PROJECT PIPELINE

BR-23-09: Tazewell County, Virginia

US 19/460 (TRAIL OF LONESOME PINE ROAD / GOV. GEORGE C. PEERY HIGHWAY) FROM LIMESTONE ROAD TO POUDING MILL BRANCH ROAD

US 19/460 (Trail of Lonesome Pine Road / Gov. George C. Peery Highway) from Limestone Road to Pounding Mill Branch Road

Complete Project Pipeline Study Report

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Chapter 1:

Needs Evaluation and Diagnosis

Introduction

Project Pipeline is a performance-based planning program to identify cost-effective solutions to multimodal transportation needs in Virginia. Through this planning process, projects and solutions may be considered for funding through programs, including SMART SCALE, revenue sharing, interstate funding, and others. Visit the Project Pipeline webpage for additional information: vaprojectpipeline.org.

This study focuses on concepts targeting identified needs including congestion mitigation, safety improvement, pedestrian and bicycle infrastructure along the corridor, and transit access. The objectives of Project Pipeline are shown below in **Figure 1.**

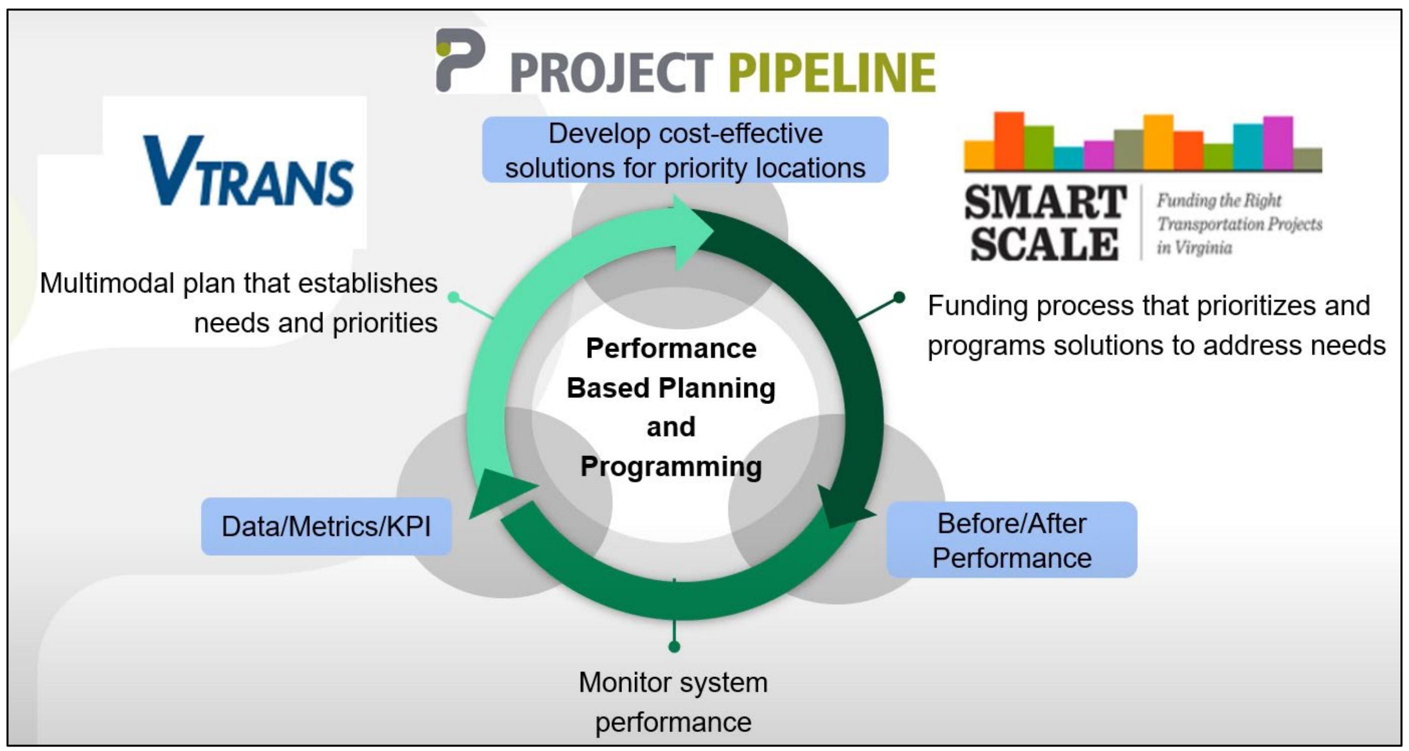


Figure 1: Project Pipeline Objectives

Background

The Office of Intermodal Planning and Investment (OIPI) prepared the VTrans Virginia's statewide transportation plan for the Commonwealth Transportation Board (CTB) in which mid-term needs (0 - 10 years) were identified for different categories listed in **Table 1.** This study focuses on addressing needs identified in VTrans, and those previously identified by the localities.

Table 1: List of VTrans Needs

VTrans Needs
Safety Improvement
Transportation Demand Management
Congestion Mitigation
Pedestrian Safety Improvement
Transit Access
Capacity Preservation
Bicycle Access

Methodology

The study is broken down into three phases. Phase 1 involves problem diagnosis and brainstorming of alternatives, Phase 2 is the detailed evaluation of alternatives and developed of initial concepts, and Phase 3 is the finalization of the preferred alternative in regard to design concept and cost estimate. Details on methods and solutions for each study phase are outlined below in **Figure 2**.

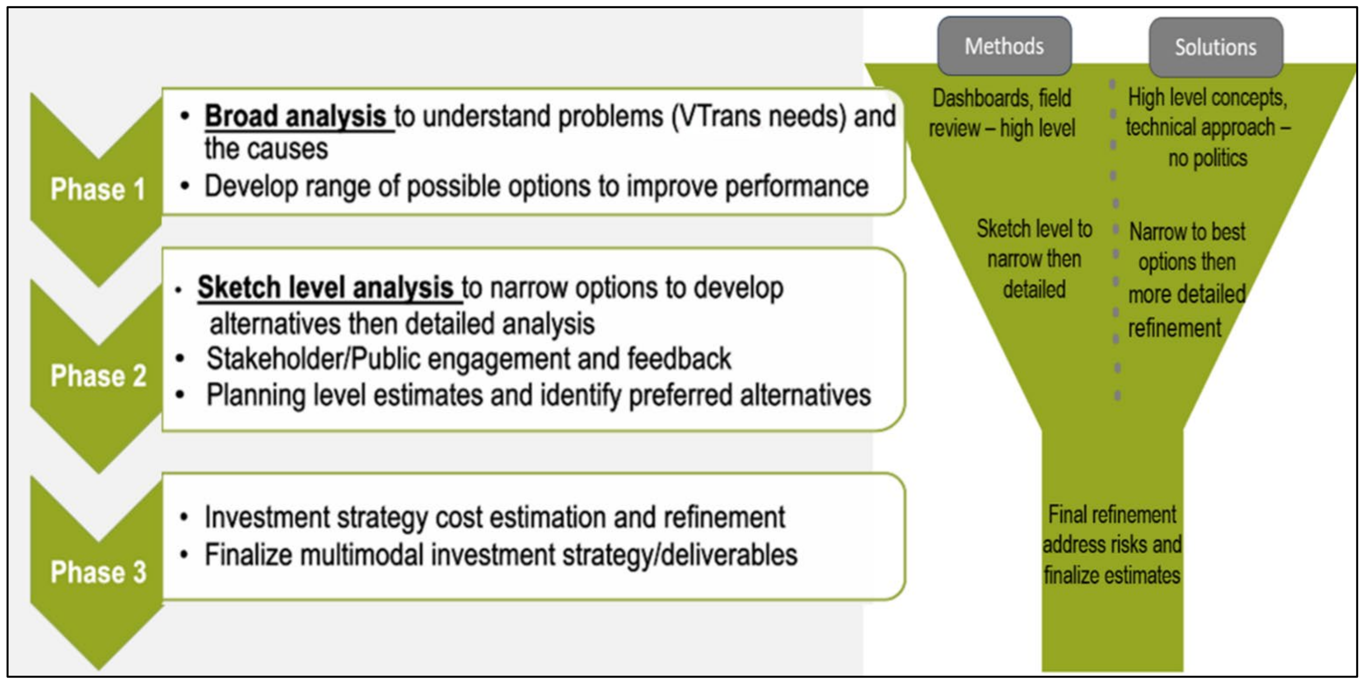


Figure 2: Study Phase Methods and Solutions

The study team is also broken down into three teams with each team simultaneously working on different areas of the study. Team 1 focuses on Traffic Operations, Capacity, and Access, Team 2 focuses on Road Reliability and Safety, while Team 3 focuses on Rail, Transit, and Transportation Demand Management (TDM), as shown in **Figure 3**. The following details the focus area of study for each team:

- Team 1 – Identify operation and access needs by conducting future traffic demand volume forecasts and performing operational analysis of future conditions using Synchro/SimTraffic. Evaluate operational mitigations such as geometric modifications, access management improvements, and installation of facilities for pedestrians and bicycles.
- Team 2 – Identify safety needs with respect to vehicles, pedestrians, and cyclists by evaluating existing roadway conditions as well as crash patterns and crash hot spot locations based on the most recent five-year crash history obtained from the Virginia Department of Transportation (VDOT) Crash Analysis Tool. Recommend safety improvement options through geometric modifications, access management improvements, and installation of facilities for pedestrians and bicycles.
- Team 3 – Identify needs with respect to rail, transit, and TDM by reviewing existing rail and transit routes and future traffic demand volume forecasts. Consider improvements that would enhance transit ridership and shift mode choice away from single-occupancy vehicles.

Figure 3: Study Team and Focus Area of Study

Study Area

The US 19/460 (Trail of the Lonesome Pine / Gov. George C. Peery Highway) study corridor from Limestone Road to Pounding Mill Branch Road is located in Tazewell County, Virginia. The 3.9-mile corridor is classified as a rural principal arterial road within the study area and is on the Corridors of Statewide Significance (CoSS). The posted speed limit is 60 MPH, the facility is a four-lane divided road, and there are no signalized intersections along the corridor. A map detailing the general location of the study area is shown below in **Figure 4**.

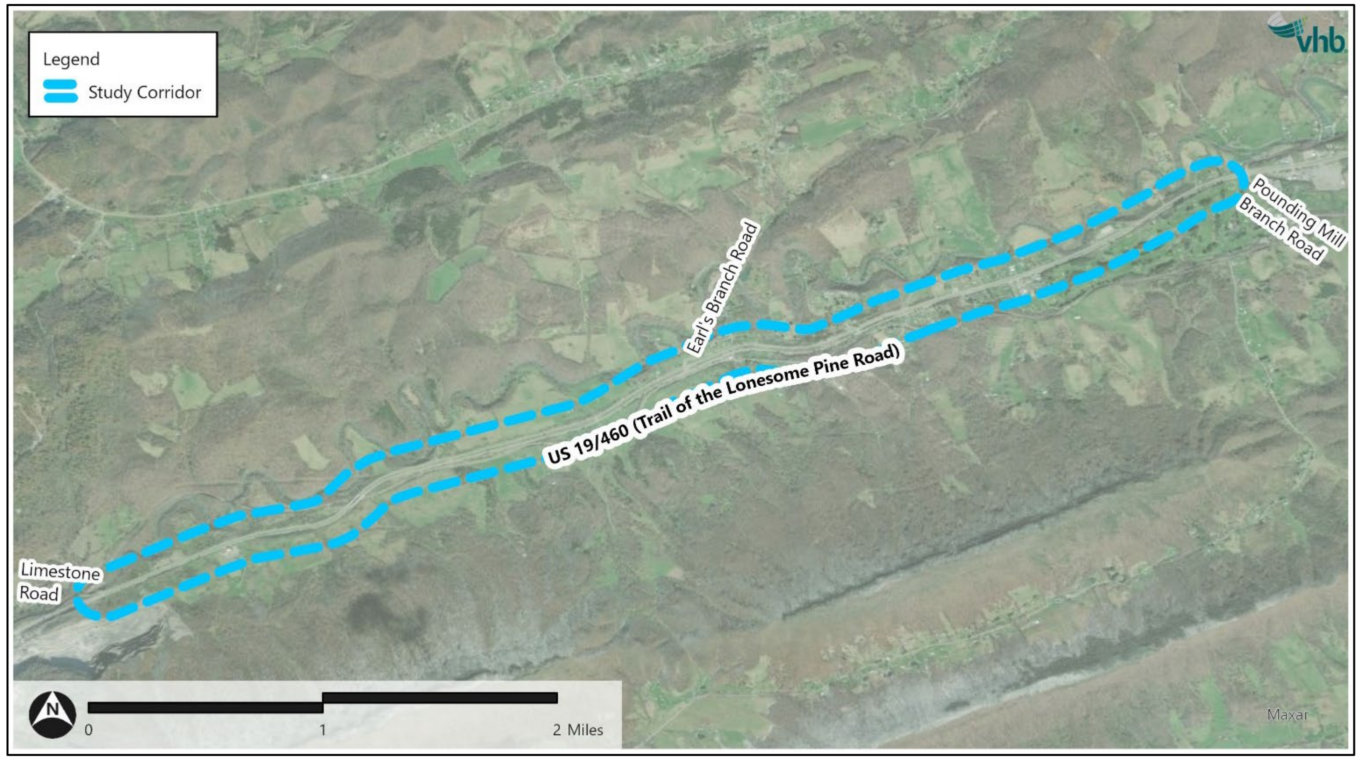


Figure 4: US 19/460 Study Area Map

VTrans is Virginia's statewide transportation plan. It identifies and prioritizes locations with transportation needs using data-informed transparent processes. The policy for identifying VTrans mid-term needs establishes multimodal need categories that correspond to the Commonwealth Transportation Board-adopted VTrans visions, goals, and objectives.[1] Each need category has one or more performance measures and thresholds to identify one or more needs. Visit the VTrans policy guide for additional information: https://vtrans.org/resources/VTrans_Policy_Guide_v6.pdf.

The mid-term needs, as identified in VTrans for the study corridor, were identified as 'Very High' for two need areas, 'Low' for one need area, and "None" for the rest of the need areas, as presented in **Table 2.** These mid-term needs, identified in VTrans, are prioritized on a tier from 1 to 4, with 1 being the most critical and 4 being the least critical. The segments ranked as "Priority 1" represent those with multiple categories identified as high in need. **Figure 5** presents a map of the study area with 2019 VTrans mid-term needs prioritized for district attention. As can be seen in the figure, there is a Priority 1 need throughout most of the study corridor.

Each VTrans need present on the US 19/460 corridor (as identified in Table 2) is individually shown in **Table 3.** This facilitates the identification of specific need locations along the corridor.

Table 2: VTrans Needs in Study Area

VTrans 2019 Mid-Term Need	District Priority*
Congestion	None
Reliability	None
Transit Access for Equity Emphasis Areas	None
Transit Access to Activity Centers	None
Pedestrian Access to Activity Centers	None
Bicycle Access to Activity Centers	None
Access to Industrial & Economic Development Areas	None
Road Safety	Very High
Capacity Preservation	Very High
Transportation Demand Management (TDM)	Low
Pedestrian Safety	None

*Max priority within study area

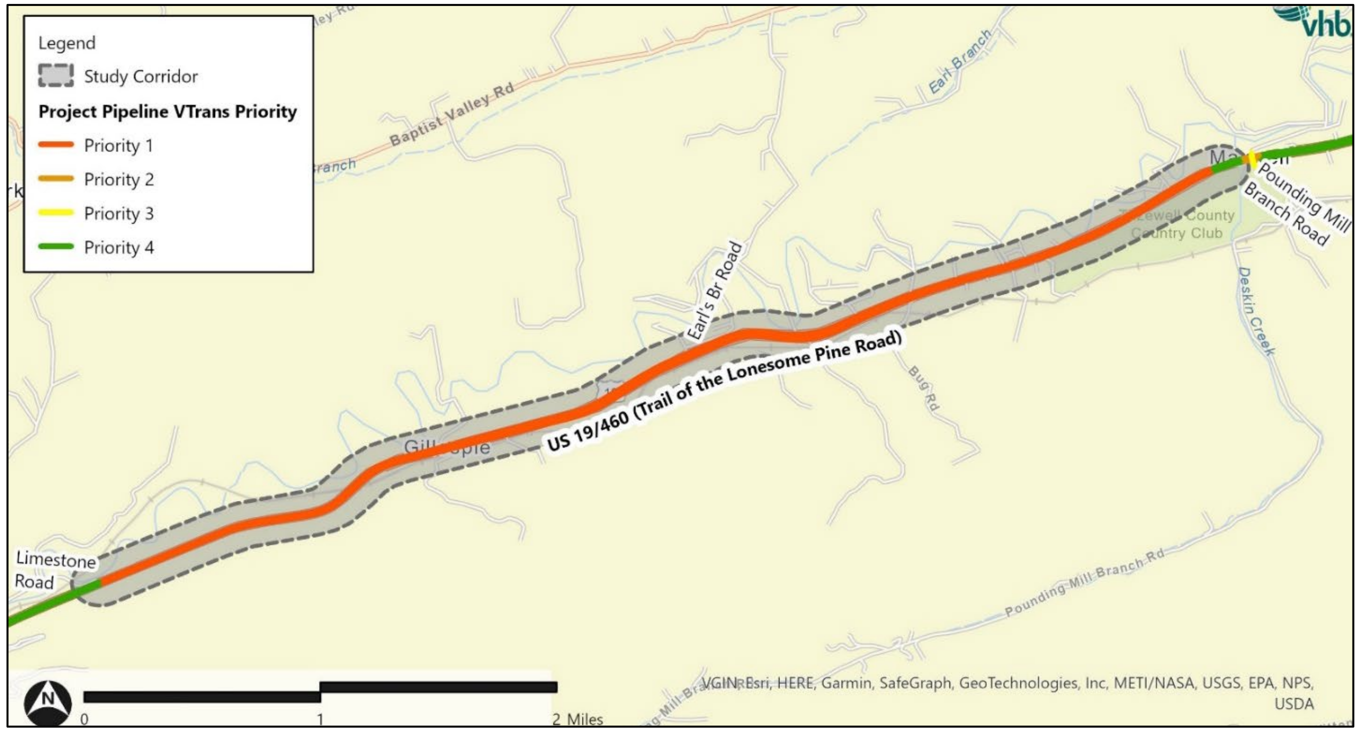


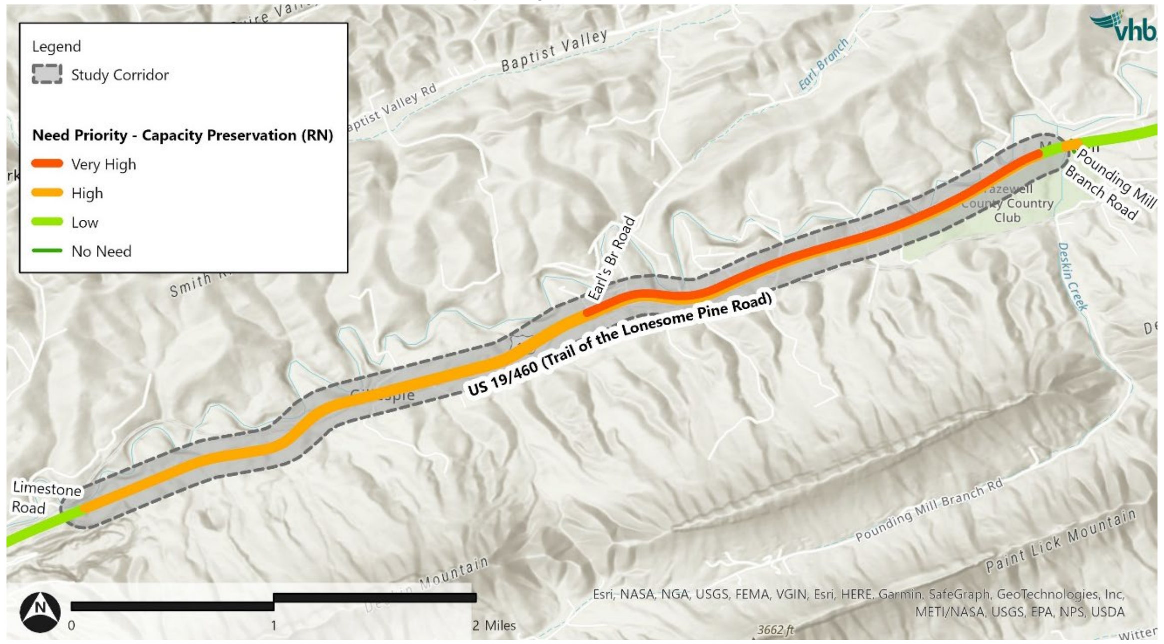
Figure 5: 2019 VTrans Prioritized Mid-term Needs in the Study Area

[1] Commonwealth Transportation Board, Actions to Approve the 2019 VTrans Vision, Goals, Objectives, Guiding Principles and the 2019 Mid-term Needs Identification Methodology and Accept the 2019 Mid-term Needs, January 15, 2020

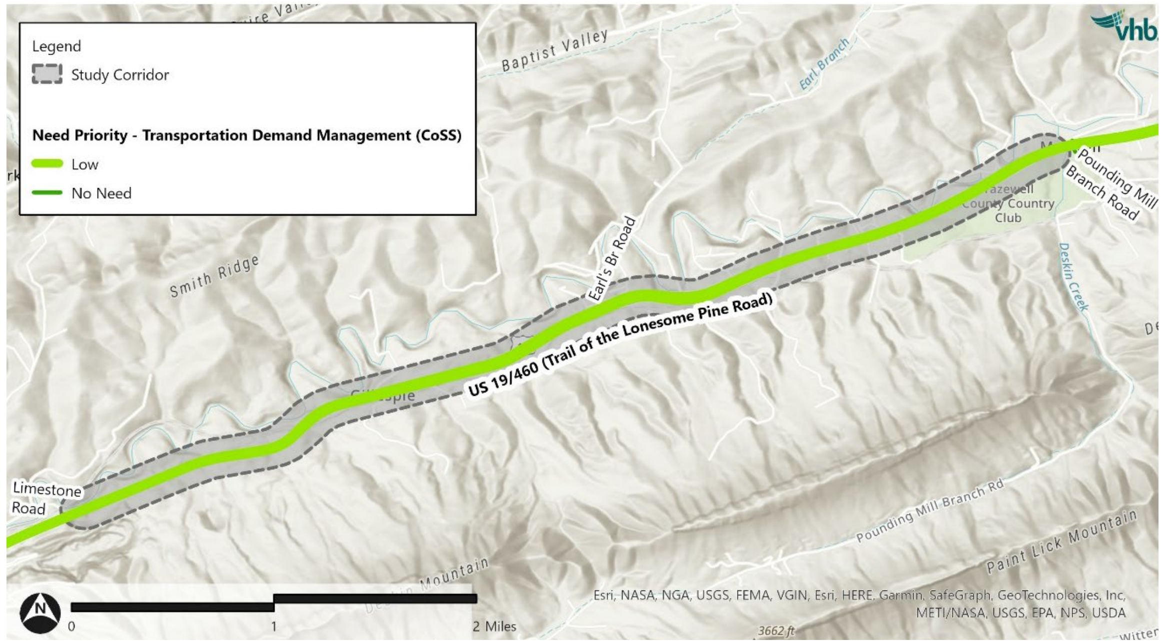
Table 3: VTrans Needs in Study Area

Road Safety

Capacity Preservation



Transportation Demand Management (TDM)



Underway Projects, Previous Studies, and Planning Documents

There are no upcoming or underway projects, recent previous studies, or relevant planning documents to discuss along the corridor.

Traffic Operations and Accessibility:

Initial diagnosis of the traffic operations and accessibility issues along the US 19/460 corridor was completed via traffic count data, field and aerial imagery review, and geospatial analysis.

Traffic Data

Traffic volume data (i.e., vehicle turning movement counts and 72-hours of volume and speed counts at two locations) was collected in May 2023 for the Pipeline Study. Peak hour turning movement counts and the raw traffic volume data are provided in **Appendix A**. VDOT's 2021 Average Annual Daily Traffic (AADT) for the US 19/460 study corridor is reported as follows:

- US 19 Western Intersection to SR 639 Earl's Branch Road: 9,800 Vehicles per Day (VPD)
- SR 639 Earl's Branch Road to Tazewell County's western border: 8,900 VPD

The 72 hours of collected volume and speed data were graphed to evaluate the temporal distribution over the data collection period. **Figure 6** shows the US 19/460 volume and speed distribution for the data collected between Limestone Road and Cuz's Cabins and Restaurant, and **Figure 7** shows the US 19/460 volume and speed distribution for the data collected between Lincoln Street and Mountain Road. In both figures, the 15-minute vehicle volume is plotted on the left vertical axis and the mean speed (MPH) is plotted on the right vertical axis. The figures show that the corridor has a relatively consistent volume level throughout the day, with only minor morning and evening peaks. The temporal speed distribution is relatively constant throughout the data collection period.

Table 4 presents volume and speed statistics derived from the 72-hour data collection, including average daily traffic, mean speed, 85th percentile speed, percent of traffic traveling above the speed limit, and vehicle fleet composition. These statistics reveal that both ends of the study corridor carry approximately the same daily traffic, there is a significant speeding issue on the corridor (due to the 85th percentile speed exceeding the posted speed limit by approximately 11 MPH), and there is a relatively significant quantity of truck traffic on the corridor.

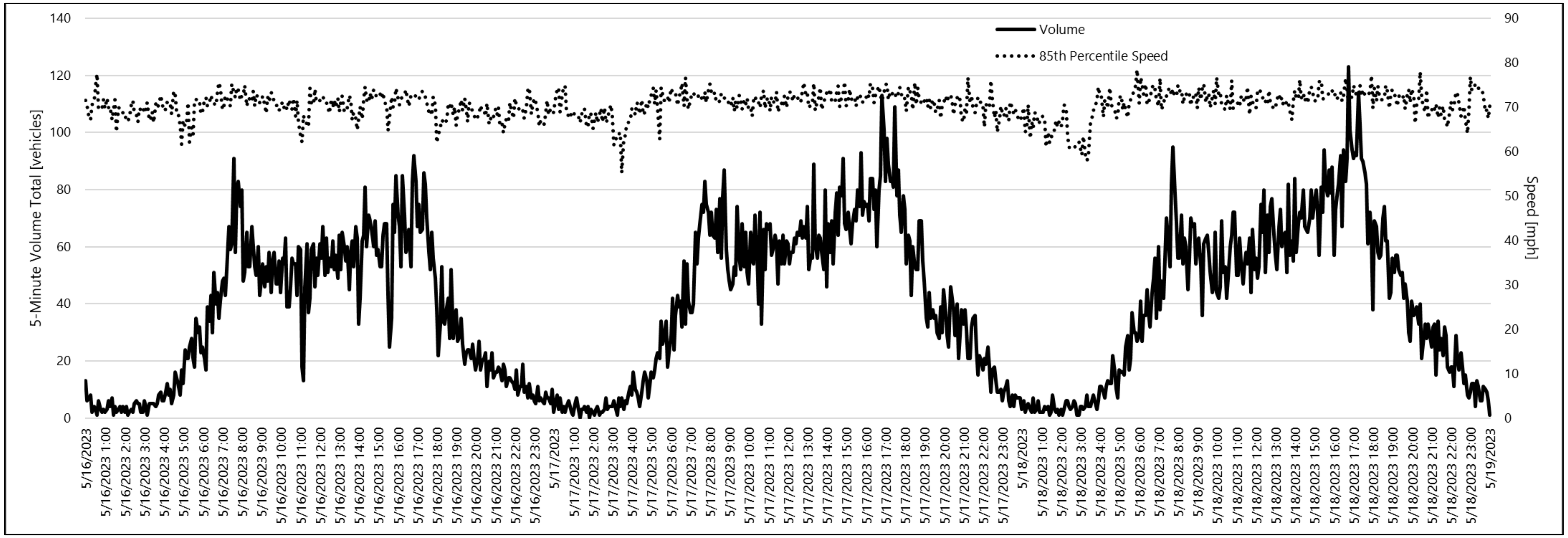


Figure 6: 72-hour Volume and Speed Distribution between Limestone Road and Cuz's Cabin Restaurant

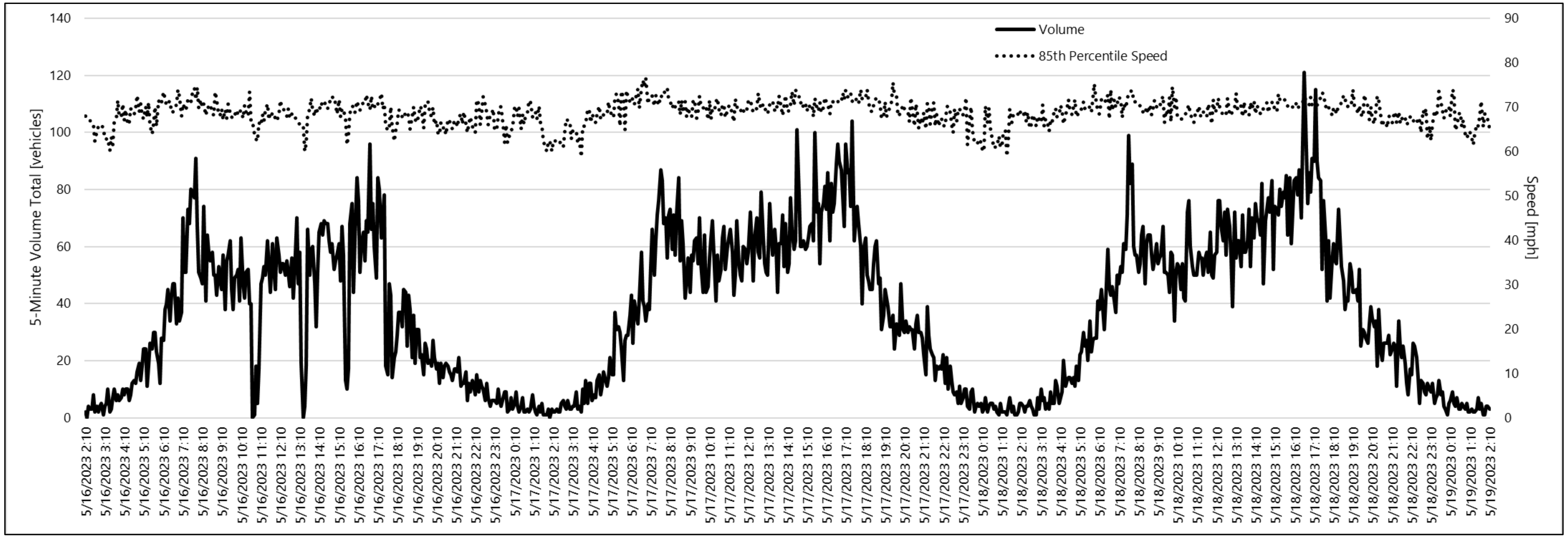


Figure 7: 72-hour Volume and Speed Distribution Between Lincoln Street and Mountain Road

Table 4: Speed and Volume Composition

5/16 to 5/18 Data Collection	Average Daily Traffic (ADT)	Mean Speed (SL[1] = 60 mph)	85th Percentile Speed (SL = 60 mph)	Speet Notes (% of Traffic)	Vehicle Composition
Between Limestone Road and Cuz's Cabins and Restaurant	11,418	64.69 mph	71.67 mph	83.1% > SL of 60 mph 53.1% > SL + 5 mph 22.5% > SL + 10 mph	82% 22 ft 22ft < 13% <45 ft 5% > 45 ft
Between Lincoln Street and Mountain Road	10,765	64.82 mph	70.81 mph	83.4% > SL of 60 mph 45.6% > SL + 5 mph 16.5% > SL + 10 mph	65% 22 ft 22ft < 30% <45 ft 5% > 45 ft

[1] SL = Speed Limit

Measures of Effectiveness

There are many measures of effectiveness (MOE) in traffic operations analysis to quantify operational and accessibility metrics and provide a basis for evaluating the performance of a transportation network. A summary of the MOEs evaluated for the study corridor during the Phase 1 analysis is presented below:

- Intersection Operations Metrics (Computed in Synchro/SimTraffic)
  - Control Delay (measured in seconds per vehicle – sec/veh)
  - Level of Service (LOS)
  - Maximum Queue Length (measured in feet – ft)

Traffic Operations Analysis Results

In Phase 1, a traffic operational analysis was performed using Synchro 11 software for the intersections along the US 19/460 corridor. Synchro is a traffic operations software package that is based upon *Highway Capacity Manual* (HCM) calculations. Utilized inputs and analysis methodologies are consistent with the VDOT *Traffic Operations and Safety Analysis Manual (TOSAM)* guidelines. AM and PM peak hour analyses were performed for the peak hour traffic volume dataset.

Table 5 presents the AM and PM peak hour Synchro analysis intersection LOS summary (reports included in **Appendix A**). As all four intersections are two-way stop-controlled, the LOS/delay for the worst operating approach is reported. As indicated in the table, there is no significant delay at the study intersections on this corridor.

Table 5: Synchro Delay and Level of Service (LOS) for Worst Approach

Intersection	Existing AM		Existing PM	
	LOS	Delay	LOS	Delay
Limestone Road	B	12.4	B	11.3
Median Crossover	A	0.0	A	0.0
Earl's Branch Road	B	11.1	A	9.9
Keen Road	B	10.0	B	11.1
Pounding Mill Branch Road / Cochran Hollow Road	B	14.5	C	15.8

"S" Curve Appropriate Design Speeds

VDOT design standards, based on the American Associated of State Highway and Transportation Official's (AASHTO's) A *Policy on Geometric Design of Highways and Streets*, dictate minimum curve radii dependent upon design speed and curve superelevation. As such, the process can be reversed to determine the appropriate operating speed that a curve's superelevation and radius are designed to accommodate. **Table 6** shows the radii and super-elevations of the western and eastern curves within the "S" curve immediately east of Earl's Branch Road, and thus what the appropriate design speed should be based on these values. The current posted speed limit on US 19/460 is 60 MPH, and the speed data shows that the 85th percentile speed is 11 MPH above the posted speed limit. As such, the operating speed of traffic through the "S" curve significantly exceeds the curvature design speed.

Table 6: Curve Radii and Design Speed

Location		Superelevation	Actual Radius	Appropriate Design Speed
Western Curve	EB Direction	12%	1,048 ft	60 MPH
	WB Direction	8%	1,146 ft	55 MPH
Eastern Curve	EB Direction	6%	1,432 ft	60 MPH
	WB Direction	8%	1,432 ft	60 MPH

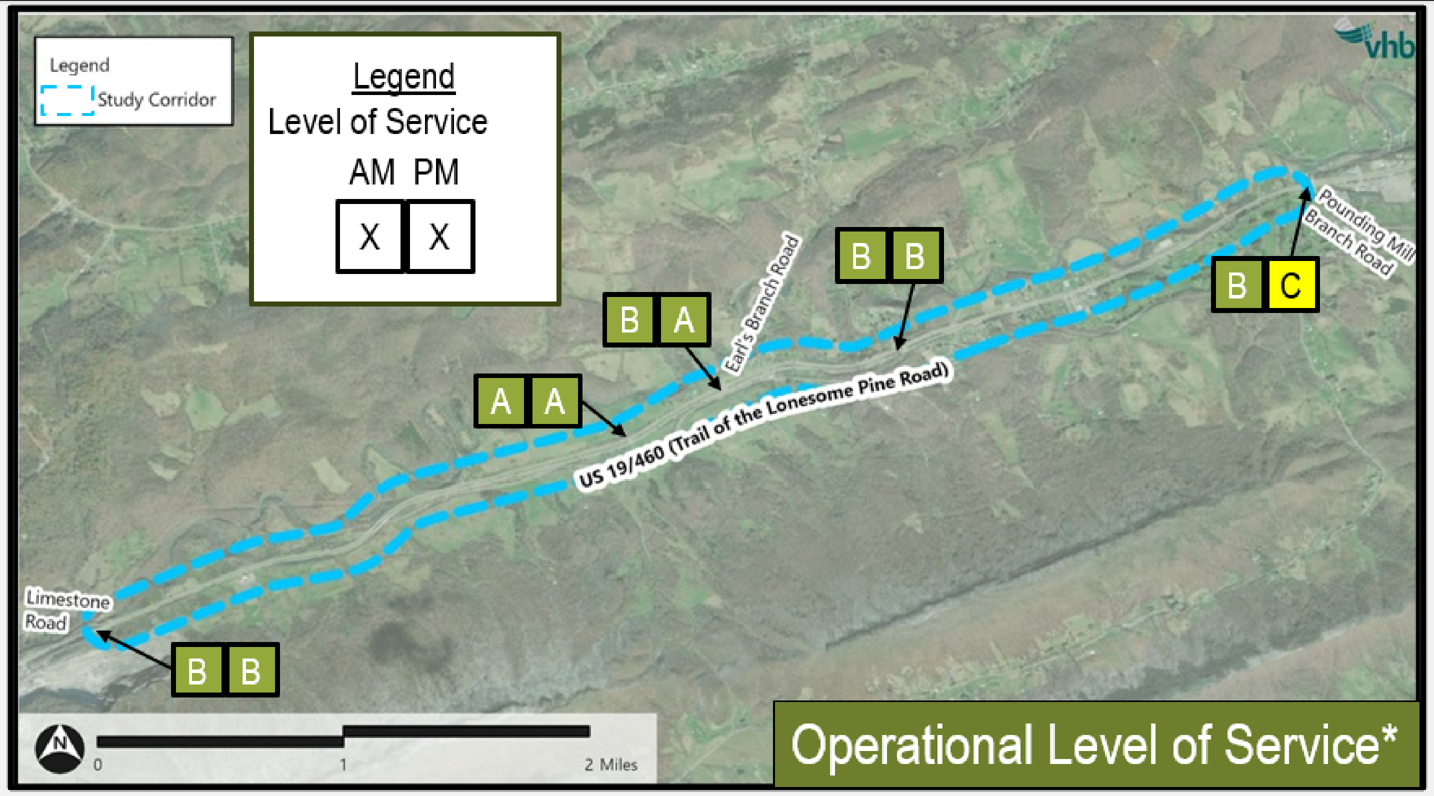
Other Operations and Access VTrans Needs

The US 19/460 study corridor has additional VTrans needs in the areas of accessibility, including transportation demand management (TDM) (low priority) and capacity preservation (very high priority). The VTrans needs are identified via a statewide screening process and must be considered through the context of the local corridor. The needs help identify corridors for additional analysis but do not necessarily indicate a transportation need. Each of these two VTrans needs are discussed in more detail in the following section.

The TDM VTrans need is automatically assigned to non-limited access facilities that are on the Corridors of Statewide Significance (CoSS), such as US 19/460. This assignment is indicative of the importance of these statewide transportation arteries to moving people and goods. The goal of TDM in general is to convert private automobile trips to carpools or multimodal (transit, walk, bike, etc.). The context of the US 19/460 study corridor is not conducive to these types of trip conversions.

The capacity preservation VTrans need is automatically assigned to corridors on the Arterial Preservation Network (APN), which is a network of VDOT-maintained roads that function similarly to the interstate system in that they convey people and goods across the state. As such, VDOT has prioritized preserving mobility on these corridors. Mobility can be hindered when there is either recurring congestion or significant safety concerns that could induce non-recurring congestion. As already documented, the recurring operations of this corridor are readily accommodated, so the capacity preservation on this corridor is more correlated to the safety performance.

Figure 8 summarizes the operations and access needs on this corridor.



*Intersection LOS is not reported for two-way stop control intersection. LOS reported is worse of side-street approach.

72-Hour Volume and Speed Data Location	Daily Traffic (ADT)	Mean Speed	85th Percentile Speed	Percent of Traffic 10+ MPH over Speed Limit
Between Limestone Road and Cuz's Cabins and Restaurant	11,400	64.7 MPH	71.7 MPH	22.5%
Between Lincoln Street and Mountain Road	10,750	64.8 MPH	70.8 MPH	16.5%

"S" Curve* Appropriate Design Speeds Location	Operating Speed	Design Speed
Westbound "West" Curve	~71 MPH	55 MPH
Eastbound "West" Curve		60 MPH
Westbound "East" Curve		60 MPH
Eastbound "East" Curve		60 MPH

* "S" curve east of Earl's Branch Road. Based on superelevation measurements by VDOT and roadway design plan curve radii.

VTrans Operations / Access Needs

NEED	PRIORITY
Capacity Preservation	**Very High**
Transportation Demand Management (TDM)	**Low**

Operations Summary

- The intersection capacity analysis revealed that drivers do not experience significant delay or queuing on any controlled vehicle movements.
- The traffic volumes indicate that the four-lane cross-section has sufficient capacity to accommodate the volume demand.
- The speed data shows that driver speeding is a significant concern along this corridor as the 85th percentile speed is greater than 10 mph above the posted speed limit.
- Design calculations indicate the operating speed of traffic exceeds the appropriate design speed of certain horizontal curves by 10-15 MPH.
- US 19/490 is a vital corridor for local and regional capacity preservation. While the operations existing data does not indicate a need to enhance the existing capacity, reducing the crash frequency on the corridor would address non-recurring congestion (i.e., incident inducing delays).

Figure 8: Operations Needs and Diagnosis

Safety and Reliability

For the analysis of existing safety conditions, the VDOT Crash Analysis Tool was utilized to determine the crash history at the study intersections along the study corridor. Crash data was collected and analyzed for a five-year period spanning from January 2018 to December 2022. The study team reviewed the crash details provided by VDOT as well as the FR300 crash reports to determine specific trends. The study team also performed geospatial analysis to identify "hot spot" areas for consideration in developing alternative improvement concepts. On the US 19/460 study corridor, there was no "reliability" VTrans need, so this topic area was not considered. Reliability is defined as the consistency of expected travel time along a corridor; as previously reported, the operations of this corridor are fine.

Safety Analysis Results

VDOT SAFETY SCREENING

Through a systemic analysis methodology that incorporates bicycle/pedestrian crash history, roadway characteristics, proximity to pedestrian generating land uses, and socioeconomic data, VDOT identifies a Pedestrian Safety Action Plan (PSAP) roadway network of high-risk corridors. US 19/460 through the study area is not a PSAP segment given its rural nature and minimal pedestrian activity.

VDOT also conducts safety screening analysis at a network level to identify critical hot spots where crashes are statistically overrepresented. A metric called Potential for Safety Improvement (PSI) is computed that identifies locations where actual crashes are overrepresented compared to what would be anticipated for a roadway of those characteristics. The top 100 intersections and segments are then ranked by PSI in each VDOT District. **Figure 9** shows that the US 19/460 study corridor contains none of the top 100 segments, but contains the 131st segment within the Bristol District, conveying the safety need at this location along the corridor.

CRASH ANALYSIS

The 35 non-animal crashes within the study area are summarized by type and severity in **Figure 10**. Nearly two-thirds of non-animal crashes were fixed object run-off-road crashes. The significant percentage of off-road crashes is reflective of the corridor design and vehicle travel speeds, as the 85th percentile speed of vehicles is higher than the appropriate design speed for several of the horizontal curves. **Figure 11** displays a heat (density) map of all crashes on the corridor; they are clearly clustered at PSI segment #131 (**Figure 9**). This is the location of the "S" curve previously discussed and the eastbound direction also has a downgrade. At this location there were 16 fixed object off-road crashes, eight of which were on the "S" curve. Most of these crashes only involved property damage, however there was one fatal crash and two that involved a severe injury. Most of these crashes also occurred in the eastbound direction.

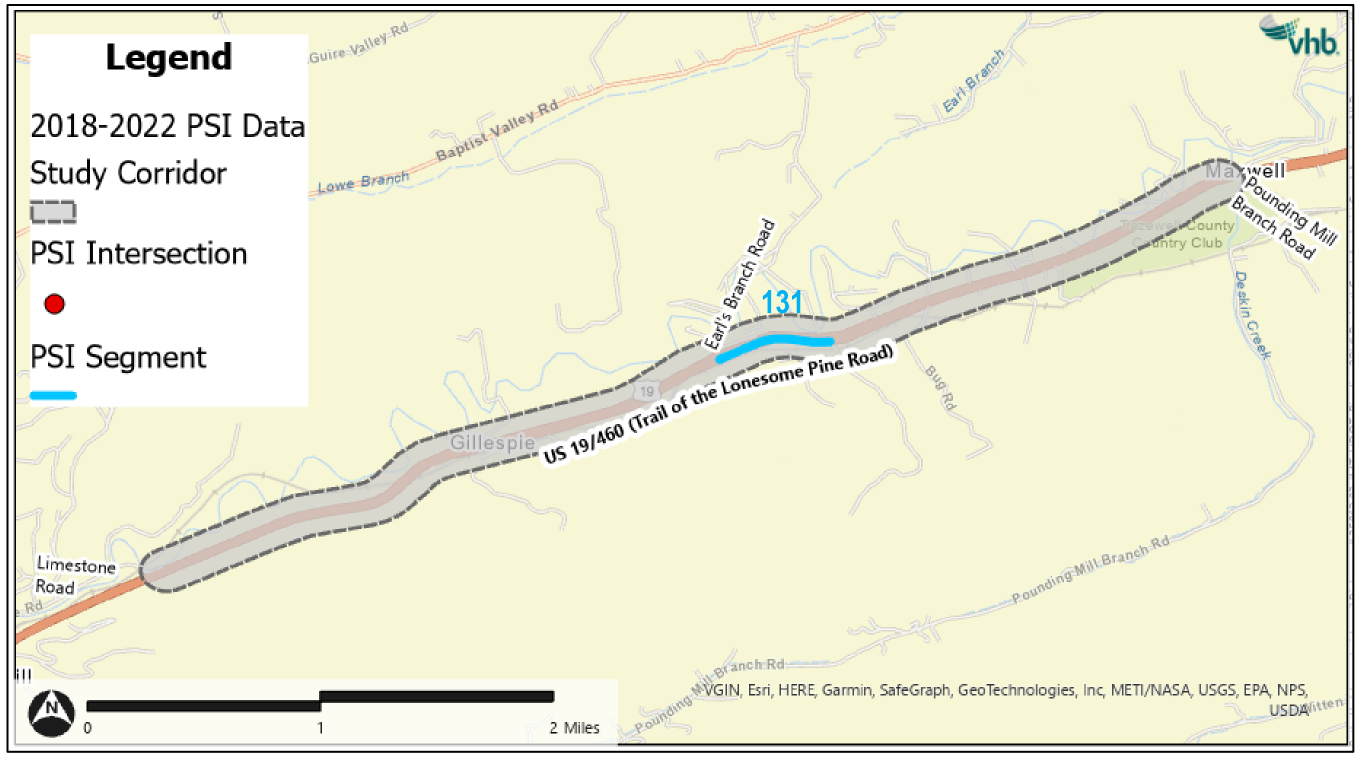


Figure 9: PSI Map of US 19/460 Corridor

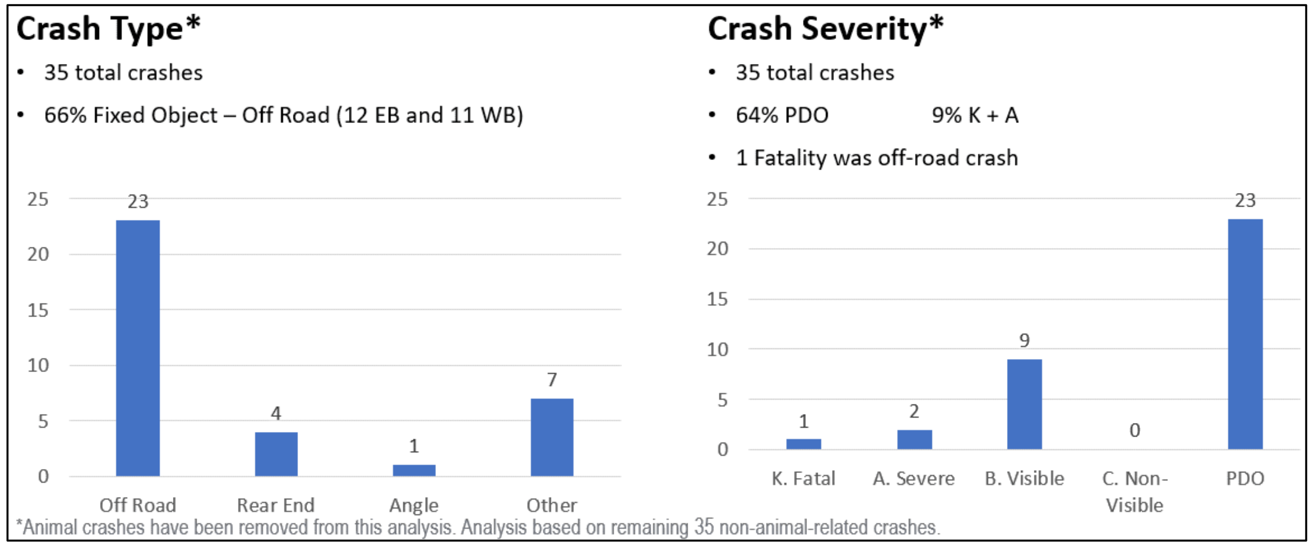


Figure 10: US 19/460 Crash Statistics

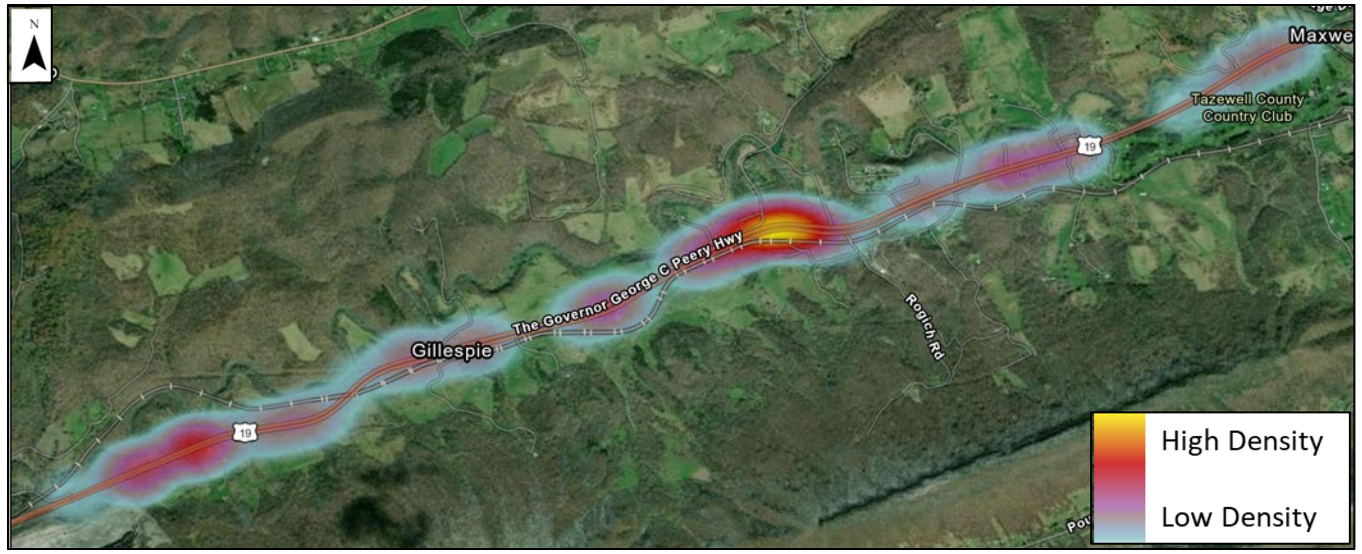


Figure 11: US 19/460 Crash Heat (Density) Map

Animal crashes are another significant crash type present in this study corridor. There were 32 *reported* animal crashes over the past five years. Research by the Virginia Transportation Research Council (VTRC) indicates that the number of *actual* animal crashes may be five times greater than the number of *reported* animal crashes. Many of these animal crashes occurred in the dark and in the westbound direction where the river is closest to the roadway. **Figure 12** shows a heatmap of the animal crashes on US 19/460. As shown in the figure, there are three hotspot locations. Animals involved in crashes included deer, bears, and cows, and these crashes had a high seasonal concentration with peak months in June, November, and December.

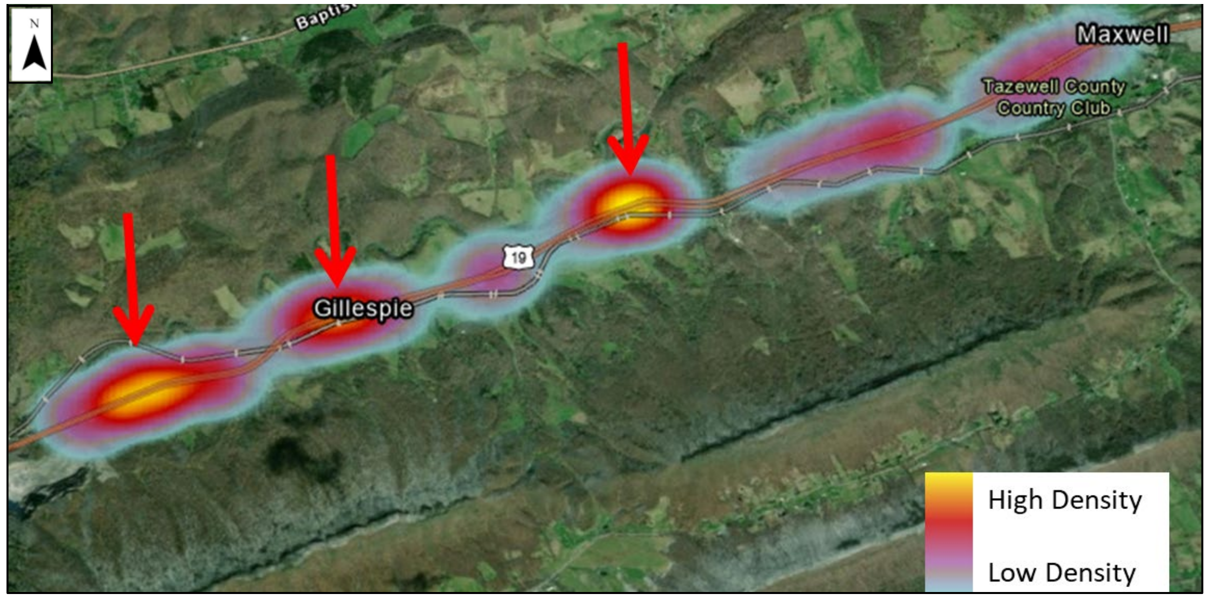


Figure 12: Animal Crash Heat (Density) Map US 19/460

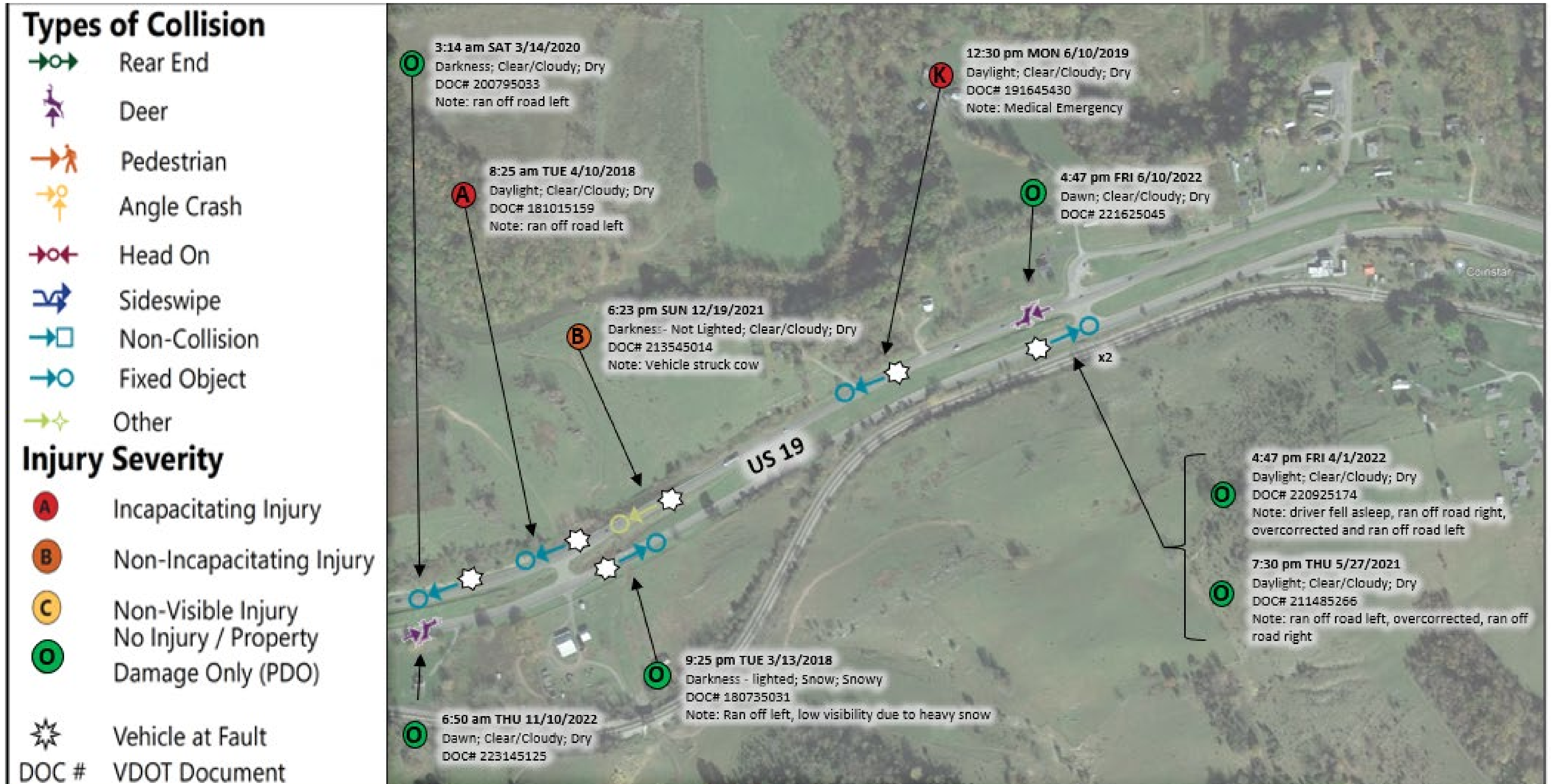
The crashes in the PSI locations were further studied to look for any patterns and trends in the location or type of crashes. The FR 300 reports as well as the VDOT crash data were used to create collision diagrams that are shown in **Figure 13 and Figure 14**. The collision diagrams show a trend of fixed object crashes around the curves, particularly the "S" Curve location near Earl's Branch Road. For many off-road crashes at this location, the vehicle ran off one side of the roadway, overcorrected, and then ran off the other side of the roadway. The high vehicle speeds (11 MPH higher than posted speed limit), eastbound downgrade, horizontal curvature, and lack of shoulder recovery space are all contributing factors to this crash pattern.

Pavement condition is also a factor in the safety of a roadway. The existing pavement conditions were considered as presented in **Table 7** based on data that was collected by VDOT from October 2019 to April 2020. Based on the findings, poor pavement condition does not appear to be a contributing factor to the off-road crash pattern.

Table 7: US 19/460 Pavement Conditions

Segment	LDR (Load Related Distress Rating)	NDR (Non-Load Related Distress Rating)	Condition
EB US 19/460 (Railroad Crossing to east end of study area)	85	84	Good
WB US 19/460 (S Curve thru east end of study area)	79	82	Good
WB US 19/460 (Railroad Crossing to S Curve)	77	82	Good

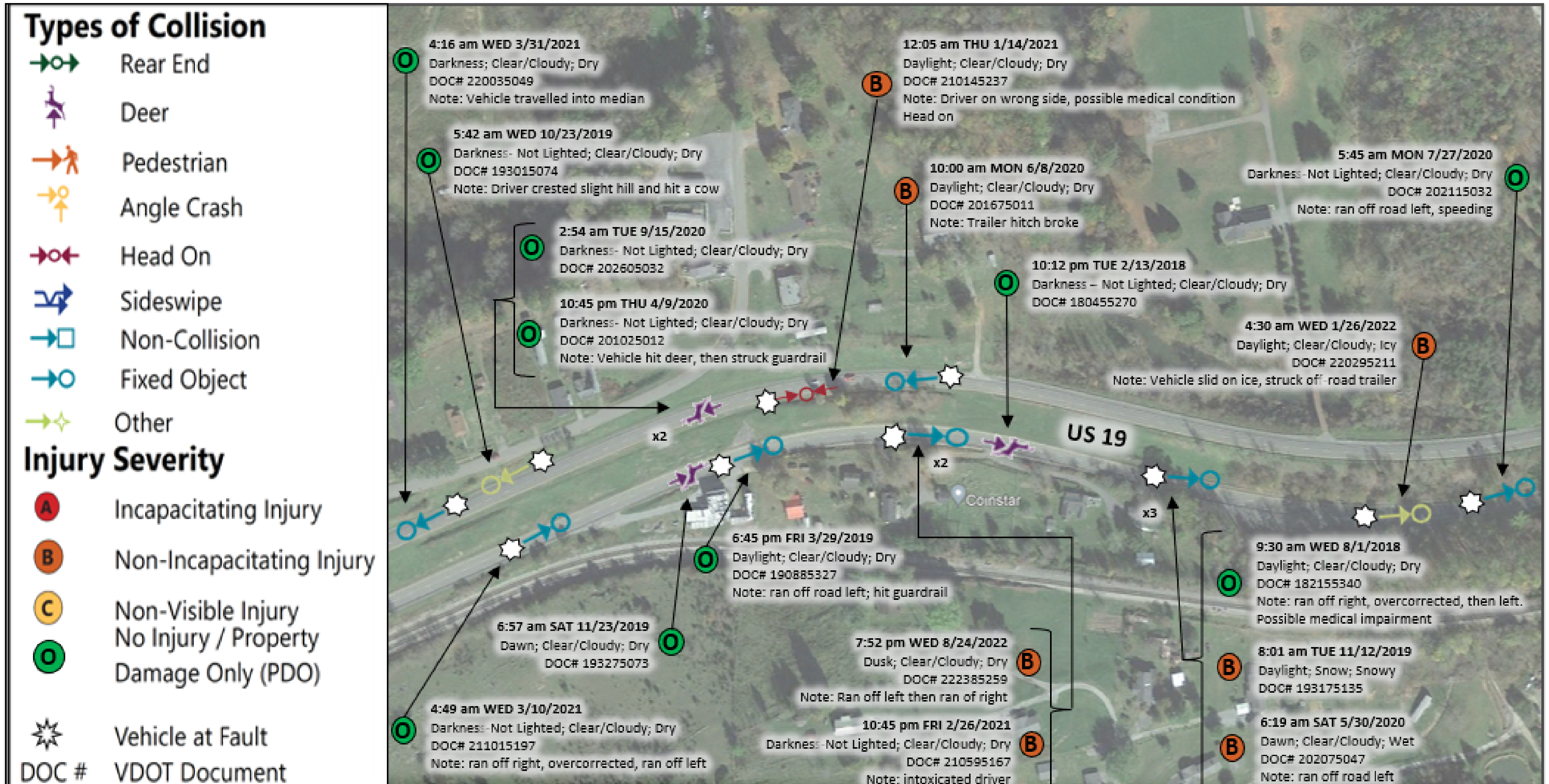
The safety and reliability needs and diagnosis (including crash type and severity by intersection) identified during the analysis are summarized in **Figure 15**.



Collision Summary

Year	Type of Collision						Time of Day			Lighting			Weather		Pavement Condition			Severity					Total
	Angle	Rear-End	Head-On	Sideswipe	Fixed Object	Other	AM Peak (7-10AM)	PM Peak (4-7PM)	Off Peak	Daylight	Dawn/Dusk	Darkness – Lighting	Clear	Rain/Snow	Dry	Wet	Icy	K	A	B	C	PDO	
2018					2		1		1	1	1		1	1	1	1			1			1	2
2019					1				1	1			1		1			1					1
2020					1				1			1	1		1							1	1
2021					1	1		1	1	1		1	2		2					1		1	2
2022					1	2		1	2	2	1		3		3							3	3
Total					6	3	1	2	6	5	2	2	8	1	8	1		1	1	1		6	9

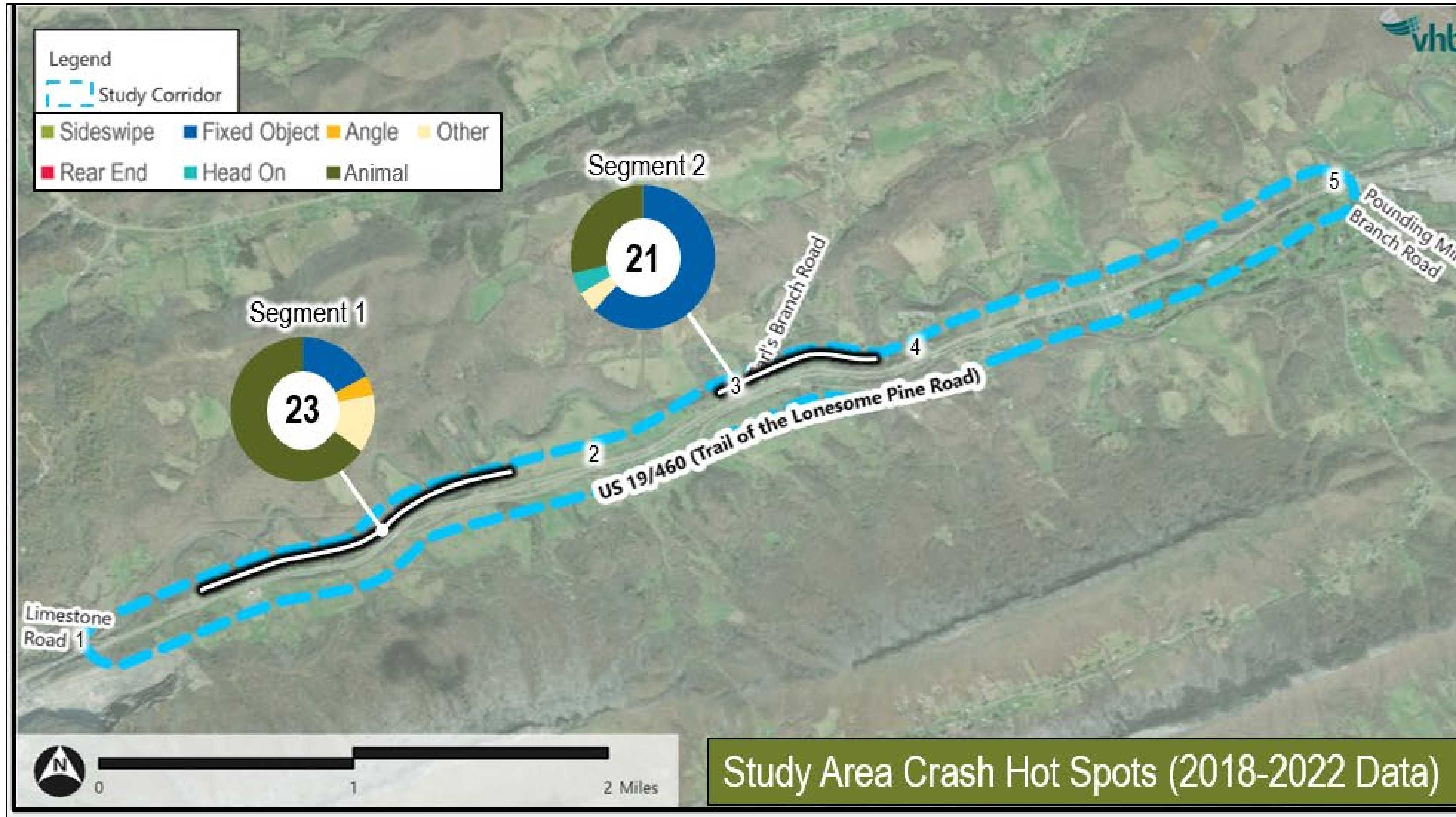
Figure 13: West Side of S Curve Collision Diagram

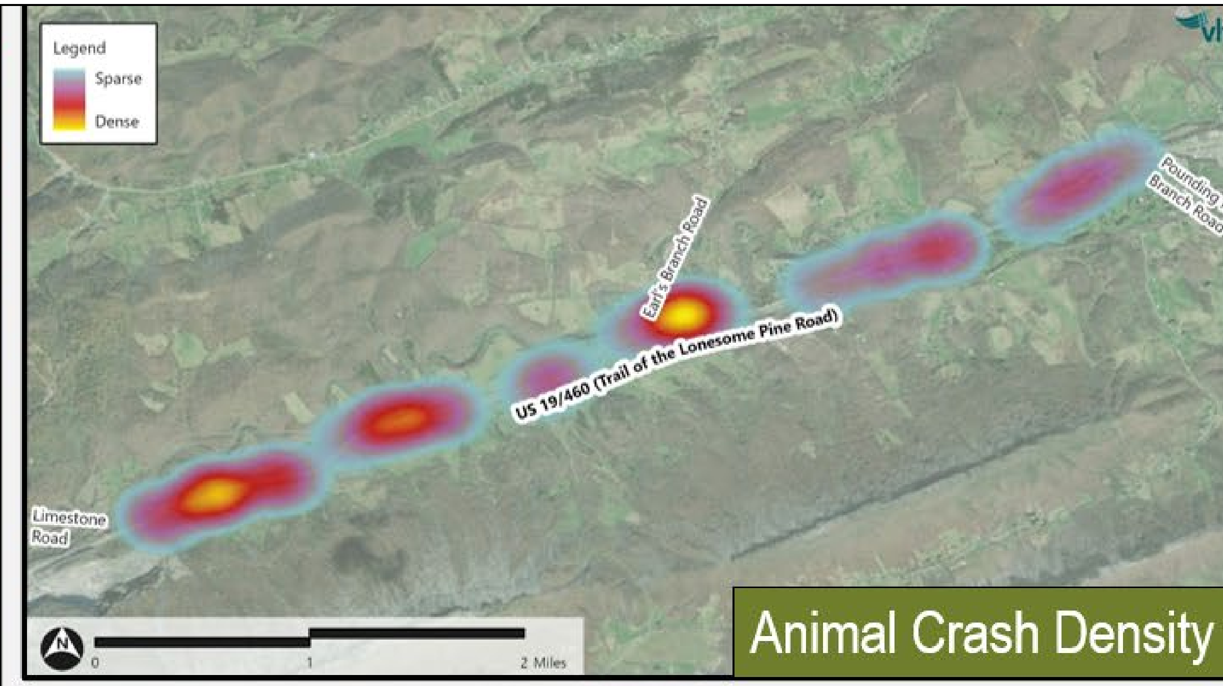


Collision Summary

Year	Type of Collision						Time of Day			Lighting			Weather		Pavement Condition			Severity					Total
	Angle	Rear-End	Head-On	Sideswipe	Fixed Object	Other	AM Peak (7-10AM)	PM Peak (4-7PM)	Off Peak	Daylight	Dawn/Dusk	Darkness – Lighting	Clear	Rain/Snow	Dry	Wet	Icy	K	A	B	C	PDO	
2018					1	1	1		1	1		1	2		2							2	2
2019					2	2	1	1	2	2	1	1	3	1	3	1				1		3	4
2020					3	2	1		4	1	1	3	5		5					2		3	5
2021			1		3				4	1		3	4		4					2		2	4
2022					1	1		1	1	1	1		2		1		1			2			2
Total			1		10	6	3	2	12	6	3	8	16	1	15	1	1			7		10	17

Figure 14: East Side of S Curve Collision Diagram





VTrans Safety / Reliability Needs

NEED	PRIORITY
Road Safety	**Very High**
Capacity Preservation	**Very High**

VDOT 2018-2022 Crash Data

Hot Spot Intersection / Segment	Crashes by Severity					
	K	A	B	C	O	Total
Segment 1	0	0	1	0	22	**23**
Segment 2	1	0	7	0	13	**21**
Total	1	0	8	0	35	**44**

K = Fatal Injury; A = Severe Injury; B = Visible Injury; C = Non-visible Injury; O = Property Damage Only

Safety Summary

- The highest concentration of crashes occurred within the "S" curve east of Earl's Branch Road. Many of the roadway departure crashes in this segment occurred in the eastbound direction of travel, which is on a downgrade and has substandard shoulders. Many of the crashes involved drivers overcorrecting after initially leaving the roadway to one side.
- There were 32 animal-related, reported crashes in a 5-year window. Per VDOT statewide research, animal crashes are sometimes *underreported by up to 500%* (i.e., 5x as many crashes as reported).
- Animal crashes were concentrated in three hot spots, seasonal (June, November, and December), and approximately 75% occurred at night. The densest cluster was 10 crashes within 1.2 miles in a 2-year span.

Figure 15: Safety and Reliability Needs and Diagnosis

FHWA Screening Tool for Equity Analysis of Projects (STEAP)

This screening shows the demographic make-up of the population residing within the study area, the city/town, the county, and then all of Virginia. The tool allows you to compare the representation of the population with regard to a demographic characteristic, such as age or household income, within the study area compared to the city/town, county, and all of Virginia. **Figure 16** shows the household incomes present in the study area compared to all of Tazewell County and the state of Virginia. **Figure 17** shows the age groups present in the study area compared to Tazewell County and the state of Virginia. These figures indicate that there is a comparable representation of all the different household income groups as well as ages in the study area compared to the percentage of household income groups and ages present in both Tazewell County and all of Virginia. **Appendix C** provides the full STEAP analysis results.

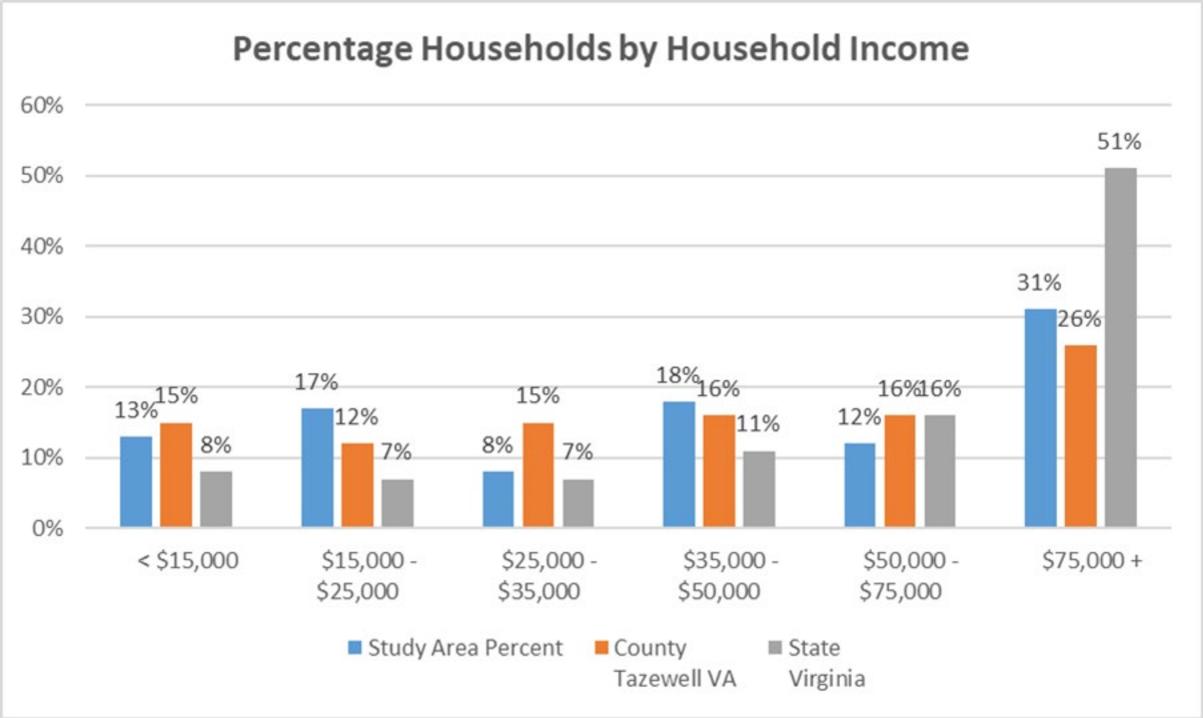


Figure 16: Percent Households by Income

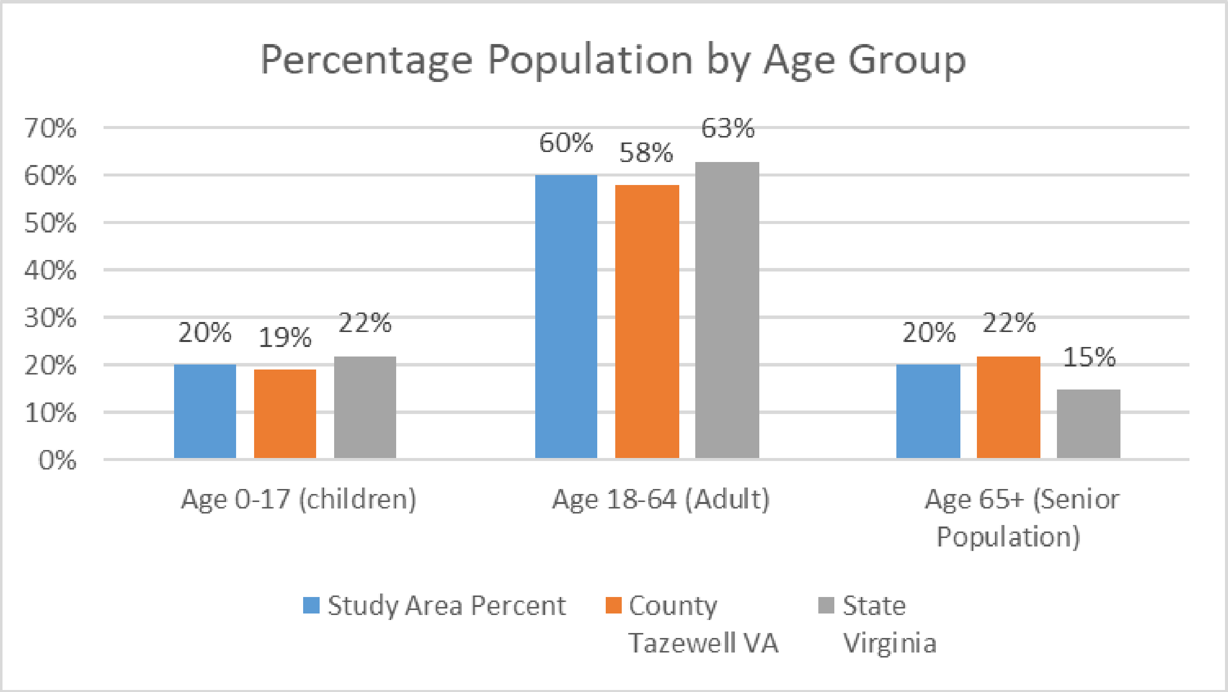


Figure 17: Percent Population by Age

Chapter 2:

Alternative Development and Refinement

Alternative Development and Screening

The study team developed alternative concepts to address the needs identified in Chapter 1 by first summarizing the existing conditions diagnoses. On the 3.9-mile study corridor, the primary need areas identified include animal crash clusters and an improvement to a horizontal "S" curve where a relatively high number of run off road crashes occurred. The study team brainstormed multiple alternatives and improvements to address the corridor's very high VTrans safety need, specifically along the eastbound direction of the "S" curve and the animal crash cluster hot spot locations. The study team presented the initial slate of alternatives to the study stakeholder, refined the alternatives based on stakeholder and public input, and then finalized a project alternative for which to seek implementation funding.

Initial Alternatives Development

Some alternatives that were considered for the corridor were access management options, rumble strips, curve warning signs, animal countermeasures, and increasing turn lane lengths. These alternatives were general safety improvements to be put in place along the corridor wherever necessary. Additional alternatives considered near the "S" curve in this early stage of alternatives development include improvements to the sight distance at the Earl's Branch Road, improvements to the residential property from the railroad tunnel, and speed limit reduction. These additional alternatives were not considered any further. Instead, the concerns specifically at the "S" curve were focused on in the next stages of the alternative's development.

"S" CURVE ALTERNATIVES

There were a higher number of off-road crash types around the "S" curve east of Earl's Branch Road. The speed data indicated that traffic is travelling 10 mph greater than the design speed. The alternatives proposed for this section of the study corridor fall under three categories: encouraging lower operating speeds, increasing the design speed of the "S" curve, and improving the recovery space in the shoulders.

ENCOURAGING LOWER OPERATING SPEEDS

The study team considered multiple alternatives to encourage slower operating speeds. One alternative consisted of narrowing the lane widths; however, the lane widths are already 11 feet, which is the minimum for this roadway. For this reason, narrowing the lane widths was not considered further. The study team also considered transverse rumble strips but did not advance this alternative due to the residential surrounding land uses. Pavement marking treatments and additional signing were also assessed to encourage slower operating speeds. Pavement marking treatments included pavement markings such as optical speed bars and in-lane curve warnings as seen in **Figure 18** and **Figure 19.** Signing alternatives included chevrons, curve warning signs, and advisory speed limit plaques.

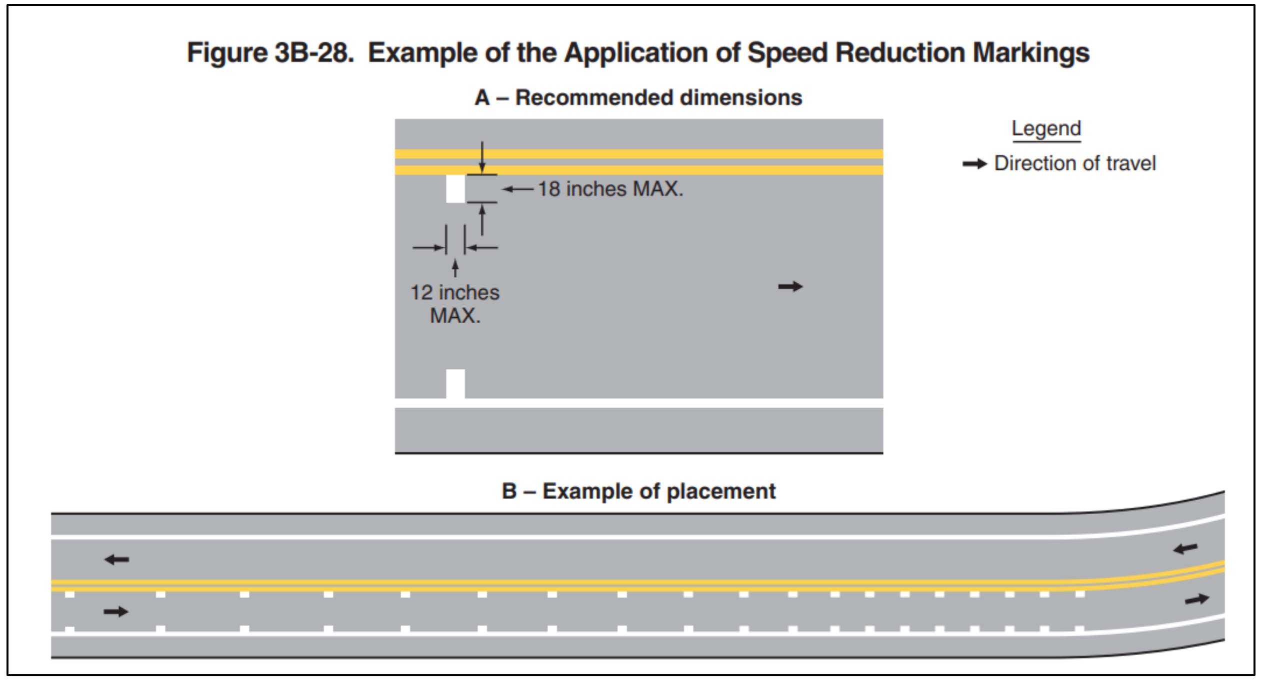


Figure 18: Speed Reduction Pavement Markings, Source: Manual of Uniform Traffic Control Devices (FHWA)

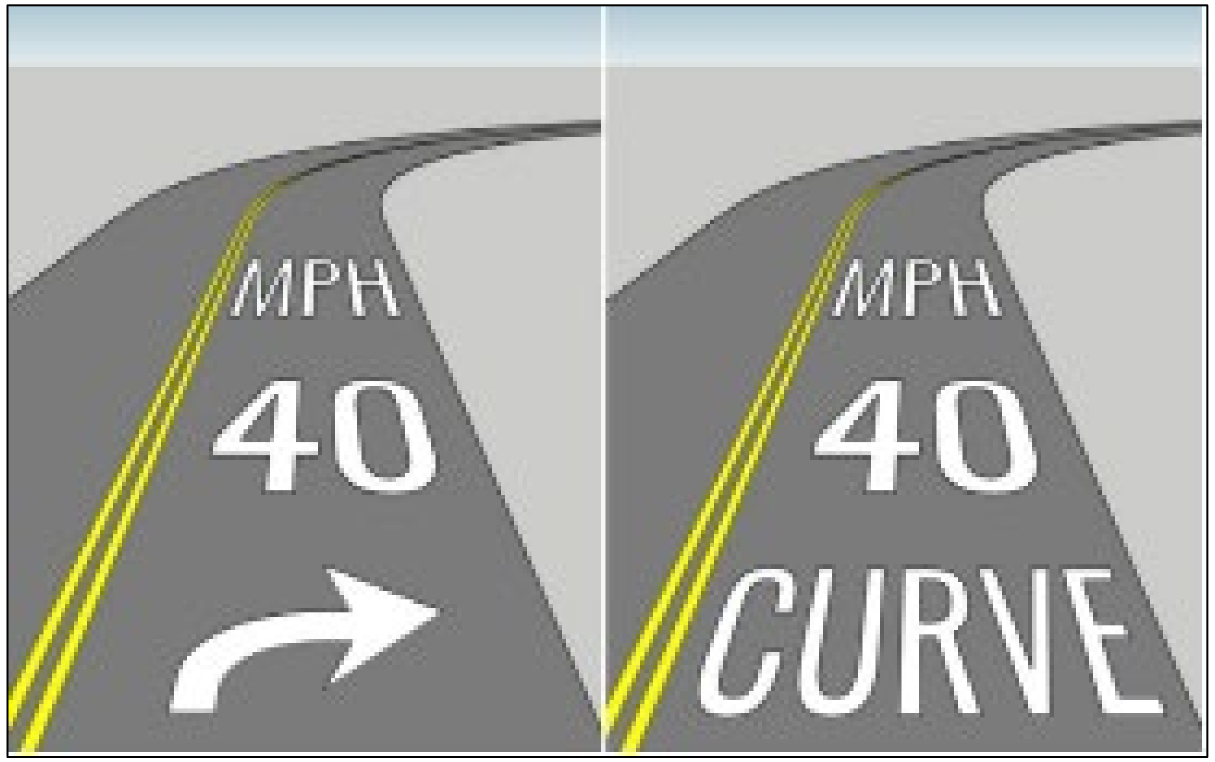


Figure 19: In-Lane Curve Warning Pavement Marking, Source: FHWA Curve Safety Solutions

Another early consideration was reassessing the current posted speed limit, specifically looking at the design components at the “S” curve. The design speed was calculated based on the original designed superelevation and recorded radius of the curves as seen in **Figure 20**. This design speed was then compared to the speed data collected, which revealed that traffic was travelling 10 mph faster than the design speed. The posted speed limit is 60 MPH. To the west of the study corridor, the posted speed limit is 55MPH, and to the east of the study corridor, the posted speed limit is 65 MPH. One consideration was to extend the 55 MPH speed limit into the study corridor and through the “S” curve; however, this alternative did not move forward.

Currently, there are no curve warning signs posted in either direction around the “S” curve. According to the MUTCD, horizontal alignment warning signs should be installed based on the speed differential between the roadway’s posted speed limit and the advisory speed limit. Chevrons can be considered but are not required according to the MUTCD. The new MUTCD has not been adopted by VDOT as of 2024, and the new MUTCD has updated the requirements for curve warning signs and chevrons compared to the old MUTCD. The recommendations made were based on the currently adopted by VDOT version of the MUTCD (2009).

INCREASING DESIGN SPEED

Increasing the design speed to reduce the speed differential between the design speed and the operating is second category of considered improvements. The first alternative to increase the design speed is the adjust the super elevation of the roadway through the curve. This could be accomplished through either repaving techniques or full reconstruction of the curve; however, the existing superelevation is the maximum allowable with the current curve radius. So, this alternative was not considered further. Another alternative is to reconstruct the entire curve with a larger radius, allowing for a higher design speed. This would be a very costly and impactful improvement that may require full property takes of the adjacent parcels. Due to the impacts and cost, this alternative was not considered. A lower-cost countermeasure considered includes applying a high friction surface treatment to increase the surface friction of the curve so that vehicle tires grip more to the pavement surface.

IMPROVING SHOULDER RECOVERY SPACE

Improvements to the roadway shoulders, such as shoulder widening, were also considered to increase the recovery and correction space for errant vehicles. Centerline rumble strips were also considered to alert drivers running over the centerline into the median. Shoulder widening, while possible in most locations, presents challenges in some locations along the corridor. Potential constraints include limited right of way, steep topography change with rock face, utilities, existing guardrail, and driveway impacts.

INTERSECTION OPERATIONS

As part of the study team’s detailed analysis, the team developed 2045 design year traffic forecasts, which are documented in **Appendix D**. None of the alternative concepts included recommendations that needed to be evaluated from an operational capacity perspective; however, the traffic forecast pattern was helpful in thinking through the future of this corridor.

Both Curves Currently Posted at 60 MPH and speed data indicates 85th Percentile is 10 MPH over SL

	Super (%)	Design Speed	Side Friction	Rmin (calc)	Rmin (rounded)
WB Curve (western curve)	8	50	0.14	757.6	758
	8	55	0.13	960.3	961
	8	60	0.12	1200.0	1200
	8	65	0.11	1482.5	1483
	8	70	0.10	1814.8	1815
	8	75	0.09	2205.9	2206

Actual Radius = 1,146 ft

	Super (%)	Design Speed	Side Friction	Rmin (calc)	Rmin (rounded)
EB Curve (western curve)	12	50	0.14	641.0	642
	12	55	0.13	806.7	807
	12	60	0.12	1000.0	1000
	12	65	0.11	1224.6	1225
	12	70	0.10	1484.8	1485
	12	75	0.09	1785.7	1786

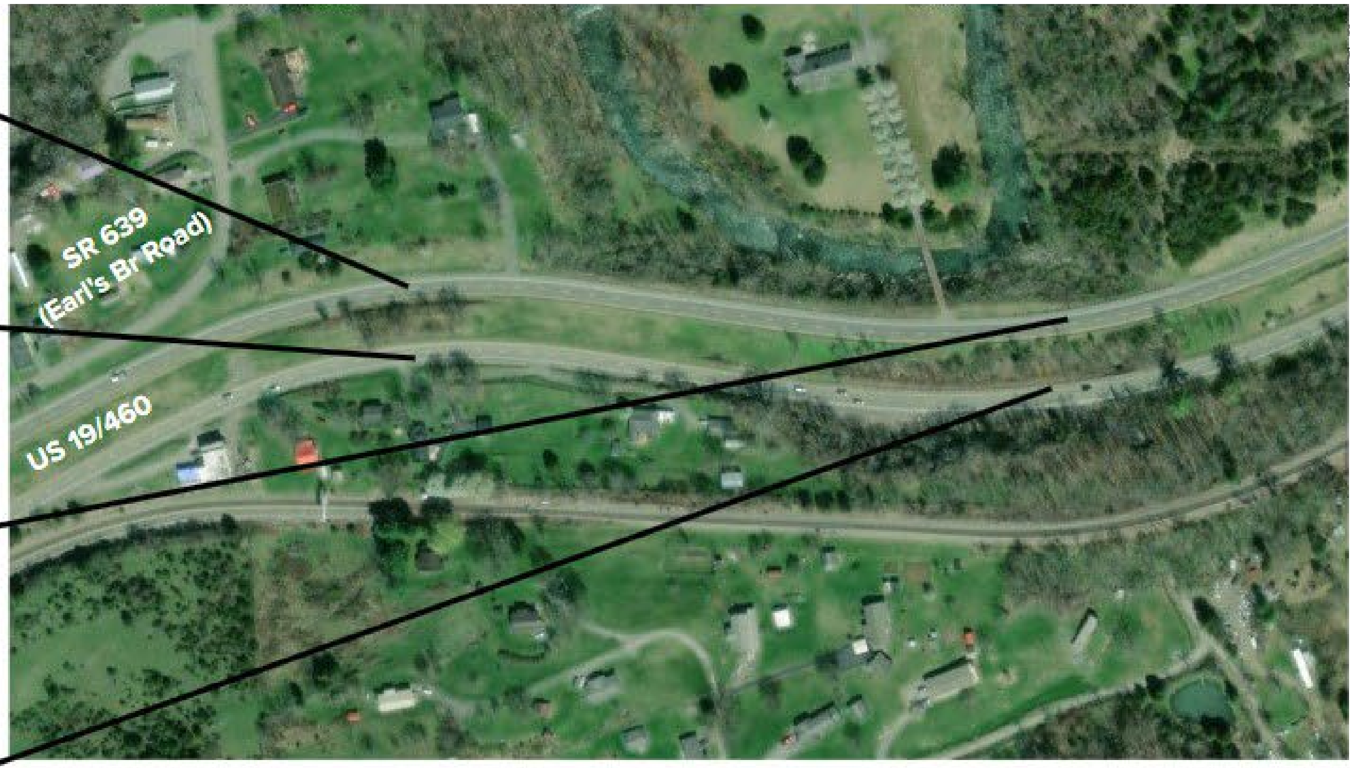
Actual Radius =1,048 ft

	Super (%)	Design Speed	Side Friction	Rmin (calc)	Rmin (rounded)
WB Curve (eastern curve)	8	50	0.14	757.6	758
	8	55	0.13	960.3	961
	8	60	0.12	1200.0	1200
	8	65	0.11	1482.5	1483
	8	70	0.10	1814.8	1815
	8	75	0.09	2205.9	2206

Actual Radius =1,432 ft

	Super (%)	Design Speed	Side Friction	Rmin (calc)	Rmin (rounded)
EB Curve (eastern curve)	6	50	0.14	833.3	834
	6	55	0.13	1061.4	1062
	6	60	0.12	1333.3	1334
	6	65	0.11	1656.9	1657
	6	70	0.10	2041.7	2042
	6	75	0.09	2500.0	2500

Actual Radius =1,432 ft



Conclusion: Traffic is potentially traveling 10-15 MPH over the recommended design speed for the curves

Figure 20: Curve Radius and Design Speed Calculation

ANIMAL CRASHES ALTERNATIVES

For animal crashes, an early alternative considered was a grade separated wildlife crossing utilizing an existing underpass, animal fencing, and dynamic animal warning signs. **Figure 21** shows some of the fencing and animal crossing options initially considered; these were subsequently discarded due to concerns with cost, railroad coordination, and pushing the animal crossing issue to the edge of the animal fencing. The hotspots for animal crashes (**Figure 22**) were considered further for other alternative development and screening.

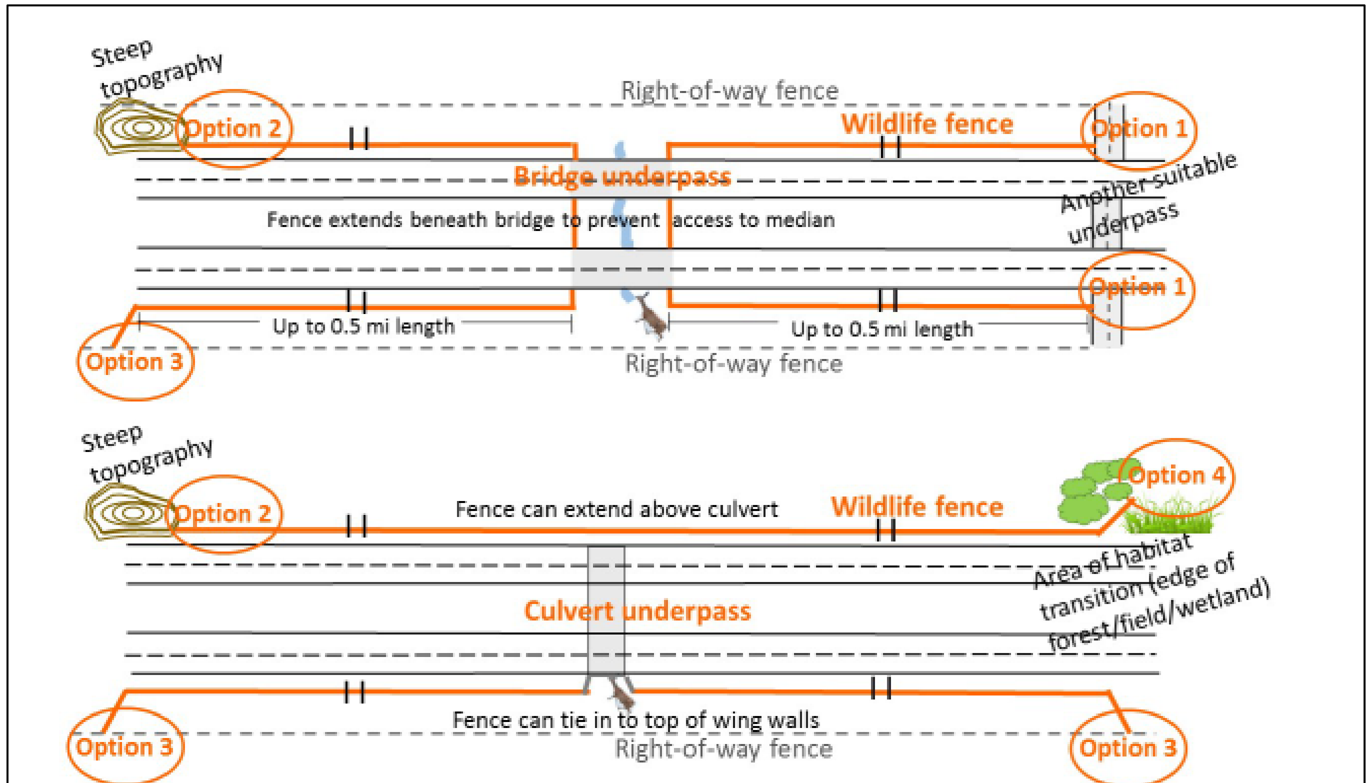


Figure 6. Illustration of wildlife fencing placement, length, and options for fence ends for bridge underpasses (top) and culverts (bottom). Fence end design options are numbered in order of effectiveness (1 to 4). Option 1 = tie fence in to another underpass suitable for wildlife use (low volume road, culvert, etc.). Option 2 = tie fence into area of steep topography. Option 3 = tie fence into right-of-way fence. Option 4 = end fence in an area of habitat transition. Hash marks along wildlife fence signify jumpout locations (discussed in a subsequent section).

Figure 21: Wildlife Fencing and Crossing Options

Source: "Large Animal Crash Countermeasures in Virginia", Virginia Transportation Research Council, April 2022.

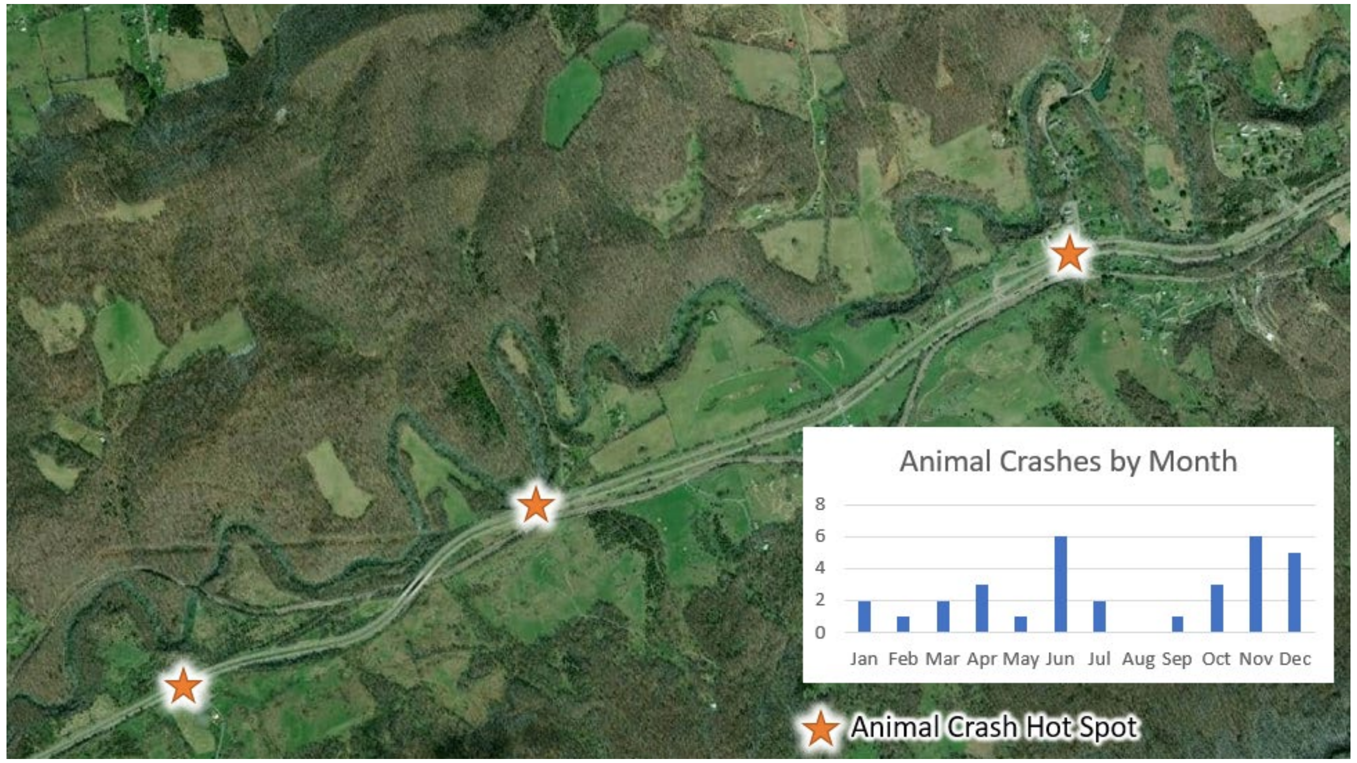


Figure 22: Animal Crash Data

To address the clusters of animal crashes shown in **Figure 22,** animal warning signs were considered. General guidance is that deer or other large animal crossing signs should be installed if there were at least 5 reported large animal/vehicle crashes in the span of one year and if the posted speed limit is 45 MPH or greater. The study corridor meets the speed limit requirements for this. While this segment of the corridor does not meet the crash threshold, it is possible that the number of animal crashes is currently underreported. Sources indicate that large animal crashes may be underreported by 5-10 times.

The crash data showed that there were higher concentrations of animal crashes in June, November and December, and a concentration in nighttime. Given these clear peaks of activity, seasonal advisory signs on changeable message signs were considered that could be activated during the historical peak crash periods. Examples of the seasonal advisory signs on changeable message signs can be seen in **Figure 23**. An animal detection warning system was another alternative considered. As of now, there are only pilots of this system deployed, and Virginia studies have found these pilots successful at detecting animals. No evaluation has been done about their effect on crash reduction. To install these warning systems, the sites need solar or power access, fiber/communication connection, more than 15 feet of right-of-way outside of the pavement, and 12 to 18 feet of flat terrain. **Figure 24** presents more information on an animal detection warning system.

	Phase 1	Phase 2
Permanent CMS	DEER CROSSING NEXT XX MILES	WATCH FOR DEER NEXT XX MILES CALL 511 FOR INFO
Portable CMS	WATCH FOR DEER	NEXT XX MILES

Figure 12. Example wildlife warning messages, which should refer to the specific animal and the length of the high-risk road segment. Further, they should be displayed seasonally (when crashes are highest) on days when no higher priority messages are to be displayed.

Figure 23: Seasonal Advisory Signs and Changeable Message Sign, *Source: "Large Animal Crash Countermeasures in Virginia", Virginia Transportation Research Council, April 2022.*

Figure 13. Photographs of the system tested in Christiansburg, Virginia, illustrating the roadside trench with the cable (top left) covered and compacted with native soil (top center). A solar power system was used to power to equipment (top right) and a deer warning sign with flashing LED lights was activated when an animal was detected by the cable (bottom). *Note:* the beacons and signs used may vary from these photos in future installations. *Photo credit: Virginia Tech Transportation Institute.*

Figure 24: Animal Detection Warning System, *Source: "Large Animal Crash Countermeasures in Virginia", Virginia Transportation Research Council, April 2022.*

Animal fencing, in combination with a grade-separated animal crossing was another alternative considered. The study considered two existing underpass locations for the separated wildlife crossing in conjunction with animal fencing. The first location, shown in **Figure 25**, is the existing overpass over the railroad. This location is in the hotspot for animal crashes and is a large enough for an animal crossing; however, was not considered further due to the concern for animal interaction with the railroad. The second location considered is approximately 1,700 feet west of Earl's Branch Road. This location is outside of the hotspot of animal crashes, and the existing culvert is smaller than preferred for a wildlife crossing.

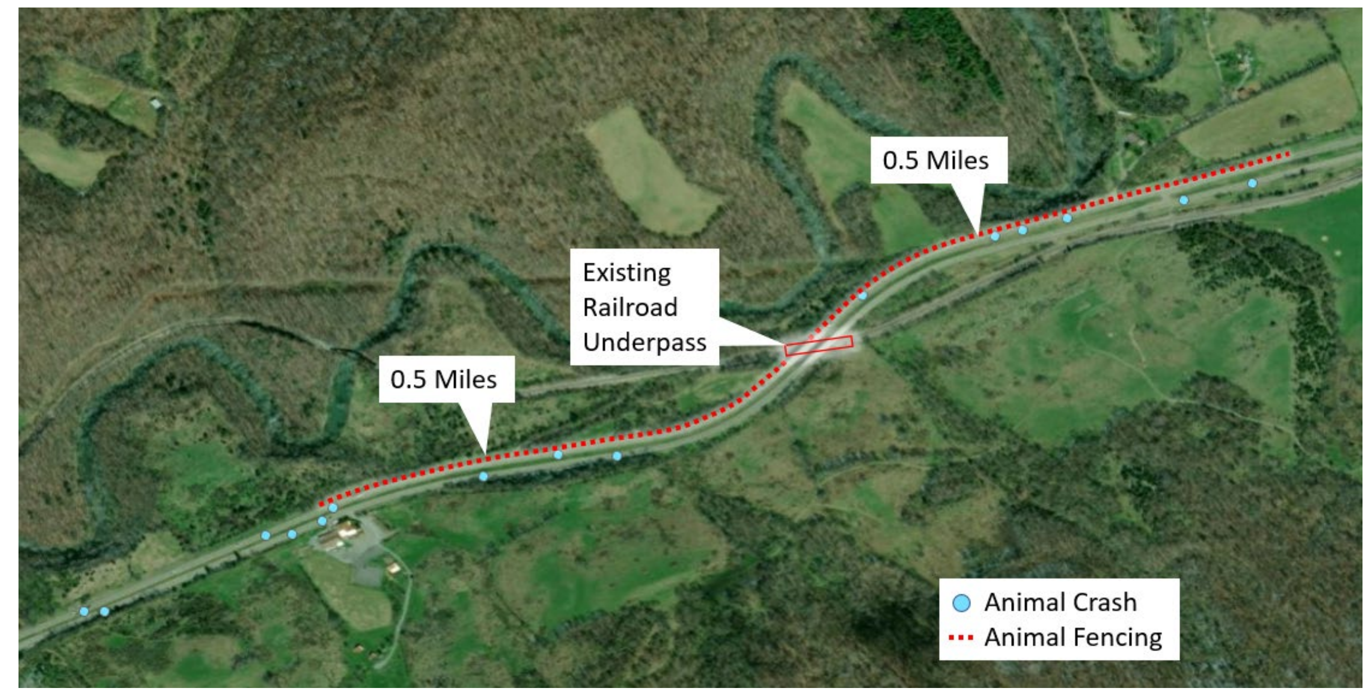


Figure 25: Animal Fencing Alternative

The animal crash alternatives were not considered further after discussing with VDOT Central Office. The study team met with VDOT Central Office Environmental Division and learned of the ongoing collaboration within VDOT Central Office to study animal crashes and identify the appropriate countermeasures statewide as well as conduct pilot studies to assess countermeasures. So, the study team decided it was best to not make a recommendation at this time. The animal crash issue is also not limited to the same bounds as the study area (i.e., animal crash hotspots could be occurring immediately outside of the study area), and some treatments (e.g., animal fencing) could just be pushing to issue to outside of the study area. Any countermeasures considered here should be considered on a corridor-wide basis.

Final Preferred Alternatives

The following preferred alternatives are the result of the development process. These alternatives have been presented to stakeholders, been analyzed by the study team, and are recommended to address safety issues and concerns at the identified locations in the study area.

"S" CURVE ALTERNATIVES

For the "S" curve, the final proposed alternatives aim to bring the study corridor closer to standard and mitigate future run off road crashes. To address the high operational speeds and to bring drivers' attention to the curves on the study corridor, the proposed alternatives include advance curve warning signs with the advisory speed of 55 mph, supplementary in-lane advance curve warning pavement markings, and chevron signs. These alternatives offer improved curve delineation, which has a CMF of 0.725 for all crashes. The in-lane curve warning pavement markings have a 0.625 CMF for all crashes in horizontal curves. These additional signs and markings will help to alert drivers of the curves and encourage drivers to maintain a lower speed.

For the eastbound direction of the "S" curves, shoulder widening is proposed. There are areas that will be able to have full standard shoulder widths built without a significant impact. However, there are some areas that will have higher costs and construction impacts due to grading and right-of-way to get the full standard shoulder width. Still, it is possible to at least install a 6-foot paved shoulder in these areas. VDOT and the district would support installing the 6-foot shoulders if that is all that can be installed without significant costs. Improving the shoulder in this direction should help prevent severe run-off road crashes by giving drivers more space to correct. The westbound direction wasn't considered because of the lack of a crash history and an existing guardrail that takes away the benefit of a shoulder widening project. The proposed shoulder widening project is for the 0.6 miles of the eastbound segment of the study corridor between Route 639 (Earl's Branch Road) and Keen Road. Rumble strips are also recommended to be installed on the inside shoulder to alert drivers that they are leaving the road. **Figure 26**, **Figure 27**, **Figure 28**, and **Figure 29** show the final recommendations on the study corridor. While a detailed cost estimate will be prepared in the Phase 3 of Project Pipeline for SMART SCALE application purposes, the preliminary cost estimate is as follows for this project:

- Preliminary Engineering = $631,500[2]
- Right of Way and Utilities = $682,500
- Construction = $6,525,500
- Total = $7,839,500

Further refinements to the concept design will be made in Phase 3, which will be reflected in the Phase 3 detailed cost estimate as well.

[2] Bristol District Location and Design staff increased the Preliminary Engineering base cost to $1,100,000 during SMART SCALE pre-application validation.

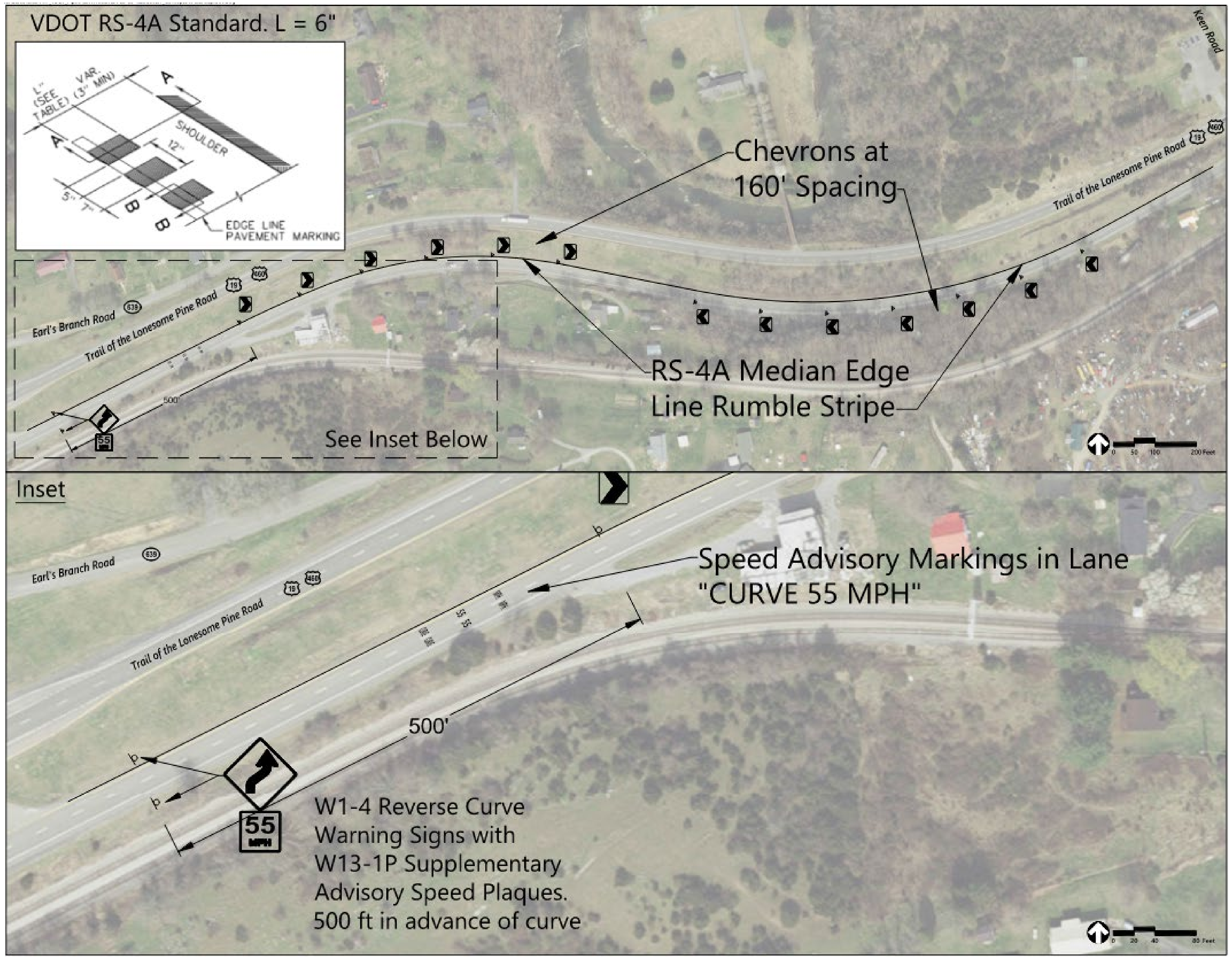


Figure 26: Proposed Alternative for "S" Curve – Signing and Marking

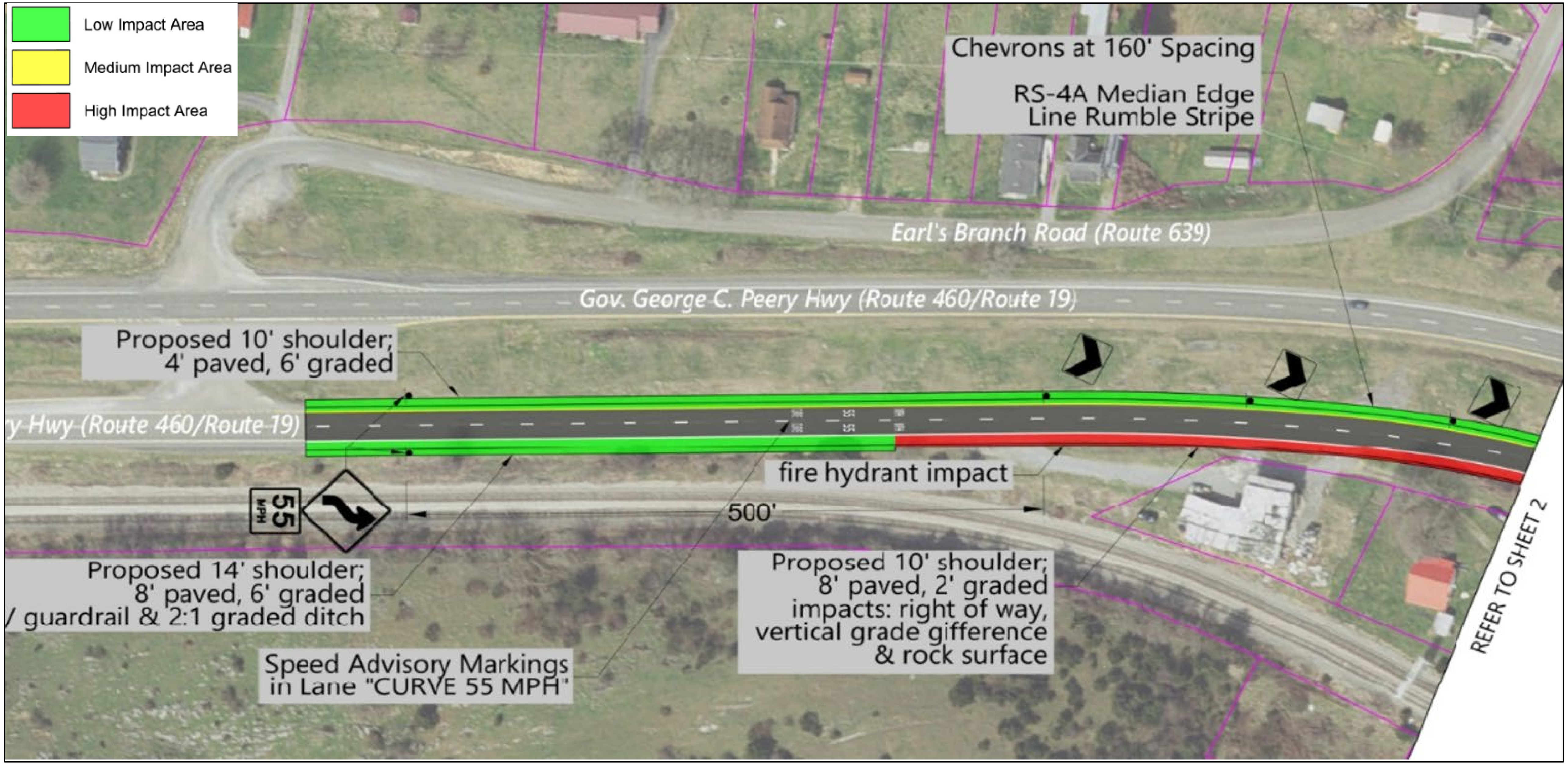


Figure 27: Shoulder Improvement Impact - Sheet 1

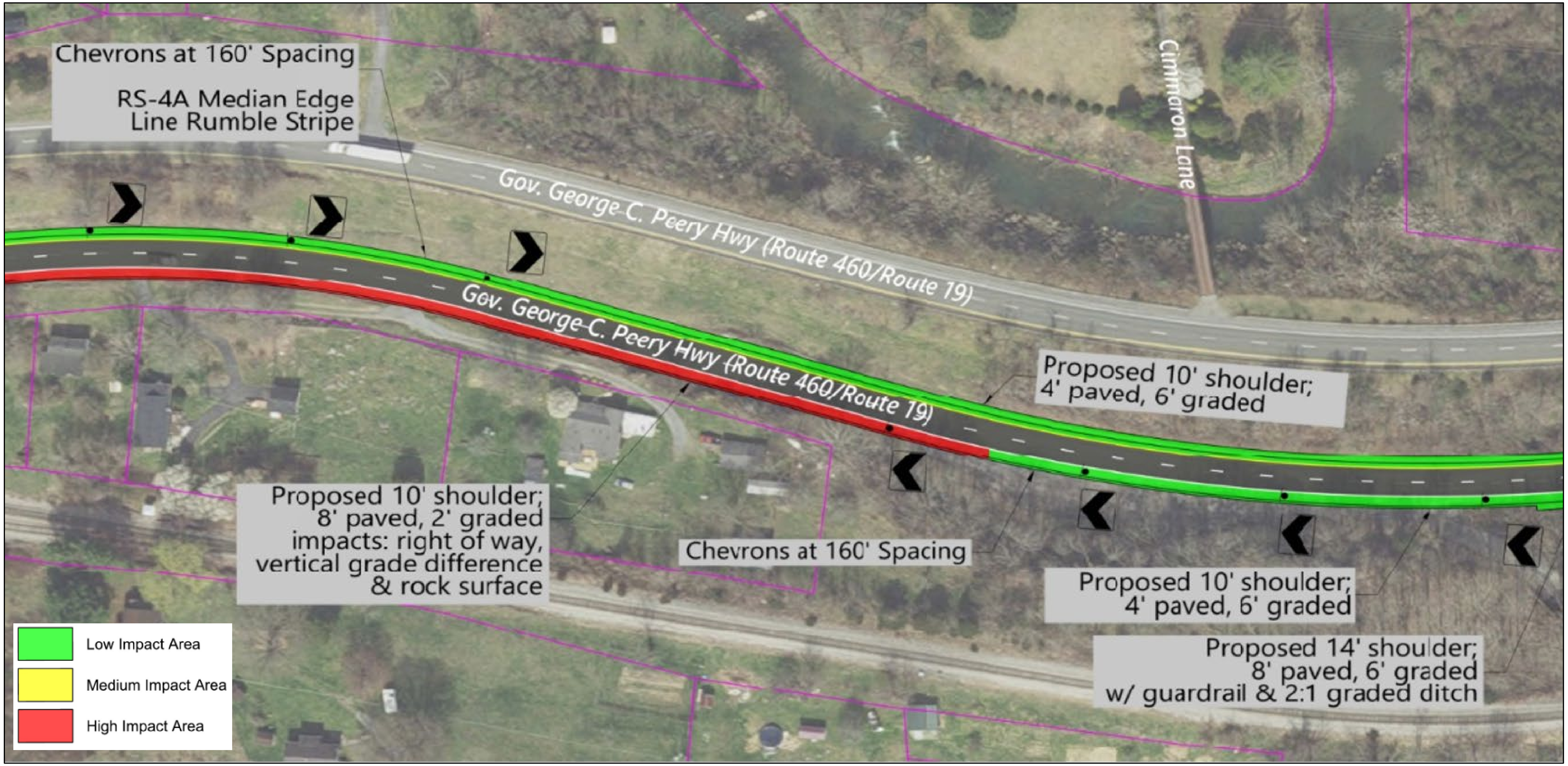


Figure 28: Shoulder Improvement Impact - Sheet 2

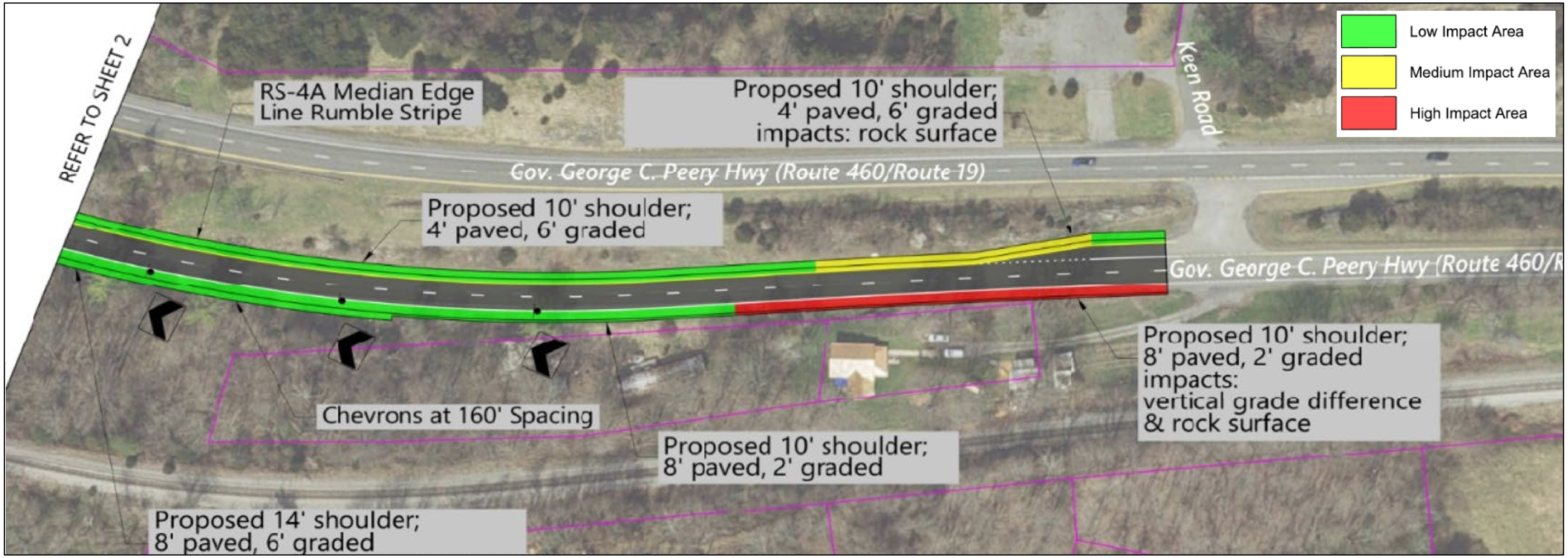


Figure 29: Shoulder Improvement Impact - Sheet 3

Chapter 3:

Public and Stakeholder Outreach and Feedback

Public Involvement:

Following the development and analysis of the Preliminary Build Alternatives, a public involvement survey was developed to determine the public's response to the recommended improvements and what they perceived as the relevant issues within the study area. This survey was available online for 14 days spanning from February 12, 2024 to February 25, 2024.

Survey Design

Public involvement for this study took place in the form of an online survey developed in VDOT's PublicInput Platform, which is an online engagement platform that is designed to educate the public while gathering informed output. The goals of this public outreach effort were to present relevant issues, educate the public on the recommended improvement concepts outlined in Chapter 2, and to receive the public's feedback on the proposed improvements.

Overall, the survey is divided into three sections, which include the following:

1. Introduction to the study and background information
2. Proposed improvements
3. Wrap up with demographic questions

The first section provides an overview of the study partners, background, and study location, as shown in **Figure 30**. In the second section, participants were presented with recommended improvements that addressed vehicular-based operation and safety needs. Participants were asked (on a 1 to 5 scale) if they opposed or supported the project concept. A score of 1 represented "strongly oppose", and a score of 5 represented "strongly support." Participants were also able to provide freeform comments on each concept. At the end of the survey, the participants were asked a few demographic questions.

A total of 376 people responded to the survey with 178 unique freeform comments. A compilation of all freeform public comments can be found in **Appendix E**.

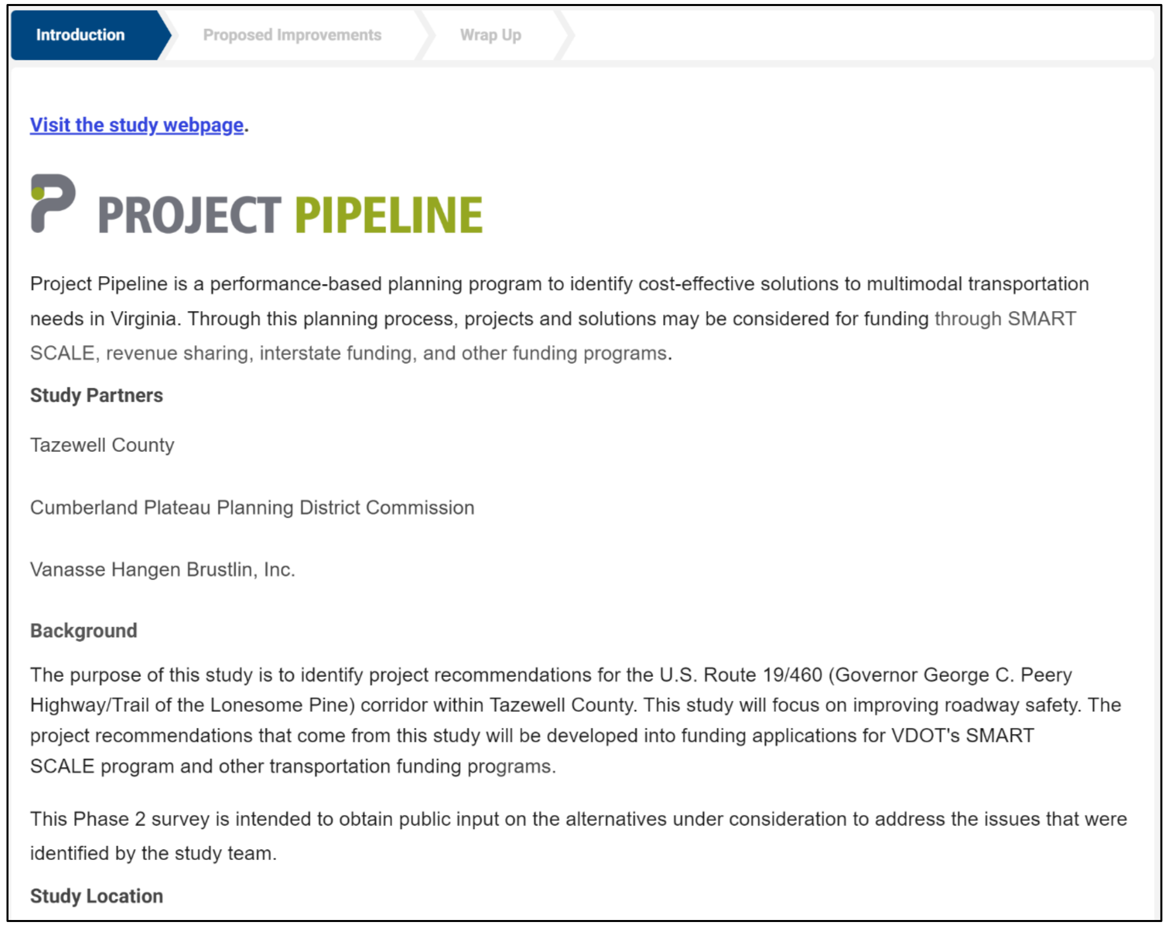


Figure 30: Public Survey Layout

Survey Questions and Results

The first concept presented to the public for feedback consisted of low-cost safety countermeasures to address the crash patterns seen at the S-curve east of Earls Branch Road. The improvements included chevrons, rumble strips, in-lane warning pavement markings, and curve warning signage. Respondents were informed that "*The eastbound U.S. 19/460 roadway curvature east of Earl's Branch Road has experienced a significant number of roadway departure crashes and is in the top 5% statewide crash risk for roadway departure crashes. Drivers are on average driving this roadway curve 15 MPH above the speed for which the roadway curve is designed. The proposed concept will add traffic signs and pavement markings to alert drivers of the roadway curve and the speed at which they should be driving. It would also add rumble strips in the median to alert drivers who are starting to depart the roadway.*" Respondents had the opportunity to rate the proposed concept on a 1 (strongly oppose) to 5 (strongly support) scale. Their feedback is recorded in **Figure 31**. The average weighted respondent score for the concept was a 4.05, indicating support for the concept since the 4.05 is a positive rating above a neutral score of 3.0.

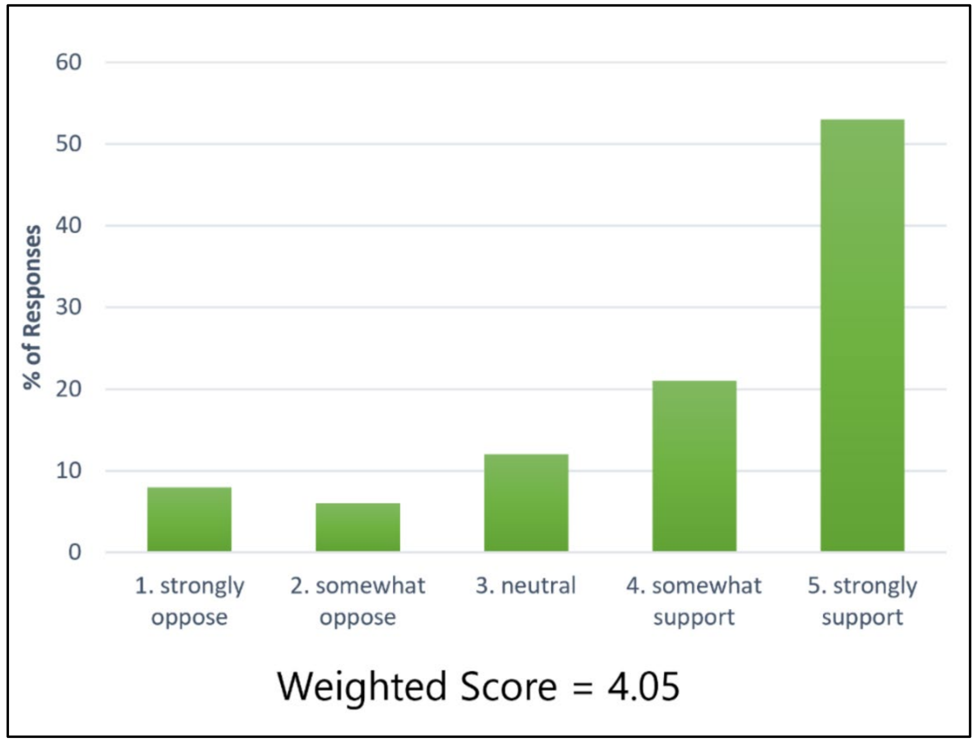


Figure 31: Respondents' Feedback on Low-Cost Countermeasures

Next, the public was invited to provide feedback on shoulder widening through the same eastbound curvature east of Earls Branch Road. The respondents were informed that "*the proposed shoulder widening would improve recovery space for drivers who begin to depart the roadway. Shoulder widening would be designed to maintain existing driveway access.*" The survey presented images that defined which shoulder widening areas would be areas of low impact (able to install full standard shoulder widths), medium impact (able to install full shoulder improvements with low constructability impacts, but significant impacts to Right of Way), and high impact (areas will not meet current standards without significant constructability and Right of Way impacts).

Figure 32 provides the public response for this concept. Based on the weighted score of the 4.24, the majority of respondents strongly support this concept.

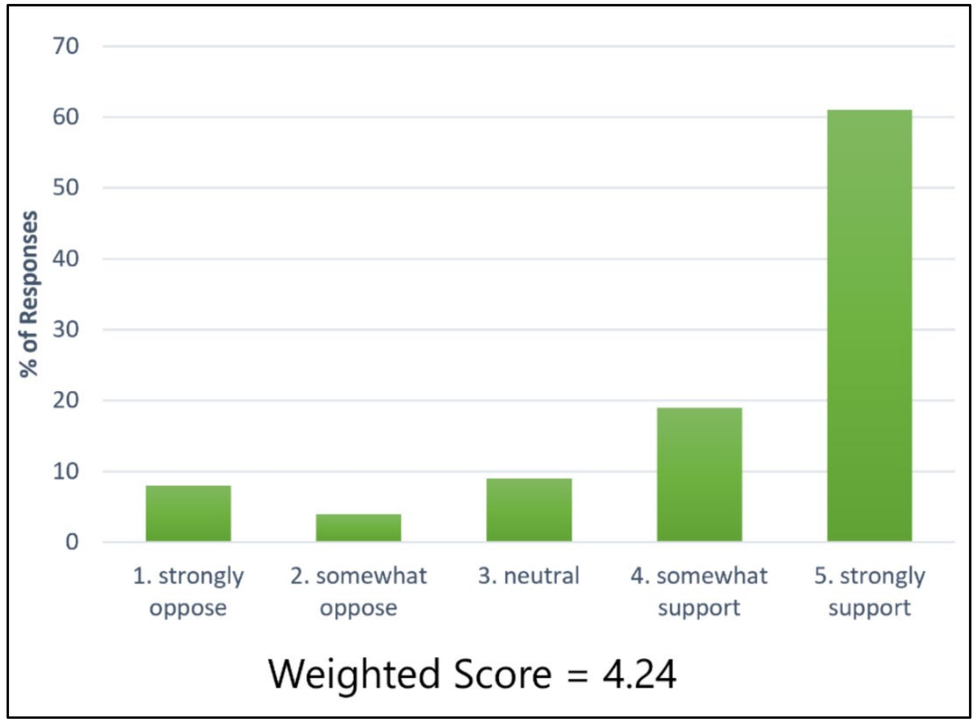


Figure 32: Respondents' Feedback on Shoulder Widening

FREEFORM SURVEY COMMENTS

In addition to being invited to score and rank the proposed alternatives, survey respondents had the option to provide freeform comments both generally on the study area and on individual concepts. The general themes of these comments are shown in **Table 8**. A compilation of all freeform public comments can be found in **Appendix E**.

Table 8: Summary of Public Comments and Study Team Responses

Public Comments and Study Team Responses		
	General Public Comment Themes	**Study Team Response**
Low-Cost Countermeasures	1. Needed improvement, general support 2. Call for illuminated chevrons 3. Call to straighten out the curve 4. Call to lower the speed limit or increase police enforcement / signs alone are not enough to slow down traffic 5. Primary issue is distracted drivers	1. Acknowledged. 2. Illuminated chevrons have increased maintenance associated with keeping them in working order, and are not recommended at this time; however, illuminated chevrons could be considered in the future. 3. Straightening out the curvature of this roadway would be a very high-cost project and would require full right-of-way takes of many adjacent properties. 4. Speed data revealed that vehicles are traveling well over the current posted speed limit. Only lowering the speed limit is not likely to result in significantly lower speeds. Instead, the countermeasures proposed are aimed at encouraging drivers to travel at lower speeds and have proven successful. Increase police enforcement could be implemented; however, that is dependent on the availability of local police staff and is not a 24/7 solution. 5. The countermeasures are targeting distracted drivers as well by calling more attention to the curvature of the roadway. Additionally, the rumble strips will alert errant drivers if they leave the roadway.
Shoulder Widening	1. Support for the concept 2. Concern that vehicles will park in the shoulder 3. Important to maintain access to fire hydrants	1. Acknowledged. 2. All driveways and property access will be maintained with the shoulder widening, and vehicles should not park within the shoulder. 3. Access to fire hydrants will be maintained with the shoulder widening.

Chapter 4:

Preferred Alternative Design Refinement

Preferred Alternative Design Refinement

Phase 3 of the Project Pipeline study advanced the design of the preferred alternative to prepare it for SMART SCALE application. This design refinement was focused on identifying all significant project features, defining project risk and contingency factors, and developing an appropriate cost estimate. The intent was to progress the design to a sufficient level (approximately 10% design) such that all necessary cost items were included in the project application.

Preferred Alternative #1: US 19/460 Corridor Shoulder Improvements

This preferred alternative was prepared for the August 1st, 2024, Round 6 SMART SCALE Application deadline. The final application included the following deliverables: design exhibit, cost estimate, project risk register, basis of design memorandum, and supporting documentation (this Pipeline study report). The improvements included in this preferred alternative #1 package include:

- Mill and overlay of eastbound US 19/460 within the project limits
- Shoulder widening of inside and outside shoulders
    - 831-feet of mill and overlay for existing 2-foot paved shoulder
    - 438-feet of 4-foot shoulder (4-foot paved)
    - 1,974-feet of 6-foot shoulder (4-foot paved plus 2-foot graded)
    - 301-feet of 7-foot shoulder (4-foot paved plus 3-foot graded)
    - 2,280 -feet of 10-foot shoulder (4-foot paved plus 6-foot graded)
    - 576-feet of 14-foot shoulder (4-foot paved plus 10-foot graded)
- Warning Signs (reverse curve ahead, supplemental speed plaques, and static chevron signs)
- Rumble Strips (replacement in kind of the existing rumble strip on the outside shoulder and new rumble strips on the inside shoulder)
- 1,178-feet of new guardrail
- Stormwater Infrastructure to accommodate improvements

Design Updates and Assumptions

As the design of these various improvements progressed, several design refinements were completed, and design assumptions clarified. These are covered in more extensive detail in the Basis of Design document (see **Appendix F**) that accompanied this project's Round 6 SMART SCALE Application, but a summary of these items is provided here. **Figure 33-Figure 35** show the refined design alternative.

- Reduced proposed shoulder widths (paved and graded) to reduce impacts to utilities, right of way, an existing culvert, and adjacent topography. Given the current lack of survey data, proposed shoulder widths were reduced to the amount that could confidently be constructed within these constraints. Additional contingency was added to the project budget to accommodate construction of wider shoulder widths if design based on topographic and right of way survey determines this is feasible.
- Added stormwater management features, including jack and bored pipe across US 19/460 to channel water into the median and proposed stormwater treatments.

The major design features and design assumptions for the proposed improvement is documented in the accompanying Basis of Design document.

Project Risk and Contingency

Contingencies per category are covered in more extensive detail in the Basis of Design document (see **Appendix F**) that accompanied this project's Round 6 SMART SCALE application. Specific project risks are highlighted in the Risk Analysis Matrix that also accompanied the application. This matrix documents the risk items, assesses their potential impact, and proposes mitigation strategies.

Cost Estimate

The cost estimate was developed via quantity take offs, historical VDOT bid prices, VDOT input, and percentage-based preliminary engineering costs. The estimate process is covered in more extensive detail in the Basis of Design document (see **Appendix F**) that accompanied this project's Round 6 SMART SCALE application.

The total project cost is estimated to be **$8,164,894** and broken down by Phase/Major area as follows:

- Preliminary Engineering Phase $1,723,526
- Right of Way and Utilities Phase $250,000
- Construction Phase (without CEI) $5,221,635
- Construction Phase (with CEI) $6,191,367

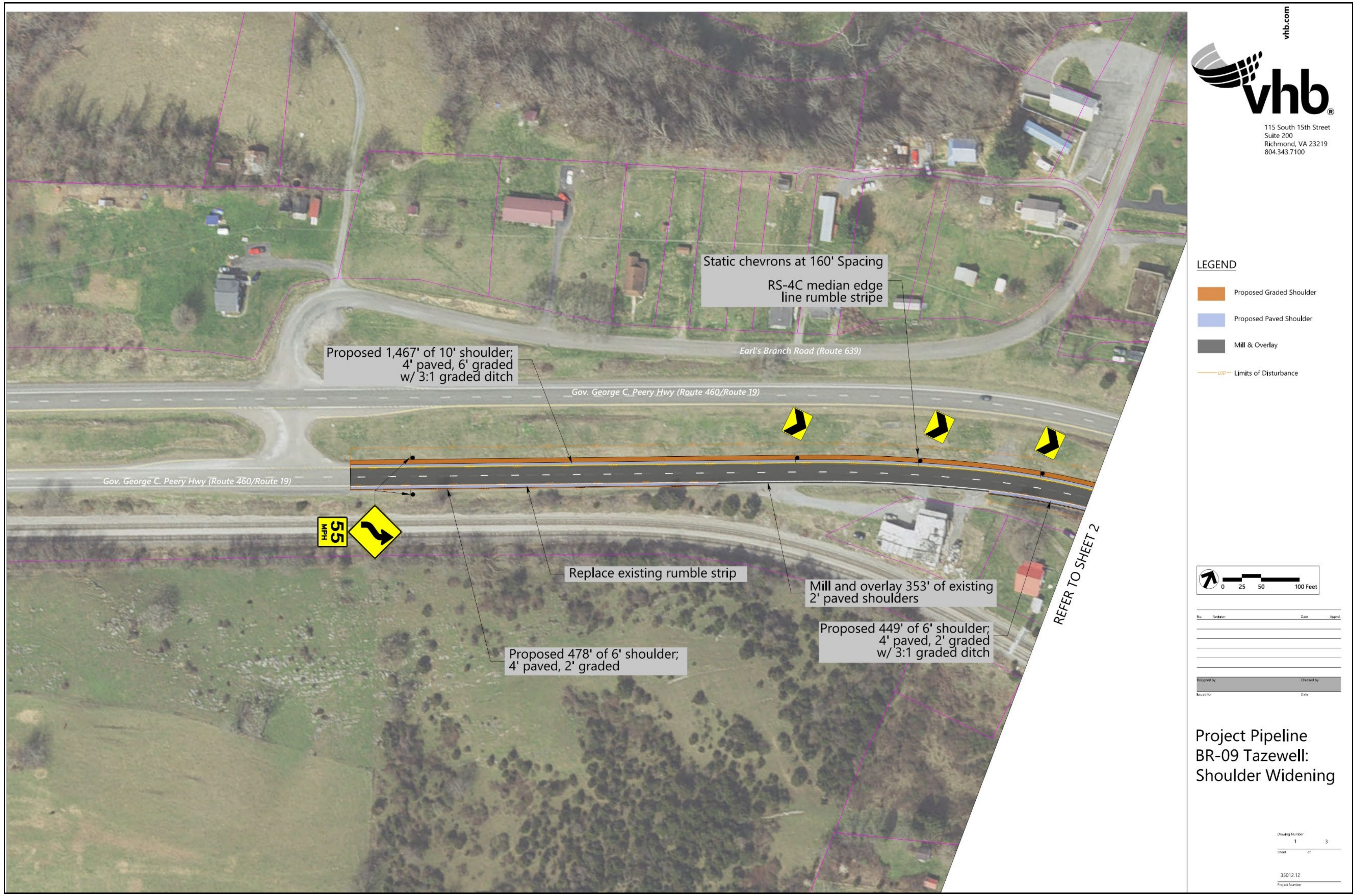


Figure 33: Shoulder Widening and Safety Improvements - Sheet 1

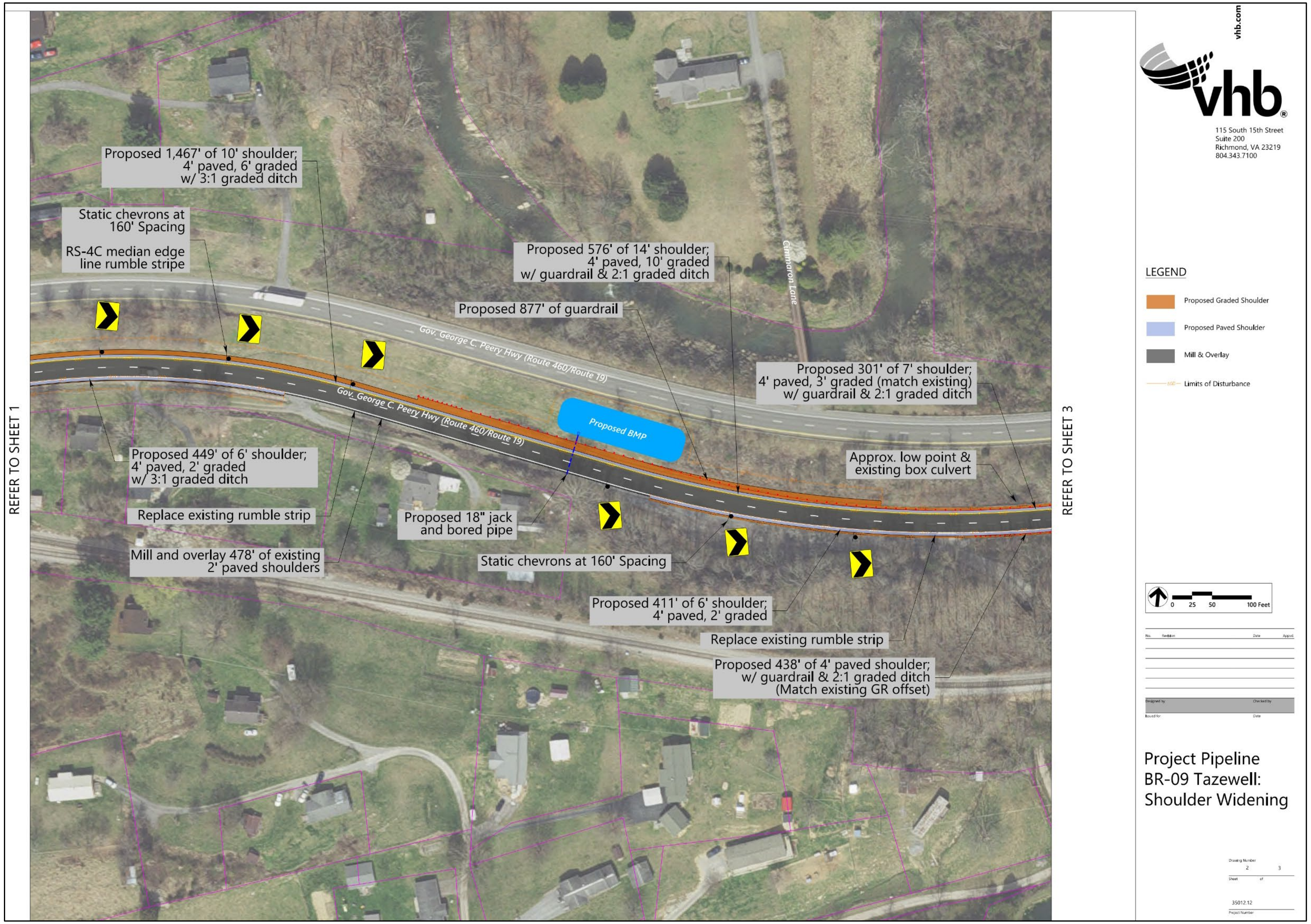


Figure 34: Shoulder Widening and Safety Improvements - Sheet 2

Figure 35: Shoulder Widening and Safety Improvements – Sheet 3