I-81 Auxiliary Lanes Exit 140 to Exit 141

CONCEPTUAL DESIGN REPORT

I-81 AUXILIARY LANES EXIT 140 TO EXIT 141

CONCEPTUAL DESIGN REPORT

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1 EXECUTIVE SUMMARY

1.1 Overview

Interstate 81 (I-81), between exits 140 and 141, experiences significant congestion daily due to high traffic volumes. The study area consisted of an approximate 1.5-mile section of northbound and southbound I-81 encompassing Exit 140 and Exit 141. The study initially sought to develop preliminary design plans and detailed costs for auxiliary lanes along northbound and southbound Interstate 81 connecting Exit 140 and Exit 141; however, by the conclusion of the study in early 2019 the study evolved into support for the implementation of the I-81 Corridor Improvement Plan.

1.2 Design Alternatives Analysis and Selection of Preferred Design Alternative

The study evaluated multiple alternatives for the design of auxiliary lanes between Exit 140 and Exit 141. Alternatives consisted of widening to the outside, widening to the inside, connecting auxiliary lanes through Exit 141 to provide continuous auxiliary lanes between Exit 140 and Exit 143, and alternatives for future extension of the auxiliary lanes south of Exit 140. Alternatives were screened based on right-of-way impacts, constructability issues, and approximate cost of construction. Alternatives were also evaluated to connect to the proposed auxiliary lanes between Exit 141 and Exit 143 and to not preclude future extension of auxiliary lanes south of Exit 140. Lastly, traffic analysis demonstrated that improvements to safety and congestion outweighed the additional costs of construction along northbound and southbound I-81 if auxiliary lanes were connected to the auxiliary lanes proposed by UPC 108906 terminating at Exit 143.

The following design elements are incorporated in the preferred design alternative for the auxiliary lanes between Exit 140 and Exit 141, which do not preclude the future extension of the auxiliary lanes south of Exit 140:

- Widen northbound and southbound I-81 to the inside (median) from Exit 140 to south of the existing I-81 bridges over Mason's Creek
- Widen northbound and southbound I-81 to the outside on the approach to the existing I-81 bridges over Mason's Creek
- Maintain the existing I-81 bridges over Mason's Creek
- Widen northbound and southbound I-81 to the inside (median) from just north of the existing I-81 bridges over Mason's Creek to the north side of Exit 141
- Connect to the northbound and southbound auxiliary lanes constructed as part of UPC 108906 between Exit 141 and Exit 143.

1.3 Design Elements

The typical section is comprised of three 12-foot travel lanes, a minimum inside shoulder width of 7 feet adjacent to concrete median barrier or 8 feet with guardrail and maintaining the existing outside paved shoulder (minimum 10 feet). There are no impacts proposed beyond the outside paved shoulder. As the widening transitions across the existing crown line, pavement buildup will be required to shift the

crown line. The vertical alignment is represented as a spline grade on the profile sheets to match existing elevations. The superelevation shown on the proposed cross sections matches the existing superelevation. This will maintain the existing cross slopes, minimize impacts to the outside shoulders, and avoid excavating into steep rock slopes and right-of-way impacts. Once the widening is complete, the mainline pavement will be milled and overlaid with 4.5 inches of asphalt. The preferred design alternative replaces all the existing guardrail within the project limits. A storm water management feature is proposed inside the southbound loop ramp at Exit 141 and does not require any additional right-of-way acquisition.

1.4 Risk Identification/Mitigation and Cost Estimating

Risk management is undertaken throughout the lifecycle of a project to track identified risks, measure the performance of mitigation, identify new risks as they arise, maintain adequate risk budgeting, and capture best practices. The initial assessment of the risks is qualitative and will be updated with quantified values as the project progresses and more project data becomes available.

The following risks were identified during the development of the study and conceptual design, and a detailed description of these risks and potential steps for mitigation can be found in **Section 7.1**:

- Maintenance of traffic
- Rock excavation/blasting
- Noise walls
- Mason's Creek stream and wetland impacts

A preliminary planning level cost estimate based on the conceptual plans for the preferred design alternative was developed through a cooperative effort between Kimley-Horn and the Virginia Department of Transportation (VDOT) Salem District. The below cost estimates are inflated to the assumed advertisement year of 2024 and construction completion in 2026.

Table 1-1 – Preliminary Cost Estimate

Total I-81 SB Auxiliary Lane	$ 20,100,061
Total I-81 NB Auxiliary Lane	$ 12,414,472
Total I-81 Auxiliary Lanes 140 to 141	**$ 32,514,533**

1.5 Next Steps

The design presented on the conceptual design plans is only to a conceptual level and further design will be needed. The following critical next steps should be undertaken early in further design development:

- Inspection of existing pipes and culverts
- Complete survey deliverables
- Confirm roadway, drainage and signing and marking plans for UPC 108906 allow for connection through Exit 141
- Begin NEPA and other environmental processes
- Begin detailed design
- Complete required traffic operations and safety analysis

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3 INTRODUCTION

3.1 Study Purpose

The initial purpose of this study was to develop preliminary design plans and a detailed cost estimate for auxiliary lanes along northbound and southbound I-81 connecting Exit 140 and Exit 141 in support of FY20 SmartScale applications for the Roanoke Valley Transportation Planning Organization (RVTPO). By the conclusion of the study in early 2019, the study evolved into support for the planning and development of future improvements as part of the I-81 Corridor Improvement Plan as described in **Section 3.4**. These auxiliary lanes purpose was to improve safety and congestion along I-81 within the study area. The study also investigated the feasibility of continuing auxiliary lanes through Exit 141 as an extension of the adjacent auxiliary lane project connecting Exit 141 to 143 on northbound and southbound I-81. Lastly, the study established the feasibility of setting up the future extension of the auxiliary lanes along northbound and southbound I-81 south of Exit 140.

3.2 Study Area

See **Figure 3.1** below for a graphical depiction of the study area for this project. The study area consisted of an approximate 1.5-mile section of northbound and southbound I-81 encompassing Exit 140 and Exit 141. The study area included the following two interchanges and eight ramps on I-81:

Exit 140

- Off-ramp from northbound I-81 to Route 311
- On-ramp from Route 311 to northbound I-81
- Off-ramp from southbound I-81 to Route 311
- On-ramp from Route 311 to southbound I-81

Exit 141

- Off-ramp from northbound I-81 to Route 419
- On-ramp from Route 419 to northbound I-81
- On-ramp from Route 419 to southbound I-81
- Off-ramp from southbound I-81 to Route 419

The study area also included northbound and southbound I-81 from approximately 0.5 miles south of Exit 140 to and north of Exit 141 to document the feasibility of a future project continuing the auxiliary lanes south of Exit 140 and a connection to the proposed northbound and southbound I-81 auxiliary lanes from Exit 141 to 143.

Figure 3-1 – Study Area

3.3 Project Background

The I-81 Corridor Improvement Study, Tier I Final Environmental Impact Statement (FEIS) (Tier I FEIS) completed in 2007 studied the entire 325 miles of the I-81 corridor in Virginia for potential improvements, including separation of trucks and passenger vehicles, managed lanes, and rail improvements. The Tier I Record of Decision (ROD) documented the Federal Highway Administration's (FHWA) decision to advance to Tier II: a non-separated, variable lane highway facility that involves construction of no more than two general purpose lanes in each direction, where needed, to address future traffic demands. Subsequently, the Tier I FEIS study divided I-81 in to eight segments for further detailed analysis which could be performed under Tier II studies. Also, the Tier I ROD documented the immediate need for smaller, independent safety and operational improvements along I-81, with the "Build" concept that was advanced into Tier II.

Following the Tier 1 ROD, VDOT began development of *The I-81 Corridor Improvement Study, Tier II Environmental Assessment* (EA) (Tier II EA) for a 32-mile segment including the area of I-81 between Exit 140 and Exit 143. This Tier II EA sought to address existing and projected (2040) traffic volumes and improve safety within the study area along I-81. VDOT placed the development of the Tier II EA on hold and never published a final document or sought a ROD; however, the conceptual design of this project utilized information contained within the unfinished Tier II EA.

In 2015 and 2016, VDOT studied the feasibility of constructing a continuous auxiliary lane between Exit 141 and Exit 143 on northbound I-81 to provide a near-term mitigation to alleviate traffic congestion. *The I-81/I-581 Auxiliary Lane Conceptual Design Report* dated June 2016 documented the findings and recommendations of this study. In 2017, VDOT applied through the HB2 (now SmartScale) funding process to fund the construction of auxiliary lanes between Exit 140 and Exit 143 along northbound I-81. During application review, benefit evaluation, and project identification, VDOT and the RVTPO adjusted the application's scope to propose auxiliary lanes between Exit 141 and Exit 143 in both the northbound and southbound directions of I-81. The adjacent project is fully funded in the current version of the Six Year Improvement Program as state project number # 0081-080-903 (UPC 108906). The conceptual design of this project relied upon elements of the on-going preliminary engineering phase for UPC 108906.

3.4 I-81 Corridor Improvement Plan

During the development of this project, the 2018 Virginia General Assembly adopted Chapter 743 of the 2018 Virginia Acts of the General Assembly. This act of the Virginia General Assembly directed the Commonwealth Transportation Board (CTB) to study the entire I-81 corridor within the Commonwealth

of Virginia, adopt an improvement plan for the corridor, and propose methods of financing such improvements. As part of the development of the I-81 Corridor Improvement Plan the CTB, Office of Intermodal Planning and Investment, VDOT, and Virginia Department of Rail and Public Transportation conducted 12 public meetings and hearings; held focus groups; received more than 2,000 public comments; and identified more than $4.3 billion in recommended improvements in the I-81 corridor including improvements within the study area of this project. Based on public input, applied prioritization methodology, and available market capacity, the I-81 Corridor Improvement Plan recommended implementing $2.14 billion in improvements during the next 7 to 10 years. The I-81 Corridor Improvement Plan recommended construction of a continuous third northbound lane from the vicinity of Exit 118 to Exit 143 and a continuous southbound auxiliary lane from Exit 143 to Exit 137. The design and findings of this study were coordinated with the I-81 Corridor Improvement Plan and recommendations. For further information on the I-81 Corridor Improvement Plan see the report as approved by the CTB in December 2018.

4 TRAFFIC ANALYSIS

4.1 Overview

The study team reviewed completed and ongoing studies along the I-81 corridor to validate the traffic analysis assumptions and to supplement data for the traffic analysis conducted as part of this study. These studies included the I-81 Tier II EA and the traffic operations analysis for UPC 108906. VDOT Salem District conducted a traffic operational analysis for existing conditions (2017), no-build conditions (2030), and design year conditions (2030) within the study area. The No-Build conditions operational analysis was used as a baseline against which the effectiveness of the proposed improvements could be measured. Raw existing traffic volumes were collected from the VDOT Traffic Monitoring System (TMS), and 48-hour counts were collected at mainline and ramp locations if traffic data was not available in TMS. A 1.8% linear growth rate was applied to existing traffic volumes to develop future 2030 conditions traffic volumes. VDOT utilized Highway Capacity Software (HCS7) for all traffic operational analysis.

4.2 Summary

The existing conditions (2017) operational analysis shows failing operations on northbound I-81 between Exit 140 and Exit 143 in the PM peak hour. A degradation in level of service is projected due to expected growth within the study area under future no-build conditions (2030). In the AM peak hour, demand is projected to exceed capacity on northbound I-81 between Exit 140 and Exit 143. In the PM peak hour, demand is projected to exceed capacity on both northbound and southbound I-81 between Exit 140 and Exit 143.

The design year conditions (2030) traffic operational analysis shows that while separate auxiliary lanes connecting Exit 140 to Exit 141 and Exit 141 to Exit 143 are projected to improve traffic operations on northbound and southbound I-81, a continuous third lane on northbound and southbound I-81 from Exit 140 to Exit 143 provides higher traffic operational benefits. All segments are projected to operate with acceptable levels of service in the AM and PM peak hours with a continuous third lane on I-81. The I-81 Corridor Improvement Plan (described above in Section 3.4 above) recommends extending the third

northbound I-81 travel lane to Exit 118 and the third southbound I-81 travel lane to Exit 137, and it is anticipated that incorporating these would further improve traffic conditions along I-81.

5 ENVIRONMENTAL

In accordance with FHWA policy, this conceptual design review was completed to evaluate the feasibility of the proposed auxiliary lanes along northbound and southbound Interstate 81 connecting Exit 140 to Exit 141. At this time, no National Environmental Policy Act (NEPA) documents are being prepared for this project as the applicable funding has not been decided at this time. A finding of operational and engineering acceptability of this review does not constitute approval of the project for construction; the required NEPA documents must be completed prior to final approval for construction. A preliminary review using NEPA process criteria was conducted for this project to determine if any sensitive sites may be present or potentially impacted by the construction of the construction of the improvements.

This preliminary environmental review identifies and assesses potential impacts from the proposed project on the social and natural environment. The review was limited to available database information. Based on this preliminary environmental review, no environmental fatal flaws or items that would prohibit the construction of the proposed improvements were identified.

The following areas were preliminarily reviewed to identify potential significant impacts:

- Socio-economic impacts
- Environmental justice
- Community facilities
- Parks and recreation facilities
- Cultural and historic resources impacts
- Section 4 (f) and Section 6 (f)
- Natural resources impacts
- Water resources
- Wildlife and habitat
- Noise impacts
- Hazardous materials impacts

The following additional areas will need to be reviewed for the required NEPA and/or SERP document during detailed design:

- Noise
- Air
- Right-of-way and relocations
- Cumulative and indirect impacts
- Public involvement
- Coordination with state environmental and natural resource agencies to provide comments on any significant environmental impacts of the project and identification of strategies to avoid or minimize those impacts

5.1 SOCIO ECONOMIC IMPACT

Kimley-Horn reviewed socio-economic impacts within the study area pertaining to environmental justice. Data was obtained from the U.S. Census Bureau 2012-2016 American Community Survey 5-Year Estimates. Population demographics to the census block level were obtained. The study area traverses Census Tract 010100 (block groups 1 and 3), Census Tract 030201 (block group 2), Census Tract 030300 (block group 4), and Census Tract 030100 (block group 1). **Table 5-1** and **Table 5-2** summarize the Census Tract's data within the study area.

Table 5-1 – Minority Population Data within the Study Area

Census Tract	Block Group	Total Population	Minority Population	% Minority
010100	BG 1	1397	348	25%
	BG 3	1235	8	1%
030201	2	1337	79	6%
030300	4	2194	36	2%
030100	1	1348	7	1%
EJ evaluation factor equals 1.1 x greater than lowest				1%

Table 5-2 – Census Tract Median Income within Study Area

Census Tract	Median Income
010100	$ 53,616.00
030201	$ 62,431.00
030300	$ 58,398.00
030100	$ 67,615.00
Salem	$ 50,590.00

The minority population of the environmental justice study area does not exceed 50 percent for any of the identified Census Tracts. However, the minority population for Census Tract 010100-1, 030201-2, and 030300-4 exceeds the Environmental Justice (EJ) factor. All Census Tracts exceed the Salem median annual household income of $50,590; therefore, no low-income population is present within the study area.

Based on this data, it is assumed that no adverse impact to identified populations may occur due to the improvements. However, adverse impacts to the identified populations existing within the study area should be further evaluated during the detailed design phase of this project and as part of the development of the required National Environment Protection Act (NEPA) should the project be funded with federal funds.

5.2 THREATENED & ENDANGERED (T&E) SPECIES

Section 7 of the Endangered Species Act (ESA) requires federal agencies to ensure that an undertaking is not likely to jeopardize the continued existence of species that are listed as endangered or threatened.

A review of the Virginia Department of Game and Inland Fisheries (VDGIF) Virginia Fish and Wildlife Information Service (VAFWIS), VDGIF's Northern Long-eared Bat (NLEB) Winter Habitat and Roost Tree Mapper, VDGIF's Little Brown Bat (MYLU) and Tri-colored (PESU) Bat Winter Habitat and Roosts

Application, Virginia Department of Conservation and Recreation's (DCR) VA Natural Heritage Data Explorer (VANHDE), Center for Conservation Biology (CCB) Bald Eagle Nest Locator, and the U.S. Fish and Wildlife Service's (USFWS) Information for Planning and Conservation (IPaC) system was conducted to determine whether known or suspected federal and state listed threatened or endangered (T&E) species, wildlife, or plant resources have been documented within the project corridor limits or a two-mile radius of the project corridor.

A copy of the documentation related to the database researched is contained in **APPENDIX B – THREATENED AND ENDANGERED SPECIES.**

5.2.1 VDGIF

The VDGIF VAFWIS Project Review Report, dated April 22, 2019 did not identify any listed species within the study area or within a two-mile radius of the project area.

VDGIF's NLEB Winter Habitat and Roost Trees Application was reviewed to identify winter habitats within 0.25-mile of the proposed project area or known maternity roosts within 150-feet of the proposed project area (accessed April 22, 2019). No known NLEB winter hibernaculum or maternity roost trees were identified within the study area, referenced ranges, or a 2-mile radius.

VDGIF's MYLU and PESU Winter Habitat and Roosts Application was reviewed to identify little brown bats (MYLU) and tri-colored bats (PESU) hibernaculum within 0.25-mile of the proposed project area and known roost trees within 150-feet of the proposed project area (accessed April 22, 2019). No known MYLU or PESU winter hibernaculum or maternity roosts were identified within the study area, referenced ranges, or 2-mile radius.

5.2.2 DCR

The proposed project area was submitted to DCR through the Virginia Natural Heritage Data Explored (NHDE) to identify natural heritage resources within the vicinity of the project area. Natural heritage resources are defined by DCR as "the habitat of rare, threatened, or endangered plant and animal species, unique or exemplary natural communities, and significant geologic formations." DCR also typically provides comments regarding anticipated negative impacts and recommendations to avoid, minimize or mitigate impacts. DCR has reviewed the project area for potential impacts to natural heritage resources and has offered comments in correspondence received from DCR, dated June 2, 2019.

<u>Global Conservation Status Rank/ State Conservation Status Rank/ Federal Legal Status/ State Legal Status</u>
Global Consevation Status Rank: G1 (Critically imperiled); G2 (Imperiled); G3 (Vulnerable); G4 (Apparently secure); G5 (Secure)
State Conservation Status Rank: S1 (Critically imperiled); S2 (Imperiled); S3 (Vulnerable); S4 (Apparently secure); S5 (Secure)
Federal Legal Status: LE (Listed endangered); LT (Listed threatened); PE (Proposed endangered); PT (Proposed threatened); C (Candidate); SOC (Species of concern); NL (Not listed)
State Legal Status: LE (Listed endangered); LT (Listed threatened); PE (Proposed endangered); PT (Proposed threatened); C (Candidate); NL (Not listed)

- North and South Forks Stream Conservation Unit (SCU) is located downstream from the project area. This SCU has been given a biodiversity ranking of B1 (high significance). SCU's identify stream reaches that contain aquatic natural heritage resources, including 2 miles upstream and 1 mile downstream of documented occurrences, and all tributaries within this reach. The natural heritage resources associated with this site are:

Noturus gilberti	Orangefin madtom	G2/S2/SOC/LT
Percina rex	Roanoke logperch	G1G2/S1S2/LE/LE
Allocapnia simmonsi	Spatulate snowfly	G3/S1S2/NL/NL

The proposed project is situated on karst-forming carbonate rock and can be characterized by sinkholes, caves, disappearing streams, and large springs. If karst features such as sinkholes, caves, disappearing streams, and large springs are encountered during the project, please coordinate with Wil Orndorff (540-230-5960 or wil.orndorff@dcr.virginia.gov) to document and minimize adverse impacts.

The DCR provided the following recommendations based on their search of its Biotics Data System:

- Coordinate with the USFWS and VDGIF on listed species;
- Develop and adhere to strict erosion and sediment control plan;
- Avoidance of karst features; and,
- Coordination with VDCR's Karst Protection Coordinator.

5.2.3 CCB

The CCB Mapper was reviewed for the presence of known bald eagles' nests. No bald eagles were identified within 660-feet of the study area (accessed April 22, 2019).

5.2.4 USFWS

The USFWS Official Species List, dated April 22, 2019, documented the following species that may occur within the vicinity of the proposed project area:

- Northern Long-eared Bat (*Myotis septentrionalis*), federally listed as Threatened – No known NLEB winter hibernaculum or maternity roost trees were identified within the study area or referenced ranges. Although this species was identified as potentially occurring within the study area, no known NLEB winter hibernaculum or maternity roost trees were identified within the proposed study area, referenced ranges, or a 2-mile radius of the project area on VDGIF's NLEB Winter Habitat and Roost Trees Application.
- Indiana Bat (*Myotis sodalis*), federally listed as Endangered – There is final critical habitat for this species. The project corridor is located outside of the critical habitat. Indiana Bats hibernate primiarily in caves or mines. Maternity sites generally are behind loose bark of trees or in tree cavities. Maternity roost and winter hibernacula likely not present. Summer habitat potentially present.
- Roanoke Logperch (*Percina rex*), federally listed as Endangered – No critical habitat has been designated for this species. The logperch typically inhabits medium to large, clear streams and small rivers of moderate to low gradient. Adults are found primarily in pools, while young are found in slow runs and pools with clean, sandy bottoms. Habitat potentially present within project area.

Based on the review of the potential time of year restrictions (TOYR) for both terrestrial and aquatic species, there may be an affect to the construction schedule due to the following:

- **Aquatic Species** – Mason's Creek provides potential habitat for the endangered Roanoke logperch. If proposed outfalls into Mason's Creek result in impacts below ordinary high water then a time-of-year restriction for all in-stream construction activities from March 15 to June 30 of any year may potentially be applicable.
- **Terrestrial Species** – The project is located within the range of the endangered Indiana Bat and threatened Northern Long-eared Bat, which can result in time-of-year restriction and compensation requirements for tree cutting. Several options exist for managing the bat considerations, to include:
    - Perform a survey for bats to verify the presence or absence of threatened or endangered (T&E) bats. The survey window for presence/absence is May 15 - August 15 each year. If T&E bats are determined to not be present then there will be no tree removal time-of-year restriction or compensation requirements. If T&E bats are determined to be present then a time-of-year restriction for tree removal from April 15 - September 15 and compensation for tree removal greater than 100 feet from the edge of existing roadway will be applicable.
    - If no bat survey is performed and it, therefore, must be assumed that T&E bats are present, then T&E bats are assumed to be present and a time-of-year restriction for tree removal from April 15-September 15 and compensation for tree removal greater than 100 feet from the edge of existing roadway will be applicable.

If a time-of-year restriction is determined to be required, then the Environmental Section will need to provide a related Special Provision to include in the contract services.

5.3 WETLANDS AND SURFACE WATERS

Topographic and National Wetland Inventory (NWI) mapping, aerial photography, and the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) soil survey data were reviewed to identify potential wetland and stream areas within and adjacent to the study area. The U.S. Geological Survey (USGS) Salem, Virginia 7.5 Minute Quadrangle maps show the site area as ranging in elevation between approximately 1,100 to 1,300 feet above the National Geodetic Vertical Datum of 1929. The USGS 1:24,000 scale topographic map for Salem, as well as the National Hydrography Dataset from the USGS were reviewed to identify surface waters within and adjacent to the study area. The referenced mapping is provided in **APPENDIX A - FIGURES.**

Likely stream and wetland features are represented within described below.

- Mason Creek and associated tributaries were identified within portions of and bisecting the proposed project area at the overpass crossing of Route 630 (Kessler Mill Road), and running along the north side I-81, parallel to the study area.
- Peters Creek bisects the northeast boundary of the study area.
- A palustrine, unconsolidated bottom, permanently flooded, and diked/impounded (PUBHh) wetland system was identified north of I-81 and west of Route 630 (Kessler Mill Road). The NWI map shows tributaries of Mason Creek feeding into the wetland system.

A field delineation in accordance with the U.S. Army Corps of Engineers (USACE) *Wetland Delineation Manual* (1987) and applicable Regional Supplement has not been conducted. Additional wetlands and Waters of the U.S. may be present within the study area.

Encroachment within some of the wetland and WOUS features identified is proposed in the conceptual design; therefore, additional coordination with the USACE to determine jurisdictional status of these features should be conducted during detailed design. Following a formal delineation of wetland and WOUS systems within the study area, efforts to avoid and minimize impacts to these features to the maximum extent practicable should be incorporated into the detailed design.

Tidal and non-tidal wetlands and WOUS are subject to the jurisdiction of the USACE and the Virginia Department of Environmental Quality (VDEQ). Subaqueous lands, tidal waters, and waters within a contributing drainage area greater than five square miles are subject to the jurisdiction of the Virginia Marine Resource Commission (VMRC). Permit types and the level of coordination will be determined based on the amount of impact to these jurisdictional areas. Permit issuance is subject to the level of effort during the design to first avoid, and then minimize impacts to jurisdictional areas.

5.4 FLOODPLAIN REVIEW

The Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRM) for Roanoke County and City of Salem, Virginia, were downloaded on April 24, 2019. The study area is depicted on Community Panel 51161C0133G. According to the FEMA Firm map, the majority of the project area is depicted as unshaded Zone X, or areas of minimal flood hazard, determined to be outside the 0.2 % annual chance floodplain. The portion of the project crossing Mason Creek and Peters Creek, southwest of Exit 141, is depicted as shaded Zone AE, special flood hazard areas without base flood elevations and subject to the 0.2% annual chance flood hazard, as well as areas of 1% annual chance flood with average depth less than one foot or within drainage areas of less than one square mile. A copy of the FEMA FIRM map is included in **APPENDIX D – FEMA FIRM MAP**.

5.5 CULTURAL AND HISTORIC RESOURCES

The Virginia Department of Historic Resources' (VDHR) Cultural Resources Information System (V-CRIS) was used to identify potentially eligible architectural or archaeological sites located within or near the project area. Under Federal law, a historic property is any district, site, building, structure, or object that is listed in or eligible for listing in the National Register of Historic Places (NRHP). To be eligible for listing, sites must meet at least one of the National Register Criteria for Evaluation, which involves examining the age, integrity, and significance of the site. Historic sites that are eligible for listing or listed on the NRHP and archaeological sites that are eligible for listing or listed on the NRHP and recommended for preservation in place are also protected under Section 4(f). Section 4(f) is further discussed in Section 5.6.

Six (6) architectural resources were identified within and immediately adjacent to the proposed project area. Additionally, six (6) archaeological resources were identified adjacent to the study area. **Table 5-3** below presents a summary of the architectural and archaeological resources and their eligibility status as identified in the V-CRIS database. The sites are shown on **Figure 4** in **APPENDIX A - FIGURES**.

Table 5-3 – Summary of Resources Identified within the Study Area

VDHR #	Resource Name	Address or Site Characteristic	Eligibility or Status
Architectural Resources			
080-5109	House, 1468 Deborah Lane (Function/Location)		Not Evaluated
080-5108	House, 1516 Deborah Lane (Function/Location)		Not Evaluated
080-0005	Farm, 1745 Loch Haven Drive (Function/Location); Brubaker House (Historic); Huffman Place (Historic)		This primary resource is no longer extant.
080-5598	Bridge, Electric Road (Function/Location)		DHR Staff: Not Eligible
080-5103	House, 3627 Green Ridge Road (Function/Location)		DHR Staff: Not Eligible
129-5137	House, 150 Freedman Lane (Function/Location)		DHR Staff: Not Eligible
Archaeological Resources			
44RN0328	Terrestrial, open air; historic domestic site		DHR Staff: Not Eligible
44RN0329	Terrestrial, open air; historic domestic site		DHR Staff: Not Eligible
44RN0334	Terrestrial, open air; pre-historic lithic reduction site		DHR Staff: Not Eligible
44RN0335	Terrestrial, open air; historic domestic site		DHR Staff: Not Eligible
44RN0336	Terrestrial, open air; historic domestic site		DHR Staff: Not Eligible
44RN0386	Dooley-Blankship Cemetery (#080-5141)	Burials relocated	DHR Staff: Not Eligible

A Phase I Cultural Resources Survey may be required within the determined Area of Potential (APE) to identify, evaluate, and determine the eligibility of historic resources. Further assessment of the project's effects to historic properties and coordination with VDHR will then be necessary for concurrence on an effect determination. If adverse effects are identified, then additional consultation including evaluation of avoidance, minimization, and mitigation of impacts would be required.

5.6 SECTION 4(f) & Section 6(f)

5.6.1 SECTION 4(f)

Section 4(f) of the Department of Transportation Act of 1966 stipulates that federal agencies cannot approve the use of land from publicly owned parks, recreation areas, wildlife and waterfowl refuges, or historic sites unless there is no prudent and feasible alternative to using that land, and the program or project includes all possible planning to minimize harm to the Section 4(f) resource. A "use" of a Section 4(f) property includes any acquisition of right-of-way or a permanent easement, temporary occupancy, or constructive use. The City of Salem GIS data, Virginia Department of Game and Inland Fisheries (DGIF) GIS data, the Virginia Department of Conservation and Recreation (DCR) GIS data, Virginia Outdoors Foundation (VOF) GIS data, U.S. Department of Agriculture (USDA) Forest Service GIS data, and the National Park Service (NPS) GIS data were reviewed to identify park and recreational facilities within the study area.

No local, state, or national parks, recreational facilities or wildlife and waterfowl refuges that are protected under Section 4(f) were identified within the study area.

Potential historic resources identified within the project area are described in Section 5.5. Depending upon the impacts to historic resources and the effect determination, additional coordination regarding Section 4(f) as it pertains to historic resources may be required.

5.6.1 SECTION 6(f)

The Land and Water Conservation Fund Act (LWCFA) of 1965 (16 USC 4601-4 et seq.) established a funding source to assist state and federal agencies in the acquisition and development of public outdoor recreational areas and facilities. Section 6(f) of the LWCFA requires that all properties "acquired or developed, either partially or wholly, with LWCF funds" must be maintained as such in perpetuity.

The Detailed Listing of Grants identified in Salem, Virginia, prepared by the National Park Service (NPS) Land and Water Conservation Fund Program are listed below in **Table 5-4**:

Table 5-4 – Summary of Land and Water Conservation Fund Projects

County/City	Grant ID	Grant Title	Grant Sponsor	Fiscal Year	Amount
Salem	82	Longwood Park	City of Salem	1972	$101,595.04

Based on GIS mapping, this site is not located within the study area. Therefore, no conversion of Section 6(f) properties is anticipated.

5.6 NOISE

The Tier II EA for the segment of I-81 included within the study area included a review of the study limits to evaluate the risk of the improvements requiring noise walls. Based on a review of the preliminary noise analysis and study contained with the Tier II EA, it is not recommended to carry any cost or risk for noise barriers within the study limits. It should be noted that should the improvement project associated with the I-81 Corridor Improvement Plan advance and design of the improvements between Exit 140 and Exit 141 be combined with improvements south of Exit 140, a significant amount of noise barriers may be required. For further information see the Tier II EA, as developed by others.

5.7 HAZARDOUS MATERIALS

The Virginia Department of Environmental Quality's (VDEQ) GIS datasets and Virginia Environmental Geographic Information Systems (VEGIS) were reviewed (accessed April 22, 2019) for known petroleum releases, tank facilities, and Voluntary Remediation Program (VRP) sites within the project area.

The study area is developed with a mix of residential and commercial uses. Commercial land uses consist of retail, restaurants, gas stations, and hotels. Based on a review of the VDEQ GIS data, petroleum release sites and registered tank facilities were identified within the project area. No VRP sites were identified within the project area. Specifically, two (2) petroleum releases and one (1) registered tank facilities were identified within the project area or immediately adjacent to the project area. Table 1.5 provides a summary of the petroleum releases and registered tank facilities within the project area. All features listed within **Table 5-5** and are depicted on **Figure 5** in **APPENDIX A - FIGURES**.

Table 5-5 – Summary of Petroleum Releases and Registered Tank Facilities

Registered Tank Facilities								
Facility Name	**Facility Address**	**Facility ID**	**Facility Type**	**Facility Active**	**Active UST**	**Inactive UST**	**Active AST**	**Inactive AST**
General Services/ Public Service Center	1216 Kessler Mill Road	2021598	Local	Y	Y – 3	Y – 3	N – 0	N - 0

Petroleum Releases						
Facility Name	**Facility Address**	**PC Number**	**Case Status**	**Release Status**	**Release Reported Date**	**Date Case Closed**
I-81 MM 140.8 NB Truck Wreck	MM 140 I-81 NB	20192150	Closed	Confirmed	2/06/2019	3/18/2019
Public Service Center	1216 Kessler Mill Road	20142041	Closed	Confirmed	7/02/2013	4/07/2014

A detailed review to assess and identify the potential for the selected contractor to encounter contamination during construction within the study area should be conducted during detailed design. In addition, if right-of-way acquisition will be required for the proposed project, a Phase I Environmental Site Assessment (ESA), conducted in accordance with the American Society of Testing and Materials (ASTM) Standard 1527-13, may be required.

6 ROADWAY DESIGN

6.1 FUNCTIONAL CLASSIFICATION

VDOT functionally classifies I-81 within the study area as an Urban Principal Arterial - Interstate with a VDOT Geometric Design Standard of GS-INT. A limited access interstate facility, I-81's original design included independently graded northbound and southbound alignments with a variable width graded median.

6.2 DESIGN CRITERIA

Conceptual roadway design was performed in accordance with the 2016 edition of the *VDOT Road and Bridge Standards*, the 2016 edition of the *VDOT Road and Bridge Specifications*, the 2018 edition of the *VDOT Road Design Manual,* the current edition of *the VDOT Drainage Manual*, the 2011 edition of the *AASHTO Green Book*, 2011 edition of the *Virginia Supplement to the 2009 Manual on Uniform Traffic Control Devices* (MUTCD), 2011 edition of the *Virginia Work Area Protection Manual* (VWAPM), and current edition of *AASHTO's A Policy on Design Standards---Interstate System*.

6.3 EXISTING CONDITIONS

VDOT provided topographic survey, including Digital Terrain Model through Anderson & Associates, Inc. under separate contract, to document the existing conditions in February 2018. Survey included a combination of aerial photogrammetry and field survey. It is understood that elevations were based on high elevation aerial photogrammetry, which means hard surface elevations are likely only accurate within six inches (6"). Survey limits covered the study area limits described above in **Section 3.2**.

Horizontal datum for this survey was NAD 83 while the vertical datum was based on NAVD 88. The topographic survey file included existing edge of pavement lines, existing guardrail locations, existing drainage structures and pipe locations, existing right-of-way (without parcel delineation or property owner information), existing bridge locations, existing sign locations, existing fence locations, survey control line, and other miscellaneous information necessary to conduct the study. Other information provided by VDOT included ortho-imagery and Digital Terrain Model. Further, VDOT, Roanoke County, City of Roanoke and City of Salem provided general information in the form of Geographic Information Systems (GIS) data including property lines, topography, wetlands, streams and aerial photos.

Kimley-Horn reviewed existing geometric conditions within study area to identify areas that do not meet current geometric standards. The standards used for this assessment included:

- *VDOT Road Design Manual* (VDOT, 2018)
- *A Policy on Geometric Design of Highways and Streets (or AASHTO Green Book), 6th Edition, American Association of State Highway and Transportation Officials* (AASHTO), 2011
- *A Policy on Design Standards Interstate System*, American Association of State Highway and Transportation Officials (AASHTO), 2005.

A review of the study area and nearby site features indicated the presence of two airports within a 5-mile radius of the proposed project limits. The two airports identified are the Roanoke-Blacksburg Regional Airport (public use) located three nautical miles northwest of Roanoke, and Trussmark Airport (privately owned) located zero nautical miles southwest of Salem. Due to the proximity of the public use airport to the project limits, additional coordination will be required between VDOT, FHWA, and FAA per Appendix A of the VDOT Road Design Manual during subsequent design stages.

6.3.1 Design Speed and Posted Speed

Kimley-Horn observed that the posted speed along I-81 within the study area was 60 mph. The *VDOT Road Design Manual* identified the selection of a roadway's design speed as essential to project development. Kimley-Horn and VDOT staff reviewed the project corridor, the existing constraints, the nature and character of the study area to determine the recommended design speed for I-81. It is noted that current published AASHTO guidance for an urban interstate with straight geometry and well-spaced interchange locations recommended a desirable minimum design speed of 70 miles per hour (mph). Further, the *VDOT Road Design Manual* required the design speed of an interstate facility to be a minimum of 5 mph higher than the posted speed. It is also noted that VDOT designated I-81 between MM 127 and MM 142 as a "Highway Safety Corridor" due to higher than expected crash rates, crash severity, excessive speeding and heavy truck traffic (See **Figure 6-1**). Based on a review of existing conditions, AASHTO and VDOT guidance, the I-81 Highway Safety Corridor and a practice of engineering judgement, a design speed of 65 mph is recommended for the study area.

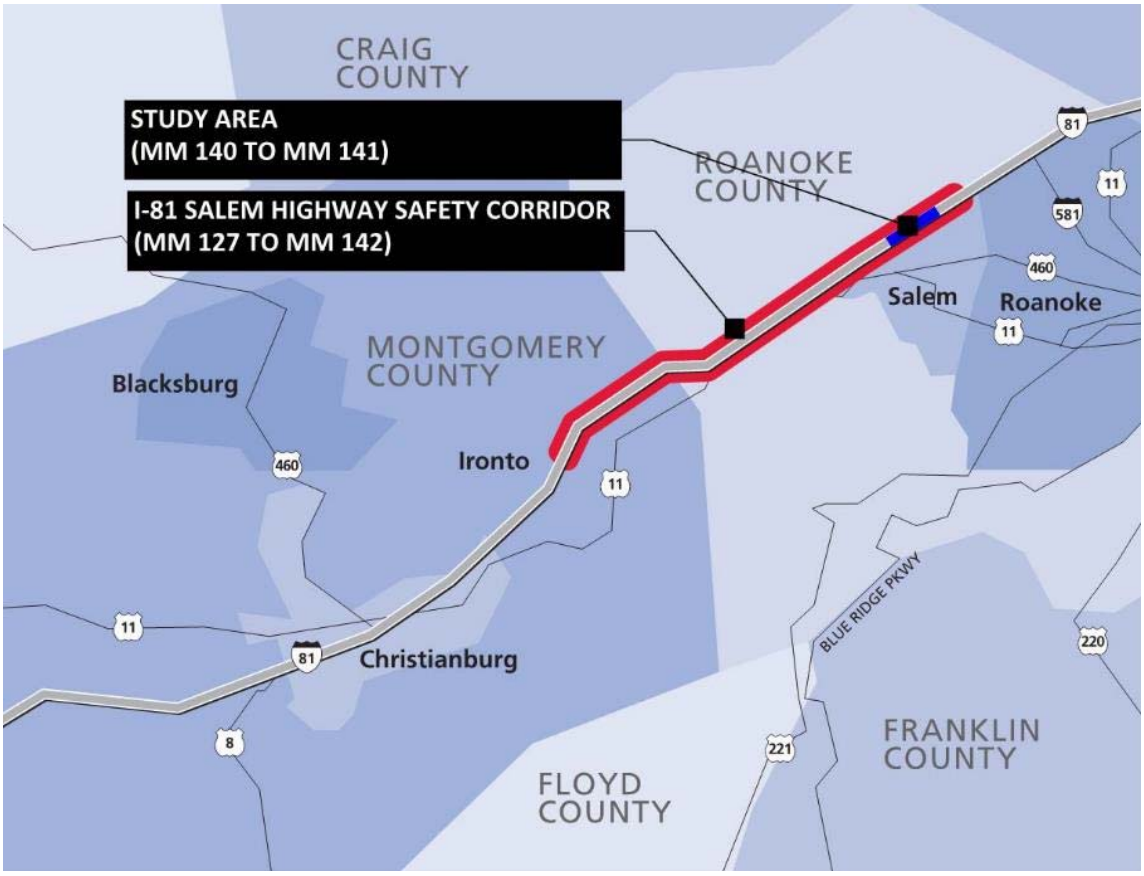

Figure 6-1 – I-81 Salem Highway Safety Corridor

6.3.2 Interchanges

The study area included the Exit 140 partial cloverleaf interchange with Route 311 (Thompson Memorial Drive) to the south and the Exit 141 partial cloverleaf interchange with Route 419 (N. Electric Road) to the north.

6.3.2.1 Interchange Spacing

Per the AASHTO Green Book, the general guidance for minimum interchange spacing is one mile for urban freeways. FHWA's Tech brief "Safety Assessment of Interchange Spacing on Urban Freeways" (Publication Number FHWA-HRT-07-031), defines interchange spacing as the distance between interchange crossroads as shown in **Figure 6-2**.

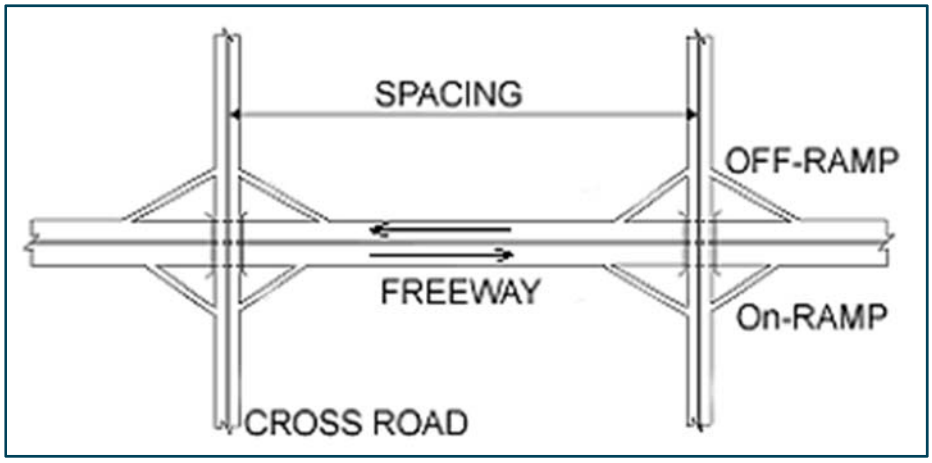

Figure 6-2 – Interchange Spacing Measurement

Source: FHWA Techbrief "Safety Assessment of Interchange Spacing on Urban Freeways" (Publication Number: FHWA-HRT-07-031)

Existing interchange spacing between interchanges within the study area is approximately 1.3 miles. The study corridor exceeds AASHTO's one-mile interchange spacing criterion between all interchanges in the study area in both the northbound and southbound travel directions.

6.3.2.2 Acceleration/Deceleration Lane Lengths

Ramp lengths and grades were obtained from roadway design plans, where available. Ramp grades not provided on roadway design plans were estimated based on field survey. The ramp speed, ramp grade, existing lane length, AASHTO standard lane length (based on the *2011 AASHTO Green Book),* and deficient length are shown for each of the acceleration and deceleration lanes in the study corridor in **Table 6-1**. Acceleration and deceleration lanes that do not meet the AASHTO standard are denoted as deficient. One of the four acceleration lane lengths are deficient, while two of the four deceleration lanes are deficient. It is noted that the acceleration lane length deficiency is not located within the limits of proposed improvements as shown on the conceptual plans. This deficiency should be evaluated/addressed should improvements be included south of Exit 140 in the future. The deficiencies with the deceleration lane lengths are all proposed to be corrected by a combination of the improvements shown on the conceptual plans and the adjacent project between Exit 141 and Exit 143 (UPC 108906.)

Table 6-1 – Acceleration/Deceleration Lane Lengths

Ramp	Design Speed (MPH)	Grade (%)	Length (feet)	Standard Length (feet)	Deficient Length (Feet)
Acceleration lanes					
Entrance ramp from Route 311 to I-81 NB	45	-4	1000	624	-
Entrance ramp from Route 311 to I-81SB	45	4	780	1768	988
Entrance ramp from Route 419 to I-81 NB	45	2	1429	1040	-
Entrance ramp from Route 419 to I-81 SB	45	-4	1614	624	-
Deceleration lanes					
Exit ramp from I-81 NB to Route 311	45	-4	500	528	28
Exit ramp from I-81 SB to Route 311	25	4	950	540	-
Exit ramp from I-81 NB to Route 419	25	4	580	540	-
Exit ramp from I-81 SB to Route 419	45	-4	1290	1896	606

6.3.3 Lane and Shoulder Widths

As-built plans indicated two 12-foot lanes with a 3-foot paved shoulder on the left and a minimum of 10-foot paved shoulder on the right for mainline northbound I-81. Survey information generally indicated two 12-foot lanes, a 3- to 4-foot paved shoulder width on the left, and a 10- to 12-foot paved shoulder on the right.

Appendix A of the *VDOT Road Design Manual* requires a minimum of 12 feet of total shoulder with a minimum of 4 feet of paved shoulder on the left and 12 feet of total shoulder with a minimum of 10' paved on the right when the mainline is two lanes in each direction. Truck traffic comprised almost one-fifth of the total traffic volume within the study area. The existence or nonexistence of a wide shoulder on which to move disabled vehicles (especially a large tractor trailer) can prevent or cause a lane to be closed. As evidenced by incident management events within the study area (as relayed by VDOT), a closure of one or both travel lanes can cause severe congestion and safety issues. A summary of paved shoulder widths is presented in **Table 6-2** below.

Table 6-2 – Existing Shoulder Width

Lane and Project Width	Percentage of Total Project Length
NB Outside Paved Shoulder (<10')	8%
NB Outside Paved Shoulder (>10')	92%
NB Inside Paved Shoulder (<4')	51%
NB Inside Paved Shoulder (>4')	49%
SB Outside Paved Shoulder (<10')	9%
SB Outside Paved Shoulder (>10')	92%
SB Inside Paved Shoulder (<4')	11%
SB Inside Paved Shoulder (>4')	89%

6.3.4 Geometric Deficiencies

Overall review of the existing geometry in the study area indicated several deficiencies associated with mainline geometric elements that do not meet current AASHTO and/or VDOT standards. Correcting existing substandard geometric deficiencies may impact grading to the outside of I-81 where the existing shoulders are not currently being impacted, which will impact steep rock cut slopes significantly increasing the excavation quantities and right-of-way impacts. Existing substandard geometric deficiencies consist of possible substandard paved shoulder widths, superelevation rates less than AASHTO minimums and tangent cross slopes less than 1% and greater than 3%.

Kimley-Horn conducted a feasibility study for the widening south of Exit 140 towards Exit 137 with focus on the existing I-81 bridges over Route 311 at Exit 140. The results of this feasibility study showed that proposed future inside shoulder width along I-81 in both directions will be substandard across the bridges over Route 311 at Exit 140. Correcting the substandard shoulder widths would require widening to both sides of both existing bridges over Route 311 with impacts the adjacent ramp gores.

These geometric deficiencies should be further studied during detailed design and shall be documented and approved by design waivers and/or design exceptions if not corrected. A summary of potential design waivers and design exceptions that may be required for this project can be found in **Section 6.8.**

6.4 DESIGN ALTERNATIVES ANALYSIS

6.4.1 Design Alternatives Considered

Two alternatives were developed to construct a continuous auxiliary lane along northbound and southbound I-81 between Exit 140 and Exit 141. VDOT provided a concept that would allow for connection of the auxiliary lanes through Exit 141 for all alternatives. This concept would provide continuous auxiliary lanes along northbound and southbound I-81 between Exit 140 and Exit 143. Kimley-Horn evaluated separate concepts for geometry that would allow and not preclude future extension of the auxiliary lanes south of Exit 140.

- Alternative 1: Widen Outside
  - Widen northbound and southbound I-81 to the outside from Exit 140 to south of the previously widened section of I-81 near the Mason's Creek bridge.
  - Maintain existing Mason's Creek bridge and rehabilitate pavement as necessary.

  - Widen I-81 northbound and southbound to the outside from north of the previously widened section of I-81 near the Mason's Creek bridge to south of Exit 141.
  - Shift from outside to inside widening northbound and southbound I-81 south of Exit 141.
  - Widen I-81 northbound and southbound to the inside (median) south of Exit 141 by constructing a graded median and/or proposed bifurcated concrete median barrier.
  - Re-align the existing entrance ramp Route 419 to northbound I-81 and connect to the northbound auxiliary lane to be constructed as part of UPC 108906. It was assumed that the re-alignment of this ramp would be constructed as part of UPC 108906, and this project would only have to re-stripe the pavement to allow for the connection of the auxiliary lane.
  - Connect to the southbound auxiliary lane to be constructed as part of UPC 108906.

- Alternative 2: Widen Inside

  - Widen northbound and southbound I-81 to the inside (median) by constructing a proposed bifurcated concrete median barrier from Exit 140 to south of the previously widened section of I-81 near the Mason's Creek bridge.
  - Shift from the existing outside widening of the previously widened section of I-81 south of the Mason's Creek bridge to inside widening constructing a graded median.
  - Maintain existing Mason's Creek bridge and rehabilitate pavement as necessary.
  - Widen I-81 northbound and southbound to the outside from north of the previously widened section of I-81 near the Mason's Creek bridge to south of Exit 141.
  - Shift from outside to inside widening of northbound and southbound I-81 south of Exit 141.
  - Widen northbound and southbound I-81 to the inside (median) south of Exit 141 by constructing a graded median and/or proposed bifurcated concrete median barrier.
  - Re-align the existing entrance ramp Route 419 to I-81 northbound and connect to the northbound auxiliary lane to be constructed as part of UPC 108906. It was assumed that the re-alignment of this ramp would be constructed as part of UPC 108906, and this project would only have to re-stripe the pavement to allow for the connection of the auxiliary lane.
  - Connect to the southbound auxiliary lane to be constructed as part of UPC 108906.

Conceptual diagrams for each design alternative are provided in **APPENDIX G – DESIGN ALTERNATIVES.**

6.4.2 Evaluation of Design Alternatives

Kimley-Horn and VDOT informally evaluated the alternatives at two meetings held on January 16, 2018 and January 30, 2018. The alternatives were screened by examining each regarding right-of-way impacts, constructability issues, and approximate cost of construction. Right-of-way (ROW) impacts were evaluated based on conceptual sketches of each alternative and the associated impacts to property adjacent to the improvements. Constructability was assessed for each alternative based on considerations regarding phasing of construction and the relative difficulty of maintaining traffic during construction of the alternative. Lastly, each alternative was screened to verify the feasibility of connecting either alternative to the northbound and southbound auxiliary lanes being designed under UPC 108906 between Exit 141 and Exit 143 and future extension of the auxiliary lanes south of Exit 140.

Right-Of-Way Impacts

The right-of-way impacts associated with Alternative 1 were more impactful than those identified for Alternative 2. The outside widening south of Mason's Creek in both the northbound and southbound directions significantly impacted the rock slopes adjacent to the roadway. The impacts to the rock slopes would extend the cut limits to the top of the existing slopes and in some cases outside the limits of existing right-of-way. The proximity of these impacts to the existing right-of-way would require fee simple right-of-way and temporary construction easements. The limits of proposed rock slopes extending out would also necessitate adjustments to the existing limited access lines and relocation of adjacent roadways.

The inside widening associated with Alternative 2 avoids improvements to the outside reducing any impacts affecting the rock slopes. Conceptual designs showed two separate storm water management facilities with one having a significant right-of-way impact. Preliminary design calculations eliminated the need for the second storm water management feature that was outside the existing right-of-way further reducing the impacts of Alternative 2.

Constructibility

The widening associated with Alternative 1 south of Mason's Creek Bridge maintains the existing crown line for both northbound and southbound alignments and widens the additional lane to the outside. Maintaining the crown line in its current location avoids constructing a leveling course prior to paving the final surface course simplifying the maintenance of traffic. If no improvements are anticipated to the inside when widening to the outside, VDOT stated that the existing widths would not be impacted. Widening to the outside impacts existing rock slopes increasing the complexity of excavation operations adjacent to the interstate and local roadways. Both alternatives require an initial narrow 4' wide deep mill operation at the edge of the through lanes on the widening side to facilitate the use of concrete median barrier during construction operations. The use of the deep mill operation(s) allows for adequate travel lane widths and room for installing the proposed pavement section beneath traffic barrier service concrete.

Alternative 2 south of Mason's Creek and the area north of Mason's Creek required shifting traffic across the existing crown line to reduce impacts to the existing rock slopes. Although this alternative required additional paving techniques and details to shift the crown line, the impacts to the outside are reduced with most of the improvements in the median. Access to the work area within the median during construction required a temporary lane shift to allow access from the existing Mason's Creek Bridge to either side.

Construction Cost

An alternative matrix was used to evaluate major design related items such as right-of-way impacts, impacts to existing signage, earthwork volumes, new mainline pavement and paved shoulder areas, mill and overlay areas, and miscellaneous items like guardrail and median barrier to help determine an order of magnitude construction cost associated with each alternative. The earthwork volumes associated with Alternative 1 were approximately double those of Alternative 2 for the northbound alignment. The southbound alignment significantly reduced the excavation making the inside alternative more cost effective. The new pavement areas were higher with Alternative 2 but showed a reduction in the mill and overlay quantity. During the alternative's analysis process, VDOT stated that the double-faced

guardrail along the southbound alignment should be removed and that all guardrail within the corridor shall be upgraded to meet current guardrail standards. Therefore, any guardrail savings recognized by either alternative was not considered when evaluating the alternatives.

Feasibility of Auxiliary Lanes Extension South Of Exit 140

During the design alternatives analysis, the existing I-81 bridges over Route 311 (Thompson Memorial Drive) at Exit 140 were evaluated to determine the feasibility of extending the auxiliary lanes south from Exit 140 to Exit 137. Alternative 1's widening to the outside would directly impact both the northbound and southbound exit and entrance ramp tie in points and necessitate significant improvements and/or reconfigurations to the existing interchange. Alternative 2's widening to the inside would not impact the northbound and southbound entrance ramp tie in points and allow for widening through the interchange with no significant geometric improvements.

EXISTING I-81 NORTHBOUND AND I-81 SOUTHBOUND BRIDGES OVER ROUTE 311

The existing northbound I-81 bridge is 3' lower than the existing I-81 southbound bridge and consists of a 7' inside shoulder, 2-12' travel lanes and a 12' outside shoulder. The existing I-81 southbound bridge consists of a 7' inside shoulder, 2-12' travel lanes, a 12' auxiliary lane and a 12' outside shoulder. The distance between the two bridges is approximately 26' 7" from out to out. VDOT stated the crown line across the bridge could not change; therefore, all widening would need occur to the inside to avoid impacts to the adjacent interchange ramps. The inside shoulder width will be reduced to 6' for the proposed widened bridge and will require a design exception. The current VDOT State Bridge Engineer expressed conditional support for this design exception, which will need to be applied for and approved during detailed design.

The existing bridge plans show that the existing median and bridge abutments were constructed on a pile supported foundation. Kimley-Horn presented two options demonstrating constructible methods for modifying the existing retaining wall to a bridge seat for the additional beams needed for widening the existing structures. The two options are depicted below in **Figure 6-3** and **Figure 6-4** below.

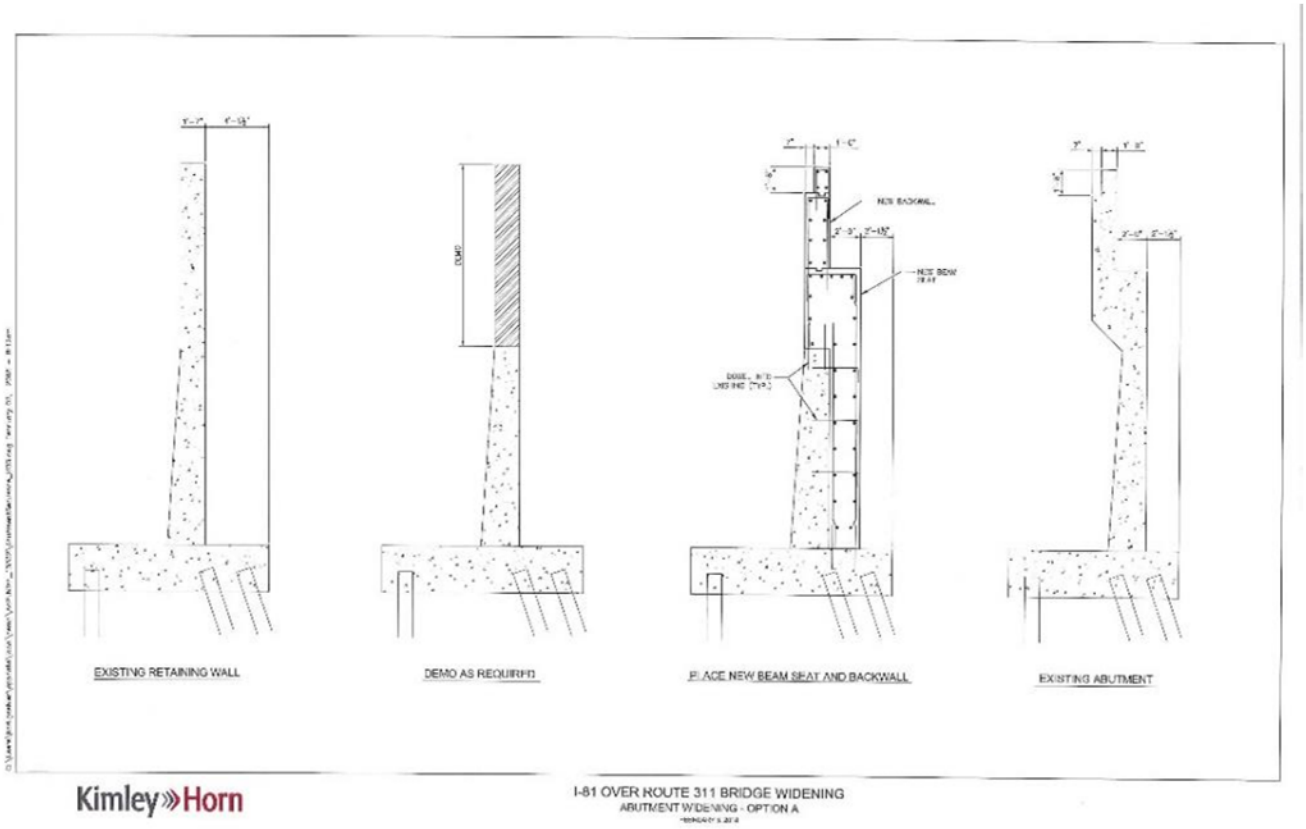

Figure 6-3 – I-81 bridges over Route 311 Abutment Widening Option A

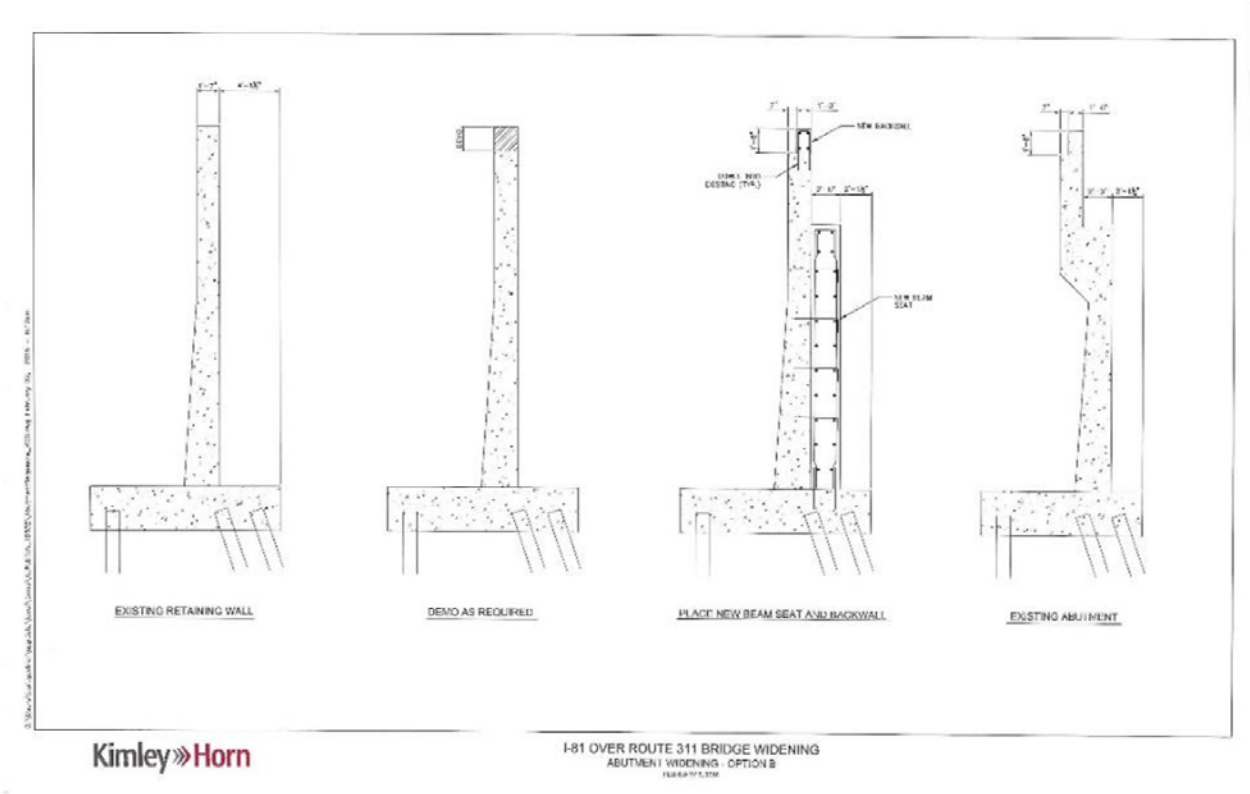

Figure 6-4 – I-81 bridges over Route 311 Abutment Widening Option A

During detailed design of widening south of Exit 140, the existing conditions should be confirmed with the existing bridge plans prior to moving forward with one of the design options. The details shown on the existing plans appear to allow for simplified construction methods using the design options presented above. VDOT referenced that the Route 311 bridges are due for routine maintenance and conditioning; however, no timeframe was known. It is recommended to request an updated bridge inspection report prior to final design and incorporating routine maintenance and conditioning repairs to the plans.

6.4.3 Preferred Design Alternative

The primary factor in selecting Alternative 2 as the preferred design alternative was the reduced impacts to the rock slopes and the ease of connecting future widening south of Exit 140. Alternative 2 eliminates impacts to the Exit 140 interchange and utilizes the existing bridge design for proposed widening to the median. It is noted that Alternative 1 and 2 were essentially the same north of Mason's Creek; therefore, the I-81 bridges over Route 311 construction and right-of-way impacts were the main factors when selecting the preferred design alternative. Conceptual design plans depicting the preferred design alternative are in **APPENDIX H – CONCEPT PLANS.**

6.5 PROPOSED GEOMETRY

Conceptual design plans for the auxiliary lanes were developed for the preferred alternative. Design criteria and guidance from those documents identified above in Section 6.1 were applied to both northbound and southbound I-81 based on functional classification and roadway design speed. The proposed design assumes a WB-67 as the design vehicle. For the purposes of this study, it was assumed that there would be no impacts to the existing bridge structure carrying northbound and southbound I-81 over Mason's Creek.

6.5.1 Typical Sections

The preferred alternative consisted of widening northbound and southbound I-81 from two lanes in each direction to three lanes in each direction by construction of a continuous auxiliary lane in the northbound and southbound directions. At Exit 140, the auxiliary lanes will begin or end at the on ramp(s) from Route 319. However, widening will continue to the median from just north of the existing northbound and southbound I-81 bridges over Route 319 to facilitate future widening south of Exit 140. At Exit 141, the auxiliary lanes will be constructed by widening to the median and connect through Exit 141 and tie to the auxiliary lanes in the northbound and southbound directions as constructed by UPC 108906.

Based on a review of constraints within the study area and as-built plans, VDOT concurred with the selection of 8' paved shoulders and 11' total shoulders for the inside shoulders along northbound and southbound I-81. The total shoulder width and paved shoulder will reduce to approximately 7' width to facilitate passage of the auxiliary lanes beneath the existing Route 419 overpass at Exit 141. The proposed typical sections for I-81 within the study are shown below in **Figure 6-5** and **Figure 6-6**.

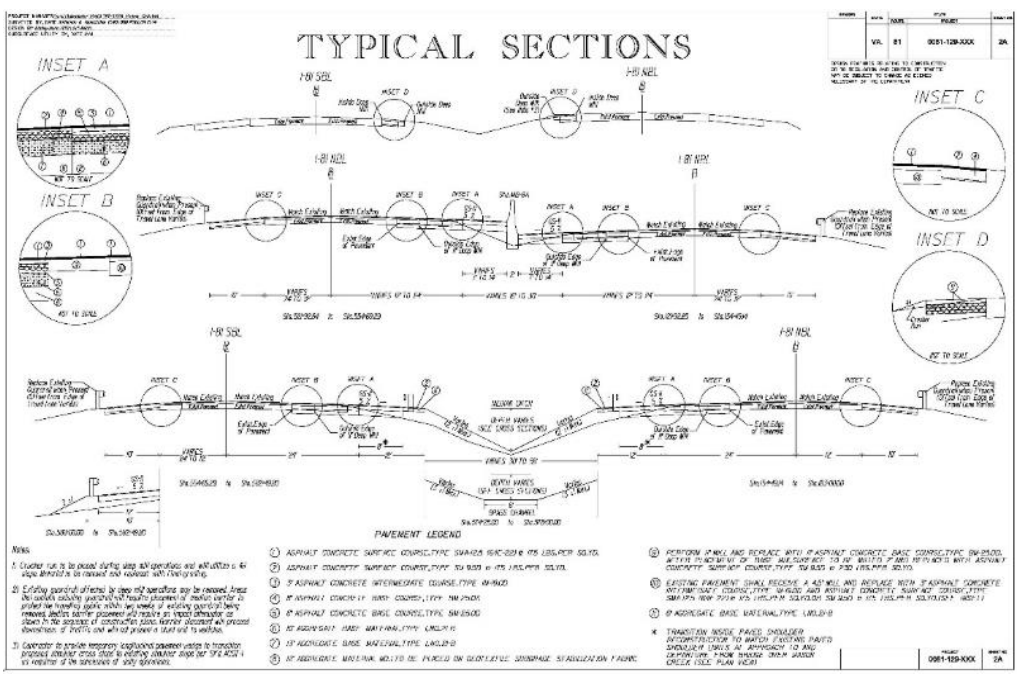

Figure 6-5 – Proposed I-81 Typical Sections

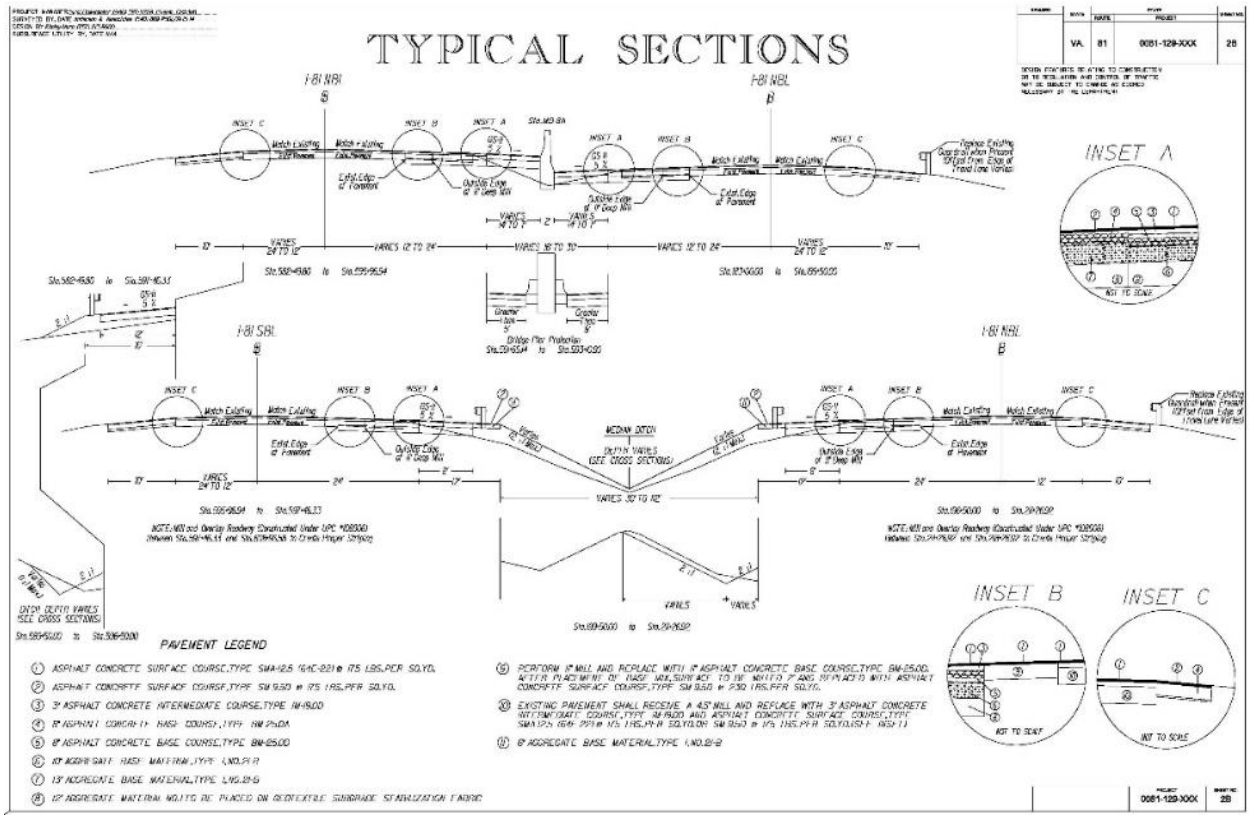

Figure 6-6 – Proposed I-81 Typical Sections

6.5.2 Horizontal Alignment

Horizontal geometry for the proposed improvements consist of adding a 12-foot auxiliary lane from the Exit 140 interchange with Route 311 (Thompson Memorial Drive) through the Exit 141 interchange with Route 419 (N. Electric Road) tying into the improvements associated with UPC 108906 extending the auxiliary lane to the southern facing ramps at the Interstate 581 interchange at Exit 143. Widening from Exit 140 to Mason Creek is predominantly to the median and accounts for pavement needed should widening be extended south of Exit 140 in the future by paving a full 12-foot travel lane and minimum 7-foot paved shoulder with a proposed concrete median barrier. Should the improvements be constructed as depicted in the conceptual plans (i.e. no widening south of Exit 140) the paved shoulder in the median will appear wider than required to not preclude future widening south of Exit 140 and requiring costly adjustments to storm sewer layout and barrier between northbound and southbound I-81. Existing shoulder pavement on the outside will be overlaid. In addition, surface course is extended underneath and beyond the guardrail per VDOT Standard MC-4. The minimum inside paved shoulder width is 7 feet and transitions between 8 feet and 14 feet throughout the project limits. This results in ultimate cross-section consisting of 7 to 8 feet inside shoulder, three 12 feet lanes, and 10 feet outside paved shoulder as shown above.

Outside shoulder edge treatment throughout the corridor consists of guardrail (in places required), ditches (in places where required), and side slopes. Inside shoulder edge treatment consists of either standard or special design concrete median barrier to address elevation differences between

northbound and southbound I-81. or guardrail, ditches and side slopes where the existing median width allows for widening without concrete median barrier. The existing Route 411 overpass bridge piers at Exit 141 are within the Clear Zone (CZ), so a bridge pier protection system is proposed to shield the hazard.

6.5.3 Vertical Alignment

Existing survey information was used to trace the profile to develop an approximate vertical spline grade. It is understood that elevations were based on high elevation aerial photogrammetry, which means hard surface elevations are likely only accurate within six inches (6”). Prior to detailed design, appropriate low level aerial photogrammetry should be obtained, and approximate spline grade confirmed.

6.5.4 Superelevation

A review of the survey information within the project limits indicated that the existing pavement cross-slopes varies significantly throughout the corridor. Some of the existing horizontal curves are not superelevated to the values required in the AASHTO Green Book for the chosen design speed. Similar to discussions and design decisions as part of the adjacent auxiliary lane project between Exit 141 and Exit 143, VDOT determined that superelevation of existing horizontal curves will not be corrected as part of the conceptual design. However, the existing cross slope outside of horizontal curves will need to be evaluated for potential slope correction should values be outside the range allowed by AASHTO guidance. Since hard surface survey elevations are not accurate less than six inches (6”) a detailed analysis was not conducted to identify substandard existing cross slopes outside horizontal curves; therefore, prior to detailed design accurate survey should be obtained and cross slopes confirmed. If proposed cross-slopes are determined to match existing with no slope correction, a design exception may be required in order to minimize any impacts to the outside shoulders and cut slopes.

6.5.5 Overhead Sign Structures and Guide Signs

Overhead guide signs are utilized along the corridor to alert motorists of upcoming decisions and traffic movements. Updating and replacing existing overhead guide signs is recommended to improve communication to the motorists, and as required by proposed improvements to the roadway geometrics. Existing guide signs were verified via a site field visit and are documented in the conceptual design plans. The guide signs will be developed using the GuideSIGN software based on the requirements of the *Virginia Supplement to the 2009 MUTCD* (2011 Edition, Revision 1) and the *Virginia Standard Highway Signs Manual* (2011).

Currently, the signing along southbound I-81 between Exit 140 and Exit 141 consists of a cantilever structure at STA 524+77 identifying Exit 140 towards Route 311 towards Salem and a ground-mounted sign at STA 547+05 identifying Exit 140 approximately ½ mile downstream. The signing along northbound I-81 between Exit 140 and Exit 141 consists of a ground-mounted sign at STA 146+75 identifying Exit 141 towards Route 419 towards Salem approximately one mile downstream and a cantilever structure at STA 191+95 identifying Exit 141 towards Route 419 towards Salem. The existing cantilever sign structures, ground-mounted signs, and respective guide sign panels must be removed as a result of the proposed roadway widening.

The proposed signing will include a proposed continuous northbound and southbound auxiliary lane between Exit 140 and Exit 141 along I-81 and follows the guidance in the 2009 Manual on Uniform Traffic Control Devices (MUTCD) using diagrammatic guide signs for a one-lane exit to the right. A series of four overhead cantilevered sign structures are proposed. The first sign will be a single sign located upstream from Exit 140 going southbound on I-81 at STA 524+75, as shown on the conceptual Signing and Marking Plans. The sign will indicate that the right lane must exit to Route 311 towards Salem. The second sign will be a single sign located approximately a half mile upstream from Exit 140 going southbound on I-81 at STA 546+50, as shown on the conceptual Signing and Marking Plans. The sign will indicate that the right lane must exit to Route 311 towards Salem. The sign will also include the physical distance of ½ mile to the exit ramp. The third sign will be a single sign located upstream from Exit 141 going northbound on I-81 at STA 144+00, as shown on the Signing and Marking Plans. The sign will indicate taking Exit 141 to travel towards Route 419 to Route 311 towards Salem and New Castle. The sign will include the physical distance of one mile to the exit ramp. The final sign will be a single sign located upstream from Exit 141 going northbound on I-81 at STA 188+00, as shown on the Signing and Marking Plans. The sign will indicate to begin to exit towards Route 419 to Route 311 towards Salem and New Castle via Exit 141.

6.5.6 Maintenance of Traffic

A preliminary MOT plan was developed using the 2011, Revision 1 *Virginia Work Area Protection Manual* (VAWAPM), including current supplemental revisions issued by VDOT. The following maintenance of traffic constraints were factored into the plan:

- Maintain all travel lanes within the project limits on northbound and southbound I-81 during day time operations
- Maintain a minimum lane width of 12 feet for northbound and southbound I-81 traffic.

The MOT plan will consist of a three-phase construction sequence.

Phase I of construction will maintain the existing two lanes of traffic on northbound and southbound I-81 within the existing lane configuration and be performed through two substages. Phase 1A will consist of installing a temporary concrete traffic barrier on the inside shoulder as a 4-foot deep mill paved shoulder operation progresses in the direction of traffic within the limits of the project. This work will necessitate closures of the northbound and southbound I-81 inside through lane during overnight temporary lane closures. Phase 1B will consist of removing existing guardrail along southbound I-81 behind the temporary concrete traffic barrier. Construction activities during this phase consist of clearing, earthwork, pavement widening, median barrier, storm drainage, guardrail, paved ditches, and bridge pier protection. The end of phase I will be the removal of the temporary concrete traffic barrier.

Phase II of construction will be performed through a multilane shift. Two lanes of through traffic will be maintained by shifting the lanes approximately 4 feet towards the median into a temporary lane configuration. Temporary concrete traffic barrier will be installed adjacent to the outside temporary lane to provide positive protection from the work zone. Construction activities during this phase consist of clearing, earthwork, pavement rehabilitation and widening, guardrail, and storm water management construction. The end of phase II will be the removal of the temporary concrete traffic barrier.

The proposed improvements include the removal and replacement of several cantilever overhead sign structures, as detailed in the Signing and Pavement Marking Plans. The construction activities associated with removing, hauling off-site, and replacement will require a specialized MOT plan. Activities associated with the removal of existing cantilever sign structures can be performed behind the temporary concrete traffic barrier adjacent to the outside travel lane during Phase II. The proposed overhead sign structures will remain cantilevered structures. The proposed sign foundations will be installed behind traffic barrier during Phase II. Erection of the proposed cantilevered sign structures will be performed during Phase II of construction and will require the use of overnight temporary lane closures.

The final construction stage, Phase III, will shift traffic into the ultimate traffic configuration consisting of two through lanes and the newly constructed continuous auxiliary lane. Using alternating temporary lane closures during off-peak hours, construction activities will consist of completing the milling and overlay of the existing through lane pavement and application of final pavement markings.

6.5.7 Right-of-Way and Utilities

The selection of the preferred alternative with widening to the median eliminated a significant portion of the risk associated with right-of-way acquisition and utilities relocation. The primary impacts to right-of-way and utilities may occur with the construction of storm water management and/or utility relocation.

6.5.7.1 Right-of-Way

The selection of the preferred design alternative eliminated the need for significant fee-simple right-of-way as part of the project design. Easements for SWM construction and utility relocation may be required and will be identified during detailed design.

6.5.7.2 Utilities

The preliminary conceptual design does not depict any proposed franchise and/or public utility relocations. A review of the as-built plans, topographic survey, and field observation indicated presence of overhead utility lines and overhead utility poles carrying telephone and power cables outside the existing right-of-way. An overhead power line crosses I-81 from the west to east side just south of Exit 141. A sub-surface utility investigation was not performed as part of this study; however, a sub-surface utility investigation should be completed prior to the detailed design to locate and identify any potential impacts. The potential for utility impacts and relocations will need to be further evaluated during the detailed design.

6.6 PRELIMINARY HYDROLOGIC/HYDRAULIC ANALYSIS

This project is located within two Virginia 6th order hydrologic unit code (HUC) watersheds: Mason Creek (030101010302/RU10) and Roanoke River – Peters Creek (030101010404/RU14). In the existing condition, all stormwater runoff within the project limits is ultimately captured by median or roadside ditch and conveyed via storm sewer, culvert, or ditch to one of the twelve major outfalls identified. In the post-development condition, most of the stormwater runoff that was previously captured by median ditches will now be captured by proposed inlets or end sections and then conveyed via proposed storm sewer to an outfall point. This project is expected to disturb approximately 18.88 acres within the identified project limits.

A summary of the drainage design and stormwater management plan is provided below. See the Hydraulics and Hydrologic Analysis Report dated May 1, 2019 for more detailed information and calculations.

6.6.1 Overall Drainage Patterns

This project is bound by two high points – one at the southern limits of the project and one at the northern limits of the project. The area between the southern project limits and Route 419 drains to the Mason Creek watershed. The area between Route 419 and the northern project limits drains to the Roanoke River – Peters Creek watershed. Mason Creek itself crosses I-81 within the project limits.

Seven outfalls are identified between the southern project limits and Mason Creek. The project site in this section is confined entirely to the I-81 median. It drains to various roadside ditches or natural channels via existing culverts or storm sewer. These ditches and channels eventually reach Mason Creek off-site while also accumulating runoff from much of the immediate surrounding area to the west and east of I-81.

Two outfalls are identified between Mason Creek and Route 419. The project site in this section consists of the I-81 median and portions of the outer roadside, including the infield area bound by the on-ramp and off-ramp connecting Route 419 to the I-81 southbound lanes. This runoff either drains directly to Mason Creek or to a natural outfall adjacent the I-81 southbound on-ramp. The existing I-81 median drains to Mason Creek, while the outfall near the ramp accumulates runoff from much of the surrounding area along Route 419 immediately to the west and east of I-81.

Three outfalls are identified between Route 419 and the northern project limits. The project site in this section consists of the I-81 median and portions of the outer roadside, including the infield area bound by the on-ramp and off-ramp connecting Route 419 to the I-81 northbound lanes. This runoff drains to various manmade and natural channels adjacent the I-81 northbound on-ramp and off-ramp. These outfalls also accumulate runoff from much of the surrounding area immediately to the west and east of I-81.

6.6.2 Drainage Design Description and Criterion

Seven outfalls are identified between the southern project limits and Mason Creek. In this section, the proposed drainage design is to install storm sewer within the I-81 median that drains the entire inside shoulder in both northbound and southbound directions. This storm sewer will discharge directly to Mason Creek at Outfall D. Due to this design, the remaining six outfalls in this section of the project will see a reduction in runoff since existing drainage areas will be diverted from them to the singular outfall at Mason Creek.

Two outfalls are identified between Mason Creek and Route 419. In this section, the proposed drainage design is to install storm sewer within the I-81 median that drains the entire inside shoulder in both northbound and southbound directions. This storm sewer design will also collect the entire median area between Route 419 and the northern project limits. Much of this median drainage will be diverted into a proposed wet pond (BMP A) located in the infield area bound by the on-ramp and off-ramp connecting Route 419 to the southbound I-81 lanes. This wet pond will help the project meet SWM quality and quantity requirements by providing nutrient treatment via runoff retention and reducing stormwater

discharge at Outfall F via runoff detention. The remaining portion of median drainage will discharge directly into Mason Creek.

Three outfalls are identified between Route 419 and the northern project limits. In this section, the "existing" bioretention facility proposed by others as part of the adjacent project to the north will be expanded to provide additional nutrient treatment for this project. Storm sewer is proposed in the vicinity of the northbound I-81 on-ramp to divert runoff from Outfall H into the bioretention area (BMP B) to maximize its treatment capabilities. Additionally, due to the proposed median drainage design described in the paragraph above, all three outfalls in this section of the project will see a reduction in runoff since existing drainage areas will be diverted from them to other areas of the project that are designed to handle the subsequent increase in runoff.

All drainage calculations follow the standards and procedures in the *VDOT Drainage Manual*. Inlet, storm sewer, and hydraulic grade line calculations were performed using the Rational method in manual spreadsheets. Storm sewer calculations were done under a 25-year design storm. Hydraulic grade line calculations were done under a 50-year check storm for roadway inundation. Spread calculations for curb inlets were done under a 10-year design storm and a 50-year check storm for roadway inundation. Ditch calculations were done in a manual spreadsheet under a 10-year design storm and a 50-year check storm for roadway inundation. Times of concentration for overland flow were calculated using the Seelye method. Times of concentration for shallow concentrated flow were calculated using the TR-55 method. Times of concentration for channel flow were calculated using the Kirpich method. Hydraflow Hydrographs Extension software was used to model the wet pond (BMP A) at Outfall F, and the runoff conditions at other critical outfalls, using the SCS method. All supporting calculations are provided in the Hydraulics and Hydrologic Analysis Report dated May 1, 2019.

6.6.3 Stormwater Management (SWM)

6.6.3.1 SWM Quality

This project will disturb approximately 18.88 acres and is required to reduce the post-development total phosphorus load by approximately 13.18 lb/yr. Nutrient credits are available for purchase in the fourth order HUC adjacent to this project (03010102). Therefore, according to IIM-LD-251.4, at least 75% of the required phosphorus reduction must be achieved on-site. The remaining 25% or less can be handled by purchasing nutrient credits.

To meet the on-site phosphorus reduction requirements, two BMPs are proposed:

- Wet Pond [BMP A] (Outfall F) – Treats approximately 7.30 acres of managed turf and 5.70 acres of impervious cover for a total phosphorus removal of 8.25 lb/yr.

- Bioretention Level 1 [BMP B] (Outfall G1) – The bioretention facility proposed by others for the adjacent project will be expanded as a part of this project to treat approximately 1.20 acres of additional impervious cover and 1.00 acres of additional managed turf for a total phosphorus removal of 1.74 lb/yr.

6.6.3.2 SWM Quantity

This project must comply with part IIB of the VSMP regulations, which stipulates post-development stormwater runoff must meet Channel Protection criteria and Flood Protection criteria. The proposed drainage improvements as described in Section 6.6.2 help the project meet these criteria via Energy Balance at ten of the twelve outfalls. The remaining two outfalls (D and E) accumulate much of the runoff from the project site, some of which has been redirected here from the other outfall locations. These two outfalls discharge directly into Mason Creek, which has an overall watershed of approximately 24 square miles (15,360 acres) at this point. The contributing drainage area from the project site is 6.18 acres at Outfall D and 1.67 acres at Outfall E. Therefore, the overall watershed of Mason Creek is greater than 1% of the contributing drainage area of the site. Since the runoff within Outfall D and E is conveyed by a proposed manmade system until discharging to Mason Creek, both Channel and Flood Protection will be met.

6.6.4 Erosion and Sediment Control

The vast majority of the disturbed area for this project is located within the I-81 median. Therefore, the proposed erosion and sediment control design for this project will consist primarily of temporary sediment traps located within the I-81 median at critical locations. In addition, the proposed wet pond (BMP A) located in the infield area bound by the on-ramp and off-ramp connecting Route 419 to the southbound I-81 lanes will act as a sediment basin during construction. Also, silt fence is to be placed along the I-81 outer roadside to protect the adjacent slopes and channels. Minimal work is proposed along the I-81 outside lanes, so this treatment is largely a precaution for any dirty water flowing across the travel lanes during construction.

6.7 MATERIALS FINDINGS/RECOMMENDATIONS

Kimley-Horn conducted a review of the as-built plans for I-81 to determine approximate existing pavement depth for mainline and shoulders. The as-built plans indicated that the existing inside and outside shoulder pavement sections were originally designed to be partial depth and may not be sufficient for mainline traffic during construction or for incident management. However, the bridge replacement plans for the current northbound and southbound I-81 bridges over Mason's Creek did show that a portion of northbound and southbound I-81 was widened for the future third lane with full depth outside shoulders. Most of existing shoulder pavements (excluding those reconstructed as part of the Mason's Creek bridge replacements) are not full depth. It is recommended to demolish and replace shoulders as appropriate. The paved shoulder section is proposed to match mainline section. VDOT did not conduct preliminary pavement coring within the study area for this project, so the condition of the existing pavement section could only be determined based on maintenance records and observations. It is recommended that pavement coring be performed during the detailed design phase including geotechnical investigation and analysis in accordance with VDOT Materials Division Memoranda of Instructions (MOI). The detailed geotechnical investigation and analysis will provide more certainty of assumptions and risk quantification/estimation regarding pavement design, suitability for re-use of existing soils, undercut and amounts of rock excavation/blasting.

VDOT Salem District expressed a desire to have full depth pavement shoulder on the outside due to potential for use as travel lanes during incident management or special events (i.e. Virginia Tech game

day event). Accordingly, the following proposed pavement section design was provided by VDOT for cost estimation.

6.7.1 Pavement Design

VDOT Salem District Materials Division provided preliminary pavement design for Interstate 81. The preliminary pavement design for the study area was assumed by VDOT to match the proposed pavement design for UPC 108906. The conceptual design plans depicted the below preliminary pavement design:

I-81 Mainline and Paved Shoulders:

- Surface: 1.5-inches Asphalt Concrete, Type SMA-12.5 (64E-22)
- Intermediate: 3.0-inches Asphalt Concrete, Type IM-19.0D
- Base: 8.0-inches Asphalt Concrete, Type BM-25.0D
- Subbase: 10-inches Aggregate Base Material, Type I, No. 21-B

Existing I-81 Mainline Mill and Overlay:

- Milling Depth: 4.5-inches
- Surface: 1.5-inches Asphalt Concrete, Type SMA-12.5 (64E-22)
- Intermediate: 3.0-inches Asphalt Concrete, Type IM-19.0D

In addition, the proposed SWM facilities along the project corridor necessitates the need for regular maintenance requiring vehicular access to the facility. Preliminary plans indicate potential location of these access routes based on the existing and proposed grading. Final location, grading, and pavement material type for the maintenance access will be determined during the detailed design phase.

6.7.2 Pavement Rehabilitation

Pavement coring was completed in 2014 and found the existing pavement in the project vicinity to consist of approximately 12.5-inches of asphalt with an old problematic surface layer approximately 3.5-inches deep. The recommendation for the mainline pavement structure as shown in section 6.7.1 is to mill 4.5-inches deep and replace with 3.0-inches IM-19.0D and 1.5-inches SMA-12.5 (64E-22). The existing shoulder rehabilitation within the Mason's Creek project limits (UPC 12180 – 1997) should utilize the same rehabilitation as shown for the mainline pavement. The existing shoulders outside the Mason's Creek project limits should be milled and replaced with full-depth pavement structure if subjected to mainline traffic. Existing shoulders not subjected to mainline traffic that are to be rehabilitated should be milled a minimum of 10-inches and replaced with 2-inches of SM-9.5D and 8-inches of BM-25.0A. In areas of soft subgrade or locations where UDs and CDs are shown on the original plans or are encountered during trenching operations, an additional 12-inchs shall be excavated and replaced with 12-inches of No. 1 Aggregate.

6.7.3 Rock

Kimley-Horn conducted visual observations of the study area on site visits and using Google Earth. Rock will likely be encountered at a shallow depth in multiple locations for the construction of excavation, SWM facilities and storm drainage pipes. The cost, schedule impacts, limitations on construction operations and proximity of adjacent travel lanes must be considered during the detailed design phase.

Selection of the preferred alternative minimized the risk of rock excavation by eliminating many deep rock cuts likely impacted by the outside widening alternative.

6.8 COMMON SENSE ENGINEERING/DESIGN WAIVERS/DESIGN EXCEPTIONS

The conceptual design sought to take advantage of common-sense design principles to be sure that the project delivers on the anticipated purpose and need of the project with the lowest construction cost.

6.8.1 Common Sense Engineering

The current design includes common-sense engineering methodologies or decisions, which are summarized below:

- Maintains existing cross slope to reduce asphalt build up and impacts to adjacent lanes/shoulders
- Maintains a consistent paved shoulder throughout multiple projects reducing unexpected changes to accessible shoulder widths increasing driver safety and minimizing impacts to existing bridge piers at Exit 141 reducing construction costs
- Request for a design exception for the inside shoulder across the relatively short I-81 bridges over Route 311 maintains consistency of the paved shoulder with the roadway section and drastically reduces the costs of widening on both sides of the existing bridge and impacting the ingress/egress of the interchange ramps

6.8.2 Design Waivers

Based on a review of the project limits and constraints of the corridor, it is anticipated that the following design waivers may be required for design of the project:

- It was determined that a design waiver will not be required for the 8-foot total shoulder width (4-foot paved) to match the adjacent project since the standard used a 'should' statement when describing inside shoulder width of a 6-lane divided roadway. If a design waiver is required, approval is likely because the width would be consistent with the adjacent projects.

6.8.3 Design Exceptions

Based on a review of the project limits and constraints of the corridor, it is anticipated that the following design exceptions may be required for design of the project:

- Match existing cross slope to not correct super elevation
- Inside shoulder width across the existing I-81 bridges over Route 311 bridges (should widening be extended south of Exit 140).
- Inside shoulder width beneath the existing Route 411 overpass.
- Inside shoulder width adjacent to propose concrete median barrier.

7 RISK IDENTIFICATION/MITIGATION & COST ESTIMATING

7.1 RISK IDENTIFICATION/MITIGATION

A risk is any uncertain event that, if it happens, can potentially interfere with successful delivery of a project. All projects have risks; however, some projects may have more significant risks than others due to technical complexity, funding, financing, and stakeholder acceptance. Risk management generally involve the process of anticipating what risks an improvement faces, mitigating them to the extent reasonably possible, and having a plan to react to them if/when they occur. This is recognized in VDOT guidance regarding the analysis of and mitigation of risks. The purpose of risk analysis and risk management during project development is to:

- Identify risks facing a project
- Identify mitigation strategies to eliminate and/or lessen the impact of risks should they occur
- Prepare adequate contingency to cover remaining and/or unknown risks
- Identify further due diligence, planning and/or analysis to eliminate and/or lessen the impact of risk

Risk management is undertaken throughout the lifecycle of a project to track identified risks, measure the performance of mitigation, identify new risks as they arise, maintain adequate risk budgeting, and capture best practices. The central tool for tracking the above is a risk register created at the very early stages of the improvement development. The risk register is then updated with new and/or closed out risks as the project progresses. The initial assessment of the risks identified in the risk register is qualitative and will be updated with quantified values as the project progresses and more project data becomes available.

Importantly, the identification of an uncertainty as a “risk” is not intended to convey that a process is flawed, or the development team has not done an adequate job. Rather, it is a tool that helps leadership to think and react proactively to plan for and mitigate impacts of various risks. Following is a list by discipline of potential issues that may affect project development, risks faced by the project and risk mitigation strategies to be applied to manage and minimize risks throughout project development.

MAINTENANCE OF TRAFFIC

Risk/Issue: Contractor shall be required to maintain two lanes during peak hours and special events, high truck volumes, and the preferred design alternative provides limited work space and access.

Description: Northbound and southbound I-81 each carry over 30,000 vehicles per day in two lanes. Further, I-81 is a major truck thoroughfare and serves as primary access to Virginia Tech for multiple sporting and graduation events each year. Further, the preferred alternative widens I-81 to the median within the study area, which will restrict the amount of available space open for construction activities.

Mitigation: A detailed maintenance of traffic plan and sequence of construction coordinated with all phases of the design will be developed to identify and mitigate risks associated with the maintenance of traffic constraints. In the interim an adequate risk contingency should be carried for programming and budgeting proposes to provide support for an inevitably expensive and detailed maintenance of traffic work package.

Rock Excavation/Blasting

Risk/Issue: Rock excavation/blasting will be required adjacent to open travel lanes.

Description: As evidenced by field inspection and construction of similar projects along I-81 near the study area, rock excavation and/or blasting is likely to be required for general excavation, median barrier construction and storm sewer installation.

Mitigation: During detailed design phase activities, the maintenance of traffic plan and sequence of construction will need to describe how rock excavation fits into the plan of construction, which may include temporary stoppages or 'slow roll' stoppages along I-81.

Noise Walls

Risk/Issue: Noise walls may be required along northbound and southbound I-81.

Description: As most of the widening within the study area is proposed within the existing median, very little work is proposed along the outside edges of northbound and southbound I-81. Further, while the properties adjacent to I-81 today do not pose a risk of noise barriers being warranted, the developed state of property adjacent to Exit 140 and Exit 141 may change and noise barrier requirements could be triggered at the time of detailed design development.

Mitigation: As part of the Tier II EA along I-81, which encompassed the study area, no noise walls between Exit 140 and Exit 141 were identified as possible. For programming and budgetary purposes, it is recommended that a risk contingency be carried that may support some construction of noise walls should the developed state change adjacent to the right-of-way. A detailed noise study will be required as part of the required National Environmental Protection Act (NEPA) document during detailed design development.

Mason's Creek Stream & Wetland Impacts

Risk/Issue: A live perennial stream serves as the major outfall for the study area with adjacent riparian wetlands. Mason's Creek likely will have time of year restrictions due to threatened and endangered species.

Description: The conceptual design anticipates stormwater outfalls to Mason's Creek. Mason's Creek may have time of year restrictions due to threatened and endangered species. Further, the conceptual design may impact WOUS and/or jurisdictional wetlands.

Mitigation: During detailed design a wetland and stream delineation should be conducted to identify limits of jurisdictional waters and wetlands. Once the limits of wetlands and streams is confirmed the stormwater outfall may be redesigned to eliminate impacts or permit can be obtained from the USACOE, DEQ and/or VMRC.

7.2 PLANNING LEVEL COST ESTIMATING

A planning level cost estimate was developed for the preferred design alternative as summarized in **Table 7-1** and **Table 7-2**. Construction (CN) costs were estimated using a combination of PCES, VDOT Planning Level Cost Estimate worksheet, and recent bid costs. Preliminary engineering (PE), Environmental Mitigation and Permitting, VDOT Oversight/Management and Construction Engineering and Inspection (CEI) costs were estimated as a percentage of construction costs by VDOT. Contingency was included on the construction cost estimate. The level of detail provided in each opinion of probable construction cost will increase with each Design Phase Submittal. As such, the contingency included in the cost estimate will be adjusted as more information becomes available, the plans are revised, and material quantities are refined.

A conceptual cost estimate based on the plans depicting the preferred design alternative was developed through a cooperative effort between Kimley-Horn and VDOT. A detailed cost estimate should be prepared during the detailed design phase.

Table 7-1 – Cost Estimate for Southbound I-81 Auxiliary Lane

Phase Description	Budget (2026)
Preliminary Engineering	$ 2,883,000
Right-of-Way and Utility Relocation	$ 146,595
Construction	$ 17,070,466
Total SB Cost Estimate Budget	$ 20,100,061

Table 7-2 – Cost Estimate for Northbound I-81 Auxiliary Lane

Phase Description	Budget (2026)
Preliminary Engineering	$ 1,760,000
Right-of-Way and Utility Relocation	$ 497,845
Construction	$ 10,156,627
Total NB Project Cost Estimate	$ 12,414,472

The cost estimates above are shown in inflated dollars assuming an advertisement year of 2024 with an end of construction year of 2026. Details of the cost estimates are included in **APPENDIX I – DETAILED COST ESTIMATES**.

8 NEXT STEPS & RECOMMENDATIONS

The design presented on the conceptual design plans is consistent with the Design Criteria in **Section 6.2** and the modified LD 436 checklist. Since the design is only to a conceptual level further design will be needed. The below list identifies some of the critical next steps that should be undertaken early in further design development.

- Inspection of existing pipes to determine condition, need for rehabilitation or replacement and appropriateness for use in the proposed design.
- Complete survey deliverables in accordance with the current edition of the VDOT Survey Manual.
- Confirm roadway, drainage and signing and marking plans for UPC 108906 present the most cost-effective means of allowing for future connection of auxiliary lanes through Exit 141.
- Further evaluate drainage outfall(s) into Mason's Creek and evaluate if time of year restrictions could impact schedule.
- Begin NEPA and other environmental processes.
- Detailed traffic operations and safety analysis (if required) including for alterations at Exit 141.