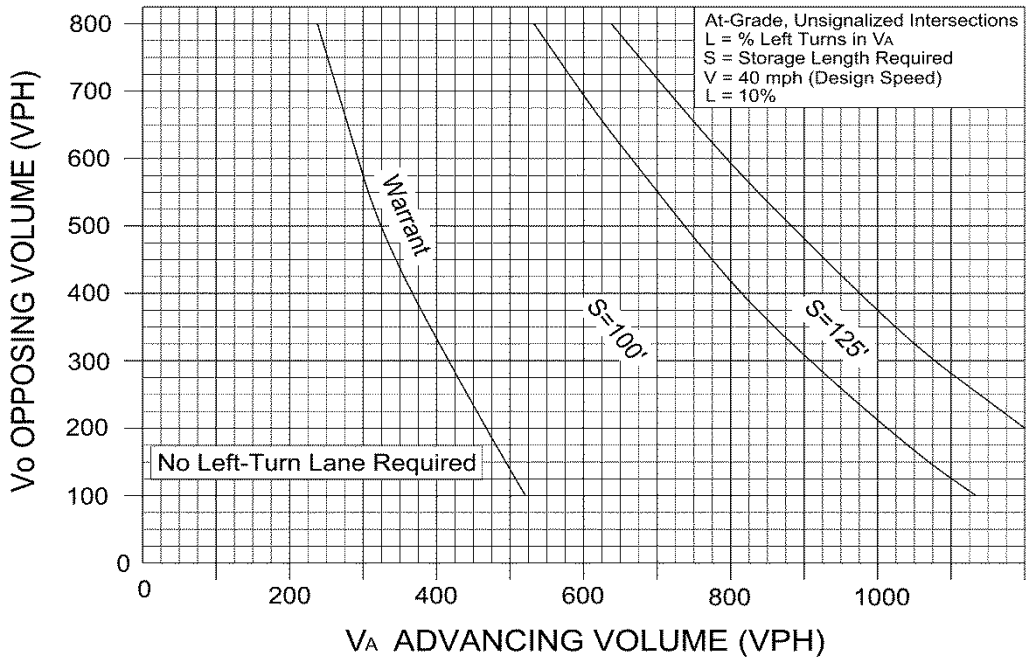
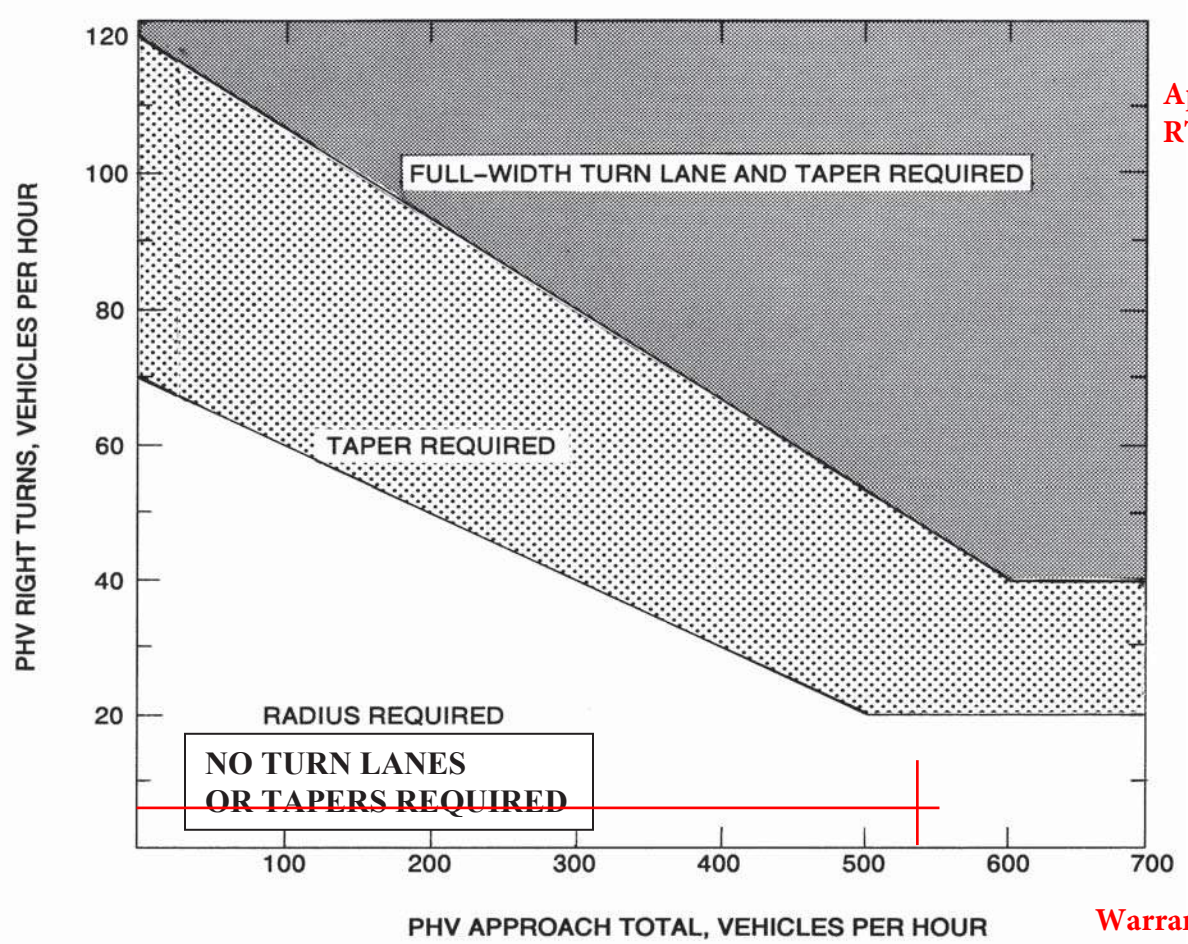


FIGURE 3-5 WARRANT FOR LEFT TURN STORAGE LANES ON TWO LANE HIGHWAY

Earlysville Road Southbound - 2021 AM Peak



App Vol = 539
RT % = 6.7%

Warrant NOT MET

FIGURE 3-26 WARRANTS FOR RIGHT TURN TREATMENT (2-LANE HIGHWAY)

Appropriate Radius required at all Intersections and Entrances (Commercial or Private).

LEGEND

PHV - Peak Hour Volume (also Design Hourly Volume equivalent)

Adjustment for Right Turns

For posted speeds at or under 45 mph, PHV right turns > 40, and PHV total < 300.
Adjusted right turns = PHV Right Turns - 20
If PHV is not known use formula: PHV = ADT x K x D

K = the percent of AADT occurring in the peak hour
D = the percent of traffic in the peak direction of flow

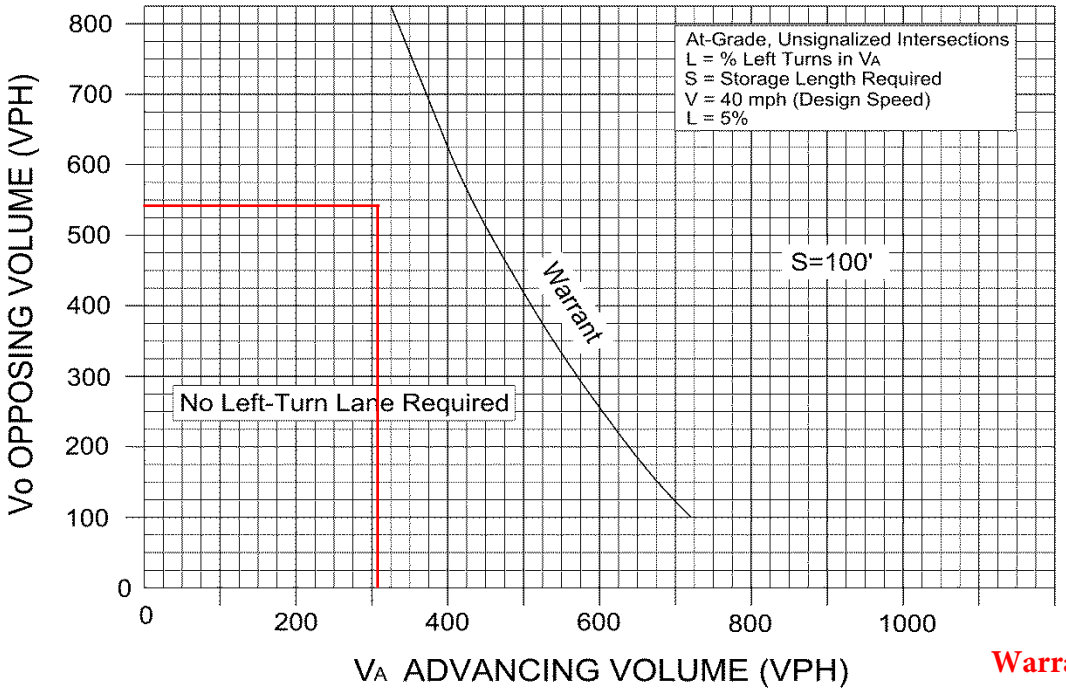
Note: An average of 11% for K x D will suffice.

When right turn facilities are warranted, see Figure 3-1 for design criteria.*

* Rev. 1/15

Earlysville Road Southbound - 2021 PM Peak

WARRANT FOR LEFT-TURN STORAGE LANES ON TWO-LANE HIGHWAY



Adv Vol = 307
LT % = 4.0%
Opp Vol = 543

Warrant NOT MET

FIGURE 3-4 WARRANT FOR LEFT TURN STORAGE LANES ON TWO LANE HIGHWAY

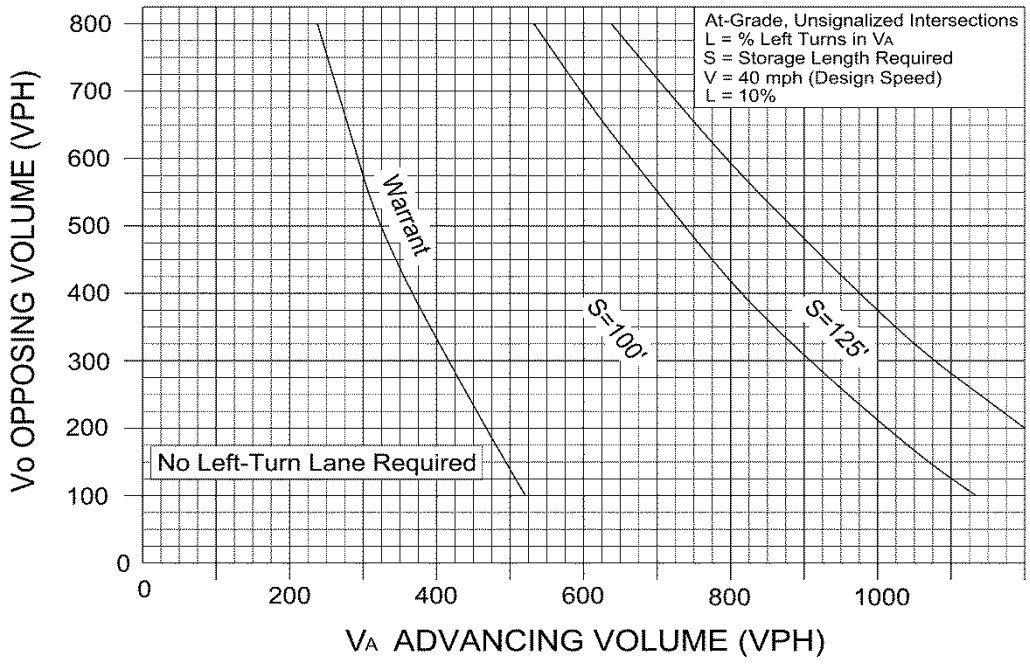
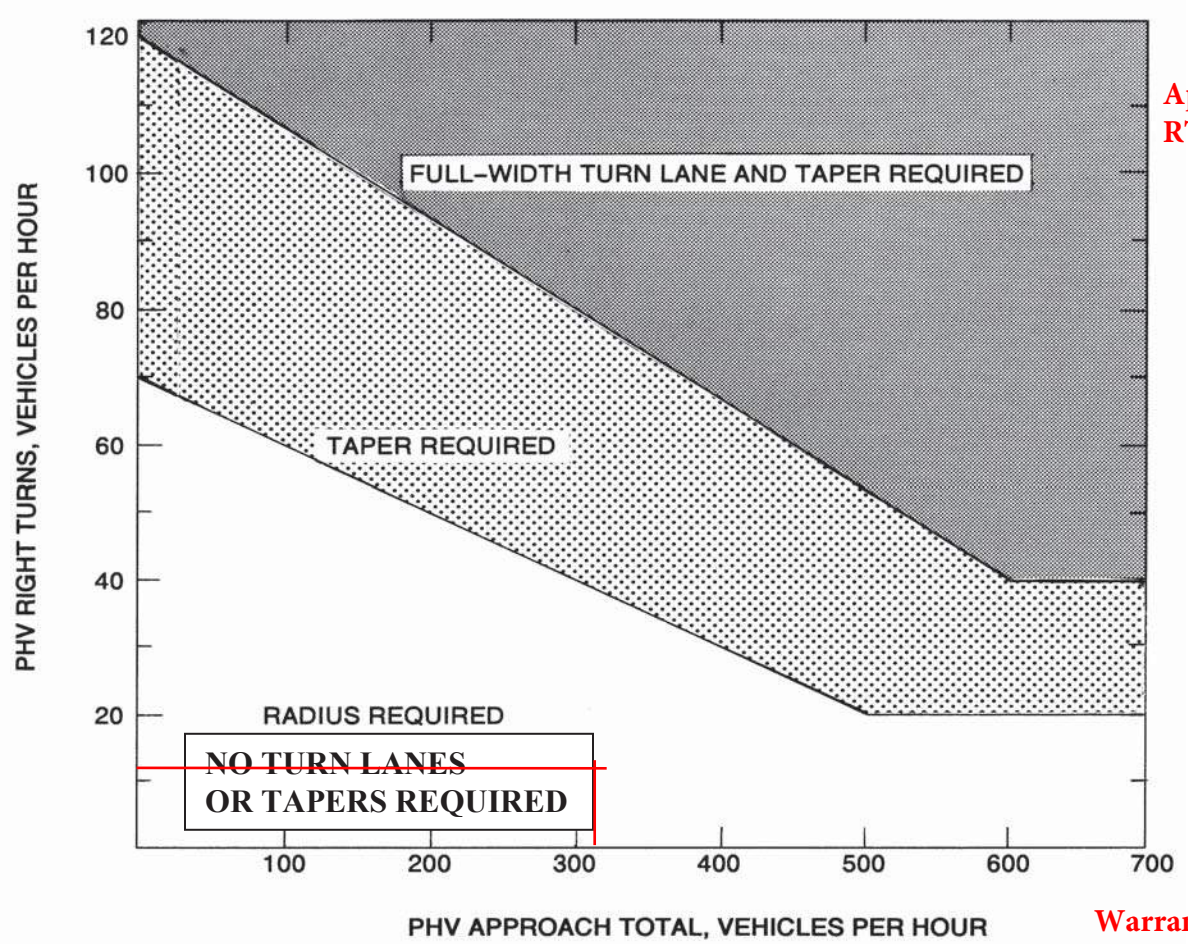


FIGURE 3-5 WARRANT FOR LEFT TURN STORAGE LANES ON TWO LANE HIGHWAY

Earlysville Road Southbound - 2021 PM Peak



App Vol = 307
RT % = 11.1%

Warrant NOT MET

FIGURE 3-26 WARRANTS FOR RIGHT TURN TREATMENT (2-LANE HIGHWAY)

Appropriate Radius required at all Intersections and Entrances (Commercial or Private).

LEGEND

PHV - Peak Hour Volume (also Design Hourly Volume equivalent)

Adjustment for Right Turns

For posted speeds at or under 45 mph, PHV right turns > 40, and
PHV total < 300.
Adjusted right turns = PHV Right Turns - 20
If PHV is not known use formula: PHV = ADT x K x D

K = the percent of AADT occurring in the peak hour
D = the percent of traffic in the peak direction of flow

Note: An average of 11% for K x D will suffice.

When right turn facilities are warranted, see Figure 3-1 for design criteria.*

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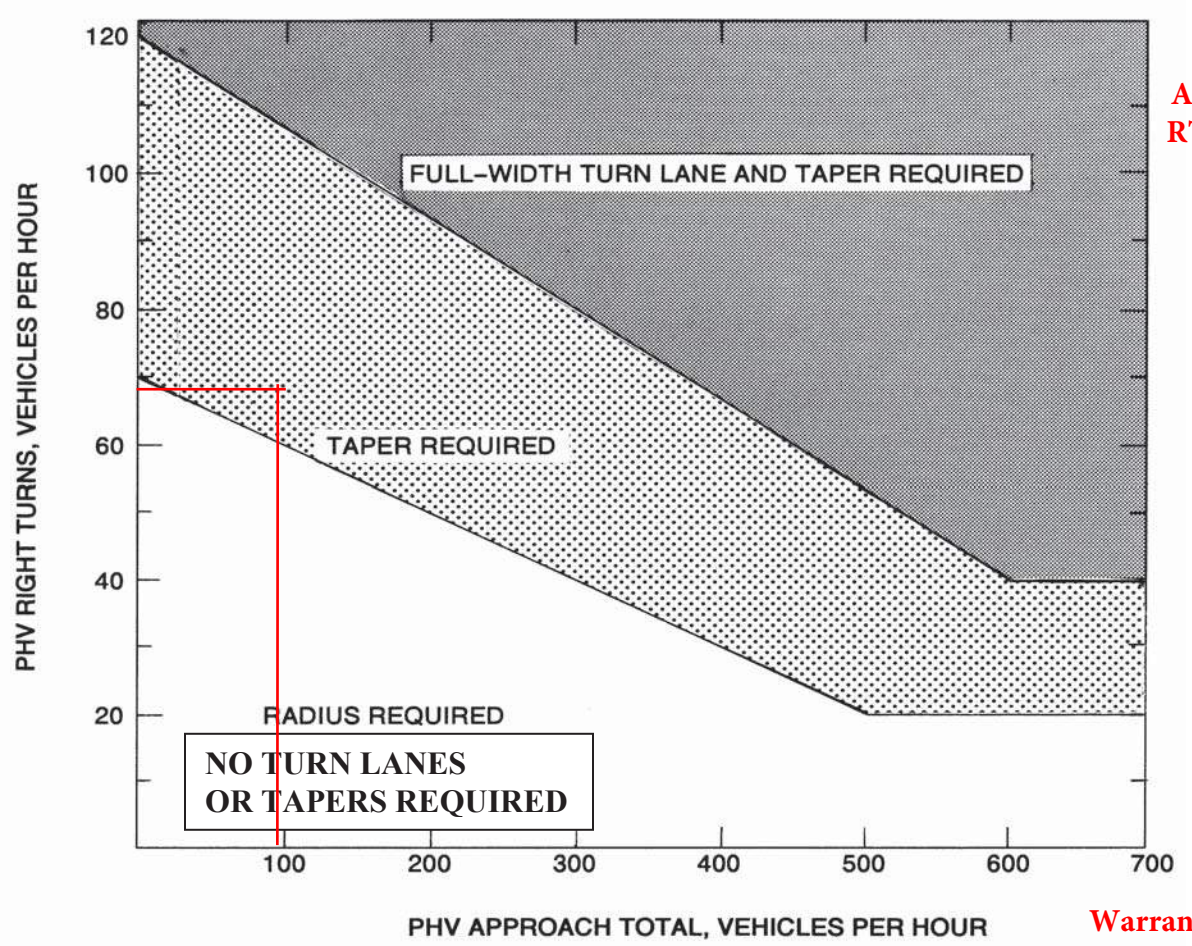
Appendix G-3

Reas Ford Road Eastbound
2021 Existing Conditions

Reas Ford Road Eastbound - 2021 AM Peak



App Vol = 96
RT % = 68.8%

Warrant MET

FIGURE 3-26 WARRANTS FOR RIGHT TURN TREATMENT (2-LANE HIGHWAY)

Appropriate Radius required at all Intersections and Entrances (Commercial or Private).

LEGEND

PHV - Peak Hour Volume (also Design Hourly Volume equivalent)

Adjustment for Right Turns

For posted speeds at or under 45 mph, PHV right turns > 40, and
PHV total < 300.
Adjusted right turns = PHV Right Turns - 20
If PHV is not known use formula: PHV = ADT x K x D

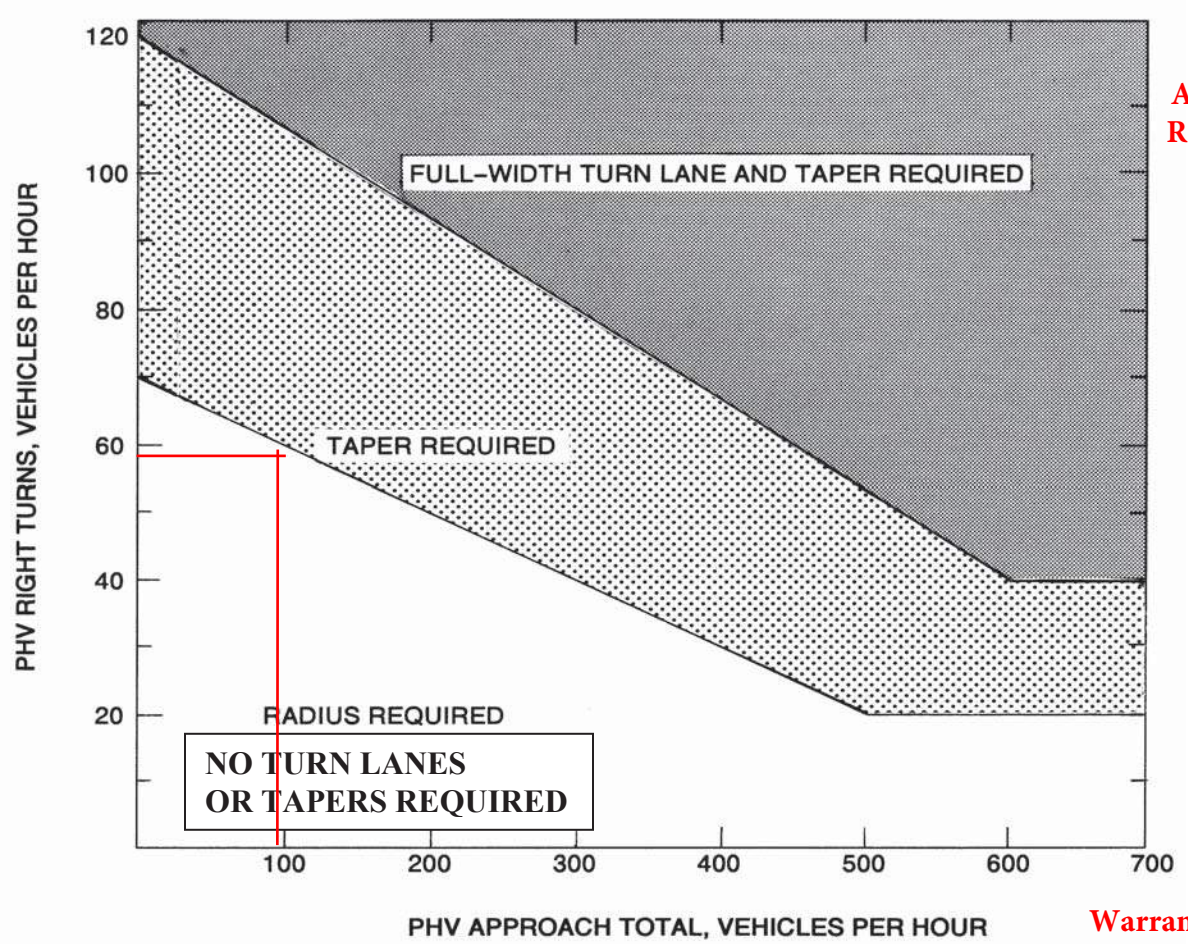
K = the percent of AADT occurring in the peak hour
D = the percent of traffic in the peak direction of flow

Note: An average of 11% for K x D will suffice.

When right turn facilities are warranted, see Figure 3-1 for design criteria.*

* Rev. 1/15

Reas Ford Road Eastbound - 2021 PM Peak



App Vol = 95
RT % = 58.9%

Warrant NOT MET

FIGURE 3-26 WARRANTS FOR RIGHT TURN TREATMENT (2-LANE HIGHWAY)

Appropriate Radius required at all Intersections and Entrances (Commercial or Private).

LEGEND

PHV - Peak Hour Volume (also Design Hourly Volume equivalent)

Adjustment for Right Turns

For posted speeds at or under 45 mph, PHV right turns > 40, and
PHV total < 300.
Adjusted right turns = PHV Right Turns - 20
If PHV is not known use formula: PHV = ADT x K x D

K = the percent of AADT occurring in the peak hour
D = the percent of traffic in the peak direction of flow

Note: An average of 11% for K x D will suffice.

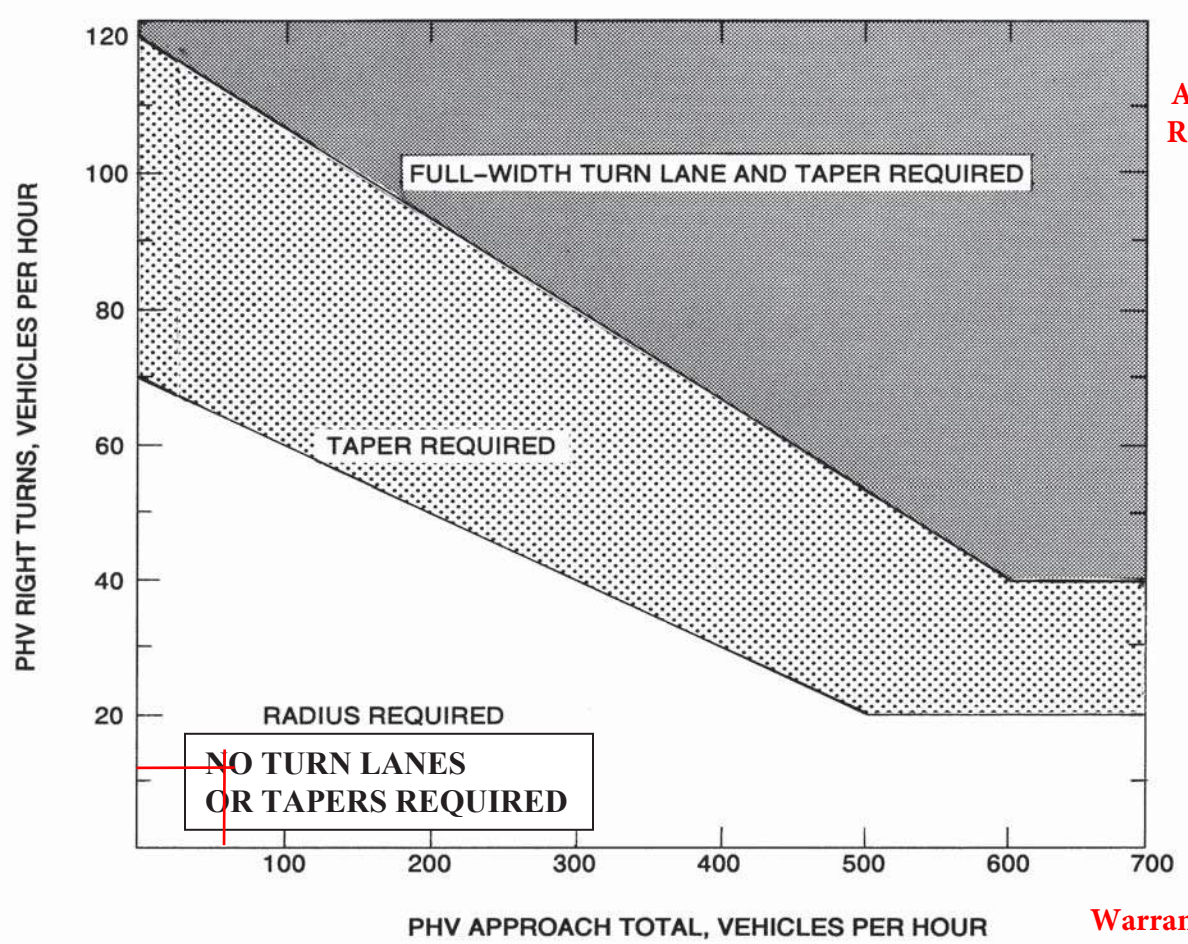
When right turn facilities are warranted, see Figure 3-1 for design criteria.*

* Rev. 1/15

Appendix G-4

Earlysville Forest Drive Westbound
2021 Existing Conditions

Earlysville Forest Drive Westbound - 2021 AM Peak



App Vol = 66
RT % = 18.2%

Warrant NOT MET

FIGURE 3-26 WARRANTS FOR RIGHT TURN TREATMENT (2-LANE HIGHWAY)

Appropriate Radius required at all Intersections and Entrances (Commercial or Private).

LEGEND

PHV - Peak Hour Volume (also Design Hourly Volume equivalent)

Adjustment for Right Turns

For posted speeds at or under 45 mph, PHV right turns > 40, and PHV total < 300.
Adjusted right turns = PHV Right Turns - 20
If PHV is not known use formula: PHV = ADT x K x D

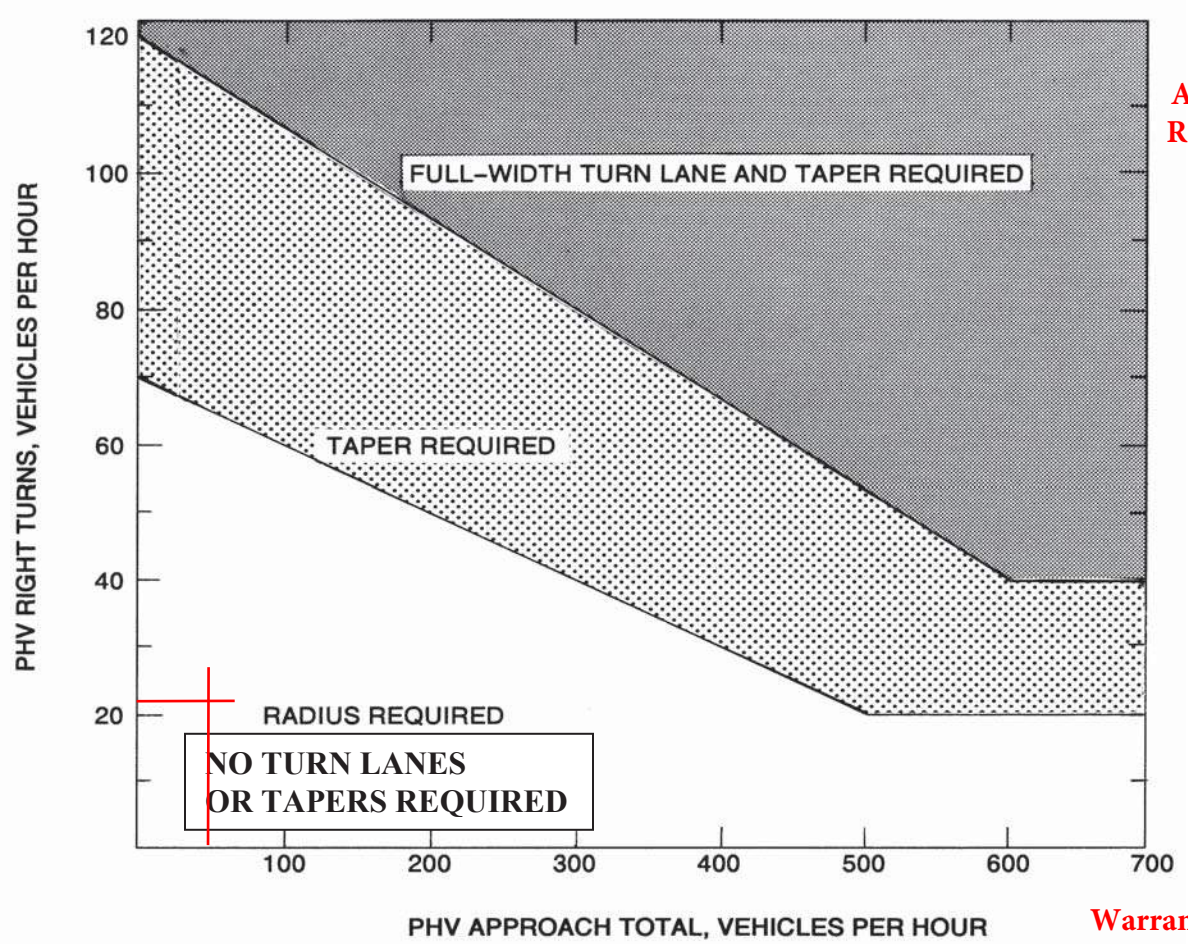
K = the percent of AADT occurring in the peak hour
D = the percent of traffic in the peak direction of flow

Note: An average of 11% for K x D will suffice.

When right turn facilities are warranted, see Figure 3-1 for design criteria.*

* Rev. 1/15

Earlysville Forest Drive Westbound - 2021 PM Peak



App Vol = 51
RT % = 43.1%

Warrant NOT MET

FIGURE 3-26 WARRANTS FOR RIGHT TURN TREATMENT (2-LANE HIGHWAY)

Appropriate Radius required at all Intersections and Entrances (Commercial or Private).

LEGEND

PHV - Peak Hour Volume (also Design Hourly Volume equivalent)

Adjustment for Right Turns

For posted speeds at or under 45 mph, PHV right turns > 40, and
PHV total < 300.
Adjusted right turns = PHV Right Turns - 20
If PHV is not known use formula: PHV = ADT x K x D

K = the percent of AADT occurring in the peak hour
D = the percent of traffic in the peak direction of flow

Note: An average of 11% for K x D will suffice.

When right turn facilities are warranted, see Figure 3-1 for design criteria.*

* Rev. 1/15

Appendix H

CMF Data

VIRGINIA STATE PREFERRED CMF LIST

Table of Contents

Introduction

A crash modification factor (CMF) is a useful tool for estimating changes in safety performance that can be expected when implementing a countermeasure. Developed using various forms of statistical analyses, they provide average changes in crash frequency, and sometimes severity, which are commonly observed when a treatment is installed.

Almost all CMFs can be found in the **Crash Modification Factors Clearinghouse**, a web-based repository of more than 6,000 CMFs covering hundreds of treatments. Often, a search for a countermeasure on the website will return many CMFs for a single treatment. As a result, this document was developed.

The Virginia State Preferred CMF List is a condensed directory with common CMFs relative to Virginia. The State preferred list contains CMFs with high quality ratings and includes the applicable crash type, area type, severity, service life, functional class, and site description. These CMFs will be used to support Virginia's HSIP program as well as other, broader applications.

CMF Example — Convert At-Grade Intersection to Interchange

The study intersection has experienced the following 15 crashes in one year:

Severity	K	A	BC	O
Crashes	1	2	5	7

Engineers want to convert this intersection to an interchange. Find CMFs in document (as shown in Figure A-1) and calculate how many crashes of each severity can be reduced. In the HSIP application, use all applicable CMFs as shown below:

- $K_{reduced}$ = *1 crash per year * (1 – 0.58) = 0.42 crashes per year*
- $A_{reduced}$ = *2 crashes per year * (1 – 0.43) = 1.14 crashes per year*
- $BC_{reduced}$ = *5 crashes per year * (1 – 0.43) = 2.85 crashes per year*
- $O_{reduced}$ = *7 crashes per year * (1 – 0.64) = 2.52 crashes per year*

Figure A-1 Convert Intersection to Interchange CMF Information

WHAT IS A CMF?

Mathematically, a CMF is a multiplicative factor used to compute the expected number of crashes after implementing a given countermeasure at a specific site. For example, a countermeasure expected to reduce the number of injury crashes by 23 percent will have a CMF of 0.77 (1 – [23/100] = 0.77). On the other hand, if the treatment is expected to increase the number of property damage crashes by 23 percent, the CMF will be = 1 - (-23/100) = 1.23.

To estimate future expected crash frequency with the treatment, the CMFs are applied to expected crash frequency assuming no changes. For example, a stop-controlled intersection is expected to experience five crashes per year. A treatment is installed with a CMF of 0.77, so the expected crash frequency with the installation would be 5*0.77 = 3.85, a reduction of 1.15 crashes per year.

HOW TO USE THIS DOCUMENT

This document consists of three tables spread over multiple pages which describe and provide supporting documentation for the CMFs. Descriptions of each table are provided later in this section. CMFs should be selected based on applicability, where the characteristics associated with the CMF closely match the characteristics of the scenario at hand. For example, CMFs often vary by crash type and crash severity. CMFs may also be specific to urban or rural areas and should be applied to situations that match.

As an example, consider the CMF "Convert At-Grade Intersection to Interchange" shown in Figure A-1. The location of interest is 4-leg at-grade intersection, and a new interchange was suggested by a safety assessment team to help mitigate crashes at this intersection. Use the CMF by crash severity to determine the expected number of crashes for the applicable severity.

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
	Convert At-Grade Intersection to Interchange	ALL	-	0.58	0.43	0.43	0.64	20	-	4-Leg Intersection	At-Grade Intersection	CMF ID: 459, 460, 461

Table 1: Virginia State Preferred CMF List

Table 1 provides CMFs by crash type and severity for the identified countermeasures. The countermeasures are separated into four categories: bike/ped, interchanges, intersections, and segments. For each countermeasure, the following information is provided:

- Countermeasure name;
- Applicable crash type, using codes defined within the key;
- Applicable area type, using codes defined within the key;
- CMFs for four severity categories;
  - Fatal Crash (K);
  - Suspected Serious Injury Crash (A);
  - Suspected Minor Injury and Possible Injury Crashes (BC); and
  - Property Damage Only (PDO) Crash (O).
- The anticipated service life for the treatment;
- The applicable functional class;
- A general site description;
- The designated prior condition for the countermeasure; and
- References for the CMF(s).

When applying these CMFs, analysts should be careful to apply the CMF only to the designated crash types and severities. However, these crash types should not limit consideration of the countermeasure's usage. Just because a CMF is not available for the specific conditions does not mean the countermeasure is not useful in that context, it just might not have been researched yet.

Countermeasures with ** listed for a CMF indicate this CMF is defined using an equation, which can be found in Table 2.

Table 2: CMFunction Equations

Some CMFs may require the use of an equation, which can be called Crash Modification Functions (CMFunctions), and the equations are provided in Table 2. For some of the more complex CMFunctions, an online calculator has been provided to assist users in determining the expected number of crashes. This calculator can be found on VDOT's HSIP **website**.

The equations are functions of existing and proposed conditions, with the units varying based on the CMF; the units can be verified in the Units column. In all cases, the existing condition is represented as the variable X and the proposed condition is represented as the variable Y. For equations that are not on the website, simply enter the existing and proposed conditions into the appropriate equation using the designated units. The resulting value from the equation is the CMF.

The countermeasures in Table 2 are divided into three categories: interchanges, intersections, and segments. Data provided for the countermeasures in Table 2 include:

- Countermeasure name.
- CMFunctions for four severity categories:
  - Fatal Crash (K);
  - Suspected Serious Injury Crash (A);
  - Suspected Minor Injury and Possible Injury Crashes (BC); and
  - Property Damage Only (PDO) Crash (O).
- Units for the existing and proposed conditions.

The resulting CMFs from the equation should be cross-referenced with Table 1 to ensure the CMF is being applied to the appropriate crash types.

Table 3: References

Specific references for the selected CMFs are provided in Table 3. The countermeasures in Table 3 are divided into four categories: bike/ped, interchanges, intersections, and segments. For each countermeasure, four pieces of data are provided:

- Countermeasure name;
- The shorthand reference from Table 1;
- The hyperlink for the first reference; and
- The hyperlink for the second reference, when applicable.

If there are questions about the study design, applicability, and/or prior conditions of a CMF, the analyst can refer to the linked documents, which can offer some clarification from the authors of the CMF study.

CAN'T FIND YOUR COUNTERMEASURE?

The list below contains an exhaustive list of countermeasures used in Virginia. If the user is proposing a countermeasure that cannot be located on this list, they are to identify relevant research supporting an estimated CMF value and submit this documentation to VDOT HSIP staff for review and approval.

PREFERRED CMF LIST KEY

Key
Crash Type

VP	Vehicle-Pedestrian	**SC**	Secondary Crashes
VT	Vehicle-Train	**VB**	Vehicle-Bicycle
SV	Single Vehicle	**HO**	Head-On
CM	Cross-Median	**CFO**	Crashes with Fixed Objects
F	Frontal	**S**	Same Direction Sideswipe
O	Opposing Direction Sideswipe		

Key
Area Type

U+S	Urban and Suburban
Sub	Suburban

▲ *Refer to the CMF Calculator on the HSIP website.*
▲ *Refer to specific treatment.*
** *Refer to Equations Sheet on page 16.*

Table 1 Virginia State Preferred CMF List

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
BIKE/PED	Add Crosswalk	VP	-	1	1	1	1	2	-	Pedestrian Crossing	No Marked Crosswalk	FHWA Safety Report
	Add Crosswalk Lighting	VP	-	0.56	0.41	0.41	0.56	15	-	Pedestrian Crosswalk	No Lighting Present	CMF ID: 441, 2379
	Add Curb Extensions/ Corner Bulb Outs	VP	-	1	1	1	1	20	-	Pedestrian Crossing at an Intersection Approach	No Bulb Outs or Curb Extensions Present	NYC Study
	Add Median Pedestrian Island	VP	-	0.75	0.75	0.75	0.75	20	-	Multilane Pedestrian Crossing	One-Stage At-Grade Pedestrian Crossing	PED CMF Toolbox
	Add or Upgrade Sidewalk	VP	-	0.12	0.12	0.12	0.12	20	-	Roadway Segment with Pedestrian Traffic Along Roadside	No Sidewalk or Deficient Sidewalk Present	PED CMF Toolbox
	Add Pedestrian Bridge	VP	-	0.1	0.1	0.1	0.14	30	-	High-Volume Pedestrian Crossing	At-Grade Pedestrian Crossing	PED CMF Toolbox
	Add Pedestrian Hybrid Beacon (PHB)	VP	U+S	0.453	0.453	0.453	0.453	20	Minor Arterial	Mid-Block Pedestrian Crossing	No Pedestrian Hybrid Beacon Present	CMF ID: 9020
	Add PHB, Advanced Yield/ Stop Markings	VP	U+S	0.432	0.432	0.432	0.432	20	Minor Arterial	Mid-Block Pedestrian Crossing	No Pedestrian Hybrid Beacon Present	CMF ID: 9021
	Add Pedestrian Signal Heads	ALL	U+S	0.85	0.85	0.85	0.96	20	-	Signalized Intersection with Pedestrian Crossings	No Pedestrian Signals Present	CMF ID: 8480, 8481
	Add Rectangular Rapid Flashing Beacon (RRFB)	VP	U+S	0.526	0.526	0.526	0.526	6	Minor Arterial	Mid-Block Pedestrian Crossing	No RRFB present	CMF ID: 9024
	Add Shared Use Path	VB	Urban	1	0.41	0.41	1	20	-	Roadway segment with Pedestrian and Bicycle Traffic	No Shared-Use Path Present	CMF ID: 4102
	Change Pedestrian Phase to Barnes Dance	VP	Urban	0.49	0.49	0.49	0.49	20	-	Signalized Intersection with Pedestrian Crossings	No Pedestrian Phasing or Standard Pedestrian Phasing	CMF ID: 4117
	Convert from Walk/ Don't Walk to Pedestrian Countdown	VP	-	0.3	0.3	0.3	0.3	20	-	Signalized Intersection with Walk/Don't Walk Pedestrian Signals	Walk/Don't Walk Pedestrian Signal	CMF ID: 5272
	Convert Mid-Block Crossing to HAWK	VP	U+S	0.453	0.453	0.453	0.453	20	Minor Arterial	Mid-Block Pedestrian Crossing	Mid-Block Crossing with No PHB or HAWK Present	CMF ID: 9020
	Convert Standard Crosswalk Pavement Marking to High-Visibility Crosswalk	VP	-	0.63	0.63	0.63	0.63	2	-	Pedestrian Crossing with Standard Crosswalk Pavement Markings	Standard Crosswalk Pavement Markings	CMF ID: 2697
	Implement Leading Pedestrian Interval	VP	Urban	0.413	0.413	0.413	0.413	20	Principal Arterial - Other	Signalized Intersection with Pedestrian Crossings	Signalized intersection with Pedestrian Signal Heads and No Leading Interval	CMF ID: 1993
	Install PHB or HAWK with Advanced Stop or Yield Markings and Signs	VP	U+S	0.432	0.432	0.432	0.432	20	Minor Arterial	Mid-Block Pedestrian Crossing	No PHB or HAWK at Mid-Block Crossing	CMF ID: 9021

Table 1 Virginia State Preferred CMF List **(cont)**

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
BIKE/PED	Install Raised Pedestrian Crossing	ALL	-	0.64	0.64	0.64	0.7	20	-	Pedestrian Crossing	At-Grade Pedestrian Crossing	PED CMF Toolbox
	Prohibit Left Turns	VP	-	0.9	0.9	0.9	0.9	6	-	Intersection with Left Turns into Pedestrian Crossings	Left Turns Allowed	Ped CMF Toolbox
	Remove Parking Near Intersection	VP	-	0.7	0.7	0.7	0.7	▲	-	Intersection with Parking on Approaches	Parking Present Near Intersection Approaches	PED CMF Toolbox
	Upgrade Crosswalk to High-Visibility	VP	-	0.52	0.52	0.52	0.52	2	-	Pedestrian Crosswalk	Standard Crosswalk Markings	CMF ID: 4658
	Widen Sidewalk at Intersection	ALL	-	1	1.12	1.12	1	20	-	Intersection with Sidewalks	Existing Sidewalk Width	CMF ID: 413
INTERCHANGE	Add Auxiliary Lane Between Entrance and Exit Ramps	ALL	-	0.77	0.77	0.77	0.79	20	Principal Arterial- Other Freeways and Expressways	Freeway Interchange Weaving Area	No Auxiliary Lane Present	CMF ID: 7440, 7441
	Add Collector-Distributor Road	ALL	-	0.9	0.9	0.9	0.9	20	-	Freeway Interchange Area	No Collector-Distributor Road Present	ISATe, HSM Chapters 18 and 19
	Add Entrance Ramp to One Side of Freeway	ALL	-	▲	▲	▲	▲	20	-	Directional Freeway Segment	Freeway Segment with No Entrance Ramp	ISATe, HSM Chapters 18 and 19
	Add Exit Ramp to One Side of Freeway	ALL	-	▲	▲	▲	▲	20	-	Directional Freeway Segment	Freeway Segment with No Exit Ramp	ISATe, HSM Chapters 18 and 19
	Convert Diamond Interchange to Diverging Diamond Interchange	ALL	Sub	0.59	0.59	0.59	0.67	20	Principal Arterial - Interstate	Diamond Interchange	Traditional Diamond Interchange	CMF ID: 8258, 8278
	Convert Diamond Interchange to SPUI	ALL	-	0.62	0.62	0.62	0.62	20	-	Diamond Interchange	Traditional Diamond Interchange	VDOT Planning Level CMFs
	Extend Deceleration Lane Length by 100 Feet	ALL	-	0.93	0.93	0.93	0.93	20	-	Freeway Segment with Deceleration Lane	Existing Deceleration Lane Length	CMD ID: 475
	Interchange Lighting	Night Time	-	0.5	0.5	0.5	0.5	15	Principal Arterial - Interstate	Freeway Interchange	No Highway Lighting Present	CMF ID: 1283
	Lengthen Acceleration Lane from X Miles to Y Miles	ALL	-	**	**	**	**	20	Principal Arterial - Interstate	Freeway Segment with Acceleration Lane	Existing Acceleration Lane of Length X Miles	CMF ID: 5215, 5216
	Replace Loop Ramp with Short Direct Ramp	ALL	-	0.7	0.7	0.7	0.7	20	-	Interchange Ramp	Existing Loop Ramp	CMF ID: 480

Table 1 Virginia State Preferred CMF List **(cont)**

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
INTERCHANGE	Widen Ramp Lane Width from X to Y in Feet	ALL	-	**	**	**	1	20	Freeway Ramp	Freeway Ramp	Existing Ramp Lane Width of X Feet	HSM Eqn 19-34
	Widen Ramp Left Shoulder	ALL	-	**	**	**	**	20	Freeway Ramp	Freeway Ramp	Existing Left-Shoulder Width of X Feet	HSM Eqn 19-36
	Widen Ramp Right Shoulder	ALL	-	**	**	**	**	20	Freeway Ramp	Freeway Ramp	Existing Right-Shoulder Width of X Feet	HSM Eqn 19-35
INTERSECTION	Install Intersection Lighting	Night Time	ALL	0.881	0.881	0.881	0.881	15	-	Intersection	No Lighting Present	CMF ID: 4462
	Increase Stopping Sight Distance on Crest Vertical Curve-Intersection Approach	ALL	Rural	0.62	0.62	0.62	0.70	20	-	Intersection Approach with Crest Vertical Curve	Crest Vertical Curve with Inadequate Sight Distance	CMF ID: 6870, 6871
	Add Flashing Lights to Railroad (RR) Crossings with Signs	VT	-	0.23	0.23	0.23	0.23	10	-	RR Grade Crossing	RR Grade Crossing with Static Warning Signs	CMF ID: 487
	Add Gates to RR Crossings with Signs	VT	-	0.06	0.06	0.06	0.06	10	Minor Arterial	RR Grade Crossing	RR Grade Crossing with Static Warning Signs	CMF ID: 489
	Adaptive Signal Control	ALL	U+S	0.92	0.92	0.92	0.83	20	-	Signalized Intersection	Non-Adaptive Traffic Signal	CMF ID: 6856, 6857
	Add 3-Inch Yellow Retroreflective Sheeting to Signal Backplates	ALL	Urban	0.85	0.85	0.85	0.85	6	-	Signalized Intersection	No Backplates Present	CMF ID: 1410
	Advanced Activated/ Dynamic Flasher	ALL	-	0.82	0.82	0.82	0.814	6	-	Signalized Intersection	Signalized Intersection with No Advance Warning System	CMF ID: 4198, 4201
	Advanced Cross Street Name Sign	ALL	-	0.99	0.99	0.99	0.984	6	-	Signalized Intersection	Signalized Intersection with No Advanced Street Sign	CMF ID: 2449, 2450
	Advanced Dilemma Zone Detection	ALL	Rural	0.918	0.887	0.887	0.918	20	-	High Speed Signalized Intersection	No Dilemma Zone Warning System	CMF ID: 4855, 4857
	Change from Permissive Left-Turn to Flashing Yellow Arrow	Left Turn	Urban	0.635	0.635	0.635	0.635	20	-	Signalized Intersection	Permissive Left-Turn Phasing	CMF ID: 4175
	Change from Permitted Left-Turn to Permitted/ Protected	Left Turn	Urban	0.862	0.862	0.862	0.862	20	-	Signalized Intersection	Permissive Left-Turn Phasing	CMF ID: 4270
	Change from Permitted Left-Turn to Protected on Major Approach	Angle	Urban	0.01	0.01	0.01	0.01	20	-	Signalized Intersection	Permissive Left-Turn Phasing on a Major Approach	CMF ID: 335
	Change from Permitted/ Protected Left-Turn to Protected on Major Approach	Angle	Urban	0.01	0.01	0.01	0.01	20	-	Signalized Intersection	Protected/Permissive or Vice-Versa Left-Turn Phasing on a Major Approach	CMF ID: 339

Table 1 Virginia State Preferred CMF List **(cont)**

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
INTERSECTION	Change from Permitted/ Protected Left-Turn to Protected on Minor Approach	Angle	Urban	0.04	0.04	0.04	0.04	20	-	Signalized Intersection	Protected/Permissive or Vice-Versa Left-Turn Phasing on a Minor Approach	CMF ID: 337
	Change from Pretimed Signal to Actuated Signal	ALL	-	0.8	0.8	0.8	0.8	20	-	Signalized Intersection	Pretimed Signal Control	NCDOT CRF List 1.6
	Change from Protected Left-Turn to Flashing Yellow Arrow	Left Turn	Urban	2.242	2.242	2.242	2.242	20	-	Signalized Intersection	Protected Left-Turn Phasing	CMF ID: 4173
	Change from Protected/ Permissive Left-Turn to Flashing Yellow Arrow	Left Turn	Urban	0.806	0.806	0.806	0.806	20	-	Signalized Intersection	Protected/Permissive Left-Turn Phasing	CMF ID: 4177
	Change Number of Approaches with Left-Turn Lanes from X Approaches to Y Approaches	ALL	ALL	**	**	**	**	20	-	Signalized Intersection	Left-Turn Lanes on X Number of Approaches	HSM
	Change Number of Approaches with Prohibited Right Turn on Red from X Approaches to Y Approaches	ALL	-	**	**	**	**	20	-	Signalized Intersection	Right Turn on Red Permitted on X Number of Approaches	CMF ID: 5194
	Change Number of Approaches with Right-Turn Lanes from X Approaches to Y Approaches	ALL	-	**	**	**	**	20	-	Signalized Intersection	Right-Turn Lanes on X Number of Approaches	HSM Table 10-14, 12-26
	Change Number of Cycles per Hour from X Cycles per Hour to Y Cycles per Hour	Rear End	U+S	**	**	**	**	20	Arterial	Signalized Intersection	X Cycles per Hour	CMF ID: 3072
	Channelize Right Turn	ALL	-	0.65	0.65	0.65	1	20	-	Signalized Intersection	No Right-Turn Channelization	FHWA CMF Desktop Reference Guide
	Closed Loop Signal System	ALL	-	0.85	0.85	0.85	0.85	20	-	Signalized Intersection	Signal System that is Not Closed Loop	NCDOT CRF List 1.7
	Convert from Pedestal-Mounted Traffic Signal to Mast Arm-Mounted Traffic Signal	ALL	Urban	0.56	0.56	0.56	0.49	20	-	Signalized Intersection	Pedestal-Mounted Signal	CMF ID: 1424, 1425

Table 1 Virginia State Preferred CMF List **(cont)**

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
INTERSECTION	Convert from Span Wire-Mounted Traffic Signal to Mast Arm-Mounted Traffic Signal	ALL	ALL	0.98	0.98	0.98	0.97	20	-	Signalized Intersection	Span Wire-Mounted Signal	UVA Khattak and Fontaine Study
	Convert to LED Signal Heads - 3-Leg Intersection	ALL	-	1.41	1.41	1.41	0.929	20	-	3-Leg Signalized Intersection	Incandascent Signal Bulbs	UVA CMF
	Convert to LED Signal Heads - 4-Leg Intersection	ALL	-	0.986	0.986	0.986	0.932	20	-	4-Leg Signalized Intersection	Incandascent Signal Bulbs	UVA CMF
	Extend Left-Turn Lane	ALL	-	0.85	0.85	0.85	1	20	-	Signalized Intersection	Existing Turn-Lane Length	FHWA Desktop Reference
	Extend Right-Turn Lane	ALL	-	0.85	0.85	0.85	1	20	-	Signalized Intersection	Existing Turn-Lane Length	FHWA Desktop Reference
	Increase All-Red Clearance Interval	ALL	Urban	0.863	0.863	0.863	0.798	20	-	Signalized Intersection	Short All-Red Clearance Interval	CMF ID: 4211, 4212
	Increase Left-Turn Lane Offset	ALL	-	0.644	0.644	0.644	0.662	20	-	Signalized Intersection	Zero or Negative Left-Turn Lane Offset	CMF ID: 6095, 6096
	Increase Yellow Change Interval by 1 Second	ALL	Urban	1.07	1.07	1.07	1.14	20	-	Signalized Intersection	Existing Yellow Interval	CMF ID:4207, 4208
	Install Red-Light Camera	ALL	U+S	0.676	0.676	0.676	1.014	20	-	Signalized Intersection	No Red-Light Camera Present	CMF ID: 6876, 6877
	Offset Right-Turn Lane	N/A	-	1	1	1	1	20	-	Signalized Intersection	No Offset for Right-Turn Lane	N/A
	Permit Right Turn on Red	ALL	-	1.07	1.07	1.07	1.07	20	-	Signalized Intersection	Right Turn on Red Prohibited	CMF ID: 4580
	Replace 8-inch Signal Heads with 12-inch Signal Heads	ALL	U+S	0.97	0.97	0.97	0.97	20	-	Signalized Intersection	8-inch Signal Heads	CMF ID: 2334
	Retroreflective Backplates and LED Signal Heads	Night Time	-	0.65	0.65	0.65	0.74	20	-	Signalized Intersections	No Retroreflective Backplates and Non-LED Signal Heads	UVA CMFs
	Add Left-Turn Lane to Major Approach of 3-Leg Stop-Controlled Intersection	ALL	-	0.56	0.56	0.56	0.56	20	-	3-Leg Stop-Controlled Intersection	Left-Turn Lanes on X Number of Approaches	HSM Table 11-22
	Change Number of Uncontrolled Approaches with Left-Turn Lanes from X Approaches to Y Approaches at 4-Leg Intersection	ALL	-	**	**	**	**	20	-	4-Leg Stop-Controlled Intersection	Left-Turn Lanes on X Number of Approaches	HSM Table 10-13

Table 1 Virginia State Preferred CMF List **(cont)**

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
INTERSECTION	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Intersection of Rural, Multilane Highway	ALL	Rural	**	**	**	**	20	-	Stop-Controlled Intersection - Rural Multilane Highway	Right-Turn Lanes on X Number of Approaches	HSM Table 11-23
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Intersection of Rural, Two-Lane Roads	ALL	Rural	**	**	**	**	20	-	Stop-Controlled Intersection - Rural Two-Lane Road	Right-Turn Lanes on X Number of Approaches	HSM Table 10-14
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Urban or Suburban Arterial Intersection	ALL	U+S	**	**	**	**	20	-	Stop-Controlled Intersection - Urban and Suburban Arterial	Right-Turn Lanes on X Number of Approaches	HSM Table 12-26
	High-Friction Surface Treatment on Approach	ALL	-	0.799	0.799	0.799	0.799	10	-	Stop-Controlled Intersection Approach	Standard Pavement on Intersection Approach	CMF ID: 2259
	Increase Intersection Sight Distance from X Feet of Available Sight Distance to Y Feet	Angle & Left Turn	-	**	**	**	**	10	-	Stop-Controlled Intersection Approach	Intersection Sight Distance of X Feet	NCHRP 17-59, Report 875
	Intersection Collision Warning System	ALL	-	0.742	0.742	0.742	0.704	6	-	Stop-Controlled Intersection	No Collision Warning System Present	CMF ID: 8474, 8475
	Reduce Intersection Skew from X to Y - 3-Leg Intersection	ALL	Rural	**	**	**	**	20	-	3-Leg Stop-Controlled Intersection	Intersection Skew Angle of X Degrees	HSM Equation: 10-22
	Reduce Intersection Skew from X to Y - 4-Leg Intersection	ALL	Rural	**	**	**	**	20	-	4-Leg Stop-Controlled Intersection	Intersection Skew Angle of X Degrees	HSM Equation: 10-23
	Systemic Signage and Pavement Marking Improvements	ALL	-	0.899	0.899	0.899	0.917	6	-	Stop-Controlled Intersection	Stop-Controlled Intersection with No Supplemental Signage	FHWA Proven Safety Counter-measures
	Transverse Rumble Strips	ALL	Rural	0.987	0.987	0.987	1.191	10	Minor Arterial	Stop-Controlled Intersection Approach	No Transverse Rumble Strips Present	CMF ID: 2707, 2708
	Add Quadrant Roadway to Intersection	N/A	-	-	-	-	-	20	-	Conventional Intersection	Conventional Intersection	N/A
	Convert 3-Leg Signalized Intersection to Continuous Green T-Intersection	ALL	-	0.846	0.846	0.846	0.958	20	-	3-Leg Signalized Intersection	Standard 3-Leg Signalized Intersection	CMF ID: 8655, 8656

Table 1 Virginia State Preferred CMF List **(cont)**

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
INTERSECTION	Convert At-Grade Intersection to Interchange	ALL	-	0.58	0.43	0.43	0.64	20	-	4-Leg Intersection	At-Grade Intersection	CMF ID: 459, 460, 461
	Convert 4-Leg Intersection to Two Offset T-Intersections	ALL	Urban	0.75	0.75	0.75	1	20	-	4-Leg Stop-Controlled Intersection	4-Leg Stop-Controlled Intersection	HSM CMF: Table 14-2
	Convert Minor Stop-Control to All-Way Stop Control	ALL	ALL	0.23	0.23	0.23	0.319	20	-	Minor Stop-Controlled Intersection	Stop-Control on Minor Approaches	CMF ID: 3127, 3128
	Convert Signalized Intersection to Roundabout	ALL	-	0.52	0.22	0.22	0.52	20	-	Signalized Intersection	Signalized Intersection	CMF ID: 225, 226
	Convert Stop-Controlled Intersection to Roundabout	ALL	ALL	0.56	0.18	0.18	0.56	20	-	Stop-Controlled Intersection	Minor Stop-Controlled Intersection	CMF ID: 227, 228
	Convert Stop-Controlled Intersection to Signalized Intersection	ALL	ALL	0.642	0.642	0.642	0.639	20	-	Stop-Controlled Intersection	Minor Stop-Controlled Intersection	CMF ID: 7983, 7986
	Convert to Displaced Left-Turn Intersection	ALL	-	0.81	0.81	0.81	0.76	20	-	High-Speed Intersection	Traditional Intersection	FHWA TechBrief
	Convert to J-Turn Intersection	ALL	Rural	0.652	0.463	0.463	0.652	20	Principal Arterial-Other	High-Speed Intersection	At-Grade Minor Stop-Controlled Intersection	CMF ID: 5555, 5556
	Convert to Median U-Turn Intersection	ALL	-	0.70	0.70	0.70	0.91	20	Arterial	High-Speed Intersection	Conventional Signalized Intersection	FHWA TechBrief
	Convert to Signalized Intersection to Signalized RCUT	ALL	-	0.78	0.78	0.78	0.85	20	-	High-Speed Signalized Intersection	Conventional Signalized Intersection	FHWA Report
	Convert to Signalized Intersection to Unsignalized RCUT	N/A	-	-	-	-	-	20	-	High-Speed Signalized Intersection	Signalized Intersection	N/A
	Convert to Unsignalized Intersection to Unsignalized RCUT	ALL	Rural	0.37	0.37	0.37	0.54	20	Principal Arterial-Other	High-Speed Stop-Controlled Intersection	Conventional Unsignalized Intersection	CMF ID: 4883, 4884
	Convert Two Offset T-Intersection, Offset by X Miles, to T-Intersections with Major Road AADT	ALL	Rural	**	**	**	**	20	-	Offset T-Intersections	T-Intersections Offset by X Miles	HSM Eqn 10-17
	Convert Unsignalized Intersection to Unsignalized Superstreet Intersection	ALL	Rural	0.37	0.37	0.37	0.54	20	Principal Arterial-Other	High-Speed Stop-Controlled Intersection	Stop-Control on Minor Approaches	CMF ID: 4883, 4884

Table 1 Virginia State Preferred CMF List **(cont)**

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
INTERSECTION	Install Interim Roundabout	ALL	ALL	0.23	0.23	0.23	0.319	5	-	Stop-Controlled Intersection	Stop-Control on Minor Approaches	CMF ID: 3127, 3128
	Remove Unwarranted Signal	ALL	U	0.76	0.76	0.76	0.76	20	Minor Arterial, Collectors	Signalized Intersection of One-Way Streets	Unwarranted Traffic Signal	CMF ID: 332
	Install Temporary Traffic Circle	N/A	-	-	-	-	-	2	-	Unsignalized Intersection	No Control, Yield Control, or Stop Controlled	N/A
SEGMENTS (FREEWAY)	Active Traffic Management with Hard Shoulder Running	ALL	-	0.69	0.69	0.69	0.75	20	Principal Arterial - Interstate	Freeway Segment	No Active Traffic Management or Hard Shoulder Running	UVA Study
	Active Traffic Management without Hard Shoulder Running	ALL	-	1.18	1.18	1.18	1.16	20	Principal Arterial - Interstate	Freeway Segment	No Active Traffic Management	UVA Study
	Add Cable Median Barrier	CM,F, O,HO	Rural	0.09	0.09	0.09	0.09	15	Principal Arterial - Interstate	Freeway Segment with Traversable Median	No Median Barrier Present	CMF ID:1966
	Add Rumble Strips to Inside Shoulder	SV	-	0.811	0.811	0.811	1	10	Principal Arterial - Intersectate	Freeway Segment	No Rumble Strips Present on Inside Shoulder	HSM Eqn 18-36
	Add Median Concrete Barrier	CM,F, O,HO	Rural	0	0	0	0	15	Principal Arterial - Other Freeways and Expressways	Freeway Segment	No Median Barrier Present	CMF ID: 2256
	Add Median Guardrail	CM	-	0.22	0.22	0.22	0.22	15	Principal Arterial - Other Freeways and Expressways	Freeway Segment	No Median Barrier Present	CMF ID: 51
	Add Rumble Strips to Outside Shoulder	SV	-	0.811	0.811	0.811	1	10	Principal Arterial - Intersectate	Freeway Segment	No Rumble Strips Present on Outside Shoulder	HSM Eqn 18-36
	Add Raised Pavement Markers	ALL	Rural	0.87	0.87	0.87	0.87	2	Principal Arterial - Other Freeways and Expressways	Freeway Segment	No Raised Pavement Markers Present	CMF ID: 5498
	Add Roadside Guardrail	ALL	-	0.84	0.84	0.99	1.06	15	Principal Arterial - Other Freeways and Expressways	Freeway Segment	No Roadside Barrier Present	CMF ID: 8391, 8392, 8393

Table 1 Virginia State Preferred CMF List **(cont)**

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
SEGMENTS (FREEWAY)	Implement Incident Management to Reduce Incident Duration Time	SC	-	0.85	0.85	0.85	0.85	6	Principal Arterial - Interstate	Freeway Segment	No Incident Management Program	VA Planning Level CMFs
	Implement Variable Speed Limits	ALL	Urban	0.71	0.71	0.71	0.75	6	Principal Arterial - Interstate	Freeway Segment	Static Posted Speed Limit	CMF ID: 8730, 8731
	Rural: Widen from 4 Lanes to 6 Lanes	ALL	Rural	0.7	0.7	0.7	0.7	20	-	Rural Freeway Segment	4-Lane Cross-Section	VDOT SPFs, Crash Rate Ratios
	Upgrade Horizontal Curve Signage	ALL	Rural	0.75	0.75	0.75	0.82	6	-	Freeway Horizontal Curve Segment	No Horizontal Curve Signs or Dirty Signs with No Retroreflectivity	CMF ID: 2431, 2433
	Upgrade Pavement Markings to Wet-Reflective Pavement Markings	ALL	-	0.881	0.881	0.881	1.032	2	Principal Arterial - Other Freeways and Expressways	Freeway Segment	Standard Pavement Markings	CMF ID: 8093, 8134
	Upgrade Roadside Guardrail	ALL	-	0.95	0.95	0.95	0.95	10	-	Freeway Segment with Roadside Guardrail	Damaged or Below Standard Guardrail	Desktop Reference Guide
	Urban: Widen from 4 Lanes to 6 Lanes	ALL	Urban	0.9	0.9	0.9	0.9	20	-	Urban Freeway Segment	4-Lane Cross-Section	VDOT SPFs, Crash Rate Ratios
	Urban: Widen from 4 Lanes to 8+ Lanes	ALL	Urban	0.75	0.75	0.75	0.75	20	-	Urban Freeway Segment	4-Lane Cross-Section	VDOT SPFs, Crash Rate Ratios
	Urban: Widen from 6 Lanes to 8+ Lanes	ALL	Urban	0.8	0.8	0.8	0.8	20	-	Urban Freeway Segment	6-Lane Cross-Section	VDOT SPFs, Crash Rate Ratios
	Widen Clear Zone from X Feet to Y Feet	SV	-	**	**	**	1	20	-	Freeway Segment	Clear Zone Width of X Feet	HSM Eqn 18-38
	Widen Median from X Feet to Y Feet	ALL	-	**	**	**	**	20	-	Freeway Segment	Median Width of X Feet	HSM Eqn 18-27
	Widen Paved Inside Shoulder from X Feet to Y Feet	ALL	-	**	**	**	**	20	-	Freeway Segment	Inside Shoulder Width of X Feet	HSM Eqn 18-26
	Widen Paved Outside Shoulder on Horizontal Curve from X Feet to Y Feet	SV	-	**	**	**	**	20	-	Freeway Horizontal Curve Segment	Outside Shoulder Width of X Feet	HSM Eqn 18-35 and Table 18-21

Table 1 Virginia State Preferred CMF List **(cont)**

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
SEGMENTS (FREEWAY)	Widen Paved Outside Shoulder on Horizontal Tangent from X Feet to Y Feet	SV	-	**	**	**	1	20	-	Freeway Horizontal Tangent Segment	Outside Shoulder Width of X Feet	HSM Eqn 18-35 and Table 18-21
SEGMENTS (NON-FREEWAY)	Add Automated Speed Enforcement Cameras	ALL	-	0.83	0.83	0.83	0.84	6	-	Non-Freeway Segment	No Automated Speed Enforcement Present	CMF ID: 2688, 4583
	Add Auxiliary Passing Lane	ALL	Rural	0.67	0.67	0.67	0.58	20	-	Rural Two-Lane Undivided Highway	No Passing Lanes Present	CMF ID: 9111, 9112
	Add Centerline Rumble Strips (Including Sinusoidal/ Mumble)	HO, O	Rural	0.55	0.55	0.55	0.63	10	-	Non-Freeway Segment	No Centerline Rumble Strips Present	CMF ID: 3355, 3360
	Add Chevron Signs at Horizontal Curves	Night Time	Rural	0.75	0.75	0.75	0.75	6	-	Small Radius Horizontal Curve on Rural Two-Lane Undivided Highway	No Chevrons Present	CMF ID: 2439
	Add Chevron Signs, Curve Warning Signs, and Sequential Flashing Beacons	Night Time	-	0.592	0.592	0.592	0.592	6	-	Horizontal Curve on Multilane Highway	No Curve Delineation Treatment Present	CMF ID: 1852
	Add Raised Pavement Markers	ALL	Rural	0.81	0.81	0.81	0.81	2	Principal Arterial - Other Freeways and Expressways	Non-Freeway Segment	No Raised Pavement Markers Present	CMF ID: 5496
	Add Safety Edge	Run Off Road	Rural	0.79	0.79	0.79	0.79	15	Principal Arterial - Other	Two-Lane Undivided Rural Highway	No Safety Edge Present	FHWA Proven Safety
	Add Segment Lighting	Night Time	Urban	0.68	0.68	0.68	0.76	15	Minor Arterial	Non-Freeway Segment	No Lighting Present	CMF ID: 7781, 7782
	Add Shoulder Rumble Strips (Including Sinusoidal/ Mumble)	Run Off Road-right	Rural	0.83	0.83	0.83	0.84	10	-	Non-Freeway Segment	No Shoulder Rumble Strips Present	CMF ID: 3442, 3447
	Add Two-Way Left-Turn Lane (2U to 3T)	ALL	-	0.739	0.739	0.739	0.797	20	-	Two-Lane Undivided Highway	No TWLTL Present	CMF ID: 2341, 2346
	Add Two-Way Left-Turn Lane (4U to 5T)	ALL	Urban	0.45	0.45	0.45	0.45	20	-	Four-Lane Undivided Highway	No TWLTL Present	CMF ID: 4084
	Breakaway Supports for Utility Poles in Clear Zones	ALL	Rural	0.94	0.94	0.94	1.00	10	-	Non-Freeway Segment	Non-Breakaway Supports	HSM Eqn 10-20
	Change 4” Wide Edgelines to 6” Wide Edgelines	ALL	Rural	0.635	0.635	0.635	0.877	2	-	Rural Two-Lane Highway	4” Edgelines	CMF ID: 4737, 4738

Table 1 Virginia State Preferred CMF List **(cont)**

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
SEGMENTS (NON-FREEWAY)	Change Driveway Density (Driveways/Mile) from X to Y	ALL	Rural	**	**	**	**	20	Principal Arterial - Other	Rural Non-Freeway Segment	Driveway Density of X Driveways per Mile	CMF ID: 1973, 2248
	Change Roadside Hazard Rating from X to Y by Flattening Roadside Slope	ALL	Rural	**	**	**	**	20	-	Two-Lane Undivided Highway	Roadside Hazard Rating of X ■	HSM Eqn 10-20
	Change Superelevation Variance from X to Y (if Variance Between 0.01 and 0.02)	ALL	Rural	**	**	**	**	20	-	Horizontal Curve on Two-Lane Undivided Highway	Superelevation Deficiency of X Feet per Foot in Decimal	HSM Eqn 10-15
	Change Superelevation Variance from X to Y (if Variance Greater than 0.02)	ALL	Rural	**	**	**	**	20	-	Horizontal Curve on Two-Lane Undivided Highway	Superelevation Deficiency of X Feet per Foot in Decimal	HSM Eqn 10-16
	Dynamic Speed Feedback Signs	ALL	Rural	0.95	0.95	0.95	0.95	6	-	Two-Lane Undivided Highway	No Dynamic Speed Feedback Sign Present	CMF ID: 6885
	Flatten Horizontal Curve	ALL	Rural	▲	▲	▲	▲	20	-	Horizontal Curve on Two-Lane Undivided Highway	Please use the Existing Horizontal Curve Geometry Tab to Calculate the CMFs	CMF ID: 9271, 9272
	Implement High-Friction Surface Treatment on Horizontal Curve	ALL	-	0.759	0.759	0.759	0.759	10	-	Horizontal Curve on Non-Freeway Segment	Horizontal Curve with Standard Pavement	CMF ID: 7900
	Increase Stopping Sight Distance on Crest Vertical Curve	ALL	Rural	0.76	0.76	0.76	0.82	20	-	Crest Vertical Curve on Two-Lane Highway	Crest Vertical Curve with Inadequate Sight Distance	CMF ID: 6868, 6869
	Pave Unpaved Shoulder	ALL	Rural	0.97	0.97	0.97	0.97	20	-	Two-Lane Undivided Rural Highway	Unpaved Shoulder	HSM Eqn 10-12, Table 10-9 and 10-10
	Pavement Resurfacing - Rural	ALL	Rural	1.03	1.03	1.03	1.03	10	-	Two-Lane Undivided Highway	Old Pavement	CMF ID: 5626
	Pavement Resurfacing - Urban	ALL	Urban	0.894	0.894	0.894	0.929	10	Principal Arterial - Other	Non-Freeway Segment	Old Pavement	CMF ID: 9289, 9290
	Prohibit On-Street Parking	ALL	Urban	0.78	0.78	0.78	0.72	20	Principal Arterial - Other	Urban Arterial with Street Parking	On-Street Parking Allowed	CMF ID: 4574, 4575
	Remove or Relocate Fixed Object Outside of Clear Zone	CFO	-	0.62	0.62	0.62	0.62	20	-	Non-Freeway Segment	Fixed Object within Clear Zone	CMF ID: 1024, 1044
	Road Diet (4U to 3T)	ALL	Urban	0.71	0.71	0.71	0.71	20	Minor Arterial	4-Lane Undivided Highway	4-Lane Cross-Section	CMF ID: 199

■ *Please go to* ***https://www.fhwa.dot.gov/publications/research/safety/99207/appd.cfm*** *for a description of RHR ratings.*

Table 1 Virginia State Preferred CMF List **(cont)**

	COUNTERMEASURE	CRASH TYPE	AREA TYPE	K	A	BC	O	SERVICE LIFE	FUNCTIONAL CLASS	SITE DESCRIPTION	PRIOR CONDITION	REFERENCE
SEGMENTS (NON-FREEWAY)	Upgrade Chevrons with Flourescent Sheeting	Night time	Rural	0.65	0.65	0.65	0.65	6	-	Horizontal Curve on Rural Two-Lane Undivided Highway	No Signs Present, Signs with No Fluorescent Sheeting, or Dirty Signs Present	CMF ID: 2434
	Upgrade Pavement Markings by Increasing Retroreflectivity	Night time	-	0.81	0.81	0.81	0.81	2	-	Non-Freeway Segment	Edgeline, Centerline, and Skip Line Pavement Markings with Low Retroreflectivity	CMF ID: 2116, 2117, 2120
	Upgrade Pavement Markings to Wet-Reflective Pavement Markings	ALL	-	0.881	0.881	0.881	1.032	2	Principal Arterial - Other Freeways and Expressways	Non-Freeway Segment	Traditional Pavement Markings	CMF ID: 8093, 8134
	Widen Clear Zone	ALL	Rural	0.78	0.78	0.78	0.78	20	-	Rural Two-Lane Highway	Rural Two-Lane Highway with Narrow Clear Zone	CMF ID: 35
	Widen Lane	ALL	Rural	0.87	0.87	0.87	0.87	20	-	Two-Lane Undivided Highway	Narrow Lane Width	HSM Table 10-8, Eqn 10-11
	Widen Average Shoulder Width	HO, CFO, O, S	Rural	▲	▲	▲	▲	20	-	Two-Lane Undivided Highway	Existing Shoulder Width	HSM 10-9

Table 2 CMFunction Equations

	COUNTERMEASURE	K	A	BC	O	UNITS
INTERCHANGE	Lengthen Acceleration Lane from X Miles to Y Miles	$e^{-4.55*[Y-X]}$	$e^{-4.55*[Y-X]}$	$e^{-4.55*[Y-X]}$	$e^{-2.59*[Y-X]}$	Miles
	Widen Ramp Lane Width from X to Y in Feet	$e^{0.0458*[X-Y]}$	$e^{0.0458*[X-Y]}$	$e^{0.0458*[X-Y]}$	1	Feet
	Widen Ramp Left Shoulder X Feet to Y Feet	$e^{0.0539*[X-Y]}$	$e^{0.0539*[X-Y]}$	$e^{0.0539*[X-Y]}$	$e^{0.0259*[X-Y]}$	Feet
	Widen Ramp Right Shoulder X Feet to Y Feet	$e^{0.0539*[X-Y]}$	$e^{0.0539*[X-Y]}$	$e^{0.0539*[X-Y]}$	$e^{0.0259*[X-Y]}$	Feet
INTERSECTION	Change Number of Approaches with Left-Turn Lanes from X Approaches to Y Approaches	0.90^{Y-X}	0.90^{Y-X}	0.90^{Y-X}	0.90^{Y-X}	Approaches
	Change Number of Approaches with Prohibited Right Turn on Red from X Approaches to Y Approaches	0.98^{Y-X}	0.98^{Y-X}	0.98^{Y-X}	0.98^{Y-X}	Approaches
	Change Number of Approaches with Right-Turn Lanes from X Approaches to Y Approaches	0.96^{Y-X}	0.96^{Y-X}	0.96^{Y-X}	0.96^{Y-X}	Approaches
	Change Number of Cycles per Hour from X Cycles per Hour to Y Cycles per Hour	$e^{-0.0444*[Y-X]}$	$e^{-0.0444*[Y-X]}$	$e^{-0.0444*[Y-X]}$	$e^{-0.0444*[Y-X]}$	Cycles per Hour
	Change Number of Uncontrolled Approaches with Left-Turn Lanes from X Approaches to Y Approaches at 4-Leg Intersection	0.72^{Y-X}	0.72^{Y-X}	0.72^{Y-X}	0.72^{Y-X}	Approaches
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Intersection of Rural, Multilane Highway	0.77^{Y-X}	0.77^{Y-X}	0.77^{Y-X}	0.77^{Y-X}	Approaches
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Intersection of Rural, Two-Lane Roads	0.86^{Y-X}	0.86^{Y-X}	0.86^{Y-X}	0.86^{Y-X}	Approaches
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Urban or Suburban Arterial Intersection	0.86^{Y-X}	0.86^{Y-X}	0.86^{Y-X}	0.86^{Y-X}	Approaches
	Increase Intersection Sight Distance from X Feet of Available Sight Distance to Y Feet	$e^{195.791*[1/Y-1/X]}$	$e^{195.791*[1/Y-1/X]}$	$e^{195.791*[1/Y-1/X]}$	$e^{203.368*[1/Y-1/X]}$	Feet

Table 2 CMFunction Equations **(cont)**

	COUNTERMEASURE	K	A	BC	O	UNITS
INTERSECTION	Reduce Intersection Skew from X to Y - 3 Leg Intersection	$e^{0.004*[Y-X]}$	$e^{0.004*[Y-X]}$	$e^{0.004*[Y-X]}$	$e^{0.004*[Y-X]}$	Degrees of Skew
	Reduce Intersection Skew from X to Y - 4 Leg Intersection	$e^{0.0054*[Y-X]}$	$e^{0.0054*[Y-X]}$	$e^{0.0054*[Y-X]}$	$e^{0.0054*[Y-X]}$	Degrees of Skew
	Convert Two Offset T-Intersection, Offset by X Miles, to 4-Leg Signalized Intersection with Major Road AADT	$\frac{0.05-0.005*\ln(AADT)}{x}+0.322$ / $\frac{2*(0.05-0.005*\ln(AADT))}{x}+0.322$	$\frac{0.05-0.005*\ln(AADT)}{x}+0.322$ / $\frac{2*(0.05-0.005*\ln(AADT))}{x}+0.322$	$\frac{0.05-0.005*\ln(AADT)}{x}+0.322$ / $\frac{2*(0.05-0.005*\ln(AADT))}{x}+0.322$	$\frac{0.05-0.005*\ln(AADT)}{x}+0.322$ / $\frac{2*(0.05-0.005*\ln(AADT))}{x}+0.322$	X-MIles AADT-Vehicles per Day
SEGMENTS (FREEWAY)	Widen Clear Zone from X Feet to Y Feet	$e^{0.00451*[X-Y]}$	$e^{0.00451*[X-Y]}$	$e^{0.00451*[X-Y]}$	1	Feet
	Widen Median from X Feet to Y Feet	$e^{0.131*[1/Y-1/X]}$	$e^{0.131*[1/Y-1/X]}$	$e^{0.131*[1/Y-1/X]}$	$e^{0.169*[1/Y-1/X]}$	Feet
	Widen Paved Inside Shoulder from X Feet to Y Feet	$e^{0.0172*[X-Y]}$	$e^{0.0172*[X-Y]}$	$e^{0.0172*[X-Y]}$	$e^{0.0153*[X-Y]}$	Feet
	Widen Paved Outside Shoulder on Horizontal Curve from X Feet to Y Feet	$e^{0.0897*[X-Y]}$	$e^{0.0897*[X-Y]}$	$e^{0.0897*[X-Y]}$	$e^{0.0840*[X-Y]}$	Feet
	Widen Paved Outside Shoulder on Horizontal Tangent from X Feet to Y Feet	$e^{0.0647*[X-Y]}$	$e^{0.0647*[X-Y]}$	$e^{0.0647*[X-Y]}$	1	Feet
	Change Driveway Density (Driveways/Mile) from X to Y	$e^{0.0152*[Y-X]}$	$e^{0.0152*[Y-X]}$	$e^{0.0152*[Y-X]}$	$e^{0.0232*[Y-X]}$	Driveways per Mile
	Change Roadside Hazard Rating from X to Y by Flattening Roadside Slope	$e^{0.0668*[Y-X]}$	$e^{0.0668*[Y-X]}$	$e^{0.0668*[Y-X]}$	$e^{0.0668*[Y-X]}$	Roadside Hazard Rating ■
	Change Superelevation Variance from X to Y (if Variance Between 0.01 and 0.02)	$\frac{1+6*[Y-0.01]}{1+6*[x-0.01]}$	$\frac{1+6*[Y-0.01]}{1+6*[x-0.01]}$	$\frac{1+6*[Y-0.01]}{1+6*[x-0.01]}$	$\frac{1+6*[Y-0.01]}{1+6*[x-0.01]}$	Feet per Foot
	Change Superelevation Variance from X to Y (if Variance Greater than 0.02)	$\frac{1.06+3*[Y-0.02]}{1.06+3*[x-0.02]}$	$\frac{1.06+3*[Y-0.02]}{1.06+3*[x-0.02]}$	$\frac{1.06+3*[Y-0.02]}{1.06+3*[x-0.02]}$	$\frac{1.06+3*[Y-0.02]}{1.06+3*[x-0.02]}$	Feet per Foot

■ *Please go to* ***https://www.fhwa.dot.gov/publications/research/safety/99207/appd.cfm*** *for a description of RHR ratings.*

Table 3 References

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
BIKE/PED	Add Crosswalk	FHWA Safety Report	*https://safety.fhwa.dot.gov/provencountermeasures/ped_medians/*	-
	Add Crosswalk Lighting	CMF ID: 441, 2379	*http://www.cmfclearinghouse.org/detail.cfm?facid=441*	*http://www.cmfclearinghouse.org/detail.cfm?facid=2379*
	Add Curb Extensions/Corner Bulb Outs	NYC Study	*http://onlinepubs.trb.org/Onlinepubs/circulars/ec019/Ec019_i3.pdf*	-
	Add Median Pedestrian Island	PED CMF Toolbox	*https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa18041/fhwasa18041.pdf*	-
	Add or Upgrade Sidewalk	PED CMF Toolbox	*https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa18041/fhwasa18041.pdf*	-
	Add Pedestrian Bridge	PED CMF Toolbox	*https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa18041/fhwasa18041.pdf*	-
	Add PHB	CMF ID: 9020	*http://www.cmfclearinghouse.org/detail.cfm?facid=9020*	-
	Add PHB, Advanced Yield/Stop Markings	CMF ID: 9021	*http://www.cmfclearinghouse.org/detail.cfm?facid=9021*	-
	Add Pedestrian Signal Heads	CMF ID: 8480, 8481	*http://www.cmfclearinghouse.org/detail.cfm?facid=8480*	*http://www.cmfclearinghouse.org/detail.cfm?facid=8481*
	Add RRFB	CMF ID: 9024	*http://www.cmfclearinghouse.org/detail.cfm?facid=9024*	-
	Add Shared Use Path	CMF ID: 4102	*http://www.cmfclearinghouse.org/detail.cfm?facid=4102*	-
	Change Pedestrian Phase to Barnes Dance	CMF ID: 4117	*http://www.cmfclearinghouse.org/detail.cfm?facid=4117*	-
	Convert from Walk/Don't Walk to Pedestrian Countdown	CMF ID: 5272	*http://www.cmfclearinghouse.org/detail.cfm?facid=5272*	-
	Convert Mid-Block Crossing to HAWK	CMF ID: 9020	*http://www.cmfclearinghouse.org/detail.cfm?facid=9020*	-
	Convert Standard Crosswalk Pavement Marking to High-Visibility Crosswalk	CMF ID: 2697	*http://www.cmfclearinghouse.org/detail.cfm?facid=2697*	-
	Implement Leading Pedestrian Interval	CMF ID: 1993	*http://www.cmfclearinghouse.org/detail.cfm?facid=1993*	-
	Install PHB or HAWK with Advanced Stop or Yield Markings and Signs	CMF ID: 9021	*http://www.cmfclearinghouse.org/detail.cfm?facid=9021*	-

Table 3 References **(cont)**

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
BIKE/PED	Install Raised Pedestrian Crossing	PED CMF Toolbox	https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa18041/fhwasa18041.pdf	-
	Prohibit Left Turns	Ped CMF Toolbox	https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa18041/fhwasa18041.pdf	-
	Remove Parking Near Intersection	PED CMF Toolbox	https://safety.fhwa.dot.gov/ped_bike/tools_solve/fhwasa18041/fhwasa18041.pdf	-
	Upgrade Crosswalk to High-Visibility	CMF ID: 4658	http://www.cmfclearinghouse.org/detail.cfm?facid=4658	-
	Widen Sidewalk at Intersection	CMF ID: 413	http://www.cmfclearinghouse.org/detail.cfm?facid=413	-
INTERCHANGE	Add Auxiliary Lane Between Entrance and Exit Ramps	CMF ID: 7440, 7441	http://www.cmfclearinghouse.org/detail.cfm?facid=7440	http://www.cmfclearinghouse.org/detail.cfm?facid=7441
	Add Collector-Distributor Road	ISATe, HSM Chapters 18 and 19	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	-
	Add Entrance Ramp to One Side of Freeway	ISATe, HSM Chapters 18 and 19	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	-
	Add Exit Ramp to One Side of Freeway	ISATe, HSM Chapters 18 and 19	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	-
	Convert Diamond Interchange to Diverging Diamond Interchange	CMF ID: 8258, 8278	http://www.cmfclearinghouse.org/detail.cfm?facid=8258	http://www.cmfclearinghouse.org/detail.cfm?facid=8278
	Convert Diamond Interchange to SPUI	VDOT Planning Level CMFs	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	-
	Extend Deceleration Lane Length by 100 Feet	CMD ID: 475	http://www.cmfclearinghouse.org/detail.cfm?facid=475	-
	Interchange Lighting	CMF ID: 1283	http://www.cmfclearinghouse.org/detail.cfm?facid=1283	-
	Lengthen Acceleration Lane from X Miles to Y Miles	CMF ID: 5215, 5216	http://www.cmfclearinghouse.org/detail.cfm?facid=5215	http://www.cmfclearinghouse.org/detail.cfm?facid=5216
	Replace Loop Ramp with Short Direct Ramp	CMF ID: 480	http://www.cmfclearinghouse.org/detail.cfm?facid=480	-
	Widen Ramp Lane Width from X to Y in Feet	HSM Eqn 19-34	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	-
	Widen Ramp Left Shoulder	HSM Eqn 19-36	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	-
	Widen Ramp Right Shoulder	HSM Eqn 19-35	http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf	-

Table 3 References **(cont)**

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
INTERSECTION	Install Intersection Lighting	**CMF ID: 4462**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4462*	-
	Increase Stopping Sight Distance on Crest Vertical Curve-Intersection Approach	**CMF ID: 6870, 6871**	*http://www.cmfclearinghouse.org/detail.cfm?facid=6870*	*http://www.cmfclearinghouse.org/detail.cfm?facid=6871*
	Add Flashing Lights to RR Crossings with Signs	**CMF ID: 487**	*http://www.cmfclearinghouse.org/detail.cfm?facid=487*	-
	Add Gates to RR Crossings with Signs	**CMF ID: 489**	*http://www.cmfclearinghouse.org/detail.cfm?facid=489*	-
	Adaptive Signal Control	**CMF ID: 6856, 6857**	*http://www.cmfclearinghouse.org/detail.cfm?facid=6856*	*http://www.cmfclearinghouse.org/detail.cfm?facid=6857*
	Add 3-Inch Yellow Retroreflective Sheeting to Signal Backplates	**CMF ID: 1410**	*http://www.cmfclearinghouse.org/detail.cfm?facid=1410*	-
	Advanced Activated/Dynamic Flasher	**CMF ID: 4198, 4201**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4198*	*http://www.cmfclearinghouse.org/detail.cfm?facid=4201*
	Advanced Cross Street Name Sign	**CMF ID: 2449, 2450**	*http://www.cmfclearinghouse.org/detail.cfm?facid=2449*	*http://www.cmfclearinghouse.org/detail.cfm?facid=2450*
	Advanced Dilemma Zone Detection	**CMF ID: 4855, 4857**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4855*	*http://www.cmfclearinghouse.org/detail.cfm?facid=4857*
	Change from Permissive Left-Turn to Flashing Yellow Arrow	**CMF ID: 4175**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4175*	-
	Change from Permitted Left-Turn to Permitted/Protected	**CMF ID: 4270**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4270*	-
	Change from Permitted Left-Turn to Protected on Major Approach	**CMF ID: 335**	*http://www.cmfclearinghouse.org/detail.cfm?facid=335*	-
	Change from Permitted/Protected Left-Turn to Protected on Major Approach	**CMF ID: 339**	*http://www.cmfclearinghouse.org/detail.cfm?facid=339*	-
	Change from Permitted/Protected Left-Turn to Protected on Minor Approach	**CMF ID: 337**	*http://www.cmfclearinghouse.org/detail.cfm?facid=337*	-
	Change from Pretimed Signal to Actuated Signal	**NCDOT CRF List 1.6**	*https://connect.ncdot.gov/resources/safety/TrafficSafetyResources/NCDOT%20CRF%20Update.pdf*	-
	Change from Protected Left-Turn to Flashing Yellow Arrow	**CMF ID: 4173**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4173*	-
	Change from Protected/Permissive Left-Turn to Flashing Yellow Arrow	**CMF ID: 4177**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4177*	-
	Change Number of Approaches with Left-Turn Lanes from X Approaches to Y Approaches	**HSM**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-

Table 3 References **(cont)**

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
INTERSECTION	Change Number of Approaches with Prohibited Right Turn on Red from X Approaches to Y Approaches	**CMF ID: 5194**	*http://www.cmfclearinghouse.org/detail.cfm?facid=5194*	-
	Change Number of Approaches with Right-Turn Lanes from X Approaches to Y Approaches	**HSM Table 10-14, 12-26**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Change Number of Cycles per Hour from X Cycles per Hour to Y Cycles per Hour	**CMF ID: 3072**	*http://www.cmfclearinghouse.org/detail.cfm?facid=3072*	-
	Channelize Right Turn	**FHWA CMF Desktop Reference Guide**	*http://www.cmfclearinghouse.org/collateral/FHWA_Desktop_Reference_Guide.pdf*	-
	Closed Loop Signal System	**NCDOT CRF List 1.7**	*https://connect.ncdot.gov/resources/safety/TrafficSafetyResources/NCDOT%20CRF%20Update.pdf*	-
	Convert from Pedestal-Mounted Traffic Signal to Mast Arm-Mounted Traffic Signal	**CMF ID: 1424, 1425**	*http://www.cmfclearinghouse.org/detail.cfm?facid=1424*	*http://www.cmfclearinghouse.org/detail.cfm?facid=1425*
	Convert from Span Wire-Mounted Traffic Signal to Mast Arm-Mounted Traffic Signal	**UVA Khattak and Fontaine Study**	*https://journals.sagepub.com/doi/abs/10.1177/0361198118768525*	-
	Convert to LED Signal Heads - 3-Leg Intersection	**UVA CMF**	*Gonzales, D. "LED Signal Head and Traffic Signal Backplate Countermeasure Effectiveness in Virginia." Semester Project, CEE 6450. Unviersity of Virginia. 2017*	-
	Convert to LED Signal Heads - 4-Leg Intersection	**UVA CMF**	*Gonzales, D. "LED Signal Head and Traffic Signal Backplate Countermeasure Effectiveness in Virginia." Semester Project, CEE 6450. Unviersity of Virginia. 2017*	-
	Extend Left-Turn Lane	**FHWA Desktop Reference**	*http://www.cmfclearinghouse.org/collateral/FHWA_Desktop_Reference_Guide.pdf*	-
	Extend Right-Turn Lane	**FHWA Desktop Reference**	*http://www.cmfclearinghouse.org/collateral/FHWA_Desktop_Reference_Guide.pdf*	-
	Increase All-Red Clearance Interval	**CMF ID: 4211, 4212**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4211*	*http://www.cmfclearinghouse.org/detail.cfm?facid=4212*
	Increase Left-Turn Lane Offset	**CMF ID: 6095, 6096**	*http://www.cmfclearinghouse.org/detail.cfm?facid=6095*	*http://www.cmfclearinghouse.org/detail.cfm?facid=6096*
	Increase Yellow Change Interval by 1 Second	**CMF ID:4207, 4208**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4207*	*http://www.cmfclearinghouse.org/detail.cfm?facid=4208*
	Install Red-Light Camera	**CMF ID: 6876, 6877**	*http://www.cmfclearinghouse.org/detail.cfm?facid=6876*	*http://www.cmfclearinghouse.org/detail.cfm?facid=6877*
	Offset Right-Turn Lane	**N/A**	*N/A*	-
	Permit Right Turn on Red	**CMF ID: 4580**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4580*	-

Table 3 References **(cont)**

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
INTERSECTION	Replace 8-inch Signal Heads with 12-inch Signal Heads	**CMF ID: 2334**	*http://www.cmfclearinghouse.org/detail.cfm?facid=2334*	-
	Retroreflective Backplates and LED Signal Heads	**UVA CMFs**	*Gonzales, D. "LED Signal Head and Traffic Signal Backplate Countermeasure Effectiveness in Virginia." Semester Project, CEE 6450. Unviersity of Virginia. 2017*	-
	Add Left-Turn Lane to Major Approach of 3-Leg Stop-Controlled Intersection	**HSM Table 11-22**	*http://www.trb.org/Publications/Blurbs/159935.aspx*	-
	Change Number of Uncontrolled Approaches with Left-Turn Lanes from X Approaches to Y Approaches at 4-Leg Intersection	**HSM Table 10-13**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Intersection of Rural, Multilane Highway	**HSM Table 11-23**	*http://www.trb.org/Publications/Blurbs/159935.aspx*	-
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Intersection of Rural, Two-Lane Roads	**HSM Table 10-14**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Change Number of Uncontrolled Approaches with Right-Turn Lanes from X to Y at Urban or Suburban Arterial Intersection	**HSM Table 12-26**	*https://www.nap.edu/catalog/23084/methodology-to-predict-the-safety-performance-of-urban-and-suburban-arterials*	-
	High-Friction Surface Treatment on Approach	**CMF ID: 2259**	*http://www.cmfclearinghouse.org/detail.cfm?facid=2259*	-
	Increase Intersection Sight Distance from X Feet of Available Sight Distance to Y Feet	**NCHRP 17-59, Report 875**	*http://www.trb.org/Publications/Blurbs/177421.aspx*	-
	Intersection Collision Warning System	**CMF ID: 8474, 8475**	*http://www.cmfclearinghouse.org/detail.cfm?facid=8474*	*http://www.cmfclearinghouse.org/detail.cfm?facid=8475*
	Reduce Intersection Skew from X to Y - 3 Leg Intersection	**HSM Equation: 10-22**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Reduce Intersection Skew from X to Y - 4 Leg Intersection	**HSM Equation: 10-23**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Systemic Signage and Pavement Marking Improvements	**FHWA Proven Safety Counter- measures**	*https://safety.fhwa.dot.gov/provencountermeasures/syst_stop_control/*	-
	Transverse Rumble Strips	**CMF ID: 2707, 2708**	*http://www.cmfclearinghouse.org/detail.cfm?facid=2707*	*http://www.cmfclearinghouse.org/detail.cfm?facid=2708*
	Add Quadrant Roadway to Intersection	**N/A**	*N/A*	-
	Convert 3-Leg Signalized Intersection to Continuous Green T-Intersection	**CMF ID: 8655, 8656**	*http://www.cmfclearinghouse.org/detail.cfm?facid=8655*	*http://www.cmfclearinghouse.org/detail.cfm?facid=8656*

Table 3 References **(cont)**

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
INTERSECTION	Convert At-Grade Intersection to Interchange	**CMF ID: 459, 460, 461**	*http://www.cmfclearinghouse.org/detail.cfm?facid=459*	*http://www.cmfclearinghouse.org/detail.cfm?facid=460 | http://www.cmfclearinghouse.org/detail.cfm?facid=461*
	Convert 4-Leg Intersection to Two Offset T-Intersections	**HSM CMF: Table 14-2**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Convert Minor Stop-Controlled to All-Way Stop Controlled	**CMF ID: 3127, 3128**	*http://www.cmfclearinghouse.org/detail.cfm?facid=3127*	*http://www.cmfclearinghouse.org/detail.cfm?facid=3128*
	Convert Signalized Intersection to Roundabout	**CMF ID: 225, 226**	*http://www.cmfclearinghouse.org/detail.cfm?facid=225*	*http://www.cmfclearinghouse.org/detail.cfm?facid=226*
	Convert Stop-Controlled Intersection to Roundabout	**CMF ID: 227, 228**	*http://www.cmfclearinghouse.org/detail.cfm?facid=227*	*http://www.cmfclearinghouse.org/detail.cfm?facid=228*
	Convert Stop-Controlled Intersection to Signalized Intersection	**CMF ID: 7983, 7986**	*http://www.cmfclearinghouse.org/detail.cfm?facid=7983*	*http://www.cmfclearinghouse.org/detail.cfm?facid=7986*
	Convert to Displaced Left-Turn Intersection	**FHWA TechBrief**	*https://safety.fhwa.dot.gov/provencountermeasures/reduced_left/*	-
	Convert to J-Turn Intersection	**CMF ID: 5555, 5556**	*http://www.cmfclearinghouse.org/detail.cfm?facid=5555*	*http://www.cmfclearinghouse.org/detail.cfm?facid=5556*
	Convert to Median U-Turn Intersection	**FHWA TechBrief**	*https://safety.fhwa.dot.gov/provencountermeasures/reduced_left/*	-
	Convert to Signalized Intersection to Signalized RCUT	**FHWA Report**	*https://www.fhwa.dot.gov/publications/research/safety/17082/17082.pdf*	-
	Convert to Signalized Intersection to Unsignalized RCUT	**N/A**	*N/A*	-
	Convert to Unsignalized Intersection to Unsignalized RCUT	**CMF ID: 4883, 4884**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4883*	*http://www.cmfclearinghouse.org/detail.cfm?facid=4884*
	Convert Two Offset T-Intersection, Offset by X Miles, to T-Intersection with Major Road AADT	**HSM Eqn 10-17**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Convert Unsignalized Intersection to Unsignalized Superstreet Intersection	**CMF ID: 4883, 4884**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4883*	*http://www.cmfclearinghouse.org/detail.cfm?facid=4884*
	Interim Roundabout	**CMF ID: 3127, 3128**	*http://www.cmfclearinghouse.org/detail.cfm?facid=3127*	*http://www.cmfclearinghouse.org/detail.cfm?facid=3128*
	Remove Unwarranted Signal	**CMF ID: 332**	*http://www.cmfclearinghouse.org/detail.cfm?facid=322*	-
	Temporary Traffic Circle	**N/A**	*N/A*	-

Table 3 References **(cont)**

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
SEGMENTS (FREEWAY)	Active Traffic Management with Hard Shoulder Running	**UVA Study**	*Boateng, R.A. "Evaluation of the Safety Effects of Active Traffic Management System on I-66 in Northern Virginia". Semester Project, CEE 6450. Unviersity of Virginia. 2017*	-
	Active Traffic Management without Hard Shoulder Running	**UVA Study**	*Boateng, R.A. "Evaluation of the Safety Effects of Active Traffic Management System on I-66 in Northern Virginia". Semester Project, CEE 6450. Unviersity of Virginia. 2017*	-
	Add Cable Median Barrier	**CMF ID: 1966**	*http://www.cmfclearinghouse.org/detail.cfm?facid=1966*	-
	Add Rumble Strips to Inside Shoulder	**HSM Eqn 18-36**	*http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf*	-
	Add Median Concrete Barrier	**CMF ID: 2256**	*http://www.cmfclearinghouse.org/detail.cfm?facid=2256*	-
	Add Median Guardrail	**CMF ID: 51**	*http://www.cmfclearinghouse.org/detail.cfm?facid=51*	-
	Add Rumble Strips to Outside Shoulder	**HSM Eqn 18-36**	*http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf*	-
	Add Raised Pavement Markers	**CMF ID: 5498**	*http://www.cmfclearinghouse.org/detail.cfm?facid=5498*	-
	Add Roadside Guardrail	**CMF ID: 8391, 8392, 8393**	*http://www.cmfclearinghouse.org/detail.cfm?facid=8391*	*http://www.cmfclearinghouse.org/detail.cfm?facid=8392*
	Implement Incident Management to Reduce Average Duration Time	**VA Planning Level CMFs**	*http://vasmartscale.org/documents/ss_planning_level_cmfs_092116.pdf*	-
	Implement Variable Speed Limits	**CMF ID: 8730, 8731**	*http://www.cmfclearinghouse.org/detail.cfm?facid=8730*	*http://www.cmfclearinghouse.org/detail.cfm?facid=8731*
	Rural: Widen from 4 Lanes to 6 Lanes	**VDOT SPFs, Crash Rate Ratios**	*http://vasmartscale.org/documents/ss_planning_level_cmfs_092116.pdf*	-
	Upgrade Horizontal Curve Signage	**CMF ID: 2431, 2433**	*http://www.cmfclearinghouse.org/detail.cfm?facid=2431*	*http://www.cmfclearinghouse.org/detail.cfm?facid=2433*

Table 3 References **(cont)**

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
SEGMENTS (FREEWAY)	Upgrade Pavement Markings to Wet-Reflective Pavement Markings	**CMF ID: 8093, 8134**	*http://www.cmfclearinghouse.org/detail.cfm?facid=8093*	*http://www.cmfclearinghouse.org/detail.cfm?facid=8134*
	Upgrade Roadside Guardrail	**Desktop Reference Guide**	*http://www.cmfclearinghouse.org/collateral/FHWA_Desktop_Reference_Guide.pdf*	-
	Urban: Widen from 4 Lanes to 6 Lanes	**VDOT SPFs, Crash Rate Ratios**	*http://vasmartscale.org/documents/ss_planning_level_cmfs_092116.pdf*	-
	Urban: Widen from 4 Lanes to 8+ Lanes	**VDOT SPFs, Crash Rate Ratios**	*http://vasmartscale.org/documents/ss_planning_level_cmfs_092116.pdf*	-
	Urban: Widen from 6 Lanes to 8+ Lanes	**VDOT SPFs, Crash Rate Ratios**	*http://vasmartscale.org/documents/ss_planning_level_cmfs_092116.pdf*	-
	Widen Clear Zone from X Feet to Y Feet	**HSM Eqn 18-38**	*http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf*	-
	Widen Median from X Feet to Y Feet	**HSM Equation 18-27**	*http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf*	-
	Widen Paved Inside Shoulder from X Feet to Y Feet	**HSM Eqn 18-26**	*http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf*	-
	Widen Paved Outside Shoulder on Horizontal Curve from X Feet to Y Feet	**HSM Eqn 18-35 and Table 18-21**	*http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf*	-
	Widen Paved Outside Shoulder on Horizontal Tangent from X Feet to Y Feet	**HSM Eqn 18-35 and Table 18-21**	*http://onlinepubs.trb.org/onlinepubs/nchrp/docs/nchrp17-45_fr.pdf*	-
SEGMENTS (NON-FREEWAY)	Add Automated Speed Enforcement Cameras	**CMF ID: 2688, 4583**	*http://www.cmfclearinghouse.org/detail.cfm?facid=2688*	*http://www.cmfclearinghouse.org/detail.cfm?facid=4583*
	Add Auxiliary Passing Lane	**CMF ID: 9111, 9112**	*http://www.cmfclearinghouse.org/detail.cfm?facid=9111*	*http://www.cmfclearinghouse.org/detail.cfm?facid=9112*
	Add Centerline Rumble Strips (Including Sinusoidal/Mumble)	**CMF ID: 3355, 3360**	*http://www.cmfclearinghouse.org/detail.cfm?facid=3355*	*http://www.cmfclearinghouse.org/detail.cfm?facid=3360*

Table 3 References **(cont)**

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
SEGMENTS (NON-FREEWAY)	Add Chevron Signs at Horizontal Curves	**CMF ID: 2439**	*http://www.cmfclearinghouse.org/detail.cfm?facid=2439*	-
	Add Chevron Signs, Curve Warning Signs, and Sequential Flashing Beacons	**CMF ID: 1852**	*http://www.cmfclearinghouse.org/detail.cfm?facid=1852*	-
	Add Raised Pavement Markers	**CMF ID: 5496**	*http://www.cmfclearinghouse.org/detail.cfm?facid=5496*	-
	Add Safety Edge	**FHWA Proven Safety Countermeasures**	*https://safety.fhwa.dot.gov/provencountermeasures/safety_edge/*	-
	Add Segment Lighting	**CMF ID: 7781, 7782**	*http://www.cmfclearinghouse.org/detail.cfm?facid=7781*	*http://www.cmfclearinghouse.org/detail.cfm?facid=7782*
	Add Shoulder Rumble Strips (Including Sinusoidal/Mumble)	**CMF ID: 3442, 3447**	*http://www.cmfclearinghouse.org/detail.cfm?facid=3442*	*http://www.cmfclearinghouse.org/detail.cfm?facid=3447*
	Add Two-Way Left-Turn Lane (2U to 3T)	**CMF ID: 2341, 2346**	*http://www.cmfclearinghouse.org/detail.cfm?facid=2341*	*http://www.cmfclearinghouse.org/detail.cfm?facid=2346*
	Add Two-Way Left-Turn Lane (4U to 5T)	**CMF ID: 4084**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4084*	-
	Breakaway Supports for Utility Poles in Clear Zones	**HSM Eqn 10-20**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Change 4” Wide Edgelines to 6” Wide Edgelines	**CMF ID: 4737, 4738**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4737*	*http://www.cmfclearinghouse.org/detail.cfm?facid=4738*
	Change Driveway Density (Driveways/Mile) from X to Y	**CMF ID: 1973, 2248**	*http://www.cmfclearinghouse.org/detail.cfm?facid=1973*	*http://www.cmfclearinghouse.org/detail.cfm?facid=2248*
	Change Roadside Hazard Rating from X to Y by Flattening Roadside Slope	**HSM Eqn 10-20**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Change Superelevation Variance from X to Y (if Variance Between 0.01 and 0.02)	**HSM Eqn 10-15**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Change Superelevation Variance from X to Y (if Variance Greater than 0.02)	**HSM Eqn 10-16**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Dynamic Speed Feedback Signs	**CMF ID: 6885**	*http://www.cmfclearinghouse.org/detail.cfm?facid=6885*	-

Table 3 References **(cont)**

	COUNTERMEASURE	REFERENCE	REFERENCE/CITATION HYPERLINK #1	REFERENCE/CITATION HYPERLINK #2
SEGMENTS (NON-FREEWAY)	Flatten Horizontal Curve	**CMF ID: 9271, 9272**	*http://www.cmfclearinghouse.org/detail.cfm?facid=9271*	*http://www.cmfclearinghouse.org/detail.cfm?facid=9272*
	Implement High-Friction Surface Treatment on Horizontal Curve	**CMF ID: 7900**	*http://www.cmfclearinghouse.org/detail.cfm?facid=7900*	-
	Increase Stopping Sight Distance on Crest Vertical Curve	**CMF ID: 6868, 6869**	*http://www.cmfclearinghouse.org/detail.cfm?facid=6868*	*http://www.cmfclearinghouse.org/detail.cfm?facid=6869*
	Pave Unpaved Shoulder	**HSM Eqn 10-12, Table 10-9 and 10-10**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Pavement Resurfacing - Rural	**CMF ID: 5626**	*http://www.cmfclearinghouse.org/detail.cfm?facid=5626*	-
	Pavement Resurfacing - Urban	**CMF ID: 9289, 9290**	*http://www.cmfclearinghouse.org/detail.cfm?facid=9289*	*http://www.cmfclearinghouse.org/detail.cfm?facid=9290*
	Prohibit On-Street Parking	**CMF ID: 4574, 4575**	*http://www.cmfclearinghouse.org/detail.cfm?facid=4574*	*http://www.cmfclearinghouse.org/detail.cfm?facid=4575*
	Remove or Relocate Fixed Object Outside of Clear Zone	**CMF ID: 1024, 1044**	*http://www.cmfclearinghouse.org/detail.cfm?facid=1024*	*http://www.cmfclearinghouse.org/detail.cfm?facid=1044*
	Road Diet (4U to 3T)	**CMF ID: 199**	*http://www.cmfclearinghouse.org/detail.cfm?facid=199*	-
	Upgrade Chevrons with Flourescent Sheeting	**CMF ID: 2434**	*http://www.cmfclearinghouse.org/detail.cfm?facid=2434*	-
	Upgrade Pavement Markings by Increasing Retroreflectivity	**CMF ID: 2116, 2117, 2120**	*http://www.cmfclearinghouse.org/detail.cfm?facid=2116*	*http://www.cmfclearinghouse.org/detail.cfm?facid=2117*
	Upgrade Pavement Markings to Wet-Reflective Pavement Markings	**CMF ID: 8093, 8134**	*http://www.cmfclearinghouse.org/detail.cfm?facid=8093*	*http://www.cmfclearinghouse.org/detail.cfm?facid=8134*
	Widen Clear Zone	**CMF ID: 35**	*http://www.cmfclearinghouse.org/detail.cfm?facid=35*	-
	Widen Lane	**HSM Table 10-8, Eqn 10-11**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-
	Widen Average Shoulder Width	**HSM Table 10-9**	*https://www.fhwa.dot.gov/publications/research/safety/99207/99207.pdf*	-

Appendix I

Previous Studies

Appendix I-1

VDOT Study

COMMONWEALTH of VIRGINIA

DEPARTMENT OF TRANSPORTATION
Culpeper District
Traffic Engineering

Route 743 & Route 660 in Albemarle County
Intersection Safety Evaluation

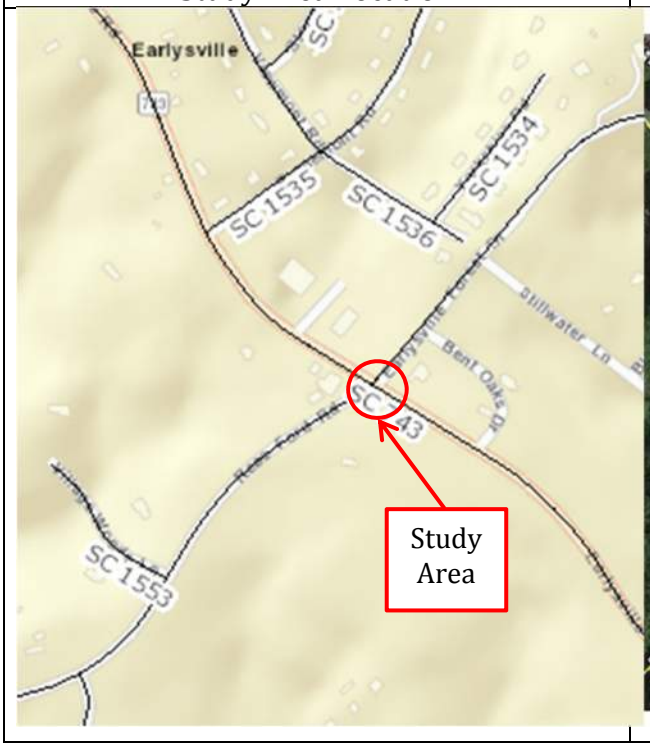
VDOT - Traffic Engineering
Culpeper District
Traffic Engineer

Route: Route 743 (Earlysville Rd) at Route 660 (Reas Ford Rd & Earlysville Forest Dr)
Location: Albemarle County, Virginia
Project Description: Intersection Safety Evaluation
Date: January 5, 2018
Prepared By: Jet R Dienner

Intersection Safety Evaluation
Route 743 and Route 660, Albemarle County

Background

Culpeper District Traffic Engineering was requested by Delegate Rob Bell on behalf of citizens and residents in the area to evaluate safety at the intersection of Route 743 (Earlysville Road) and Route 660 (Reas Ford Road & Earlysville Forest Dr). This intersection has been the subject of several study requests in the past, and this document is intended to provide information and guidance for future improvements as traffic volumes and development increases in this area in the future. Crash data, intersection sight distance, signal warrants, turn lane warrants, and sign and pavement markings were reviewed to identify possible operational and safety improvements. The subject intersection is shown in the study area maps below.

Study Area Location	Study Area Aerial
	

Existing Conditions

Route 743 (Earlysville Road) is a two lane roadway with an additional right turn lane in the northbound direction. It has a functional classification of Urban Collector, with a 2016 AADT of 9,500 vehicles per day, and is posted at 35 MPH within the limits of the study area. Route 660 west of the intersection (Reas Ford Rd) is a two lane roadway with a Rural Major Collector functional classification, a 2016 AADT of 2,000 vehicles per day, and is posted at 35 MPH within the limits of the study area. Route 660 east of the intersection (Earlysville Forest Dr) is a two lane roadway with a Urban Local functional classification, a 2016 AADT of 1,000 vehicles per day, and is posted at 35 MPH within the limits of the study area. Both approaches of Route 743 have appropriate MUTCD compliant advance intersection warning signs. Both approaches of Route 660 are currently stop-controlled at the intersection with appropriate MUTCD compliant "Stop Ahead" signs installed in advance of the intersection. The eastbound approach of Route 660 includes "Stop Ahead" pavement markings.

Crash Analysis

Five years of the most current crash data (June 1, 2012 through June 30, 2017) was examined. During that time frame there were 12 crashes within 300' of the intersection. These crashes included four angle crashes, three left turn crashes, two road departure crashes, and three rear end crashes. Of the twelve crashes, there were three injury crashes resulting in four total injuries. One of the injury crashes was an angle crash resulting in two injuries, one road departure crash resulting in one injury, and the remaining injury came from a rear end crash. See exhibit 1 (of this report) for a detailed crash diagram.

Sight Distance Analysis

Sight Distance is a critical factor that plays into the cause of many angle crashes at an intersection. The AASHTO Green-book states that the Intersection sight distance for a 35 MPH roadway is a distance of 390 feet. The minimum measured sight distance was 420' on the SB approach of Route 660. Left and Right sight distance requirements were exceeded for all approaches of the intersection as shown on the sight distance diagram (exhibit 2 of this report). It was observed that the stop bar on the SB approach can be shifted 8' closer to the edge of travel way, which will increase the sight distance on this approach by 40'+/-.

Signal Warrant Analysis-Methodology

The 2009 Edition of the MUTCD lists various Traffic Signal warrants to analyze in consideration for the installation of a Traffic Signal at intersecting roadways. For this safety study Warrant 1 -- Eight-Hour Vehicular Volume, Warrant 2 -- Four-Hour Vehicular Volume, and Warrant 7 -- Crash Experience, were analyzed to determine if this intersection would meet any of these warrants. Warrant 3 -- Peak Hour was not analyzed as the Peak Hour warrant is applicable only in "unusual cases, such as office complexes, manufacturing plants, industrial complexes, or high-occupancy vehicle facilities that attract or discharge large numbers of vehicles over a short time" (2009 MUTCD, Section 4C.04). Based on the classification of the major route and field observation, the peak hour warrant did not currently apply. Refer to Chapter 4C, "Traffic Control Signal Needs Studies" in the 2009 edition of the MUTCD for detailed descriptions of each traffic signal Warrant criteria. A 12 hour turning movement count was collected on November 14, 2016 from 6:30 AM to 6:30 PM. The data gathered was used to analyze the 8 and 4 hour warrants. Based on the Urban Collector functional classification of Route 743, the close proximity to neighborhoods, and the posted 35 MPH speed limit, urban values were used. PC Warrants software was used to analyze the data (exhibit 3 of this report). It was noted during the 12 hour field observation that minimal delay and queue lengths were observed. The longest observed queue was six vehicles on EB 660. The following summarizes the findings regarding the signal warrant analysis for the study intersection. The current traffic volumes **do not meet eight or four hour signal warrants**. The minor route (Route 660) traffic volumes are 30% below the threshold for meeting eight hour signal Warrant 1A. Results of the signal warrant analysis for the eight and four hour warrants and the crash warrant are below:

Results

Warrant 1, Eight-Hour Vehicular Volume:

Condition A: The minimum vehicular volume is intended for application at locations where a large volume of intersecting traffic is the principal reason to consider installing a traffic control signal. For Route 743, Condition A requires 500 vehicles per hour for any eight hours of the average day; Route 660 is required to carry 150 vehicles per hour for the same eight hours (Table 4C-1) on the highest volume approach. Route 660 carries 124 vehicles in its peak hour with no right turn discount.

Due to the minor street approach volumes, Warrant 1A **is not met**.

Condition B: The interruption of continuous traffic is intended for application at locations where Condition A is not satisfied and where the traffic volume on a major street is so heavy that traffic on a minor intersecting street suffers excessive delay or conflict in entering or crossing the major street. The volumes required for the same eight hours for Route 743 and Route 660 are 750 vehicles per hour and 75 vehicles per hour respectively. Route 743 only carries sufficient volume to meet Condition B for 2 of the counted hours.
Due to lack of sufficient volumes Warrant 1B **is not met**.

Condition C: The combination of conditions A and B is intended for application at location where Condition A is not satisfied and Condition B is not satisfied only after an adequate trial of other alternatives that could cause less delay and inconvenience to traffic has failed to solve the traffic problems. For Condition C, 80% of the volumes in both Condition A and B must be met. Based on current volumes this intersection does not meet this criterion.

Due to lack of sufficient volumes, Warrant 1C **is not met**.

Table 4C-1. Warrant 1, Eight-Hour Vehicular Volume

Condition A—Minimum Vehicular Volume

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	500	400	350	280	150	120	105	84
2 or more	1	600	480	420	336	150	120	105	84
2 or more	2 or more	600	480	420	336	200	160	140	112
1	2 or more	500	400	350	280	200	160	140	112

Condition B—Interruption of Continuous Traffic

Number of lanes for moving traffic on each approach		Vehicles per hour on major street (total of both approaches)				Vehicles per hour on higher-volume minor-street approach (one direction only)			
Major Street	Minor Street	100%[a]	80%[b]	70%[c]	56%[d]	100%[a]	80%[b]	70%[c]	56%[d]
1	1	750	600	525	420	75	60	53	42
2 or more	1	900	720	630	504	75	60	53	42
2 or more	2 or more	900	720	630	504	100	80	70	56
1	2 or more	750	600	525	420	100	80	70	56

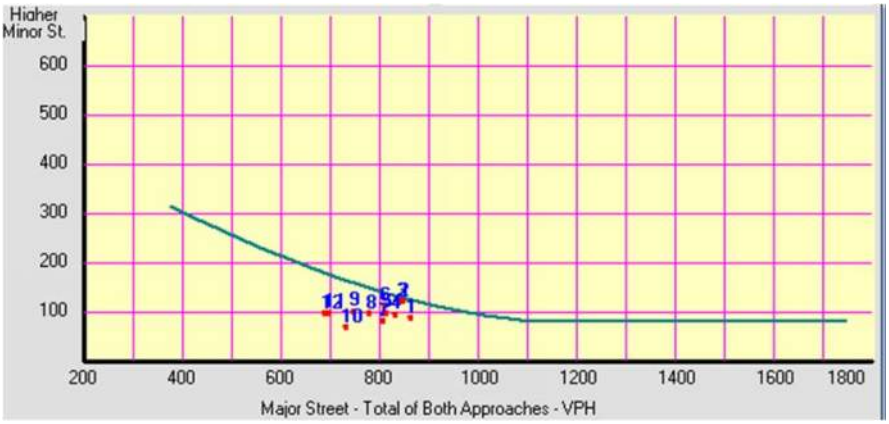
[a] Basic minimum hourly volume
[b] Used for combination of Conditions A and B after adequate trial of other remedial measures
[c] May be used when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000
[d] May be used for combination of Conditions A and B after adequate trial of other remedial measures when the major-street speed exceeds 40 mph or in an isolated community with a population of less than 10,000

Warrant 2, Four-Hour Vehicular Volume

The four hour vehicular volume signal warrant conditions are intended to be applied where the volume of intersecting traffic is the principal reason to consider installing a traffic control signal. Warrant 2 requires that for any four hours of the day the vehicles per hour from the minor street plotted with the total vehicles per hour for the same four hours must fall above the curve shown below. The required minimum volume on Route 660 only met for the required volumes for 1 out of the required 4 hours.

The minor approaches do not have sufficient volume for four hours a day and Warrant 2 **is not met**.

Four-Hour Vehicular Volume Warrant Curve Plot



Warrant 7, Crash Experience

Two correctable crashes (by type) occurred in the most recent year of crash data. In order for the crash warrant to be met, five crashes of a correctable type must occur at the intersection within the 12 month study period, after an adequate trial of alternatives with satisfactory observance and enforcement has failed to reduce the crash frequency. Current district average is one per year. See exhibit 1 (of this report) for a detailed crash diagram.

The two crashes of a correctable type in the intersection within the past 12 months does not meet the five required by the warrant. Warrant 7 **is not met**.

Turn Lane Warrant Analysis-Methodology

Turn Lane Warrants were examined for all approaches per the guidance provided in Appendix F, Section 3 "Turning Lanes" of the VDOT Road Design Manual. These warrants were provided as a part of this report to provide an analysis of how the intersection is functioning operationally, and provide guidance for recommended improvements as traffic volumes and development in the area increases. These analyses are attached as Exhibit 4 of this report. The table below summarizes the results:

TURN LANE WARRANT SUMMARY (L= Storage Lane Length, T=Taper Length)				
	Right Turn Lane/Taper	Right Turn Storage Lane & Taper Length	Left Turn Lane/Taper	Left Turn Storage Lane & Taper Length
Route 743 NB	N/A	Existing	Meets Turn Lane & Taper Warrants	L= 200', T=200'
Route 743 SB	Meets Taper Warrant Only	T=200'	Does not meet warrants	N/A
Route 660 EB	Meets Turn Lane & Taper Warrants	L= 200', T=200'	Does not meet warrants	N/A
Route 660 WB	Does not meet warrants	N/A	Does not meet warrants	N/A

Study Summary and Proposed Recommendations

Upon review of the intersection crash history, existing traffic control devices, daily traffic volumes, and available sight distance, it has been determined that the existing roadway geometrics and traffic control devices are functionally adequate in safely controlling the current volume of traffic at this intersection. While the current crash volumes are relatively low, the study revealed things that can be improved in the short, intermediate, and long-term to improve the safety and functionality of the intersection as traffic volumes and development increases. These results and recommendations are listed below.

Results of the crash data and signal warrants show that a signal is NOT warranted at Route 743 (Earlysville Rd) and Route 660 (Reas Ford Rd & Earlysville Forest Dr). None of the signal warrants, including the crash warrant, were currently met. The current stop signs and advance warning signs are appropriate as installed with no upgrades recommended at the time of this study.

Recommendations have been categorized into short, intermediate and long-term. These are typically defined as follows:

Short Term Recommendations can be generalized as improvements that are low cost, quickly implementable (within a few weeks to a few months), require little or no engineering design, typically require no right-of way, and can be done with state or contractor work forces.

Intermediate Term Recommendations can be generalized as improvements that are low to mid-range in cost, implementable within six months to a couple years, require minimal engineering design, typically require little or no right-of way, and can be implemented partially or in full with state or contractor work forces.

Long Term Recommendations can be generalized as those improvements that are mid to high cost, require planning and design, may take one to six years to implement, typically require right-of way, and are typically implemented through a contract with contractor work forces.

Short Term Recommendations:

- Refresh “Stop Ahead” pavement markings
- Shift WB approach stop bar to improve sight distance
- Refresh EB approach stop bar

The review of the pavement markings and intersection sight distance revealed some things that can be upgraded and improved to improve the overall safety of intersection. The current “Stop Ahead” pavement marking on the eastbound approach of Route 660 are faded and should be refreshed. The transverse white lines prior and after these pavement markings should be removed. The existing stop bar on the WB approach of 660 is currently 16’ from the edge of the travel lane on Route 743. Shifting this stop bar forward 8’ would improve the sight distance left by 40+/-, improving driver reaction/response time and improving safety. See exhibit 5 for the proposed pavement marking plan which includes both of these short term recommendations.

Intermediate Term Recommendations:

- Upgrade existing commercial entrances to meet VDOT standards
- Install a right turn lane on the EB approach

Results of the 5-year crash analysis show that there have been three crashes related to left turn movements into the commercial parcel on the northwest corner. This parcel does not currently have an entrance that meets VDOT Access Management standards. This entrance should be improved to meet standards in the future as it is developed.

Results of the turn lane warrants analysis revealed that a right turn lane is warranted on the EB approach of Route 660. Based on field observation, and the collected turning movement counts, this right turn is the highest volume turn movement of all (left or right) approaches. It is recommended that a right turn lane be constructed as funding and right of way become available (potentially with the development of the adjacent parcel). It appears that this turn lane could be constructed with minimal right of way acquisition, and grading/utility impacts, and it would currently provide the most Intermediate Term benefit to the operations of the intersection.

Long Term Recommendations

- Evaluate and install a roundabout as the preferred intersection alternative

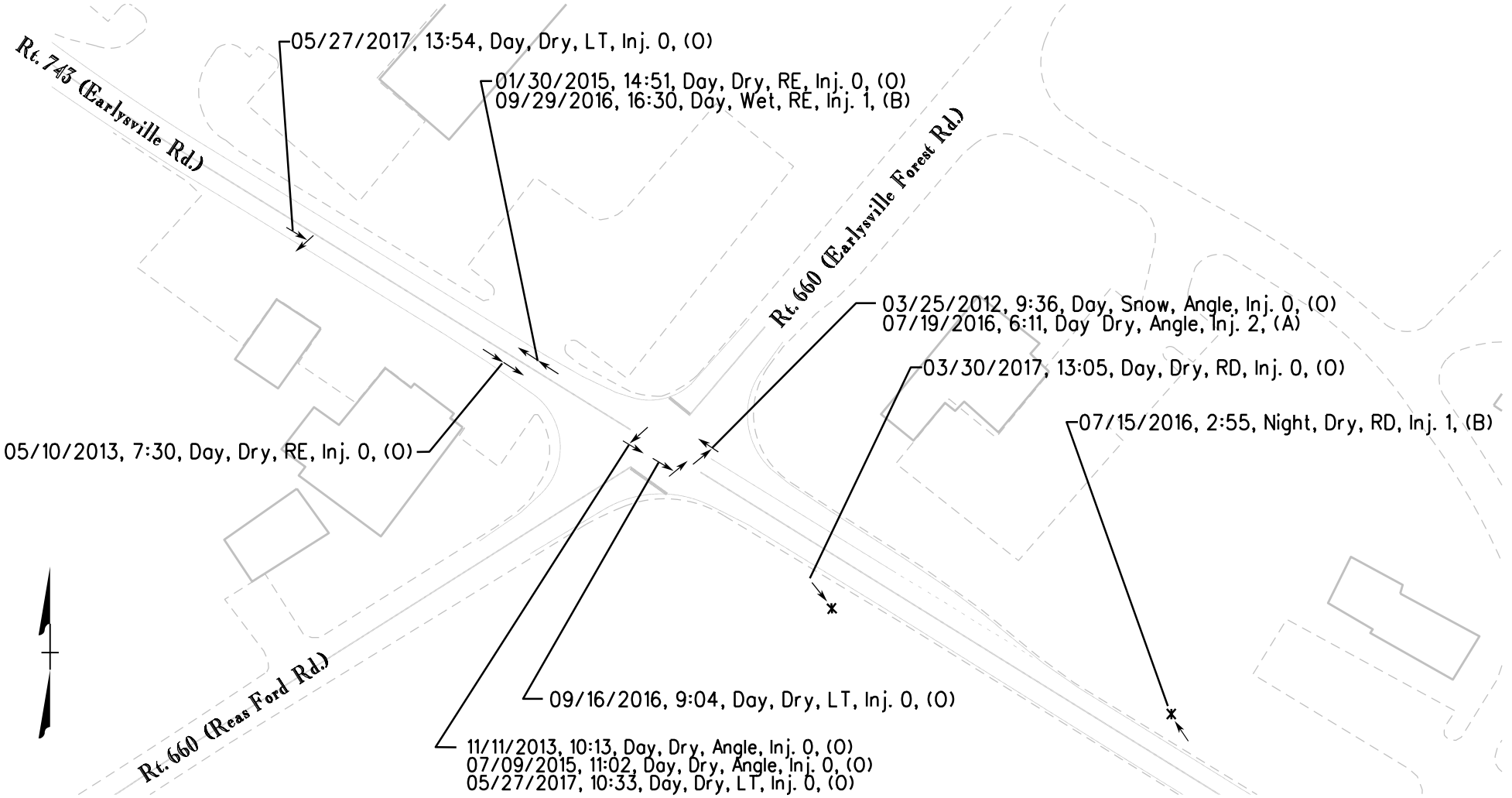
The results from the turn lane analysis show that right and left turn lanes are warranted under current traffic volumes on the EB and NB approaches. As traffic volumes and development increases in the area queues and delays are likely to increase to a point where operations and safety will warrant significant intersection upgrades. While a right tune lane on the EB approach is an intermediate term recommendation at this location, a left turn lane would cost significantly more due to the right of way acquisition and utility relocation cost. Additionally the potential points of conflict would not be reduced by the addition of turn lanes, and the NB approach grades limit sight distance to potential queued traffic increasing the risk of rear end crashes. Based operations, safety, and NB sight distance it is recommended that a roundabout be evaluated in the future as the preferred alternative.

EXHIBIT 1
Crash Diagram

COLLISION DIAGRAM

Rte. 743 (Earlysville Rd.) at Rt. 660 (Reas Ford Rd.)

Albemarle County



VDOT

CULPEPER DISTRIC
TRAFFIC ENGINEERING

1601 ORANGE ROAD
CULPEPER, VA 22701

NOT TO SCALE

SEVERITY	2012	2013	2014	2015	2016	2017	TOTAL
K	0	0	0	0	0	0	0
A	0	0	0	0	1	0	1
B	0	0	0	0	2	0	2
C	0	0	0	0	0	0	0
O	0	3	0	2	1	3	9

*Five years of Crash Data from June 1st, 2012 thru June 30, 2017 was examined for this report.

YR	2012	2013	2014	2015	2016	2017	TOTAL
ANGLE	0	2	0	1	1	0	4
RT	0	0	0	0	0	0	0
LT	0	0	0	0	1	2	3
SS	0	0	0	0	0	0	0
RD	0	0	0	0	1	1	2
RE	0	1	0	1	1	0	3
TOTAL	0	3	0	2	4	3	12

Day – 11 Dry – 10
Night – 1 Wet/Icy/Snowy – 2

LEGEND

Angle = Through
RT = Right Turn
LT = Left Turn
SS = Side Swipe
RD = Road Departure
RE = Rear End
→ = Vehicle

December 4, 2017

EXHIBIT 2

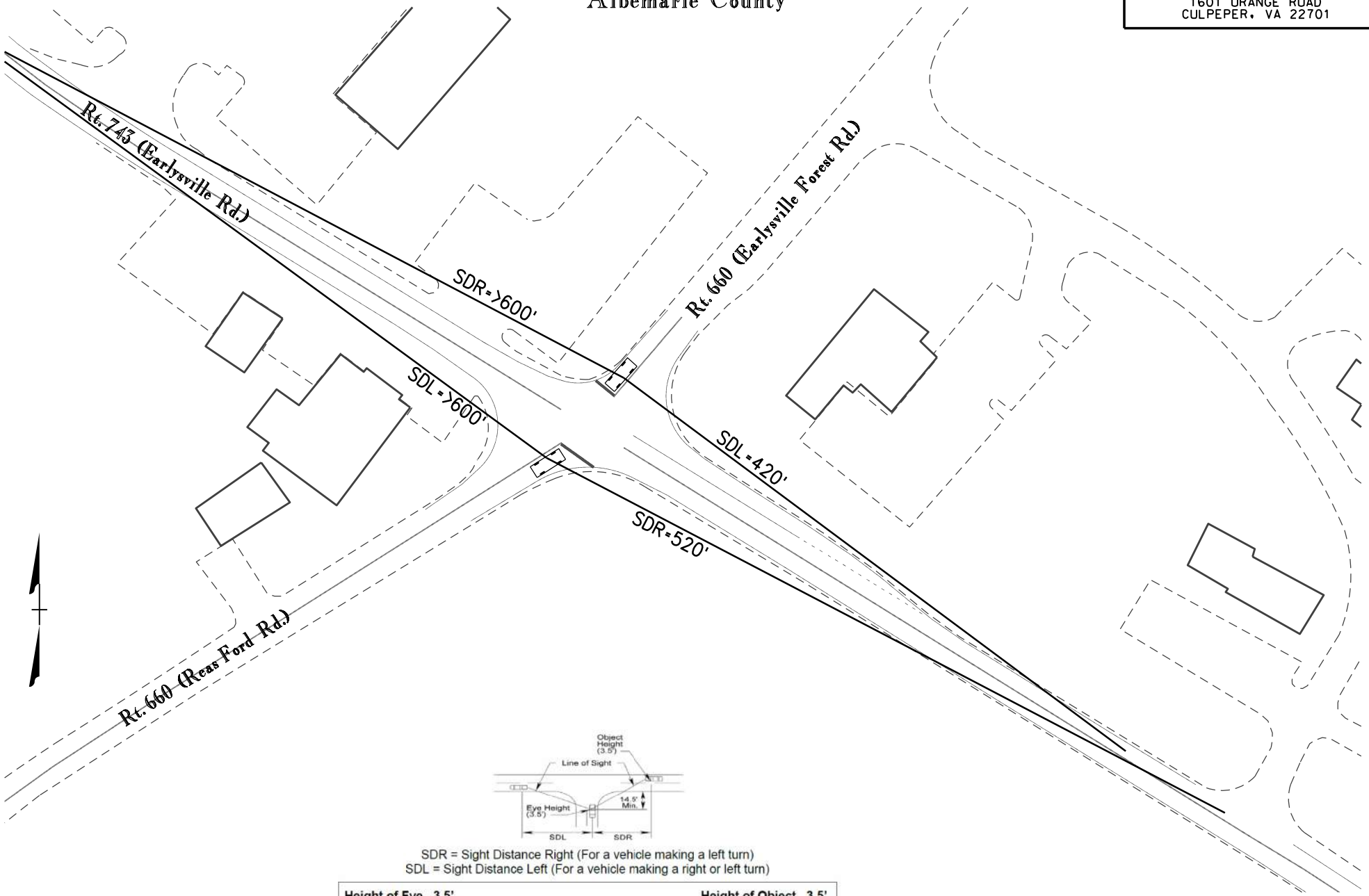
Sight Distance Diagram

SIGHT DISTANCE DIAGRAM

Rte. 743 (Earlysville Rd.) at Rt. 660 (Reas Ford Rd.)

Albemarle County

VDOT
CULPEPER DISTRIC
TRAFFIC ENGINEERING
1601 ORANGE ROAD
CULPEPER, VA 22701



SDR = Sight Distance Right (For a vehicle making a left turn)
SDL = Sight Distance Left (For a vehicle making a right or left turn)

Height of Eye 3.5'										Height of Object 3.5'
Design Speed (mph)**	**20**	**25**	**30**	**35**	**40**	**45**	**50**	**55**	**60**	**65**	**70**
SDL=SDR: 2 Lane Major Road	225	280	335	390	445	500	555	610	665	720	775

NOT TO SCALE

December 4, 2017

EXHIBIT 3

PC Warrants Report

VDOT Culpeper District Traffic Division

Route 743 (Earlysville Rd) and Route 660 (Reas Ford Rd)

Signal Warrants - Summary

Major Street Approaches

Northbound: **4750**
Number of Lanes: **1**
85% Speed < 40 MPH.
Total Approach Volume: **3,424**

Southbound: **4750**
Number of Lanes: **1**
85% Speed < 40 MPH.
Total Approach Volume: **3,267**

Minor Street Approaches

Eastbound: **1000**
Number of Lanes: **1**
Total Approach Volume: **866**

Westbound: **500**
Number of Lanes: **1**
Total Approach Volume: **563**

Warrant Summary **(Urban values apply.)**

Warrant 1 - Eight Hour Vehicular Volumes ..... **Not Satisfied**

Warrant 1A - Minimum Vehicular Volume ..... **Not Satisfied**
Required volumes reached for 0 hours, 8 are needed

Warrant 1B - Interruption of Continuous Traffic ..... **Not Satisfied**
Required volumes reached for 3 hours, 8 are needed

Warrant 1 A&B - Combination of Warrants ..... **Not Satisfied**
Required volumes reached for 1 hours, 8 are needed

Warrant 2 - Four Hour Volumes ..... **Not Satisfied**
Number of hours (0) volumes exceed minimum < minimum required (4).

Warrant 3 - Peak Hour ..... **Not Evaluated**

Warrant 3A - Peak Hour Delay ..... **Not Evaluated**

Warrant 3B - Peak Hour Volumes ..... **Not Evaluated**

Warrant 4 - Pedestrian Volumes ..... **Not Evaluated**

Warrant 5 - School Crossing ..... **Not Evaluated**

Warrant 6 - Coordinated Signal System ..... **Not Evaluated**

Warrant 7 - Crash Experience ..... **Not Satisfied**
Number of accidents (2) is less than minimum (5). Volume minimums are not met.

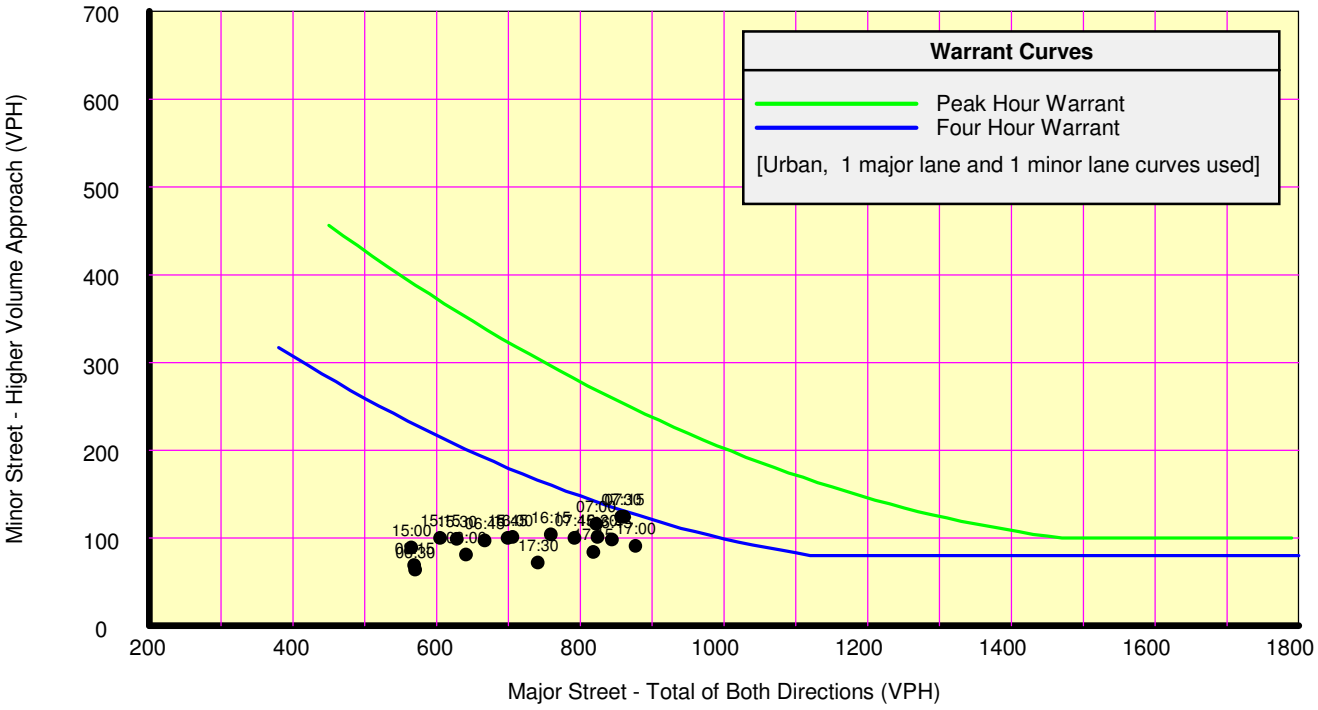
Warrant 8 - Roadway Network ..... **Not Evaluated**

Warrant 9 - Intersection Near a Grade Crossing ..... **Not Evaluated**

VDOT Culpeper District Traffic Division

Route 743 (Earlysville Rd) and Route 660 (Reas Ford Rd)

Signal Warrants - Summary



Analysis of 8-Hour Volume Warrants:

War 1A-Minimum Volume

Hour Begin	Major Total	Minor Vol	Minor Dir	Maj 500	Min 150
17:00	877	91	EB	Yes	No
07:15	861	124	EB	Yes	No
07:30	857	124	EB	Yes	No
16:45	844	98	EB	Yes	No
16:30	824	101	EB	Yes	No
07:00	822	116	EB	Yes	No
17:15	818	84	EB	Yes	No
07:45	792	100	EB	Yes	No
16:15	759	104	EB	Yes	No
17:30	741	72	EB	Yes	No
16:00	706	101	EB	Yes	No
15:45	699	100	EB	Yes	No
06:45	667	97	EB	Yes	No
08:00	641	81	EB	Yes	No
15:30	628	99	EB	Yes	No
15:15	605	100	EB	Yes	No
06:30	570	64	EB	Yes	No
08:15	569	69	EB	Yes	No
15:00	565	89	EB	Yes	No
14:45	535	84	EB	Yes	No
14:30	524	70	EB	Yes	No
17:45	513	48	EB	Yes	No
14:15	498	65	EB	No	No
13:45	498	52	EB	No	No

War 1B-Interruption of Traffic

Hour Begin	Major Total	Minor Vol	Minor Dir	Maj 750	Min 75
07:00	822	116	EB	Yes	Yes
17:15	818	84	EB	Yes	Yes
16:15	759	104	EB	Yes	Yes
16:00	706	101	EB	No	Yes
15:45	699	100	EB	No	Yes
06:45	667	97	EB	No	Yes
08:00	641	81	EB	No	Yes
15:30	628	99	EB	No	Yes
15:15	605	100	EB	No	Yes
06:30	570	64	EB	No	No
08:15	569	69	EB	No	No
15:00	565	89	EB	No	Yes
14:45	535	84	EB	No	Yes
14:30	524	70	EB	No	No
14:15	498	65	EB	No	No
13:45	498	52	EB	No	No
13:30	481	54	EB	No	No
13:00	449	44	EB	No	No
08:45	448	49	W	No	No
12:00	420	67	EB	No	No
12:45	417	52	EB	No	No

War 1C-Combination of Warrants

Hour Begin	Major Total	Minor Vol	Minor Dir	Maj 600	Min 120
07:15	861	124	EB	Yes	Yes
17:00	877	91	EB	Yes	No
16:45	844	98	EB	Yes	No
16:30	824	101	EB	Yes	No
07:00	822	116	EB	Yes	No
17:15	818	84	EB	Yes	No
16:15	759	104	EB	Yes	No
17:30	741	72	EB	Yes	No
16:00	706	101	EB	Yes	No
15:45	699	100	EB	Yes	No
06:45	667	97	EB	Yes	No
15:30	628	99	EB	Yes	No
15:15	605	100	EB	Yes	No
06:30	570	64	EB	No	No
08:15	569	69	EB	No	No
15:00	565	89	EB	No	No
14:45	535	84	EB	No	No
14:30	524	70	EB	No	No
17:45	513	48	EB	No	No
14:15	498	65	EB	No	No
13:45	498	52	EB	No	No
14:00	496	61	EB	No	No
08:30	491	54	W	No	No
13:15	488	41	EB	No	No

EXHIBIT 4

Turn Lane Warrants Analysis

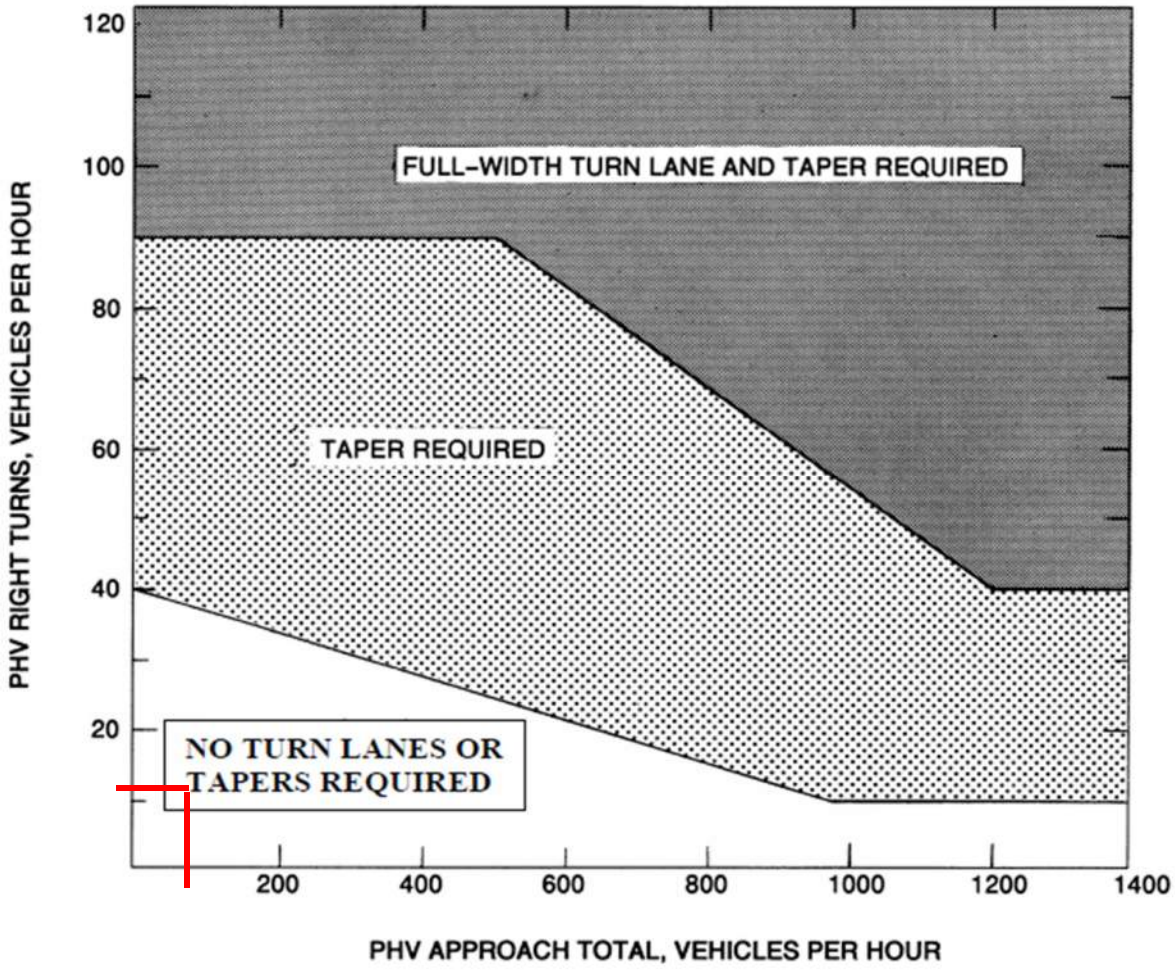
WARRANTS FOR RIGHT TURN TREATMENT (2-LANE HIGHWAY)

Major Route & Direction: **Route 660 WB**

Right Turn Volume (vph)	12
Approach Total (vph)	81

Right Turn Lane & Taper NOT WARRANTED

Based on Figure 3-1: N/A



Note: This spreadsheet is intended to supplement the guidance provided in Appendix F, Section 3 Turning Lanes, of the VDOT Road Design Manual. This policy should be fully reviewed and understood prior to using this application.

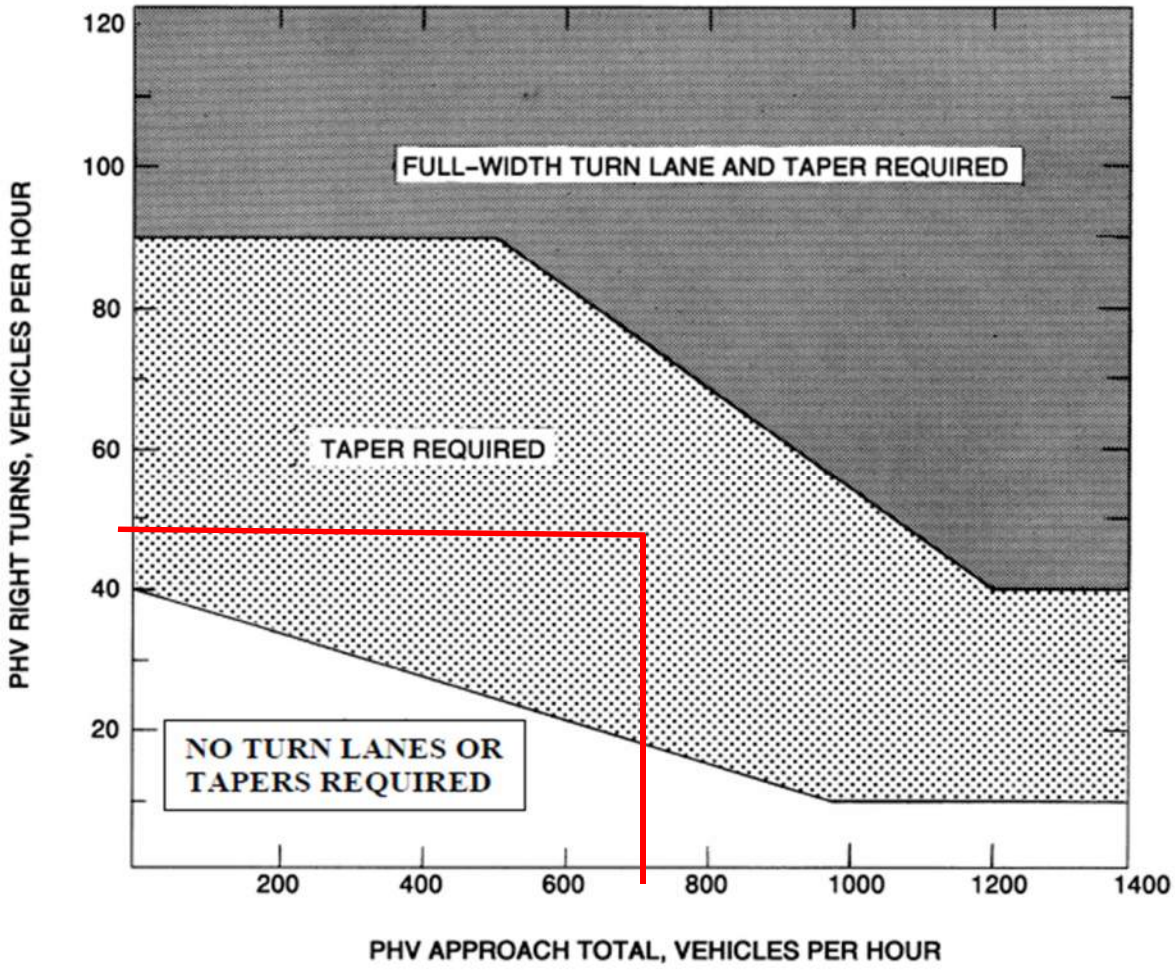
WARRANTS FOR RIGHT TURN TREATMENT (2-LANE HIGHWAY)

Major Route & Direction: **Route 743 SB**

Right Turn Volume (vph)	**48**
Approach Total (vph)	**696**

Right Turn Taper IS WARRANTED

Based on Figure 3-1: Taper length should be 200'

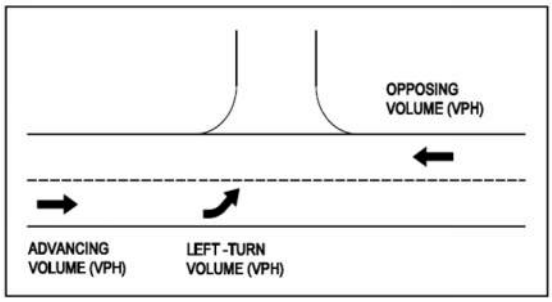


Note: This spreadsheet is intended to supplement the guidance provided in Appendix F, Section 3 Turning Lanes, of the VDOT Road Design Manual. This policy should be fully reviewed and understood prior to using this application.

WARRANTS FOR LEFT TURN LANES ON TWO-LANE HIGHWAYS

Major Route & Direction: **Route 743 SB**

Left Turn Volume (vph)	**9**
Advancing Volume (vph)	**174**
Opposing Volume (vph)	**598**
Design Speed (mph) *	**45**



Left Turn Lane NOT WARRANTED

VPH OPPOSING VOLUME	ADVANCING VOLUME			
	5% LEFT TURNS	10% LEFT TURNS	20% LEFT TURNS	30% LEFT TURNS
	40-MPH DESIGN SPEED*			
800	330	240	180	160
600	410	305	225	200
400	510	380	275	245
200	640	470	350	305
100	720	515	390	340
	50-MPH DESIGN SPEED*			
800	280	210	165	135
600	**350**	280	195	170
400	430	320	240	210
200	550	400	300	270
100	615	445	335	295
	60-MPH DESIGN SPEED*			
800	230	170	125	115
600	290	210	160	140
400	365	270	200	175
200	450	330	250	215
100	505	370	275	240

TABLE 3-2

Source: Adapted from 2011 AASHTO Green Book, Chapter 9, Section 9.7.3, Page 9-132, Table 9-23

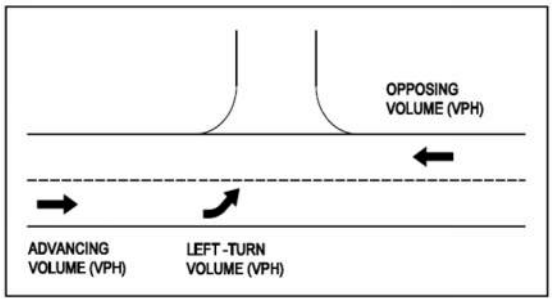
* USE DESIGN SPEED IF AVAILABLE, IF NOT USE LEGAL SPEED LIMIT.

Note: This spreadsheet is intended to supplement the guidance provided in Appendix F, Section 3 Turning Lanes, of the VDOT Road Design Manual. This policy should be fully reviewed and understood prior to using this application.

WARRANTS FOR LEFT TURN LANES ON TWO-LANE HIGHWAYS

Major Route & Direction: **Route 743 NB**

Left Turn Volume (vph)	**68**
Advancing Volume (vph)	**530**
Opposing Volume (vph)	**183**
Design Speed (mph) *	**45**



Based on Figure 3-1: Storage length should be 200', with a 200' Taper.

Left Turn Lane IS WARRANTED

VPH OPPOSING VOLUME	ADVANCING VOLUME			
	5% LEFT TURNS	10% LEFT TURNS	20% LEFT TURNS	30% LEFT TURNS
	40-MPH DESIGN SPEED*			
800	330	240	180	160
600	410	305	225	200
400	510	380	275	245
200	640	470	350	305
100	720	515	390	340
	50-MPH DESIGN SPEED*			
800	280	210	165	135
600	350	280	195	170
400	430	320	240	210
200	550	400	**300**	270
100	615	445	335	295
	60-MPH DESIGN SPEED*			
800	230	170	125	115
600	290	210	160	140
400	365	270	200	175
200	450	330	250	215
100	505	370	275	240

TABLE 3-2

Source: Adapted from 2011 AASHTO Green Book, Chapter 9, Section 9.7.3, Page 9-132, Table 9-23

* USE DESIGN SPEED IF AVAILABLE, IF NOT USE LEGAL SPEED LIMIT.

Note: This spreadsheet is intended to supplement the guidance provided in Appendix F, Section 3 Turning Lanes, of the VDOT Road Design Manual. This policy should be fully reviewed and understood prior to using this application.

Created by Culpeper District Traffic Division

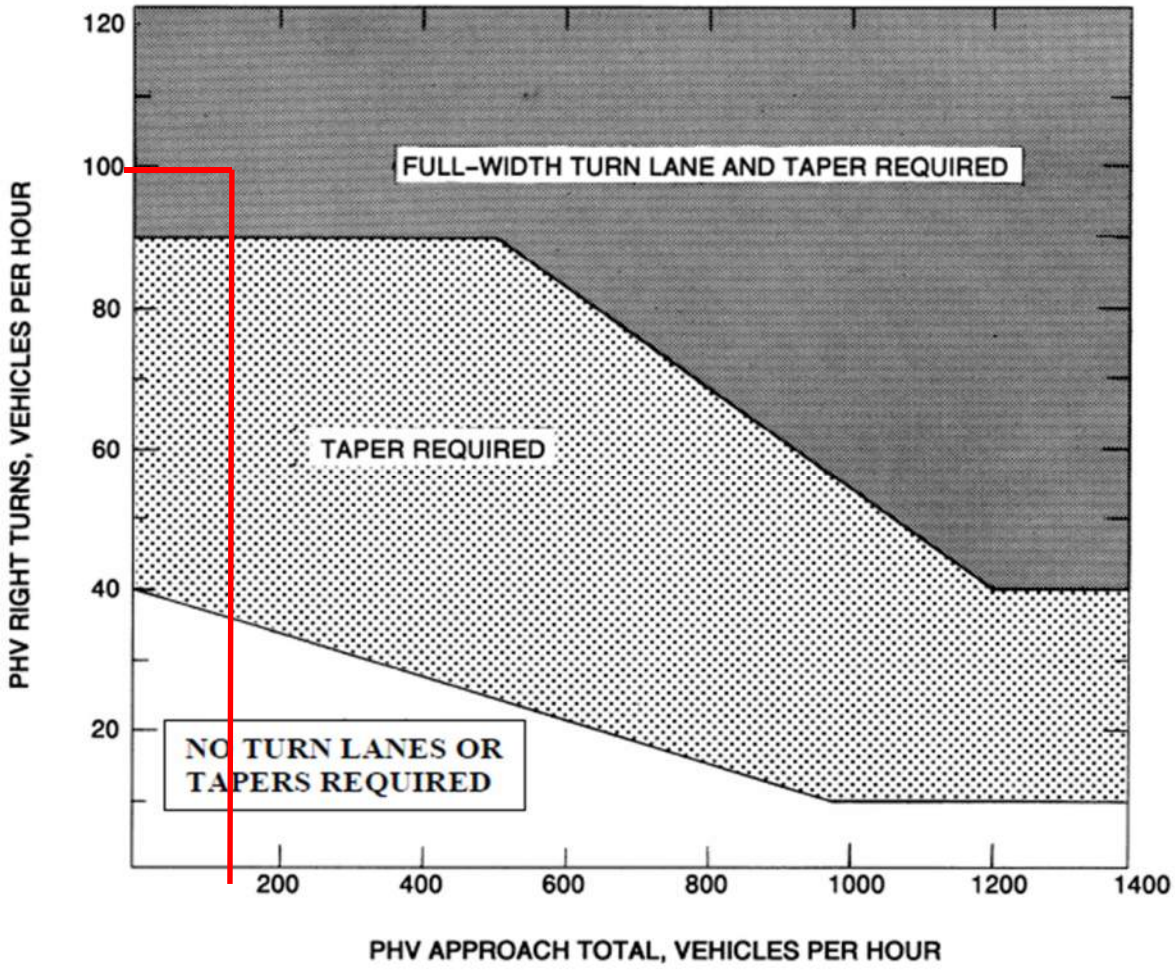
WARRANTS FOR RIGHT TURN TREATMENT (2-LANE HIGHWAY)

Major Route & Direction: **Route 660 EB**

Right Turn Volume (vph)	**100**
Approach Total (vph)	**124**

Right Turn Lane & Taper IS WARRANTED

Based on Figure 3-1: Storage length should be 200', with a 200' Taper.



Note: This spreadsheet is intended to supplement the guidance provided in Appendix F, Section 3 Turning Lanes, of the VDOT Road Design Manual. This policy should be fully reviewed and understood prior to using this application.

EXHIBIT 5

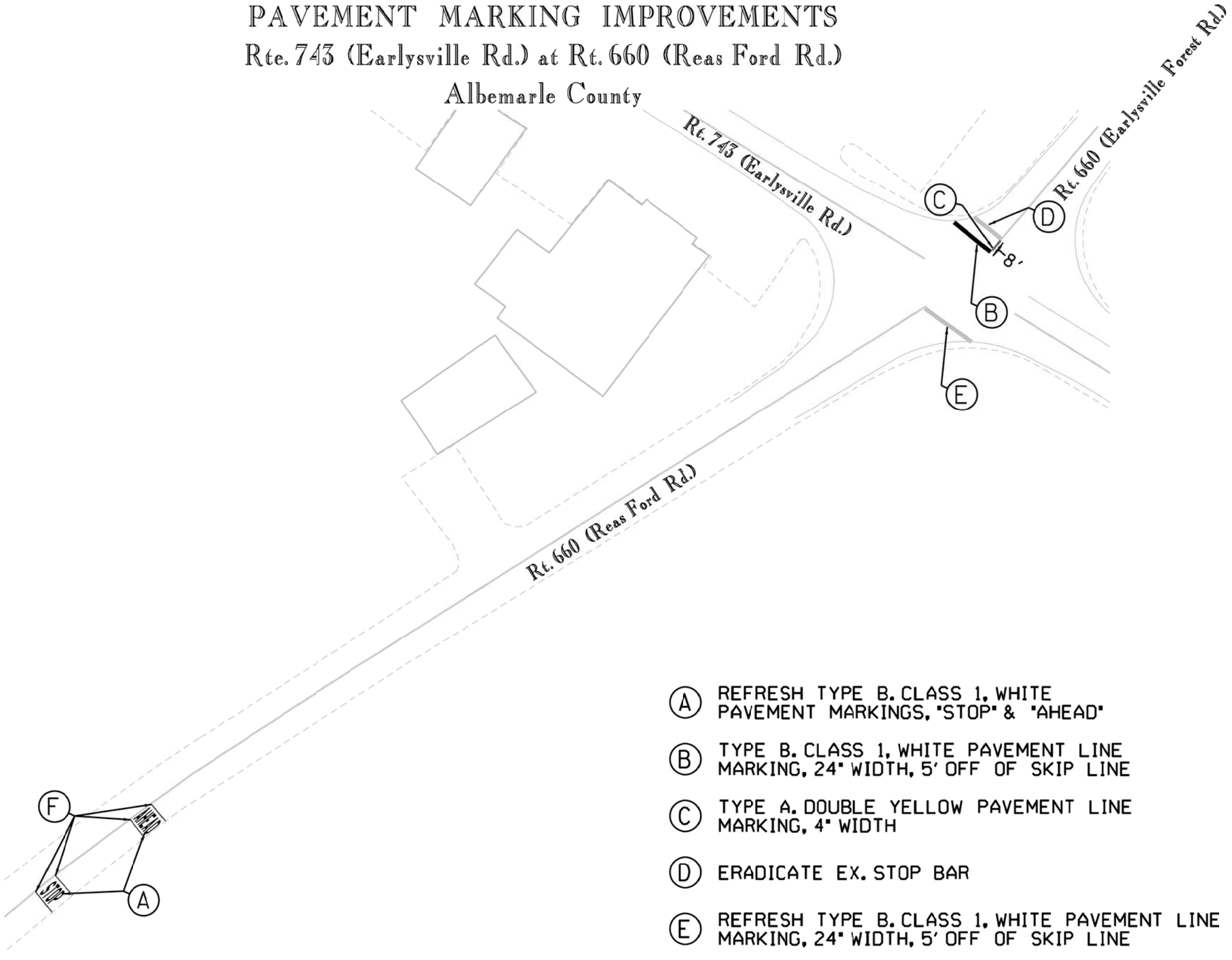
Proposed Pavement Marking Plan

STATE	ROUTE	PROJECT	SHEET NO.
VA.	660		1

PAVEMENT MARKING IMPROVEMENTS

Rte. 743 (Earlysville Rd.) at Rt. 660 (Reas Ford Rd.)

Albemarle County



(A) REFRESH TYPE B. CLASS 1, WHITE PAVEMENT MARKINGS, "STOP" & "AHEAD"

(B) TYPE B. CLASS 1, WHITE PAVEMENT LINE MARKING, 24" WIDTH, 5' OFF OF SKIP LINE

(C) TYPE A. DOUBLE YELLOW PAVEMENT LINE MARKING, 4" WIDTH

(D) ERADICATE EX. STOP BAR

(E) REFRESH TYPE B. CLASS 1, WHITE PAVEMENT LINE MARKING, 24" WIDTH, 5' OFF OF SKIP LINE

(F) ERADICATE EX. TRANVERSE LINES

VDOT
CULPEPER DISTRIC
TRAFFIC ENGINEERING
1601 ORANGE ROAD
CULPEPER, VA 22701

NOT TO SCALE

December 4, 2017	PROJECT ·	SHEET NO. 1

EXHIBIT 6
Conceptual Right Turn Lane Improvements

STATE	ROUTE	PROJECT	SHEET NO.
VA.	660		/

CONCEPTUAL TURN IMPROVEMENTS

Rte. 743 (Earlysville Rd.) at Rt. 660 (Reas Ford Rd.)

Albemarle County

NOT TO SCALE

VDOT

CULPEPER DISTRIC
TRAFFIC ENGINEERING

1601 ORANGE ROAD
CULPEPER, VA 22701

December 4, 2017	PROJECT ·	SHEET NO. 1

Appendix I-2

Kimley Horn Study

Earlysville Road (Route 743) and Reas Ford Road (Route 660)

Intersection Safety Review

Albemarle County, VA

November 2019

Prepared for:
Virginia Department of Transportation

Prepared by:
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Richmond, Virginia 23230
P: 804.673.3882

Kimley-Horn Project #: 117473204

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1.0 Introduction

The Virginia Department of Transportation (VDOT) has received complaints and various inquiries from members of the Albemarle County Board of Supervisors, local emergency services personnel, and local residents regarding the perception of safety issues at the Earlysville Road (Route 743) and Reas Ford Road (Route 660) intersection in Albemarle, Virginia. Further discussions between VDOT and Albemarle County led to the need to evaluate the existing conditions at the study intersection. This evaluation will be used to identify potential transportation improvement solutions at the study intersection and to assist VDOT and Albemarle County staff in their discussions with property owners and developers as they convey future plans and projects in the vicinity of the study intersection. Specifically, the intended outcomes of this study were to:

- Determine the safety and integrity of existing transportation infrastructure
- Provide recommended improvements that improve safety and mobility at the intersection

The purpose of this study was to evaluate potential improvements to the intersection of Earlysville Road and Reas Ford Road to enhance intersection safety and operations. This study focused primarily on safety during typical weekday operations. Traffic operations and access management were also analyzed in order to develop a cohesive recommendation. The limits of this study area are defined by the functional area of the Earlysville Road and Reas Ford Road intersection, which is approximately 500 feet on each approach.

This study will serve as a technical document that describes and illustrates the feasibility of the proposed alternatives as well as the associated potential operational and safety impacts of each.

2.0 Existing Conditions

2.1 Field Review

A field review was conducted on September 3, 2019 to observed existing conditions at the study intersection. Available traffic, crash and asset data was obtained from VDOT and used to document existing conditions. During the field review, the following information was observed and collected.

- Observations of existing roadway geometrics, such as lane designations, signing, striping, posted speed limits, sight distance restrictions, potential design impacts or constraints
- Observations of existing roadway conditions to determine opportunities for improvements to increase safety
- Observations of traffic operations including passenger cars and trucks
- Digital photographs to capture the study area characteristics observed

The existing conditions analyses were developed using the data collected during the field review supplemented by visual observations of the operational characteristics.

2.2 Roadway Characteristics

Earlysville Road is classified as an urban major collector according to VDOT's 2014 Functional Classification map. The section of roadway within the study area is oriented in an east-west direction and is a two-lane, undivided roadway with a paved shoulder ranging from 0 to 10 feet wide and an open ditch cross section. Photographs 1 and 2 show the westbound and eastbound approaches, respectively. The Earlysville Road posted speed limit is 35 MPH near Reas Ford Road. The posted speed limit increases to 45 MPH approximately 300 feet east of the intersection. A Cross Road (W2-1) warning sign is located approximately 525 feet in advance of Reas Ford Road on the eastbound and westbound approaches.

Reas Ford Road is classified as a rural major collector south of Earlysville Road according to VDOT's 2014 Functional Classification map. The roadway is referred to as Reas Ford Road south of Earlysville Road and is referred to as Earlysville Forest Drive north of Earlysville Road. The section of roadway within the study area is oriented in a north-south direction and is a two-lane, undivided roadway with no shoulder and an open ditch cross section. Photographs 3 and 4 show the northbound and southbound approaches, respectively. The Reas Ford Road/Earlysville Forest Drive posted speed limit is 35 MPH near Earlysville Road. A Stop Ahead (W3-1) warning sign is located approximately 300 feet in advance of Earlysville Road on the northbound approach.

Photograph 1:
Westbound Approach – Earlysville Road

Photograph 2:
Eastbound Approach – Earlysville Road

Photograph 3:
Northbound Approach – Reas Ford Road

Photograph 4:
Southbound Approach – Earlysville Forest Drive

The study intersection currently operates as a two-way stop intersection. A variety of land uses are located within the vicinity of the subject intersection, including residential, commercial, and civic (e.g. post office) uses. The northbound and southbound approaches are stop-controlled and the eastbound and westbound approaches are free-flow. Turn lanes are not provided at the study intersection except for a right-turn lane on the westbound approach on Earlysville Road. Intersection lighting and bicycle and pedestrian accommodations are not provided at the study intersection. A Vehicular Traffic (W11-1) warning sign with a Share the Road (W16-1P) plaque is located approximately 250 feet east of the intersection along Earlysville Road.

The required sight distance on a 35 MPH roadway (per the VDOT Road Design Manual) is 390 feet. The sight distance on the northbound approach, looking to the left, is approximately 200 feet, which is below the minimum required. An intersection with a sight distance of 200 feet would only accommodate a design speed of approximately 17 MPH.

2.3 Traffic Volumes

A weekday 12-hour (6:30 AM – 6:30 PM) turning movement count was conducted at the study intersection on Tuesday, November 14, 2017 and included in Appendix A. Weekday AM and PM peak hours were computed to be 7:30-8:30 AM and 5:00-6:00 PM, respectively. Based on the 2018 VDOT published traffic data, the approximate annual average daily traffic (AADT) volume on Earlysville Road is 9,700 vehicles per day (VPD) near Reas Ford Road. The approximate AADT volume on Reas Ford Road is 2,000 VPD to the south of Earlysville Road. The approximate AADT on Earlysville Forest Drive is 1,000 VPD to the north of Earlysville Road.

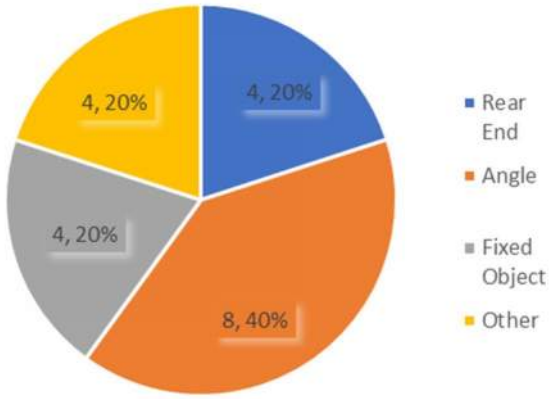
2.4 Crash Analysis

Crash analysis for the study intersection was conducted using the latest five years of available crash data. Crash reports dating from January 1, 2014 to May 31, 2019 were obtained from VDOT. Over the five-year period, twenty crashes were reported within a 500-foot radius of the study intersection.

- 2014: 0 crashes
- 2015: 3 crashes
- 2016: 4 crashes
- 2017: 8 crashes
- 2018: 4 crashes
- 2019: 1 crash

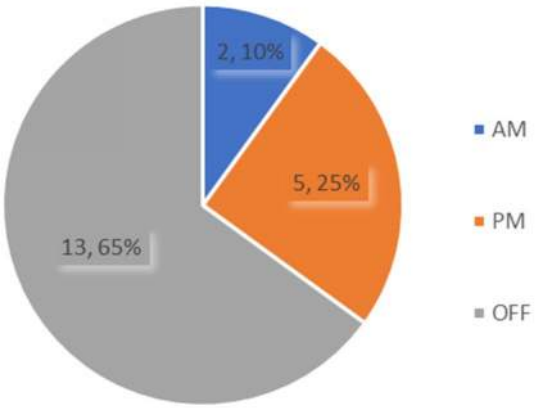
Overall, there were no noteworthy crash patterns identified at the study intersection. The following subsections provide additional information associated with the twenty total crashes that occurred at the study intersection.

Crash by Type



- A majority of crashes (40%) were angle collisions. However, these crashes were divided between the various approaches and turning movements.
- The remaining 12 crashes were equally divided between rear-end, fixed object, and other.

Crashes by Time of Day



- The majority of crashes (13 crashes or 65%) occurred during off peak periods.
- The majority of the peak period crashes (5 of the 7 total peak period crashes) occurred during the PM peak period.

Crash Severity

No fatal crashes occurred at the study intersection. Ten (50%) of the crashes resulted in an injury. Three of these were Type A crashes, six were Type B, and one was Type C.

Weather Conditions

Eighteen of the twenty crashes occurred during clear weather conditions at the study intersection.

Light Conditions

Sixteen (80%) of the twenty crashes occurred during daylight conditions at the study intersection.

2.5 Intersection Capacity Analyses

Capacity analyses allow traffic engineers to assess the operational conditions and identify the impacts of traffic on the surrounding roadway network. The Transportation Research Board's (TRB) *Highway Capacity Manual* (HCM) methodologies govern the methodology for evaluating capacity and the quality of service provided to road users traveling through a roadway network. There are six letter grades for Levels of Service (LOS) ranging from A to F, with LOS A representing the best operating conditions and LOS F representing the worst operating conditions.

Intersection level of service is defined in terms of delay (seconds per vehicle), a measure of driver discomfort, frustration, fuel consumption, and lost travel time. ~~Error! Reference source not found.~~ Table 1 summarizes the delay associated with each unsignalized and roundabout intersection LOS category.

Table 1: Intersection Level of Service Criteria

LOS	Intersection Delay (sec/veh)	
	Unsignalized	Roundabout/Signalized
A	0 - 10	0 - 10
B	>10 - 15	>10 – 20
C	>15 - 25	>20 – 35
D	>25 – 35	>35 – 55
E	>35 – 50	>55 – 80
F	>50	>80

** Source: Transportation Research Board, Highway Capacity Manual 2000*

The unsignalized study intersection was analyzed using Synchro based on methodologies in the HCM 6. Existing conditions Synchro delay and LOS results are shown in ~~Error! Reference source not found.~~ Table 2. Synchro output sheets are included in Appendix D.

The stop-controlled approaches (northbound and southbound) currently experience moderate to long delays in the peak hours as shown in Table 5. It is typical for stop sign controlled side streets intersecting major streets to experience long delays during peak hours, while the majority of the traffic moving through the intersection on the major street experiences little or no delay.

Table 2: 2017 Existing Conditions Synchro Results

Time of Day	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
Lane Group	AM Peak Hour		PM Peak Hour	
Earlysville Rd (EB) LTR	0.1	A	0.7	A
Earlysville Rd (WB) LTR	2.8	A	1.0	A
Reas Ford Rd (NB) LTR	37.5	E	35.5	E
Earlysville Forest Dr (SB) LTR	130.4	F	34.8	D

3.0 Alternative Development and Analysis

All traffic operations analysis for alternatives analysis was conducted using 2017 volumes. The VDOT Junction Screening Tool (VJUST) version 1.02 was used to develop potential alternatives to consider for analysis. Results from the VJUST analysis are included in Appendix C. After consideration of the VJUST results, a roundabout was selected as an alternative to further evaluate. Traditional intersection configuration analyses were conducted using Synchro while roundabout analyses were conducted using SIDRA.

The following alternatives were evaluated:

- Alternative 1: Low-Cost Countermeasures
- Alternative 2: Mini-Roundabout
- Alternative 2: Signalized Intersection

3.1.1 Alternative 1 (Low-Cost Countermeasures)

Alternative 1 consists of the implementation of multiple low-cost countermeasures for stop-controlled intersections. Alternative 1 does not improve any access management issues, operations issues, nor heavily improve any safety issues, but would reduce potential risks within the intersection. According to FHWA, this alternative "involves deploying a group of multiple low-cost countermeasures, such as enhanced signing and pavement markings…to increase driver awareness and recognition of the intersection and potential conflicts." The following treatments are recommended.

- Earlysville Road
  - Doubled up (left and right), oversized advance intersection (W2-1) warning signs, with street name sign (W16-8aP) plaques
  - Enhanced pavement markings that delineate through lane edge lines
- Reas Ford Road/ Earlysville Forest Drive
  - Doubled up (left and right), oversized advance "Stop Ahead" (W3-1) intersection warning signs
  - Doubled up (left and right), oversized Stop (R1-1) signs
  - Retroreflective sheeting on sign posts

- Properly placed stop bar
- Removal of any vegetation or obstruction that limits sight distance

The implementation of these low-cost countermeasures at stop-controlled intersections can result in a 10% reduction in injury and fatal crashes, based on Crash Reduction Factors (CRF).

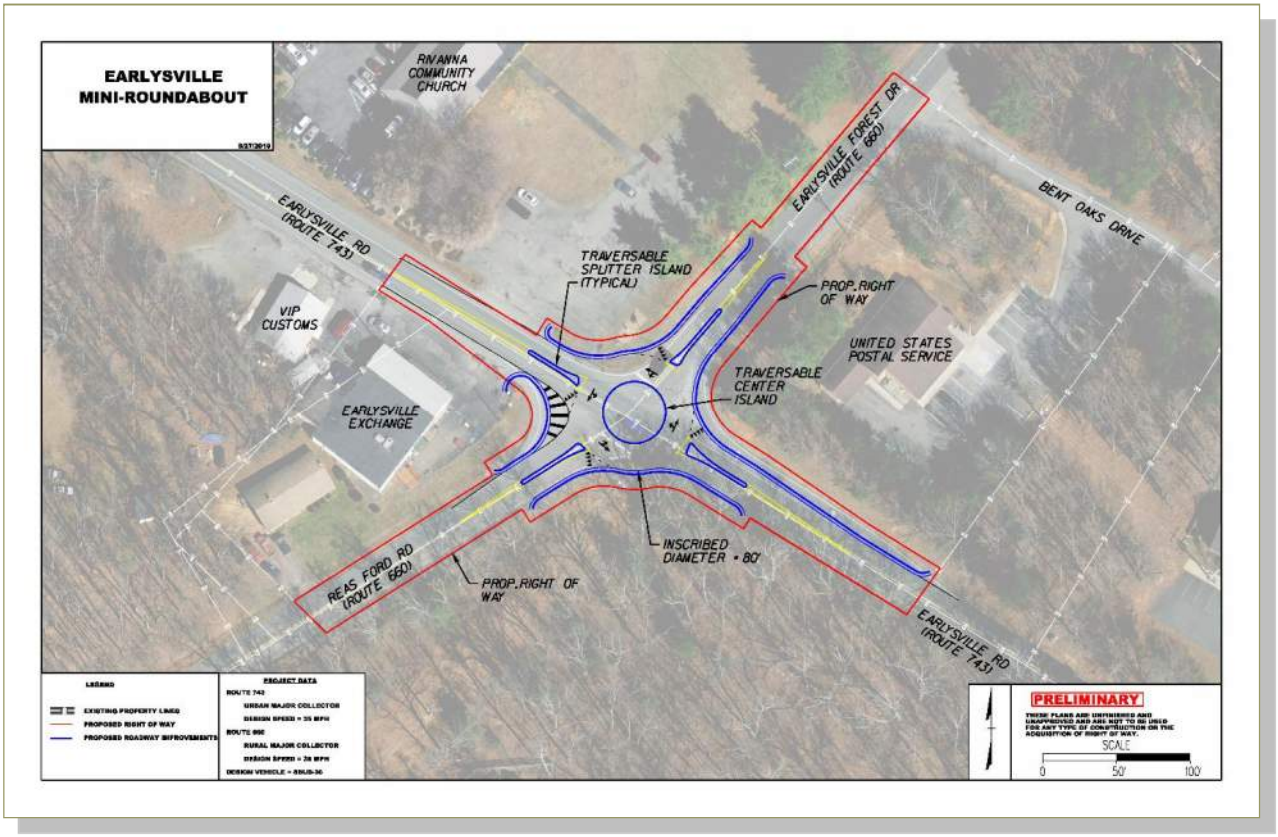
Traffic conditions are not expected to change with the implementation of Alternative 1, therefore a separate traffic operations analysis was not conducted.

Figure 1

3.1.2 Alternative 2 (Mini-Roundabout)

As shown in ~~Error! Reference source not found.,~~ Alternative 2 consists of the reconfiguration of the subject intersection to a mini-roundabout. In addition to an improvement to intersection capacity, the proposed roundabout would potentially improve safety as well by reducing the number of conflict points in the intersection. The installation of a roundabout can expect a 72% reduction in all intersection related crashes. The proposed roundabout would also mitigate sight distance deficiency on the northbound approach and act as a traffic calming measure on all approaches of the intersection. The analysis herein was based on minimum design requirements found in the *VDOT Road Design Manual – Appendix F* and the *National Cooperative Highway Research Program (NCHRP) Report 672: Roundabouts: An Informational Guide, Second Edition*, 2010.

Figure 1: Alternative #2 – Mini-Roundabout



The roundabout alternative was analyzed using SIDRA, which uses the HCM 6 traffic signal delay thresholds to determine LOS. To evaluate the study intersection, existing traffic volume data was used in conjunction with existing and proposed geometric data to determine the LOS.

The construction of a roundabout at the study intersection is expected to improve traffic operations for the northbound and southbound approaches while still maintaining short to moderate levels of delay along the eastbound and westbound approaches. The increase in control delay for the eastbound and westbound approaches is to be expected when converting free-flow movements to yield-controlled. Table 6 summarizes the delay for Alternative 2. Additional information is provided in Appendix D.

Table 3: 2017 Alternative 2 (Proposed Mini-Roundabout) SIDRA Results

Time of Day	Delay (sec/veh)	LOS	Delay (sec/veh)	LOS
Lane Group	AM Peak Hour		PM Peak Hour	
Earlysville Rd (EB) LTR	20.5	C	5.8	A
Earlysville Rd (WB) LTR	5.3	A	9.7	A
Reas Ford Rd (NB) LTR	5.1	A	17.9	C
Earlysville Forest Dr (SB) LTR	27.2	D	6.5	A

3.2 Alternative 3: Signalized Intersection

A signal warrant analysis was conducted to determine if a signal is justified at this location. The results of that analysis, described further below, did not support the installation of a traffic signal, therefore no additional traffic operations or safety analysis was performed and this alternative was not carried forward for further design or cost considerations.

3.2.1 Traffic Signal Warrant

A traffic signal warrant analysis was performed using the 2017 turning movement count data collected at the study intersection. Traffic signal warrants were performed based on methodologies defined in the Manual of Uniform Traffic Control Devices (MUTCD, 2009 edition). This approach is consistent with methods used by VDOT to determine whether a traffic signal should be considered at an intersection. Nine warrants are documented in the MUTCD, which provides guidance on justification of traffic signal installation. The results of the nine warrants are provided below.

Warrants 1 through 3

Warrant 1 (Eight-Hour Vehicular Volume), Warrant 2 (Four-Hour Vehicular Volume), and Warrant 3 (Peak Hour) were evaluated at the study intersection. Warrant 1 contains three conditions, which are shown in Error! Reference source not found.. The results of Warrants 1 through 3 are shown in Error! Reference source not found..

Table 4: MUTCD Warrant 1 Conditions

Warrant 1	Eight-Hour Vehicular Volume
Condition A	Minimum Vehicular Volume
Condition B	Interruption of Continuous Traffic
Combination	Combination of Condition A and Condition B

Table 5: Traffic Signal Warrant Analysis Results

	Warrant 1A	Warrant 1B	Warrant 1 Combination	Warrant 2	Warrant 3
2017 Existing	Not Met (1 of 8 hours satisfied)	Not Met (5 of 8 hours satisfied)	Not Met (4 of 8 hours satisfied)	Not Met (3 of 4 hours satisfied)	Met

Under existing traffic conditions, the study intersection is not projected to meet traffic signal Warrant 1 or Warrant 2. At this time, only Warrant 3 is met. Although Warrant 3 is met, a traffic signal would not be warranted at this intersection without satisfying the eight-hour volumes. Traffic signal warrant worksheets are included in Appendix B. Should existing traffic volumes, patterns or land uses change in the vicinity of the intersection, a traffic signal warrant analysis may need to be conducted to consider the future conditions.

Warrant 4

Warrant 4 (Pedestrian Volume) is intended for applications where traffic volume on a major street is so heavy that pedestrians experience excessive delay in crossing the major street. To meet the requirements for Warrant 4, the pedestrian volume crossing the major street along with the major street traffic volume at an intersection (or midblock location) during an average day are plotted against two charts provided in the MUTCD. On the first chart, each of any four hours must exceed the warrant, while on the second chart any one hour must exceed the warrant. No pedestrians were counted at the subject intersection during the 12-hour traffic count conducted; therefore, the pedestrian volume requirements of Warrant 4 were not met.

Warrant 5

Warrant 5 (School Crossing) is intended for application where school children crossing the major street are the principal reason to install a traffic signal. To meet the requirements for Warrant 5, there must be a minimum of 20 students during the highest crossing hour across the major street. There are no schools near the study intersection, and the counted volume of pedestrians does not meet the 20-student minimum. Therefore, Warrant 5 was not met.

Warrant 6

Warrant 6 (Coordinated Signal System) is applicable in situations where a coordinated signal system necessitates the installation of a traffic control signal to maintain proper platooning of vehicles. The subject intersection is not located within a coordinated network; therefore, Warrant 6 was not met.

Warrant 7

Warrant 7 (Crash Experience) is intended for application where the severity and frequency of crashes are the principle reasons to consider installing a traffic control signal. To meet the requirements for Warrant 7, there must be a history of crashes amounting to at least five crashes within the past year resulting in personal injury or property damage above the reporting thresholds. These crashes must also be of such a type that is correctable by the installation of a traffic signal. An adequate trial of alternatives must also have been attempted. In addition to meeting these criteria, certain vehicular and pedestrian volumes must be present for eight hours of the day. Based on a review of the crash data from 2015 through 2019, only one year had five preventable crashes occur at the subject intersection and the remaining years all had less than five. Additionally, these five crashes were not all susceptible to correction by a traffic signal; therefore, Warrant 7 was not met.

Warrant 8

Warrant 8 (Roadway Network) is intended for application where some intersections might be justified to encourage concentration and organization of traffic flow on a roadway network. To meet the requirements for

Warrant 8, the *MUTCD* states that the intersection must have an existing or immediately projected entering volume of at least 1,000 vehicles per hour during the peak hour of a typical weekday and five-year projected traffic volumes that meet one or more of Warrants 1, 2, and 3 during an average weekday or 1,000 vehicles per hour for each of any five hours of a typical weekend (Saturday or Sunday). The current traffic volumes exceed 1,000 vehicles per hour, but future traffic volumes were not projected. If the projected traffic volumes meet one or more of Warrants 1, 2, and 3 during an average weekday, then Warrant 8 may be met in the future.

Warrant 9
Warrant 9 (Intersection Near a Grade Crossing) is intended for use at intersections where the conditions described in the other eight traffic signal warrants are not met. To meet the requirements of Warrant 9, proximity to a railroad grade crossing on an intersection approach controlled by a Stop or Yield sign is the principal reason to consider installing a traffic control signal. As no grade crossings exist within 140 feet of the subject intersection, Warrant 9 was not evaluated.

3.2.2 Traffic Signal Warrant Results

Based on an analysis of the MUTCD Traffic Signal Warrants 1 through 9, a traffic signal is not warranted at the Earlysville Road and Reas Ford Road intersection. VDOT does not support the installation of traffic signals for just meeting peak hour warrants. Error! Reference source not found. provides a summary of the results of Warrants 1 through 9.

Table 6: Traffic Signal Warrant Analysis Results

Warrants								
1	2	3	4	5	6	7	8	9
Not Met	Not Met	Met	Not Met	Not Met	Not Met	Not Met	Not Met	Not Met

3.3 Conceptual Design and Planning Level Cost Estimates

The approximate planning level cost estimate is based a combination of PCES, the 2015 version of Transportation and Mobility Planning Division Statewide Planning Level Cost Estimate Spreadsheet, quantity take-offs, and recent bid costs. Table 7 includes a cost breakdown of the roadway; construction contingency; construction, engineering, and inspection (CEI); preliminary engineering (PE); and right-of-way acquisition and utility relocation costs. The planning level cost estimate is preliminary and is not based on design.

3.3.1 Alternative 1 (Low-Cost Countermeasures)

Based on a review of available right-of-way near the intersection, it is anticipated Alternative 1 will not require the acquisition of additional right-of-way. It is assumed the proposed improvements could be delivered with maintenance staff resources, so it is assumed to be a no-plan project.

The Right-of-Way Acquisition and Utility Relocation Costs for Alternative 1 (Low-Cost Countermeasure) are shown as $0 since these improvements should not impact right-of-way or utilities.

It is assumed that these improvements may be considered maintenance activities.

3.3.2 Alternative 2

For Alternative 2, depicted in Figure 1, it was determined that the construction of a mini-roundabout, with an inscribed diameter between 80 feet, would lessen the impacts to existing right-of-way when compared to a single-lane roundabout, with an inscribed diameter between 90-120 feet. Although the study intersection lies within prescriptive right-of-way, these additional right-of-way impacts can alter the timeframe for implementation and estimated planning level cost.

Prescriptive right-of-way is right-of-way in perpetuity for the use of a state-maintained roadway and its continual maintenance. The right-of-way measures 15 feet from either side of the centerline of the roadway. Typically, the purchase of the 15 feet of right-of-way has zero value but would still require a signed acquisition from the adjacent parcel owner.

A modified mini-roundabout with shoulder, as opposed to curb and gutter, was analyzed, but it was determined that the shoulder and ditch design would require additional right-of-way and utility impacts. These impacts were determined to be larger than the cost of the proposed curb and gutter and drainage features associated with the selected mini-roundabout. A single-lane roundabout with shoulders was not analyzed as the *VDOT Road Design Manual* states that single-lane roundabouts shall be provided with curb and gutter on the outside of the circulatory roadway.

The following considerations should be considered during the design phase of the proposed mini-roundabout (Alternative 2).

- Truck turning movements must be accommodated during mini-roundabout design. A traversable center island and additional pavement for acute right turns will be required with a mini-roundabout to prevent truck over tracking.
- A school bus was used as a design vehicle for developing this alternative. This leads to a larger inscribed diameter and circulatory lane width than if a passenger car was used.
- All existing right-of-way in the area is prescriptive.
- Existing access to adjacent parcels and driveway locations should be able to be maintained in a proposed roundabout configuration. The concrete splitter island on the eastbound approach on Earlysville Road may need to be shortened and supplemented with pavement marking to allow turning movements into Rivanna Community Church and Earlysville Exchange.
- The proposed mini-roundabout is likely to increase the impervious (paved) area at one or more drainage outfalls of the study intersection. Current drainage and stormwater management regulations will need to be considered.

For Alternative 2 (Mini-Roundabout) the Right-of-Way Acquisition and Utility Relocation cost is made up of nearly 60% utility relocations. The utilities that have been estimated to be relocated include 3 distribution towers and 2 service poles. These have been estimated to be relocated due to the grading and drainage needed for the mini-roundabout.

Table 7: Planning Level Cost Estimates

	Alternative 1 Low-Cost Countermeasures (2019 dollars)	Alternative 2 Mini-Roundabout (2019 dollars)
Construction Cost (with 25% Contingency)	$60,000	$1,066,000
Construction, Engineering, & Inspection (CEI)	$10,000	$178,000
Preliminary Engineering	$0	$235,000
Right-of-Way Acquisition and Utility Relocation	$0	$474,000
Project Total	$70,000	$1,998,000

3.3.3 Additional Design Recommendations

Access-managements recommendations may be designed within the influence area of the study intersection to improve the safety and flow of traffic along Route 743 and Route 660. These following recommendations should

be considered in the further to supplement Alternative 1 and Alternative 2 in order to provide adequate intersection/access spacing in accordance with VDOT's Minimum Spacing Standards for Commercial Entrances, Intersections, and Median Crossovers from the *VDOT Road Design Manual.*

- Commercial access to Earlysville Exchange and VIP Customs
  - A better defined commercial access with new curb and gutter in the west quadrant of the study intersection.
  - Potential impacts to parking access for Earlysville Exchange and VIP Customs may trigger additional right-of-way and zoning impacts
  - Potential impacts to the flow of travel through each site may be mitigated by a one-way drive aisle with parallel parking and right-in only and right-out only entrances to the site.
  - It is assumed that these improvements are minor and could be covered by a Minimal-Plan Project. However, due to the impacts to the site parking, the right-of-way impacts would be considered moderate.

3.4 Alternative Comparison

Based on an evaluation of the proposed alternatives analysis provided herein, the study team developed the following comparative conclusions. Alternative 2 (mini-roundabout), operationally performs with less vehicle delay than Alternative 1 (low-cost countermeasures). Both Alternative 1 and Alternative 2 provide positive crash reduction; however, Alternative 2 provides a greater benefit. Alternative 2 provides overall greater safety and operational benefits to the traveler.

A summary of the pros and cons of Alternative 1 and Alternative 2 is provided in Table 8 and Table 9, respectively.

Table 8: Alternative 1 Benefits and Limitations Summary

Improvement Benefits	Improvement Limitations
❖ No right-of-way required ❖ Improves safety - 10% reduction in injury and fatal crashes ❖ Increases driver awareness and recognition of the intersection and potential conflicts	❖ Does not improve traffic operations ❖ Does not help reduce vehicle speeds on Earlysville Road (traffic calming)

Table 9: Alternative 2 Benefits and Limitations Summary

Improvement Benefits	Improvement Limitations
❖ Increases intersection volume capacity ❖ Improves safety - 72% crash reduction ❖ Requires vehicles to slow down before entering the roundabout (traffic calming) ❖ Improves northbound sight distance for Reas Ford Road approach ❖ Accommodates school buses, fire trucks, and other large vehicles	❖ Right-of-way required ❖ Utilities impacted ❖ Construction cost

4.0 Recommendations

Alternative 2 (mini-roundabout) is recommended for construction at the Earlysville Road and Reas Ford Road/Earlysville Forest Drive intersection to improve both the safety and operations of the intersection. However, should funding constraints exist,. Alternative 1 (low cost countermeasures) should be implemented as a near-term improvement to reduce crash risk within the intersection.

Public outreach should be performed within the local area to educate the public on the benefits of a roundabout and to educate drivers the rules of a roundabout (http://www.virginiadot.org/innovativeintersections/).

Appendix A: Turning Movement Count Data

Intersection: Rt 743 and Rt 660
Start Date: 11/14/2017
Start Time: 6:30:00 AM

County: Albemarle

	Route 660 EB				Route 743 SB				Route 660 WB				Route 743 NB					
Start Time	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds	Right	Thru	Left	Peds		
6:30 AM	5	0	1	0	3	88	0	0	3	0	4	0	0	8	8	0	120	675
6:45 AM	10	0	4	0	5	91	0	0	0	2	6	0	1	10	7	0	136	816
7:00 AM	14	0	3	0	12	122	2	0	1	1	15	0	3	14	3	0	190	997
7:15 AM	23	0	4	0	8	150	4	0	2	1	6	0	1	26	4	0	229	1053
7:30 AM	31	1	7	0	8	159	3	0	1	0	17	0	2	26	6	0	261	1062
7:45 AM	22	0	11	0	22	191	3	0	4	1	10	0	4	34	15	0	317	968
8:00 AM	24	0	1	0	10	136	2	0	2	1	23	0	3	35	9	0	246	797
8:15 AM	22	1	4	0	10	139	0	0	5	1	16	0	3	31	6	0	238	702
8:30 AM	13	0	2	0	5	102	2	0	2	0	11	0	5	21	4	0	167	597
8:45 AM	12	0	2	0	11	57	3	0	3	1	10	0	6	34	7	0	146	544
9:00 AM	10	0	3	0	1	77	2	0	0	2	13	0	3	29	11	0	151	495
9:15 AM	7	1	2	0	5	63	1	0	3	1	8	0	5	31	6	0	133	463
9:30 AM	6	1	3	0	6	51	2	0	1	2	5	0	4	27	6	0	114	441
9:45 AM	9	1	6	0	4	35	2	0	2	1	9	0	3	21	4	0	97	467
10:00 AM	6	1	4	0	7	51	4	0	4	2	5	0	4	23	8	0	119	509
10:15 AM	4	4	4	0	2	50	2	0	3	1	9	0	5	24	3	0	111	510
10:30 AM	5	2	3	0	7	50	3	0	11	1	5	0	2	38	13	0	140	525
10:45 AM	10	2	5	0	4	59	4	0	1	0	7	0	8	35	4	0	139	509
11:00 PM	11	2	6	0	5	39	0	0	3	1	6	0	6	32	9	0	120	499
11:15 PM	10	6	4	0	1	42	3	0	3	1	6	0	3	38	9	0	126	518
11:30 PM	6	5	2	0	4	40	3	0	2	1	17	0	9	27	8	0	124	513
11:45 PM	9	0	4	0	6	40	2	0	0	0	10	0	5	42	11	0	129	522
12:00 PM	8	0	11	0	5	54	0	0	1	0	4	0	6	45	5	0	139	530
12:15 PM	10	0	5	0	4	35	1	0	2	1	13	0	3	38	9	0	121	500
12:30 PM	12	1	4	0	2	48	2	0	3	1	9	0	5	37	9	0	133	510
12:45 PM	9	0	7	0	2	36	5	0	1	1	7	0	6	48	15	0	137	507
1:00 PM	10	1	4	0	4	36	0	0	4	1	7	0	6	28	8	0	109	536
1:15 PM	6	1	0	0	4	37	6	0	1	2	7	0	8	50	9	0	131	569
1:30 PM	7	1	6	0	2	43	3	0	2	1	4	0	7	48	6	0	130	573
1:45 PM	6	0	2	0	7	50	1	0	5	5	4	0	7	69	10	0	166	591
2:00 PM	5	3	4	0	5	38	2	0	5	1	3	0	12	53	11	0	142	602
2:15 PM	8	1	11	0	4	33	0	0	1	0	7	0	4	59	7	0	135	605
2:30 PM	6	1	5	0	7	44	4	0	3	0	7	0	7	57	7	0	148	643
2:45 PM	9	1	7	0	4	48	3	0	7	2	9	0	7	69	11	0	177	676
3:00 PM	9	1	6	0	4	35	1	0	0	1	5	0	14	59	10	0	145	703
3:15 PM	12	3	10	0	15	42	2	0	5	2	8	0	4	67	3	0	173	763
3:30 PM	16	4	6	0	2	41	4	0	4	1	13	0	5	71	14	0	181	783
3:45 PM	9	2	11	0	5	45	3	0	4	1	5	0	13	89	17	0	204	841
4:00 PM	16	0	11	0	5	39	0	0	6	0	9	0	11	96	12	0	205	847
4:15 PM	11	1	12	0	3	45	2	0	7	2	4	0	12	82	12	0	193	895
4:30 PM	13	2	12	0	6	42	2	0	1	0	3	0	17	125	16	0	239	949
4:45 PM	7	4	12	0	5	37	5	0	3	0	5	0	6	105	21	0	210	971
5:00 PM	16	1	13	0	6	54	2	0	3	2	2	0	19	109	26	0	253	1001
5:15 PM	10	4	7	0	4	35	5	0	1	2	2	0	15	144	18	0	247	934
5:30 PM	13	0	11	0	5	45	2	0	1	1	7	0	14	149	13	0	261	849
5:45 PM	11	0	5	0	5	40	0	0	3	1	8	0	28	128	11	0	240	588
6:00 PM	11	2	10	0	3	33	2	0	1	0	5	0	10	97	12	0	186	348
6:15 PM	8	0	1	0	0	31	1	0	0	1	8	0	12	93	7	0	162	162

	RT	EB	L		RT	SB	L		RT	WB	L		RT	NB	L	
	99	2	23		50	625	8		12	3	66		12	126	36	
PHF	0.798387	0.5	0.522727		0.568182	0.818063	0.666667		0.6	0.75	0.717391		0.75	0.9	0.6	
	50	5	36		20	174	9		8	6	19		76	530	68	
PHF	0.78125	0.3125	0.692308		0.833333	0.805556	0.45		0.666667	0.75	0.59375		0.678571	0.889262	0.653846	

Appendix B: Traffic Signal Warrant

Route 743 and Route 660

TRAFFIC SIGNAL VOLUME WARRANT ANALYSIS

Based on 2009 MUTCD

INTERSECTION NAME:	Route 743 and Route 660	COUNT DATE:	11/14/17
INTERSECTION CONDITION:	Existing Two-Way STOP Control		
MAJOR STREET:	Route 743	# OF APPROACH LANES:	1
MINOR STREET:	Route 660	# OF APPROACH LANES:	1

ISOLATED COMMUNITY WITH POPULATION LESS THAN 10,000 (Y OR N): Y

85TH PERCENTILE SPEED GREATER THAN 40 MPH ON MAJOR STREET (Y OR N): Y

	MAJOR ST BOTH APPROACHES	MINOR ST HIGHEST APPROACH	WARRANT 1, Condition A			WARRANT 1, Condition B			WARRANT 1, Combination Warrant						WARRANT 2	WARRANT 3
									CONDITION A			CONDITION B				
			MAJOR STREET	MINOR STREET	BOTH MET	MAJOR STREET	MINOR STREET	BOTH MET	MAJOR STREET	MINOR STREET	BOTH MET	MAJOR STREET	MINOR STREET	BOTH MET		
THRESHOLD VALUES →			350	105		525	53		280	84		420	42			
06:00 AM TO 07:00 AM																
07:00 AM TO 08:00 AM	822	116	Y	Y	**Y**	Y	Y	**Y**	Y	Y	**Y**	Y	Y	**Y**	**Y**	**Y**
08:00 AM TO 09:00 AM	641	81	Y			Y	Y	**Y**	Y			Y	Y	**Y**		
09:00 AM TO 10:00 AM	399	49	Y						Y				Y			
10:00 AM TO 11:00 AM	410	50	Y						Y				Y			
11:00 AM TO 12:00 PM	384	65	Y				Y		Y				Y			
12:00 PM TO 01:00 PM	420	67	Y				Y		Y			Y	Y	**Y**		
01:00 PM TO 02:00 PM	449	44	Y						Y			Y	Y	**Y**		
02:00 PM TO 03:00 PM	496	61	Y				Y		Y			Y	Y	**Y**		
03:00 PM TO 04:00 PM	565	89	Y			Y	Y	**Y**	Y	Y	**Y**	Y	Y	**Y**		
04:00 PM TO 05:00 PM	706	101	Y			Y	Y	**Y**	Y	Y	**Y**	Y	Y	**Y**	**Y**	
05:00 PM TO 06:00 PM	877	91	Y			Y	Y	**Y**	Y	Y	**Y**	Y	Y	**Y**	**Y**	
06:00 PM TO 07:00 PM																
	6,169	814			**1**			**5**			**4**			**8**	**3**	**1**
			8 HOURS NEEDED			8 HOURS NEEDED			8 HOURS OF BOTH COND. A AND COND. B NEEDED						4 HRS NEEDED	1 HR NEEDED
			NOT SATISFIED			**NOT SATISFIED**			**NOT SATISFIED**						**NOT SATISFIED**	**SATISFIED**

Appendix C: VJUST Results

VDOT Junction Screening Tool

Results Worksheet

General Information	
Project Title:	Earlysville Intersection Safety Review
EW Facility:	Route 660 (Reas Ford Road)
NS Facility:	Route 743 (Earlysville Road)
Date:	September 11, 2019

Volumes (veh/hr)	U-Turn / Left	Through	Right
Eastbound	66	3	12
Westbound	23	2	99
Northbound	8	625	50
Southbound	36	126	12

General Instructions: All intersection and interchange configurations have a default assumption of one exclusive lane per movement. No results shall be interpreted until the user has verified the lane configurations on each worksheet.

Intersection Results

Type	Dir	Maximum V/C (Congestion)	Accommodation Compared to Conventional (Pedestrian)	Weighted Total Conflict Points (Safety)	Notes
50 Mini Roundabout	-	0.77		8	
75 Mini Roundabout	-	0.76		8	
Roundabout	-	0.56		8	
Two-Way Stop Control	-	0.35		48	

Information

Congestion	The maximum v/c ratio represents the worst v/c of all zones that make up an intersection.
Pedestrian	Compares the potential of each design to accommodate pedestrians based on safety, wayfinding, and delay. Potential is qualitatively defined as better (+), similar (blank cell), or worse (-) than a conventional intersection or traditional diamond interchange.
Safety	Weighted Total = (2 x Crossing Conflicts) + Merging Conflicts + Diverging Conflicts

VDOT Junction Screening Tool

Input Worksheet

Project Title:	*Earlysville Intersection Safety Review*
E-W Facility:	*Route 660 (Reas Ford Road)*
N-S Facility:	*Route 743 (Earlysville Road)*
Date:	*September 11, 2019*

Traffic Volume Demand

Direction	Volume (veh/hr)				Truck Percent (%)
	U-Turn / Left		Through	Right	
Eastbound	66		3	12	2.00%
Westbound	23		2	99	2.00%
Northbound	8		625	50	2.00%
Southbound	36		126	12	2.00%
Adjustment Factor	0.80	0.95		0.85	
Suggested	**U - 0.8**	**L - 0.95**		**0.85**	
Truck to PCE Factor			**Suggested = 2.00**		2.00
Critical Lane Volume			1600		

Equivalent Passenger Car Volume

	Volume (pc/hr)			
	U-Turn / Left	Through	Right	Approach
Eastbound	67	3	12	82
Westbound	23	2	101	126
Northbound	8	638	51	697
Southbound	37	129	12	178

Notes:

Left-turn Adjustment Factor	*Conversion of left-turning vehicles to equivalent through vehicles*
Right-turn Adjustment Factor	*Conversion of right-turning vehicles to equivalent through vehicles*
U-turn Adjustment Factor	*Conversion of U-turning vehicles to equivalent through vehicles*
Truck to PCE Factor	*1 truck = X Passenger Car Equivalents*
Critical Lane Volume Sum Limit	*Saturation value for critical lane volume sum at an intersection*

VDOT Junction Screening Tool

Possible Configurations

Indicate with a "Y" or "N" if each intersection or interchange configuration should or should not be considered. Use the information links for guidance. Then, click the "Show/Hide Configurations button" to hide the worksheets for the configurations that will not be considered.

#	Intersections	Information	Consider?	Justification
	Signalized Intersections			
1	Conventional	-	N	
2	Bowtie	Link	N	
3	Center Turn Overpass	Link	N	
4	Continuous Green-T	Link	N	
5	Echelon	Link	N	
6	Full Displaced Left Turn	Link	N	
7	Median U-Turn	Link	N	
8	Partial Displaced Left Turn	Link	N	
9	Partial Median U-Turn	Link	N	
10	Quadrant Roadway N-E	Link	N	
11	Quadrant Roadway N-W	Link	N	
12	Quadrant Roadway S-E	Link	N	
13	Quadrant Roadway S-W	Link	N	
14	Restricted Crossing U-Turn	Link	N	
15	Single Loop	Link	N	
16	Split Intersection	Link	N	
	Unsignalized Intersections			
17	50 Mini Roundabout	Link	Y	
18	75 Mini Roundabout	Link	Y	
19	Roundabout	Link	Y	
20	Two-Way Stop Control	-	Y	
#	**Interchanges**	**Information**	**Consider?**	**Justification**
21	Traditional Diamond	Link	N	
22	Contraflow Left	Link	N	
23	Displaced Left Turn	Link	N	
24	Diverging Diamond	Link	N	
25	Double Roundabout	Link	N	
26	Michigan Urban Diamond	Link	N	
27	Partial Cloverleaf	Link	N	
28	Single Point	Link	N	
29	Single Roundabout	Link	N	

VDOT Junction Screening Tool

Directional Questions and Base Lane Configurations

Before entering a base number of through lanes for each direction, answer all applicable directional question for each intersection or interchange configuration selected for consideration. Navigate to the lane configuration worksheet for example diagrams, if provided.

Intersections	Question	Direction
Bowtie	N/A	N/A
Continuous Green-T	N/A	N/A
Echelon	N/A	N/A
Median U-Turn	N/A	N/A
Partial Displaced Left Turn	N/A	N/A
Partial Median U-Turn	N/A	N/A
Restricted Crossing U-Turn	N/A	N/A
Single Loop	N/A	N/A
Split Intersection	N/A	N/A
Interchanges	**Question**	**Direction**
All	N/A	N/A

Base Number of Through Lanes

Enter a base number of through lanes for each direction. The number of through lanes entered will populate on each non-roundabout lane configuration worksheet. This tool also allows the user to enter the number of through lanes on the lane configuration worksheets directly. This base number may be overwritten on individual lane configuration worksheets. Turn lanes, shared lanes, and channelized lanes must still be entered in each lane configuration worksheet.

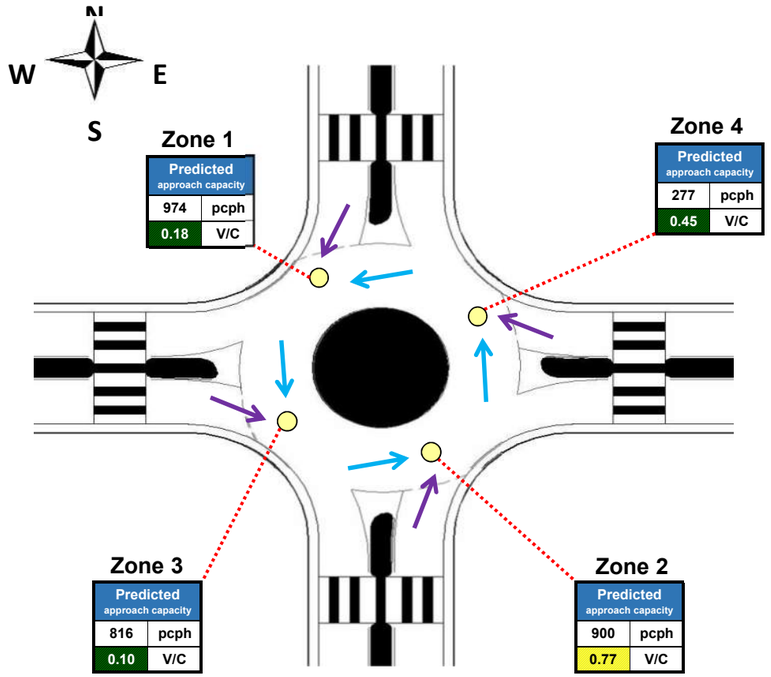
Eastbound	1
Westbound	1
Northbound	1
Southbound	1

50' ICD Mini-Roundabout

DESIGN AND RESULTS

Project Name:	*Earlysville Intersection Safety Review*
EW Facility:	*Route 660 (Reas Ford Road)*
NS Facility:	*Route 743 (Earlysville Road)*
Date:	*September 11, 2019*

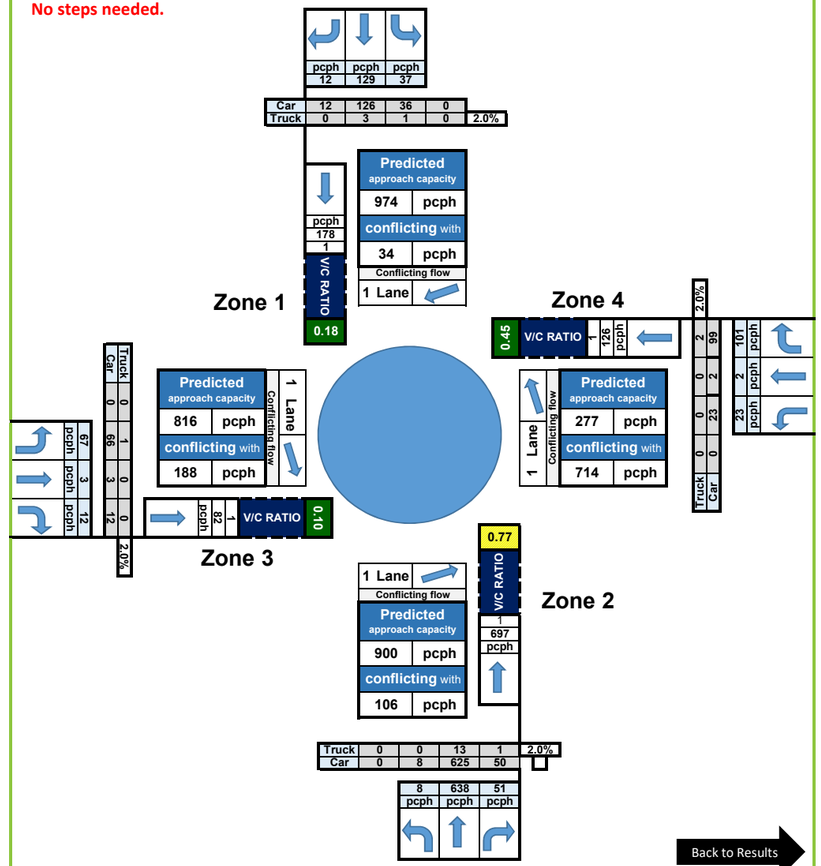
Critical Lane Volume Sum			
< 1200	1200 - 1399	1400 - 1599	≥ 1600
VOLUME / CAPACITY RATIO:	0.77		



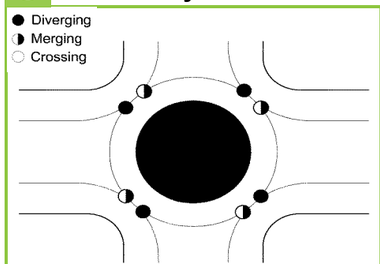
50' ICD Mini-Roundabout

DATA INPUT AND CONFIGURATION

No steps needed.



Safety - Conflict Point Diagram



Conflict Type	Count
Crossing	0
Merging	4
Diverging	4
Total	**8**

Conflict Type	Weight
Crossing	2
Merging	1
Diverging	1

Weighted Total Conflict Points

8

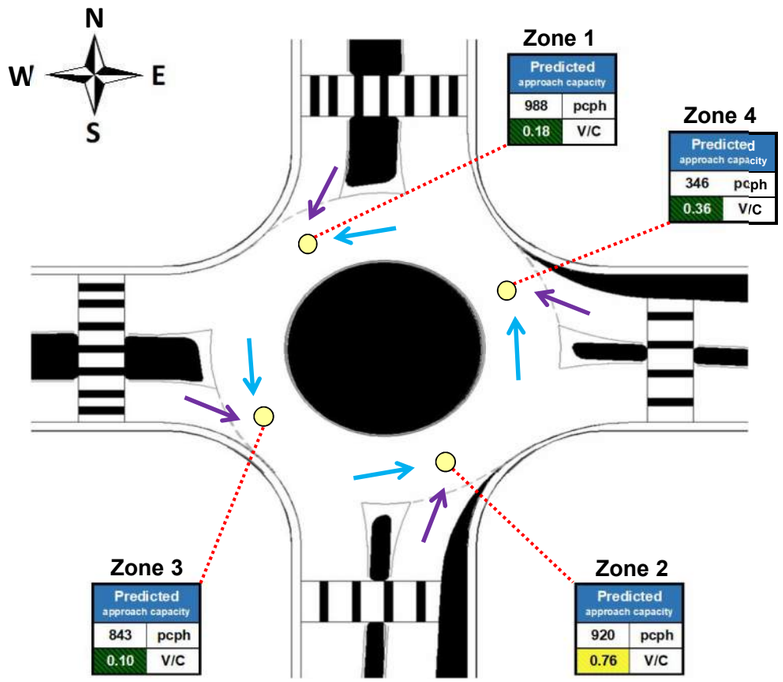
Assumptions

- This worksheet does not use the CLV methodology. The calculations are based on the article *Determination of Mini-Roundabout Capacity in the United States* , published in the *Journal of Transportation Engineering* .

75' ICD Mini-Roundabout

DESIGN AND RESULTS

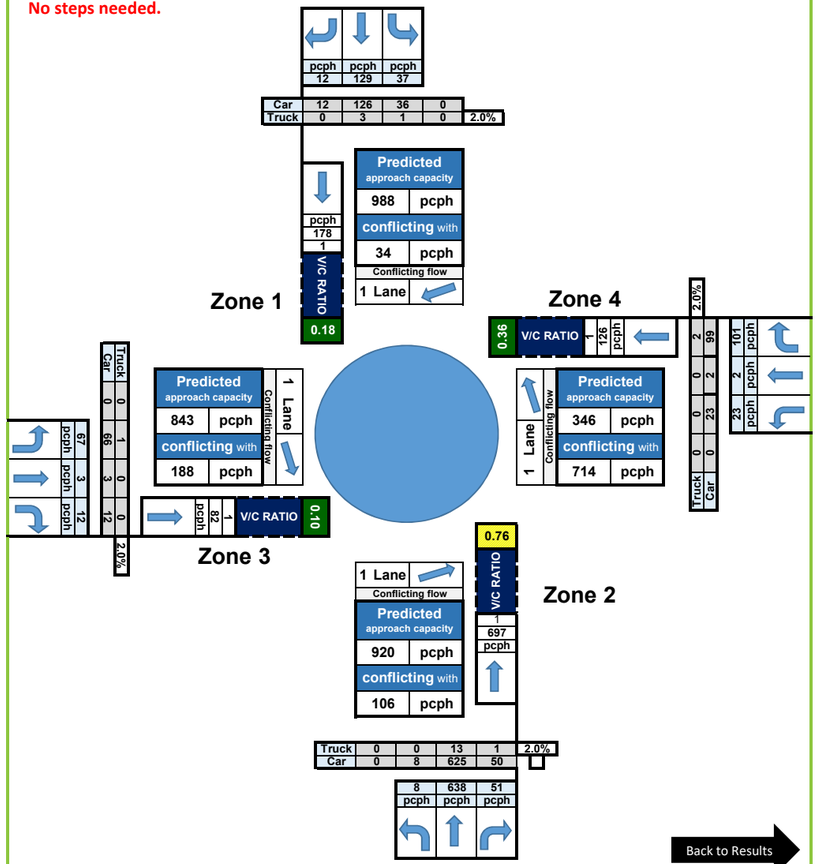
		Critical Lane Volume Sum			
Project Name:	*Earlysville Intersection Safety Review*	< 1200	1200 - 1399	1400 - 1599	≥ 1600
EW Facility:	*Route 660 (Reas Ford Road)*				
NS Facility:	*Route 743 (Earlysville Road)*	VOLUME / CAPACITY RATIO:	0.76		
Date:	*September 11, 2019*				



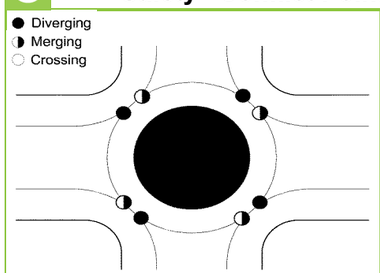
75' ICD Mini-Roundabout

DATA INPUT AND CONFIGURATION

No steps needed.



Safety - Conflict Point Diagram



Conflict Type	Count
Crossing	0
Merging	4
Diverging	4
Total	**8**

Conflict Type	Weight
Crossing	2
Merging	1
Diverging	1

Weighted Total Conflict Points

8

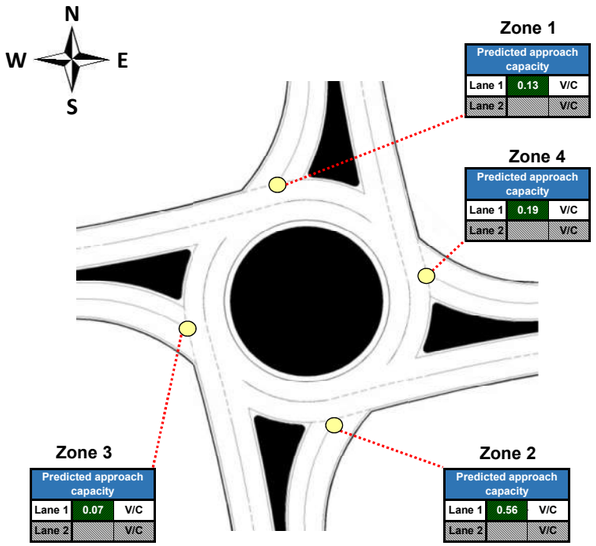
Assumptions

- This worksheet does not use the CLV methodology. The calculations are based on the article *Determination of Mini-Roundabout Capacity in the United States* , published in the *Journal of Transportation Engineering* .

Roundabout

DESIGN AND RESULTS

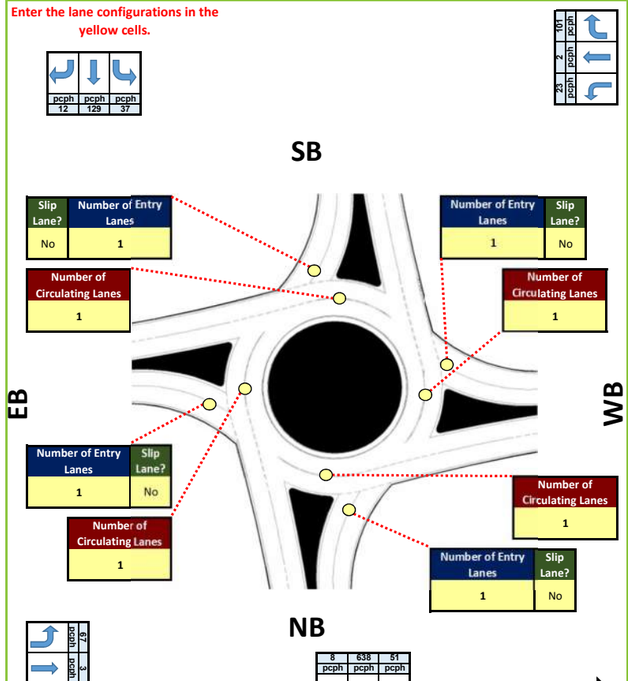
Project Name:	Earlysville Intersection Safety Review	Critical Lane Volume Sum			
EW Facility:	Route 660 (Reas Ford Road)	< 1200	1200 - 1399	1400 - 1599	≥ 1600
NS Facility:	Route 743 (Earlysville Road)	VOLUME / CAPACITY RATIO:	0.56		
Date:	September 11, 2019				



Roundabout

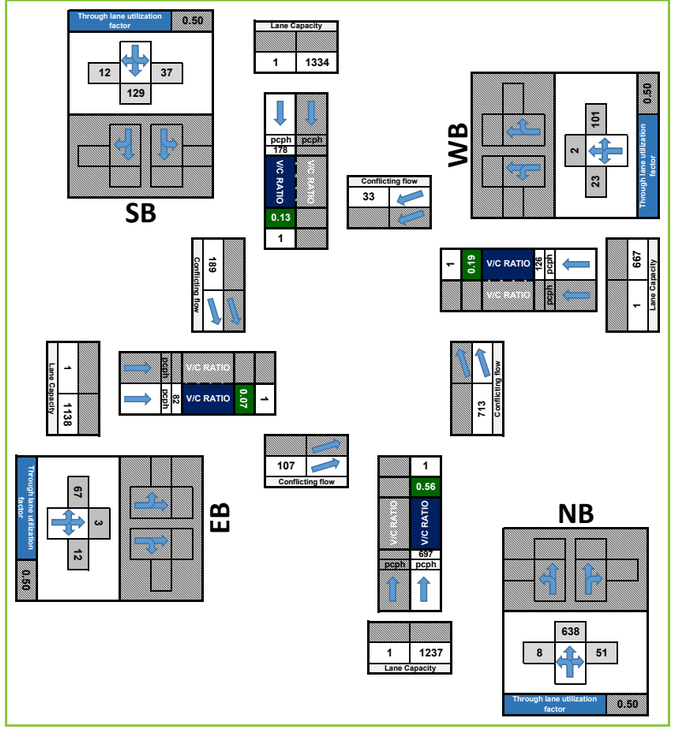
DATA INPUT AND CONFIGURATION

Enter the lane configurations in the yellow cells.



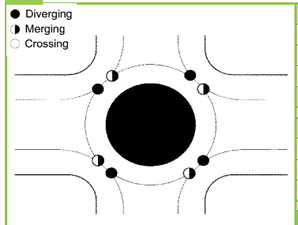
Roundabout

CAPACITY CALCULATIONS



EQUATION: A x exp(-B x Q)				
Number of Entry Lanes	Number of Circulating Lanes	Lane	A	B
1	1	-	1380	0.00102
1	2	-	1420	0.00085
2	1	Left	1420	0.00091
2	1	Right	1420	0.00091
2	2	Left	1350	0.00092
2	2	Right	1420	0.00085

Safety - Conflict Point Diagram



Conflict Type	Count
Crossing	0
Merging	4
Diverging	4
Total	**8**

Conflict Type	Weight
Crossing	2
Merging	1
Diverging	1

Weighted Total Conflict Points

8

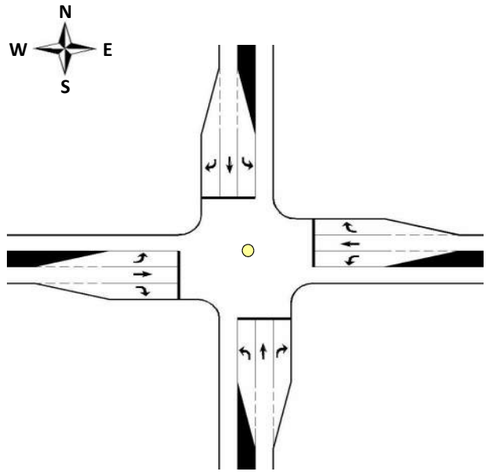
Assumptions

- The number of circulating lanes in one quadrant is assumed to be equal to the number of exiting lanes in the next quadrant.
- The roundabout is limited to a maximum of two entry lanes and two circulating lanes.
- All left-turning vehicles are assumed to stay in the innermost lane until exiting the roundabout.
- This worksheet does not use the CLV methodology. The calculations are based on the *HCM 6th Edition* .

Two-Way Stop Control (TWSC)

DESIGN AND RESULTS

		Critical Lane Volume Sum			
Project Name:	*Earlysville Intersection Safety Review*	< 1200	1200 - 1399	1400 - 1599	≥ 1600
EW Facility:	*Route 660 (Reas Ford Road)*				
NS Facility:	*Route 743 (Earlysville Road)*	VOLUME / CAPACITY RATIO:			0.35
Date:	*September 11, 2019*				

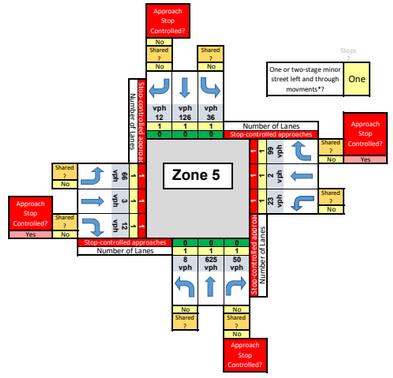


Note: This diagram does not reflect the actual lane configuration of the intersection

Two-Way Stop Control (TWSC)

DATA INPUT AND CONFIGURATION

Step 1: Identify which approaches are stop-controlled by selecting "Yes" from the drop-down box.
Step 2: Enter the lane configurations in the yellow cells.



MAJOR	MINOR
NB	EB
SB	WB

Major street lanes	2
M1 Shared?	FALSE
M4 Shared?	FALSE

Priority	MVMT	Rank
7	EBL	4
8	EBT	3
9	EBR	2
10	WBL	4
11	WBT	3
12	WBR	2
4	NBL	2
5	NBT	1
6	NBR	1
1	SBL	2
2	SBT	1
3	SBR	1

Priority	Rank	Flow Rates	Lanes	Shared?	Stop controlled?	Truck %
1	2	36	1	No		0.02
4	2	8	1	No		0.02
7	4	66	1	No	Yes	0.02
8	3	3	1		Yes	0.02
9	2	12	1	No	Yes	0.02
10	4	23	1	No	Yes	0.02
11	3	2	1		Yes	0.02
12	2	99	1	No	Yes	0.02
2	1	126	1			0.02
3	1	12	1	No	No	0.02
5	1	625	1	No		0.02
6	1	50	1	No	No	0.02

Two-Way Stop Control (TWSC)

HCM 6 CALCULATIONS

Conflicting Flows

$v_{c,1}$	675.00
$v_{c,4}$	138.00
$v_{c,7}$	914.50
$v_{c,8}$	889.00
$v_{c,9}$	126.00
$v_{c,10}$	852.50
$v_{c,11}$	851.00
$v_{c,12}$	625.00
$v_{c,1,1}$	198.00
$v_{c,1,7}$	716.50
$v_{c,4,8}$	198.00
$v_{c,4,9}$	691.00
$v_{c,1,10}$	641.00
$v_{c,4,10}$	211.50
$v_{c,1,11}$	641.00
$v_{c,4,11}$	210.00

Critical Headways

$t_{c,1}$	4.12
$t_{c,4}$	4.12
$t_{c,7}$	7.12
$t_{c,8}$	6.52
$t_{c,9}$	6.22
$t_{c,10}$	7.12
$t_{c,11}$	6.52
$t_{c,12}$	6.22
$t_{c,1,7}$	6.12
$t_{c,1,8}$	5.52
$t_{c,4,8}$	5.52
$t_{c,1,10}$	6.12
$t_{c,4,10}$	6.12
$t_{c,1,11}$	5.52
$t_{c,4,11}$	5.52

Follow-Up Headways

$t_{f,1}$	2.22
$t_{f,4}$	2.22
$t_{f,7}$	3.52
$t_{f,8}$	4.02
$t_{f,9}$	3.32
$t_{f,10}$	3.52
$t_{f,11}$	4.02
$t_{f,12}$	3.32

Potential Capacities

$c_{p,1}$	916.28
$c_{p,4}$	1445.72
$c_{p,7}$	253.63
$c_{p,8}$	282.38
$c_{p,9}$	924.39
$c_{p,10}$	279.37
$c_{p,11}$	297.15
$c_{p,12}$	484.78

Two-Stage Potential Capacities

$c_{p,1,1}$	803.83
$c_{p,1,7}$	420.94
$c_{p,1,8}$	737.13
$c_{p,4,8}$	445.56
$c_{p,1,10}$	463.13
$c_{p,4,10}$	790.61
$c_{p,1,11}$	469.43
$c_{p,4,11}$	728.37

y_7	5.68
y_8	3.19
y_{10}	0.41
y_{11}	0.45

Mvmt 1, excl left	$p_{0,1}$ 0.96
Mvmt 4, excl left	$p_{0,4}$ 0.99
Mvmt 1, shared left	$p^*_{y,1}$ 0.96
Mvmt 4, shared left	$p^*_{y,4}$ 0.99
Mvmt 7, 4-leg	$p^*_{y,7}$ 0.949
Mvmt 10, 4-leg	$p^*_{y,10}$ 0.945

$x_{g,1,2,4}$	0.07
$x_{g,4,1,2}$	0.35

One Stage

$f_{g,7}$	0.96
$f_{g,8}$	0.96
$f_{g,9}$	0.00
$f_{g,10}$	0.00

Two Stage

$f_{g,7}$	0.96
$f_{g,8}$	0.99
$f_{g,9}$	0.96
$f_{g,10}$	0.99

Movement Capacities

$c_{m,1}$	916.28
$c_{m,4}$	1445.72
$c_{m,7}$	193.92
$c_{m,8}$	269.78
$c_{m,9}$	924.39
$c_{m,10}$	264.10
$c_{m,11}$	283.90
$c_{m,12}$	484.78

Two-Stage Movement Capacities

$c_{m,7,1}$	772.24
$c_{m,7,4}$	331.70
$c_{m,8,4}$	708.17
$c_{m,8,8}$	443.09
$c_{m,1,10}$	460.56
$c_{m,4,10}$	746.51
$c_{m,1,11}$	466.83
$c_{m,4,11}$	699.75

$c_{t,7}$	256.01
$c_{t,8}$	341.70
$c_{t,10}$	367.88
$c_{t,11}$	374.41

$p_{g,7}$	0.99
$p_{g,8}$	0.99
$p'_{y,7}$	0.96
$p'_{y,10}$	0.96

$f_{g,7}$	0.99
$f_{g,8}$	0.96
$f_{g,9}$	0.79
$f_{g,10}$	0.94

Shared Movement Capacities

0	0.00
0	
0	
0	0.00
0	

Single-Stage Movement Capacities

$c_{m,1}$	193.92
$c_{m,4}$	269.78
$c_{m,10}$	264.10
$c_{m,11}$	283.90

Movement Capacities

1	916.28
2	1800.00
3	1500.00
4	1445.72
5	1800.00
6	1500.00
7	193.92
8	269.78
9	924.39
10	264.10
11	283.90
12	484.78

$p_{g,1}$	0.99
$p_{g,1,7}$	0.80
$f_{p,t}$	0.76
$f_{p,10}$	0.95

$p_{g,1,8}$	1.00
$p_{g,1,11}$	1.00

Movement V/C

1	0.04
2	0.07
3	0.01
4	0.01
5	0.35
6	0.03
7	0.34
8	0.01
9	0.01
10	0.09
11	0.01
12	0.20

Intersection V/C

0.35

V/C Not Reported for Any Movements?

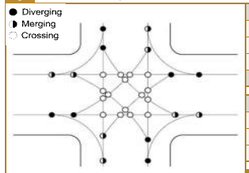
No

a	0.91

*Assumption: One storage space in median (n_s = 1) for two-stage turns

Saturation Flow Rates	
Through	1800
Right	1500

Safety - Conflict Point Diagram



Conflict Type	Count
Crossing	16
Merging	8
Diverging	8
Total	**32**

Conflict Type	Weight
Crossing	2
Merging	1
Diverging	1

Weighted Total Conflict Points

48

Assumptions

- This worksheet does not use the CLV methodology. The calculations are based on the *HCM, 6th Edition* . The calculations are based on vehicles per hour.

Appendix D: Level of Service Worksheets

AM Peak Period

MOVEMENT SUMMARY

Site: 101 [Route 743 and Route 660]

Earlysville Safety Analysis
Site Category: (None)
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	Distance ft	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed mph
South: Route 743												
3	L2	60	2.0	0.197	5.1	LOS A	1.4	35.3	0.29	0.13	0.29	32.8
8	T1	140	2.0	0.197	5.1	LOS A	1.4	35.3	0.29	0.13	0.29	33.0
18	R2	16	2.0	0.197	5.1	LOS A	1.4	35.3	0.29	0.13	0.29	32.4
Approach		216	2.0	0.197	5.1	LOS A	1.4	35.3	0.29	0.13	0.29	32.9
East: Route 660												
1	L2	92	2.0	0.129	5.3	LOS A	0.7	18.6	0.49	0.33	0.49	31.9
6	T1	4	2.0	0.129	5.3	LOS A	0.7	18.6	0.49	0.33	0.49	32.1
16	R2	20	2.0	0.129	5.3	LOS A	0.7	18.6	0.49	0.33	0.49	31.5
Approach		116	2.0	0.129	5.3	LOS A	0.7	18.6	0.49	0.33	0.49	31.8
North: Route 743												
7	L2	12	2.0	0.876	27.2	LOS D	31.9	810.6	1.00	1.05	1.67	25.0
4	T1	762	2.0	0.876	27.2	LOS D	31.9	810.6	1.00	1.05	1.67	25.1
14	R2	88	2.0	0.876	27.2	LOS D	31.9	810.6	1.00	1.05	1.67	24.8
Approach		862	2.0	0.876	27.2	LOS D	31.9	810.6	1.00	1.05	1.67	25.1
West: Route 660												
5	L2	43	2.0	0.467	20.5	LOS C	3.8	97.2	0.98	1.06	1.21	26.8
2	T1	4	2.0	0.467	20.5	LOS C	3.8	97.2	0.98	1.06	1.21	26.9
12	R2	124	2.0	0.467	20.5	LOS C	3.8	97.2	0.98	1.06	1.21	26.5
Approach		171	2.0	0.467	20.5	LOS C	3.8	97.2	0.98	1.06	1.21	26.6
All Vehicles		1365	2.0	0.876	21.0	LOS C	31.9	810.6	0.84	0.84	1.29	26.8

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 6).
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

PM Peak Period

MOVEMENT SUMMARY

Site: 101 [Route 743 and Route 660]

Earlysville Safety Analysis
Site Category: (None)
Roundabout

Movement Performance - Vehicles

Mov ID	Turn	Demand Flows Total veh/h	Demand Flows HV %	Deg. Satn v/c	Average Delay sec	Level of Service	95% Back of Queue Vehicles veh	95% Back of Queue Distance ft	Prop. Queued	Effective Stop Rate	Aver. No. Cycles	Average Speed mph
South: Route 743												
3	L2	117	2.0	0.773	17.9	LOS C	11.7	298.0	0.77	0.44	0.77	27.8
8	T1	596	2.0	0.773	17.9	LOS C	11.7	298.0	0.77	0.44	0.77	27.9
18	R2	100	2.0	0.773	17.9	LOS C	11.7	298.0	0.77	0.44	0.77	27.5
Approach		812	2.0	0.773	17.9	LOS C	11.7	298.0	0.77	0.44	0.77	27.9
East: Route 660												
1	L2	32	2.0	0.116	9.7	LOS A	0.7	18.5	0.83	0.74	0.83	30.2
6	T1	8	2.0	0.116	9.7	LOS A	0.7	18.5	0.83	0.74	0.83	30.4
16	R2	12	2.0	0.116	9.7	LOS A	0.7	18.5	0.83	0.74	0.83	29.9
Approach		52	2.0	0.116	9.7	LOS A	0.7	18.5	0.83	0.74	0.83	30.2
North: Route 743												
7	L2	20	2.0	0.270	6.5	LOS A	1.9	47.0	0.48	0.30	0.48	32.5
4	T1	215	2.0	0.270	6.5	LOS A	1.9	47.0	0.48	0.30	0.48	32.7
14	R2	24	2.0	0.270	6.5	LOS A	1.9	47.0	0.48	0.30	0.48	32.1
Approach		259	2.0	0.270	6.5	LOS A	1.9	47.0	0.48	0.30	0.48	32.6
West: Route 660												
5	L2	52	2.0	0.155	5.8	LOS A	0.9	23.4	0.54	0.38	0.54	32.3
2	T1	16	2.0	0.155	5.8	LOS A	0.9	23.4	0.54	0.38	0.54	32.5
12	R2	64	2.0	0.155	5.8	LOS A	0.9	23.4	0.54	0.38	0.54	31.9
Approach		132	2.0	0.155	5.8	LOS A	0.9	23.4	0.54	0.38	0.54	32.1
All Vehicles		1256	2.0	0.773	13.9	LOS B	11.7	298.0	0.69	0.42	0.69	29.3

Site Level of Service (LOS) Method: Delay & v/c (HCM 6). Site LOS Method is specified in the Parameter Settings dialog (Site tab).
Roundabout LOS Method: Same as Sign Control.
Vehicle movement LOS values are based on average delay and v/c ratio (degree of saturation) per movement.
LOS F will result if v/c > 1 irrespective of movement delay value (does not apply for approaches and intersection).
Intersection and Approach LOS values are based on average delay for all movements (v/c not used as specified in HCM 6).
Roundabout Capacity Model: SIDRA Standard.
HCM Delay Formula option is used. Control Delay does not include Geometric Delay since Exclude Geometric Delay option applies.
Gap-Acceptance Capacity: SIDRA Standard (Akçelik M3D).
HV (%) values are calculated for All Movement Classes of All Heavy Vehicle Model Designation.

Intersection	
Int Delay, s/veh	16.3

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		⇕			⇂	↱		⇕			⇕	
Traffic Vol, veh/h	8	625	50	36	126	12	23	2	99	66	3	12
Future Vol, veh/h	8	625	50	36	126	12	23	2	99	66	3	12
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	100	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	66	81	56	60	90	75	52	50	79	71	75	60
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	12	772	89	60	140	16	44	4	125	93	4	20

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	156	0	0	861	0	0	1121	1117	817	1165	1145	140
Stage 1	-	-	-	-	-	-	841	841	-	260	260	-
Stage 2	-	-	-	-	-	-	280	276	-	905	885	-
Critical Hdwy	4.12	-	-	4.12	-	-	7.12	6.52	6.22	7.12	6.52	6.22
Critical Hdwy Stg 1	-	-	-	-	-	-	6.12	5.52	-	6.12	5.52	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.12	5.52	-	6.12	5.52	-
Follow-up Hdwy	2.218	-	-	2.218	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Cap-1 Maneuver	1424	-	-	781	-	-	183	207	376	171	200	908
Stage 1	-	-	-	-	-	-	359	380	-	745	693	-
Stage 2	-	-	-	-	-	-	727	682	-	331	363	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	1424	-	-	781	-	-	163	187	376	104	180	908
Mov Cap-2 Maneuver	-	-	-	-	-	-	163	187	-	104	180	-
Stage 1	-	-	-	-	-	-	353	374	-	733	635	-
Stage 2	-	-	-	-	-	-	647	625	-	215	357	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.1	2.8	37.5	130.4
HCM LOS			E	F

Minor Lane/Major Mvmt	NBLn1	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	277	1424	-	-	781	-	-	125
HCM Lane V/C Ratio	0.627	0.009	-	-	0.077	-	-	0.936
HCM Control Delay (s)	37.5	7.5	0	-	10	0	-	130.4
HCM Lane LOS	E	A	A	-	A	A	-	F
HCM 95th %tile Q(veh)	3.9	0	-	-	0.2	-	-	6.1

Intersection	
Int Delay, s/veh	5.9

Movement	EBL	EBT	EBR	WBL	WBT	WBR	NBL	NBT	NBR	SBL	SBT	SBR
Lane Configurations		⇕			⇃	↱		⇕			⇕	
Traffic Vol, veh/h	9	174	20	68	530	76	36	5	50	19	6	8
Future Vol, veh/h	9	174	20	68	530	76	36	5	50	19	6	8
Conflicting Peds, #/hr	0	0	0	0	0	0	0	0	0	0	0	0
Sign Control	Free	Free	Free	Free	Free	Free	Stop	Stop	Stop	Stop	Stop	Stop
RT Channelized	-	-	None	-	-	None	-	-	None	-	-	None
Storage Length	-	-	-	-	-	100	-	-	-	-	-	-
Veh in Median Storage, #	-	0	-	-	0	-	-	0	-	-	0	-
Grade, %	-	0	-	-	0	-	-	0	-	-	0	-
Peak Hour Factor	45	80	83	65	88	67	69	31	78	59	75	66
Heavy Vehicles, %	2	2	2	2	2	2	2	2	2	2	2	2
Mvmt Flow	20	218	24	105	602	113	52	16	64	32	8	12

Major/Minor	Major1			Major2			Minor1			Minor2		
Conflicting Flow All	715	0	0	242	0	0	1149	1195	230	1122	1094	602
Stage 1	-	-	-	-	-	-	270	270	-	812	812	-
Stage 2	-	-	-	-	-	-	879	925	-	310	282	-
Critical Hdwy	4.12	-	-	4.12	-	-	7.12	6.52	6.22	7.12	6.52	6.22
Critical Hdwy Stg 1	-	-	-	-	-	-	6.12	5.52	-	6.12	5.52	-
Critical Hdwy Stg 2	-	-	-	-	-	-	6.12	5.52	-	6.12	5.52	-
Follow-up Hdwy	2.218	-	-	2.218	-	-	3.518	4.018	3.318	3.518	4.018	3.318
Pot Cap-1 Maneuver	885	-	-	1324	-	-	176	186	809	183	214	500
Stage 1	-	-	-	-	-	-	736	686	-	373	392	-
Stage 2	-	-	-	-	-	-	342	348	-	700	678	-
Platoon blocked, %		-	-		-	-						
Mov Cap-1 Maneuver	885	-	-	1324	-	-	146	157	809	137	180	500
Mov Cap-2 Maneuver	-	-	-	-	-	-	146	157	-	137	180	-
Stage 1	-	-	-	-	-	-	717	668	-	363	339	-
Stage 2	-	-	-	-	-	-	282	301	-	613	660	-

Approach	EB	WB	NB	SB
HCM Control Delay, s	0.7	1	35.5	34.8
HCM LOS			E	D

Minor Lane/Major Mvmt	NBLn1	EBL	EBT	EBR	WBL	WBT	WBR	SBLn1
Capacity (veh/h)	246	885	-	-	1324	-	-	172
HCM Lane V/C Ratio	0.538	0.023	-	-	0.079	-	-	0.304
HCM Control Delay (s)	35.5	9.2	0	-	8	0	-	34.8
HCM Lane LOS	E	A	A	-	A	A	-	D
HCM 95th %tile Q(veh)	2.9	0.1	-	-	0.3	-	-	1.2