VDOT

ENVIRONMENTAL ASSESSMENT

Air Quality Technical Report

February, 2020

495 ExpressLanes NORTHERN EXTENSION

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Executive Summary

The Virginia Department of Transportation (VDOT), in coordination with the Federal Highway Administration (FHWA) as the lead federal agency, is evaluating an extension of the Interstate 495 (I-495) Express Lanes along approximately three miles of I-495, also referred to as the Capital Beltway, from their current northern terminus in the vicinity of the Old Dominion Drive overpass to the George Washington Memorial Parkway (GWMP) in the McLean area of Fairfax County, Virginia. Pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended, and in accordance with FHWA regulations[1], an Environmental Assessment (EA) is being prepared to analyze the potential social, economic, and environmental effects associated with the improvements being evaluated.

The purpose of this Air Quality Technical Report is to evaluate potential impacts that could result from implementation of the Build Alternative. Information in this report provides an overview of the regulatory context, methods used to identify existing resources, potentially affected resources identified within the study area, and potential impacts to air quality associated with the implementation of the Build Alternative. The findings of this technical report support discussions presented in the EA.

The proposed improvements were assessed for potential air quality impacts and conformity consistent with all applicable air quality regulations and guidance. All models, methods and assumptions applied in modeling and analyses were made consistent with those provided or specified in the VDOT Resource Document[2]. The assessment indicates that the project would meet all applicable federal and state transportation conformity regulatory requirements as well as air quality guidance under NEPA. As such, the project will not cause or contribute to a new violation of the national ambient air quality standards (NAAQS) established by the US Environmental Protection Agency (US EPA). Additional detail on the analyses conducted for this project is provided below.

Carbon Monoxide (CO)
As the project is located in a region that is attainment of the CO NAAQS, only NEPA applies. EPA project-level ("hot-spot") transportation conformity requirements for CO do not apply.

For purposes of NEPA, worst-case emission and dispersion modeling for CO was conducted for the project for the following intersections:

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[1] NEPA and FHWA's regulations for Environmental Impact and Related Procedures can be found at 42 USC § 4332(c), as amended, and 23 CFR § 771, respectively.

[2] In 2016, in order to facilitate and streamline the preparation of project-level air quality analyses, and maintain high quality standards for modeling and documentation, the Department created a new resource for modeling. Titled the "Resource Document", it includes a general reference document as well as an associated online data repository (DR) for all modeling inputs needed for project-level air quality analyses in Virginia. The VDOT Resource Document and DR address in a comprehensive fashion the models, methods and assumptions (including data and data sources as well as protocols) needed for the preparation of air quality analyses for transportation projects by or on behalf of the Department. The latest version of the VDOT Resource Document and DR along with air quality-related programmatic agreements are available on or via the Department website (http://www.virginiadot.org/projects/environmental_air_section.asp).

- Route 123 and Tysons Boulevard
- Route 123 and Capital One Tower Drive/ Old Meadow Road
- Route 123 and Scotts Crossing Boulevard/ Colshire Drive

In addition, the interchange of the I-495 with the Dulles Toll Road was also evaluated given the nature of the project and the fact that this interchange represents the highest confluence of traffic and roadway capacity within the study area.

The worst-case modeling assumptions used are consistent with EPA and FHWA guidance as well as the VDOT Resource Document and included:

For emission factor modeling:

- Regional registration (age) distributions were applied that were not adjusted (as a limitation of the EPA MOVES model) for mileage accumulation rates that generally decline with age. This assumption effectively weights older higher-emitting vehicles the same as newer lower-emitting vehicles, resulting in higher estimates for fleet-average emission factors.
- Worst-case emission factor selected as that for the maximum (or higher) road grade for each link.

For dispersion modeling:

- Traffic volumes representing Level of Service (LOS) E conditions, which typically exceeds actual opening and design year Average Daily Traffic (ADT) forecasts for build scenarios by substantial margins, were used. Depending on the project, volumes may also be increased with the worst-case assumption of additional through lane(s) to account for auxiliary lanes or ramps.
- Worst-case receptor locations on the edge of the roadway right-of-way, i.e., at the closest possible point to roadway.
- Worst-case geometric assumptions that serve to concentrate traffic, emissions and concentrations to the greatest extent possible:
    - Zero vertical separation for the grade separation (interchange)
    - Zero median widths for arterial streets and minimum distance for freeways
    - The interchange modeled with all lanes immediately parallel to each other rather than spreading the lanes across the wider area it will occupy, concentrating emissions. This also positions receptor locations much closer to the emission sources than would typically occur.
- Other federal default data for most model inputs (e.g., low wind speeds, surface roughness, and stability class), which result in higher modeled estimates of ambient concentrations than are expected to occur in practice.

Mobile Source Air Toxics (MSATs)

Federal Highway Administration (FHWA) guidance[3] (2016) states that "*EPA identified nine compounds with significant contributions from mobile sources that are among the national and regional-scale cancer risk drivers or contributors and non-cancer hazard contributors from the 2011 National Air Toxics Assessment (NATA)*[4]*. These are 1,3-butadiene, acetaldehyde, acrolein, benzene, diesel particulate matter (diesel PM), ethylbenzene, formaldehyde, naphthalene, and polycyclic organic matter*." The FHWA guidance specifies three possible tiers of MSAT analysis and associated traffic volume and other criteria, based on which this project may be categorized as one with higher potential MSAT effects based primarily on the forecast traffic volumes for this project. A quantitative assessment was therefore conducted for the project, following FHWA guidance for projects with higher potential impacts.

Overall, best available information indicates that, nationwide, regional levels of MSATs are expected to decrease in the future due to ongoing fleet turnover and the continued implementation of increasingly more stringent emission and fuel quality regulations. Nonetheless, technical shortcomings of emissions and dispersion models and uncertain science with respect to health effects effectively limit meaningful or reliable estimates of MSAT emissions and effects of this project at this time. While it is possible that localized increases in MSAT emissions may occur as a result of this project, emissions will likely be lower than present levels in the design year of this project as a result of EPA's national control programs that are projected to reduce annual MSAT emissions by over 80 percent between 2010 and 2050. Although local conditions may differ from these national projections in terms of fleet mix and turnover, vehicle-miles-travelled (VMT) growth rates, and local control measures, the magnitude of the EPA-projected reductions is so great (even after accounting for VMT growth) that MSAT emissions in the study area are likely to be lower in the future in nearly all cases.

Greenhouse Gases (GHGs)

The traffic analysis completed for this project shows that in 2045 the build alternative will lead to lower increases in VMT than the no-build alterative when compared to the 2018 baseline, specifically the build will increase affected 2045 VMT by 22.4% over 2018, while the no-build increases VMT by 28.9% over the same period. At the same time the Energy Information Administration (EIA)[5] projects that average fuel economy for light-duty vehicles will improve by 65% between 2018 and 2050. With the relative fuel economy of the vehicle fleet by 2045 far outpacing the expected increase in VMT in the area affected by the project, it is reasonable to expect overall GHG emissions will decline. As the 2045 Build scenario is expected to have lower VMT than the no-build alternative, an additional decrease in GHG emissions will be achieved should the project go forward.

Some additional GHG emissions increases can be expected due to construction of the project (estimated at approximately 5% of the total project lifetime emissions) and due to increased

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[3] FHWA, "*INFORMATION: Updated Interim Guidance on Mobile Source Air Toxic Analysis in NEPA Documents*", October 18, 2016. See: http://www.fhwa.dot.gov/environment/air_quality/air_toxics/

[4] See: https://www.epa.gov/national-air-toxics-assessment

[5] See page Annual Energy Outlook 2019, Page 124. The increase in VMT is calculated to 2050 because AEO2015 does not include data for 2045.

maintenance activities due to the expanded roadway. Finally, the express lanes will directly encourage carpooling, vanpooling, and improve potential future I-495 bus operations that would result in a decrease in GHG emissions.

Indirect Effects and Cumulative Impacts (IECI):
A qualitative assessment of the potential for indirect effects and cumulative impacts attributable to this project was conducted. It concluded that the potential effects or impacts are not expected to be significant given available information from pollutant-specific analyses (CO and MSATs) and regional conformity analyses.

More specifically, the quantitative assessments conducted for project-specific CO, quantitative analyses for MSAT impacts and the regional conformity analysis conducted for ozone can all be considered indirect effects analyses because they look at air quality impacts attributable to the project that occur in the future. These analyses demonstrate that, in the future: 1) air quality impacts from CO will not cause or contribute to violations of the CO NAAQS; 2) MSAT emissions will be significantly lower than they are today; and 3) the mobile source emissions budgets established for the region for purposes of meeting the ozone NAAQS will not be exceeded.

Regarding the potential for cumulative impacts, the latest regional conformity analysis conducted by the National Capital Region Transportation Planning Board (NCRTPB, which is the Metropolitan Planning Organization or MPO for the Washington, D.C., metropolitan area) represents a cumulative impact assessment for purposes of regional air quality. The conformity analysis quantifies the amount of mobile source emissions for which the area is designated nonattainment that will result from the implementation of all reasonably foreseeable regionally significant transportation projects in the region (i.e., those proposed for construction funding over the life of the region's transportation plan). The most recent conformity analysis was completed in October 2018, with FHWA and FTA issuing a conformity finding on December 13, 2018 for the Visualize 2045 Long-Range Transportation Plan (LRTP) and Fiscal Year (FY) 2019-2024 Transportation Improvement Program (TIP). The analysis demonstrated that the incremental impact of the proposed project on mobile source emissions, when added to the emissions from other past, present, and reasonably foreseeable future actions, is in conformance with the State Implementation (Air Quality) Plan (SIP) and will not cause or contribute to a new violation, increase the frequency or severity of any violation, or delay timely attainment of the NAAQS established by EPA.

Mitigation:
Emissions may be produced in the construction of this project from heavy equipment and vehicle travel to and from the site, as well as from fugitive sources. Construction emissions are short term or temporary in nature. To mitigate these emissions, all construction activities are to be performed in accordance with VDOT *Road and Bridge Specifications*[6].

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[6] See: http://www.virginiadot.org/business/const/spec-default.asp

The Virginia Department of Environmental Quality (VDEQ) provides general comments for projects by jurisdiction. Their comments in part address mitigation. For Fairfax county, VDEQ comments relating to mitigation are[7] "*…all reasonable precautions should be taken to limit the emissions of VOC and NOx. In addition, the following VDEQ air pollution regulations must be adhered to during the construction of this project: 9 VAC 5-130, Open Burning restrictions*[8]*; 9 VAC 5-45, Article 7, Cutback Asphalt restrictions*[9]*; and 9 VAC 5-50, Article 1, Fugitive Dust precautions*[10]."

Project Status in the Regional Transportation Plan and Program:
Federal conformity requirements, including specifically 40 CFR 93.114[11] and 40 CFR 93.115[12], apply as the area in which the project is located is designated as nonattainment for ozone. Accordingly, there must be a currently conforming transportation plan and program at the time of project approval, and the project must come from a conforming plan and program (or otherwise meet criteria specified in 40 CFR 93.109(b))[13]. As of the date of preparation of this analysis, the project was included in the currently conforming Visualize 2045 LRTP and FY 2019-2024 TIP. The LRTP and TIP are developed by the NCRTPB, whose members include VDOT[14].

Since the approval of the LRTP and TIP, VDOT has proposed changes to the project. To ensure that these changes would have no impact on the conformity finding, NCRTPB performed a sensitivity analysis that they documented in a June 30, 2019 letter to VDOT[15]. Based on the results of the sensitivity analysis, NCRTPB drew the following conclusions[16]: "*Since the analysis shows that the proposed changes to the project would (1) result in non-substantive amount of change in regional emissions; (2) result in decreased emissions; and (3) result in emissions that are within the mobile budgets for the 2025 forecast year, we believe it is reasonable to conclude that the pollutant levels for other forecasts years (2030, 2040 and 2045) will also be within the mobile budgets*."

These and other regional changes will be included in the upcoming air quality conformity analysis of the 2020 Amendment to the Visualize 2045 Plan and the FY2021-2024 TIP. This new regional air quality conformity determination is anticipated to be completed by March 2020.

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[7] Spreadsheet entitled: "DEQ SERP Comments rev8b", March 2017, downloaded from the online data repository for the VDOT Resource Document. http://www.virginiadot.org/projects/environmental_air_section.asp

[8] See: https://law.lis.virginia.gov/admincode/title9/agency5/chapter130/section100/

[9] See: http://leg1.state.va.us/cgi-bin/legp504.exe?000+reg+9VAC5-45-760

[10] See: http://leg1.state.va.us/cgi-bin/legp504.exe?000+reg+9VAC5-50-60

[11] See: https://www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol20/xml/CFR-2014-title40-vol20-sec93-114.xml

[12] See: https://www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol20/xml/CFR-2014-title40-vol20-sec93-115.xml

[13] See: https://www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol20/xml/CFR-2014-title40-vol20-sec93-109.xml

[14] See: http://www.mwcog.org/transportation/tpb/.

[15] Letter from Kanathur Srikanth, Director, Department of Transportation Planning, Metropolitan Washington Council of Governments to Norman Whitaker, Transportation Planning Director, VDOT Northern Virginia District, June 30, 2019. See: https://www.mwcog.org/events/2019/?F_committee=194, July Item 3 Letter, or https://www.mwcog.org/file.aspx?&A=aG2FDR8gA2PJr7stqM1MdqSjsI3CpsnEBd9V1uocMps%3d

[16] These results may also be considered to support application of 40 CFR 93.122(g), "*Reliance on previous emissions analysis*" for regional conformity demonstrations, given that the modeled de minimis changes in emissions (of 0.0%, as reported in the June 30, 2019 NCRTPB letter) by definition may be considered to be not significant.

1.0 Project Background

1.1 Introduction

The Virginia Department of Transportation (VDOT), in coordination with the Federal Highway Administration (FHWA) as the lead federal agency, is evaluating an extension of the Interstate 495 (I-495) Express Lanes along approximately three miles of I-495, also referred to as the Capital Beltway, from their current northern terminus in the vicinity of the Old Dominion Drive overpass to the George Washington Memorial Parkway (GWMP) in the McLean area of Fairfax County, Virginia. Pursuant to the National Environmental Policy Act (NEPA) of 1969, as amended, and in accordance with FHWA regulations[17], an Environmental Assessment (EA) is being prepared to analyze the potential social, economic, and environmental effects associated with the improvements being evaluated.

The purpose of this Air Quality Technical Report (AQTR) is to evaluate potential impacts that could result from implementation of the Build Alternative. Information in this report provides an overview of the regulatory context, methods used to identify existing resources, potentially affected resources identified within the study area, and potential impacts to air quality associated with the implementation of the Build Alternative. The findings of this technical report support discussions presented in the EA.

1.1.1 Project Termini

The project includes an extension of the existing Express Lanes from their current northern terminus south of the Old Dominion Drive Overpass to the GWMP. Although the GWMP provides a logical northern terminus for this study, additional improvements are anticipated to extend approximately 0.3 miles north of the GWMP to provide a tie-in to the existing road network in the vicinity of the American Legion Memorial Bridge (ALMB). The project also includes access ramp improvements and lane reconfigurations along portions of the Dulles Toll Road and the Dulles International Airport Access Highway, on either side of the Capital Beltway, from the Spring Hill Road Interchange to the Route 123 interchange. The proposed improvements entail new and reconfigured express lanes ramps and general purpose lanes ramps at the Dulles Interchange and Route 123/I-495 interchange ramp connections.

1.1.2 Study Area

In order to assess and document relevant resources that may be affected by the proposed project, the study area for this EA extends beyond the immediate area of the proposed improvements described above. The study area for the EA includes approximately four miles along I-495 between the Route 123 interchange and the ALMB up to the Maryland state line. The study area also extends approximately 2,500 feet east along the GWMP. Intersecting roadways and interchanges are also included in the study area, as well as adjacent areas within 600 feet of the existing edge of pavement, as shown in **Figure 1-1.1**. The study area boundary is a buffer around the road corridor that includes all natural, cultural, and physical resources that

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[17] NEPA and FHWA's regulations for Environmental Impact and Related Procedures can be found at 42 USC § 4332(c), as amended, and 23 CFR § 771, respectively.

must be analyzed in the EA. It does not represent the limits of disturbance (LOD) of the project nor imply right-of-way take or construction impact, but rather extends beyond the project footprint to tie into the surrounding network, including tying into future network improvements. **Figure 1.1.1** depicts the project termini, study area, and LOD.

1.1.3 Purpose and Need

The purpose and need for the extension of Express Lanes on I-495 between Route 267 and the GWMP is to:

- Reduce congestion;
- Provide additional travel choices; and
- Improve travel reliability.

A detailed description of the purpose and need for the proposed project can be found in Chapter 1.0 of the EA.

1.2 Alternatives

Two alternatives are being considered in the EA: the No Build Alternative[18], and the Build Alternative, described below. Additional information on the Build Alternative is included in the *I-495 Alternatives Technical Report* (VDOT, 2019a).

1.2.1 No Build Alternative

Under the No Build Alternative, the Express Lanes would not be extended beyond the current northern terminus at Old Dominion Drive. There would be no change to existing access points, and I-495 would remain in its present configuration. VDOT would continue maintenance and repairs of the existing roadway, as needed, with no substantial changes to current capacity or management activities.

1.2.2 Build Alternative

The Build Alternative would extend the existing four I-495 Express Lanes from their current terminus between the I-495/Route 267 interchange and the Old Dominion Drive Overpass north approximately 2.3 miles to the GWMP.

Additional improvements are anticipated to extend approximately 0.3 miles north of the GWMP to tie into the existing road network in the vicinity of the ALMB. The Build Alternative would retain the existing number of general purpose (GP) lanes within the study area.

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[18] For the air quality analysis, carbon monoxide was not evaluated specifically for the No-Build Scenario and is instead addressed by the FHWA-VDOT, *"No-Build Analysis Agreement for Air and Noise Studies"*, letter dated May 22, 2009.

Exhibit 1.1.1: I-495 Express Lanes Northern Extension Project Limits

Direct access ramps would be provided from the I-495 Express Lanes to the Dulles Toll Road and the GWMP. Access would also be provided between the I-495 GP and Express Lanes at the Route 267 interchange: from northbound GP lanes to northbound Express Lanes, and from southbound Express Lanes to southbound GP lanes, located within the current interchange footprint. These connections have been accounted for in the LOD and are described in more detail in the *I-495 Alternatives Technical Report* (VDOT, 2019a) and the *I-495 Traffic and Transportation Technical Report* (VDOT, 2019b).

The Build Alternative includes an approximately 3.1-mile 10-foot-wide shared-use path, consistent with the Fairfax County Countywide Trails Plan Map (FCDPZ, 2018) that is not provided under the existing condition.

1.3 Project Status in the Regional Transportation Plan and Program

As of the date of preparation of this analysis, the project is included in the currently conforming Visualize 2045 LRTP and FY 2019-2014 TIP[19]. The LRTP and TIP are developed by the NCRTPB, whose members include VDOT[20]."

Since the approval of the LRTP and TIP, VDOT has proposed changes to the project. To ensure that these changes would have no impact on the conformity finding, NCRTPB performed a sensitivity analysis that they documented in a June 30, 2019 letter to VDOT[21]. As stated in the letter, "*The proposed changes extend the existing temporary peak-period north bound shoulder express lane to the George Washington Parkway and make the shoulder lane a permanent component of the express lanes, add a new ramp from the west-bound Dulles Toll Road to the north-bound express lanes, and add two slip ramps just south of the Dulles Toll Road interchange.*"

Based on the results of the sensitivity analysis, NCRTPB drew the following conclusions[22]: "*Since the analysis shows that the proposed changes to the project would (1) result in non-substantive amount of change in regional emissions; (2) result in decreased emissions; and (3) result in emissions that are within the mobile budgets for the 2025 forecast year, we believe it is reasonable to conclude that the pollutant levels for other forecasts years (2030, 2040 and 2045) will also be within the mobile budgets.*"

These and other regional changes will be included in the upcoming air quality conformity analysis of the 2020 Amendment to the Visualize 2045 Plan and the FY2021-2024 TIP. This new regional air quality conformity determination is anticipated to be completed by March 2020.

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[19] See Section 2.2.1 "*Project-Inclusion in Regional Transportation Plans and Programs*" for background on the regulatory requirements.

[20] See: http://www.mwcog.org/transportation/tpb/.

[21] Letter from Kanathur Srikanth, Director, Department of Transportation Planning, Metropolitan Washington Council of Governments to Norman Whitaker, Transportation Planning Director, VDOT Northern Virginia District, June 30, 2019. . See: https://www.mwcog.org/events/2019/?F_committee=194, July Item 3 Letter, or https://www.mwcog.org/file.aspx?&A=aG2FDR8gA2PJr7stqM1MdqSjsI3CpsnEBd9V1uocMps%3d

[22] These results may also be considered to support application of 40 CFR 93.122(g), "*Reliance on previous emissions analysis*" for regional conformity demonstrations, given that the modeled de minimis change in emissions (of 0.0%, as reported in the June 30, 2019 NCRTPB letter) by definition may be considered to be not significant.

1.4 Summary of Traffic Data and Forecasts

Traffic forecasting and operations planning was completed for the I-495 NEXT project using a multi-step approach. This is documented in the *Scoping Framework Document for I-495 NEXT Project, FHWA Concurrence for Approach and Methodology* dated November 15, 2018, a copy of which can be found in **Appendix B**. At the time the study area, shown in **Figure 1.4.1**, was slightly different than the current project limits. The traffic analysis however covers a wider area so this slight variation in the project boundaries has no impact on the resulting traffic forecasts. The traffic forecasting consisted of two main parts:

Travel Demand Forecasting

- A traffic forecasting effort was done at the regional level utilizing the Metropolitan Washington Council of Governments (MWCOG) travel demand model calibrated to 2018 baseline data.
- The MWCOG model was strategically modified with specific alterations to improve the accuracy and reliability of forecasts for the I-495 study corridor, roadways connected to the corridor, and transit services in the vicinity of the corridor.
- The validation process focused on the I-495 Traffic Operations Analysis Study Area as shown in Exhibit 1.4.2. Comparisons were done between the daily counts versus model forecasts, peak period traffic counts to modeled data during the same periods, and AM and PM observed speeds and travel times to model speeds and travel times.
- The results of the modeling were used for ascertaining general traffic growth patterns/changes within the study area.
- Output volumes from the model, along with available traffic county data, was postprocessed using NCHRP 255/765 guidance to yield forecasted volumes
- Note that while the project is scheduled to open in 2023, VDOT has found that express lanes generally take 2-3 years to reach full utilization such that users become familiar with the system and its advantages. Therefore 2025 was modeled as this represents three years after the project opening and fully accounts for this phenomenon. As 2025 would also include three additional years of growth in background traffic, it is also a more conservative (higher) traffic volume for use in the air quality analysis.
- Diagrams of the final daily traffic forecasts for the mainline corridor can be found in **Appendix A,** along with the baseline 2018 intersection counts.
- Additional information can be found in the *I-495 NEXT Travel Demand Forecasting Framework Memorandum* in **Appendix C**.

Traffic Operations Analysis

- Surface street intersection operations were evaluated through a combination of Synchro 10 (in order to develop preliminary optimization for phasing and signal timing) and VISSIM (for microsimulation and analysis). Transit routes and stops were coded into the study area VISSIM network where they affect or could affect I-495 and related facility operations.
- VISSIM Version 9.0, Build 13 was also used to perform a comprehensive network traffic analysis performed within the study area limits and on I-495 itself.
- The intersection operations analyses were important for the air quality study as they were used to rank the intersections for evaluation.

- The extent of the Traffic Study Area is shown in **Figure 1.4.2**
- A summary of the intersection operations analyses, including a consistent set of Measures of Effectiveness (MOES), is provided in **Appendix D**
- The technical memorandum *I-495 NEXT Traffic Operations Analysis Framework* provides additional detail and can be found in **Appendix E**

Exhibit 1.4.1: Project Study Area as per the Traffic Analysis

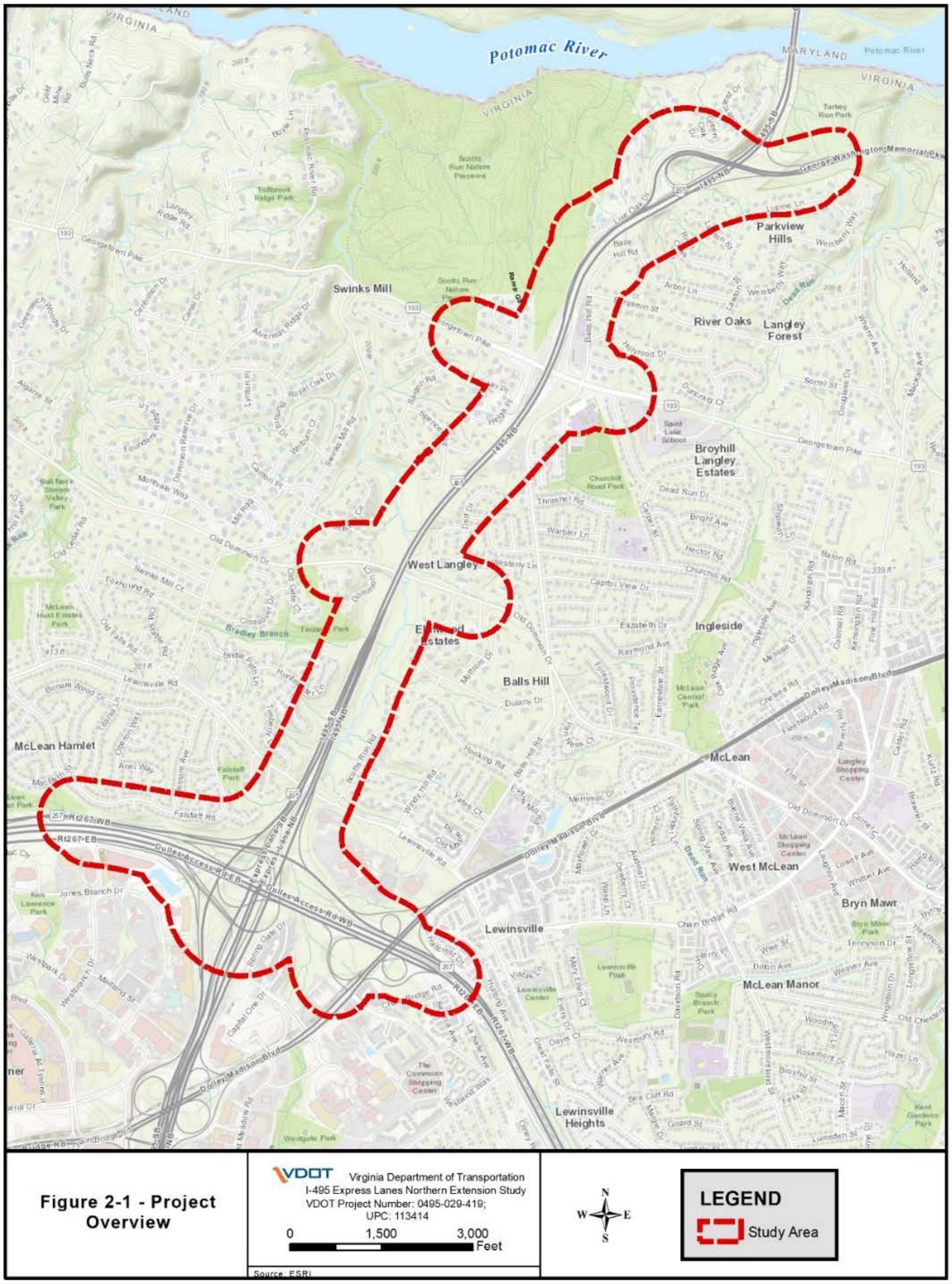

Exhibit 1.4.2: Traffic Study Area

Source: Scoping Framework Document for I-495 NEXT Project, Kimley Horn, November 15, 2018

2.0 Regulatory Requirements and Guidance

2.1 National Environmental Policy Act of 1969 (NEPA)

Federal requirements for air quality analyses for transportation projects derive from the National Environmental Policy Act (NEPA) and, where applicable, the federal transportation conformity rule (40 CFR Parts 51 and 93). NEPA guidance for air quality analyses for transportation projects may be found on or via the FHWA website for planning and the environment[23].

2.1.1 FHWA Guidance for Implementing NEPA for Air Quality

For purposes of NEPA, general guidance for project-level air quality analyses is provided in the FHWA 1987 Technical Advisory 6640.8A, "*Guidance for Preparing and Processing Environmental and Section 4(f) Documents*"[24]. That guidance focuses on carbon monoxide. FHWA provides separate guidance for mobile source air toxics (MSATs)[25,26], including responses to "Frequently Asked Questions" (FAQs)[27].

2.1.2 Programmatic Agreements

In order to streamline the preparation of project-level air quality analyses conducted for purposes of NEPA, VDOT has implemented several programmatic agreements with FHWA. Copies of current agreements are available on the VDOT website[28].

2.1.2.1 Project-Level Air Quality Analyses for Carbon Monoxide

In 2016, FHWA and VDOT executed the "*Programmatic Agreement for Project-Level Air Quality Analyses for Carbon Monoxide*" (2016 FHWA-VDOT PA, or 2016 PA), updating the prior (2009) PA. It specifies technical criteria for determining whether project-specific modeling for carbon monoxide will be needed and was developed based on templates originally created in the 2015 NCHRP study "*Programmatic Agreements for Project-Level Air Quality Analyses*"[29]. As the NCHRP template did not include skewed intersections, the 2016 FHWA-VDOT PA incorporates by reference the thresholds that were established for skewed intersections in the 2009 FHWA-DOT

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[23] See: http://www.fhwa.dot.gov/environment/index.cfm

[24] See: https://www.environment.fhwa.dot.gov/projdev/impTA6640.asp

[25] FHWA, "*INFORMATION: Updated Interim Guidance on Mobile Source Air Toxic Analysis in NEPA Documents*", October 18, 2016. See: http://www.fhwa.dot.gov/environment/air_quality/air_toxics/

[26] See: http://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/

[27] See: https://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/moves_msat_faq.cfm

[28] See: http://www.virginiadot.org/projects/environmental_air_section.asp

[29] ICF International, Zamurs and Associates LLC, and Volpe Transportation Systems Center, "Programmatic Agreements for Project-Level Air Quality Analyses", NCHRP 25-25 (78), 2015. http://apps.trb.org/cmsfeed/TRBNetProjectDisplay.asp?ProjectID=3311

PA. It is noteworthy that the 2015 NCHRP study report specifically acknowledged that its national-level templates were modeled on the 2009 FHWA-VDOT PA[30].

The 2009 FHWA-VDOT "*Project-Level Carbon Monoxide Air Quality Studies Agreement*"[31] (2009 PA) was based on the results of extensive modeling of worst-case analyses for skewed intersections, which are presented in a separate Technical Support Document[32]. The 2009 PA incorporated new technical criteria and thresholds (based on the worst-case modeling results) and represented a major update to prior agreements executed in 2004[33] and 2000[34].

2.1.2.2 No-Build Analysis Agreement for Air and Noise Studies

On May 22, 2009, FHWA and VDOT executed a "*No-Build Analysis Agreement for Air and Noise Studies*" (2009 No-Build Agreement) [35]. With regard to air quality, the 2009 No-Build Agreement only addresses CO. It requires:

> *…for transportation projects within the Commonwealth of Virginia that require a carbon monoxide (CO) air study under the current Project-Level CO Air Quality Studies Agreement in effect between VDOT and FHWA, the following will govern the need for analysis of the interim and design year no-build alternatives in CO air studies:*
>
> *A. Any project that qualifies for a Categorical Exclusion (CE) will be exempt from analysis of the no-build alternatives, although VDOT may choose to analyze the no-build alternatives if they determine it appropriate;*
>
> *B. Any project that qualifies for an Environmental Assessment (EA) will generally be exempt from analysis of the no-build alternatives, although VDOT may choose to analyze the no-build alternatives if they determine it appropriate;*
>
> *C. Any project that qualifies for an Environmental Impact Statement (EIS) will require analysis of the no-build alternative; …*

2.2 Transportation Conformity

The US Environmental Protection Agency (EPA) issued the federal transportation conformity rule (40 CFR Parts 51 and 93) pursuant to requirements in the Clean Air Act (CAA) as amended[36,37]. Copies of the EPA conformity regulation and associated guidance are available on

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[30] *Ibid*, page x.

[31] "*Project-Level Carbon Monoxide Air Quality Studies Agreement*", FHWA-VDOT letter agreement executed February 27, 2009.

[32] "*FHWA-VDOT Agreement On Project-Level Carbon Monoxide Air Quality Studies - Technical Support Document*", February 2009.

[33] FHWA-VDOT, "*Project Level Air Quality Studies Agreement*", letter dated August 4, 2004 from FHWA to VDOT.

[34] FHWA-VDOT, "*VDOT request to raise the ADT threshold at which quantitative project-level carbon monoxide analyses are conducted*", letter dated August 7, 2000.

[35] FHWA-VDOT, "*No-Build Analysis Agreement for Air and Noise Studies*", letter dated May 22, 2009.

[36] See: http://www.epa.gov/air/caa/.

[37] While corresponding state regulations for transportation conformity may apply, they generally focus on consultation requirements (rather than technical) and are therefore not addressed here. See: http://law.lis.virginia.gov/admincode/title9/agency5/chapter151/

the EPA website[38]. In general, the rule requires conformity determinations for transportation plans, programs and projects in "*non-attainment or maintenance areas for transportation-related criteria pollutants for which the area is designated nonattainment or has a maintenance plan*" (40 CFR 93.102(b))[39].

2.2.1 Project-Inclusion in Regional Transportation Plans and Programs

For projects in nonattainment or maintenance areas, the federal transportation conformity rule requires a currently conforming transportation plan and program at the time of project approval (40 CFR 93.114)[40] and for the project to be from a conforming plan and program (40 CFR 93.115)[41]. If the project is of a type that is not required to be specifically identified in the plan, the project must be consistent with the policies and purpose of the transportation plan and not interfere with other projects specifically included in the transportation plan (40 CFR 93.115(b)).

Additionally, the design concept and scope of the project as specified in the program at the time of the regional conformity determination should be adequate to determine its contribution to regional emissions, and any mitigation measures associated with the project should have written commitments from the project sponsor and/or operator (40 CFR 93.115(c)).

2.2.2 FHWA Categorical Finding for Carbon Monoxide

The federal transportation conformity rule at 40 CFR 93.123(a)(3) provides an option for the US Department of Transportation (US DOT), in consultation with EPA, to make a categorical hot-spot finding for CO based on appropriate modeling. In February 2014, the FHWA implemented a new categorical finding for CO, which they developed in consultation and cooperation with EPA. The FHWA updated the finding in 2017[42]. In concept, the FHWA categorical finding serves effectively the same purpose for conformity purposes as a programmatic agreement does for NEPA. Note, under the terms of the 2016 FHWA-VDOT PA previously referenced and/or the VDOT Resource Document (via the protocol stated in Sections 3.22 and 4.2.3), and although Virginia no longer has a maintenance area for CO, the federal categorical finding for CO may still be applied for NEPA purposes at the discretion of the Department.

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[38] See: http://www.epa.gov/otaq/stateresources/transconf/index.htm

[39] See Sections 3.1-3.2 for more information on nonattainment and maintenance areas and the attainment status of the project area.

[40] See: https://www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol20/xml/CFR-2014-title40-vol20-sec93-114.xml

[41] See: https://www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol20/xml/CFR-2014-title40-vol20-sec93-115.xml

[42] See: https://www.fhwa.dot.gov/environment/air_quality/conformity/policy_and_guidance/cmcf_2017/index.cfm

3.0 Ambient Air Quality

3.1 National Ambient Air Quality Standards (NAAQS)

Exhibit 3.1.1 presents the national ambient air quality standards (NAAQS) established by the EPA for criteria air pollutants, namely: carbon monoxide (CO), sulfur dioxide (SO_2), ozone (O_3), particulate matter (PM), nitrogen dioxide (NO_2), and lead (Pb). There are two types of NAAQS—primary and secondary: "*Primary standards provide public health protection, including protecting the health of "sensitive" populations such as asthmatics, children, and the elderly. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings.*"[43]

Areas that have never been designated by EPA as nonattainment for one or more of the NAAQS are classified as attainment areas (or as unclassifiable where monitoring data is insufficient, but the area is presumed to pass), while areas that do not meet one or more of the NAAQS may be designated by EPA as nonattainment areas for that or those criteria pollutants. Areas that have failed to meet the NAAQS in the past but have since re-attained them may be re-designated as attainment (maintenance) areas, which are commonly referred to as maintenance areas, once a maintenance plan has been approved by EPA.

EPA provides the following background information on CO[44]:

> *Carbon monoxide (CO) is a colorless, odorless gas emitted from combustion processes. Nationally and, particularly in urban areas, the majority of CO emissions to ambient air come from mobile sources. CO can cause harmful health effects by reducing oxygen delivery to the body's organs (like the heart and brain) and tissues. At extremely high levels, CO can cause death.*

Note EPA revoked the 1997 annual primary $PM_{2.5}$ NAAQS effective October 24, 2016 with the implementation of the 2012 $PM_{2.5}$ NAAQS[45]. With that revocation, conformity requirements were eliminated for northern Virginia for $PM_{2.5}$, which had been in maintenance for that pollutant. For reference, the NAAQS are presented in Exhibit 2.1.1, expressed in units of Parts Per Million (PPM), Parts Per Billion (PPB), and micrograms per cubic meter ($\mu g/m^3$).

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[43] From the preamble to the EPA NAAQS table: https://www.epa.gov/criteria-air-pollutants/naaqs-table

[44] See: https://www.epa.gov/co-pollution

[45] On August 24, 2016, EPA issued a final rule (81 FR 58010), effective October 24, 2016, on "*Fine Particulate Matter National Ambient Air Quality Standards: State Implementation Plan Requirements*" that stated, in part: "*Additionally, in this document the EPA is revoking the 1997 primary annual standard for areas designated as attainment for that standard because the EPA revised the primary annual standard in 2012.*" See: https://www.gpo.gov/fdsys/pkg/FR-2016-08-24/pdf/2016-18768.pdf .

Exhibit 2.1.1: National Ambient Air Quality Standards (US EPA Tabulation)

Pollutant		**Primary/ Secondary**	**Averaging Time**	**Level**	**Form**
Carbon Monoxide (CO)		Primary	8 hours	9 ppm	Not to be exceeded more than once per year
			1 hour	35 ppm	
Lead (Pb)		Primary and secondary	Rolling 3-month average	0.15 µg/m^3(1)	Not to be exceeded
Nitrogen Dioxide (NO_2)		Primary	1 hour	100 ppb	98th percentile of 1-hour daily maximum concentrations, averaged over 3 years
		Primary and secondary	1 year	53 ppb(2)	Annual Mean
Ozone (O_3)		Primary and secondary	8 hours	0.070 ppm(3)	Annual fourth-highest daily maximum 8-hour concentration, averaged over 3 year
Particle Pollution	$PM_{2.5}$	Primary	1 year	12.0 µg/m^3	Annual mean, averaged over 3 years
		Secondary	1 year	15.0 µg/m^3	Annual mean, averages over 3 years
		Primary and secondary	24 hours	35 µg/m^3	98th percentile, averaged over 3 years
	PM_{10}	Primary and secondary	24 hours	150 µg/m^3	Not to be exceeded more than once per year on average over 3 years
Sulfur Dioxide (SO_2)		Primary	1 hour	75 ppb(4)	99th percentile of 1-hour daily maximum concentrations averaged over 3 years
		Secondary	3 hour	0.5 ppm	Not to be exceeded more than once per year

(1) In areas designated nonattainment for the Pb standards prior to the promulgation of the current (2008) standards, and for which implementation plans to attain or maintain the current (2008) standards have not been submitted and approved, the previous standards (1.5 µg/m^3 as a calendar quarter average) also remain in effect.

(2) The level of the annual NO_2 standard is 0.053 ppm. It is shown here in terms of ppb for the purposes of clearer comparison to the 1-hour standard level.

(3) Final rule signed October 1, 2015, and effective December 28, 2015. The previous (2008) O_3 standards additionally remain in effect in some areas. Revocation of the previous (2008) O_3 standards and transitioning to the current (2015) standards will be addressed in the implementation rule for the current standards.

(4) The previous SO_2 standards (0.14 ppm 24-hour and 0.03 ppm annual) will additionally remain in effect in certain areas: (1) any area for which it is not yet 1 year since the effective date of designation under the current (2010) standards, and (2)any area for which implementation plans providing for attainment of the current (2010) standard have not been submitted and approved and which is designated nonattainment under the previous SO_2 standards or is not meeting the requirements of a SIP call under the previous SO_2 standards (40 CFR 50.4(3)), A SIP call is an EPA action requiring a state to resubmit all or part of its State Implementation Plan to demonstrate attainment of the require NAAQS.

Source: Excerpted from: https://www.epa.gov/criteria-air-pollutants/naaqs-table, accessed 10/9/2019.

3.2 Air Quality Attainment Status of Project Area

The EPA Green Book[46] lists non-attainment, maintenance, and attainment areas across the nation. It lists the jurisdictions within the area in which the project is located as being in attainment for all the NAAQS except ozone.

The Virginia Department of Environmental Quality (VDEQ) provides general comments by jurisdiction on proposed projects. For the jurisdiction in which the project is located (Fairfax County), they state that[47]*:*

> *This project is located within a Marginal 8-hour Ozone Nonattainment area, and a volatile organic compounds (VOC) and nitrogen oxides (NOx) Emissions Control Area. As such, all reasonable precautions should be taken to limit the emissions of VOC and NOx. In addition, the following VDEQ air pollution regulations must be adhered to during the construction of this project: 9 VAC 5-130, Open Burning restrictions; 9 VAC 5-45, Article 7, Cutback Asphalt restrictions; and 9 VAC 5-50, Article 1, Fugitive Dust precautions.*

3.3 Air Quality Data and Trends

3.3.1 Carbon Monoxide (CO)

As shown in Exhibit 3.3.1, and due primarily to the implementation of more stringent vehicle emission and fuel quality standards, the national trend in ambient concentrations of CO is and has been downward for decades. The national trend is reflected in the relatively very low ambient CO concentrations observed in Virginia, as summarized in Exhibits 3.3.2 and 3.3.3. Currently, all values in Virginia are well under the one- and eight-hour NAAQS for CO.

3.3.2 Other Criteria Pollutants

VDEQ issues an annual report summarizing air quality monitoring data for the previous year and updating long-term trend data for certain of the criteria pollutants tabulated in Exhibit 3.1.1[48]. Exhibits 3.3.3 through 3.3.6 are excerpts from that report showing ambient air quality trends by pollutant over the previous decade. The trend lines are generally flat or downward, reflecting the benefit of emission reduction measures or programs implemented for both mobile sources (e.g., more stringent emission and fuel quality standards) and stationary sources (industry etc.). For these figures, pollutants are measured in parts per million (ppm) or parts per billion (ppb).

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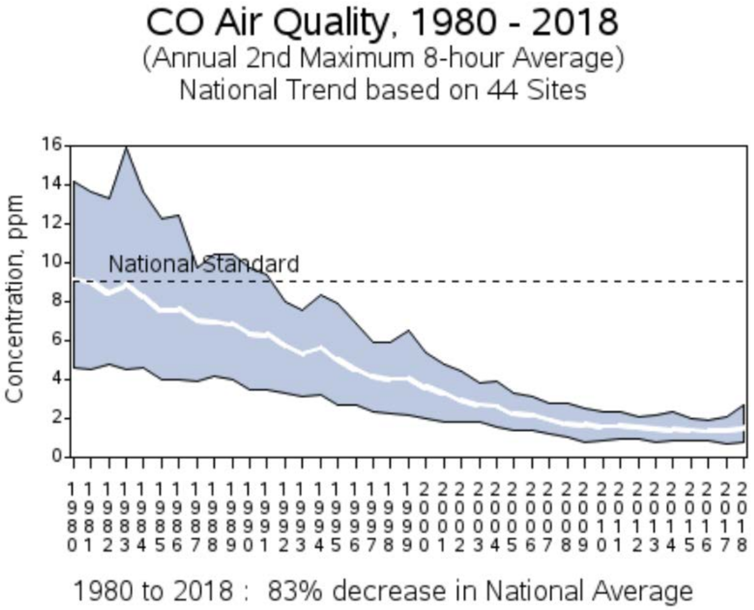
[46] EPA Green Book: https://www.epa.gov/green-book

[47] Spreadsheet entitled: "DEQ SERP Comments rev8b", March 2017

[48] The current edition (2016) of the VDEQ Annual Report does not provide a comparable chart showing recent trend lines for Pb, $PM_{2.5}$ or PM_{10}.

Exhibit 3.3.1: Nationwide Long-Term Trend in Ambient CO Concentrations



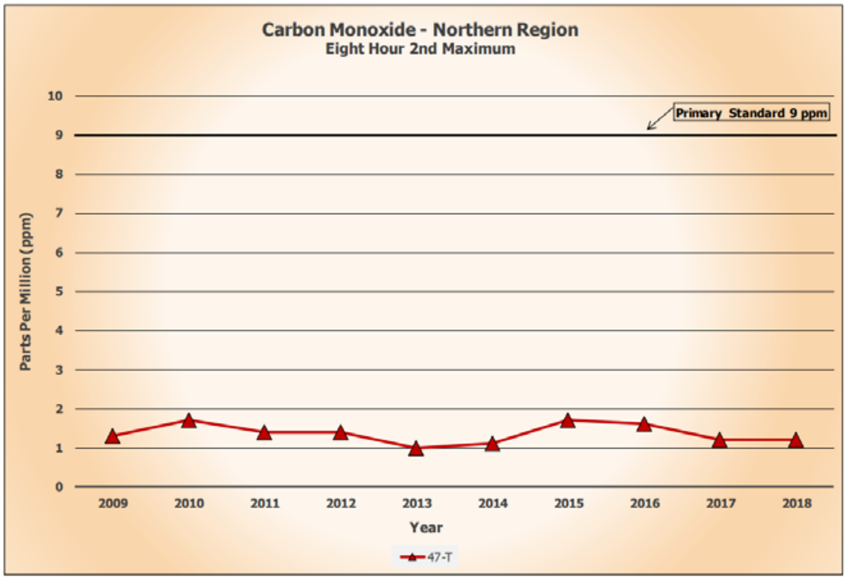
Source: https://www.epa.gov/air-trends/carbon-monoxide-trends, accessed October 7, 2019.

Exhibit 3.3.2: Ambient Concentrations of Carbon Monoxide in Virginia

Site	**2018**			
	1-Hour Avg. (ppm)		**8-Hour Avg. (ppm)**	
	1st Max.	**2nd Max.**	**1st Max.**	**2nd Max.**
(19-A6) **Roanoke Co.**	0.8	0.8	0.7	0.7
(72-M) **Henrico Co.**	1.1	1.1	0.8	0.8
(158-X) **Richmond**	1.4	1.3	1.3	1.2
(179-K) **Hampton**	0.8	0.7	0.6	0.6
(181-A1) **Norfolk**	1.8	1.4	1.0	1.0
(46-C2) **Fairfax Co.**	1.3	1.2	1.0	0.9
(47-T) Arlington **Co.**	21.6	1.6	1.6	1.2

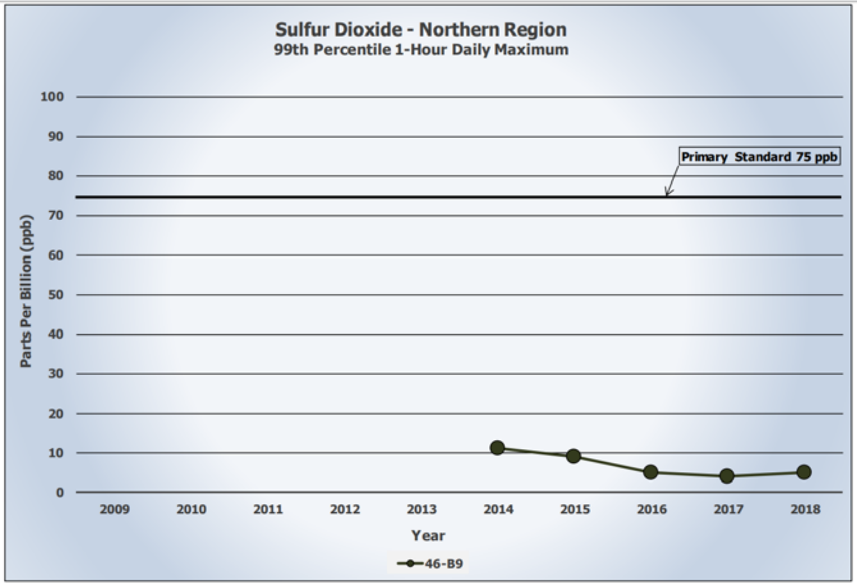
Source: Virginia Department of Environmental Quality, "Virginia Ambient Air Monitoring 2017 Data Report", November 2018. See: http://www.deq.virginia.gov/Programs/Air/AirMonitoring/Publications.aspx

Exhibit 3.3.3: Trend in Ambient CO Concentrations



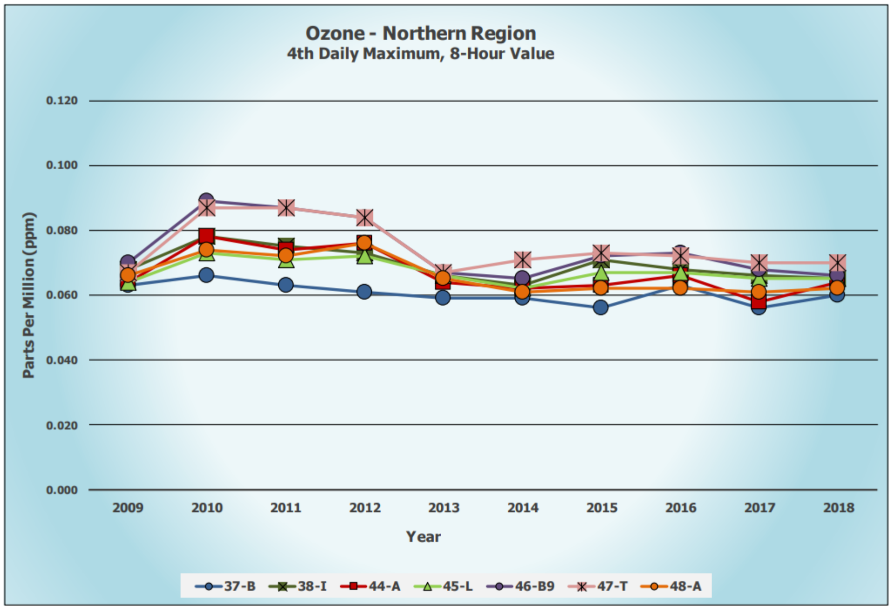
Source: Virginia Department of Environmental Quality, "Virginia Ambient Air Monitoring 2018 Data Report", October2019 See: http://www.deq.virginia.gov/Programs/Air/AirMonitoring/Publications.aspx

Exhibit 3.3.4: Trend for 1-hour Sulfur Dioxide (PPM) – Northern Region



Source: Virginia Department of Environmental Quality, "Virginia Ambient Air Monitoring 2018 Data Report", October 2019. See: http://www.deq.virginia.gov/Programs/Air/AirMonitoring/Publications.aspx

Exhibit 3.3.5: Trend for 8-hour Ozone (PPM) – Northern Region



Source: Virginia Department of Environmental Quality, "Virginia Ambient Air Monitoring 2018 Data Report", October 2019. See: http://www.deq.virginia.gov/Programs/Air/AirMonitoring/Publications.aspx

3.3.3 Mobile Source Air Toxics (MSATs)

The EPA Ambient Air Toxic Monitoring (ATMN) is an important part of the effort to control air toxics pollutant which consists of both national and community-scale programs. In support of this national effort and for the benefit of the commonwealth, and additional information can be found on the VDEQ website[49]. Briefly, the VDEQ currently operates two ambient air toxics monitoring programs in Virginia:

National Air Toxics Trends Stations Network:
In 2002, EPA deployed the National Air Toxics Trends Stations (NATTS) network. The objective for the NATTS network is to provide long-term monitoring data for a limited number of air toxics across representative areas of the country in order to establish overall trends for these pollutants. In July 2008, the Virginia Department of Environmental Quality began operating a NATTS located at the MathScience Innovation Center, 2401 Hartman Street, Richmond.

Urban Air Toxics Monitoring Network:
In 2002, The Virginia Department of Environmental Quality established Urban Air Toxic Monitoring (UATM) stations as part of ATMN. These stations are the State/EPA Region III cooperative-monitoring sites. Data collected from these sites are used to characterize the present urban air toxic concentrations including trend analysis. The UATM allows DEQ to assess the reasonableness of the National Air Toxics Assessment (NATA).

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[49] See: https://www.deq.virginia.gov/Programs/Air/AirMonitoring/AirToxicMonitoringNetwork(ATMN).aspx accessed January 2, 2020

4.0 Project Assessment

4.1 Application of the VDOT Resource Document

In 2016, the Department created the VDOT Project-Level Air Quality Resource Document and associated online data repository to facilitate and streamline the preparation of project-level air quality analyses for purposes of NEPA and conformity[50]. Inter-agency consultation was conducted with FHWA Division and Headquarters and other agencies (including EPA) before the Resource Document was finalized. The Resource Document was updated in 2018 to address changes in applicable regulation and guidance.

With regards to this project, the models, methods/protocols and assumptions as specified or referenced in the VDOT Resource Document were applied without substantive change as defined in that document. The memorandum in **Appendix I** details the air quality modeling approach as originally envisioned.

4.2 Carbon Monoxide Assessment

4.2.1 Background

As presented previously (Section 3.3), ambient concentrations of CO, both nationally and locally, have decreased since the standard was introduced in 1971 to levels well below the applicable NAAQS. This has occurred as a result of improved emission control technology and in spite of concurrent increases in VMT. The reduced levels of CO are the result of ever more stringent emission standards along with implementation of more stringent fuel quality standards.

Exhibits 4.2.1 and 4.2.2 present, respectively, the long-term trends in vehicle-miles-traveled (VMT) at the national level (public road) and recent trends in VMT and related statistics for Virginia. At the national level, VMT has increased significantly over the past several decades, with local trends generally reflecting the national. Exhibit 4.2.3 presents the increasingly more stringent new vehicle exhaust emission standards for CO as introduced by the US EPA over the past few decades, which served to offset the growth in VMT.

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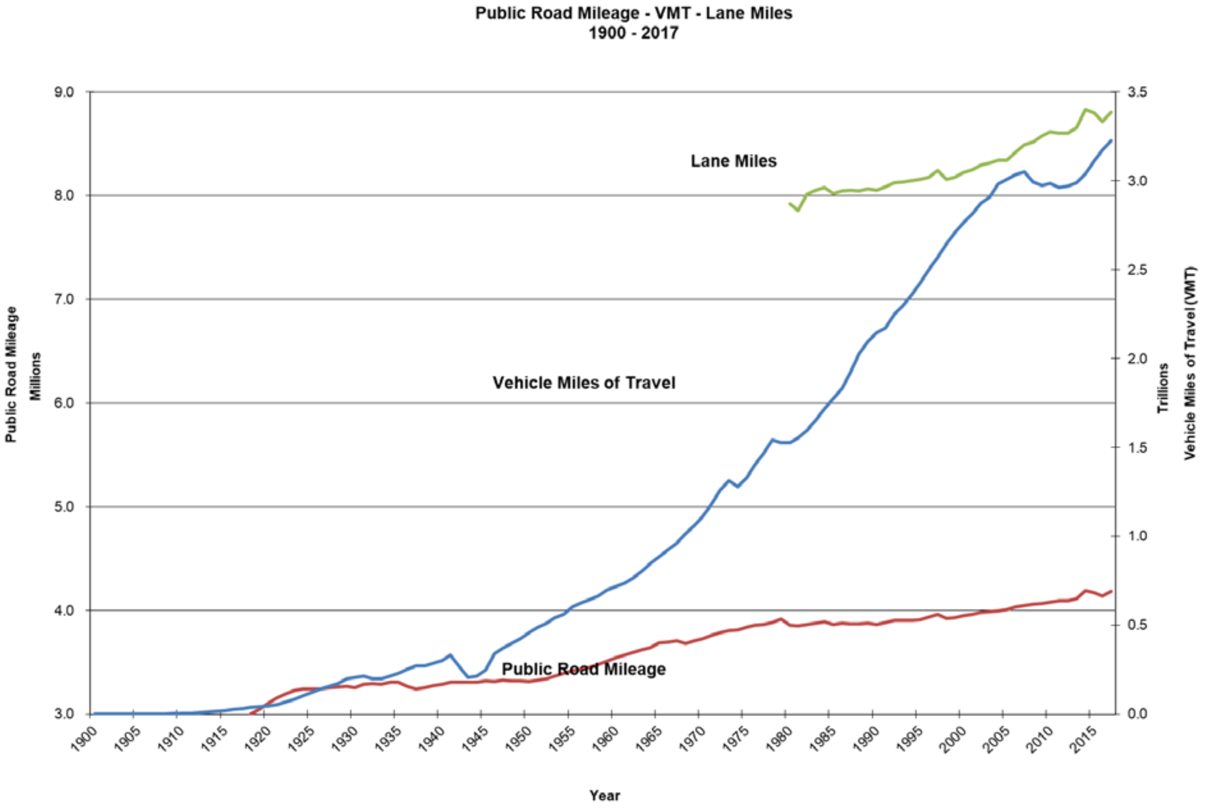
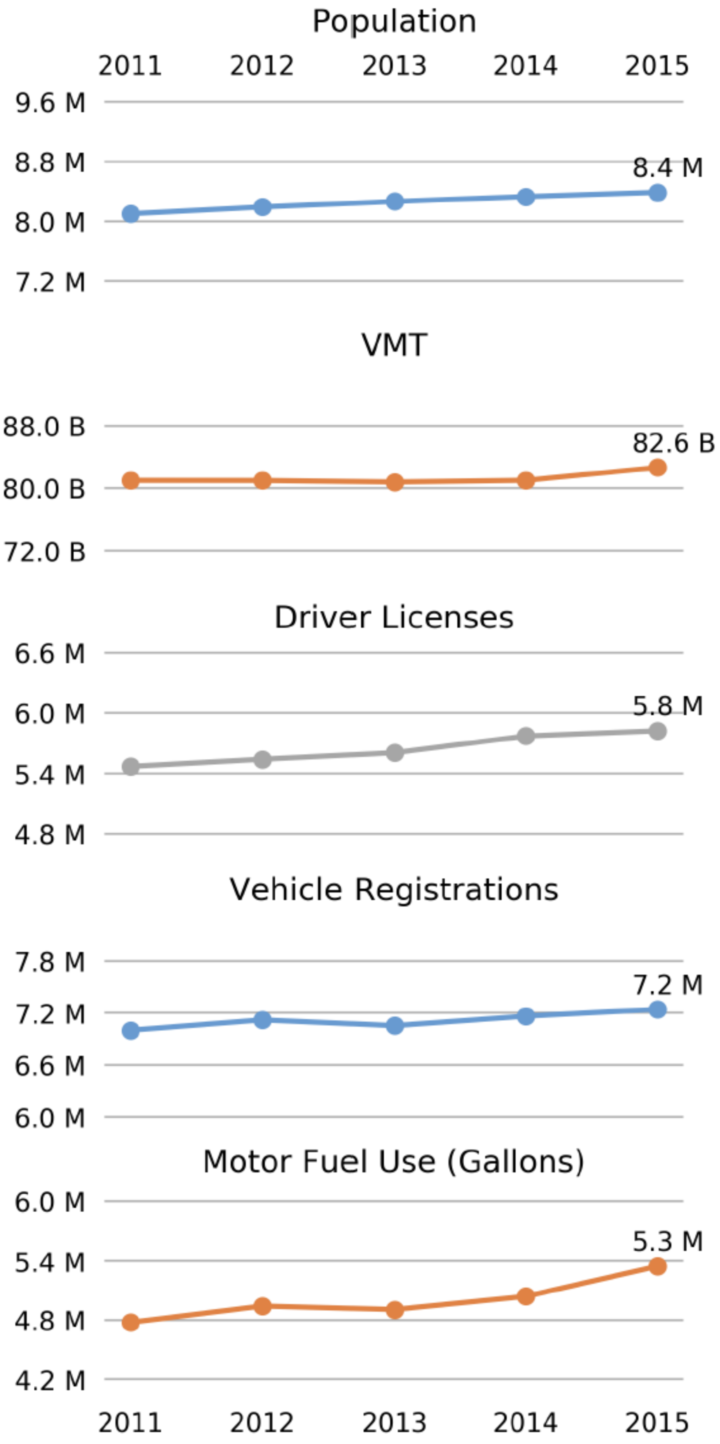
[50] See: http://www.virginiadot.org/projects/environmental_air_section.asp Accessed October 31, 2019

Exhibit 4.2.1: Public Road Mileage, Lane-Miles and Vehicle Miles Traveled (VMT)



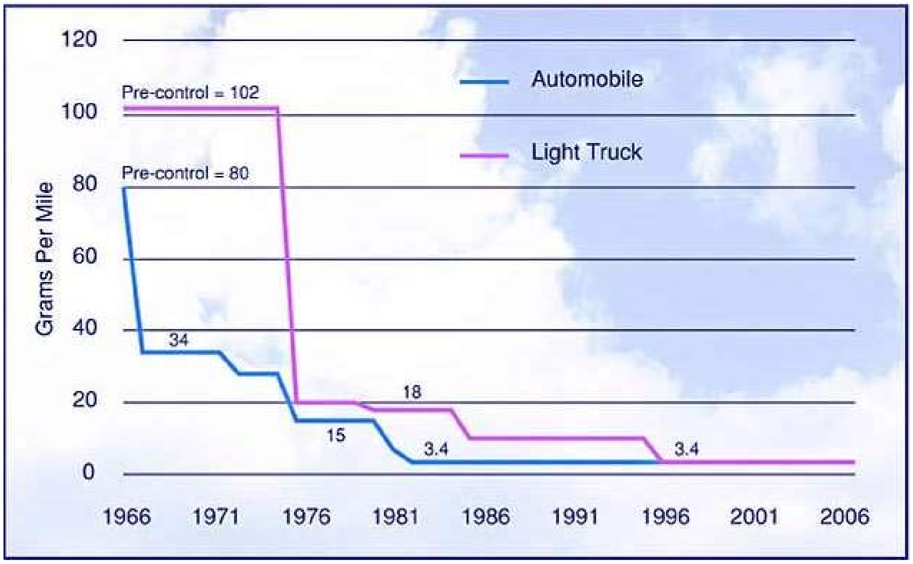
Source: FHWA Office of Highway Policy Information web site, accessed 10/7/2019.
See: https://www.fhwa.dot.gov/policyinformation/statistics/2017/vmt421c.cfm

Exhibit 4.2.2: Recent Trends in VMT and Related Statistics for Virginia



Source: FHWA Office of Highway Policy Information web site, accessed 10/7/2019. https://www.fhwa.dot.gov/policyinformation/statistics/abstracts/2015/virginia_2015.pdf

Exhibit 4.2.3: Federal Emission Standards for CO for New Automobiles and Light Trucks



Source: U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. Transportation Energy Data Book: Edition 24, ORNL-6973. December 2004.

4.2.2 Level of Analysis Determination

4.2.2.1 Screening for Quantitative or Qualitative Analysis

The project is not exempt based on EPA's list of exempt projects and, as such, a CO evaluation is required.

4.2.2.2 Application of Other Programmatic Agreements

The 2009 FHWA-VDOT No-Build Agreement (Section 2.1.2.2) may be applied for this project, therefore project-specific modeling of the no-build alternative is not required. The criteria specified in the No-Build Agreement are met for this project given that:

- the project location is not within a maintenance area for CO, and
- an Environmental Impact Statement (EIS) is not planned.

4.2.3 Worst-Case Modeling Overview

A worst-case modeling approach was applied throughout this analysis. This very conservative approach by design uses worst-case assumptions for modeling inputs so that the results (modeling estimates for emissions and ambient concentrations) will be significantly worse than (i.e., in excess of) what may reasonably be expected for the project. If the applicable NAAQS for CO are still met despite the worst-case modeling assumptions, then there is a high level of confidence that the potential for air quality impacts from the project would be minimal.

It bears noting that the underlying reason that a worst-case modeling approach may be applied for CO is that vehicle emission rates are currently very low as a result of stringent emission and fuel quality standards that have been implemented in order to reduce emissions. That is, improved fuel quality combined with continuing turnover nationwide of the on-road motor vehicle fleet to vehicles designed and constructed to meet increasingly more stringent EPA exhaust emissions standards have resulted in a long-term downward trend in emissions. As a result of the reduced emissions, the long-term trend in ambient concentrations for CO has also been steadily downward, despite increasing VMT nationwide and locally. Background concentrations for CO are now very low and well under the NAAQS, both nationwide and in Virginia.

All modeling conducted for this project was consistent with applicable federal requirements and guidance (as referenced in Section 2) as well as the VDOT Project-Level Air Quality Resource Document. EPA guidance, which is more detailed and technically only required for conformity applications, was also applied for this project for purposes of increased transparency.

4.2.4 Traffic Data and Forecasts for the CO Analysis

As described in Section 1.2 of this report, a traffic analysis was completed for this project with the results being used as the basis for the air quality analysis. Traffic forecasts were developed to represent existing 2018 baseline conditions, as well as both no-build and build scenarios for the Interim/Opening Year (2023) and the Design Year (2045). In the case of the opening year, VDOT recognizes that express lanes such as those proposed for 495 NEXT generally take two to three years to reach equilibrium/full utilization. To account for this, traffic forecasting was completed for a 2025 analysis year instead of the expected opening year of 2023. These 2025 forecasted volumes were combined with 2021 emission rates used to represent the 2023 opening year. The higher future year traffic volumes combined with higher near-term emission rates yields a conservative (high) forecast for emissions for both the MSATs and CO analyses. The travel demand modeling and traffic forecasting are discussed in more detail in the reports and summary tables in **Appendices B-F**.

The traffic analysis identified all intersections impacted by the project. Following EPA guidance[51,52] and consistent with the VDOT Resource Document, the top congested and highest volume intersections were identified. They are shown in Exhibit 4.2.4. Ten of the intersections were selected for ranking for worst-cast modeling; many of the others were forecasted to operate at LOS C or better and would not require analysis. These ten intersections served as the starting point for selecting the top three worst-case intersections. The traffic operation analysis, which is summarized in Appendix D, used a combination of both Synchro for the wider area and a more compact VISSIM simulation of the area of most interest nearest the proposed express lanes. Exhibit 4.2.4 shows the extent of the Synchro and VISSIM networks. From these simulations the delay, level of service and traffic volume for every intersection identified was estimated, and the results placed in an Excel table in order to rank the intersections.

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[51] EPA guidance was applied (directly or modified, e.g., to rank only the top ten intersections) although not strictly required for this project, as it is not in a nonattainment or maintenance area for carbon monoxide and therefore not subject to EPA transportation conformity rule requirements or guidance for carbon monoxide.

[52] "*1992 Guideline for Modeling Carbon Monoxide from Roadway Intersections,*" (EPA-454/R-92-005, November 1992); available online at: www.epa.gov/scram001/guidance/guide/coguide.pdf.

Exhibit 4.2.4: Intersections Considered for CO Modeling

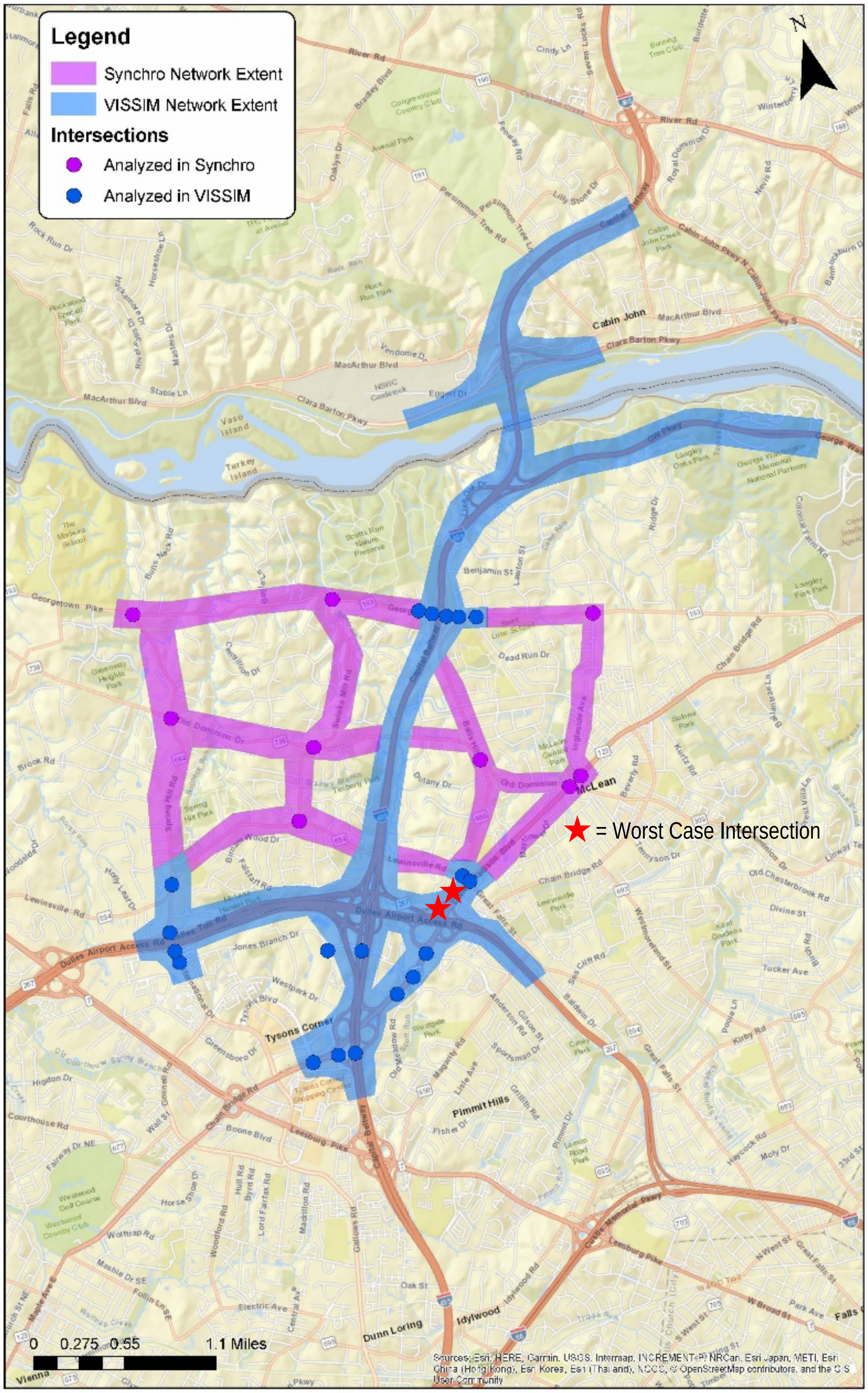

Exhibit 4.2.5: Study Intersections Considered for CO Modeling

Signalized Intersection	**2045 Build**		
	Volume	LOS	Delay
Route 123 and Tysons Boulevard	6,763	F	207.4
Route 123 and Capital One Tower Drive/ Old Meadow Road	6,021	E	78.1
Route 123 and Scotts Crossing Boulevard/ Colshire Drive	5,900	E	71.9
Route 123 and NB I-495 Ramp	5,649	≤ C	24.1
Route 123 and EB DTR/SB I-495 C-D Road	5,266	≤ C	10.1
Route 123 at Old Dominion Drive	4,985	D	36.4
Route 123 and Lewinsville Road/ Great Falls Street	4,749	F	253.4
Route 123 and Route 267 Eastbound Off-Ramp/ Anderson Road	4,181	F	86.8
Route 123 at Ingleside Avenue	3,725	≤ C	2.0
International Drive and Spring Hill Road/ Jones Branch Drive	3,023	D	54.1

If the worst-case intersections do not show an exceedance of the NAAQS, then none of the intersections would be expected to do so. In other words, the intersections selected for worst-case modeling following EPA guidance would have the highest potential CO impacts; intersections with lower traffic volumes and less congestion would have lower potential for ambient air quality impacts. Thus, if no exceedances of the CO NAAQS are modeled for the opening and design years for each of the worst-case intersections evaluated, then it can reasonably be assumed that the project would not cause or contribute to a violation of the CO NAAQS at any location throughout the project corridor.

Exhibit 4.2.5 shows the volumes and measures of effectiveness used to rank the intersections in order to identify the worst-case locations. The three locations of interest were the following intersections:

- Route 123 and Tysons Boulevard
- Route 123 and Capital One Tower Drive/ Old Meadow Road
- Route 123 and Scotts Crossing Boulevard/ Colshire Drive

While additional intersections could have been analyzed, the three selected, in particular Route 123 and Scotts Crossing Boulevard/ Colshire Drive, are the largest in the study area.

In addition to the intersections evaluated, CO concentrations along the I-495 mainline were modeled, again using a worst-case modeling approach in which volumes at capacity were substituted for forecasted volumes (which were lower). Given this approach, traffic volumes and therefore modelled emissions and near-road concentrations would be highest where there is the greatest confluence of travel lanes. As such, the interchange of I-495 with the Dulles Toll Road was also selected for worst-case modeling for CO.

Exhibit 4.2.6 below compares the assumed worst-case traffic volumes (which are consistent with the values specified in the VDOT Resource Document) to the forecasts developed by the project traffic forecasting team. The forecasted volumes are substantially lower than the assumed worst-case volumes in each scenario in all cases.

4.2.5 Alternatives Modeled

There is only one preferred alternative for this study. While there are detailed projections of the expected traffic volumes at each of the worst-case intersections, a worst-case analysis was performed with traffic volumes set to the maximum throughput, as suggested in the VDOT Resource Document. An analysis was done representing the opening year (2023 – represented by using 2025 traffic volume forecasts combined with 2021 emissions rates) and the design year (2045) of the project.

4.2.6 Worst-Case Modeling Configuration

The three intersections identified as the worst-case locations remain relatively unchanged from the current configuration in all future year scenarios, both the build and no-build. As there is only one preferred alternative being pursued at this time, the worst-case modeling configurations at these locations would be as follows:

- At all locations, 6-lanes in each direction was assumed on Route 123 itself, 5-through/through-&-right lanes plus an additional lane to account for the left turn storage lanes.
- The cross-streets were modeled as follows: 4 lanes on Tysons Boulevard in each directions, 3 lanes on Capital One Tower Drive & Old Meadow Road, and 3 lanes on Colshire Drive and 5 lanes on Scotts Crossing Boulevard.
- For the interchange evaluation, 6-lanes on I-495 and 7-lanes on Dulles Toll Road in each direction was assumed.
- Volumes per lane were set to 1230 vehicles/hour/lane for the arterial roadways and 2400 vehicles/hour/lane for freeways. This far exceeds all the forecasted traffic volumes.
- Emission factors were taken for grades set to +5% on all approaches, and 0% on all departures. While this combination of grades is unlikely, 0% departure grades have higher emissions than the -5% that would logically be expected. This combination yields a conservative estimate of overall emissions. When compared to the available grades in the preliminary design work, this combination will lead to higher emissions being calculated than if emission factors for the actual (lower) grades were used.
- Speeds on arterials were conservatively assumed to be 45 MPH as the MOVES modeling yielded the highest emission rates at that speed (25, 35 and 45 MPH were investigated). Speed was assumed to be 55 MPH for freeways, the current posted speed.
- For the interchange analysis, no elevation difference was assumed between I-495 and the Dulles Toll Road. For dispersion modeling, emissions emitting from the same elevation would combine, as opposed to grade separated location where emissions would disperse above and below each other. This assumption would model higher CO concentrations at adjacent locations and would, again, yield more conservative results.

Exhibit 4.2.6: PM Peak Hour Volumes, Delay, and Level of Service (LOS) at Intersections

Signalized Intersection	**2045 Build**		
	Vol.	LOS	Delay *
Route 123 and Tysons Boulevard	6763	F	207.4
Route 123 and Capital One Tower Drive/ Old Meadow Road	6021	E	78.1
Route 123 and Scotts Crossing Boulevard/ Colshire Drive	5900	E	71.9
Route 123 and NB I-495 Ramp	5649	≤C	24.1
Route 123 and EB DTR/SB I-495 C-D Road	5266	≤C	10.1
Route 123 at Old Dominion Drive	4985	D	36.4
Route 123 and Lewinsville Road/ Great Falls Street**	4749	F	253.4
Route 123 and Route 267 Eastbound Off-Ramp/ Anderson Road**	4181	F	86.8
Route 123 at Ingleside Avenue	3725	≤C	2.0

*Delay is in seconds per vehicle

** While these locations have poor LOS, they both contain fewer lanes then top 3 intersections, hence the worst-case screening from the first three intersections also determines if these intersection would be of concern

Highlighted cells are the 3 worst-case intersections.

Exhibit 4.2.7: Comparison of Project Forecasts for Peak Hour Traffic Volumes and VDOT Resource Document Worst-Case Volumes as Applied for the CO Worst-Case Analysis

Location	PM Peak Hour Forecast Traffic Volumes			Worst-Case Volumes for CO Screening[53]			
					% Difference		
	2018*	2025	2045	Volume	2018	2025	2045
Route 123 and Tysons Boulevard	6,655	6,417	6,763	24,600	370%	383%	364%
Route 123 and Capital One Tower Drive/ Old Meadow Road	5,545	5,696	6,021	22,140	399%	389%	368%
Route 123 and Scotts Crossing Boulevard/ Colshire Drive	4,590	5,444	5,900	24,600	536%	452%	417%
I-495 and Dulles Toll Road	39,250	50,420	52,510	62,400	159%	124%	119%

* 2018 Volumes were obtained from the baseline count data, all other volumes are from intersection simulation/operations analyses

4.2.7 Emission Modeling

Modeling inputs are summarized in this section, with a summary of the key worst-case assumptions provided at the end. Appendix B provides additional background on modeling inputs as applied in this analysis.

4.2.7.1 Model Selection

The current official EPA emission model, MOVES2014b, was applied for this analysis[54]. It is the most recent and up-to-date version of the software from EPA.

4.2.7.2 Mapping of MOVES Model Vehicle and Road Types

For reference, Exhibit 4.2.8 presents the mapping for vehicle types between the MOVES model and the Highway Performance Monitoring System (HPMS). Exhibit 4.2.9 presents the corresponding mapping for road types between the MOVES model and federal functional classes.

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[53] Volumes represent Highway Capacity Manual (HCM) maximum capacity. These exceed actual volumes therefore yielding conservative (higher) results

[54] See: https://www.epa.gov/moves

Exhibit 4.2.8: MOVES Source Types and HPMS Vehicle Types

MOVES Source Types and HPMS Vehicle Types			
Source Type ID	**Source Types**	**HPMS Vehicle Type ID**	**HPMS Vehicle Type**
11	Motorcycle	10	Motorcycles
21	Passenger Car	25	Light Duty Vehicles Short and Long Wheelbase
31	Passenger Truck		
32	Light Commercial Truck		
41	Intercity Bus	40	Buses
42	Transit Bus		
43	School Bus		
51	Refuse Truck	50	Single Unit Trucks
52	Single Unit Short-haul Truck		
53	Single Unit Long-haul Truck		
54	Motor Home		
61	Combination Short-haul Truck	60	Combination Trucks
62	Combination Long-haul Truck		

Source: Excerpted from US EPA, "MOVES2014 and MOVES2014a Technical Guidance: Using MOVES to Prepare Emission Inventories for State Implementation Plans and Transportation Conformity", EPA-420-B-15-093, November 2015

Exhibit 4.2.9: Road Type Mapping

FFC	Federal Functional Class	MOVES RTypeID	MOVES Road Type
0	Off-Network	1	Off-Network
1	Rural Principal Arterial - Interstate	2	Rural Restricted Access
2 6 7 8 9	Rural Principal Arterial - Other Rural Minor Arterial Rural Major Collector Rural Minor Collector Rural Local System	3	Rural Unrestricted Access
11 12	Urban Principal Arterial - Interstate Urban Principal Arterial - Other Freeways or Expressways	4	Urban Restricted Access
14 16 17 19	Urban Principal Arterial - Other Urban Minor Arterial Urban Collector Urban Local System	5	Urban Unrestricted Access

4.2.7.1 MOVES Model Input Summary

Exhibit 4.2.10(a) and (b) present a summary of data and data sources for MOVES model inputs for the main screen and the project data manager respectively, as applied for the worst-case emission factor modeling for this project. As noted above, all modeling inputs were taken from or otherwise made consistent with those specified or referenced in the VDOT Resource Document[55], which includes data from the NCRTPB Air Quality Conformity Determination for the Visualize 2045 Long Range Transportation Plan and Fiscal Year 2019-2024 Transportation Improvement Program (Visualize 2045 Conformity Analysis). Note that the default files were readily available for 2017, 2021 and 2045, which did not correspond to the actual opening (2023) of the project. As average emission rates are forecasted to trend downwards over time as older vehicles meeting less stringent standards are retired and replaced with cleaner vehicles, selecting emission factors for 2021 instead of 2023 would serve as a worst-case assumption. Also, the selection of emissions rates for 2021 to represent 2023 simplifies the development of inputs for the MOVES model. Therefore, for both these reasons, 2021 emission factors were selected. Hour 5:00-5:59 p.m. was selected in MOVES modeling to represent PM peak hour scenario as the PM peak hour has higher traffic volumes than the AM peak hour, thus representing the worse-case traffic condition.

A representative example of a MOVES run specification file as applied in this project is provided in **Appendix H**.

Exhibit 4.2.10 (a): MOVES Input Summary for CO – Main Screen

Parameter	**MOVES Input**
Scale	Project
Time Spans	MOVES Time Aggregation Level: Hour Years: Opening (2023), and Horizon (2045) Month, Day & Hour: January, Weekday, 5:00-5:59 p.m.
Geographic Bounds	Fairfax County, VA
Vehicles/Equipment	Consistent with those files specified in the MOVES2014a files from Visualize 2045 Air Quality Conformity Analysis for Fairfax County
Road Types	Urban Unrestricted Access & Urban Restricted Access
Pollutants and Processes	CO Exhaust and Crankcase Exhaust (running emissions only)
Output	Units: grams, million BTU, and miles
Emission Factor Script	CO_CAL3QHC_EF.sql (EPA)

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[55] The tables are based on the one presented in Appendix E1 of the VDOT Resource Document (2016),

Exhibit 4.2.10 (b): MOVES Input Summary for CO – Project Data Manager

Hoteling	MOVES Defaults
I/M Programs	Consistent with the MOVES2014a files from Visualize 2045 Air Quality Conformity Analysis for Fairfax County
Retrofit Data	MOVES Defaults
Age (Vehicle Registration) Distributions	Consistent with the MOVES2014a files from Visualize 2045 Air Quality Conformity Analysis for Fairfax County
Fuels	Consistent with the MOVES2014a files from Visualize 2045 Air Quality Conformity Analysis for Fairfax County
Meteorology Data	Consistent with the MOVES2014a files from Visualize 2045 Air Quality Conformity Analysis for Fairfax County
Links	Generic links including: *a.* Idle links: assume average speed 0, average road grades from 5% to -5% with 1 degree increment, and MOVES road type 5 (urban unrestricted road type) *b.* Free flow inks: assume average speed from 25mph to 45mph with 5 mph increment for MOVES road type 5 (urban unrestricted road type), and average speed of 55mph for MOVES road type 4 (urban restricted road type), average road grades from 5% to -5% with 1 degree increment
Link Source Type Hour Fraction	Estimated from source type population MOVES2014a inputs consistent with the Visualize 2045 Air Quality Conformity Analysis for Fairfax County
Link Drive Schedule (optional)	Not applied.
Operating Mode Distribution (optional)	
Off-Network	Not applicable

4.2.7.2 Modeling Results for Emission Factors

Exhibit 4.2.11 presents the final set of emission factors that were generated using MOVES2014b and applied for dispersion modeling for the worst-case analyses for this project. For purposes of worst-case modeling, 5% grades exceed those likely in the final design, making them conservative. Also, 2021 is two years earlier than the 2023 opening year. As average emission rates are anticipated to decrease over time, the emissions rates used are higher than the rates for the exact 2023 opening year.

For reference, **Appendix G** provides detailed exhibits that present the modeled emission factors for this project as a function of average speed and average road grade for local streets (urban unrestricted access facilities), for each of the project opening and design years respectively. For this project, emission factors were taken directly from the modeling results. Note modeled emissions are sensitive to both speed and average road grade.

Exhibit 4.2.11: MOVES Fleet Average Worst-Case CO Emission Factors Summary

MOVES Road Type	Speed (mph)	Emission Factor (g/mi)*		Road Grade (%)
		2021	2045	
5	Idle	5.42	1.92	0
5	45	5.33	2.11	5
4	55	5.69	2.29	5

**Grams per vehicle hour for idle operation*

4.2.8 Dispersion Modeling

Worst-case modeling inputs for dispersion modeling are summarized in this section. Exhibit 4.2.12 provides detailed dispersion (and emission) modeling inputs for CO as applied in this analysis.

4.2.8.1 Model Selection

The current official EPA air quality (dispersion) model, CAL3QHC Version 2.0, was applied for this analysis[56]. Consistent with the VDOT Resource Document, a graphical user interface (*Cal3i*) was applied to streamline the file preparation and modeling process. *Cal3i* was developed by FHWA; its predecessor *Cal3Interface* was initially released in December 2006, with subsequent periodic updates. By assisting modelers in specifying appropriate inputs for worst-case scenario modeling and screening analyses, the FHWA software interface helps guide and streamline the modeling process, improve quality control and assurance, and minimize time and costs for modeling[57].

4.2.8.2 CAL3QHC Modeling Inputs

Exhibit 4.2.12 presents the worst-case modeling inputs applied for this analysis. As noted with the table, the inputs were taken from or made consistent with those specified in the VDOT Resource Document. Sample copies of CAL3QHC input files and output files (generated using CAL3i) are provided in **Appendix H** to this report.

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[56] CAL3QHC may be applied for screening analyses for CO, per Section 4.2.3.1(b) of "*Revisions to the Guideline on Air Quality Models: Enhancements to the AERMOD Dispersion Modeling System and Incorporation of Approaches to Address Ozone and Fine Particulate Matter*". See: https://www.gpo.gov/fdsys/pkg/FR-2017-01-17/pdf/2016-31747.pdf

[57] FHWA develops and maintains graphical user interface software to facilitate and streamline dispersion modeling for state DOTs and other users. *Cal3Interface* was originally designed as a user-friendly interface model for the US EPA CALINE3 and CAL3QHC models. It was released in December 2006 and has been updated periodically since. The latest version ("*Cal3i*") is based upon their initial version and includes significant new features and enhancements. For more background on the *Cal3Interface* model and the FHWA worst-case scenario modeling guidance, see:

- M. Claggett (FHWA), "CAL3Interface – A Graphical User Interface for the CALINE3 and CAL3QHC Highway Air Quality Models", ca 2006.
- M. Claggett (FHWA), "Update of FHWA's Cal3Interface – A Graphical User Interface for the CALINE3 and CAL3QHC Highway Air Quality Models", ca 2008

Receptor locations (geographical locations or points for which CO concentrations are estimated with the model) were generally determined following EPA guidance as incorporated into the FHWA Cal3i software package. For worst-case modeling purposes, all receptors were located along the default right-of-way edge. The receptors were located:

- at the corners of the roadway intersections or crossings (i.e., at the intersection of the right-of-way edges);
- along each side of the intersecting roadways at 82 feet (25 meters) and 164 feet (50 meters) from the corners (as the segment length permits); and
- at or near the midpoint of each side of the intersecting roadways.

Exhibit 4.2.13 (a) and Exhibit 4.2.13 (b) present the worst-case configuration for the build alternative as modeled for the project. Note, to simplify the modeling and as a conservative (worst-case) approach, turn lanes were treated as full length through and turn lanes. All the lanes would carry worst-case traffic volumes. Receptor locations are shown in the exhibit.

4.2.8.1 Modeling Results for Carbon Monoxide

Exhibit 4.2.14 presents the forecast maximum concentrations for CO for the worst-case scenarios modeled. All forecasts include background concentrations as noted previously. The persistence factor to convert 1-hr to 8-hr CO concentrations was 0.78 as per the VDOT Resource Document.

As shown in Exhibit 4.2.14, modeled emissions and maximum concentrations are highest for the project-opening year. For the Route 123 and Tysons Boulevard intersection, the forecast maximum concentrations for CO reach 5.7 and 4.6 ppm in the project opening year, respectively, against the one- and eight-hour standards of 35 and 9 ppm. The location of the forecast maximum concentration for the intersection is the receptor highlighted in red in Exhibit 4.2.13 (a), located at the northwest corner of the intersection. The forecast peak concentrations drop to 3.2 and 2.6 ppm respectively for the one- and eight-hour standards for the design year.

For the Route 123 and Capital One Tower Drive/ Old Meadow Road intersection, the forecast maximum concentrations for CO reach 5.6 and 4.5 ppm in the project opening year, respectively, against the one- and eight-hour standards of 35 and 9 ppm. The location of the forecast maximum concentration for the intersection is the receptor highlighted in red in Exhibit 4.2.13 (b), located at the northwest corner of the intersection. The forecast peak concentrations drop to 3.2 and 2.6 ppm respectively for the one- and eight-hour standards for the design year.

For the Route 123 and Scotts Crossing Boulevard/ Colshire Drive intersection, the forecast maximum concentrations for CO reach 5.8 and 4.7 ppm in the project opening year, respectively, against the one- and eight-hour standards of 35 and 9 ppm. The location of the forecast maximum concentration for the intersection is the receptor highlighted in red in Exhibit 4.2.13 (c), located at the southeast corner of the intersection. The forecast peak concentrations drop to 3.2 and 2.6 ppm respectively for the one- and eight-hour standards for the design year.

Exhibit 4.2.12: CAL3QHC Worst-Case Analysis Inputs

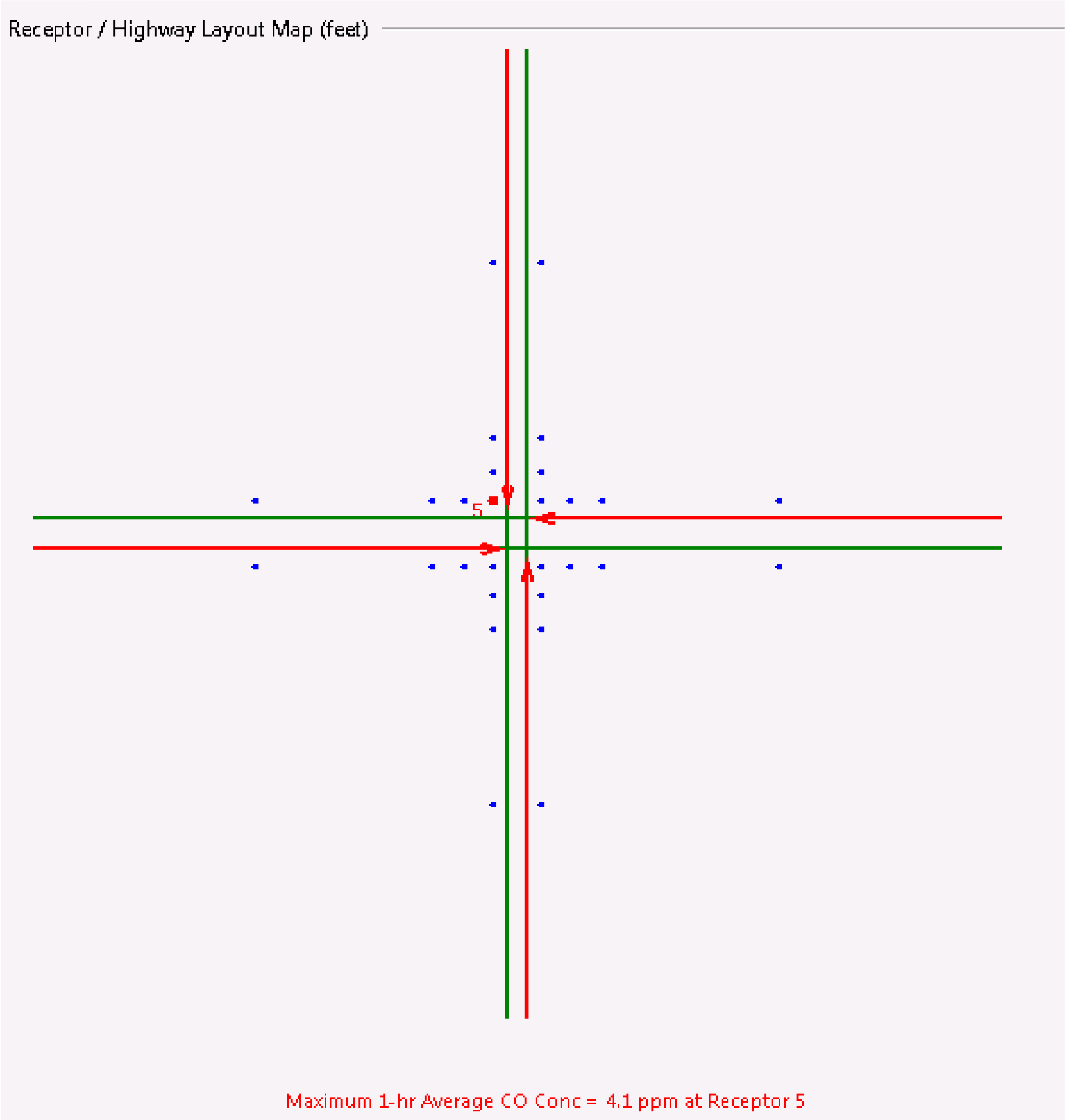
CAL3QHC Parameters	**Typical Worst-Case Analysis Inputs***
Surface Roughness Coefficient (cm)	Urban = 108 (consistent with FHWA Categorical Finding)
Wind Speed (meters per second)	1.0
Wind Direction Increments (degrees, multipliers)	10 (1-36)
Stability Class	Urban Areas: 4 (D-Neutral)
Mixing Height (meters)	1000
Setting Velocity (cm/s)	0
Deposition Velocity (cm/s)	0
Median Width (ft)	▪ Street:0 ▪ Freeways: 3
Source Height (ft)	0
Receptor Height (ft)	5.9
Receptor Locations	Along the right of way edge, with defaults of 10 feet for intersections and 20 feet for freeways.
Background Concentration (ppm)	Zero (as input to CAL3QHC) *1.6 ppm (One-hour) & 1.4 ppm (eight-hour), as added to CAL3QHC modeling results (VDOT Resource Document values for northern Virginia).*
Persistence Factor	0.78 (default for NOVA from VDOT Resource Document)
Averaging Time (min)	60min
Volumes (vehicle per hour) (vph)	VDOT Resource Document defaults, which are based on the HCM (2010): ▪ Street (Metropolitan Areas): 1,230 vphpl x no. of lanes ▪ Freeways: 2,400 vphpl x no. of lanes
Saturation Flow Rate (vphpl)	VDOT Resource Document default for a metropolitan area with population>250,000 (based on HCM 2010, Exhibit 18-28): 1,900 veh/h/ln
Signal Data	▪ Defaults per HCM 2010 (Exhibit 18-28) and the CAL3QHC User's Guide, EPA-454/R-92-006 (Revised), 1995: - Signal Type = 1 (pre-timed) - Arrival Rate = 3 (average) ▪ Defaults per CAL3QHC User's Guide: - Clearance Lost Time (s) = 2 ▪ Worst-case defaults where project-specific information is not available: - Average Cycle Length (s): 120 - Average Red Time Length (s): 68
Link Width (ft)	• Free flow link width = width of the traveled roadway (all lanes), plus 3 m (10 ft) on each side of the roadway to account for the mixing zone created by the wake of moving vehicles • Queue link width = the width of the traveled roadway only • Lane width = 12

* *Unless otherwise specified, all inputs were taken from or consistent with those specified in the VDOT Resource Document.*

For the I-495 and Dulles Toll Road interchange, the forecast maximum concentrations for CO reach 9.8 and 7.8 ppm in the project opening year, respectively, against the one- and eight-hour standards of 35 and 9 ppm. The location of the forecast maximum concentration for the intersection is the receptor highlighted in red in Exhibit 4.2.13 (d), located at the northeast corner of the interchange. The forecast peak concentrations drop to 4.9 and 4 ppm respectively for the one- and eight-hour standards for the design year.

In all scenarios, forecast peak concentrations for CO are well below the respective one- and eight-hour standards of 35 and 9 ppm. In general, emissions and ambient concentrations drop significantly over time (through the opening and design years) due to continued fleet turnover to vehicles constructed to more stringent emission standards.

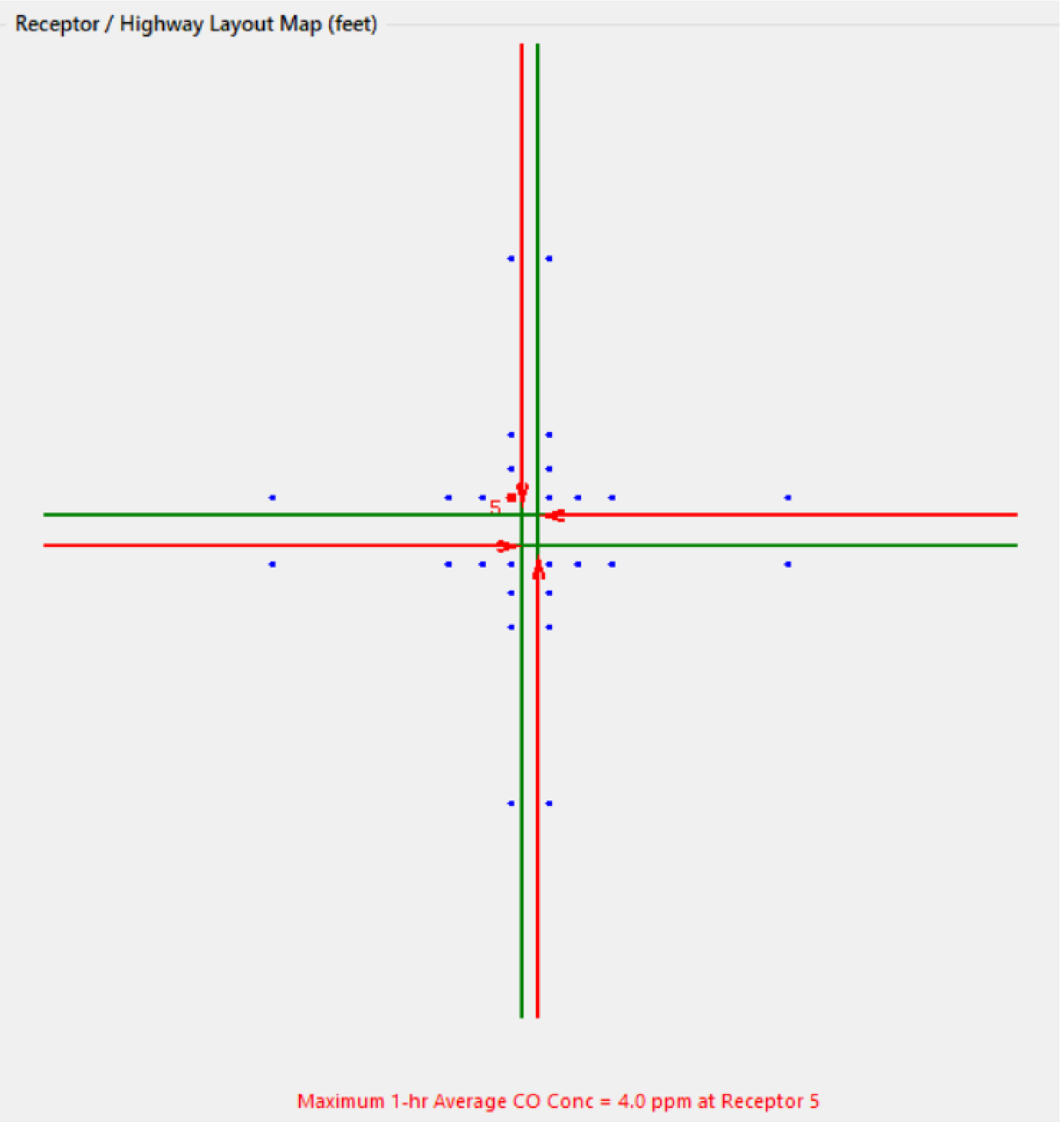
Exhibit 4.2.13 (a): CO Dispersion Modeling Worst-Case Configuration & Receptor Locations – Route 123 & Tysons Boulevard



Maximum 1-hr Average CO Conc = 4.1 ppm at Receptor 5

Source: Excerpted from FHWA Cal3i model output.

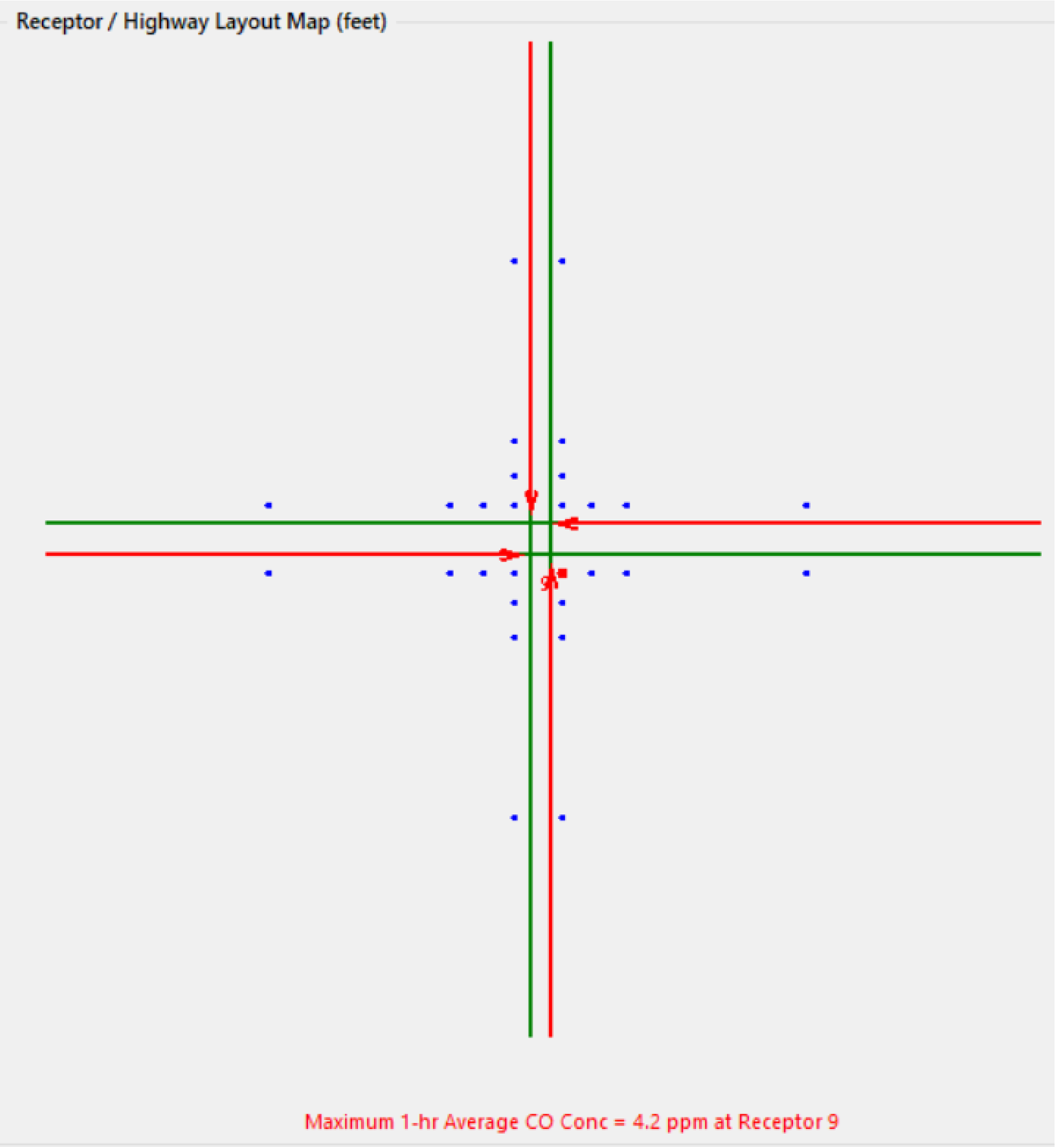
Exhibit 4.2.13 (b): CO Dispersion Modeling Worst-Case Configuration & Receptor Locations – Route 123 & Capital One Tower Drive/ Old Meadow Road



Maximum 1-hr Average CO Conc = 4.0 ppm at Receptor 5

Source: Excerpted from FHWA Cal3i model output.

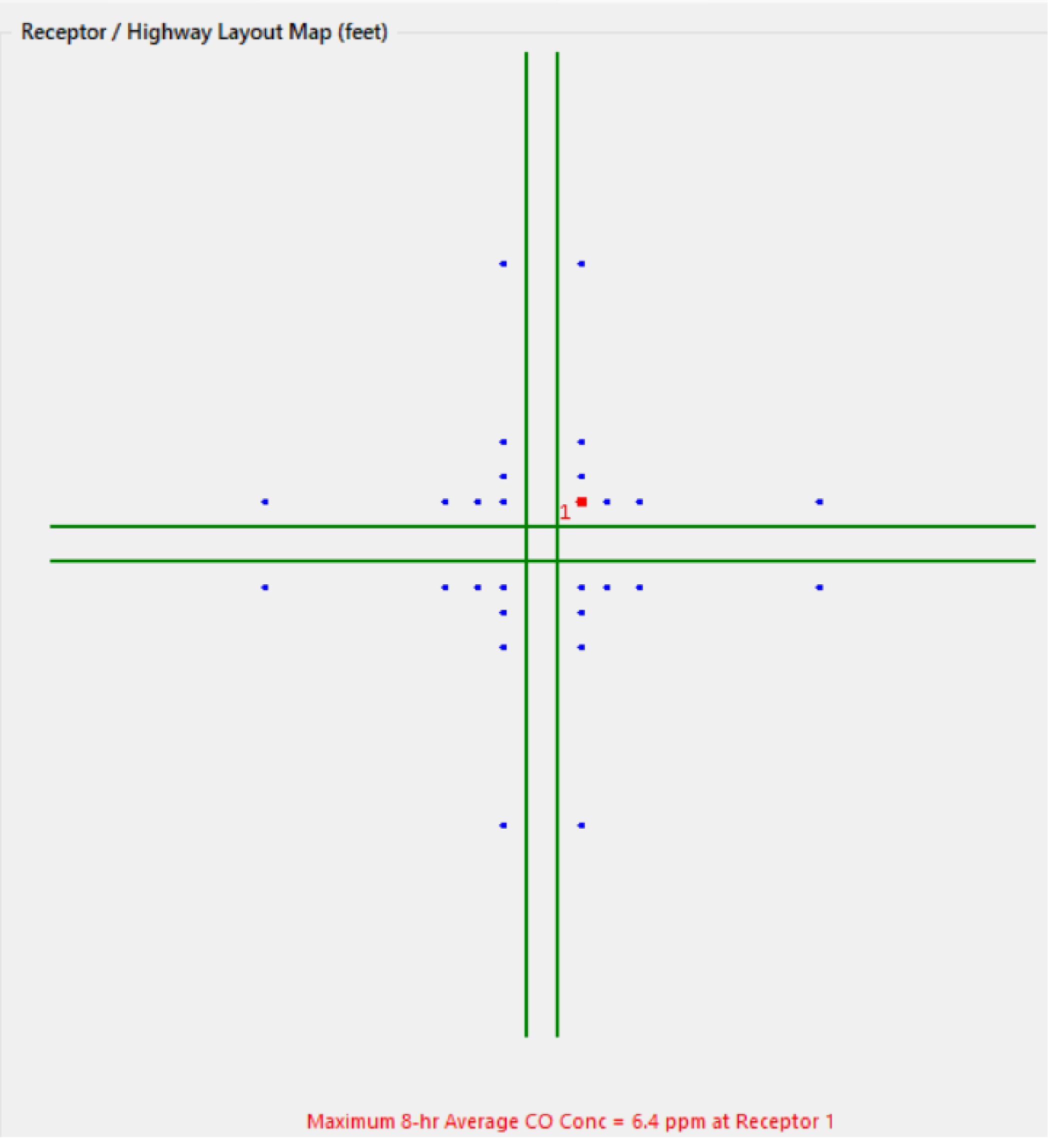
Exhibit 4.2.13 (c): CO Dispersion Modeling Worst-Case Configuration & Receptor Locations – Route 123 & Scotts Crossing Boulevard/ Colshire Drive



Maximum 1-hr Average CO Conc = 4.2 ppm at Receptor 9

Source: Excerpted from FHWA Cal3i model output.

Exhibit 4.2.13 (d): CO Dispersion Modeling Worst-Case Configuration & Receptor Locations – I-495 & Dulles Toll Road



Maximum 8-hr Average CO Conc = 6.4 ppm at Receptor 1

Source: Excerpted from FHWA Cal3i model output.

Overall, the results indicate that, even assuming worst-case traffic volumes, ambient levels of CO in the vicinity of the project are expected to decline significantly over time and to remain below both the one-hour and the eight-hour NAAQS. The project therefore is not expected to cause or contribute to a violation of the CO standards.

Exhibit 4.2.14: Worst-Case CAL3QHC Modeling Results for CO

Intersection	Averaging Period	2023[1,2] (ppm)	2045[1,2] (ppm)	NAAQS (ppm)
Route 123 and Tysons Boulevard	1-Hour	5.7	3.2	35
	8-Hour	4.6	2.6	9
Route 123 and Capital One Tower Drive/ Old Meadow Road	1-Hour	5.6	3.2	35
	8-Hour	4.5	2.6	9
Route 123 and Scotts Crossing Boulevard/ Colshire Drive	1-Hour	5.8	3.2	35
	8-Hour	4.7	2.6	9
I-495 & Dulles Toll Road	1-Hour	9.8	4.9	35
	8-Hour	7.8	4.0	9

Notes:

1. *Including background concentrations of 1.6 and 1.4 ppm for the one- and eight-hour standards respectively, based on trend date for Northern Virginia, as specified in the VDOT Resource Document (2016). Receptor locations noted are only for the first location if more than one location has the same value.*
2. *In keeping with the FHWA-VDOT 2009 Agreement for No-Build Analyses, a no-build scenario analysis was determined to not be needed for this project, given: a) the project location (not within a nonattainment or maintenance area for CO), and b) the level of environmental documentation planned for this project (i.e., not an environmental impact statement).*

4.2.9 Construction Emissions

Construction of this project would cause only temporary increases in emissions. A quantitative assessment of construction emissions is not required as the project location is not in an area subject to project-level conformity requirements for CO. Additionally, even if conformity did apply, the primary criterion for conducting construction emission analyses for conformity purposes (five years, per 40 CFR 93.123(c)(5))[58] would not be expected to be exceeded for the construction of this project.

4.2.10 Summary of Assumptions for the Worst-Case Analysis

All modeling inputs including all worst-case assumptions applied in this analysis were made consistent with all applicable VDOT, EPA and FHWA requirements and guidance. Worst-case assumptions included:

For emission factor modeling:

- Regional registration (age) distributions were applied that were not adjusted (as a limitation of the EPA MOVES model) for mileage accumulation rates that generally decline with age. This assumption effectively weights older higher-emitting vehicles the same as newer lower-emitting vehicles, resulting in higher estimates for fleet-average emission factors.

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[58] See: https://www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol20/xml/CFR-2014-title40-vol20-sec93-123.xml

- Worst-case emission factor selected as that for the maximum (or higher) road grade for each link.
- Traffic volumes used were higher HCM capacity values as opposed to forecasted volumes
- On unrestricted roadways, speeds we assumed to be 45 MPH as this had the highest corresponding emission rates.

For dispersion modeling:

- Traffic volumes representing LOS E conditions, which typically exceeds actual opening and design year ADT forecasts for build scenarios by substantial margins. Depending on the project, volumes may also be increased with the worst-case assumption of additional through lane(s) to account for auxiliary lanes or ramps.
- Worst-case receptor locations on the edge of the roadway right-of-way, i.e., at the closest possible point to roadway.
- Worst-case geometric assumptions that serve to concentrate traffic, emissions and concentrations to the greatest extent possible:
    - Zero vertical separation for the grade separation (interchange)
    - Zero median widths for arterial streets and minimum distance for freeways
- Other federal default data for most model inputs (e.g., low wind speeds, surface roughness, and stability class), which result in higher modeled estimates of ambient concentrations than are expected to occur in practice.

Overall, the use of worst-case modeling inputs for all scenarios results in conservatively modeled results, with estimates of CO concentrations well over what would reasonably be expected. Despite the worst-case assumptions, the NAAQS would not be exceeded for each case.

4.3 Mobile Source Air Toxics (MSATs) Assessment

FHWA most recently updated its guidance for the assessment of MSATs in the NEPA process for highway projects in 2016. The updated guidance states that “EPA identified nine compounds with significant contributions from mobile sources that are among the national and regional-scale cancer risk drivers or contributors and non-cancer hazard contributors from the 2011 National Air Toxics Assessment (NATA). These are 1,3-butadiene, acetaldehyde, acrolein, benzene, diesel particulate matter (diesel PM), ethylbenzene, formaldehyde, naphthalene, and polycyclic organic matter.” It also specifies three possible categories or tiers of analysis, namely, 1) projects with no meaningful potential MSAT effects or exempt projects (for which MSAT analyses are not required), 2) projects with low potential MSAT effects (requiring only qualitative analyses), and 3) projects with higher potential MSAT effects (requiring quantitative analyses).

4.3.1 Level of Analysis Determination

In accordance with FHWA MSAT guidance, the project is best characterized as one with “higher potential MSAT effects” since projected design year traffic is expected to exceed the 140,000 to 150,000 AADT criteria. Specifically, the 2025 Build scenario is expected to have ADT volumes on the I-495 general purpose and express lanes reaching 189,600 ADT at the southern project boundary to as high as 261,400 ADT just prior the American Legion Bridge. Diagrams summarizing the ADT throughout the project corridor for each alternative are presented in **Appendix A**. As a result, a quantitative assessment of MSAT emissions projections was conducted for the affected network consistent with FHWA guidance. The assessment is presented below.

4.3.2 MSAT Analysis

4.3.2.1 Background

Controlling air toxic emissions became a national priority with the passage of the Clean Air Act Amendments (CAAA) of 1990, whereby Congress mandated that the EPA regulate 188 air toxics, also known as hazardous air pollutants. The EPA assessed this expansive list in its rule on the Control of Hazardous Air Pollutants from Mobile Sources (Federal Register, Vol. 72, No. 37, page 8430, February 26, 2007), and identified a group of 93 compounds emitted from mobile sources that are part of EPA’s Integrated Risk Information System (IRIS). In addition, EPA identified nine compounds with significant contributions from mobile sources that are among the national and regional-scale cancer risk drivers or contributors and non-cancer hazard contributors from the original 2011 National Air Toxics Assessment (NATA)[59]. These are 1,3-butadiene, acetaldehyde, acrolein, benzene, diesel particulate matter (diesel PM), ethylbenzene, formaldehyde, naphthalene, and polycyclic organic matter. While FHWA considers these the priority mobile source air toxics, the list is subject to change and may be adjusted in consideration of future EPA rules.

4.3.2.2 Motor Vehicle Emissions Simulator (MOVES)

According to EPA, MOVES2014 is a major revision to MOVES2010 and improves upon it in many respects. MOVES2014 includes new data, new emissions standards, and new functional improvements and features. It incorporates substantial new data for emissions, fleet, and activity developed since the release of MOVES2010. These new emissions data are for light- and heavy-duty vehicles, exhaust and evaporative emissions, and fuel effects. MOVES2014 also adds updated vehicle sales, population, age distribution, and VMT data. MOVES2014 incorporates the effects of three new Federal emissions standard rules not included in MOVES2010. These new standards are all expected to impact MSAT emissions and include Tier 3 emissions and fuel standards starting in 2017 (79 FR 60344), heavy-duty greenhouse gas regulations that phase in during model years 2014-2018 (79 FR 60344), and the second phase of light duty greenhouse gas regulations that phase in during model years 2017-2025 (79 FR 60344). Since the release of MOVES2014, EPA has released MOVES2014a and MOVES2014b. In

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[59] Ibid

the November 2015 MOVES2014a Questions and Answers Guide[60], EPA states that for on-road emissions, MOVES2014a adds new options requested by users for the input of local VMT, includes minor updates to the default fuel tables, and corrects an error in MOVES2014 brake wear emissions. The change in brake wear emissions results in small decreases in PM emissions, while emissions for other criteria pollutants remain essentially the same as MOVES2014. In the August 2018 MOVES2014b Questions and Answers Guide[61], EPA states that MOVES2014b improves nonroad engine population growth rates, nonroad Tier 4 engine emission rates and sulfur levels of nonroad diesel fuels. EPA does not consider MOVES2014b to be a major MOVES update for SIP and transportation conformity purposes for on-road emissions.

Using EPA's MOVES2014a model, as shown in the Exhibit 4.3.1 below, FHWA estimates that even if VMT increases by 45 percent from 2010 to 2050 as forecast, a combined reduction of 91 percent in the total annual emissions for the priority MSAT is projected for the same time period.

Diesel PM is the dominant component of MSAT emissions, making up 50 to 70 percent of all priority MSAT pollutants by mass, depending on calendar year. Users of MOVES2014a will notice some differences in emissions compared with MOVES2010b. MOVES2014a is based on updated data on some emissions and pollutant processes compared to MOVES2010b and reflects the latest Federal emissions standards in place at the time of its release. In addition, MOVES2014a emissions forecasts are based on lower VMT projections than MOVES2010b, consistent with recent trends suggesting reduced nationwide VMT growth compared to historical trends.

The implications of MOVES on MSAT emissions estimates compared to MOBILE are: lower estimates of total MSAT emissions; significantly lower benzene emissions; significantly higher diesel PM emissions, especially for lower speeds. Consequently, diesel PM is projected to be the dominant component of the emissions total.

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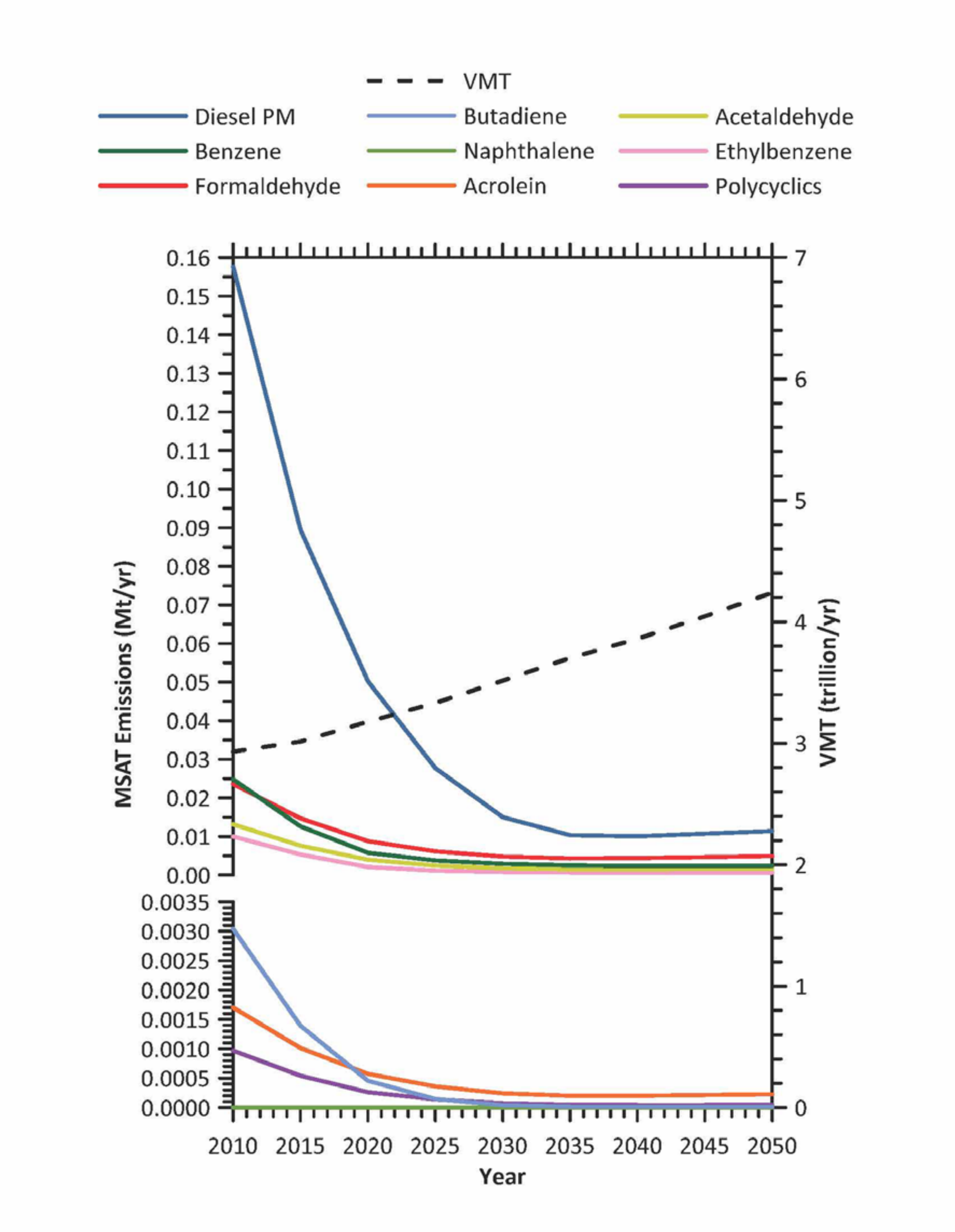
[60] https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100NNR0.txt

[61] https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100V7H1.pdf

Exhibit 4.3.1: National MSAT Emission Trends 2010-2050 for Vehicles Operating on Roadways Using EPA's MOVES 2010b Model



Note: Trends for specific locations may be different, depending on locally-derived information representing vehicle-miles travelled, vehicle speeds, vehicle mix, fuels, emission control programs, meteorology, and other factors

Source: EPA MOVES2014a model runs conducted by FHWA, September 2016.

4.3.2.3 MSAT Research

Air toxics analysis is a continuing area of research. While much work has been done to assess the overall health risk of air toxics, many questions remain unanswered. In particular, the tools and techniques for assessing project-specific health outcomes as a result of lifetime MSAT exposure remain limited. These limitations impede the ability to evaluate how potential public health risks posed by MSAT exposure should be factored into project-level decision-making within the context of NEPA.

Nonetheless, air toxics concerns continue to arise on highway projects during the NEPA process. Even as the science emerges, the public and other agencies expect FHWA to address MSAT impacts in its environmental documents. The FHWA, EPA, the Health Effects Institute, and others have funded and conducted research studies to try to more clearly define potential risks from MSAT emissions associated with highway projects. The FHWA will continue to monitor the developing research in this field. An overview of recent research is provided in Appendix D of FHWA guidance[62].

4.3.2.4 Project-Level MSAT Discussion

A quantitative MSAT analysis was conducted for this project consistent with the latest guidance from FHWA as referenced earlier. These include the Interim Guidance Update, the FHWA "Quick-start Guide for Using MOVES for a NEPA Analysis", and the FHWA FAQS for MSAT analyses.

4.3.2.5 MOVES Model Input Summary

Exhibits 4.3.2 (a) and (b) present a summary of data and data sources for MOVES2014b model inputs for the main screen and the project data manager respectively, as applied for the worst-case emission factor modeling for this project.

As noted above, all modeling inputs were taken from or otherwise made consistent with those specified or referenced in the VDOT Resource Document[63], which includes data from the National Capital Region Transportation Planning Board (TPB) Air Quality Conformity Determination for the Visualize 2045 Long Range Transportation Plan and Fiscal Year 2019-2024 Transportation Improvement Program (Visualize 2045 Conformity Analysis). Note that MOVES default files for the DC region were readily available for 2017, 2021 and 2045, while the actual base and opening years of the project are 2018 and 2023, respectively. It was determined that interpolating the MOVES inputs to 2018 and 2023 would introduce variability into the analysis without increasing the overall precision. Also average emission rates are forecasted to trend downwards over time as older vehicles meeting less stringent standards are retired and replaced with cleaner vehicles. As such, 2017 and 2021 inputs and analysis years were used to represent 2018 and 2023, respectively, to simplify the development of inputs for the MOVES model. Combining the higher 2017 and 2021 emission rates with the traffic forecasts developed for 2018 and 2025, respectively, yields a very conservative worst-case MSAT emissions

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[62] See: https://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/msat/page04.cfm

[63] The tables are based on the one presented in Appendix E1 of the VDOT Resource Document (2016),

inventory for comparison. As was noted in the traffic section earlier, the analysts chose to forecast volumes for 2025 instead of 2023, the actual opening year of the project.
VDOT's experience with express lanes is that it takes approximately two to three years to reach full adoption by drivers. Given that 2025 represents an additional two years of growth in background traffic, 2025 traffic forecasts can reasonably be expected to exceed those in 2023. This too is a conservative value to use in the MSAT evaluation.

Exhibit 4.3.2(a): MOVES2014b Input Summary for MSATs – Main Screen

Parameter	**MOVES Input**
Scale	County/Inventory
Time Spans	MOVES Time Aggregation Level: Hour Years: Base (using 2017 MOVES runs for 2018), Opening (using 2021 MOVES runs for 2023), and Design (2045) Month, Day & Hour: Seasonal (Jan., Apr., Jul. & Oct.), Weekday/end, All hours
Geographic Bounds	Fairfax County (with links limited to just the impact area determined in the NEPA Traffic Study for this project)
Vehicles/Equipment	Consistent with those files specified in the MOVES2014a files from Visualize 2045 Air Quality Conformity Analysis for Fairfax County
Road Types	Urban and rural restricted and unrestricted
Pollutants and Processes	Pollutants: All MSATs as specified in FHWA guidance (including the associated pollutant chains/prerequisites) Processes: Running exhaust, crankcase running exhaust, evap permeation, and evap fuel leaks.
Output	Units: grams, Million BTU, and miles Activity: Distance Travelled and Population Time: 24-Hour Day Location: County Fuel Type: Selected for diesel PM runs; Not selected for non-diesel PM runs

Exhibit 4.3.2(b): MOVES2014b Input Summary for MSATs – County Data Manager

Parameter	MOVES Input
Vehicle Type VMT	VMT: Derived from project-specific TDM forecasts for the links identified in the NEPA Traffic Analysis by alternative. Used HPMS VMT inputs from the Visualize 2045 Air Quality Conformity Analysis for Fairfax County to disaggregate project VMT to MOVES input vehicle classes. VMT Fractions (month, day and hour): Consistent with those files specified in the MOVES2014a files from Visualize 2045 Air Quality Conformity Analysis for Fairfax County.
Hoteling	MOVES Defaults
I/M Programs	Consistent with the MOVES2014a files from Visualize 2045 Air Quality Conformity Analysis for Fairfax County
Retrofit Data	MOVES Defaults
Ramp Fraction (VHT-based)	Calculated based on project-specific network link data by alternative
Road Type Distributions	Calculated based on project-specific network link data by alternative
Source (Vehicle) Type Population	Adjusted inputs from the Visualize 2045 conformity analysis by applying project area to county VMT ratio.
Starts	MOVES Defaults
Age (Registration) Distribution	Consistent with the MOVES2014a files from Visualize 2045 Air Quality Conformity Analysis for Fairfax County
Average Speed Distributions (VHT-based)	Calculated based on project-specific network link data by alternative
Fuels	Consistent with the MOVES2014a files from Visualize 2045 Air Quality Conformity Analysis for Fairfax County
Meteorology	Consistent with the MOVES2014a files from Visualize 2045 Air Quality Conformity Analysis for Fairfax County

A representative example of a MOVES run specification files as applied in this project is provided in **Appendix F**. In general:

- The extent of the affected network for the MSAT analysis was identified using the regional Travel Demand Forecast Model for each analysis year, No-Build and Build as developed by the project traffic team.
- The available travel demand modeling runs used were for 2018 (base year), 2025 (as a worst-case assumption with higher traffic volumes to represent the 2023 opening year), and 2045 as the design year.
- The affected networks for each alternative and analysis year were developed using FHWA criteria, namely daily volume change and travel time change for congested and uncongested links, for which reliable forecast data were available.
- Based on traffic projections for the base, opening year and design years, the segments directly associated with the Study Corridor and those roadways in the affected network where the AADT is expected to change +/- 5 percent or more and where their travel time is expected to change by +/- 10 percent for the Build Alternatives compared to the No-Build Alternatives were identified. The full affected network which includes the links affected by both volume and travel time changes (shown in red) is presented in Exhibit 4.3.2 representing both the 2025 and 2045 conditions. Consistent with FHWA guidance, spurious results in the form of roadway links that would not be expected to be affected by the project (but otherwise met the change criteria) were treated as artifacts of

the model and removed by the traffic analysis team. Also, a limited number of additional links were added to make the affected network relatively contiguous.

- The travel demand modeling yielding some lines where the link was part of the affected network in one direction but not the other, and this is reflected in the affected network
- For portions of I-496 outside of the traffic study area with existing express lanes, links included as part of the affected network were not the result of traffic moving from the general purpose lanes to the express lanes, but were included as they met the thresholds for inclusion on the affected network due to growth in traffic on both the express lanes and the general purpose lanes, confirmed by spot-checks of the results.
- The EPA MOVES2014b model was utilized in order to obtain estimates for emissions for each MSAT.
- The MOVES2014b run spec and inputs were consistent with FHWA recommendations for conducting a quantitative MSAT analysis, including evaluating four months to represent the different seasons, averaging the resulting emissions for a typical day and multiplying by 365 to obtain average annual emissions for each pollutant.
- MSAT runs were developed for the base year 2018 scenario (using 2017 MOVES inputs from the regional conformity analysis to represent 2018), the opening year 2023 Build and No-Build conditions (using 2021 MOVES conformity inputs to represent 2023), and the Design year 2045 Build and No-Build conditions. The MOVES input data were downloaded from the VDOT online air quality data repository.

The results of the quantitative MSAT analysis are presented in Exhibits 4.3.3 and 4.3.4 showing the changes in emissions between the Base Year and future Build/No-Build scenarios. These tables show that MSAT emissions are expected to decrease slightly for the Build scenario conditions when compared to the No-Build condition for 2045. The differences between the no-build and build scenario for 2023 are less consistent, but the small differences likely represent the variability inherent to travel demand models. Most importantly all MSAT pollutant emissions are expected to significantly lower in the Opening and Design years when compared to the Base Year conditions. These reductions occur despite projected increases in VMT from 2018 to the 2023 and 2045 Build scenarios.

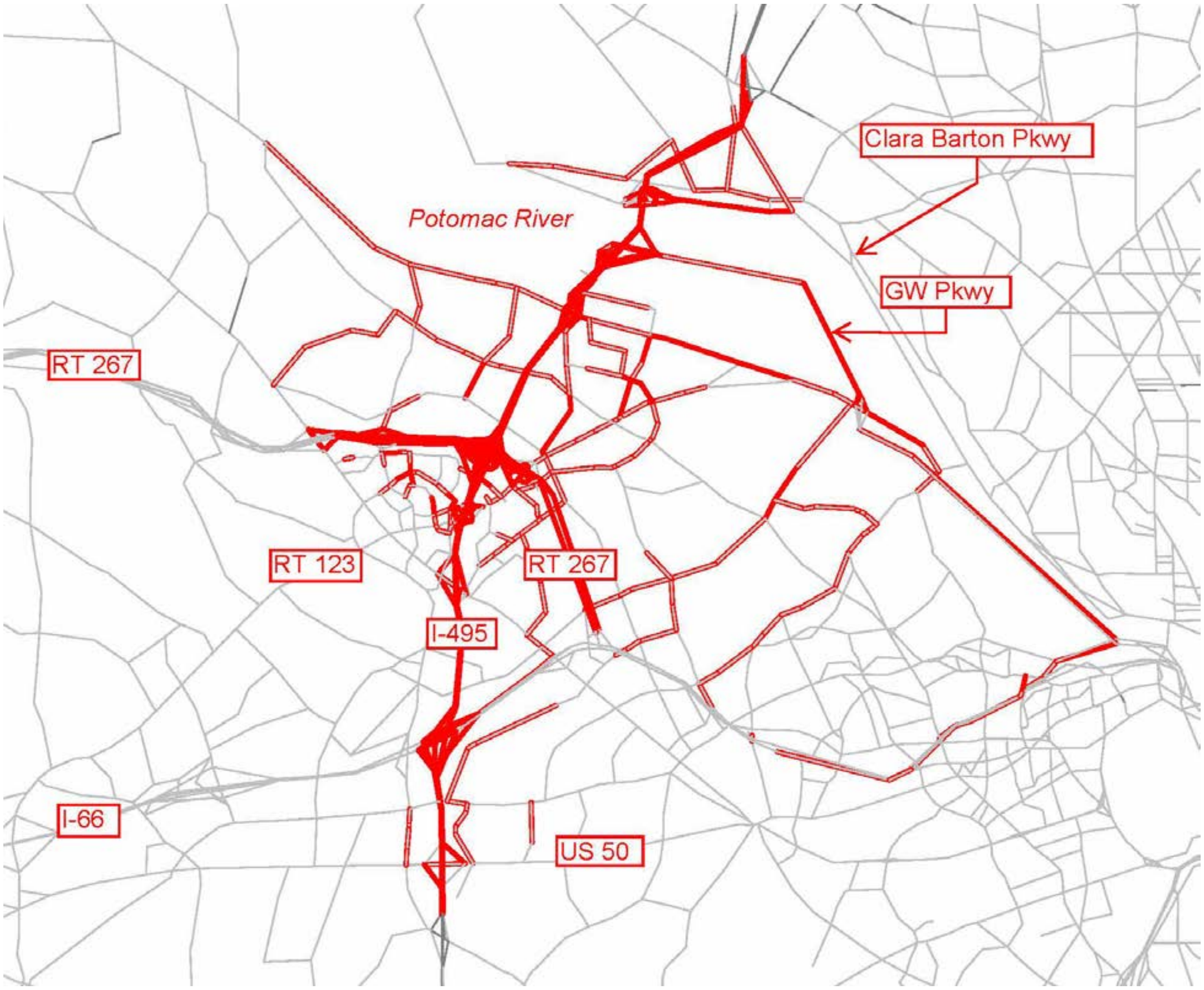
In general:

- For each MSAT and analysis scenario, the long-term trend in emissions is downward. The downward trend in emissions is a result of technological improvements, i.e., more stringent vehicle emission and fuel quality standards coupled with ongoing fleet turnover and is achieved despite increased VMT in this period.
- For each MSAT and analysis year, the forecast emissions for build and no-build are nearly identical, i.e., the differences in emissions between build and no-build are very small especially compared to the long-term downward trend in emissions for each MSAT.

More specifically:

- All MSAT emissions for the Build scenario are expected to slightly decrease between values statistically equal to zero and 0.047 tpy in both the Opening Year 2023 and the Design Year 2045 when compared to the No-Build condition. Diesel PM had the highest decreases in Build MSAT emissions compared to the No-Build, while 1,3 Butadiene and POM had the smallest decreases.

Exhibit 4.3.2: MSAT Affected Network



- MSAT emissions for the Opening year Build conditions are expected to decrease between 0.012 tpy and 1.452 tpy compared to the Base year conditions, and MSAT emission for the Design year Build conditions are expected to decrease between 0.029 tpy and 3.165 tpy compared to the Base conditions. The slight decrease in Ethyl Benzene (<1%) and VMT (1.4%) between the 2023 no-build and build scenarios are insignificant and likely the result of the inherent variability of the travel demand modeling. Diesel PM had the highest decrease in MSAT emissions compared to the Existing conditions while POM had the lowest decrease in emissions.

In all cases, the magnitude of emissions is small in the opening and design years and significantly lower than in the base year.

Exhibit 4.3.3: Annual MSAT Emissions by Year, Scenario and Pollutant on the Affected Network

Pollutant	2018 (tpy)	2023 (tpy)		2045 (tpy)	
	Base Year	No Build	Build	No Build	Build
Diesel PM	3.687	2.283	2.235	0.549	0.523
Benzene	0.456	0.346	0.341	0.121	0.115
1,3-Butadiene	0.046	0.026	0.025	0.001	0.001
Formaldehyde	0.729	0.575	0.531	0.279	0.265
Acrolein	0.048	0.035	0.033	0.013	0.012
POM	0.035	0.025	0.023	0.006	0.006
Naphthalene	0.078	0.058	0.054	0.022	0.021
Ethyl Benzene	0.263	0.205	0.207	0.109	0.103
Acetaldehyde	0.340	0.257	0.238	0.099	0.094
VMT (million VMT)	1,400.6	1,523.5	1,545.4	1,791.6	1,713.7

Exhibit 4.3.4: Projected Annual MSAT Change in Emissions on the "Affected Network"

Pollutant	Change from No Build (tpy)		Change from Base Year (tpy)	
	2023	2045	2023	2045
Diesel PM	-0.047	-0.027	-1.452	-3.165
Benzene	-0.005	-0.006	-0.114	-0.340
1,3-Butadiene	-0.001	0.000	-0.021	-0.046
Formaldehyde	-0.044	-0.014	-0.198	-0.464
Acrolein	-0.003	-0.001	-0.015	-0.036
POM	-0.001	0.000	-0.012	-0.029
Naphthalene	-0.004	-0.001	-0.024	-0.057
Ethyl Benzene	0.002	-0.006	-0.056	-0.160
Acetaldehyde	-0.019	-0.005	-0.103	-0.246
VMT (million VMT)	21.9	-77.8	144.9	313.1

Overall, the results of the MSAT analysis are consistent with national MSAT emission trends predicted by FHWA. No meaningful increases in MSATs have been identified and are not expected to cause an adverse effect on human health as a result of any of the Build scenario in future years.

4.3.2.6 Incomplete or Unavailable Information for Project-Specific MSAT Health Impacts Analysis

In FHWA's view, information is incomplete or unavailable to credibly predict the project-specific health impacts due to changes in MSAT emissions associated with a proposed set of highway alternatives. The outcome of such an assessment, adverse or not, would be influenced more by the uncertainty introduced into the process through assumption and speculation rather than any genuine insight into the actual health impacts directly attributable to MSAT exposure associated with a proposed action.

The EPA is responsible for protecting the public health and welfare from any known or anticipated effect of an air pollutant. They are the lead authority for administering the CAA and its amendments and have specific statutory obligations with respect to hazardous air pollutants and MSAT. The EPA is in the continual process of assessing human health effects, exposures, and risks posed by air pollutants. They maintain the Integrated Risk Information System (IRIS), which is "a compilation of electronic reports on specific substances found in the environment and their potential to cause human health effects" (EPA, https://www.epa.gov/iris/). Each report contains assessments of non-cancerous and cancerous effects for individual compounds and quantitative estimates of risk levels from lifetime oral and inhalation exposures with uncertainty spanning perhaps an order of magnitude.

Other organizations are also active in the research and analyses of the human health effects of MSAT, including the Health Effects Institute (HEI). Several HEI studies are summarized in Appendix D of FHWA's Updated Interim Guidance on Mobile Source Air Toxic Analysis in NEPA Documents. Among the adverse health effects linked to MSAT compounds at high exposures are: cancer in humans in occupational settings; cancer in animals; and irritation to the respiratory tract, including the exacerbation of asthma. Less obvious is the adverse human health effects of MSAT compounds at current environmental concentrations (HEI Special Report 16, https://www.healtheffects.org/publication/mobile-source-air-toxics-critical-review-literature-exposure-and-health-effects) or in the future as vehicle emissions substantially decrease.

The methodologies for forecasting health impacts include emissions modeling; dispersion modeling; exposure modeling; and then final determination of health impacts – each step in the process building on the model predictions obtained in the previous step. All are encumbered by technical shortcomings or uncertain science that prevents a more complete differentiation of the MSAT health impacts among a set of project alternatives. These difficulties are magnified for lifetime (i.e., 70 year) assessments, particularly because unsupportable assumptions would have to be made regarding changes in travel patterns and vehicle technology (which affects emissions rates) over that time frame, since such information is unavailable.

It is particularly difficult to reliably forecast 70-year lifetime MSAT concentrations and exposure near roadways; to determine the portion of time that people are actually exposed at a specific location; and to establish the extent attributable to a proposed action, especially given that some of the information needed is unavailable.

There are considerable uncertainties associated with the existing estimates of toxicity of the various MSAT, because of factors such as low-dose extrapolation and translation of occupational exposure data to the general population, a concern expressed by HEI[64] . As a result, there is no national consensus on air dose-response values assumed to protect the public health and welfare for MSAT compounds, and in particular for diesel PM. The EPA states that with respect to diesel engine exhaust, "[t]he absence of adequate data to develop a sufficiently confident dose-response relationship from the epidemiologic studies has prevented the estimation of inhalation carcinogenic risk (https://www.epa.gov/iris.)"

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[64] Special Report 16, https://www.healtheffects.org/publication/mobile-source-air-toxics-critical-review-literature-exposure-and-health-effects

There is also the lack of a national consensus on an acceptable level of risk. The current context is the process used by the EPA as provided by the CAA to determine whether more stringent controls are required in order to provide an ample margin of safety to protect public health or to prevent an adverse environmental effect for industrial sources subject to the maximum achievable control technology standards, such as benzene emissions from refineries. The decision framework is a two-step process. The first step requires EPA to determine an "acceptable" level of risk due to emissions from a source, which is generally no greater than approximately 100 in a million. Additional factors are considered in the second step, the goal of which is to maximize the number of people with risks less than 1 in a million due to emissions from a source. The results of this statutory two-step process do not guarantee that cancer risks from exposure to air toxics are less than 1 in a million; in some cases, the residual risk determination could result in maximum individual cancer risks that are as high as approximately 100 in a million. In a June 2008 decision, the U.S. Court of Appeals for the District of Columbia Circuit upheld EPA's approach to addressing risk in its two-step decision framework. Information is incomplete or unavailable to establish that even the largest of highway projects would result in levels of risk greater than deemed acceptable.[65]

Because of the limitations in the methodologies for forecasting health impacts described, any predicted difference in health impacts between alternatives is likely to be much smaller than the uncertainties associated with predicting the impacts. Consequently, the results of such assessments would not be useful to decision makers, who would need to weigh this information against project benefits, such as reducing traffic congestion, accident rates, and fatalities plus improved access for emergency response, that are better suited for quantitative analysis.

4.3.2.7 Conclusions for MSATs

As discussed above, technical shortcomings of emissions and dispersion models and uncertain science with respect to health effects prevent meaningful or reliable estimates of MSAT emissions and effects of this project at this time. While it is possible that localized increases in MSAT emissions may occur as a result of this project, emissions will likely be lower than present levels in the design year of this project as a result of EPA's national control programs that are projected to reduce annual MSAT emissions by over 80 percent between 2010 and 2050. Although local conditions may differ from these national projections in terms of fleet mix and turnover, VMT growth rates, and local control measures, the magnitude of the EPA-projected reductions is so great (even after accounting for VMT growth) that MSAT emissions in the study area are likely to be lower in the future in nearly all cases.

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[65] https://www.cadc.uscourts.gov/internet/opinions.nsf/284E23FFE079CD59852578000050C9DA/$file/07-1053-1120274.pdf

4.4 Greenhouse Gases

In the absence of applicable federal guidance, a GHG assessment is provided below for informational purposes.

Carbon dioxide (CO_2) is the largest component of human produced emissions; other prominent GHG emissions include methane (CH_4), nitrous oxide (N_2O) and hydrofluorocarbons (HFCs). Emissions of GHGs are different from criteria air pollutants since their effects in the atmosphere are global rather than localized, and also since they remain in the atmosphere for decades to centuries, depending on the species.

GHG emissions from vehicles using roadways are a function of distance travelled (expressed as vehicle miles travelled, or VMT), vehicle speed, fuel type and road grade. GHG emissions are also generated during roadway construction and maintenance activities.

Under the No-Build Alternative, VMT would increase between 2018 and 2045 as the growth in employment and population in the NOVA/DC region is expected to continue (These trends are discussed in more detail in the *Socioeconomics, Land Use, and Visual Impacts Technical Report*.) However, under the build scenario, the increase VMT compared to existing conditions is expected to be less than the build. Under the No-Build Alternative, VMT increases approximately 28.9% between 2018 and 2045; under the Build Alternatives, VMT would increase by approximately 22.4% compared to 2018 levels.

A major factor in mitigating this increase in VMT is EPA’s GHG emissions standards, implemented in concert with national fuel economy standards[66]. The Energy Information Administration (EIA)[67] estimated that fuel economy will improve by 65% between 2018 and 2050 for all light-duty vehicles. This improvement in vehicle emissions rates is more than sufficient to offset the increase in VMT. Thus, the project area would see a net reduction in GHG emissions under the Build Alternative compared to the no-build and existing conditions.

Construction and subsequent maintenance of the project would generate GHG emissions. Preparation of the roadway corridor involves a considerable amount of energy consumption and resulting GHG emissions; manufacture of the materials used in construction and fuel used by construction equipment also contribute to GHG emissions. Typically, construction emissions associated with a new roadway account for a relatively minor amount of the total 20-year lifetime emissions from the roadway, although this can vary widely with the extent of construction activity and the number of vehicles that use the roadway.

The addition of new roadway miles within the study area would also increase the energy and GHG emissions associated with maintaining those new roadway miles in the future. Total

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[66] Final Rule - 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards, Environmental Protection Agency, 40 CFR Parts 85, 86, and 600 Department of transportation, National Highway Traffic Safety Administration 49 CFR Parts 523, 531, 533, 536, and 537 (October 15, 2012)

[67] See page Annual Energy Outlook 2019, Page 124. The increase in VMT is calculated to 2050 because AEO 2019 does not include statistic calculated to 2045.

roadway miles in the study area that need to be maintained on an ongoing basis would increase by approximately 20% on I-495 relative to the No-Build Alternative as the project goes from a 5 to 6 lane cross section. The increase in maintenance needs due to the addition of new roadway infrastructure would be partially offset reduced traffic on alternate routes traffic that would otherwise take. Finally, the express lanes will directly encourage carpooling, vanpooling, and improve potential future I-495 bus operations that would increase the use of these modes of transport, reducing VMT and resulting in a decrease in GHG emissions.

4.5 Indirect Effects and Cumulative Impacts (IECI) Assessment

Indirect effects are defined by the CEQ as “effects which are caused by the action and are later in time or farther removed in distance but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water or other natural systems, including ecosystems” (40 CFR 1508.8(b)). For transportation projects, induced growth is attributed to changes in accessibility caused by the project that influences the location and/or magnitude of future development.[68]

Cumulative impacts are “the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.” (40 CFR 1508.7). According to the Federal Highway Administration’s (FHWA) *Interim Guidance: Questions and Answers Regarding the Consideration of Indirect and Cumulative Impacts in the NEPA Process*, cumulative impacts include the total of all impacts to a particular resource that have occurred, are occurring, and will likely occur as a result of any action or influence, including the direct and reasonably foreseeable indirect impacts of a proposed project. Cumulative impacts include indirect effects. The potential for indirect effects or cumulative impacts to air quality that may be attributable to this project is not expected to be significant for two reasons.

First, regarding the potential for indirect effects, the quantitative assessments conducted for project-specific CO, qualitative analyses for MSAT impacts and the regional conformity analysis conducted for ozone can all be considered indirect effects analyses because they look at air quality impacts attributable to the project that occur in the future. These analyses demonstrate that, in the future: 1) air quality impacts from CO will not cause or contribute to violations of the CO NAAQS, 2) MSAT emissions will be significantly lower than they are today, and 3) the mobile source emissions budgets established for the region for purposes of meeting the ozone NAAQS will not be exceeded.

Second, regarding the potential for cumulative impacts, the most recent regional conformity analysis conducted by the NCRTPB, Visualize 2045 LRTP and Fiscal Year 2019-2024 TIP, represents a cumulative impact assessment for purposes of regional air quality.

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[68] See: http://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_466.pdf

- The existing air quality designations for the region are based, in part, on the accumulated mobile source emissions from past and present actions, and these pollutants serve as a baseline for the current conformity analysis.
- The conformity analysis quantifies the amount of mobile source emissions for which the area is designated nonattainment/maintenance that will result from the implementation of all reasonably foreseeable regionally significant transportation projects in the region (i.e., those proposed for construction funding over the life of the region's transportation plan).
- The most recent conformity analysis referenced above was completed in October 2018, with FHWA and FTA issuing a conformity finding on December 13, 2018. This analysis demonstrated that the incremental impact of the proposed project on mobile source emissions, when added to the emissions from other past, present, and reasonably foreseeable future actions, is in conformance with the SIP and will not cause or contribute to a new violation, increase the frequency or severity of any violation, or delay timely attainment of the NAAQS established by EPA.

Therefore, the indirect and cumulative effects of the project are not expected to be significant.

5.0 Mitigation

Emissions may be produced in the construction of this project from heavy equipment and vehicle travel to and from the site, as well as from fugitive sources. Construction emissions are short term or temporary in nature. To mitigate these emissions, all construction activities are to be performed in accordance with VDOT *Road and Bridge Specifications*[69].

In addition, as noted previously, the VDEQ provides general comments for projects by county. Their comments for Fairfax County in part address mitigation[70]: "*…all reasonable precautions should be taken to limit the emissions of VOC and NOx. In addition, the following VDEQ air pollution regulations must be adhered to during the construction of this project: 9 VAC 5-130, Open Burning restrictions*[71]*; 9 VAC 5-45, Article 7, Cutback Asphalt restrictions*[72]*; and 9 VAC 5-50, Article 1, Fugitive Dust precautions*[73]*.*"

6.0 Consultation

6.1.1 Public Consultation

Public consultation is generally conducted and documented within the overall NEPA process, and not separately by subject area (including air quality). Please refer to the overall NEPA documentation for a summary of public consultation activities for this project.

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[69] See http://www.virginiadot.org/business/const/spec-default.asp

[70] Spreadsheet entitled: "DEQ SERP Comments rev8b", March 2017

[71] See: https://law.lis.virginia.gov/admincode/title9/agency5/chapter130/section100/

[72] See: http://leg1.state.va.us/cgi-bin/legp504.exe?000+reg+9VAC5-45-760

[73] See: http://leg1.state.va.us/cgi-bin/legp504.exe?000+reg+9VAC5-50-60

6.1.2 Models, Methods, Assumptions and Protocols Specified in the VDOT Resource Document

All models, methods, assumptions and protocols specified or referenced within the VDOT Resource Document[74] for projects in northern Virginia were subjected to inter-agency consultation for conformity (IACC) and NEPA (IAC) with FHWA, EPA, DEQ and other agencies prior to being finalized in 2016. IACC was required at that time as it was before project-level conformity requirements in northern Virginia were eliminated for CO (with the expiry of the CO maintenance plan on March 16, 2016) and $PM_{2.5}$ (with the revocation by EPA of the applicable annual primary NAAQS effective October 24, 2016). Appendix A of the Resource Document provides a summary of the consultation process and results.

7.0 Conclusions

The proposed improvements were assessed for potential air quality impacts and compliance with applicable air quality regulations and guidance. All models, methods/protocols and assumptions applied in modeling and analyses were made consistent with those provided or specified in the VDOT Resource Document. The assessment indicates that the project would meet all applicable air quality requirements of the National Environmental Policy Act (NEPA) and federal and state transportation conformity regulations. As such, the project will not cause or contribute to a new violation, increase the frequency or severity of any violation, or delay timely attainment of the NAAQS established by the EPA.

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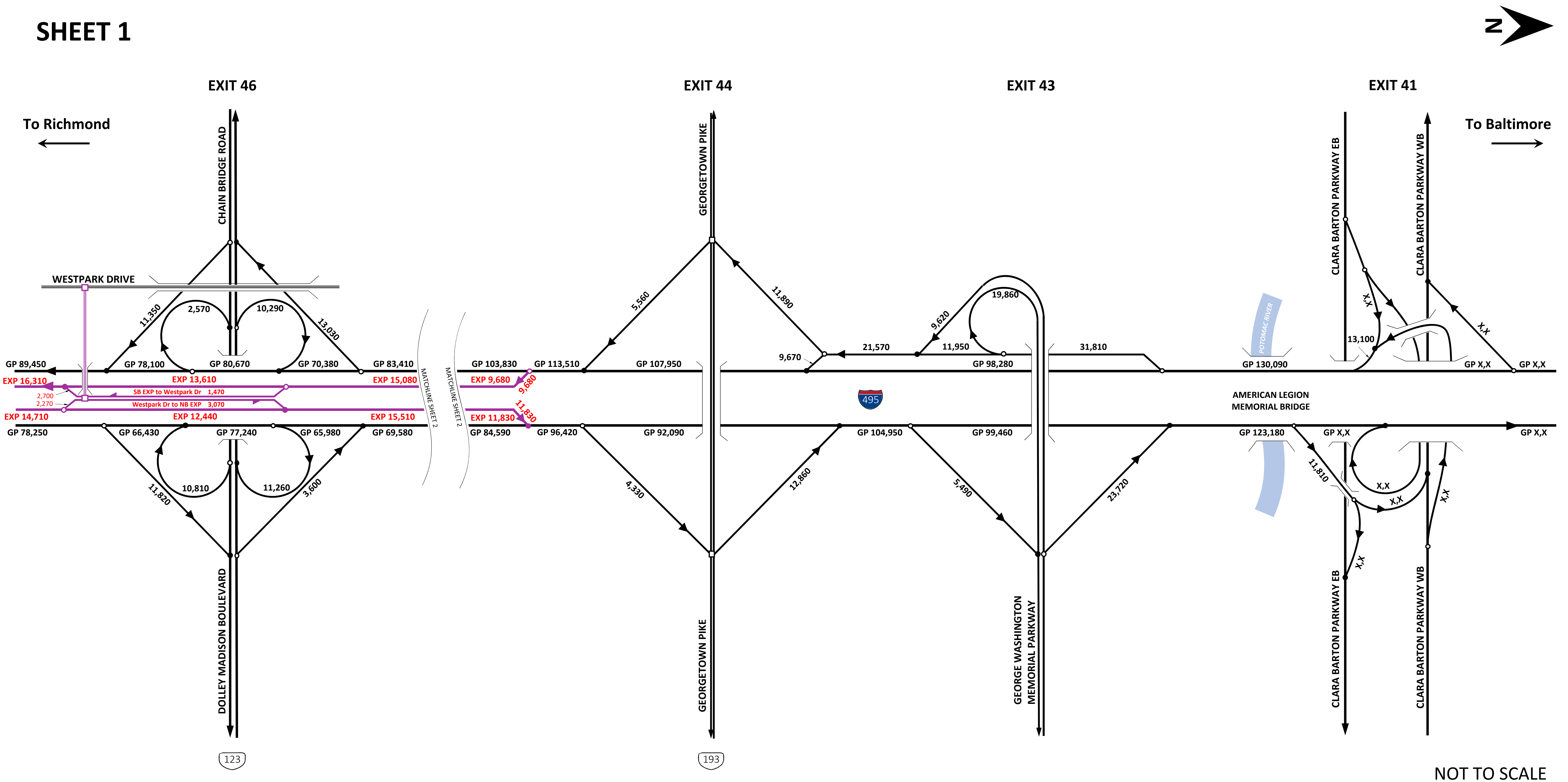
[74] See: http://www.virginiadot.org/projects/environmental_air_section.asp

Appendix A: Average Daily Traffic Mainline Forecasts and 2018 Intersection Baseline Volumes

SHEET 1



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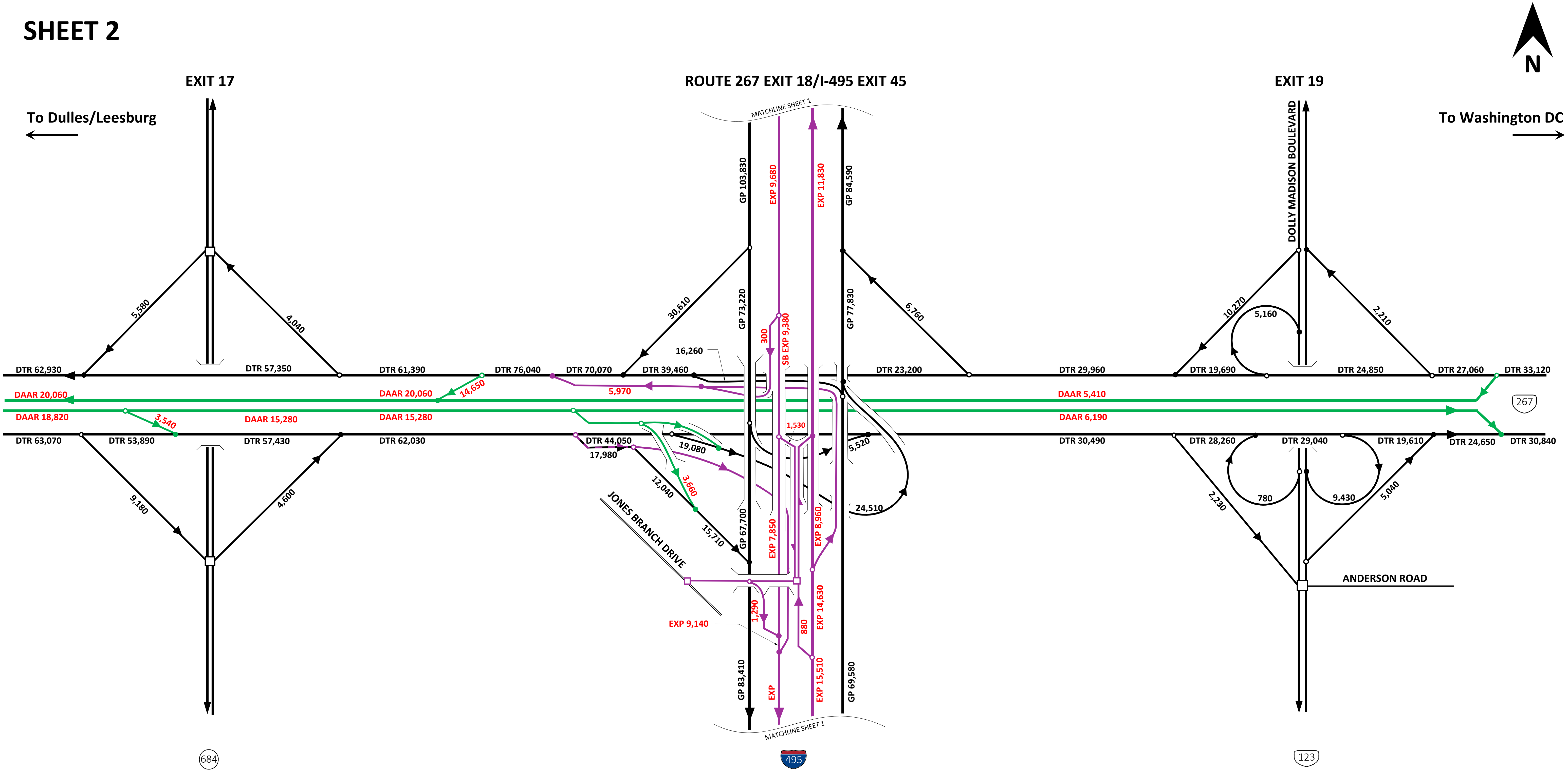

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2025 No-Build ADT Volumes

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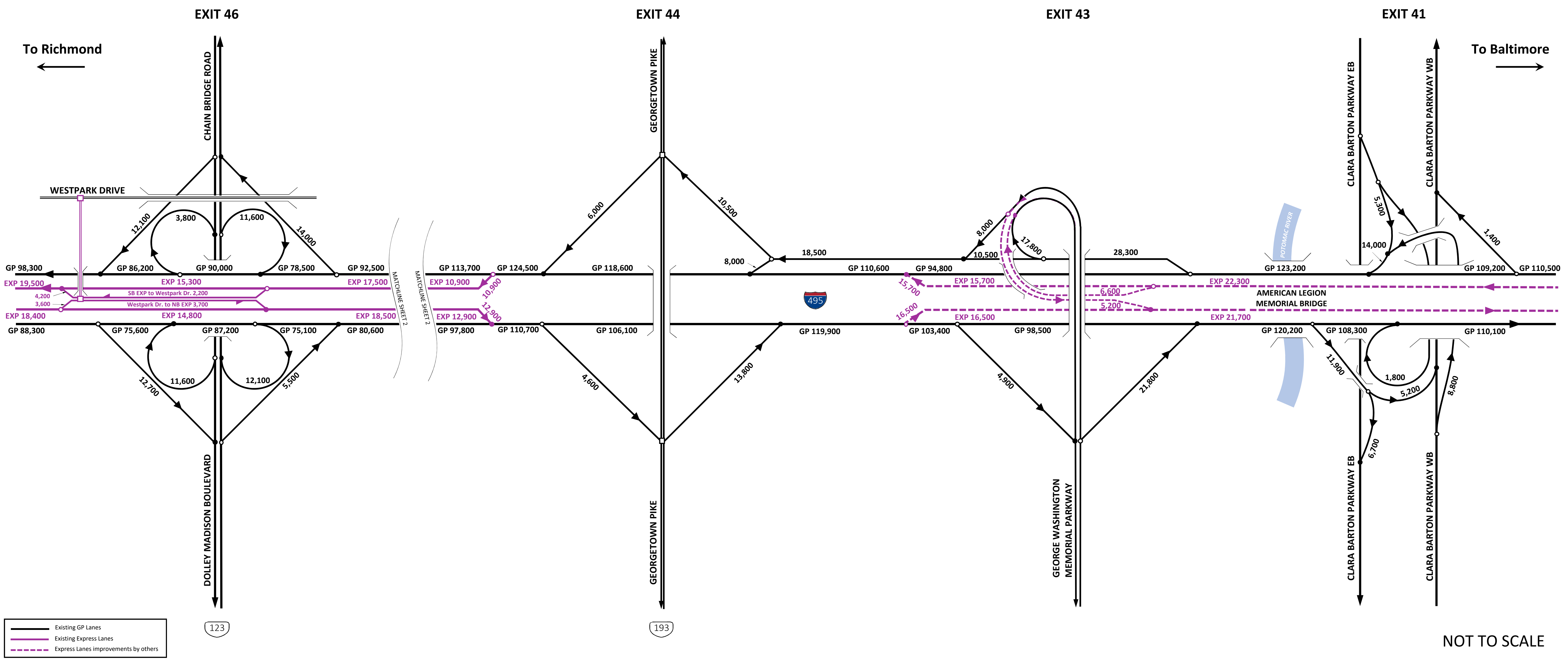
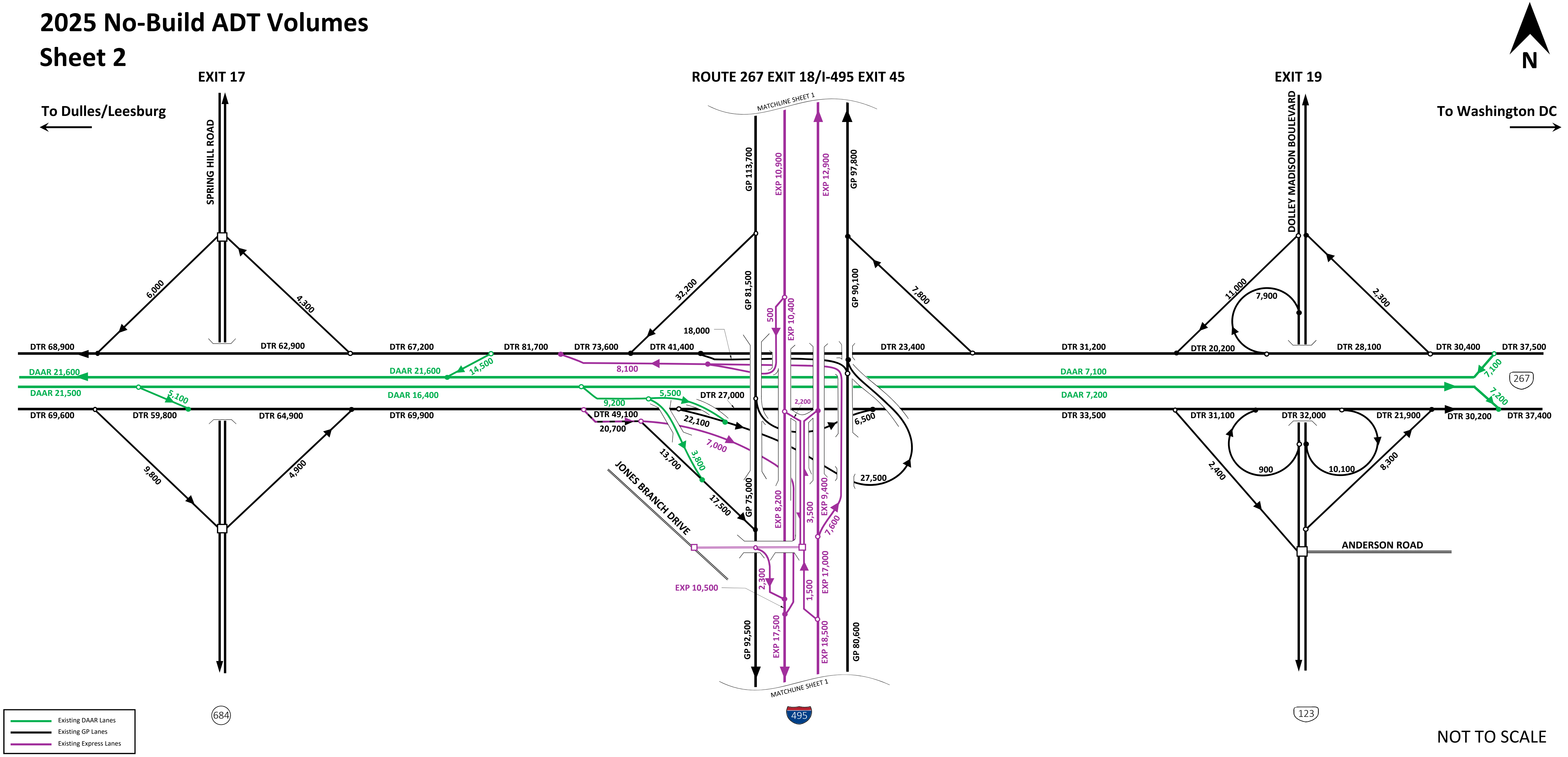


2025 No-Build ADT Volumes
Sheet 2



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2025 Build ADT Volumes

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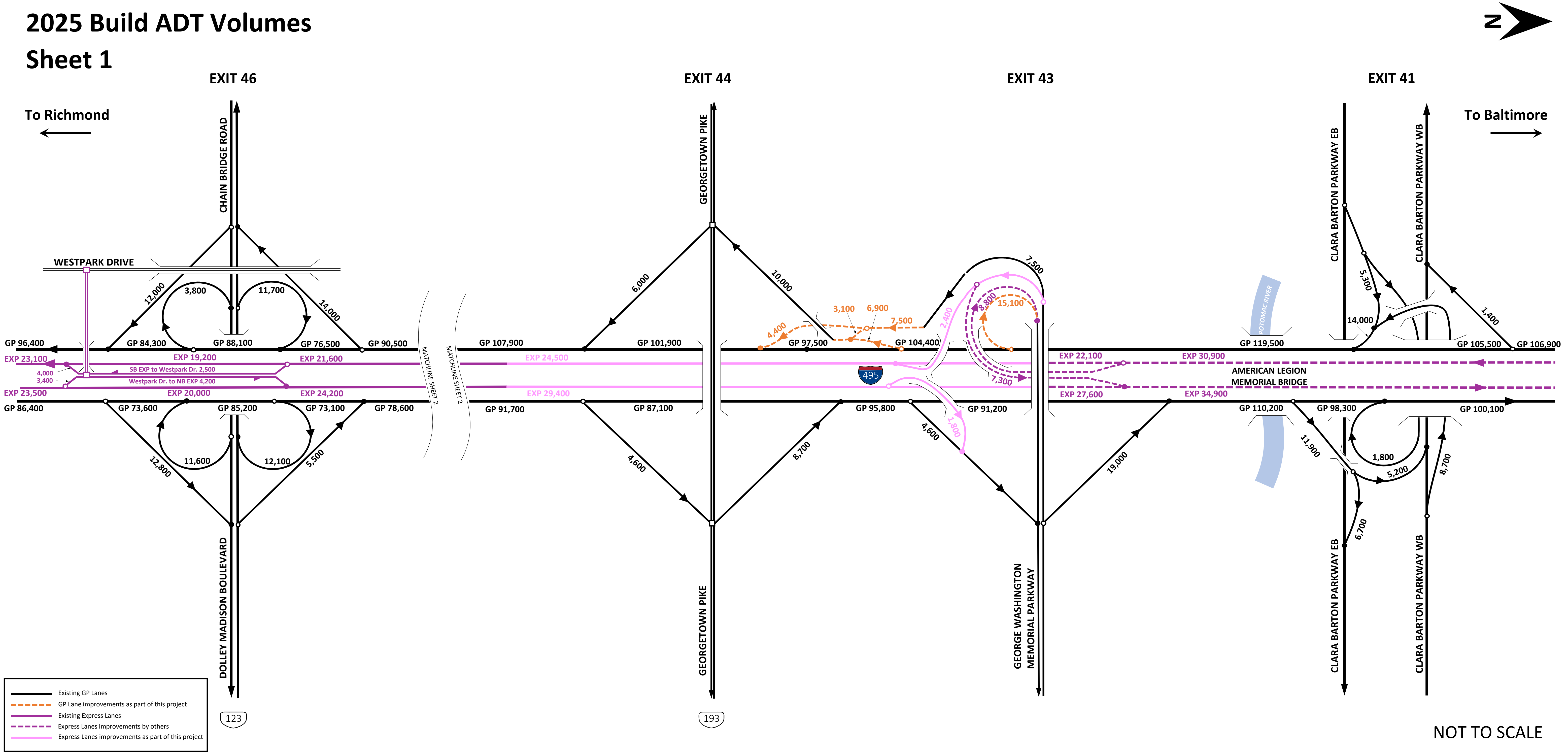
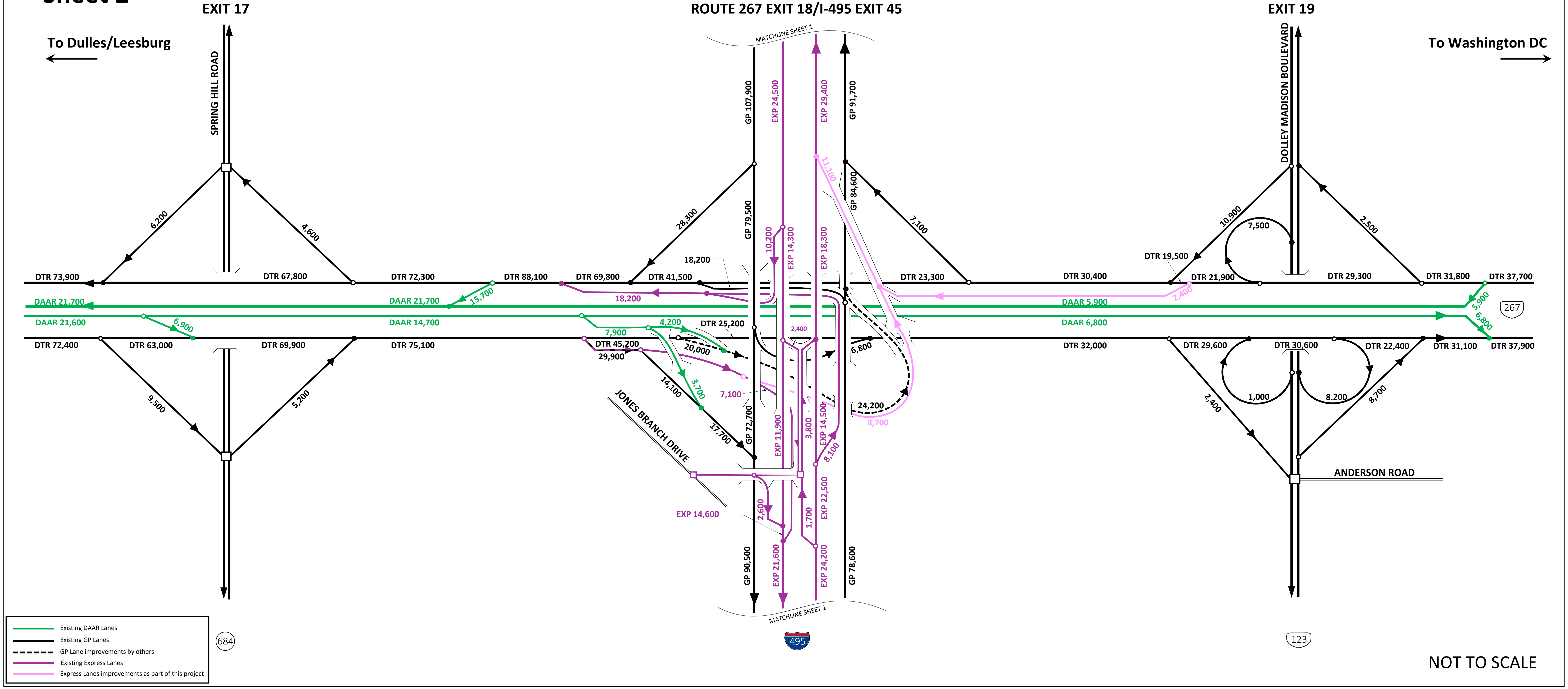
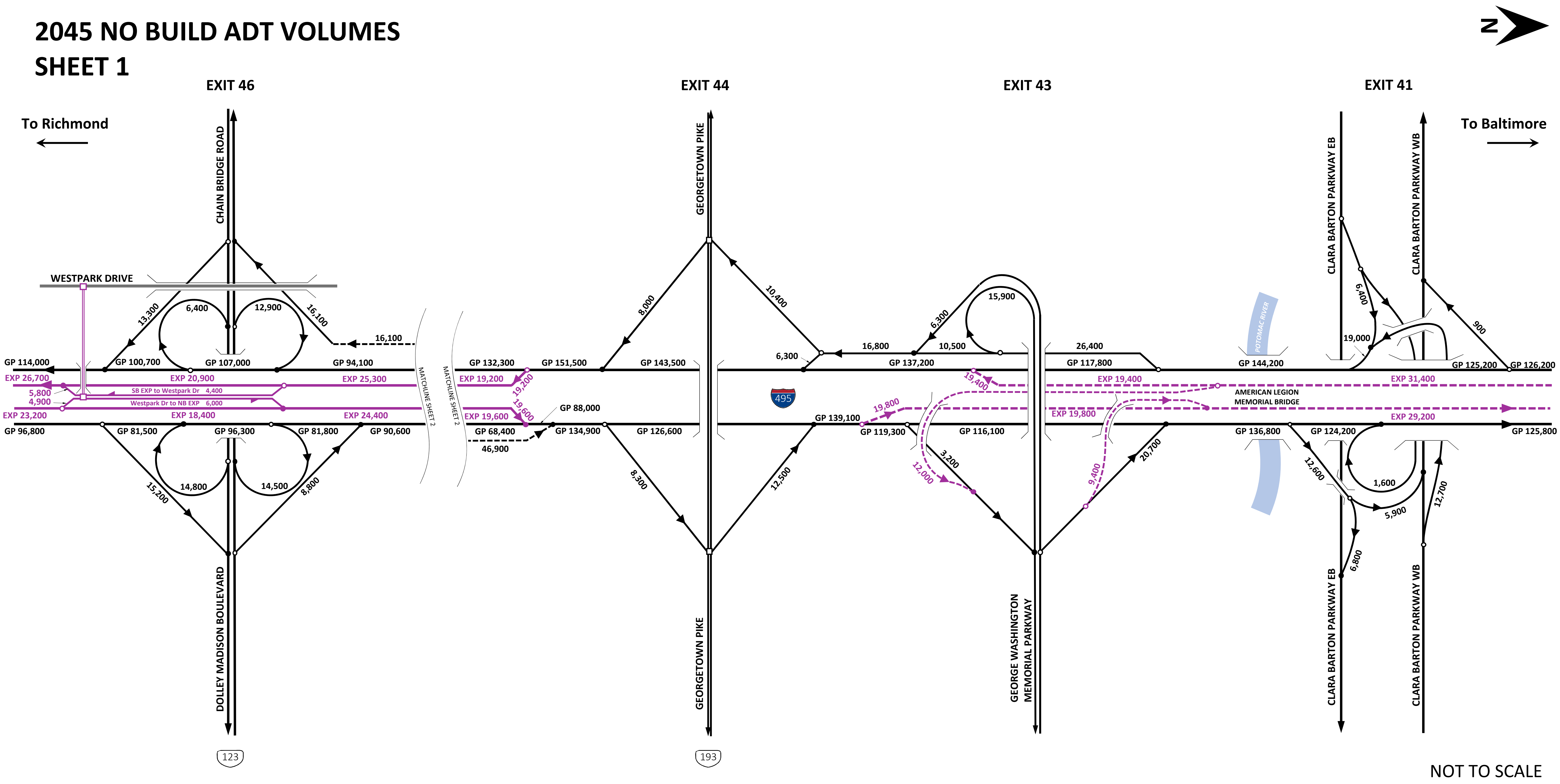


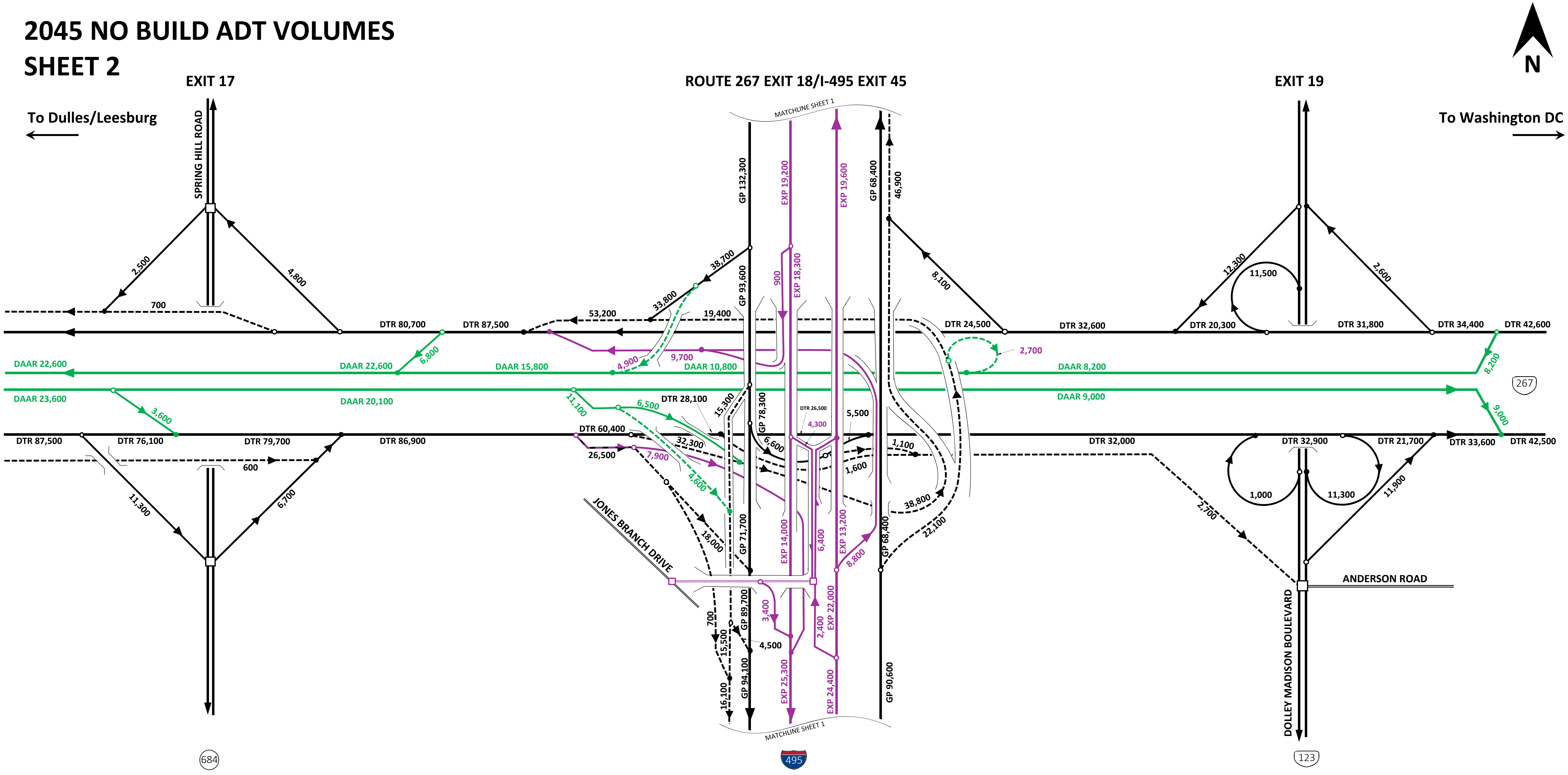
2025 Build ADT Volumes
Sheet 2



2045 NO BUILD ADT VOLUMES
SHEET 1



2045 NO BUILD ADT VOLUMES
SHEET 2



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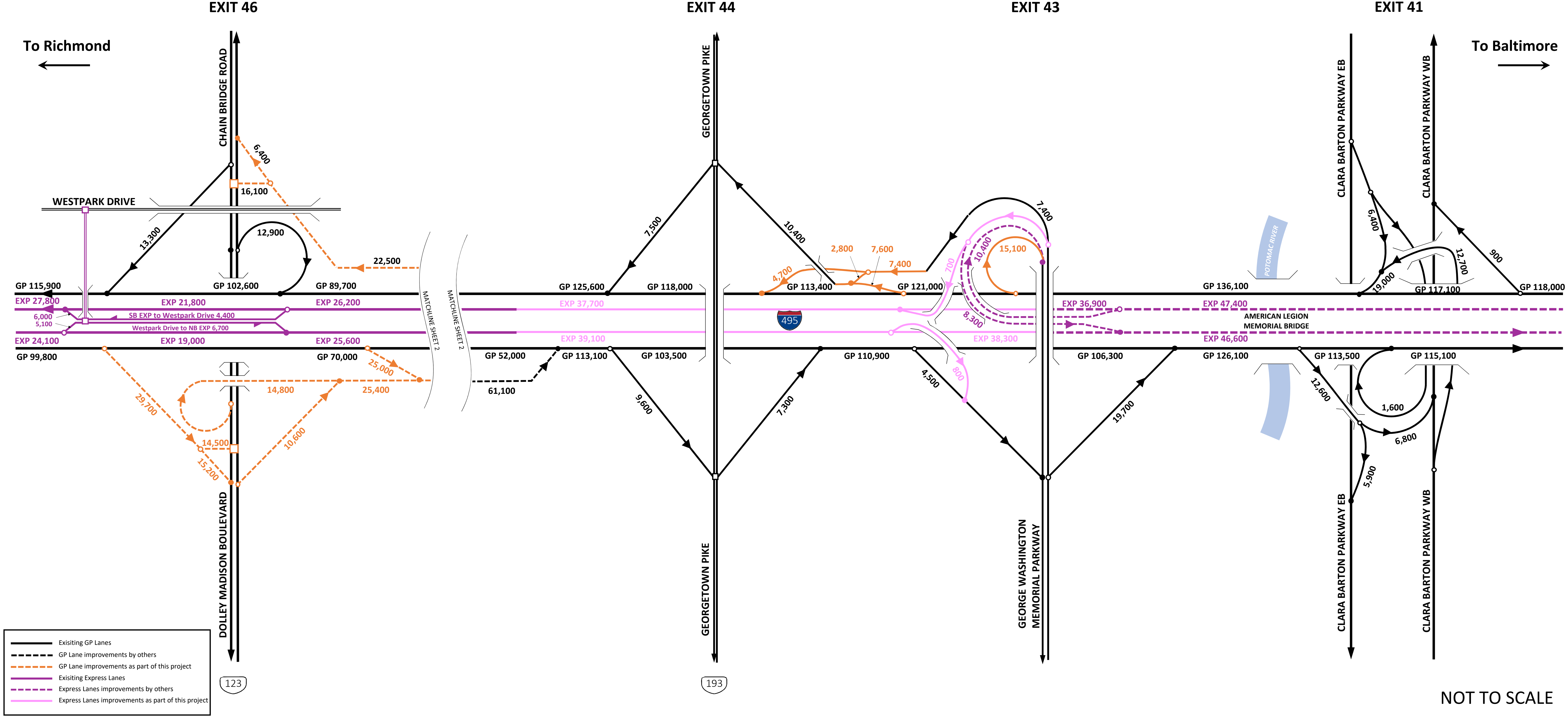
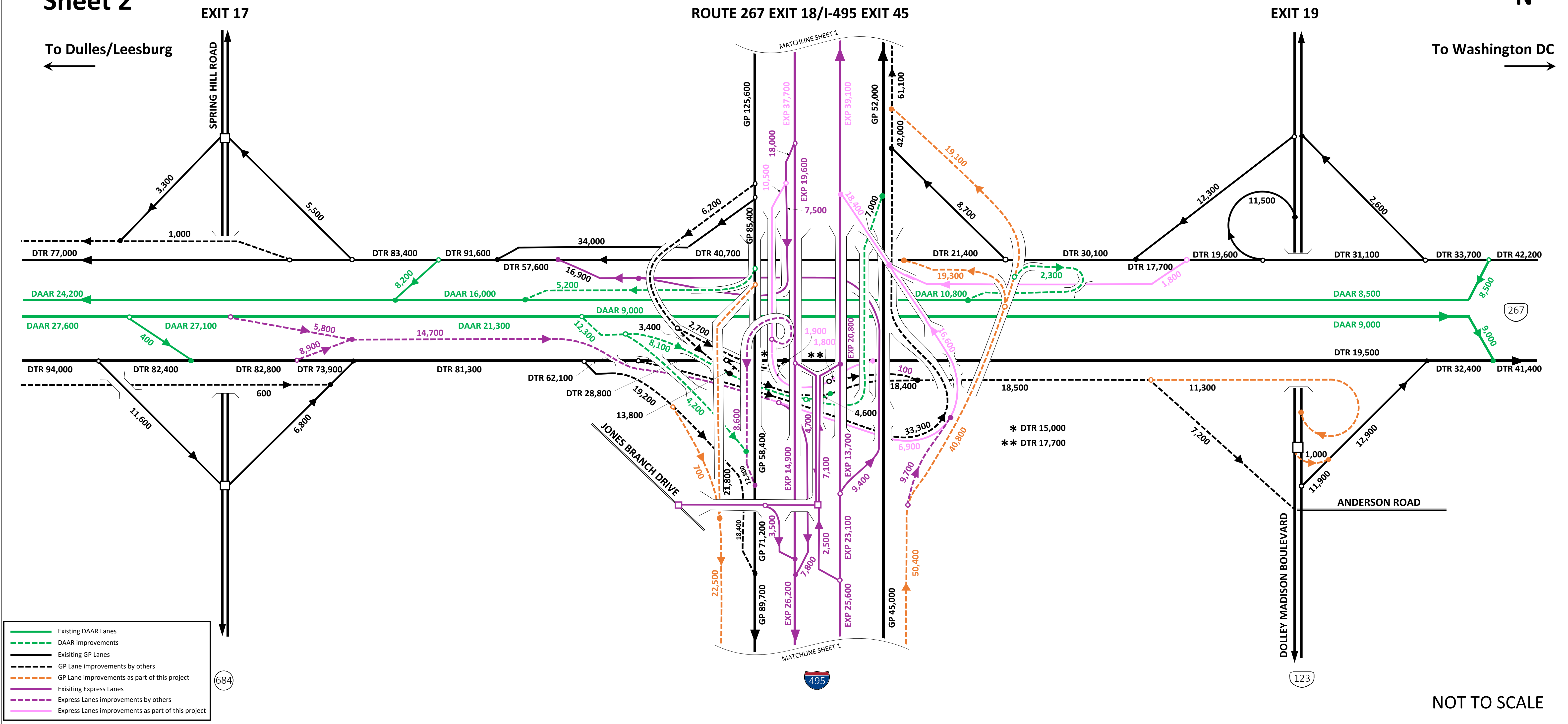
2045 Build ADT Volumes

Sheet 1



2045 Build ADT Volumes

Sheet 2



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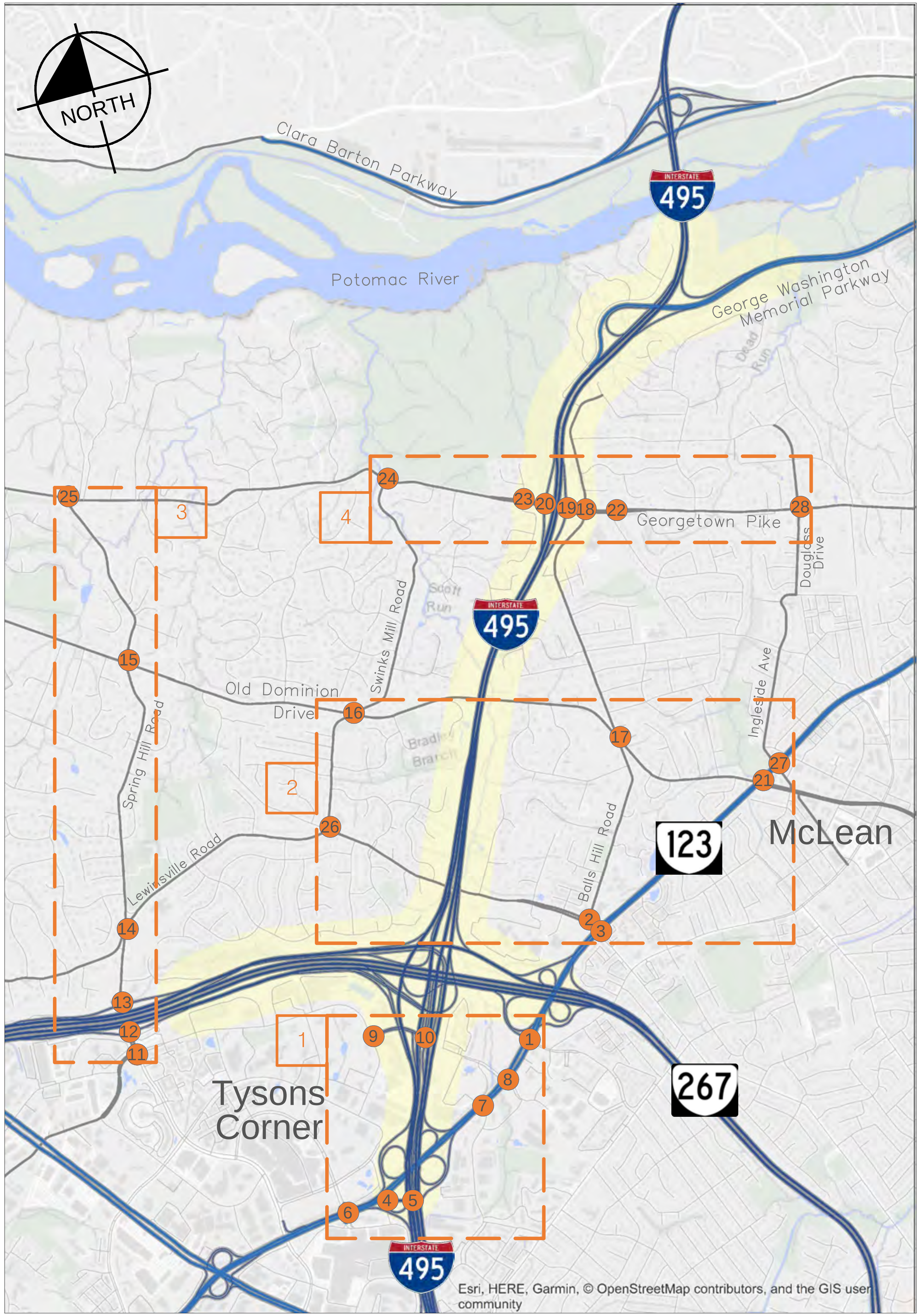

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Legend

X Intersection Group Number

X Intersection Number

▨ Project Study Area

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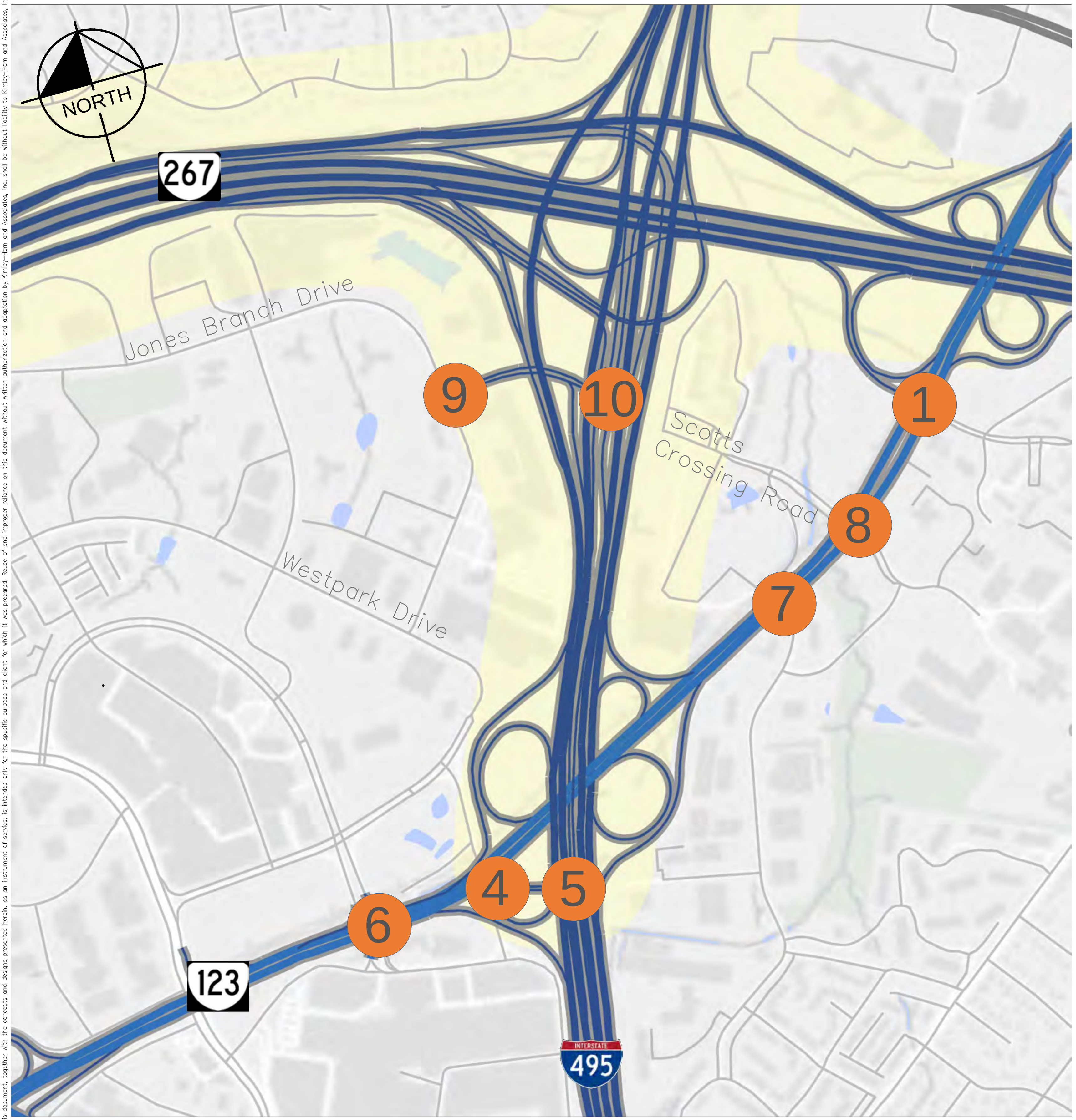
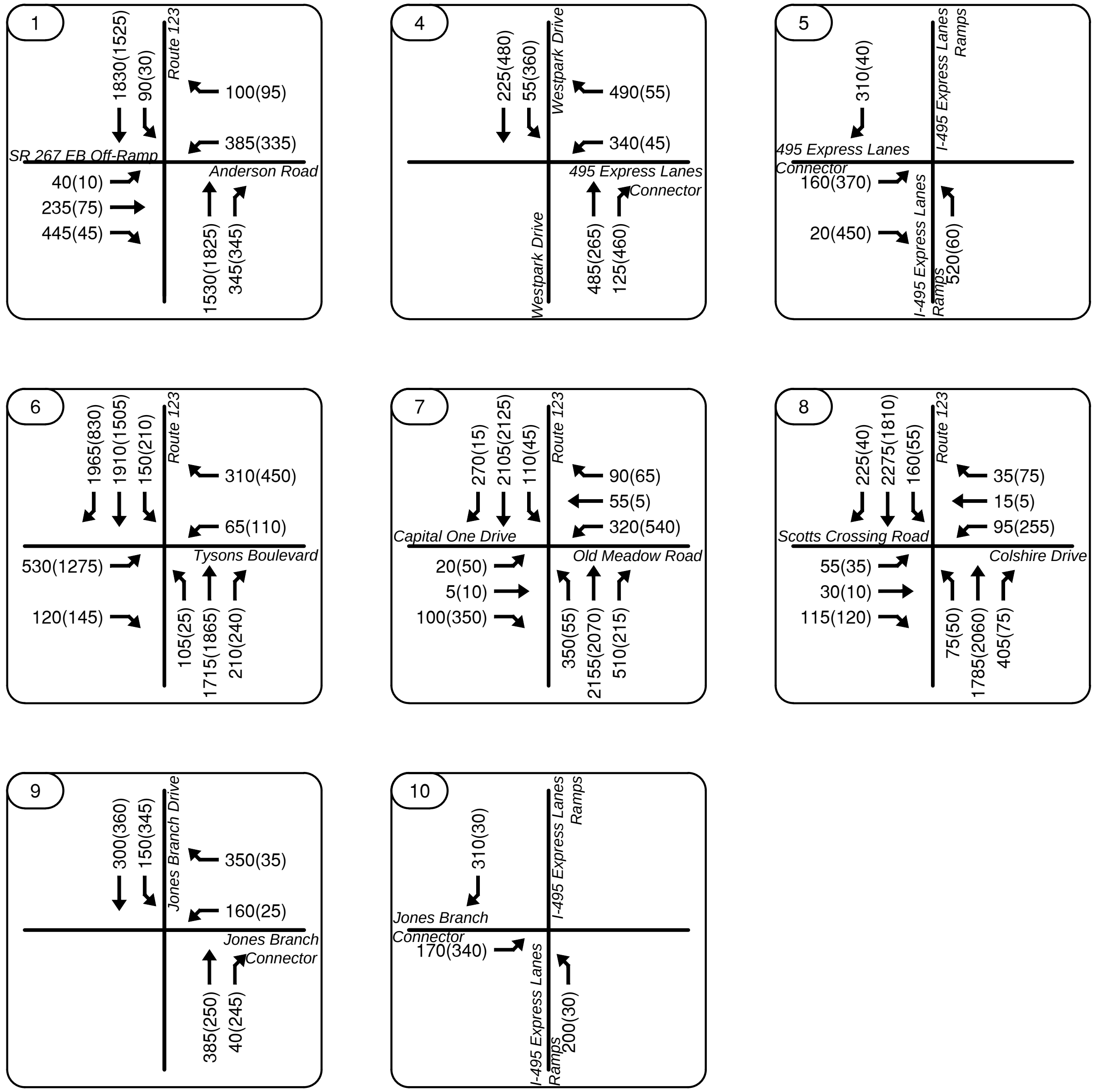
495 ExpressLanes NORTHERN EXTENSION

AM (PM) Peak Hour Existing Intersection Volumes

FIGURE KEY





NOTE - Intersection Volumes Inset Boxes are oriented to the North

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● Intersection Number

495 ExpressLanes
NORTHERN EXTENSION

AM (PM) Peak Hour Existing Intersection Volumes

FIGURE
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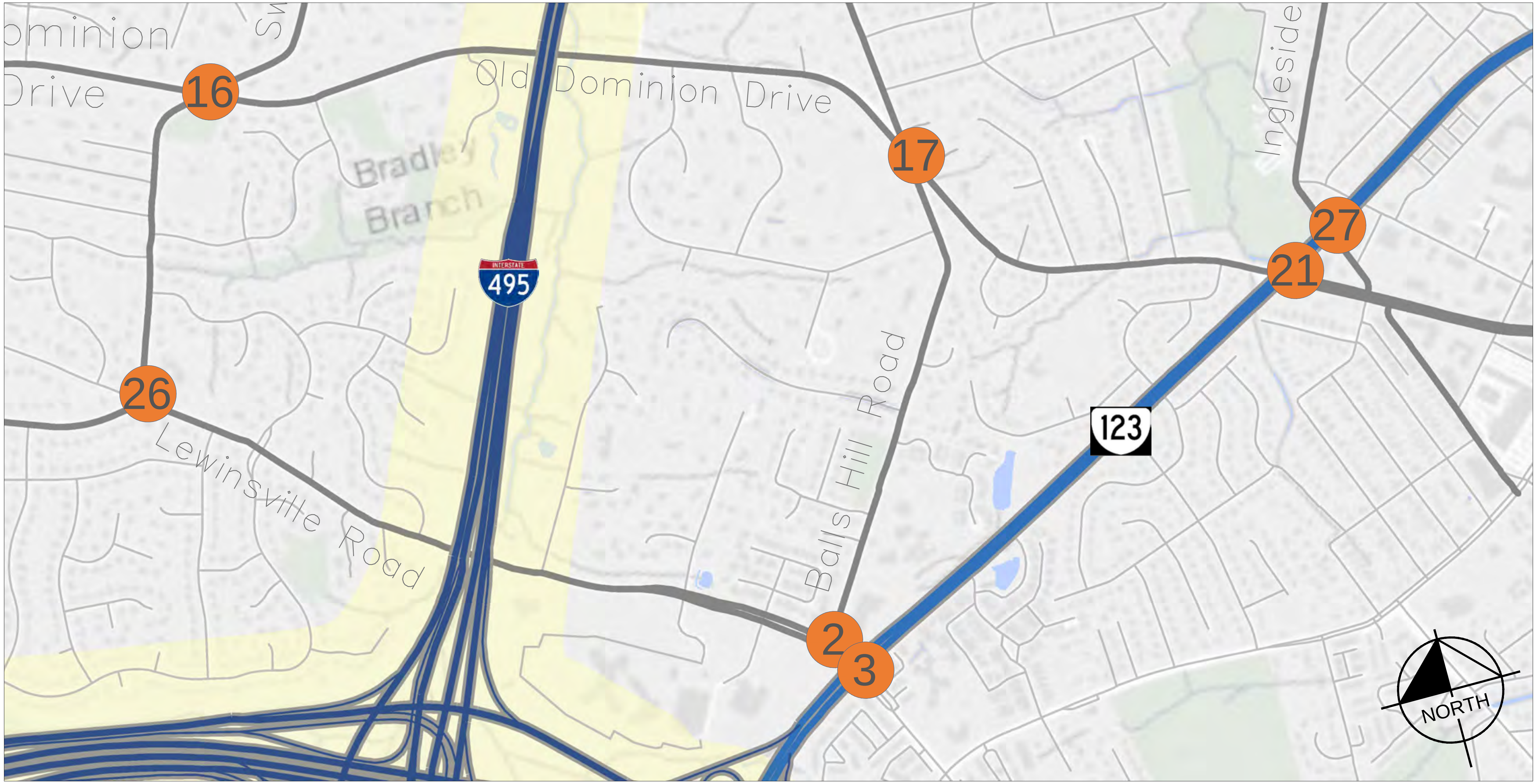

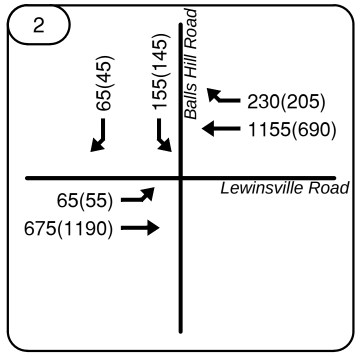

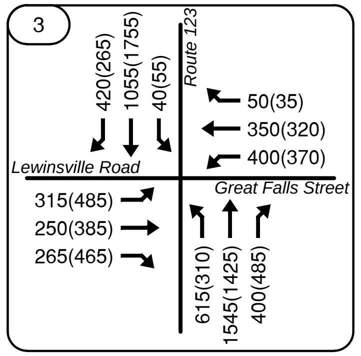

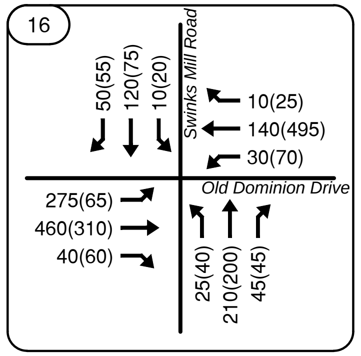

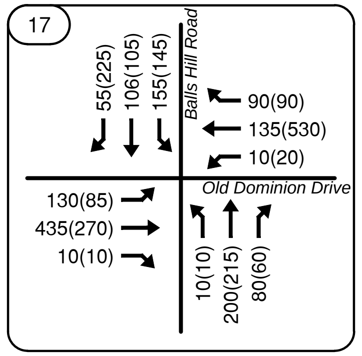

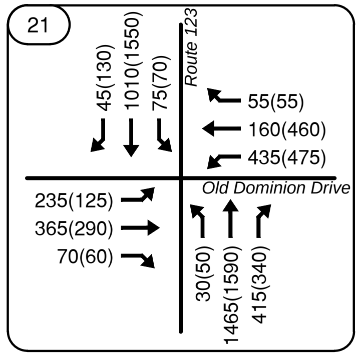

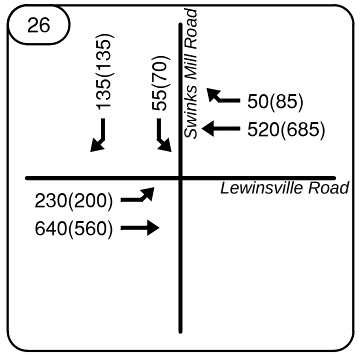

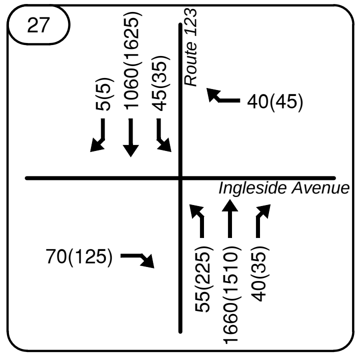

NOTE - Intersection Volumes Inset Boxes are oriented to the North

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X Intersection Number

AM (PM) Peak Hour Existing
Intersection Volumes

FIGURE
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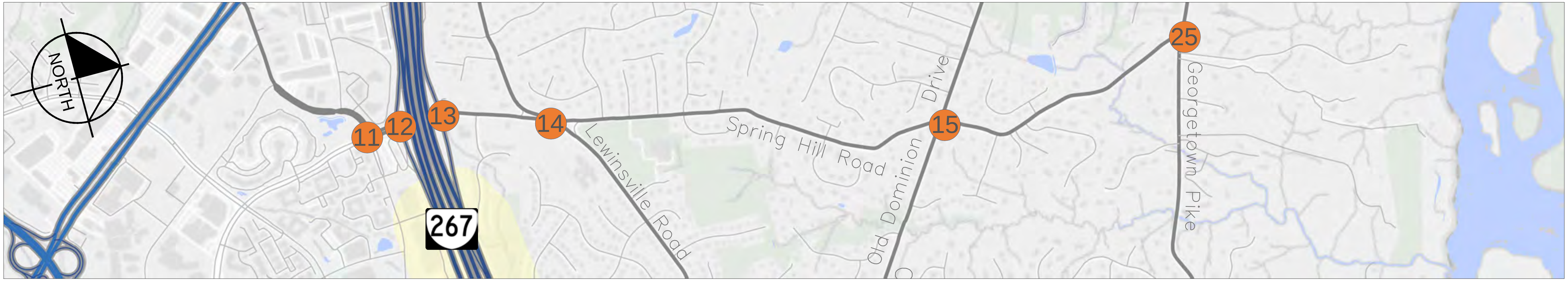

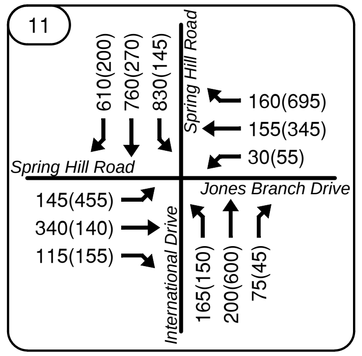

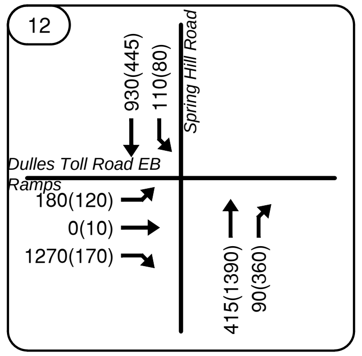

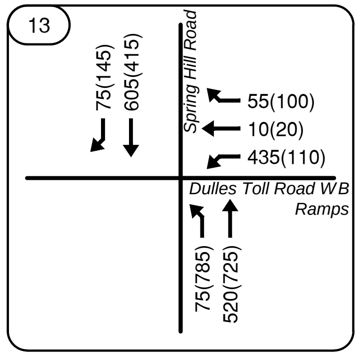

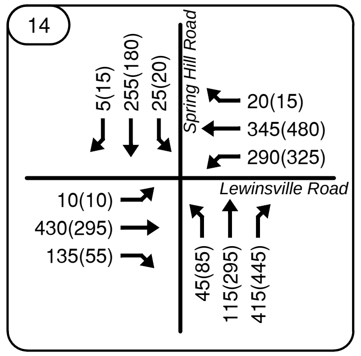

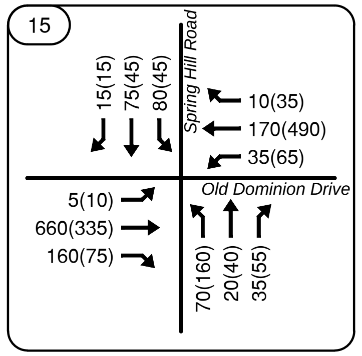

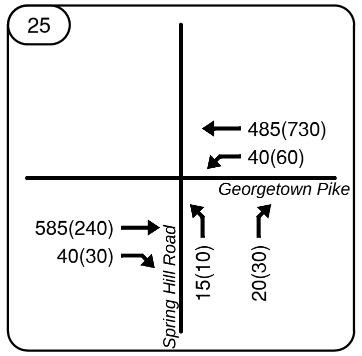

NOTE - Intersection Volumes Inset Boxes are oriented to the North

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Legend

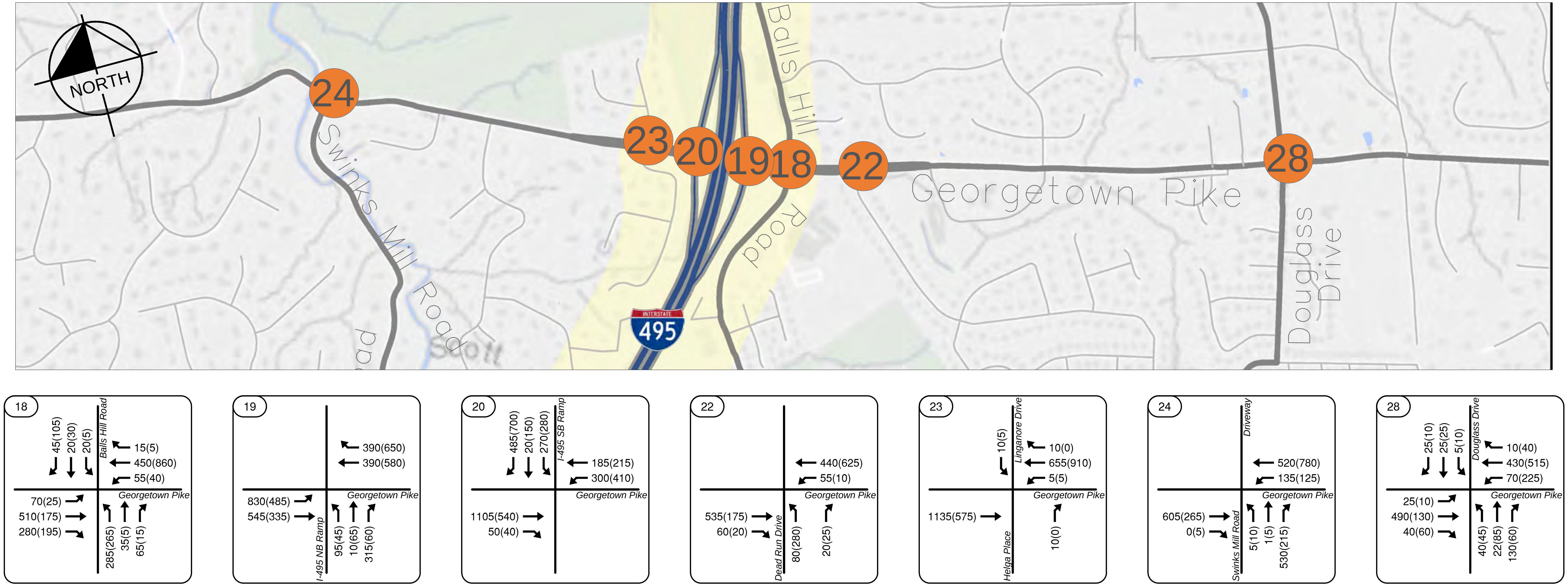
X Intersection Number

495 ExpressLanes NORTHERN EXTENSION

AM (PM) Peak Hour Existing Intersection Volumes

FIGURE

3



NOTE - Intersection Volumes Inset Boxes are oriented to the North

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Legend

X Intersection Number

AM (PM) Peak Hour Existing Intersection Volumes

FIGURE

4

Appendix B: Scoping Framework Document for I-495 NEXT Project - FHWA Concurrence for Approach and Methodology

I-495 Express Lanes Northern Extension Project (I-495 NEXT Project)

FINAL EXECUTED VERSION

Scoping Framework Document for *I-495 NEXT Project*

FHWA Concurrence for Approach and Methodology

VDOT Contract ID No. 45978 /Project No. 113414

NOVEMBER 15, 2018

Prepared for:

VDOT Virginia Department of Transportation

U.S. Department of Transportation Federal Highway Administration

NOVA District, Fairfax
Central Office, Richmond

Virginia Division, Richmond

Prepared by:

ATCS®

Kimley»Horn

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ATTACHMENTS/APPENDICES

1. I-495 NEXT Traffic Operation Analysis Framework Memorandum
2. I-495 NEXT Travel Demand Forecasting Memorandum
3. I-495 NEXT VISSIM Calibration Memorandum
4. I-495 NEXT Crash Analysis Framework Memorandum
5. I-495 NEXT Air/Noise Analysis Framework Memorandum

INTRODUCTION

This document outlines the scope of work for the traffic forecasting and analysis associated with the I-495 NEXT Project. The consultant team will provide technical support of the National Environmental Policy Act (NEPA) studies (documented in an Environmental Assessment), Preliminary Engineering and Options Development, and other analyses performed in support of the associated technical reports prepared to inform the NEPA decision making process. This task will primarily focus on efforts to prepare a Traffic and Transportation Technical Report (TATTR) and a system Interchange Justification Report (IJR) based on the guidance from VDOT Central Office that is updated from the previous IIM 200.9, in order to be consistent with the May 2017 update to FHWA policy on NEPA and IJRs for federal actions involving interchanges and interstate access. The TATTR and IJR will serve to support the technical studies as a part of VDOT’s I-495 NEXT Project, and to document the project traffic analysis.

Background

The Virginia Department of Transportation (VDOT), in partnership with the Federal Highway Administration (FHWA), is developing transportation improvements in the I-495 corridor from the Dulles Toll Road (State Route 267) to the vicinity of the American Legion Bridge and the Maryland state line, called the I-495 Express Lanes Northern Extension (NEXT) project. The project proposes to add two (2) managed lanes in each direction, and the study corridor extends approximately three miles from the I-495 interchange with the Dulles Toll Road to the George Washington Memorial Parkway (GWMP) in the McLean area of Fairfax County.

The Capital Beltway, or I-495, is a 64-mile multi-lane circumferential freeway centered around Washington, D.C. and passing through Maryland and Virginia. The Virginia portion of I-495 is 22 miles, extending from the Woodrow Wilson Bridge in Alexandria to the American Legion Bridge in Fairfax County. The existing I-495 facility within the study area currently has four northbound and four southbound general purpose lanes, with auxiliary lanes or collector-distributor roadways provided at several interchanges. North of the study area, I-495 at the American Legion Bridge has a total of 10 lanes, eight general purpose through lanes and two auxiliary lanes that connect Clara Barton Parkway in Maryland and the GWMP in Virginia.

The existing I-495 Express Lanes extend for 14 miles along I-495, from the I-95/I-495/I-395 interchange in Springfield to south of Old Dominion Drive in McLean (just north of the Dulles Toll Road interchange). The two existing northbound Express Lanes end just south of Old Dominion Drive by merging into a single lane-controlled shoulder/travel lane, which is open to traffic during the AM and PM peak periods. This fifth lane continues for a total length of approximately 1.8 miles before merging with the general purpose lanes at the GWMP interchange. The Express Lanes are separated from the general purpose lanes by flexible bollards. All buses and vehicles with two axles can access the Express Lanes 24 hours a day, seven days a week. High-Occupancy Vehicles (HOV) with three or more occupants are not charged a toll. No trucks are currently permitted to use the Express Lanes.

Current Studies

The proposed effort will be comprehensive in its scope and multi-purpose. The analysis will serve to develop the environmental documentation needed per NEPA, the operational analysis report needed for interchange justification/modification, preliminary engineering, and an assessment of potential costs and revenues from variably-priced express lanes.

The following studies have been conducted to support the further development and documentation of specific infrastructure and operations recommendations for the I-495 NEXT Project:

- Final EIS Completed April 2006 (Project northern terminus near George Washington Parkway)
- ROD Issued June 2006
- IJR Approved December 2007 (northern terminus revised to north of Lewinsville Road, 5th GP lane south of Rte. 193)
- NEPA Reevaluations Completed (May 2007, June 2008, December 2008, May 2009, July 2009)
- Dulles Interchange NEPA Reevaluation November 2009
- Dulles Interchange IJR Approved December 2009
- Express Lanes and Dulles Interchange Open to traffic November 2012
- I-495 North Shoulder Lane Use Project (1½ Mile Express Lanes Merge to GW Parkway)

Document Purpose

This IJR scoping document describes the format and content of an IJR for one combination of access options and a single Build Alternative concept, as identified in the EA. This combination will be referred to as the *Preferred Alternative*. In terms of the IJR, the Preferred Alternative consists of the following:

- General purpose lanes
- Express Lanes carrying HOV-3 traffic, toll-paying traffic, and trucks (assumed conservative case)
- Transportation system management
- ITS

The I-495 NEXT Project EA and IJR will document the need for new and modified access to support and accommodate the Express Lanes, and general purpose lane modifications. The IJR will be submitted in coordination with preliminary design plans and the EA prepared by VDOT. The EA and preliminary engineering plans are being prepared concurrently with the IJR.

It should also be noted that the Express Lanes carrying HOV, toll-paying vehicles, trucks, and any potential new transit service will have connectivity to the existing high-occupancy, variably priced Express Lanes along I-495 and recently-constructed Express Lanes along I-66 Inside the Beltway between I-495 and the Washington, DC, boundary (via the Dulles Toll Road Connector).

PURPOSE & NEED

The Purpose and Need for the EA has not yet been fully established but will be developed as part of NEPA scoping process and included in the IJR. A number of corridor transportation needs have been identified in the Draft In-progress Purpose and Need. Needs for the I-495 corridor are related to issues such as:

- Reduce congestion and improve roadway safety
- Provide additional travel choices
- Improve travel reliability

Reduce Congestion and Improve Roadway Safety. In the fourth quarter of 2017, I-495 between I-66 and the I-270 Spur, including the study area and the American Legion Bridge, was ranked second on the list of top ten bottlenecks in the Washington, D.C. region by the National Capital Region Transportation Planning Board, up from being ranked fifth in 2016 (TPB, 2017). The GWMP is used as a primary commuting route and also experiences moderate congestion throughout its length, but particularly on the on ramp to I-495 northbound in the PM peak period (NPS NCR Long Range Transportation Plan, 2018).

Congestion and unsafe weaving movements of vehicles at the northern terminus of the I-495 Express Lanes also results in crashes and safety concerns in the study area. According to crash data collected along northbound I-495 from the Dulles Toll Road interchange to the American Legion Bridge over an approximate nine-month period starting November 17, 2012 (the opening of the existing I-495 Express Lanes), a total of 81 crashes were recorded in the study area. Of the 81 crashes recorded, 57 (approximately 70 percent) of the crashes occurred between south of the Dulles Toll Road interchange to the off-ramp at Georgetown Pike. The most common contributing circumstances recorded by police officers were congestion and vehicles changing lanes. Furthermore, the segment within the study area between Old Dominion Drive and the off-ramp to Georgetown Pike had the highest crash density with a crash rate of 152 (per 100 million VMT), which is far above the Northern Virginia Average Interstate Crash Rate of 99 (per 100 million VMT) (VAP3, Detail-Level Project Screening Report, 2014).

Provide Additional Travel Choices. The existing I-495 and I-95 Express Lanes create a 40-mile HOV and bus network in northern Virginia and provide additional travel choices for a variety of users. However, because the existing Express Lanes end at Old Dominion Drive, travel choices for all northbound travelers are limited. No commuter bus service is offered within the study area or over the American Legion Bridge due to the absence of dedicated or managed lanes that would allow buses to travel more efficiently. Both HOV and single-occupant vehicles choosing to use the existing Express Lanes are forced to rejoin the GP lanes north of Old Dominion Drive with no options to bypass congestion or bottlenecks. Travelers are therefore less likely to choose carpooling, vanpooling, or transit options because these options are no more efficient than driving alone.

Commuter choices are also affected by access. The northbound and southbound I-495 Express Lanes are accessible in both directions from Westpark Boulevard and Jones Branch Drive. From Route 7 and eastbound Route 267, only the southbound Express Lanes are accessible. There is currently no direct access to the northbound Express Lanes from Route 267 or Route 7. There is also no direct access to and from the Express Lanes in either direction from GWMP. Also, the planned I-495/I-270 Managed Lanes Study is evaluating the feasibility of Express Lanes along the entire I-495 corridor in Maryland, including the American Legion Bridge. Because the I-495 Express Lanes in Virginia currently end two miles south of the American Legion Bridge, there would be a two-mile gap in the I-495 Express Lanes network, representing the only interruption in Express Lanes service for the entire 64-mile I-495 loop. Travel choices for both northbound and southbound travelers would continue to be limited within this two-mile stretch because all Express Lanes users would be forced to merge into GP lanes, with no options to bypass congestion or bottlenecks.

Improve Travel Reliability. A 2016 commuter survey conducted by MWCOG revealed that over 80 percent of commuters in the region add extra time to their commutes to account for travel time variability due to congestion, bottlenecks, crashes, weather events, and other factors. These issues contribute to highly variable travel speeds and travel times for all users within the study area, including single occupancy, HOV, transit, and freight vehicles alike. Motorists who report using HOV or Express Lanes save an average of 20 minutes on their commute; however, due to congestion and reduced travel speeds at the northern terminus of the northbound I-495 Express Lanes, users traveling to Maryland or the GWMP are not able to reap the full benefits of the existing Express Lanes. The duration and extent of congestion within the study area is expected to increase with population, employment, and subsequent traffic volumes. Variability in travel speeds and travel times is therefore expected to worsen in the future. The proposed project will extend the I-495 Express Lanes from their existing northern terminus to Maryland, providing a seamless reliable travel option for HOV or toll-paying motorists traveling to or from Maryland and the GWMP.

PROJECT SCOPE & ASSUMPTIONS SUMMARY

The proposed project scope for the EA includes four general purpose lanes (keeping the same number of general purpose lanes that are utilized now) and two Express Lanes in each direction of I-495, consistent with the existing I-495 Express Lanes configuration south of the project limits. The approach to the preparation of the EA, IJR, preliminary engineering effort, and supporting technical studies will be closely coordinated among VDOT, VAP3, FHWA, and MDOT/SHA.

Scoping Definitions:

Two Express Lanes

Two lanes in each direction of I-495 that would operate as a high-occupancy variably priced toll facility with non-toll vehicles required to carry three or more persons or as required by the Code of Virginia.

Four General Purpose Lanes

Four non-tolled general purpose lanes in each direction at all times open to all traffic with shoulders [no traffic use of shoulders].

Auxiliary Lanes

The CLRP and previously approved IJRs and NEPA documents commit to implementing one northbound and one southbound auxiliary lane between the Dulles Toll Road and Georgetown Pike by 2030, consistent with the CLRP.

Dulles Interchange Long Range Plan

The CLRP and previously approved IJRs and NEPA documents reference a master plan for the Dulles Interchange that was developed in coordination with MWAA and FHWA in 2009 and 2010. The plan provides for full connectivity between the Dulles Toll Road, Dulles Airport Access Road, and I-495 General Purpose Lanes and Express Lanes. The plan was approved in concept by FHWA and the original I-495 Express Lanes were constructed to facilitate the future construction of the additional ramp movements. Several ramps included in the Long Range Plan are proposed to be constructed as part of the scope of this project.

Milestone Schedule Approach & IJR Review Process

- IJR Scoping Framework Document Concurrence – FHWA meetings required.
- Development of IJR simulation models for the Preferred Alternative:
    - 2018 Existing Conditions
    - 2025 and 2045 No-Build Conditions
    - 2025 and 2045 Build Conditions
- VISSIM model simulation – walk-through meeting with FHWA and VDOT.
    - Will include base model summary and calibration of existing model
- Interim results review – submittal of revised/post-processed Measures of Effectiveness (MOEs).
- Submittal of Draft IJR document.
- Concurrent VDOT/FHWA review of Draft IJR document.

- Comment resolution meeting with FHWA and VDOT.
- Comments responses and IJR revisions – Prepare Final IJR document.
- Submit Final IJR document – Northern Virginia (NOVA) District Office => VDOT Central Office => FHWA Virginia Division Field Office => FHWA Headquarters.
- 30 days required for VDOT and FHWA final review processing to issue a *Finding of Engineering and Operational Acceptability* => Confirmation of NEPA compliance => **Final IJR Approval.**

Interstate Access Request Review occurs on 3 levels:

- **Traffic forecasts** – VDOT Northern Regional Operations (NRO) - Traffic Engineering and Transportation Planning.
- **Draft IJR Report** – VDOT NOVA District Office, VDOT Central Office, FHWA Virginia Division, and FHWA Headquarters (HQ).
- **Final IJR Report** – VDOT Central Office, FHWA Virginia Division, and FHWA HQ.

ASSUMPTIONS

Study Area Limits

The Project Footprint Study Area for the I-495 NEXT Project spans I-495 from the Dulles Toll Road interchange (Route 267) to the American Legion Bridge (north of the George Washington Memorial Parkway [GWMP]). The Traffic Operational Analysis Study Area includes the full extent of the Project Footprint Study Area as well as one additional intersection north and south, extending from just south of the Chain Bridge Road (Route 123) interchange to the bridge over Seven Locks Road in Maryland, which is just south of the Cabin John Parkway interchange. The Traffic Operational Analysis Study Area also includes the following interchanges and intersections:

- The GWMP from I-495 to the bridge over Turkey Run loop road, which is just west of the Turkey Run Farm interchange
- Clara Barton Parkway and its interchange with I-495, including all ramps at that interchange, from a location just east of the Clara Barton Parkway/Carderock interchange to a location just east of the Clara Barton Parkway/Clara Barton Access Road interchange
- Georgetown Pike (VA Route 193), including its interchange with I-495 and all ramps, ramp terminals and road segments contained therein, as well as the section of Georgetown Pike from the Spring Hill Road intersection to the Dead Run Drive intersection, including intersections with: Swinks Mill Rd, Linganore Drive/Helga Place and Balls Hill Road
- Old Dominion Drive (VA Route 738), from the Spring Hill Road intersection to the Balls Hill Road intersection, including the intersections at the termini and the intersection with Swinks Mill Road
- Swinks Mill Road (VA Route 684) from its intersection with Georgetown Pike to its intersection with Lewinsville Road, including the intersections at the termini and its intersection with Old Dominion Drive
- Lewinsville Road (VA Route 694), from its intersection with Spring Hill Road to its intersection with Dolley Madison Road, including the intersections at the termini and its intersections with Swinks Mill Road and Balls Hill Road
- Chain Bridge Road (VA Route 123), including its interchange with I-495 with all ramps, ramp terminals and road segments contained therein, as well as the section from its intersection with Tysons Blvd/Tysons Mall Ring Road entrance to its intersection with Great Falls Street / Lewinsville Road, inclusive, and its intersections with Old Meadow Road / Capital One Tower Drive, Scotts Crossing Road / Colshire Drive, and Anderson Road / Dulles Toll Road Connector ramp terminal within that section

- Dulles Toll Road (VA Route 267) / Dulles Airport Access Road from just west of the Spring Hill Road to the bridge over Magarity Road, which is east of the Dulles Toll Road / Dolley Madison Boulevard (VA Route 123) interchange
- Spring Hill Road (VA Route 684), including its interchange with Dulles Toll Road with all ramps, ramp terminals and road segments contained therein, and the section of Spring Hill Road from its intersection with Georgetown Pike to its intersection with Tyco Road/Jones Branch Road intersection, inclusive, and its intersections with Old Dominion Drive and Lewinsville Road within that section

Figure 1 shows the various components of the project study area for the I-495 NEXT Project:

- **Yellow – Project Footprint Study Area.** The I-495 NEXT Project Study area includes I-495 from the Dulles Toll Road interchange to the American Legion Bridge, including all ramp termini of interchanges over that section
- **Blue – Traffic Operations Analysis Study Area.** The Traffic Operations Analysis Study Area, described in detail above, includes the full extent of the Project Footprint Study Area as well as one interchange north and south on I-495, and a number of additional intersections and interchanges which directly affect, and are affected by operations on I-495 within the Project Footprint Study Area

Figure 1: Project Study Area

Data Collection

Traffic Volumes

Intersection turning movement counts were conducted for a 15-hour time period from 5 AM to 8 PM which would include AM and PM peak period. For mainline segments, traffic counts were conducted before and after each major interchange along with all the ramps in the Study area. Data was collected in May and June 2018, prior to the end of the school year, and was summarized in 15-minute intervals.

Traffic count locations are shown in Figure 2 and listed in **the I-495 NEXT Traffic Operation Analysis Framework Memorandum**.

Traffic volumes used in the traffic and operations analysis will consist of the following:

- **Existing (2018)** – Developed from field counts (ramps, freeway mainline, and intersection turning movements) conducted during typical weekdays in May and June 2018 while Fairfax County schools were still in session. Traffic counts were taken on the same days as other locations wherever possible to minimize variability in the calibration process. Count data will be post-processed and balanced between all adjacent locations in the traffic operations analysis study area.
- **Opening Year (2025)** – No Build and one Build alternative developed through modifications to the MWCOG 2025 travel demand model for the I-495 corridor and post-processed based on 2018 data collection.
- **Design Year (2045)** – No Build and one Build alternative developed through modifications to the MWCOG 2045 travel demand model for the I-495 corridor and post-processed based on 2018 data collection.

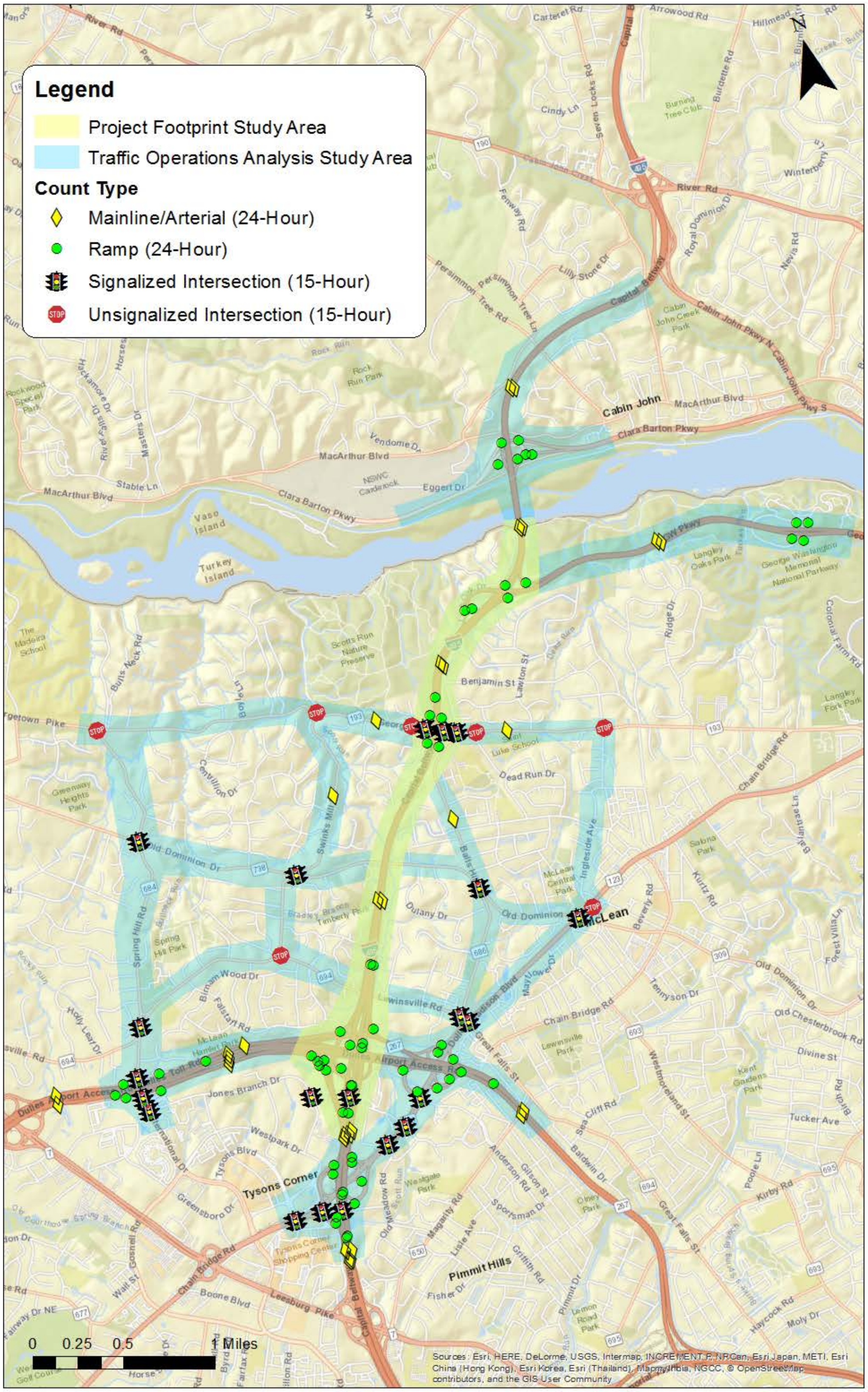


Figure 2: Traffic Count Locations

Origin-Destination Data

The traffic simulation modeling effort will route vehicles through the traffic network according to origin-destination routing. Origin-destination data will be reviewed from the following sources:

- StreetLight Data, which via a VDOT subscription provides customized origin-destination data with a very high level of spatial accuracy based on aggregated cellular device GPS/location-based services data. StreetLight Data allows for a user to provide custom origins and destinations, such as on- and off-ramps for all freeways in a study area or entry/exit links to a study area. It is anticipated that StreetLight Data will be used as the basis for origin-destination routing for the existing conditions traffic analysis, at the very least for the freeway and ramp segments of the study area.
- MWCOG regional travel demand model, which outputs O-D matrices for various vehicle types between each traffic analysis zone (TAZ) in the Washington, DC, metropolitan area. The travel patterns within the model base year (2017) have been calibrated against 2007/2008 regional household travel survey data, so the travel patterns are somewhat dated. Additionally, this dataset is not as granular as needed to account for freeway weaving proportions. However, given that the travel demand model provides O-D matrices for future years, it is anticipated that these may be used as the basis for vehicle routing in future analysis year scenarios.

Speeds and Travel Times

Floating car travel were conducted in June 2018 during the AM and PM peak periods. Wherever possible, travel times were collected on the same days as traffic counts to minimize variability in the calibration process. Travel time segments are listed in the **I-495 NEXT Traffic Operation Analysis Framework Memorandum**.

Time Periods:

- Weekday (Tuesday, Wednesday or Thursday) AM Peak Period: runs beginning no earlier than 5:30 AM and concluding not later than 9:30 AM
- Weekday (Tuesday, Wednesday or Thursday) PM Peak Period: runs beginning no earlier than 3:00 PM and concluding not later than 7:00 PM

In addition, INRIX vehicle probe speed data has been queried for the corridor using the RITIS Congestion Scan tool, which provides a “heat map” of vehicle speeds temporally and spatially along a corridor. This data has been pulled for “average weekdays” (Tuesday, Wednesday, and Thursday) for the 12 most recently available months of data (July 2017 through June 2018).

Queueing Data

Queuing within the study area is notably inconsistent and can oscillate numerous times within the peak periods, or be absent altogether on some days. A qualitative subjective assessment will be conducted for queue lengths at targeted locations in addition to the review of freeway mainline congestion/queues against the speed heat maps. Queueing along the freeway segments of the corridor will be provided via the INRIX heat map and verified against Google Maps’ typical traffic. Queueing along arterials and ramps will be obtained via screen captures from Google Maps’ typical traffic. Targeted spot locations and the methodology have been identified in the I-495 NEXT Traffic Analysis Microsimulation Calibration Methodology Memorandum. This memorandum was approved and signed by the VDOT NoVA District Traffic Engineer on July 27, 2018.

Analysis Scenarios

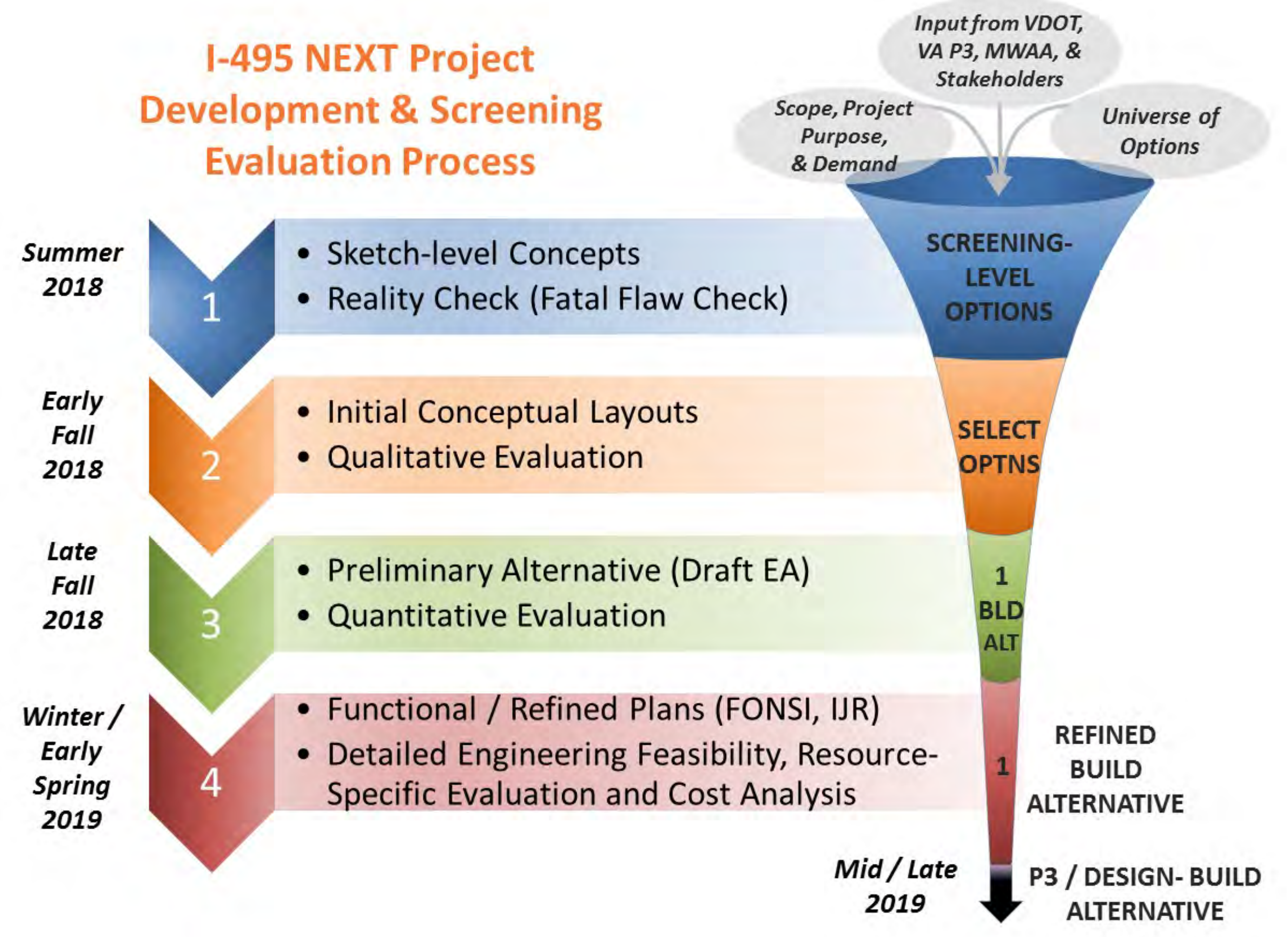
All analysis scenarios will be evaluated against the typical weekday AM peak period and PM peak period. The exact hours of analysis hours will be determined after assessing the traffic data and diurnal patterns.

- **Existing Conditions** – Calibrated against 2018 traffic conditions and the 2017 MWCOG model.
- **No-Build (w/ CLRP) Conditions** (2025 and 2045) – The 2025 and 2045 No-Build scenario assumes the existing transportation system in addition to all projects funded for construction in the *National Capital Region's Draft 2017 CLRP* through 2025 and 2045. The TPB adopted the 2016 CLRP in November 2016. Some of the regionally significant and corridor-specific projects include the following (taken from http://www.mwcog.org/clrp/projects/highway.asp):
    - I-495 Managed Lanes / I-270 Managed Lanes in Maryland
    - Transform I-66 Outside the Beltway – widening and express lanes, plus HOV-3
    - Transform I-66 Inside the Beltway – widening and dual-direction express lanes by 2045, plus HOV-3; note that the regional CLRP assumes that by 2045, I-66 is tolled in both directions during the peak period east of I-495, but it currently is only tolled in one direction in the peak period (eastbound in the AM and westbound in the PM).
    - Dulles Toll Road interchange ramps and Dulles Airport Access Road ramps by 2030
    - Metro Silver Line Extension to Dulles Airport and Loudoun County
    - Completion of the Jones Branch Connector
- **Build Conditions** – Assumes the No-Build configuration as a base condition and will reflect geometry, access points, and lane configuration proposed in the preliminary I-495 express lanes design concepts developed by the NEPA team and preliminary design team. The Consultant team will code express lanes, new access points, and other network changes, along with updated traffic demand and routing decisions for the 2025 and 2045 Build scenarios.

Proposed Modifications in Access (Express Lanes Access Alternatives)

Proposed modifications in access will be determined as part of the Preliminary Engineering and Options Development. The Consultant Team will use an iterative process to refine and improve roadway design based on traffic operations results. For this process, the team will develop "mini" VISSIM models for access options which will be utilized to test and evaluate traffic impacts of concept refinements. The Consultant Team will incorporate these improvements and additions that are ultimately adopted for the build concept into the overall VISSIM models used to perform the traffic analysis for the IJR. Any modifications in access adopted for the build concept will be documented in the IJR.

Figure 3: Alternatives / Options Development and Screening Process



Drafts of the Express Lane access locations for an interim year (2025) and a Preferred Alternative (2045) are shown in **Figure 4** and **Figure 5**. . VDOT will coordinate with MDOT/State Highway Administration to reach an agreement that will allow HOV-3+ users to get in and out of the Virginia Express Lanes without paying a toll. The existing entrance to the southbound I-495 Express Lanes will be modified to account for the proposed system connection with Maryland's future Express Toll Lanes, and a new entrance ramp from the general purpose lanes is anticipated to be constructed north of the American Legion Bridge as part of Maryland's project.

VDOT is considering potential phasing of the project improvements at the Dulles Interchange. This includes constructing the proposed southbound Express Lanes ramp to eastbound Dulles toll Road (Route 267). The ramp will be included in the NEPA action / footprint and will be included in the design horizon year (2045) in the IJR, but will be assumed as not part of the opening year (2025) in the IJR.

Figure 4: Express Lane Access Movements Interim Year 2025

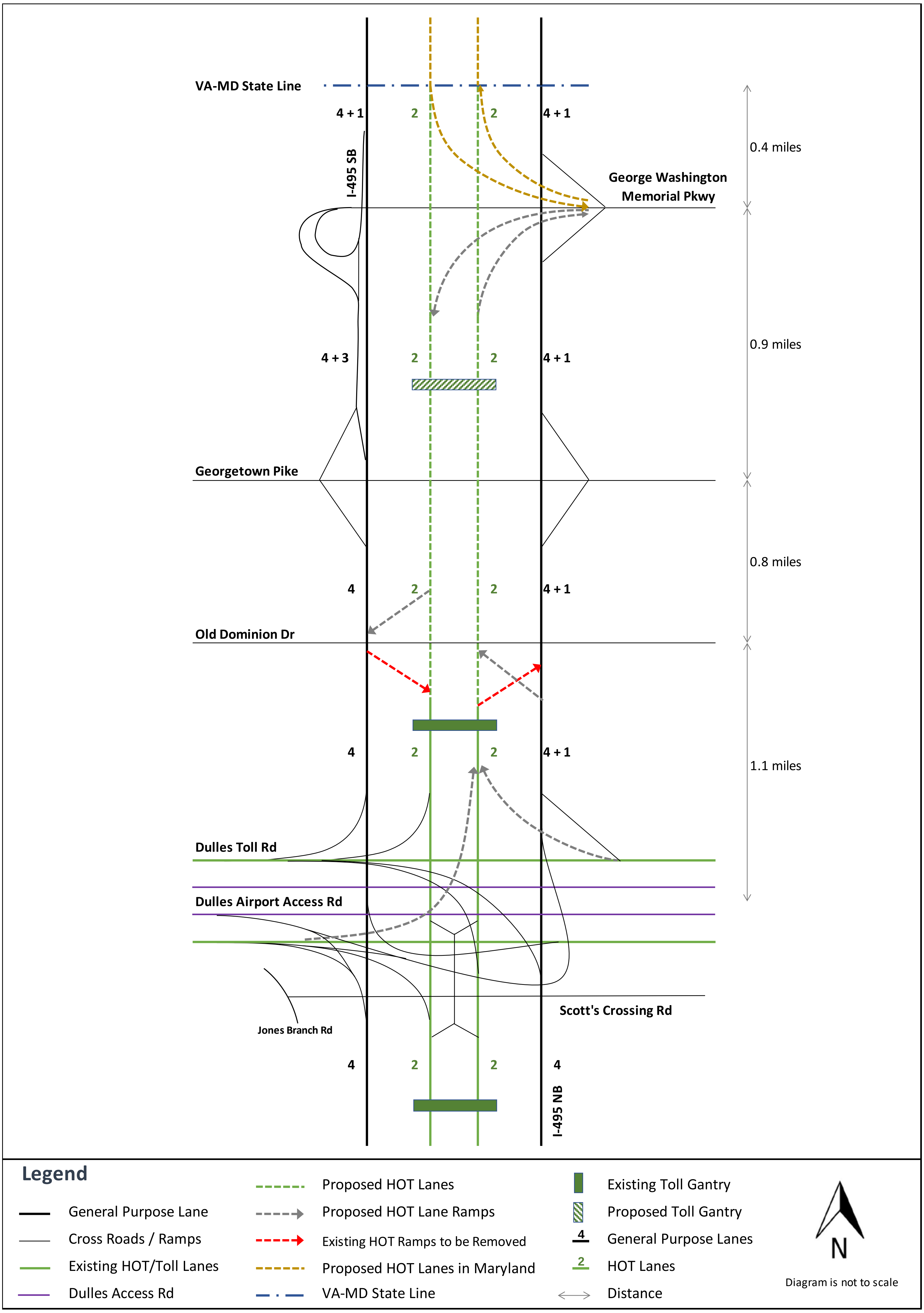
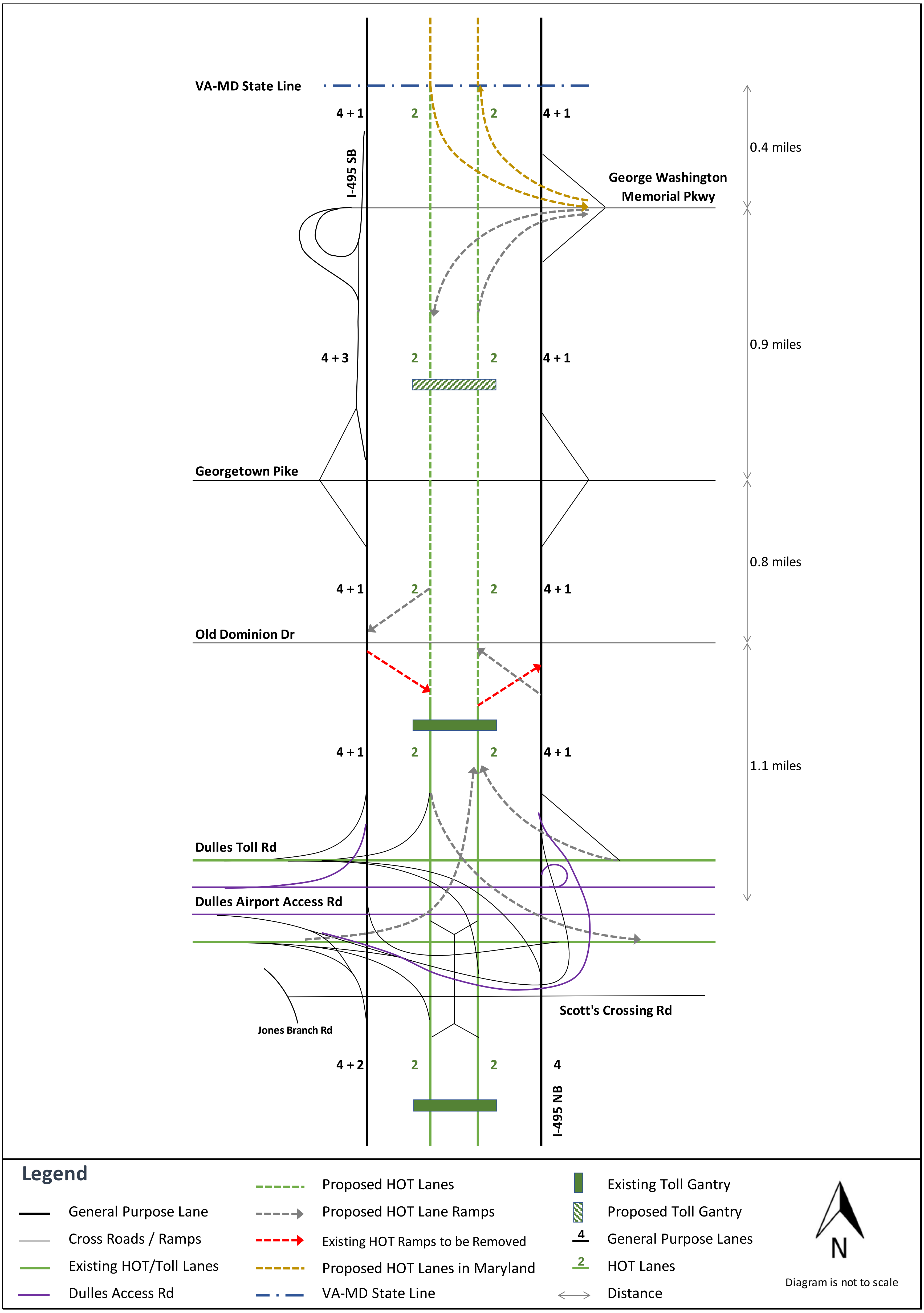


Figure 5: Express Lane Access Preferred Alternative 2045



Travel Demand Modeling Methodology and Key Assumptions

The latest MWCOG travel demand model version based on the 3,722 traffic analysis zone (TAZ) system will be used in conjunction with Round 9.1 Cooperative Forecasts (socioeconomic data) for the Existing, Opening, and Design model years. The MWCOG model base year is 2017; a project Existing Conditions (year 2018) model will be prepared, modified and calibrated to reflect field counts. Modifications will be carried forward into future analysis year model scenarios.

The MWCOG model will be strategically modified with specific alterations to improve the accuracy and reliability of forecasts for the I-495 study corridor, roadways connected to the corridor, and transit services in the vicinity of the corridor. The calibration targets will be based on guidance from the FHWA Transportation Model Improvement Program (TMIP) *Travel Model Validation and Reasonableness Checking Manual* and the Virginia *Travel Demand Modeling Policies and Procedures Manual*. Because the MWCOG/TPB Model is already subject to scrutiny as a regional model which has been a subject of FHWA's TMIP Peer Review process, the validation process for the I-495 Project NEXT model will focus on the I-495 Traffic Operations Analysis Study Area and will compare: daily counts versus model forecasts, peak period traffic counts to modeled data during the same periods, and AM and PM observed speeds and travel times to model speeds and travel times.

Toll Diversion Curves from OP3's consultant, based on existing express lane usage on the Capital Beltway Express Lanes, will also be validated in order to increase confidence in the model and maintain relative consistency between traffic and revenue studies for I-495 in Virginia, and regional planning studies of MDOT's proposed managed lanes system in Maryland. The MWCOG model will be used as the starting point for estimating usage of the Express Lanes and the breakdown of toll-paying versus HOV trips. The MWCOG model is a "four-step," trip-based regional travel demand model with a macroscopic, static equilibrium traffic assignment. Toll values provided as inputs in dollars are converted to value-of-time for the assignment process. These toll values can vary according to different vehicle classes and time of day; additionally, tolls can be represented by a fixed point or be distance-based tolls (as is the case with the Express Lane system in Northern Virginia). The model uses a speed feedback (SFB) loop which iterates through all four steps to ensure that travel speeds output from the traffic assignment are the same as those used as inputs to the trip distribution and mode choice. Output volumes from the model will be post-processed using NCHRP 255/765 guidance.

Travel demand forecasting activity will be coordinated between the traffic and revenue study, IJR, and NEPA effort in order to maintain consistency in forecasting among these efforts to the maximum extent practical. Alterations to the MWCOG travel demand model to improve corridor calibration may include:

- Highway network modifications to better represent study area facilities as they exist and are planned, such as modifications to link facility types. Ramps will be micro-coded to improve forecasts and correlation to the microsimulation process.
- Traffic Analysis Zone (TAZ) splits and centroid connector location changes to improve model loading for all modeled modes of transportation.
- Changes to external trip assumptions to improve consistency with origin-destination data and traffic and revenue evaluations.
- Use of toll diversion methodology to forecast Express Lane trips.
- Changes in the time-of-day distribution to improve forecasting of peak period trips, changes in the Volume Delay Function (VDF) curves, and changes in the default speed and capacity of some facility types.

Key assumptions associated with the travel forecasting process are included in the **I-495 NEXT Travel Demand Forecasting Framework Memorandum.**

Methodology and Key Assumptions for Post-Processing of Modeling Results

Post-processing of travel demand model output is necessary to develop traffic volume forecasts for analysis of operations during peak periods/peak hours. Post-processing of travel demand forecasts for vehicular volumes will follow NCHRP 255/765 guidelines and the TFlowFuzzy methodology included in the VISUM planning tool for estimating balanced No-Build and Build peak period volumes. The post-processing methodology will account for peak spreading of demand, as the hourly capacity of a given link will be used as a threshold for forecast volumes. Forecasted volumes above this threshold will be post-processed onto adjacent shoulder hours.

Existing balanced volumes will be developed outside of the MWCOG travel demand model using field count data; origin-destination (O-D) routing will be obtained utilizing StreetLight Data and the O-D matrix will be adjusted using VISUM's TFlowFuzzy methodology to match target balanced volumes along the corridor.

Traffic Operational Analysis Methods/Parameters

Traffic Analysis Tools

VISSIM Version 9.0, Build 13 will be used for a comprehensive network traffic analysis performed within the study area limits. (Reference analysis tool selection matrix, *VDOT Traffic Operations and Safety Analysis Manual [TOSAM]* V1.0[1], Appendix D.) Additional calibration, based on simulated volume processed, travel times, queues, and speed profiles, will be performed against 2018 measured field conditions and traffic data.

Surface street intersection operations will be evaluated through a combination of Synchro 10 (in order to develop preliminary optimization for phasing and signal timing) and VISSIM (for microsimulation and analysis). Transit routes and stops will be coded into the study area VISSIM network where they affect or could affect I-495 and related facility operations.

Vehicle Classes

The following vehicle classes will be assumed for the traffic operations analysis VISSIM modeling:

- General purpose (non-toll-paying) cars
- HOV3+ cars
- HOT (toll paying) cars
- GP (non-toll-paying) trucks
- HOT (toll paying) trucks

Measures of Effectiveness

The following measures of effectiveness (MOEs) will be used for the operational analysis of the roadway network under existing and future Build and No-Build conditions. Wherever possible, MOEs will be provided in graphical format or GIS maps. These MOEs will be developed according to guidance from the VDOT TOSAM.

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[1] http://www.virginiadot.org/business/resources/TOSAM.pdf

Freeway Performance Measures

- Simulated Average Speed (mph)
- Simulated Average Density (simulated vehicles per lane per mile, color-coded similar to the analogous HCS Density-Based LOS Thresholds but not reported as LOS)
- Simulated Volume (vehicles per hour)

The VISSIM freeway MOEs will be reported for each freeway segment. Methodology for the merge/diverge/weave segment analyses will be consistent with procedures outlined in the *Highway Capacity Manual* for the area of influence within the designated segments. This methodology will be consistent with the TOSAM. In addition, the following freeway MOEs also are proposed for reporting in the IJR:

- **Percent of Demand Served.** Simulated Volume (*processed volumes*) divided by Actual Volume (*input volumes*).
- **Simulated Ramp Queue Length.** Reported average and maximum queue lengths (feet).
- **Simulated Travel Time.** Reported for select network origin-destination travel paths (seconds).
- **Congestion *Heat Maps*.** Incremental speeds reported for aggregated lanes, by time interval (mph).

Additionally, for freeway segments, lane-by-lane MOE graphics will be produced showing individual lane speeds and densities.

Arterial/Intersection Performance Measures

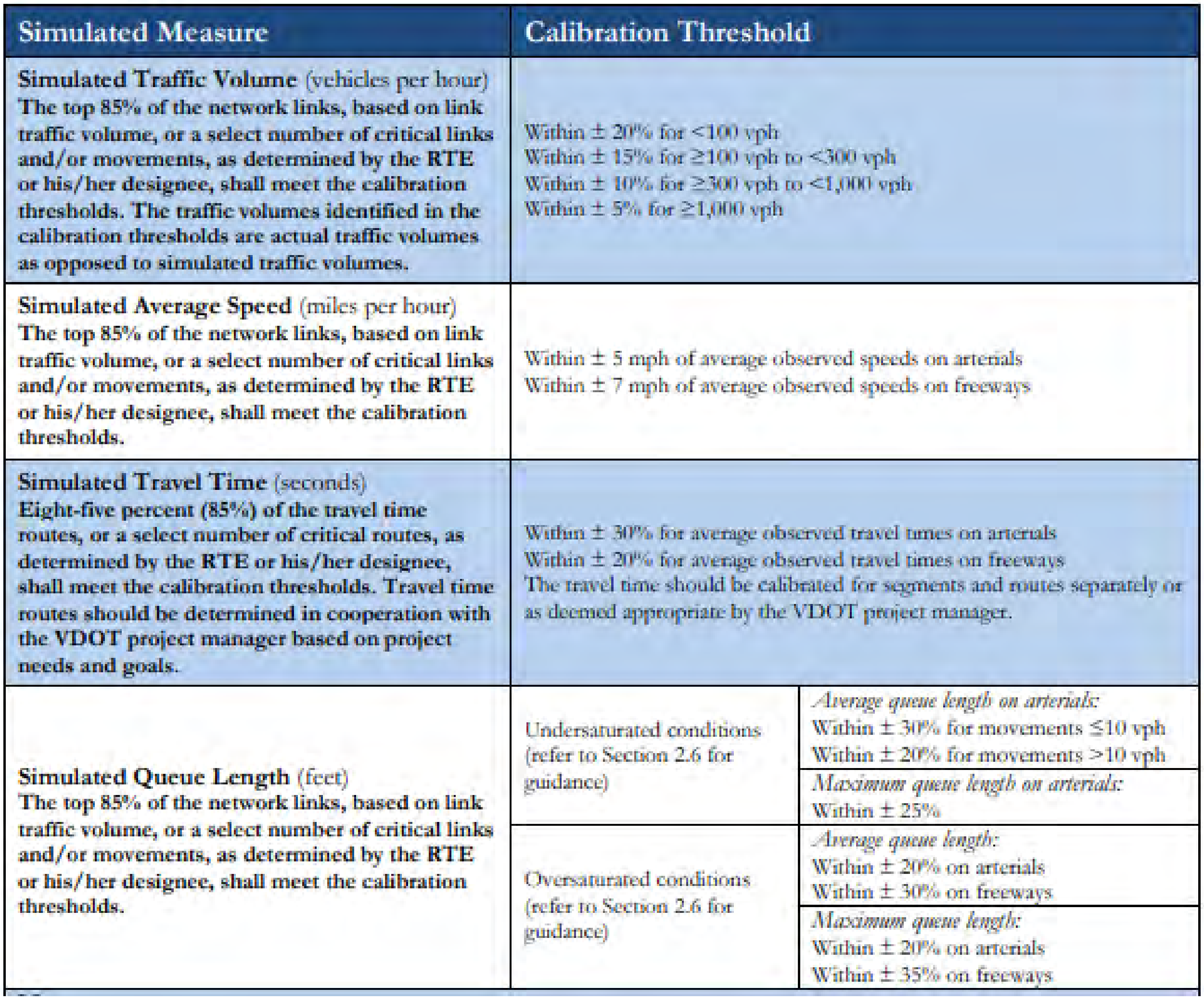
- **Simulated Intersection Level of Service (LOS) and Average Control Delay.** Reported by approach and by intersection (seconds per simulated vehicle, color-coded in similar fashion as the analogous Highway Capacity Manual (HCM) Delay-Based LOS Thresholds but again not reported as LOS). Delay will be reported as “microsimulation delay” per guidance from the VDOT TOSAM.
- **Simulated Intersection Approach Queue.** Reported by movement (feet).
- **Percent of Demand Served.** Simulated Volume (*processed volumes*) divided by Actual Volume (*input volumes*).

Traffic Modeling Methodology and Main Assumptions

Calibration Methodology for Base Models

The VISSIM base models will be calibrated based on guidance from the *VDOT Traffic Operations and Safety Analysis Manual (TOSAM)*, Version 1.0 which takes into account the FHWA guidance. Figure 6 shows the criteria and acceptance targets from the TOSAM.

Figure 6: VDOT TOSAM Calibration Criteria and Acceptance Targets



Simulated Measure	Calibration Threshold	
Simulated Traffic Volume (vehicles per hour) **The top 85% of the network links, based on link traffic volume, or a select number of critical links and/or movements, as determined by the RTE or his/her designee, shall meet the calibration thresholds. The traffic volumes identified in the calibration thresholds are actual traffic volumes as opposed to simulated traffic volumes.**	Within ± 20% for <100 vph Within ± 15% for ≥100 vph to <300 vph Within ± 10% for ≥300 vph to <1,000 vph Within ± 5% for ≥1,000 vph	
Simulated Average Speed (miles per hour) **The top 85% of the network links, based on link traffic volume, or a select number of critical links and/or movements, as determined by the RTE or his/her designee, shall meet the calibration thresholds.**	Within ± 5 mph of average observed speeds on arterials Within ± 7 mph of average observed speeds on freeways	
Simulated Travel Time (seconds) **Eight-five percent (85%) of the travel time routes, or a select number of critical routes, as determined by the RTE or his/her designee, shall meet the calibration thresholds. Travel time routes should be determined in cooperation with the VDOT project manager based on project needs and goals.**	Within ± 30% for average observed travel times on arterials Within ± 20% for average observed travel times on freeways The travel time should be calibrated for segments and routes separately or as deemed appropriate by the VDOT project manager.	
Simulated Queue Length (feet) **The top 85% of the network links, based on link traffic volume, or a select number of critical links and/or movements, as determined by the RTE or his/her designee, shall meet the calibration thresholds.**	Undersaturated conditions (refer to Section 2.6 for guidance)	*Average queue length on arterials:* Within ± 30% for movements ≤10 vph Within ± 20% for movements >10 vph
		Maximum queue length on arterials: Within ± 25%
	Oversaturated conditions (refer to Section 2.6 for guidance)	*Average queue length:* Within ± 20% on arterials Within ± 30% on freeways
		Maximum queue length: Within ± 20% on arterials Within ± 35% on freeways

Table 1 shows the criteria and thresholds proposed for VISSIM model calibration. The criteria listed below deviates from TOSAM requirements for simulated average speeds and simulated queue length. Speeds are highly variable on the interstate mainline as well as on the local arterial network and residential roadways, and can vary substantially by hour and by day. Instead, the simulated average speed will be captured as part of the travel time calibration process and the visual review of bottleneck locations against speed heat maps will be conducted. Average speeds will still be extracted from the VISSIM models along the freeway corridors (I-495 general purpose, I-495 HOT, and SR 267) at one-half mile intervals and compared visually against speed heat maps generated from INRIX vehicle probe data.

Similarly, queuing within the study area is notably inconsistent and can oscillate numerous times within the peak periods, or be absent altogether on some days. A qualitative subjective assessment will be conducted for queue lengths at targeted locations in addition to the review of freeway mainline congestion/queues against the speed heat maps. The targeted locations have been identified in **I-495 NEXT VISSIM Calibration Memorandum** which was approved and signed by the VDOT NoVA District Traffic Engineer on July 27, 2018

Table 1: VISSIM Calibration Criteria and Acceptance Targets

Calibration Item	Basis	Criteria	Target
Simulated Traffic Volume (Intersections)	**By Intersection Approach**	Within ± 20% for <100 vph	At least 85% of all Intersection Approaches
		Within ± 15% for ≥ 100 vph to < 300 vph	
		Within ± 10% for ≥ 300 vph to < 1,000 vph	
		Within ± 5% for ≥ 1,000 vph	
Simulated Traffic Volume (Freeways)	**By Freeway Segment**	Within ± 20% for <100 vph	At least 85% of all Freeway Segments
		Within ± 15% for ≥ 100 vph to < 300 vph	
		Within ± 10% for ≥ 300 vph to < 1,000 vph	
		Within ± 5% for ≥ 1,000 vph	
Simulated Travel Time	**By Route**	Within ± 30% for average travel times on arterials	At least 85% of all Travel Time Routes (Including Segments)
		Within ± 20% for average travel times on freeways	
Maximum Simulated Queue Length	**By Approach for Targeted Critical Locations**	Modeled queues qualitatively reflect the impacts of observed queues	Qualitative Visual Match
Visual Review of Bottleneck Locations	**Targeted Critical Locations**	Speed heat maps qualitatively reflect patterns and duration of congestions	Qualitative Subjective Assessment

Potential Adjustments for Calibration

Adjustments to the VISSIM model during the calibration process will follow guidance from the VDOT TOSAM. These adjustments could include modifications to lane change distance for connectors, driver behavior along freeways and arterials, adjustments to desired speeds for vehicles at the network termini (such as along I-495 northbound leaving the study area), etc. The technical memorandum detailing calibration results will identify any potential deviations from TOSAM guidance.

Quality Control and Assurance

The development of VISSIM models includes an extensive quality assurance/quality control process. All network inputs entered by a modeler will be checked by another modeler not associated with the development of the section. All routes and signal settings will be checked by a second modeler different from the one who entered the inputs into the VISSIM models. Close coordination will be maintained throughout the modeling effort to incorporate adequate geometric improvements into the VISSIM models.

Seeding Time, Simulation Time, and Number of Runs

After assessing the existing traffic counts and the diurnal patterns, the initialization/seeding time and the model simulation run time will be determined. Figure 7 shows the INRIX speed heat map for the I-495 northbound general purpose lanes (pulled from RITIS for average Tuesdays, Wednesdays, and Thursdays from July 2017 to June 2018) and proposed analysis time periods and "network representative" or peak hours (for volume balancing purposes and MOE summaries). Upon review of the INRIX speed data, the slowest speeds and heaviest queues during both the AM and PM are along I-495 northbound.

- AM: proposed analysis period from 6:45 AM to 9:45 AM; network representative hour from 7:45 AM to 8:45 AM. Queue spillback is tied to the on-ramp from GWMP and the weave across the American Legion Bridge, with the slowest speeds and longest queues occurring during the peak hour.
- PM: proposed analysis period from 2:45 PM to 5:45 PM; network representative hour from 3:45 PM to 4:45 PM. During the early afternoon hours (after approximately 2 PM), queue spillback and congestion along I-495 northbound is again tied to the on-ramp from GWMP and the weave across the American Legion Bridge. During the later afternoon hours (after approximately 3:30 PM, queues from downstream congestion in Maryland have spilled back across the American Legion Bridge, resulting in a single continuous queue. At this point, the back of the queue is observed to stabilize for several hours, essentially suggesting that demand is not increasing and being processed at the same rate as it arrives.

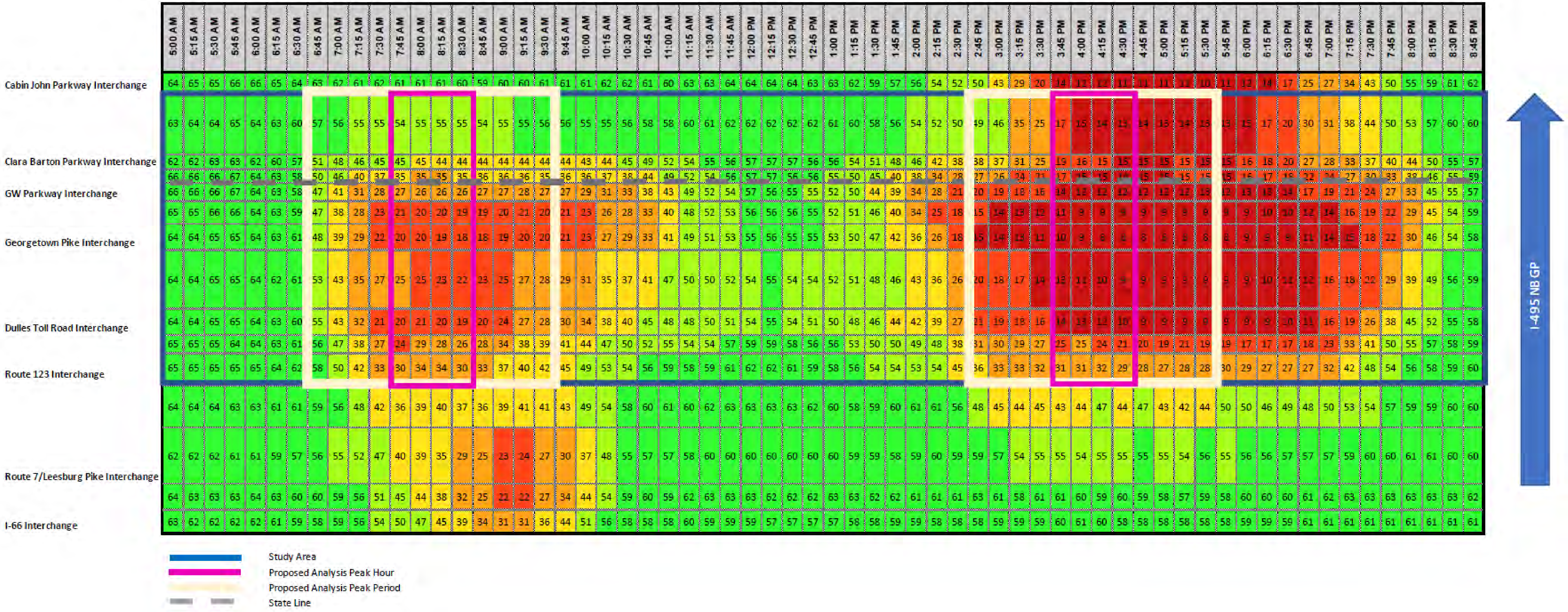
The model simulation period will be longer than the three-hour analysis period, as a seeding period will be provided prior to this analysis period to allow traffic volume to load into the network. The actual seeding period time will be established during the calibration process. MOEs will be reported for all three hours of the analysis period.

Given the stochastic nature of the VISSIM models, they need to be run with several different random seeds (to be determined based on statistical analysis) and the results need to be post-processed and averaged to determine the current state of traffic operations in the corridor. The total number of runs necessary for the analysis will be determined based on guidance from the TOSAM. The VDOT Sample Size Determination Tool, which was developed based on FHWA's statistical process to ensure that an appropriate number of microsimulation runs are performed at a 95th percentile confidence level, will be used per guidance from the TOSAM.

Demand Review

As shown in Figure 7, the study area experiences severe congestion for several hours each day. The I-495 corridor is oversaturated and processes less traffic than its capacity, as observed in existing field counts. The existing demand is likely much higher than these processed throughput counts. The project team has received estimated demand volumes from Maryland SHA for overlapping segments of the project study area (from just south of Georgetown Pike to all points north). VISSIM inputs may be revised using an iterative manual process taking into account MDSHA demand estimates and unconstrained 15-minute flow data from various input locations. The INRIX data allows for estimation of the duration and distance of queues along the I-495 mainline, which can in turn be used to estimate the unserved demand during the peak period. The end result will still be a VISSIM model in which demand has been increased, but throughput aligns with balanced counts and speeds match field data.

Figure 7: INRIX Speed Heat Map for I-495 Northbound GP and Proposed Analysis Periods



	5:00 AM	5:15 AM	5:30 AM	5:45 AM	6:00 AM	6:15 AM	6:30 AM	6:45 AM	7:00 AM	7:15 AM	7:30 AM	7:45 AM	8:00 AM	8:15 AM	8:30 AM	8:45 AM
Cabin John Parkway Interchange	64	65	65	66	66	65	64	63	62	61	62	61	61	61	60	59
	63	64	64	65	64	63	60	57	56	55	55	54	55	55	55	54
Clara Barton Parkway Interchange	62	62	63	63	62	60	57	51	48	46	45	45	45	44	44	44
	66	66	66	67	64	63	58	50	46	40	37	35	35	35	35	36
GW Parkway Interchange	66	66	66	67	64	63	58	47	41	31	28	27	26	26	26	27
	65	65	66	66	64	63	59	47	38	28	23	21	20	20	19	19
Georgetown Pike Interchange	64	64	65	65	64	63	61	48	39	29	22	20	20	19	18	18
	64	64	65	65	64	62	61	53	43	35	27	25	25	23	22	23
Dulles Toll Road Interchange	64	64	65	65	64	63	60	55	43	32	21	20	21	20	19	20
	65	65	65	64	64	63	61	56	47	38	27	24	29	28	26	28
Route 123 Interchange	65	65	65	65	65	64	62	58	50	42	33	30	34	34	30	33
	64	64	64	63	63	61	61	59	56	48	42	36	39	40	37	36
Route 7/Leesburg Pike Interchange	62	62	62	61	61	59	57	56	55	52	47	40	39	35	29	25
	64	63	63	63	64	63	60	60	59	56	51	45	44	38	32	25
I-66 Interchange	63	62	62	62	62	61	59	58	59	56	54	50	47	45	39	34

	9:00 AM	9:15 AM	9:30 AM	9:45 AM	10:00 AM	10:15 AM	10:30 AM	10:45 AM	11:00 AM	11:15 AM	11:30 AM	11:45 AM	12:00 PM	12:15 PM	12:30 PM	12:45 PM
Cabin John Parkway Interchange	60	60	61	61	61	62	62	61	60	63	63	64	64	64	64	63
	55	55	56	56	55	55	56	58	58	60	61	62	62	62	62	62
Clara Barton Parkway Interchange	44	44	44	44	43	44	45	49	52	54	55	56	57	57	57	56
	36	36	35	36	36	37	38	44	49	52	54	56	57	57	56	56
GW Parkway Interchange	27	28	27	27	29	31	33	38	43	49	52	54	57	56	55	55
	20	21	20	21	23	26	28	33	40	48	52	53	56	56	56	55
Georgetown Pike Interchange	19	20	20	21	23	27	29	33	41	49	51	53	55	56	55	55
	25	27	28	29	31	35	37	41	47	50	50	52	54	55	54	54
Dulles Toll Road Interchange	24	27	28	30	34	38	40	45	48	48	50	51	54	55	54	51
	34	38	39	41	44	47	50	52	55	54	54	57	59	59	58	56
Route 123 Interchange	37	40	42	45	49	53	54	56	59	58	59	61	62	62	61	59
	39	41	41	43	49	54	58	60	61	60	62	63	63	63	63	62
Route 7/Leesburg Pike Interchange	23	24	27	30	37	48	55	57	57	58	60	60	60	60	60	60
	22	22	27	34	44	54	59	60	59	62	63	63	63	62	62	62
I-66 Interchange	31	31	36	44	51	56	58	58	58	60	59	59	59	57	57	57

	1:00 PM	1:15 PM	1:30 PM	1:45 PM	2:00 PM	2:15 PM	2:30 PM	2:45 PM	3:00 PM	3:15 PM	3:30 PM	3:45 PM	4:00 PM	4:15 PM	4:30 PM	4:45 PM
Cabin John Parkway Interchange	63	62	59	57	56	54	52	50	43	29	20	14	12	12	11	11
	61	60	58	56	54	52	50	49	46	35	25	17	15	14	13	14
Clara Barton Parkway Interchange	56	54	51	48	46	42	38	38	37	31	25	19	16	15	15	15
	55	50	45	40	38	34	28	27	26	24	21	17	15	15	14	15
GW Parkway Interchange	52	50	44	39	34	28	21	20	19	18	16	14	12	12	12	12
	52	51	46	40	34	25	18	15	14	13	12	11	9	8	9	9
Georgetown Pike Interchange	53	50	47	42	36	26	18	15	14	13	11	10	9	8	6	8
	52	51	48	46	43	36	26	20	18	17	14	13	11	10	9	9
Dulles Toll Road Interchange	50	48	46	44	42	39	27	21	19	18	16	14	13	12	10	9
	56	53	50	50	49	48	38	31	30	29	27	25	25	24	21	20
Route 123 Interchange	58	56	54	54	53	54	45	36	33	33	32	31	31	32	29	28
	60	58	59	60	61	61	56	48	45	44	45	43	44	47	44	47
Route 7/Leesburg Pike Interchange	60	59	59	58	59	60	59	59	57	54	55	55	54	55	55	55
	63	63	62	62	61	61	61	63	61	58	61	61	60	59	60	59
I-66 Interchange	57	58	58	59	59	58	58	58	59	59	59	60	61	60	58	58

	5:00 PM	5:15 PM	5:30 PM	5:45 PM	6:00 PM	6:15 PM	6:30 PM	6:45 PM	7:00 PM	7:15 PM	7:30 PM	7:45 PM	8:00 PM	8:15 PM	8:30 PM	8:45 PM
Cabin John Parkway Interchange	11	11	10	11	12	14	17	25	27	34	43	50	55	59	61	62
	13	14	13	13	15	17	20	30	31	38	44	50	53	57	60	60
Clara Barton Parkway Interchange	15	15	15	15	16	18	20	27	28	33	37	40	44	50	55	57
	15	15	15	15	16	17	19	22	24	27	30	33	38	46	55	59
GW Parkway Interchange	12	12	13	12	13	13	14	17	19	21	24	27	33	45	55	57
	9	9	8	9	9	10	10	12	14	16	19	22	29	45	54	59
Georgetown Pike Interchange	5	8	6	8	9	9	9	11	14	15	18	22	30	46	54	58
	9	9	9	9	9	10	11	12	16	18	22	29	39	49	56	59
Dulles Toll Road Interchange	9	9	9	9	9	9	10	11	16	19	26	38	45	52	55	58
	19	21	19	19	17	17	17	18	23	33	41	50	55	57	58	59
Route 123 Interchange	27	28	28	30	29	27	27	27	32	42	48	54	56	58	59	60
	43	42	44	50	50	46	49	48	50	53	54	57	59	59	60	60
Route 7/Leesburg Pike Interchange	55	54	56	55	56	56	57	57	57	59	60	60	61	61	60	60
	58	57	59	58	60	60	60	61	62	63	63	63	63	63	63	62
I-66 Interchange	58	58	58	58	59	59	59	61	61	61	61	61	61	61	61	61

SAFETY ANALYSIS

A safety analysis will be conducted, consistent with VDOT IIM-LD-200.9. The analysis will involve the analysis of existing highway safety conditions and reported motor vehicle crashes on roads in the study area for a period of five (5) years, and the development of qualitative and quantitative measures to evaluate proposed alternatives and assess the safety effects of interstate access modifications on I-495 and the adjacent arterial network within the study area. The Enhanced Interchange Safety Analysis Tool (ISATe) will be used to evaluate the quantitative safety impacts of interstate access modifications on I-495. Since the ISATe model was not developed for and is therefore not appropriate for the analysis of facilities with express lanes, this proposed safety analysis will feature the development of Safety Performance Functions for express lanes and inclusion of crash predictions from the application of those functions. In addition, Highway Safety Manual (HSM) methodologies will be used to evaluate the quantitative safety effects of the proposed interstate access modifications, notably geometric changes at the interchanges and ramp terminals on the intersecting arterial system adjacent to the interchanges and the resulting changes in traffic volumes projected to occur. In addition, a qualitative safety analysis will be performed.

Reported Crash Data, Crash Summaries & Collision Diagrams

Data on motor vehicle crashes reported on I-495 mainline, ramps, Collector-Distributor Road sections, selected arterial segments and at-grade intersections within the IJR study area will be analyzed and summarized. Data on reported crashes from January 1, 2013, to December 31, 2017, will be solicited and obtained from the Virginia Department of Transportation, the Maryland Department of Transportation, and the National Park Service for roads in the study area that were previously identified for the traffic operations analysis. The study area includes sections of the George Washington Memorial Parkway and sections of the Clara Barton Parkway, which are maintained by NPS, and sections of I-495 in Maryland which are maintained by the MDSHA of the MDOT.

The crash data will be summarized in a tabular format for up to 10 crash factors, such as weather conditions, lighting conditions, type of collision, day-of-week/time-of-day, and severity of crash, among others. The data will be summarized to identify trends in reported crashes, crash patterns and high-crash locations.

Crash location maps and crash density “heat” maps will be developed to display the following crash types along the I-495 study corridor:

- Total number of crashes
- Fatal + Injury crashes
- Crashes reported during the Weekday AM peak period (e.g., 5 AM to 10 AM)
- Crashes reported during the Weekday PM peak period (e.g., 3 PM to 8 PM)
- Rear-end crashes
- Sideswipe, same direction crashes
- Fixed-object, ran-off-road crashes

Mainline crash density histograms will be developed for I-495 from the Dulles Toll Road (VA 267) to the American Legion Memorial Bridge over the Potomac River, summarized in logical segments. The type and severity of crashes for each segment within the safety analysis study area also will be summarized.

Crash rates will be estimated and summarized, in tabular format, for the I-495 general purpose lane segments for the latest 5-year period and compared using the following crash rates provided by VDOT Central Office:

- Total Crash rates and Fatal+Injury crash rates for all Interstates in Virginia
- Total crash rates and Fatal+Injury crash rates for the Capital Beltway, which includes sections of I-495 and I-95 in Virginia.

Exposure estimates for the calculation of crash rates will be based on best available estimates of Average Annual Daily Traffic (AADTs). The results of this safety analysis will be used during the preliminary design phase of the project and during the development and screening of proposed interchange concepts phase of the project.

A field review will be conducted to complement the analysis of crashes reported over the five-year period. The results of this field review will be summarized in a brief technical memorandum to be used during the development of the design concepts. Crash trends and crash patterns will be described within hot spot locations.

Qualitative Analysis

A qualitative analysis of proposed improvements for one Preferred Build alternative will be completed. Engineering judgment, human factors analysis techniques to assess the ability of drivers to safely perform driving task and make speed, steering, and navigational decisions, and published literature will be used in this qualitative safety assessment. Concept plans will be reviewed and potential safety issues that warrant mitigation will be identified. These potential safety deficiencies will be identified in description detail, and the rationale for the safety concern will be documented in a concise memo. Extensive use will be made of relevant documents, positive guidance principles, human factors manuals, guidelines and processes for highway engineers and geometric design, and NCHRP and FHWA reports on safety effects related to interchanges, intersections, freeways, arterials, and ramp junctions. Notable documents include NCHRP report 600, “Application of Human Factor Guidelines for Road Systems”, AASTHO’s “Highway Safety Design and Operations Guide” (i.e., the old AASHTO Yellow Book), ITE’s “Human Factors Issues in Intersection Safety,” FHWA reports such as “Driver Expectations When Navigating Complex Interchanges, materials cited in the National Highway Institute’s “Human Factors for Transportation Engineers,” and other relevant literature, such as “Human Factors Associated with Interchange Design Features.” Drivers, often have difficulties following through the sequence of driving tasks, which leads to driving errors. The most common driving errors include improper lookout (faulty visual surveillance), inattention, false assumption, excessive speed, improper maneuvers, improper evasive action, and internal distraction.

The objective of the qualitative safety analysis is to identify assess the relative level of safety that is likely to result from proposed improvements by considering the potential effect of the following on driver expectancies, the demands on and capabilities of the driver to perform all subtasks of the driving tasks, driver information processing capabilities, and driver decision making capabilities especially at route choice decision points:

- Geometric characteristics, including grades, vertical alignment, horizontal alignment, cross-sections,
- Roadside features.
- Conflict points

- Traffic operations, including weaving, lane changing, merging, diverging and stopping
- Relative safety hazards

A brief summary of the qualitative safety assessment for the Preferred Build alternative will be prepared.

Quantitative Analysis

A quantitative analysis to evaluate the No-Build scenario and the benefits of the proposed improvements for the I-495 general purposes mainline and ramps associated with the Preferred Build improvement conditions. To minimize cost and schedule impacts, the quantitative analysis will be performed using an approach tailored to fit the intended purpose of the IJR document.

For the IJR, a planning-level crash analysis will be performed using the aforementioned tools to compare only the differences between the No-Build and Preferred Build alternatives corresponding to I-495 interchanges, freeway segments, ramp segments, intersections, and arterials affected by new ramps or access to/from the Express Lanes facility.

Assumptions regarding safety and crash analysis:

- Safety analyses will only be conducted on the roadway sections identified in the study area, consisting of interstate mainline segments, ramp segments, C-D Road segments, ramp termini, and at selected at-grade intersections.

- ISATe will be used to evaluate freeway and interchange safety for the general purpose lane sections, based on FHWA/AASHTO regulations and guidance. Using reported crash history and best available exposure estimates for the sections of the I-495 Express Lanes, safety performance functions will be developed for Express Lane sections. Then, those safety performance functions will be applied to develop estimated crash predictions for the future years (2025 and 2045) for both the No-Build and the Preferred Build alternatives.

- HSM NCHRP 17-38 spreadsheets (Virginia edition) will be used to analyze 5 years of continuous crash data for the crossroad segments. ISATe will be used to analyze the crossroad ramp terminal intersections within these segments.

- Freeway analysis will be limited to the I-495 mainline facility, and no analysis will be performed for the Express Lane facility, since current analysis tools do not provide for crash prediction and safety performance evaluation on Express Lane facilities.

- Quantitative analysis will be performed within the analysis limits of the available safety analysis tools; however, it should be noted that some geometric configurations are not able to be modeled using these tools. In these situations, qualitative analysis will be incorporated into the evaluation to supplement any gaps in the quantitative analysis.

- All crash data will be provided by VDOT in GIS shapefile or geodatabase format. The consultant team will rely on the crash data directly from the VDOT Roadway Network System (RNS) and will not review individual crash reports to verify the accuracy of the information.

Deliverables

- Crash field review technical memorandum

- Existing safety conditions memorandum
- Qualitative Safety Assessment of the Preferred Build Alternative memorandum
- Crash/safety analysis sections for the IJR and TTR.

REPORT DELIVERABLES

The following documents will be produced as deliverables during the course of the project and for the culmination of analysis and data collection.

- **Existing Conditions Technical Memorandum**. The following will be included within the Existing Conditions Technical Memorandum:
  - Data collection overview
  - Review of volumes development process (describing count data post-processing and volume balancing)
  - Travel demand forecast model calibration and outputs
  - Traffic simulation model calibration
  - Documentation of existing conditions (outputs from traffic simulation model supplemented by discussion of field conditions)
  - Safety analysis for the study area
- **Draft Traffic and Transportation Report (TATTR).** Prepared in support of the EA (to be included as an appendix to the NEPA documentation). For the entire study area, a technical report will be prepared to document and support all analysis that is performed for the determination of traffic volume forecasts, traffic impacts as they relate to NEPA and the proposed action, the inputs and analysis that feed the Air Quality Analysis, and the data to support the Noise Analysis. This document also will be used as a supporting technical report for the system-wide IJR described below.
- **Final TATTR.** Incorporate VDOT/FHWA comments and submit modified document that will secure interstate access approval from FHWA. It is assumed that concurrent reviews will occur on the preliminary Final TATTR, with a consolidated set of review comments at the conclusion of the draft review.
- **Draft IJR.** Incorporate traffic engineering and operational analysis as well as results from the VAP3's Proposed Design Plans and EA into the IJR. IJR will be prepared based on the guidance set forth in IIM-LD200.9 with exceptions to be consistent with the May 2017 update to FHWA policy on NEPA and IJRs per VDOT's direction. This document will note any potential Limited Access changes required, as well as any potential Design Exceptions or Design Waivers being requested. The IJR will also include a discussion on the use of available typical section width and how that width will be distributed for the proposed typical, showing a hierarchy for distributing the available width between shoulders, travel lanes, and median width. A draft version of the document will be provided to VDOT Central Office and FHWA (Virginia Division Office and Headquarters Office) for review and comments. For budgeting purposes, it is assumed that concurrent reviews will occur, with a consolidated set of review comments at the conclusion of the draft review.
- **Final IJR.** Incorporate VDOT and FHWA comments and submit modified document that will secure IJR approval from FHWA. It is assumed that concurrent reviews will occur on the preliminary Final IJR, with a consolidated set of review comments at the conclusion of the preliminary final review.

Review Process

It is anticipated that a two-week comment period will be provided for review of the Draft IJR. These comments will be addressed within 3 weeks of being received upon which a final report will be submitted.

Accepted and agreed upon by FHWA & VDOT:

______________________________	______________
Virginia Department of Transportation Northern Virginia District/Virginia MegaProjects Project Manager	Date
______________________________	______________
Virginia Department of Transportation Northern Virginia District/Virginia MegaProjects Project Director	Date
______________________________	______________
Virginia Department of Transportation Northern Virginia District/Traffic Engineering	Date
______________________________	______________
Virginia Department of Transportation Northern Virginia District/Location and Design	Date
______________________________	______________
Virginia Department of Transportation Central Office	Date
______________________________	______________
FHWA Virginia Division Office	Date

MEMORANDUM

To: Rahul Trivedi, P.E., VDOT NoVA District Transportation Planning Manager
Amir Shahpar, P.E., VDOT NoVA District Modeling Manager
Abi Lerner, P.E., VDOT Project Manager

From: Rob Prunty, P.E.
Raj Paradkar, P.E.
Anthony Gallo, P.E.
Sarah Knox, P.E.
Kimley-Horn and Associates, Inc.

Date: August 26, 2018

Subject: I-495 NEXT Travel Demand Forecasting Framework

Introduction

This memorandum documents the travel demand forecasting framework associated with the I-495 NEXT Project. This memorandum is intended to supplement the overarching I-495 NEXT Project Scoping Framework Document.

The following elements of the traffic operations analysis are laid out in detail in this document:

- Travel demand modeling assumptions and calibration/validation
- Traffic volume post-processing for use in traffic operations and air/noise analysis

Travel Demand Modeling Methodology

Existing Conditions Model Calibration and Validation

The latest MWCOG travel demand model version on the 3,722 traffic analysis zone (TAZ) system will be used in conjunction with Round 9.1 Cooperative Forecasts (socioeconomic data) for the Existing, Opening, and Design model years. The MWCOG model base year is 2017; a project Existing Conditions (year 2018) model will be prepared, modified and calibrated to reflect field counts. Modifications will be carried forward into future analysis year model scenarios.

The MWCOG model will be strategically modified with specific alterations to improve the accuracy and reliability of forecasts for the I-495 study corridor, roadways connected to the corridor, and transit services in the vicinity of the corridor. The calibration targets will be based on guidance from the FHWA Transportation Model Improvement Program (TMIP) *Travel Model Validation and Reasonableness Checking Manual* and the Virginia *Travel Demand Modeling Policies and Procedures Manual*. Because the MWCOG/TPB Model is already subject to scrutiny as a regional model which has been a subject of FHWA's TMIP Peer Review process, the validation process for the I-495 Project NEXT model will focus on the I-495 Traffic Operations Analysis Study Area and will include the following comparisons:

- Regional comparisons to VDOT AADTs at the daily level (daily level only)
    - Percent difference in total volume for cutlines
- I-495 NEXT study area comparisons to field traffic counts (AM/PM periods and daily)
    - R-squared between modeled volumes and counts on links
    - Percent difference in total volumes for freeways/arterials
    - Percent root mean squared error (%RMSE) by volume group or facility type
- Travel time comparisons of model outputs to floating car runs data collected (AM/PM periods only; reasonableness checks only)

Table 1 provides a listing of travel demand model calibration criteria, which were discussed and verbally approved by VDOT during a call on July 24, 2018.

Table 1. Travel Demand Forecast Model Calibration Criteria

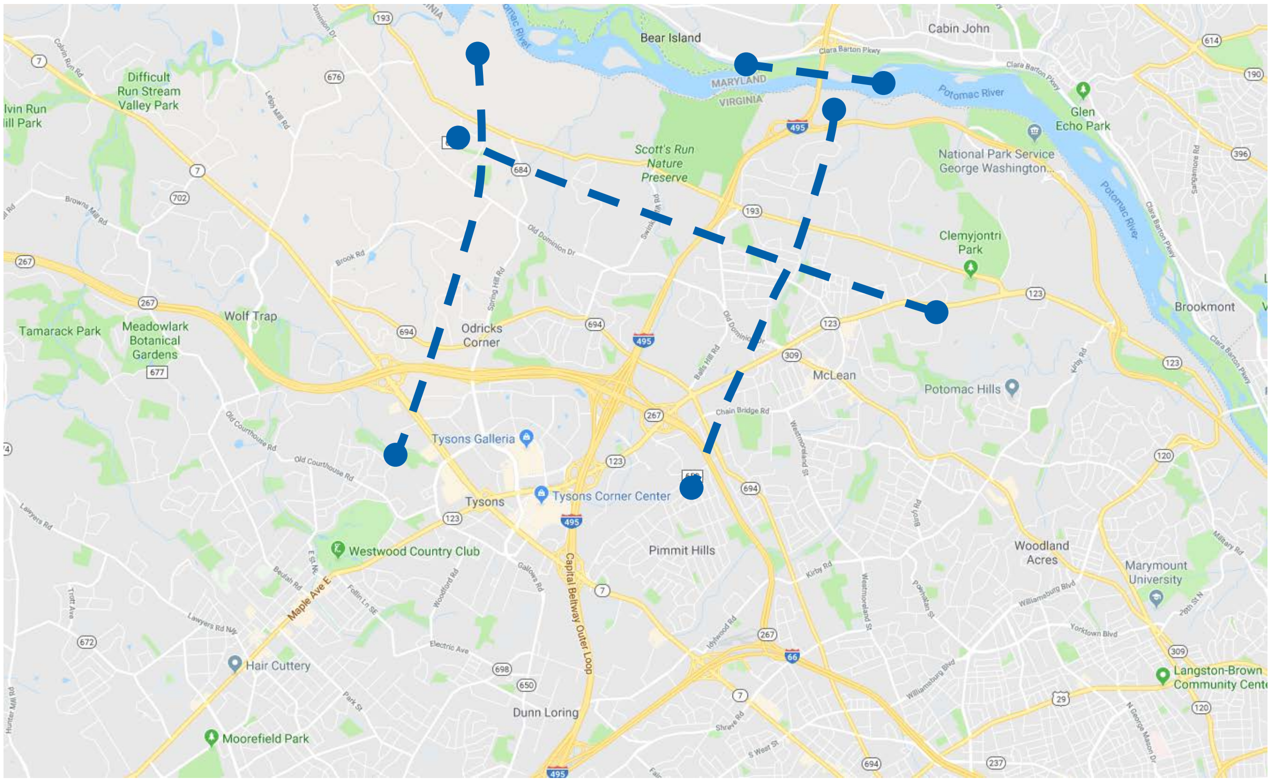
Calibration Scale	Calibration Check	Calibration Threshold			
Regional	% Difference in Total Volume for Cutlines (24-Hour Volumes)	Cutline Volume	VTM	FHWA	***Proposed***
		50,000	10%	35%	***10%***
		100,000	8.75%	25%	***10%***
		150,000	7.50%	20%	***10%***
		200,000	6.25%	18%	***8%***
		250,000	5%	15%	***7%***
Study Area	R-Squared between modeled volume and counts on links (AM Period, PM Period, and 24-Hour Volumes)		VTM	FHWA	***Proposed***
			0.9	0.88	***0.9***
	% Difference in Total Volume by Facility Type (AM Period, PM Period, and 24-Hour Volumes)	Facility Type	VTM	FHWA	***Proposed***
		Freeways	6%	7%	***6%***
		Major Arterials	7%	10%	***10%***
		Minor Arterials	10%	15%	***15%***
	%RMSE by Facility Type (AM and PM Period)	Facility Type	VTM	FHWA	***Proposed***
		Freeways	30%	-	***30%***
		Major Arterials	45%	-	***45%***
		Minor Arterials	60%	-	***60%***
		Overall	40%	-	***40%***
	%RMSE by Facility Type (24-Hour Volumes)	Facility Type	VTM	FHWA	***Proposed***
		Freeways	20%	-	***20%***
		Major Arterials	35%	-	***35%***
		Minor Arterials	50%	-	***50%***
		Overall	30%	-	***30%***
	Travel Times (AM and PM Period)	No specific measures in VTM or FHWA; compare model outputs to floating car travel runs and check to see if travel times are within min and max of observed travel times. Note that these are reasonableness checks only.			

The following regional cut-lines will be used in the calibration process:

- East/west travel west of study area
    - Georgetown Pike west of Spring Hill Road
    - Old Dominion Drive west of Spring Hill Road
    - Lewinsville Road west of Spring Hill Road
    - Route 267 between Route 7 and Spring Hill Road
    - Route 7 just east of Route 267
- East/west travel east of study area
    - George Washington Memorial Parkway east of I-495
    - Georgetown Pike east of I-495
    - Old Dominion Drive between Balls Hill Road and Route 123
    - Route 123 east of Lewinsville Road/Great Falls Street
    - Chain Bridge Road east of Great Falls Street
    - Great Falls Street east/south of Chain Bridge Road
    - Route 267 east of Route 123
- North/south travel north of study area
    - I-495 American Legion Bridge
- North/south travel within study area
    - Spring Hill Road south of Georgetown Pike
    - Swinks Mill Road south of Georgetown Pike
    - I-495 south of Georgetown Pike
    - Balls Hill Road south of Georgetown Pike
    - Douglas Drive south of Georgetown Pike
    - Route 123 west/south of Georgetown Pike

Figure 1 shows a map of the proposed cut-lines for the calibration process.

Figure 1. Proposed Cut-Lines for Travel Demand Model Calibration Process.



Toll Diversion Curves from OP3's consultant, based on existing express lane usage on the Capital Beltway Express Lanes, will also be validated in order to increase confidence in the model and maintain relative consistency between traffic and revenue studies for I-495 in Virginia, and regional planning studies of MDOT's proposed managed lanes system in Maryland.

Travel demand forecasting activity will be coordinated between the traffic and revenue study, and IJR/NEPA effort in order to maintain consistency in forecasting among these efforts to the maximum extent practical. Alterations to the MWCOG travel demand model to improve corridor calibration may include:

- Highway network modifications to better represent study area facilities as they exist and are planned, such as modifications to link facility types. Ramps will be micro-coded to improve forecasts and correlation to the microsimulation process.
- Traffic Analysis Zone (TAZ) splits and centroid connector location changes to improve model loading for all modeled modes of transportation.
- Changes to external trip assumptions to improve consistency with origin-destination data and traffic and revenue evaluations.
- Use of toll diversion methodology to forecast Express Lane trips.

- Changes in the time-of-day distribution to improve forecasting of peak period trips, changes in the Volume Delay Function (VDF) curves, and changes in the default speed and capacity of some facility types.

Future Analysis Scenario Assumptions

The I-495 NEXT traffic analysis will assess operations for a project Design Year of 2045 and Interim Year of 2025. The traffic analysis will account for a No-Build scenario and one Build alternative. Separate travel demand model networks will be developed for each of the future-year scenarios to be used for forecasting traffic volumes.

The travel demand model No-Build networks will include all roadway projects in the most up-to-date regional CLRP. In addition, the No-Build networks will account for the following elements:

- **I-495/Dulles Toll Road Interchange Ramps** – currently unbuilt ramps at the I-495/Dulles Toll Road, including ramps to and from the I-495 Express Lanes and Dulles Airport Access Road, for which preliminary engineering has completed and construction is anticipated prior to the I-495 NEXT project being in place.
- **Auxiliary lanes along I-495** – general-purpose auxiliary lanes to be added along I-495 between the Dulles Toll Road interchange and the Georgetown Pike interchange
- **Express Lanes in Maryland** – the I-495 NEXT team will be coordinating closely with the Maryland Department of Transportation (MDOT) on plans for a network of express lanes in Maryland, including lanes along I-495 and I-270. These plans are currently ongoing, but the I-495 NEXT No-Build and Build networks will contain the same assumptions for the Express Lanes in Maryland:

    - Locations of access and network structure
    - Vehicle types allowed in express lanes, including those which must pay a toll and those which are exempt (if any) – could include HOV2/HOV3+ or trucks

Summary of Travel Demand Modeling Assumptions

Table 1 lists key assumptions associated with the travel forecasting process.

Table 2: Travel Demand Forecasting Model Assumptions

<table>
<tr><th>Model Parameter</th><th>Assumption</th><th>Comments</th></tr>
<tr><td colspan="3">Model</td></tr>
<tr><td>**Analysis Years**
2018 (Existing)
2025 (Interim Year)
2045 (Design Year)</td><td><u>MWCOG Model</u>
2018 (Validation Year)
2025
2045</td><td>MWCOG travel demand model has model inputs at 5-year increments plus a year 2017 input dataset. Intermediate years can be developed by interpolating input data and modifying networks to represent planned conditions.</td></tr>
<tr><td>**Time Periods**</td><td>Four time periods are modeled in the forecasts. The sum of the four time periods represents average weekday daily traffic:
<table>
<tr><th>Period</th><th>Hours</th></tr>
<tr><td>AM</td><td>6 a.m. – 9 a.m.</td></tr>
<tr><td>Midday</td><td>9 a.m. – 3 p.m.</td></tr>
<tr><td>PM</td><td>3 p.m. – 7 p.m.</td></tr>
<tr><td>Night</td><td>7 p.m. – 6 a.m.</td></tr>
</table></td><td>Hours split based on MWCOG household survey data (2007/2008).</td></tr>
<tr><td>**Speed**</td><td>Consistent with current conditions in the HOV and general purpose (GP) lanes.</td><td>Consistent with existing conditions. Same as speed/travel time curves based on MWCOG unless validation suggests modification.</td></tr>
<tr><td>**Link Capacity**</td><td>Lane capacities are defined consistent with the MWCOG model approach.</td><td>The MWCOG facility and area type capacity tables are used to determine link capacities. Use same speed-flow curves consistent with TPB model unless validation suggests modification.</td></tr>
<tr><td>**Peak Factors**</td><td>Peak period to peak hour factors:
<table>
<tr><th>Period</th><th>2010</th><th>2025</th><th>2040</th></tr>
<tr><td>AM</td><td>0.417</td><td>0.38</td><td>0.34</td></tr>
<tr><td>PM</td><td>0.294</td><td>0.272</td><td>0.25</td></tr>
</table></td><td>Existing peak period values were derived from the 2007/2008 MWCOG Household Travel Survey. The peak hour factors decline in future years in recognition of the increased congestion expected in the region causing less peaked periods. This assumption spreads the traffic evenly over the entire peak period.</td></tr>
<tr><td>**Socioeconomic Data**</td><td>MWCOG Round 9.1 socioeconomic data will be used.</td><td></td></tr>
</table>

Table 2: Travel Demand Forecasting Model Assumptions

Model Parameter	*Assumption*	*Comments*
Network		
Project Description (I-495 Northern Extension)	Two Express Lanes in each direction along I-495 between the Dulles Toll Road (Route 267) and George Washington Memorial Parkway. Specifics to be addressed in the preliminary design effort.	
Project Extent	Dulles Toll Road in Tysons to GWMP near Maryland State Line	
I-495 (Capital Beltway) Express Lanes	Existing: Express Lanes on I-495 between I-95/I-395 and Dulles Toll Road Future: Existing Express Lanes on I-495 plus new Express Lanes in Maryland along I-495 and I-270.	Access, tolling parameters, and vehicle restrictions for I-495 Express Lanes in Maryland to be determined in coordination with MDOT.
HOV	Beginning in 2020, all HOV facilities in the Northern Virginia area are assumed to become HOV-3+.	I-495 and I-95 Express Lanes are free to HOV-3 vehicles currently; HOV lanes along I-66 and Dulles Toll Road are HOV-2 currently. HOV restrictions in Maryland to be determined in coordination with MDOT. See Table 3 for further explanation.
Toll Assumptions		
Tolling Methodology	Tolling assumptions will be kept consistent with MWCOG's default factors for I-495, I-95/395, and I-66 HOT Lanes in the final assignment iteration.	
Toll Approach	Variable toll rates by roadway segment, based on maintaining Express Lane speed goal of 55 mph.	Adopted to account for varying demand levels along the length of the project.
Mode Assumptions in I-495 NEXT Express Lanes		

Table 2: Travel Demand Forecasting Model Assumptions

Model Parameter	*Assumption*	*Comments*
Vehicle Class	HOV-3+: Free Other cars and medium trucks: Toll Heavy trucks: Are permitted in the I-495 Express Lanes from the Dulles Toll Road to the project terminus north of the GWMP.	Vehicle class restrictions for I-495 Express Lanes in Maryland to be determined in coordination with MDOT
HOV Vehicles	Use the MWCOG model HOV module. Beginning in 2020, all HOV facilities in Northern Virginia area will be HOV-3+.	The HOV estimates provided are an output of the *mode choice* and *carpool occupancy* models developed by MWCOG.

Table 3. HOV and Tolling Assumptions for Facilities in Study Area

Facility	2018	2025	2045
I-495 (Existing Express Lanes Network)	All vehicles except trucks permitted in barrier-separated express lanes. All vehicles except HOV3+ must pay a toll.		
Dulles Toll Road (SR 267)	HOV2+ vehicles only allowed in left-most lane eastbound (AM peak) and westbound (PM peak)	HOV3+ vehicles only allowed in left-most lane eastbound (AM peak) and westbound (PM peak)	
I-66 (Outside the Beltway)	HOV2+ vehicles only allowed in left-most lane eastbound (AM peak) and westbound (PM peak)	All vehicles (including trucks) permitted in barrier-separated express lanes. All vehicles except HOV3+ must pay a toll.	
I-66 (Inside the Beltway)	All vehicles except trucks permitted. During AM peak eastbound and PM peak westbound, lanes are tolled except for HOV2+ vehicles.	All vehicles except trucks permitted. During AM peak eastbound and PM peak westbound, lanes are tolled except for HOV3+ vehicles.	All vehicles except trucks permitted. During AM peak and PM peak in both directions, lanes are tolled except for HOV3+ vehicles.

Traffic Volume Post-Processing

Post-processing of travel demand model output is necessary to develop traffic volume forecasts for analysis of operations during peak periods/peak hours. Post-processing of travel demand forecasts for vehicular volumes will follow NCHRP 255/765 guidelines for estimating balanced No-Build and Build peak period volumes. Existing balanced volumes will be developed outside of the MWCOG travel demand model using field count data; origin-destination (O-D) routing will be obtained utilizing StreetLight Data or the MWCOG model, and the O-D matrix will be adjusted using VISUM's TFlowFuzzy methodology to match target balanced volumes along the corridor. The O-D matrix will be imported into VISSIM for traffic microsimulation analysis.

Traffic volumes for the traffic operations analysis and air quality and noise analyses for future scenarios will be developed using travel demand model outputs and NCHRP 255/765 guidelines. For future scenario VISSIM microsimulation analysis, O-D routing will again be developed using MWCOG model outputs as a seeding matrix and VISUM's TFlowFuzzy process to create an adjusted O-D matrix that matches target forecast volumes in the study area.

Conclusion

The travel demand model methodology and calibration/validation criteria were reviewed with VDOT staff on a call on July 24, 2018. This methodology will be carried forward for travel demand forecasting for the I-495 NEXT project.

MEMORANDUM

To: Ivan Horodyskyj, P.E., VDOT NoVA District Traffic Engineer
Abi Lerner, P.E., VDOT Project Manager

From: Rob Prunty, P.E.
Raj Paradkar, P.E.
Anthony Gallo, P.E.
Kimley-Horn and Associates, Inc.

Date: August 29, 2018

Subject: I-495 NEXT Traffic Operations Analysis Framework

Introduction

This memorandum documents the traffic operations analysis framework associated with the I-495 NEXT Project. This memorandum is intended to supplement the overarching I-495 NEXT Project Scoping Framework Document.

The following elements of the traffic operations analysis are laid out in detail in this document:

- Traffic data collection
- Traffic analysis tools and measures of effectiveness (MOEs)
- Traffic simulation model calibration methodology and assumptions

Traffic Data Collection

Traffic Volumes

The following intersection locations will have traffic counts conducted in the year 2018 and be analyzed as part of the traffic operations analysis:

1. Westpark Drive Connector at I-495 Express Lane ramp terminals
2. Westpark Drive Connector at West Park Drive
3. Route 123 at Tysons Boulevard / Entrance to Tysons Mall Ring Road
4. Route 123 at Old Meadow Road / Capital One Tower Drive
5. Route 123 at Scotts Crossing Road / Colshire Drive
6. Route 123 at Anderson Road / Dulles Toll Road Connector ramp terminal
7. Route 123 at Great Falls Street / Lewinsville Road
8. Lewinsville Road at Balls Hill Road
9. Lewinsville Road at Swinks Mill Road
10. Lewinsville Road at Spring Hill Road
11. Spring Hill Road at Dulles Toll Road WB ramp terminals
12. Spring Hill Road at Dulles Toll Road EB ramp terminals
13. Spring Hill Road at International Drive / Jones Branch Drive

14. Jones Branch Drive at Jones Branch Connector
15. Jones Branch Connector at I-495 Express Lane ramp terminals
16. Old Dominion at Spring Hill Road
17. Old Dominion at Swinks Mill Road
18. Old Dominion at Balls Hill Road
19. Georgetown Pike at Dead Run Drive
20. Georgetown Pike at Balls Hill Road
21. Georgetown Pike at NB I-495 GP NB ramp terminals
22. Georgetown Pike at SB I-495 GP NB ramp terminals
23. Georgetown Pike at Linganore Drive / Helga Place
24. Georgetown Pike at Swinks Mill Road
25. Georgetown Pike at Spring Hill Road
26. Georgetown Pike at Douglass Drive
27. Route 123 at Ingleside Avenue
28. Route 123 at Old Dominion Drive

The following interchanges will have traffic counts conducted in the year 2018 and will be analyzed as part of the traffic operations analysis:

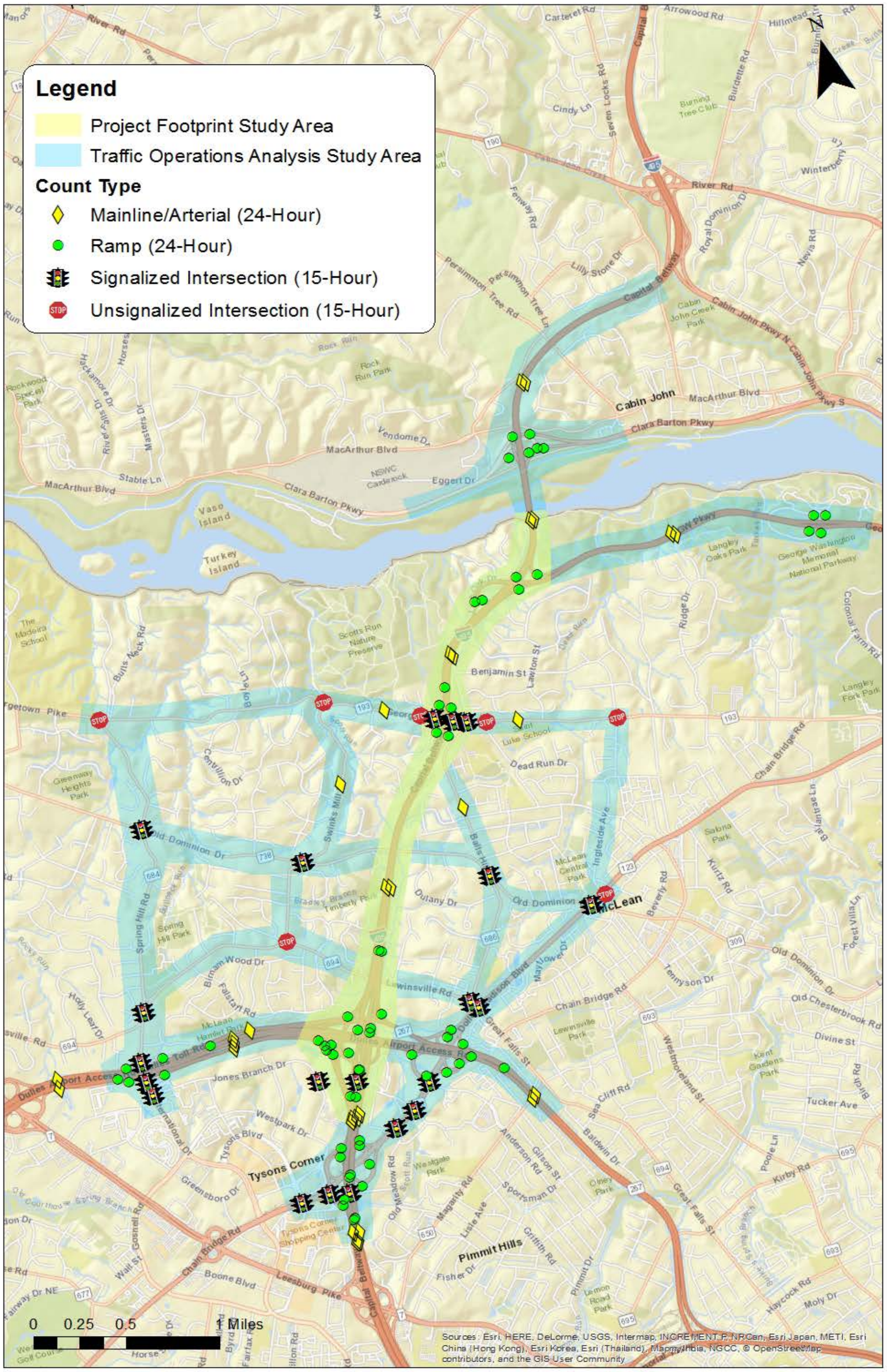
1. I-495 GP at Route 123
2. I-495 Express Lanes at Westpark Drive Connector
3. I-495 Express Lanes at Jones Branch Connector
4. I-495 GP at Dulles Toll Road and Dulles Airport Access Road
5. I-495 Express Lanes at Dulles Toll Road
6. I-495 at Georgetown Pike
7. I-495 at George Washington Memorial Parkway
8. I-495 at Clara Barton Parkway
9. Dulles International Airport Access Highway ramps to / from Dulles Toll Road (VA Route 267), east and west of I-495
10. Dulles Toll Road (VA Route 267) at Spring Hill Road (VA Route 684)
11. Dulles Toll Road (VA Route 267) at Dolley Madison Road (VA Route 123)
12. George Washington Memorial Parkway and Turkey Run Park

Traffic count locations are shown in Figure 1.

Traffic volumes used in the traffic and operations analysis will consist of the following:

- **Existing (2018)** – Developed from field counts (ramps, freeway mainline, and intersection turning movements) conducted in June 2018. Count data will be post-processed and balanced between all adjacent locations in the traffic operations analysis study area.
- **Opening Year (2025)** – No Build and one Build alternative developed through modifications to the MWCOG 2025 travel demand model for the I-495 corridor and post-processed based on 2018 data collection.
- **Design Year (2045)** – No Build and one Build alternative developed through modifications to the MWCOG 2045 travel demand model for the I-495 corridor and post-processed based on 2018 data collection.

Figure 1: Traffic Count Locations



Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

Origin-Destination Data

The traffic simulation modeling effort will route vehicles through the traffic network according to origin-destination routing. Origin-destination data will be reviewed from the following sources:

- StreetLight Data, which via a VDOT subscription provides customized origin-destination data with a very high level of spatial accuracy based on aggregated cellular device GPS/location-based services data. StreetLight Data allows for a user to provide custom origins and destinations, such as on- and off-ramps for all freeways in a study area or entry/exit links to a study area. It is anticipated that StreetLight Data will be used as the basis for origin-destination routing for the existing conditions traffic analysis, at the very least for the freeway and ramp segments of the study area.
- MWCOG regional travel demand model, which outputs O-D matrices for various vehicle types between each traffic analysis zone (TAZ) in the Washington, DC, metropolitan area. The travel patterns within the model base year (2017) have been calibrated against 2007/2008 regional household travel survey data, so the travel patterns are somewhat dated. Additionally, this dataset is not as granular as needed to account for freeway weaving proportions. However, given that the travel demand model provides O-D matrices for future years, it is anticipated that these may be used as the basis for vehicle routing in future analysis year scenarios.

Speeds and Travel Times

Floating car travel time runs were conducted in June 2018 during the AM and PM peak periods for the following segments:

Corridor #	Corridor Name
1	I-495 Northbound – From south of Route 123 to River Road CD road;
3	I-495 Southbound – From River Road CD road to south of Route 123;
2	I-495 Northbound to DTR Westbound – From Route 123 to Spring Hill Road;
8	DTR Eastbound to I-495 Southbound – From west of Spring Hill Road to south of Route 123
4	I-495 Southbound to DTR Connector Eastbound from River Road CD road to east of Route 123
10	DTR Westbound Connector to I-495 Northbound – from east of Route 123 to River Road CD road.
5	I-495 Southbound to DTR Westbound – From River Road CD road to Spring Hill Road;
7	DTR Eastbound to I-495 Northbound – From west of Spring Hill Road to River Road CD road;
6	DTR Eastbound – From west of Spring Hill Road to east of Route 123;
9	DTR Westbound – From east of Route 123 to west of Spring Hill Road

In addition, INRIX vehicle probe speed data has been queried for the corridor using the RITIS Congestion Scan tool, which provides a "heat map" of vehicle speeds temporally and spatially along a corridor. This data has been pulled for "average weekdays" (Tuesday, Wednesday, and Thursday) for the 12 most recently available months of data (July 2017 through June 2018).

Queueing Data

Queueing along the freeway segments of the corridor will be provided via the INRIX heat map and verified against Google Maps' typical traffic. Queueing along arterials and ramps will be obtained via screen captures from Google Maps' typical traffic. Targeted spot locations will be verified in the field.

Traffic Operational Analysis Tools and Measures

Traffic Analysis Tools

VISSIM Version 9.0 will be used for a comprehensive network traffic analysis for the freeways, interchanges, and adjacent intersections within the traffic operations analysis area limits. (Reference analysis tool selection matrix, *VDOT Traffic Operations and Safety Analysis Manual [TOSAM]* V1.0[1], Appendix D.) Additional calibration, based on simulated volume processed, travel times, queues, and speed profiles, will be performed against 2018 measured field conditions and traffic data.

Surface street intersection operations will be evaluated through a combination of Synchro 10 (in order to develop preliminary optimization for phasing and signal timing) and VISSIM (for microsimulation and analysis). The expanded arterial network beyond intersections immediately adjacent to freeway interchanges in the corridor will be evaluated solely through Synchro. Transit routes and stops will be coded into the study area VISSIM network where they affect or could affect I-495 and related facility operations. The VISSIM and Synchro study areas are shown in Figure 2.

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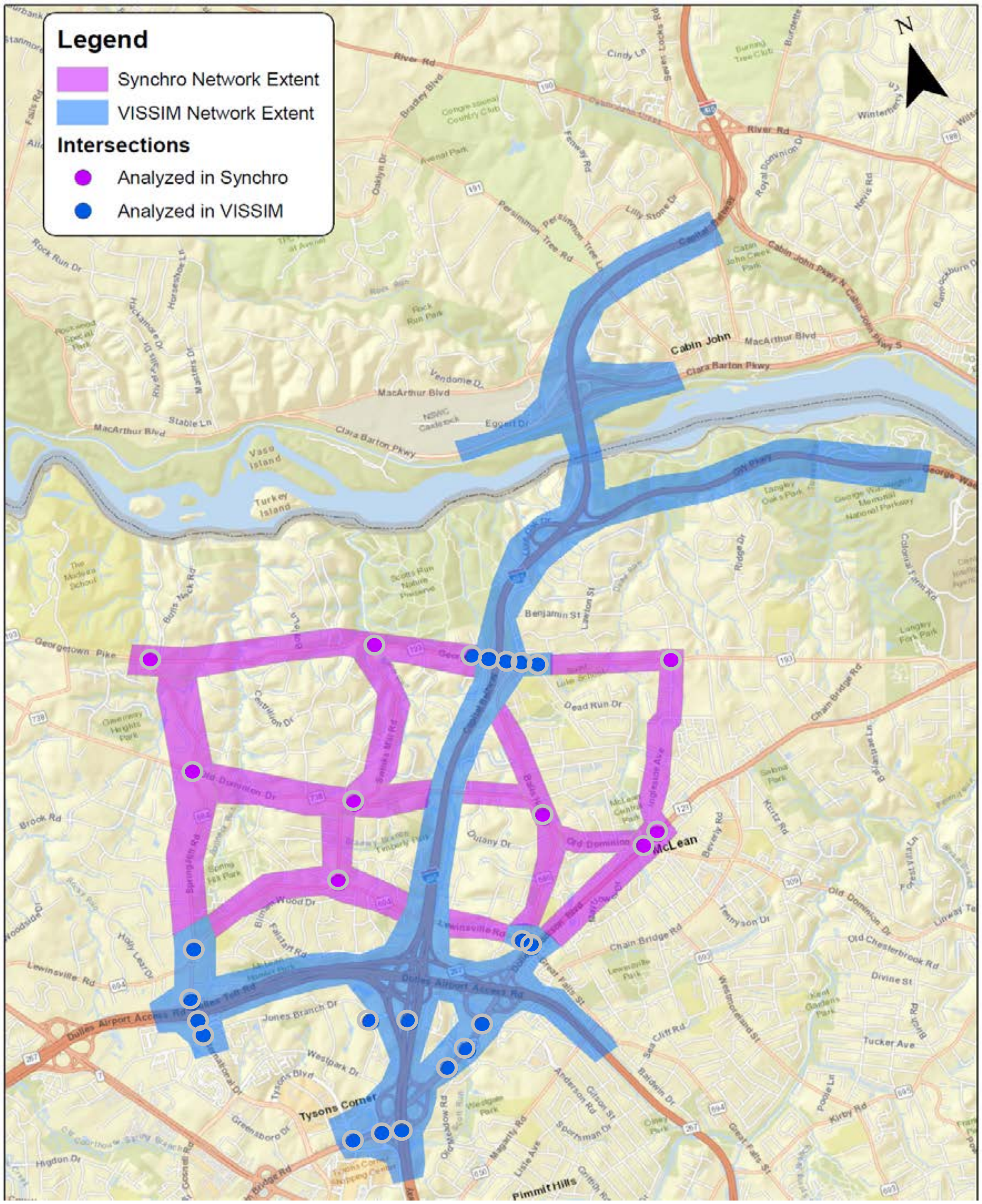
[1] http://www.virginiadot.org/business/resources/TOSAM.pdf

Figure 2. I-495 NEXT Traffic Operations VISSIM and Synchro Analysis Areas



Vehicle Classes

The following vehicle classes will be assumed for the traffic operations analysis VISSIM modeling:

- General purpose (non-toll-paying) cars
- HOV3+ cars
- HOT (toll paying) cars
- GP (non-toll-paying) trucks
- HOT (toll paying) trucks

Measures of Effectiveness

The following measures of effectiveness (MOEs) will be used for the operational analysis of the roadway network under existing and future Build and No-Build conditions.

Freeway Performance Measures

- Simulated Average Speed (mph)
- Simulated Average Density (pc/ln/mile, color-coded similar to the equivalent Density-Based LOS Thresholds)
- Simulated Volume (vehicles per hour)

The VISSIM freeway MOEs will be reported for each freeway segment. In addition, the following freeway MOEs also are proposed for reporting in the IJR:

- **Percent of Demand Served.** Simulated Volume (*processed volumes*) divided by Actual Volume (*input volumes*).
- **Simulated Ramp Queue Length.** Reported for 50th and 95th percentiles (feet).
- **Simulated Travel Time.** Reported for select network origin-destination travel paths (seconds).
- **Congestion *Heat Maps*.** Incremental speeds reported for aggregated lanes, by time interval (mph).

Arterial/Intersection Performance Measures

- **Simulated Intersection Level of Service (LOS) and Average Control Delay.** Reported by approach and by intersection (sec/veh, color-coded in similar fashion as the equivalent Highway Capacity Manual (HCM) Delay-Based LOS Thresholds).
- **Simulated Intersection Approach Queue.** Reported by movement (feet).
- **Percent of Demand Served.** Simulated Volume (*processed volumes*) divided by Actual Volume (*input volumes*).

Traffic Modeling Methodology and Assumptions

Calibration Methodology for Base Models

The VISSIM base models will be calibrated based on guidance from *VDOT Traffic Operations and Safety Analysis Manual (TOSAM)*, Version 1. A full review of the criteria and acceptance targets is provided in the attached **I-495 NEXT Traffic Analysis Microsimulation Calibration Methodology Memorandum**. This memorandum was approved and signed by the VDOT NoVA District Traffic

Engineer on July 27, 2018. The following criteria and thresholds are proposed for VISSIM model calibration:

Calibration Item	Basis	Criteria	Target
Simulated Traffic Volume (Intersections)	**By Intersection Approach**	Within ± 20% for <100 vph	At least 85% of all Intersection Approaches
		Within ± 15% for ≥ 100 vph to < 300 vph	
		Within ± 10% for ≥ 300 vph to < 1,000 vph	
		Within ± 5% for ≥ 1,000 vph	
Simulated Traffic Volume (Freeways)	**By Freeway Segment**	Within ± 20% for <100 vph	At least 85% of all Freeway Segments
		Within ± 15% for ≥ 100 vph to < 300 vph	
		Within ± 10% for ≥ 300 vph to < 1,000 vph	
		Within ± 5% for ≥ 1,000 vph	
Simulated Travel Time	**By Route**	Within ± 30% for average travel times on arterials	At least 85% of all Travel Time Routes (Including Segments)
		Within ± 20% for average travel times on freeways	
Maximum Simulated Queue Length	**By Approach for Targeted Critical Locations**	Modeled queues qualitatively reflect the impacts of observed queues	Qualitative Visual Match
Visual Review of Bottleneck Locations	**Targeted Critical Locations**	Speed heat maps qualitatively reflect patterns and duration of congestion	Qualitative Subjective Assessment

The following locations have been proposed for queue length calibration and reporting:

Queue Type	**Location**
Ramp	Ramp from SR 267 EB to I-495 NB GP
Ramp	Ramp from DAAR EB to I-495 NB GP
Ramp	Ramp from SR 267 EB to I-495 SB GP
Ramp	Ramp from SR 267 EB to Route 123 NB
Ramp	Ramp from Georgetown Pike (SR 193) to I-495 NB GP
Ramp	Ramp from George Washington Memorial Parkway NB to I-495 NB GP
Approach	Georgetown Pike (SR 193) EB approaching I-495 NB GP ramps
Approach	Georgetown Pike (SR 193) WB approaching I-495 NB GP ramps

Approach	Balls Hill Rd NB approaching Georgetown Pike
Approach	Spring Hill Rd NB approaching Lewinsville Road
Approach	Route 123 NB approaching Great Falls St
Approach	Lewinsville Road EB approaching Balls Hill Road

Potential Adjustments for Calibration

Adjustments to the VISSIM model during the calibration process will follow guidance from the VDOT TOSAM. These adjustments could include modifications to lane change distance for connectors, driver behavior along freeways and arterials, adjustments to desired speeds for vehicles at the network termini (such as along I-495 northbound leaving the study area), etc. The technical memorandum detailing calibration results will identify any potential deviations from TOSAM guidance.

Simulation Time, Seeding Time, and Number of Runs

The I-495 NEXT traffic operations study area is a severely oversaturated network during the weekday AM and PM peak periods, with several hours of congestion in both directions along I-495, especially along I-495 northbound approaching the American Legion Bridge. During these congested periods, traffic volume throughput is constrained due to low speeds and can be much lower than the actual maximum counted volumes along the freeway. Due to the oversaturated conditions, the analysis period was selected based on the heaviest periods of congestion and slowest speeds experienced along the corridor.

Figure 3 shows 15-minute average speeds along the I-495 northbound general purpose lanes through the study area for average weekdays (Tuesday, Wednesday, and Thursday) from July 2017 through June 2018. Note that during both the AM and PM peak periods, speeds along I-495 northbound are slower than speeds along I-495 southbound due to the downstream bottleneck at the American Legion Bridge. Thus, the analysis period and peak hours have been selected specifically based on congestion in the I-495 northbound general purpose lanes.

Figure 3 also show the proposed simulation analysis periods, which were also approved by the VDOT NoVA District Traffic Engineer as documented in the attached memorandum. These analysis periods would each be preceded by a 30-minute seeding period in the VISSIM models:

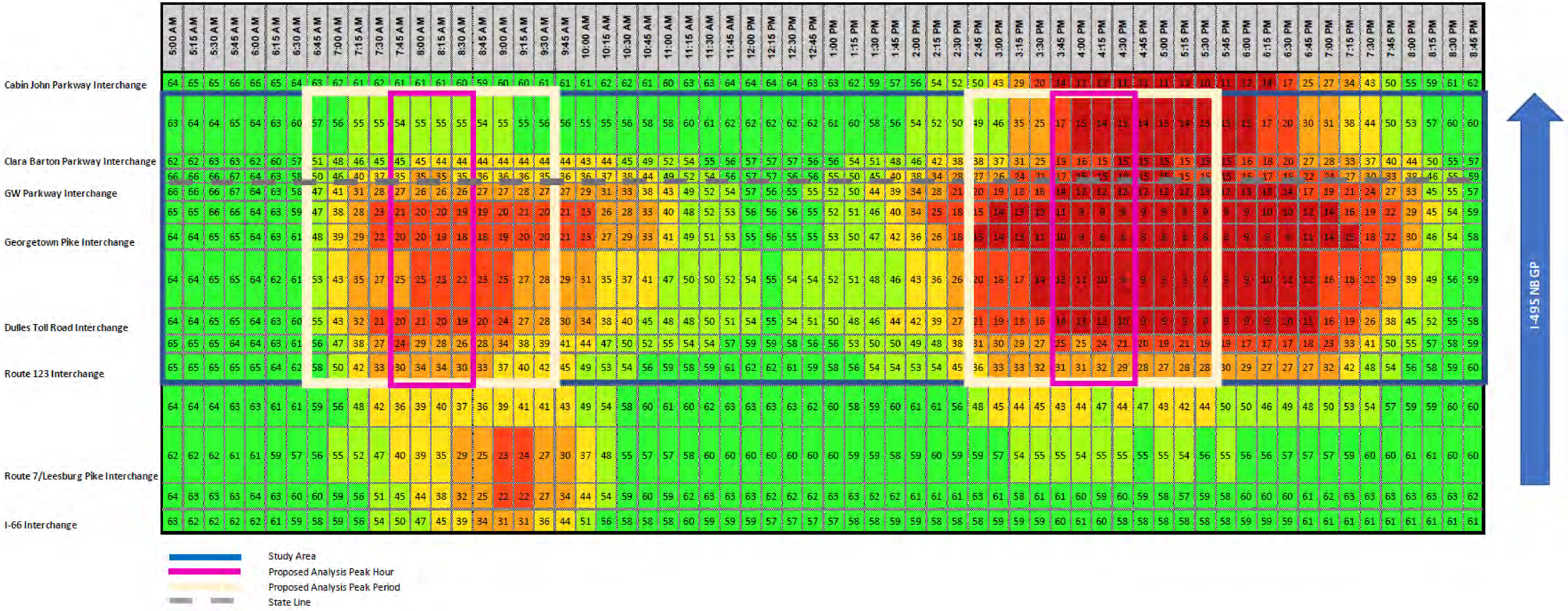


Figure 3: INRIX 15-Minute Average Speeds Along I-495 Northbound GP and Proposed Simulation Analysis Periods

	5:00 AM	5:15 AM	5:30 AM	5:45 AM	6:00 AM	6:15 AM	6:30 AM	6:45 AM	7:00 AM	7:15 AM	7:30 AM	7:45 AM	8:00 AM	8:15 AM	8:30 AM	8:45 AM	9:00 AM	9:15 AM	9:30 AM	9:45 AM	10:00 AM	10:15 AM	10:30 AM	10:45 AM	11:00 AM	11:15 AM	11:30 AM	11:45 AM	12:00 PM	12:15 PM	12:30 PM	12:45 PM	1:00 PM	1:15 PM	1:30 PM	1:45 PM	2:00 PM	2:15 PM	2:30 PM	2:45 PM	3:00 PM	3:15 PM	3:30 PM	3:45 PM	4:00 PM	4:15 PM	4:30 PM	4:45 PM	5:00 PM	5:15 PM	5:30 PM	5:45 PM	6:00 PM	6:15 PM	6:30 PM	6:45 PM	7:00 PM	7:15 PM	7:30 PM	7:45 PM	8:00 PM	8:15 PM	8:30 PM	8:45 PM
Cabin John Parkway Interchange	64	65	65	66	66	65	64	63	62	61	62	61	61	61	60	59	60	60	61	61	61	62	62	61	60	63	63	64	64	64	64	63	63	62	59	57	56	54	52	50	43	29	20	14	11	12	11	11	11	11	10	11	12	14	17	25	27	34	43	50	55	59	61	62
	63	64	64	65	64	63	60	57	56	55	55	54	55	55	55	54	55	55	56	56	55	55	56	58	58	60	61	62	62	62	62	62	61	60	58	56	54	52	50	49	46	35	25	17	15	14	13	14	15	14	13	13	15	17	20	30	31	38	44	50	53	57	60	60
Clara Barton Parkway Interchange	62	62	63	63	62	60	57	51	48	46	45	45	45	44	44	44	44	44	44	44	43	44	45	49	52	54	55	56	57	57	57	56	56	54	51	48	46	42	38	38	37	31	25	19	16	15	15	15	15	15	15	15	16	18	20	27	28	33	37	40	44	50	55	57
	66	66	66	67	64	63	58	50	46	40	37	35	35	35	35	36	36	36	35	36	36	37	38	44	49	52	54	56	57	57	56	56	55	50	45	40	38	34	28	27	26	24	21	17	15	15	14	15	15	15	15	15	16	17	18	22	24	27	30	33	38	46	55	59
GW Parkway Interchange	66	66	66	67	64	63	58	47	41	31	28	27	26	26	26	27	27	28	27	27	29	31	33	38	43	49	52	54	57	56	55	55	52	50	44	39	34	28	21	20	19	18	16	14	12	12	12	12	12	12	13	12	13	13	14	17	19	21	24	27	33	45	55	57
	65	65	66	66	64	63	59	47	38	28	23	21	20	20	19	19	20	21	20	21	23	26	28	33	40	48	52	53	56	56	56	55	52	51	46	40	34	25	18	15	14	13	12	11	9	9	9	9	9	9	9	9	9	10	10	12	14	16	19	22	29	45	54	59
Georgetown Pike Interchange	64	64	65	65	64	63	61	48	39	29	22	20	20	19	18	18	19	20	20	21	23	27	29	33	41	49	51	53	55	56	55	55	53	50	47	42	36	26	18	15	14	13	11	10	9	8	8	8	8	8	8	8	9	9	9	11	14	15	18	22	30	46	54	58
	64	64	65	65	64	62	61	53	43	35	27	25	25	23	22	23	25	27	28	29	31	35	37	41	47	50	50	52	54	55	54	54	52	51	48	46	43	36	26	20	18	17	14	12	11	10	9	9	9	9	9	9	9	10	11	12	16	18	22	29	39	49	56	59
Dulles Toll Road Interchange	64	64	65	65	64	63	60	55	43	32	21	20	21	20	19	20	24	27	28	30	34	38	40	45	48	48	50	51	54	55	54	51	50	48	46	44	42	39	27	21	19	18	16	14	13	12	10	9	9	9	9	9	9	9	10	11	16	19	26	38	45	52	55	58
	65	65	65	64	64	63	61	56	47	38	27	24	29	28	26	28	34	38	39	41	44	47	50	52	55	54	54	57	59	59	58	56	56	53	50	50	49	48	38	31	30	29	27	25	25	24	21	20	19	21	19	19	17	17	17	18	23	33	41	50	55	57	58	59
Route 123 Interchange	65	65	65	65	65	64	62	58	50	42	33	30	34	34	30	33	37	40	42	45	49	53	54	56	59	58	59	61	62	62	61	59	58	56	54	54	53	54	45	36	33	33	32	31	31	32	29	28	27	28	28	30	29	27	27	27	32	42	48	54	56	58	59	60
	64	64	64	63	63	61	61	59	56	48	42	36	39	40	37	36	39	41	41	43	49	54	58	60	61	60	62	63	63	63	63	62	60	58	59	60	61	61	56	48	45	44	45	43	44	47	44	47	43	42	44	50	50	46	49	48	50	53	54	57	59	59	60	60
	62	62	62	61	61	59	57	56	55	52	47	40	39	35	29	25	23	24	27	30	37	48	55	57	57	58	60	60	60	60	60	60	60	59	59	58	59	60	59	59	57	54	55	55	54	55	55	55	55	54	56	55	56	56	57	57	57	59	60	60	61	61	60	60
Route 7/Leesburg Pike Interchange	64	63	63	63	64	63	60	60	59	56	51	45	44	38	32	25	22	22	27	34	44	54	59	60	59	62	63	63	63	62	62	62	63	63	62	62	61	61	61	63	61	58	61	61	60	59	60	59	58	57	59	58	60	60	60	61	62	63	63	63	63	63	63	62
I-66 Interchange	63	62	62	62	62	61	59	58	59	56	54	50	47	45	39	34	31	31	36	44	51	56	58	58	58	60	59	59	59	57	57	57	57	58	58	59	59	58	58	58	59	59	59	60	61	60	58	58	58	58	58	58	59	59	59	61	61	61	61	61	61	61	61	61

- AM peak: 6:45 AM to 9:45 AM (peak hour 7:45 AM to 8:45 AM). This will capture the onset of queueing back from the American Legion Bridge and the start of the dissipation of the queue. The peak hour captures the current worst extent of queueing.
- PM peak: 2:45 PM to 5:45 PM (peak hour 3:45 PM to 4:45 PM). This peak period is intended to capture queue formation from the American Legion Bridge *before the queue from points further north in Maryland spill back and create a single continuous queue*. This can be observed in the figure, as prior to approximately 3:30 PM, congestion in Virginia does not continue into Maryland. By approximately 4:00 PM, a single continuous area of congestion is present from north of the study area through the Route 123 interchange. Between approximately 4:00 PM and 7:00 PM, however, the extent of queueing stays relatively consistent – to the Route 123 interchange. The congestion does not fully dissipate until after 8:00 PM on average – note that the proposed traffic analysis period is not recommended to last until this point. Rather, the proposed traffic analysis period captures the onset of queueing (from when the queue is not due to spillback from Maryland) until it reaches its maximum.

Although the peak period in the afternoon and evening typically extends beyond six hours of congestion, the proposed analysis periods will still capture the onset of congestion and maximum extents of congestion, while allowing for the analysis to proceed in a streamlined manner within the scope and schedule of the project.

Conclusion

The VISSIM calibration criteria and simulation analysis peak hours and peak periods have been reviewed and approved by the VDOT NoVA District Traffic Engineer. The elements of the traffic analysis framework were presented to VDOT staff on July 20, 2018. The analysis tools and framework described in this document will be carried forward for the I-495 NEXT project.

ATCS Kimley»Horn

MEMORANDUM

To: Ivan Horodyskyj, P.E., VDOT NoVA District Traffic Engineer
Abi Lerner, P.E., VDOT Project Manager

From: Rob Prunty, P.E.
Raj Paradkar, P.E.
Anthony Gallo, P.E.
Kimley-Horn and Associates, Inc.

Date: July 24, 2018

Subject: I-495 NEXT Traffic Analysis Microsimulation Calibration Methodology

Introduction

This memorandum documents the proposed calibration methodology for the I-495 Northern Extension (NEXT) project traffic operations analysis in support of the project National Environmental Policy Act (NEPA) studies and Preliminary Engineering and Operations Development. The ATCS/Kimley-Horn consultant team (henceforth referred to as "consultant team") has proposed a traffic microsimulation calibration methodology based on guidance set forth in the VDOT *Traffic Operations and Safety Analysis Manual* (TOSAM)[1], Version 1.0 (released November 2015). This manual, which is currently being updated to Version 2.0, contains direction related to calibration of VISSIM models that are considered mandatory conditions in which any deviations require approval from the Regional (now District) Traffic Engineer or his/her designee. The consultant team is requesting approval for deviations in calibration methodology for specific criteria (simulated average speeds and simulated queue lengths), given the volatile traffic flows and inconsistent queuing in the study area, as well as the direction from VDOT to streamline the project scale and schedule. The proposed alternative methodologies for calibration of these measures are documented below.

In conjunction with the VISSIM calibration, this memorandum also includes a discussion of the proposed simulation analysis period. The consultant team also requests approval for using these proposed periods in the VISSIM microsimulation analysis.

VISSIM Calibration Methodology

Existing conditions (2018) microsimulation networks will be developed using VISSIM 9.0 software. The VISSIM study area is shown in Figure 1.

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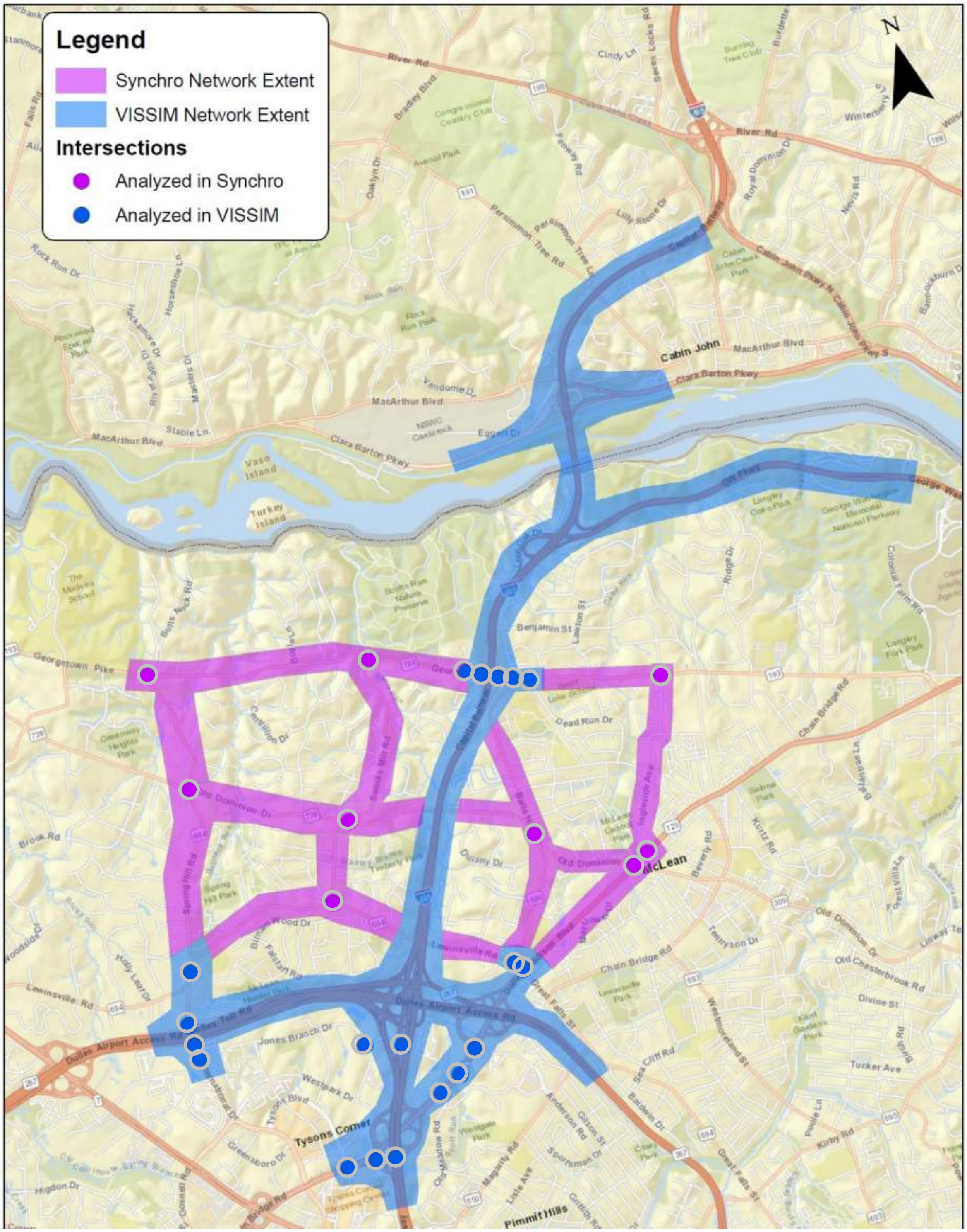
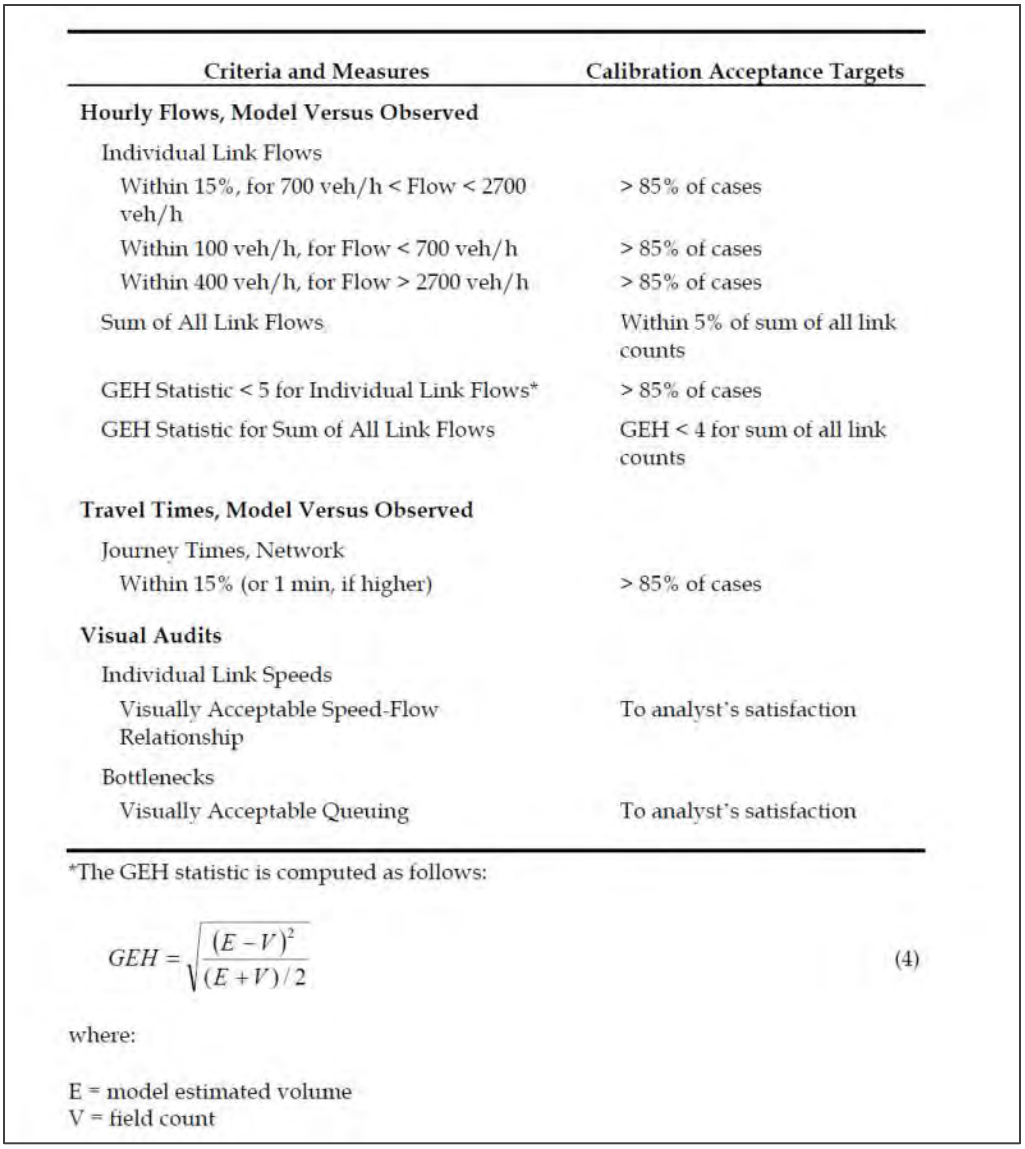
[1] http://www.virginiadot.org/business/resources/TOSAM.pdf

Figure 1. I-495 NEXT Traffic Operations Analysis Study Area



The VISSIM base models will be calibrated based on guidance from the *FHWA Traffic Analysis Toolbox Volume III* and the TOSAM. **Error! Not a valid bookmark self-reference.** shows the criteria and acceptance targets from the FHWA Toolbox that are recommended to be used in determining when calibration is achieved; Figure 3 shows the criteria and acceptance targets from the TOSAM.

Figure 2: FHWA Toolbox Calibration Criteria and Acceptance Targets



Criteria and Measures	Calibration Acceptance Targets
Hourly Flows, Model Versus Observed	
Individual Link Flows	
Within 15%, for 700 veh/h < Flow < 2700 veh/h	> 85% of cases
Within 100 veh/h, for Flow < 700 veh/h	> 85% of cases
Within 400 veh/h, for Flow > 2700 veh/h	> 85% of cases
Sum of All Link Flows	Within 5% of sum of all link counts
GEH Statistic < 5 for Individual Link Flows*	> 85% of cases
GEH Statistic for Sum of All Link Flows	GEH < 4 for sum of all link counts
Travel Times, Model Versus Observed	
Journey Times, Network	
Within 15% (or 1 min, if higher)	> 85% of cases
Visual Audits	
Individual Link Speeds	
Visually Acceptable Speed-Flow Relationship	To analyst's satisfaction
Bottlenecks	
Visually Acceptable Queuing	To analyst's satisfaction

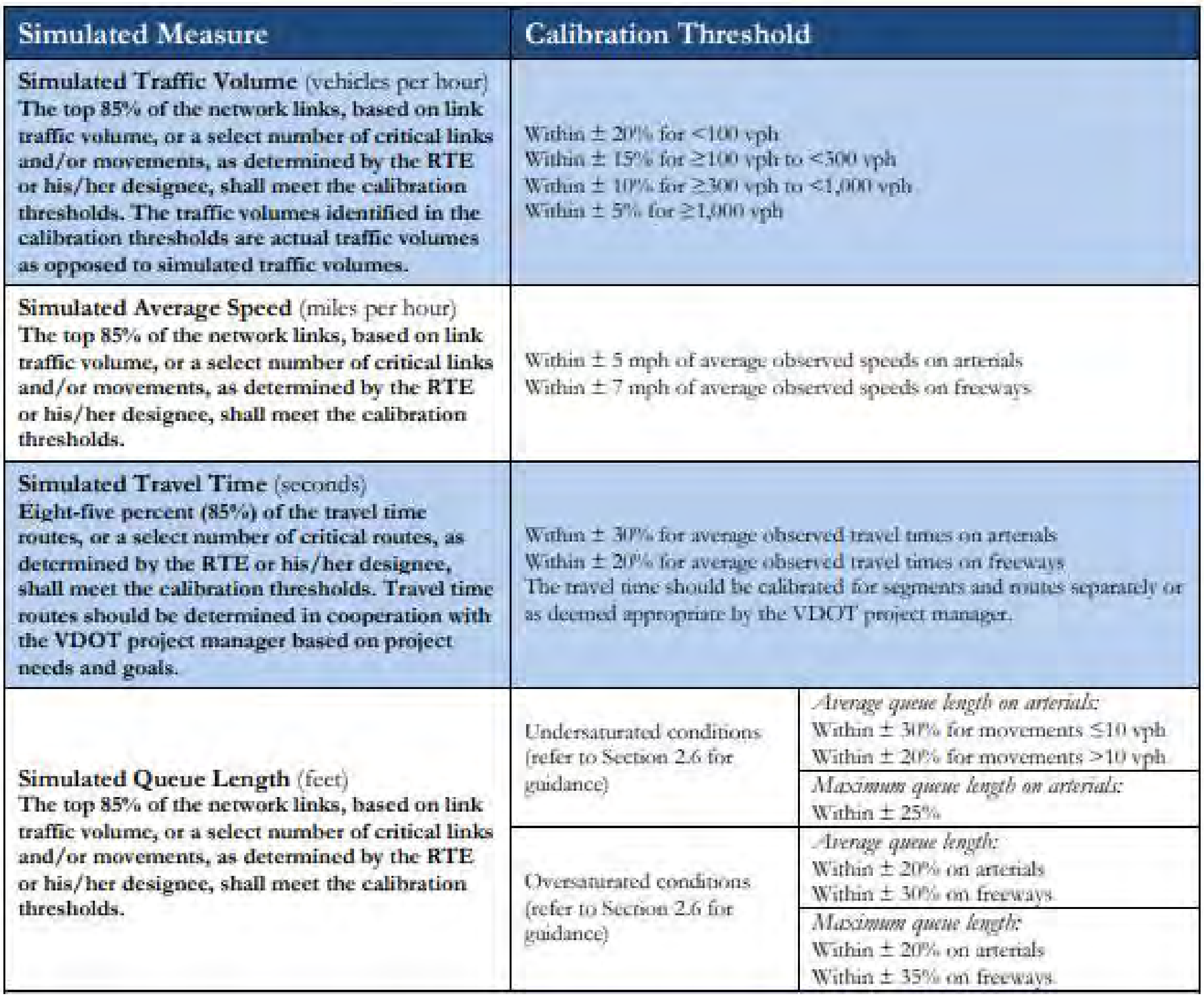
*The GEH statistic is computed as follows:

$$GEH = \sqrt{\frac{(E-V)^2}{(E+V)/2}} \tag{4}$$

where:

E = model estimated volume
V = field count

Figure 3: VDOT TOSAM Calibration Criteria and Acceptance Targets



Simulated Measure	Calibration Threshold	
Simulated Traffic Volume (vehicles per hour) **The top 85% of the network links, based on link traffic volume, or a select number of critical links and/or movements, as determined by the RTE or his/her designee, shall meet the calibration thresholds. The traffic volumes identified in the calibration thresholds are actual traffic volumes as opposed to simulated traffic volumes.**	Within ± 20% for <100 vph Within ± 15% for ≥100 vph to <300 vph Within ± 10% for ≥300 vph to <1,000 vph Within ± 5% for ≥1,000 vph	
Simulated Average Speed (miles per hour) **The top 85% of the network links, based on link traffic volume, or a select number of critical links and/or movements, as determined by the RTE or his/her designee, shall meet the calibration thresholds.**	Within ± 5 mph of average observed speeds on arterials Within ± 7 mph of average observed speeds on freeways	
Simulated Travel Time (seconds) **Eight-five percent (85%) of the travel time routes, or a select number of critical routes, as determined by the RTE or his/her designee, shall meet the calibration thresholds. Travel time routes should be determined in cooperation with the VDOT project manager based on project needs and goals.**	Within ± 30% for average observed travel times on arterials Within ± 20% for average observed travel times on freeways The travel time should be calibrated for segments and routes separately or as deemed appropriate by the VDOT project manager.	
Simulated Queue Length (feet) **The top 85% of the network links, based on link traffic volume, or a select number of critical links and/or movements, as determined by the RTE or his/her designee, shall meet the calibration thresholds.**	Undersaturated conditions (refer to Section 2.6 for guidance)	*Average queue length on arterials:* Within ± 30% for movements ≤10 vph Within ± 20% for movements >10 vph
		Maximum queue length on arterials: Within ± 25%
	Oversaturated conditions (refer to Section 2.6 for guidance)	*Average queue length:* Within ± 20% on arterials Within ± 30% on freeways
		Maximum queue length: Within ± 20% on arterials Within ± 35% on freeways

The following criteria and thresholds are proposed for VISSIM model calibration:

Calibration Item	Basis	Criteria	Target
Simulated Traffic Volume (Intersections)	**By Intersection Approach**	Within ± 20% for <100 vph	At least 85% of all Intersection Approaches
		Within ± 15% for ≥ 100 vph to < 300 vph	
		Within ± 10% for ≥ 300 vph to < 1,000 vph	
		Within ± 5% for ≥ 1,000 vph	
Simulated Traffic Volume (Freeways)	**By Freeway Segment**	Within ± 20% for <100 vph	At least 85% of all Freeway Segments
		Within ± 15% for ≥ 100 vph to < 300 vph	
		Within ± 10% for ≥ 300 vph to < 1,000 vph	
		Within ± 5% for ≥ 1,000 vph	
Simulated Travel Time	**By Route**	Within ± 30% for average travel times on arterials	At least 85% of all Travel Time Routes (Including Segments)
		Within ± 20% for average travel times on freeways	
Maximum Simulated Queue Length	**By Approach for Targeted Critical Locations**	Modeled queues qualitatively reflect the impacts of observed queues	Qualitative Visual Match
Visual Review of Bottleneck Locations	**Targeted Critical Locations**	Speed heat maps qualitatively reflect patterns and duration of congestion	Qualitative Subjective Assessment

DEVIATIONS FROM TOSAM REQUIREMENTS

The following requirements from the TOSAM have been modified for the proposed VISSIM calibration process for this project:

- Simulated Average Speed – the TOSAM requires that the top 85 percent of network links (based on link traffic volumes) or a select number of critical links and/or movements, as determined by the DTE or his/her designee, meet a calibration threshold of average speeds within 5 mph for arterials and 7 mph for highways.
  - *Speeds are highly variable on the interstate mainline as well as on the local arterial network and residential roadways, and can vary substantially by hour and by day. The consultant team proposes that simulated average speed be captured as part of the travel time calibration process and the visual review of bottleneck locations against speed heat*

maps. Average speeds will still be extracted from the VISSIM models along the freeway corridors (I-495 general purpose, I-495 HOT, and SR 267) at one-half mile intervals and compared visually against speed heat maps generated from INRIX vehicle probe data.

- Simulated Queue Length – the TOSAM requires that the top 85 percent of network links (based on link traffic volumes), or a select number of critical links and/or movements, as determined by the DTE or his/her designee, meet calibration thresholds of measured queue lengths depending on whether conditions are oversaturated or undersaturated. These thresholds are detailed in Figure 3.
  - *Queuing within the study area is notably inconsistent and can oscillate numerous times within the peak periods, or be absent altogether on some days. The consultant team proposes that a qualitative subjective assessment be conducted for queue lengths at targeted locations in addition to the review of freeway mainline congestion/queues against the speed heat maps. Targeted locations will be determined in conjunction with the DTE for freeway ramps and arterials. Several proposed targeted locations are suggested in the following table:*

Queue Type	**Location**
Ramp	Ramp from SR 267 EB to I-495 NB GP
Ramp	Ramp from DAAR EB to I-495 NB GP
Ramp	Ramp from SR 267 EB to I-495 SB GP
Ramp	Ramp from SR 267 EB to Route 123 NB
Ramp	Ramp from Georgetown Pike (SR 193) to I-495 NB GP
Ramp	Ramp from George Washington Memorial Parkway NB to I-495 NB GP
Approach	Georgetown Pike (SR 193) EB approaching I-495 NB GP ramps
Approach	Georgetown Pike (SR 193) WB approaching I-495 NB GP ramps
Approach	Balls Hill Rd NB approaching Georgetown Pike
Approach	Spring Hill Rd NB approaching Lewinsville Road
Approach	Route 123 NB approaching Great Falls St
Approach	Lewinsville Road EB approaching Balls Hill Road

POTENTIAL ADJUSTMENTS FOR CALIBRATION

Adjustments to the VISSIM model during the calibration process will follow guidance from the VDOT TOSAM. These adjustments could include modifications to lane change distance for connectors, driver behavior along freeways and arterials, adjustments to desired speeds for vehicles at the network termini (such as along I-495 northbound leaving the study area), etc. The technical memorandum detailing calibration results will identify any potential deviations from TOSAM guidance.

Simulation Analysis Period

The I-495 NEXT traffic operations study area is a severely oversaturated network during the weekday AM and PM peak periods, with several hours of congestion in both directions along I-495, especially along I-495 northbound approaching the American Legion Bridge. During these congested periods, traffic volume throughput is constrained due to low speeds and can be much lower than the actual maximum counted volumes along the freeway. Figure 4 shows an example of this phenomenon along the I-495 northbound general purpose lanes over three days in June 2018. During the PM peak period, starting around 2 PM, traffic counts decrease and do not get above 5,000 vph across a four-lane section, which theoretically should be able to carry much higher volumes. Due to the oversaturated conditions, the consultant team does not recommend using the maximum recorded values from traffic counts to represent peak conditions in the study area; rather, the consultant team recommends selecting an analysis period based on the heaviest periods of congestion and slowest speeds experienced along the corridor.

Figure 4. Hourly Traffic Counts along I-495 Northbound GP south of Route 267

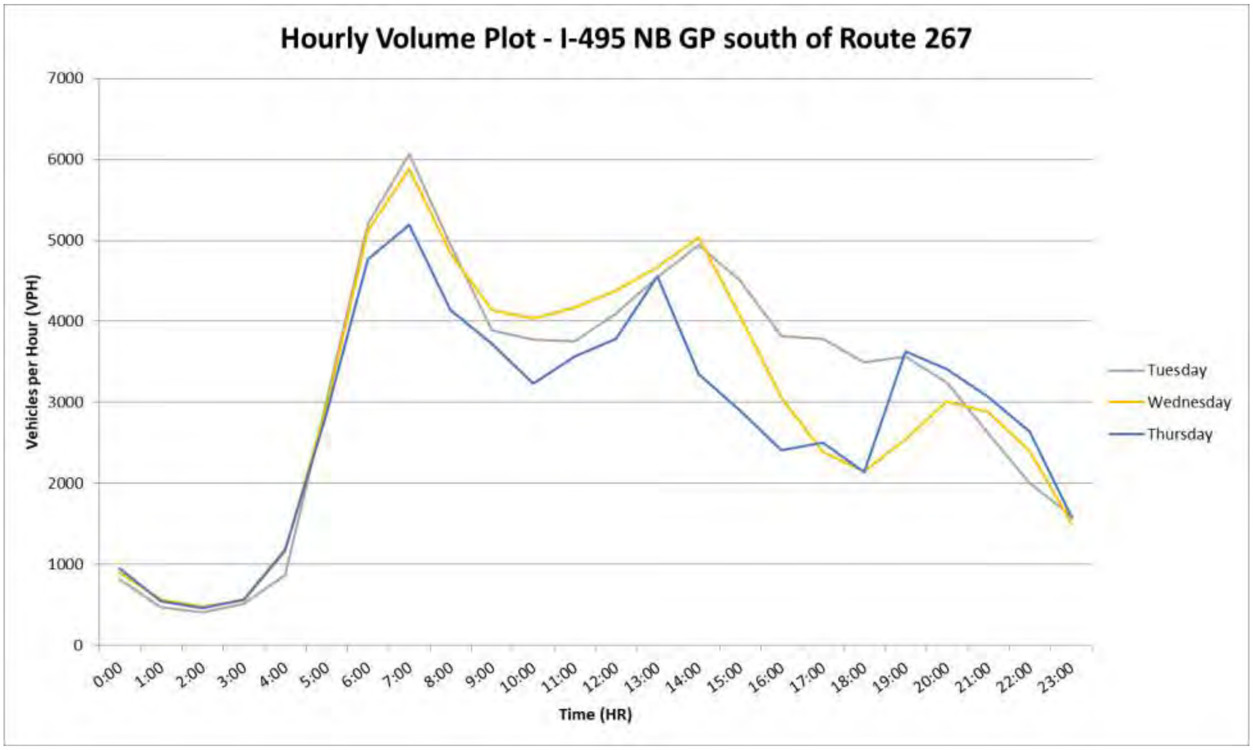


Figure 5 shows 15-minute average speeds along the I-495 northbound general purpose lanes through the study area for average weekdays (Tuesday, Wednesday, and Thursday) from July 2017 through June 2018. Note that during both the AM and PM peak periods, speeds along I-495 northbound are slower than speeds along I-495 southbound due to the downstream bottleneck at the American Legion Bridge. The consultant team recommends selecting an analysis period based specifically on congestion in the I-495 northbound general purpose lanes.

Figure 5 also shows the consultant team’s proposed simulation analysis periods. These analysis periods would each be preceded by a 30-minute seeding period in the VISSIM models.

- AM peak: 6:45 AM to 9:45 AM (peak hour 7:45 AM to 8:45 AM). This will capture the onset of queueing back from the American Legion Bridge and the start of the dissipation of the queue. The peak hour captures the current worst extent of queueing.
- PM peak: 2:45 PM to 5:45 PM (peak hour 3:45 PM to 4:45 PM). This peak period is intended to capture queue formation from the American Legion Bridge *before the queue from points further north in Maryland spill back and create a single continuous queue*. This can be observed in the figure, as prior to approximately 3:30 PM, congestion in Virginia does not continue into Maryland. By approximately 4:00 PM, a single continuous area of congestion is present from north of the study area through the Route 123 interchange. Between approximately 4:00 PM and 7:00 PM, however, the extent of queueing stays relatively consistent – to the Route 123 interchange. The congestion does not fully dissipate until after 8:00 PM on average – note that the proposed traffic analysis period is not recommended to last until this point. Rather, the proposed traffic analysis period captures the onset of queueing (from when the queue is not due to spillback from Maryland) until it reaches its maximum.

While neither of the proposed analysis periods capture the entire period of congestion along the northbound direction of I-495, the consultant team does not recommend creating a microsimulation analysis for those full periods, based on VDOT’s request to streamline the analysis and focus on the areas and times of greatest importance. For example, although the peak period in the afternoon / evening typically extends beyond six hours of congestion, the proposed analysis periods for study will still capture the onset of congestion and maximum extents of congestion, while allowing for the analysis to proceed in a streamlined manner within the scope and schedule of the project.

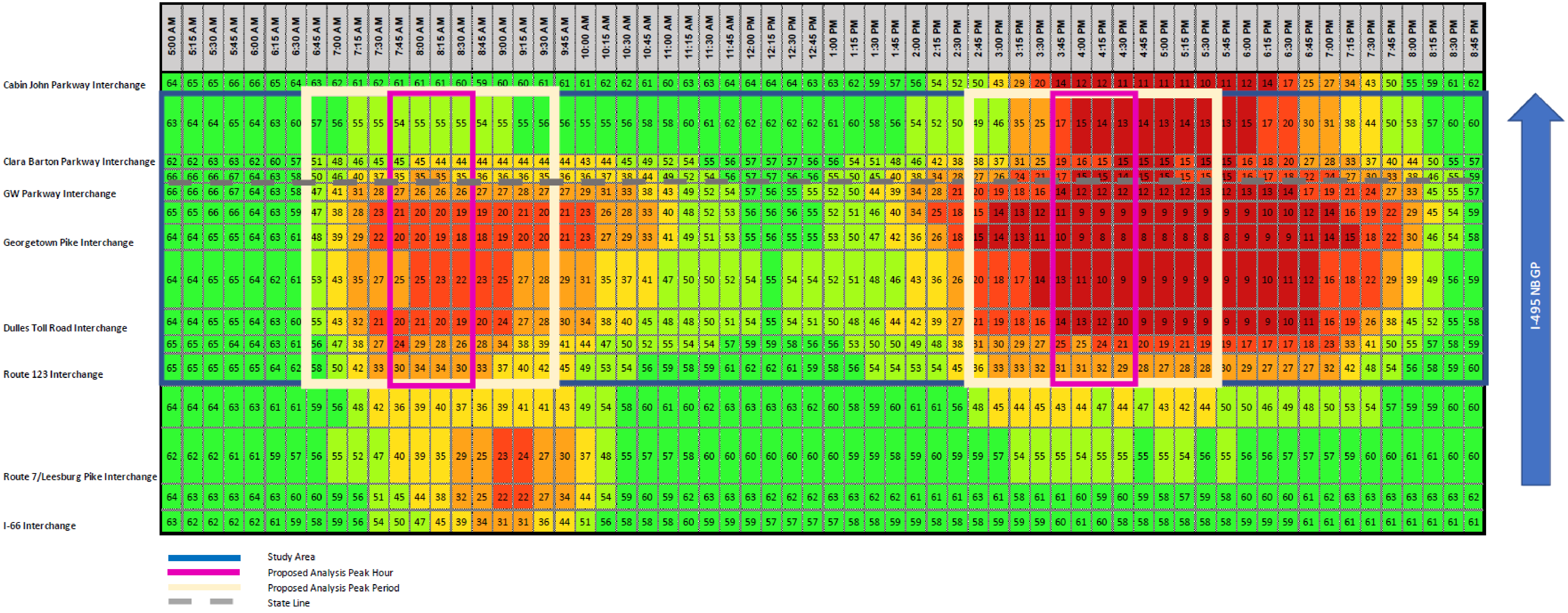


Figure 5: INRIX 15-Minute Average Speeds Along I-495 Northbound GP and Proposed Simulation Analysis Periods

	5:00 AM	5:15 AM	5:30 AM	5:45 AM	6:00 AM	6:15 AM	6:30 AM	6:45 AM	7:00 AM	7:15 AM	7:30 AM	7:45 AM	8:00 AM	8:15 AM	8:30 AM	8:45 AM
Cabin John Parkway Interchange	64	65	65	66	66	65	64	63	62	61	62	61	61	61	60	59
	63	64	64	65	64	63	60	57	56	55	55	54	55	55	55	54
Clara Barton Parkway Interchange	62	62	63	63	62	60	57	51	48	46	45	45	45	44	44	44
	66	66	66	67	64	63	58	50	46	40	37	35	35	35	35	36
GW Parkway Interchange	66	66	66	67	64	63	58	47	41	31	28	27	26	26	26	27
	65	65	66	66	64	63	59	47	38	28	23	21	20	20	19	19
Georgetown Pike Interchange	64	64	65	65	64	63	61	48	39	29	22	20	20	19	18	18
	64	64	65	65	64	62	61	53	43	35	27	25	25	23	22	23
Dulles Toll Road Interchange	64	64	65	65	64	63	60	55	43	32	21	20	21	20	19	20
	65	65	65	64	64	63	61	56	47	38	27	24	29	28	26	28
Route 123 Interchange	65	65	65	65	65	64	62	58	50	42	33	30	34	34	30	33
	64	64	64	63	63	61	61	59	56	48	42	36	39	40	37	36
Route 7/Leesburg Pike Interchange	62	62	62	61	61	59	57	56	55	52	47	40	39	35	29	25
	64	63	63	63	64	63	60	60	59	56	51	45	44	38	32	25
I-66 Interchange	63	62	62	62	62	61	59	58	59	56	54	50	47	45	39	34

	9:00 AM	9:15 AM	9:30 AM	9:45 AM	10:00 AM	10:15 AM	10:30 AM	10:45 AM	11:00 AM	11:15 AM	11:30 AM	11:45 AM	12:00 PM	12:15 PM	12:30 PM	12:45 PM
Cabin John Parkway Interchange	60	60	61	61	61	62	62	61	60	63	63	64	64	64	64	63
	55	55	56	56	55	55	56	58	58	60	61	62	62	62	62	62
Clara Barton Parkway Interchange	44	44	44	44	43	44	45	49	52	54	55	56	57	57	57	56
	36	36	35	36	36	37	38	44	49	52	54	56	57	57	56	56
GW Parkway Interchange	27	28	27	27	29	31	33	38	43	49	52	54	57	56	55	55
	20	21	20	21	23	26	28	33	40	48	52	53	56	56	56	55
Georgetown Pike Interchange	19	20	20	21	23	27	29	33	41	49	51	53	55	56	55	55
	25	27	28	29	31	35	37	41	47	50	50	52	54	55	54	54
Dulles Toll Road Interchange	24	27	28	30	34	38	40	45	48	48	50	51	54	55	54	51
	34	38	39	41	44	47	50	52	55	54	54	57	59	59	58	56
Route 123 Interchange	37	40	42	45	49	53	54	56	59	58	59	61	62	62	61	59
	39	41	41	43	49	54	58	60	61	60	62	63	63	63	63	62
Route 7/Leesburg Pike Interchange	23	24	27	30	37	48	55	57	57	58	60	60	60	60	60	60
	22	22	27	34	44	54	59	60	59	62	63	63	63	62	62	62
I-66 Interchange	31	31	36	44	51	56	58	58	58	60	59	59	59	57	57	57

	1:00 PM	1:15 PM	1:30 PM	1:45 PM	2:00 PM	2:15 PM	2:30 PM	2:45 PM	3:00 PM	3:15 PM	3:30 PM	3:45 PM	4:00 PM	4:15 PM	4:30 PM	4:45 PM
Cabin John Parkway Interchange	63	62	59	57	56	54	52	50	43	29	20	14	12	12	11	11
	61	60	58	56	54	52	50	49	46	35	25	17	15	14	13	14
Clara Barton Parkway Interchange	56	54	51	48	46	42	38	38	37	31	25	19	16	15	15	15
	55	50	45	40	38	34	28	27	26	24	21	17	15	15	14	15
GW Parkway Interchange	52	50	44	39	34	28	21	20	19	18	16	14	12	12	12	12
	52	51	46	40	34	25	18	15	14	13	12	11	9	9	9	9
Georgetown Pike Interchange	53	50	47	42	36	26	18	15	14	13	11	10	9	8	8	8
	52	51	48	46	43	36	26	20	18	17	14	13	11	10	9	9
Dulles Toll Road Interchange	50	48	46	44	42	39	27	21	19	18	16	14	13	12	10	9
	56	53	50	50	49	48	38	31	30	29	27	25	25	24	21	20
Route 123 Interchange	58	56	54	54	53	54	45	36	33	33	32	31	31	32	29	28
	60	58	59	60	61	61	56	48	45	44	45	43	44	47	44	47
Route 7/Leesburg Pike Interchange	60	59	59	58	59	60	59	59	57	54	55	55	54	55	55	55
	63	63	62	62	61	61	61	63	61	58	61	61	60	59	60	59
I-66 Interchange	57	58	58	59	59	58	58	58	59	59	59	60	61	60	58	58

	5:00 PM	5:15 PM	5:30 PM	5:45 PM	6:00 PM	6:15 PM	6:30 PM	6:45 PM	7:00 PM	7:15 PM	7:30 PM	7:45 PM	8:00 PM	8:15 PM	8:30 PM	8:45 PM
Cabin John Parkway Interchange	11	11	10	11	12	14	17	25	27	34	43	50	55	59	61	62
	13	14	13	13	15	17	20	30	31	38	44	50	53	57	60	60
Clara Barton Parkway Interchange	15	15	15	15	16	18	20	27	28	33	37	40	44	50	55	57
	15	15	15	15	16	17	18	22	24	27	30	33	38	46	55	59
GW Parkway Interchange	12	12	13	12	13	13	14	17	19	21	24	27	33	45	55	57
	9	9	9	9	9	10	10	12	14	16	19	22	29	45	54	59
Georgetown Pike Interchange	8	8	8	8	9	9	9	11	14	15	18	22	30	46	54	58
	9	9	9	9	9	10	11	12	16	18	22	29	39	49	56	59
Dulles Toll Road Interchange	9	9	9	9	9	9	10	11	16	19	26	38	45	52	55	58
	19	21	19	19	17	17	17	18	23	33	41	50	55	57	58	59
Route 123 Interchange	27	28	28	30	29	27	27	27	32	42	48	54	56	58	59	60
	43	42	44	50	50	46	49	48	50	53	54	57	59	59	60	60
Route 7/Leesburg Pike Interchange	55	54	56	55	56	56	57	57	57	59	60	60	61	61	60	60
	58	57	59	58	60	60	60	61	62	63	63	63	63	63	63	62
I-66 Interchange	58	58	58	58	59	59	59	61	61	61	61	61	61	61	61	61

Study Area
Proposed Analysis Peak Hour
Proposed Analysis Peak Period
State Line

Conclusion

Recognizing the large scale of the I-495 NEXT traffic analysis efforts and constrained schedule, the consultant team requests that the District Traffic Engineer approve these proposed deviations in simulated speeds and simulated queue lengths from the VDOT TOSAM for the traffic microsimulation calibration. These deviations will not impact the ability of the microsimulation model to accurately represent typical real-world traffic conditions, and will instead focus the traffic analysis efforts on the most critical locations to the project.

Similarly, the consultant team requests that the District Traffic Engineer approve the proposed simulation analysis periods for the microsimulation model. These periods will capture the onset of congestion and maximum extents of congestion.

VDOT NoVA District Traffic Engineer Concurrence

Date

Kimley»Horn ATCS®

MEMORANDUM

To: Ivan Horodyskyj, P.E., VDOT NoVA District Traffic Engineer
Abi Lerner, P.E., VDOT Project Manager

From: Rob Prunty, P.E., Kimley-Horn
Warren E. Hughes, P.E., ATCS, P.L.C.
Ram Jagannathan, ATCS, P.L.C.
ATCS, PLC

Date: August 27, 2018

Subject: I-495 NEXT Crash Analysis Framework

Introduction

This memorandum documents the details associated with the crash analysis framework for the I-495 Express Lanes Northern Extension Project. This memorandum is intended to supplement the information presented in the I-495 NEXT Project Scoping Framework Document.

The following elements of the crash and safety analysis are laid out in detail in this document:

- Data collection
- Existing crash analysis methodology, measures of effectiveness, and assumptions
- Development of Safety Performance Function (SPF) for Express Lanes
- Crash prediction methodology for freeway and ramp segments
- Crash prediction methodology for ramp junctions, at-grade intersections and arterial segments
- Qualitative safety analysis methodology

Data Collection

Five years of crash data (January 1, 2013 to December 31, 2017) will be used in this study. Available VDOT crash data will be collected for crashes reported on arterial segments, at-grade intersections, ramps and freeway segments within the study area that are in Virginia. Crash data will also be collected from the Maryland State Highway Administration (MDSHA) for those segments of roads in Maryland that are within the traffic operations study area. Due to the fact that National Park Service (NPS) Police report crashes on the George Washington Memorial Parkway (GWMP) and the Clara Barton Parkway using a different crash report form, crash data will also be collected from the National Park Service for segments of those parkways that are within the traffic operations study area.

In addition, the Consultant Team will make use of the VDOT's Tableau tool to extract data on reported crashes from VDOT's crash database. The Consultant Team will request copies of FR300 reports only for specific crashes to develop more detailed crash summaries and collision diagrams where appropriate. Since the study area includes roads that are under the responsibility of the National Park Service (i.e., George Washington Memorial Parkway and Clara Barton Parkway) and the Maryland State Highway

Administration, the Consultant Team will solicit data on reported crashes on their roads within the traffic operations study area. This will ensure that all reported crashes that occur in and near the GWMP / I-495 interchange and on the American Legion Bridge can properly be included in the analysis. We recognize that VDOT, MWAA, MDSHA/MDOT and NPS may have different thresholds for crash reporting, specifically with respect to crash severity. We plan to use the crash severity determined by the agencies as-is while including the reporting criteria in the appendix of the document. All crash data will be provided by VDOT in GIS shapefile or geodatabase format. The Consultant Team will rely on the crash data directly from the VDOT RNS and will not review individual crash reports to verify the accuracy of that information.

To develop crash rates, data on vehicle exposure will be gathered from all available sources, including Average Daily Traffic (ADT) flows contained in the Virginia DOT annual traffic count books and data on historical ADT flows from the Maryland State Highway Administration. In addition, exposure data will be solicited from the operators of the I-495 Express Lanes for the last five years, since data is not reported by VDOT for these express lanes. Lastly, exposure data will be requested from the NPS for the parkway segments, including ramps and other roadway facilities maintained by the NPS that are within the traffic operations study area.

Existing Crash Analysis Methodology, Measures of Effectiveness, and Assumptions

The Consultant Team will analyze and summarize VDOT-provided crash data for I-495 and Dulles Toll Road mainline and ramps and intersecting (at an interchange) surface streets within the IJR study area. To the extent possible, the Consultant Team will develop a simplified crash "pin" map for the segments of the GWMP within the traffic operations study area. In addition, the Consultant Team will develop summaries and graphics of reported crashes on the segments of I-495 in Maryland to better understand crash patterns that may be affected by traffic conditions in Virginia.

The Consultant Team will summarize crash data in a tabular format for up to 10 elements such as weather conditions, lighting conditions, type of collision, and severity of crash. The Consultant Team will summarize data to identify crash patterns and high crash locations.

The Consultant Team will develop directional crash density "heat" maps to display the following crash patterns along the I-495 and Dulles Toll Road study corridors:

- Total number of crashes;
- Injury crashes;
- Lighting conditions;
- AM peak period conditions;
- PM peak period conditions;
- Rear-end crashes;
- Sideswipe same direction crashes; and
- Fixed-object off-road crashes.

The Consultant Team will develop mainline crash density histograms for I-495 from Route 123 to the American Legion Bridge, and along the Dulles Toll Road / Dulles Airport Access Road from Spring Hill Road to Route 123 (Dolley Madison Blvd), summarized in half-mile segments. The Consultant Team also will summarize the type of crashes for each half-mile segment within the study area.

The Consultant Team will identify high-crash locations along the corridor. The Consultant Team will use a 95th percentile confidence interval (average plus two standard deviations) for the corridor as a threshold for determining high crash locations. Sections with total crashes above the 95th percentile confidence interval will be considered a high-crash location. The Consultant Team will provide a summary of crashes at these locations in tabular format.

The Consultant Team will summarize crashes, in tabular format, for the latest five-year period and compare the following crash rates provided by VDOT Central Office:

- Crash, injury, and fatality crash rates for I-495 and Dulles Toll Road within the study area;
- Crash, injury, and fatality crash rates for I-495 and Dulles Toll Road statewide; and
- Statewide crash, injury, and fatality average crash rates for interstates.

Safety performance will be investigated to understand the nuances and impacts of weather, roadway lighting, traffic volumes, pavement condition, driver impairment and distraction, presence of work zone, work zone activity levels, etc. In this analysis, crash frequency, crash rate, crash severity and magnitude of crashes will be investigated to better understand past safety performance of I-495 Express Lanes in order to develop relationships (i.e., safety performance functions) for the analysis of future year traffic conditions under the Build and the No Build alternatives.

The implications with respect to existing and current safety issues and crash patterns from this safety analysis will be used to inform the roadway designers during the preliminary design phase of the project and during the development and screening of proposed interchange concepts phase of the project.

Development of Safety Performance Functions for Express Lanes

The Highway Safety Manual (HSM), first edition, does not have a prediction methodology for estimating the safety performance of urban interstates that also contain Express Lanes. For the I-495 Express Lanes Northern Extension study, the availability of safety performance functions would help predict the expected crash performance on Express Lanes after project completion. Hence, this study will use Interchange Safety Analysis Tool-Enhanced (ISATe) for analyzing the safety performance of the general purpose sections and interchanges. In addition, the study will build safety performance functions for this project using available crash data on I-495 Express Lanes (EL). the objective is to develop the relationships such that future year crash experience can be estimated for both existing express lane sections on I-495 and for new express lane sections that will be included in the Build alternative. Some inherent assumptions used in this study are listed below:

- The driver behavior and familiarity with the roadway are similar for current I-495 Express lanes and I-495 General Purpose lanes.

- The weather conditions on current I-495 EL and I-495 general purpose lanes are similar as they are geographically proximate.

- The traffic composition on current I-495 EL and I-495 NEXT are similar.

For the purpose of building the crash prediction model for the express lanes, the following interchange pairs / segments on I-495 used in the study are listed below:

- South End – Braddock Road
- Braddock Rd - Route 236

- Route 236 – Gallows Road
- Gallows Road - Route 50
- Route 50 - Lee Hwy
- Lee Hwy - I-66
- I-66 - Route 7
- Route 7 - Route 123
- Route 123 – VA 267
- VA 267 – North End

Crash Prediction Methodology for Freeway and Ramp Segments and Assumptions

The Consultant Team will conduct a safety and crash analysis consistent with VDOT's IIM-LD-200.9. The Consultant Team's analysis will involve qualitative and quantitative measures to evaluate proposed alternatives and demonstrate the effects of interstate access modifications on safety of I-495 and the local surface street system. The Consultant Team will use ISATe to evaluate the quantitative effect of interstate access modifications on safety on I-495 general purpose lanes and HSM methodologies to evaluate the safety impacts of the proposed interchange concepts on the arterial system adjacent to the interchanges. Assumptions for the safety analysis are given below:

- Safety analyses will be performed for interstate mainline segments, ramp termini, and adjacent crossroads segments and crossroad intersections within the IJR study area, limited to the area for traffic data collection;
- FHWA's Enhanced Interchange Safety Analysis Tool (ISATe) will be used to evaluate freeway and interchange safety, based on FHWA/AASHTO regulations and guidance;
- The Highway Safety Manual (HSM) and NCHRP 17-38 spreadsheets (VA editions) will be used to analyze five-year continuous crash history for the crossroad segments. ISATe will be used to analyze the crossroad ramp terminal intersections within these segments;
- Freeway analysis will focus on the I-495 Mainline Facility. To the extent possible within the available reported crash data for express lanes in Virginia, the Consultant team will develop a safety performance function for express lane sections. Currently available analysis tools do not provide for crash prediction and safety performance evaluation of managed lane facilities (express lanes). If the review agencies deem that the methodology and results are applicable, then the safety results for the express lanes will be included in the analysis.;
- Qualitative assessments will be performed for conditions where the quantitative analysis is not appropriate.;
- Quantitative analysis will be performed within the limits of the available safety analysis tools. However, it should be noted that some geometric conditions are not able to be modeled using these tools. In these situations, qualitative analysis will be incorporated into the evaluation to supplement any gaps in the quantitative analysis; and
- Using ISATe, the safety performance of the I-495 NEXT interchanges will be predicted for future traffic volumes.

The EL SPF-based crash predictions will be added as a layer on top of the ISATe crash predictions for the GP Lanes and Ramps to compare the safety performance of the Build and No-Build conditions for future years.

Crash Prediction Methodology for Ramp Junctions, At-Grade Intersections and Arterial Segments and Assumptions

For VA Route 193, we will use the HSM to predict crashes on the arterial segments and intersections. Intersection boundaries will encompass 500 feet of roadway on all intersecting approaches. We plan to analyze the interchange ramp terminals and all signalized intersections within a radius of 0.5 mile from the interchange ramp terminals on VA Route 193. We will use the calibration factors for VA and check to see if the crash predictions are reasonable. If needed, we will refine the calibration factors for the SPFs in the HSM using additional VA data. The limit of the crash prediction will be for multiple-vehicle crashes only. Given the limited amount of data, we will not be able to predict additional single-vehicle, vehicle-bicycle, and vehicle-pedestrian crashes.

Qualitative Safety Analysis Methodology and Assumptions

Finally, a driver Info Overload analysis will be conducted. For every 1/10th of a mile, the number of signs needed to be processed by the driver will be documented and the burdensome nature of the same will be qualitatively ranked on a five-point scale (low-effort to extreme-effort). Based on the results of the qualitative analysis, the development of the IJR Guide Sign Plan will be guided to identify concerns with respect to signing deficiencies.

MEMORANDUM

To: Susan Shaw – VDOT MegaProjects Director

From: Kimley-Horn and Associates
Rob Prunty, P.E.
Adrienne Ameel, P.E.

Cc: Abraham Lerner – Associate Manager of Special Project Development

Date: October 31, 2018

Subject: I-495 Project Next – Environmental Traffic Data (ENTRADA) and Air Quality Impact Analysis Traffic Data

ENVIRONMENTAL TRAFFIC DATA (ENTRADA)

Traffic data sets will be prepared for the NEPA-level Noise Impacts analysis. Project level Noise locations will be identified using FHWA and EPA protocol and/or guidance documentation consistent with VDOT's practice. The traffic analysis data required for ENTRADA will include existing (2018) year, and build and no-build scenarios for the design (2045) year. The ENTRADA study area limits were determined based on a meeting with VDOT on August 29, 2018. The ENTRADA study area map is shown in **Figure 1**.

The ENTRADA study area includes the following:

- Mainline roadways;
- Cross streets associated with existing interchanges;
- Intersections/Interchanges; and
- Parallel facilities with an AADT greater than 3,000 within the project corridor (as defined by the second signalized public road intersection on either side of I-495, excluding I-495 ramp termini).

ENTRADA Version 2018-09 from VDOT will be utilized, in combination a macro-driven master database that links the various files for all the segments. Synchro 9 will be utilized for intersection analysis reporting for the NEPA team.

The traffic data for the Noise analysis will be developed using the regional travel demand modeling (TDM) output files encompassing the I-495 study corridor and affected transportation network for the base year and the build and no-build scenario for the design year 2045. The travel demand forecasts will be post processed and developed using NCHRP Report 765 and NCHRP Report 255 guidelines. Each link within the TDM output files will contain a link identifier, link length (miles), AADT, number of lanes, HPMS area type, HPMS functional classification, free-flow speed, and hourly lane capacity (vehicles/hour/lane). The following post-processed environmental traffic volume data will be provided:

- Average annual daily traffic (AADT), levels of service, average annual truck traffic (AATT), and capacity-constrained peak-period volumes as well as operating, posted and congested speeds for each link in the project area;
- Percent trucks with two axles and six tires, the percent trucks with three or more axles, and directional distributions;
- For the mainline, intersections/interchanges and parallel facilities, directional volumes, including turning or ramp movements (vehicles/hr/link);
- Lane configuration diagrams for each mainline roadway and intersection/interchange within the project corridor showing through and turn lanes; and
- Signal timings (cycle lengths and phasing, approach splits), as well as Level of Service based on control delay (includes intersection and approach delays).

The data will be compiled using VDOT’s ENTRADA spreadsheets (2018-09) and Synchro files. Both Excel and pdf files of the spreadsheets will be produced.

The following inputs will be set up on a master project database and imported into each specific segment file for the creation of the ENTRADA files:

- Segment Length (miles) - The segment length will be the length of the segment in the 2045 design year;
- Area Type - Will be verified by field observations and confirmed with VDOT;
- Directional Percent Hourly Truck Traffic - Sourced from the MWCOG Model and be consistent with the peak period characteristics being modeled in VISSIM. They will be verified with the available existing traffic data; and
- Existing Hourly Speeds by Direction - Will be verified by existing traffic data and consistent with the peak period characteristics being modeled in VISSIM.

The following physical characteristics will be collected and entered as input (by individual segment) for 2045 build/no-build scenario for the creation of the ENTRADA files. Based on discussions with VDOT, it was determined that 2025 build/no-build scenarios were not necessary for the ENTRADA files. The existing physical conditions would be assumed unless changes are being made in future scenarios.

- Cross Section;
- Number of Lanes;
- Outside Shoulder Width (ft);
- Inside Shoulder Width (ft);
- Lane Width;
- Terrain - The terrain will be consistent with GIS topo and verified with field observations;
- Interchange/Access Density (per mile);
- Posted Speed; and
- Number of Signals (in length of facility).

The following characteristics for signalized facilities will be collected and entered as input (by individual segment) for the existing scenario for the creation of ENTRADA files, and developed for the build/no-build scenarios. Any adjustments and post-processing of volumes made for the peak period characteristics, as used for the detailed traffic operational analysis (for the TATTR and IJR), will be consistently applied for those values in ENTRADA:

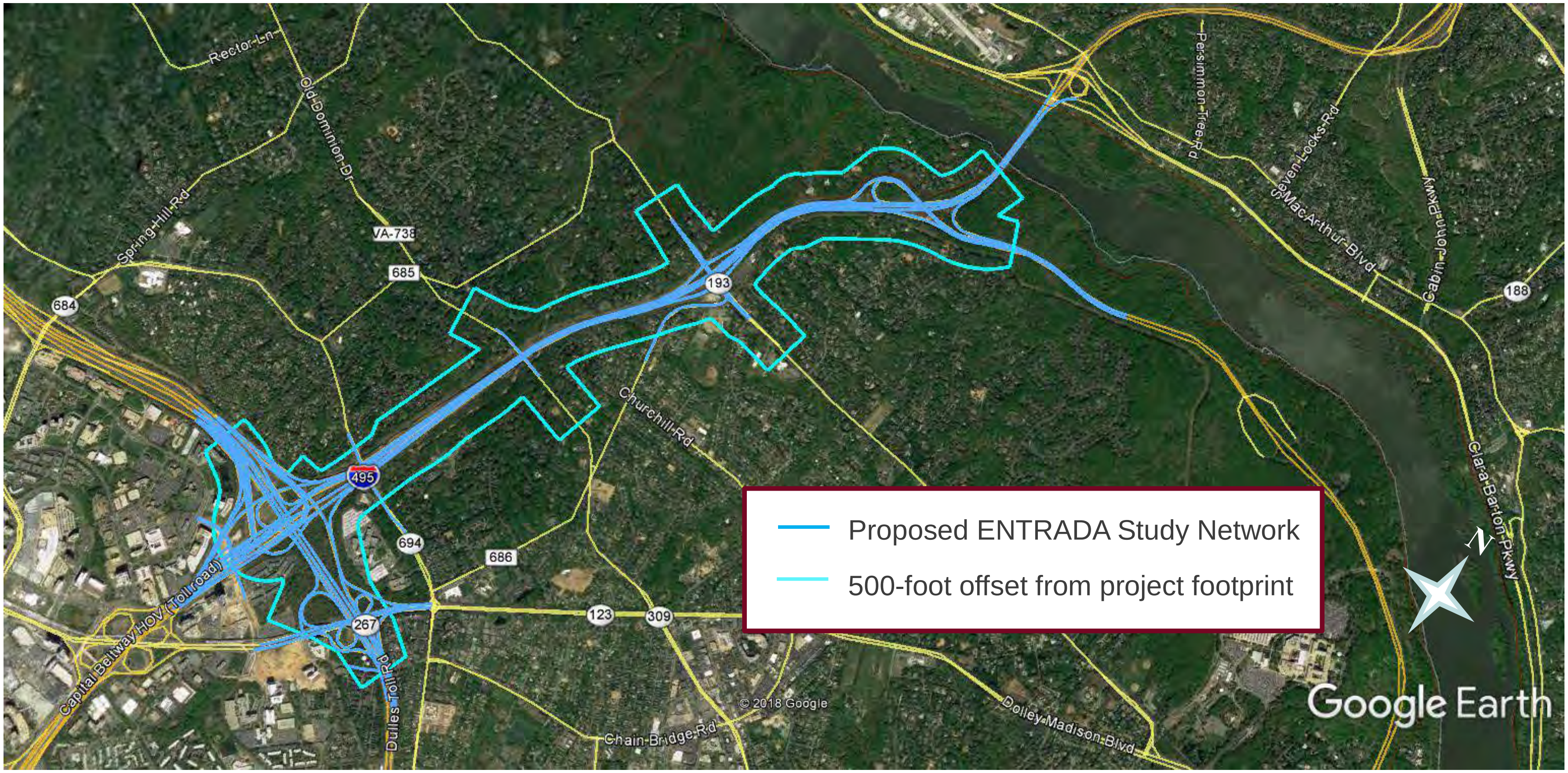
- Signal Cycle length;
- Signal Green Time; and
- Segment Delay Adjustment Factor.

The following characteristics for each scenario will be developed for the creation of the ENTRADA files and will be sourced from the MWCOG Model. Any adjustments and post-processing of volumes made for the peak period characteristics, as used for the detailed traffic operational analysis (for the TATTR and IJR), will be consistently applied for those values in ENTRADA:

- Capacity (pcphpl);
- Facility Type;
- ADT - Will be verified with existing traffic data;
- % trucks of the ADT - Will be derived from existing traffic classification count data;
- K-factors for each hour - Will be derived from existing traffic data as a basis and adjusted for future conditions based on factors used for the MWCOG Model; and
- Directional Split (D-factor) for each hour - Will be verified with existing traffic data and derived MWCOG Model outputs for future conditions.

The ENTRADA study area map is shown in **Figure 1**. The study area network extends beyond the 500-foot offset from the project footprint in order to include complete segmentation elements that are located partially within the 500-foot offset area.

Figure 1 –ENTRADA Study Area



AIR QUALITY

MSAT Analysis

Using the regional TDM output files to prepare a quantitative mobile source air toxics (MSAT) analysis for the I-495 study corridor for the existing (2018), opening year (2025, no-build and build), and design year (2045, no-build and build). For purposes of the MSAT analysis, the affected transportation network could include roadways located several miles away from the project corridor, based on the results of the quantitative comparison between the no-build and the build scenarios for increases in traffic forecast volumes (VDOT typically uses +/- 5% per FHWA guidance) on major roadway links within the Northern Virginia region (as determined by model runs using the MWCOG Model).

The following deliverables will be produced:

- ENTRADA information sets for VDOT NEPA team for existing conditions (2018) (five electronic copies in Excel format linked to a macro-driven master database file);
- Synchro files for all intersections identified within the NEPA traffic analysis study area (five electronic copies);
- Lane diagrams for the Existing scenario (five electronic copies);
- Traffic information listed above, compiled into tabular form in a consolidated NEPA Traffic Input Data Report (five electronic copies); and
- MSAT analysis inputs for VDOT NEPA team (five electronic copies).

Appendix C: I-495 NEXT Travel Demand Forecasting Framework Memorandum

MEMORANDUM

To:	Rahul Trivedi, P.E., VDOT NoVA District Transportation Planning Manager Amir Shahpar, P.E., VDOT NoVA District Modeling Manager Abi Lerner, P.E., VDOT Project Manager
From:	Rob Prunty, P.E. Raj Paradkar, P.E. Anthony Gallo, P.E. Sarah Knox, P.E. Kimley-Horn and Associates, Inc.
Date:	August 26, 2018
Subject:	I-495 NEXT Travel Demand Forecasting Framework

Introduction

This memorandum documents the travel demand forecasting framework associated with the I-495 NEXT Project. This memorandum is intended to supplement the overarching I-495 NEXT Project Scoping Framework Document.

The following elements of the traffic operations analysis are laid out in detail in this document:

- Travel demand modeling assumptions and calibration/validation
- Traffic volume post-processing for use in traffic operations and air/noise analysis

Travel Demand Modeling Methodology

Existing Conditions Model Calibration and Validation

The latest MWCOG travel demand model version on the 3,722 traffic analysis zone (TAZ) system will be used in conjunction with Round 9.1 Cooperative Forecasts (socioeconomic data) for the Existing, Opening, and Design model years. The MWCOG model base year is 2017; a project Existing Conditions (year 2018) model will be prepared, modified and calibrated to reflect field counts. Modifications will be carried forward into future analysis year model scenarios.

The MWCOG model will be strategically modified with specific alterations to improve the accuracy and reliability of forecasts for the I-495 study corridor, roadways connected to the corridor, and transit services in the vicinity of the corridor. The calibration targets will be based on guidance from the FHWA Transportation Model Improvement Program (TMIP) *Travel Model Validation and Reasonableness Checking Manual* and the Virginia *Travel Demand Modeling Policies and Procedures Manual*. Because the MWCOG/TPB Model is already subject to scrutiny as a regional model which has been a subject of FHWA's TMIP Peer Review process, the validation process for the I-495 Project NEXT model will focus on the I-495 Traffic Operations Analysis Study Area and will include the following comparisons:

- Regional comparisons to VDOT AADTs at the daily level (daily level only)
    - Percent difference in total volume for cutlines
- I-495 NEXT study area comparisons to field traffic counts (AM/PM periods and daily)
    - R-squared between modeled volumes and counts on links
    - Percent difference in total volumes for freeways/arterials
    - Percent root mean squared error (%RMSE) by volume group or facility type
- Travel time comparisons of model outputs to floating car runs data collected (AM/PM periods only; reasonableness checks only)

Table 1 provides a listing of travel demand model calibration criteria, which were discussed and verbally approved by VDOT during a call on July 24, 2018.

Table 1. Travel Demand Forecast Model Calibration Criteria

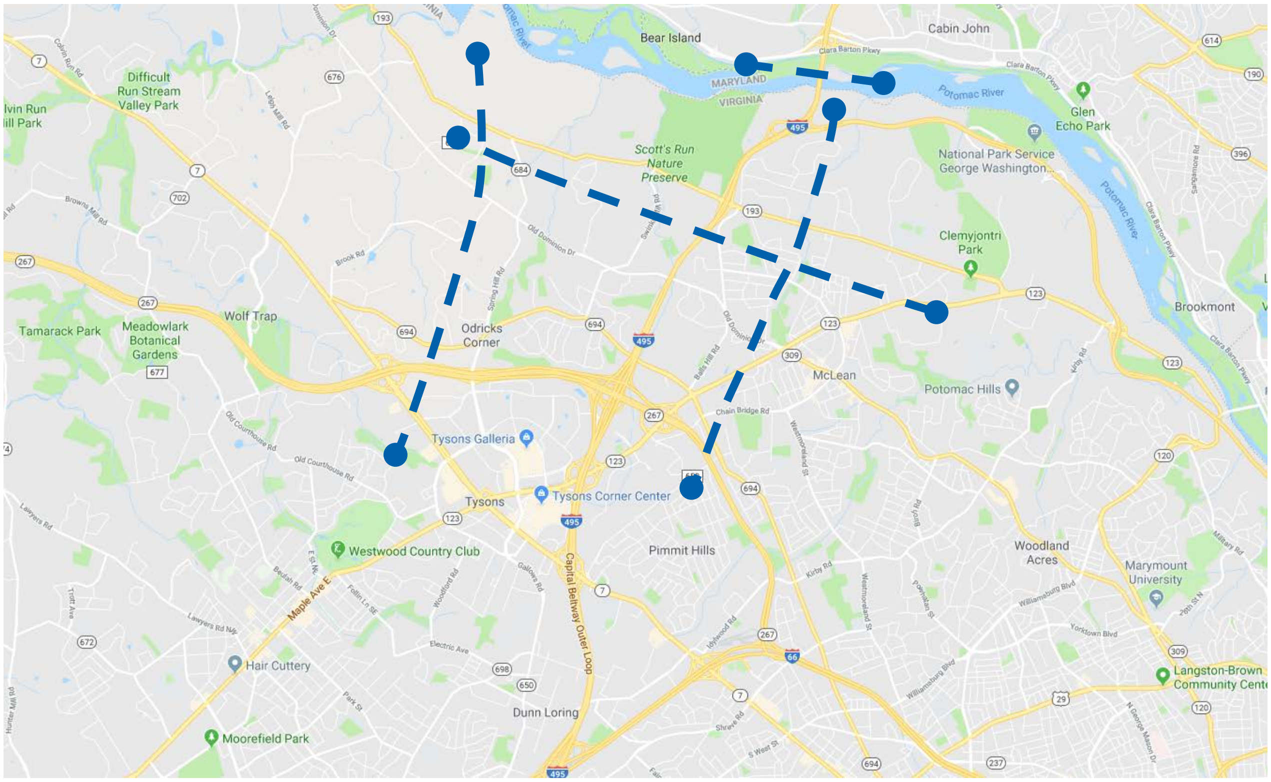
Calibration Scale	**Calibration Check**	**Calibration Threshold**			
Regional	% Difference in Total Volume for Cutlines (24-Hour Volumes)	Cutline Volume	VTM	FHWA	***Proposed***
		50,000	10%	35%	***10%***
		100,000	8.75%	25%	***10%***
		150,000	7.50%	20%	***10%***
		200,000	6.25%	18%	***8%***
		250,000	5%	15%	***7%***
Study Area	R-Squared between modeled volume and counts on links (AM Period, PM Period, and 24-Hour Volumes)		VTM	FHWA	***Proposed***
			0.9	0.88	***0.9***
	% Difference in Total Volume by Facility Type (AM Period, PM Period, and 24-Hour Volumes)	Facility Type	VTM	FHWA	***Proposed***
		Freeways	6%	7%	***6%***
		Major Arterials	7%	10%	***10%***
		Minor Arterials	10%	15%	***15%***
	%RMSE by Facility Type (AM and PM Period)	Facility Type	VTM	FHWA	***Proposed***
		Freeways	30%	-	***30%***
		Major Arterials	45%	-	***45%***
		Minor Arterials	60%	-	***60%***
		Overall	40%	-	***40%***
	%RMSE by Facility Type (24-Hour Volumes)	Facility Type	VTM	FHWA	***Proposed***
		Freeways	20%	-	***20%***
		Major Arterials	35%	-	***35%***
		Minor Arterials	50%	-	***50%***
		Overall	30%	-	***30%***
	Travel Times (AM and PM Period)	No specific measures in VTM or FHWA; compare model outputs to floating car travel runs and check to see if travel times are within min and max of observed travel times. Note that these are reasonableness checks only.			

The following regional cut-lines will be used in the calibration process:

- East/west travel west of study area
    - Georgetown Pike west of Spring Hill Road
    - Old Dominion Drive west of Spring Hill Road
    - Lewinsville Road west of Spring Hill Road
    - Route 267 between Route 7 and Spring Hill Road
    - Route 7 just east of Route 267
- East/west travel east of study area
    - George Washington Memorial Parkway east of I-495
    - Georgetown Pike east of I-495
    - Old Dominion Drive between Balls Hill Road and Route 123
    - Route 123 east of Lewinsville Road/Great Falls Street
    - Chain Bridge Road east of Great Falls Street
    - Great Falls Street east/south of Chain Bridge Road
    - Route 267 east of Route 123
- North/south travel north of study area
    - I-495 American Legion Bridge
- North/south travel within study area
    - Spring Hill Road south of Georgetown Pike
    - Swinks Mill Road south of Georgetown Pike
    - I-495 south of Georgetown Pike
    - Balls Hill Road south of Georgetown Pike
    - Douglas Drive south of Georgetown Pike
    - Route 123 west/south of Georgetown Pike

Figure 1 shows a map of the proposed cut-lines for the calibration process.

Figure 1. Proposed Cut-Lines for Travel Demand Model Calibration Process.



Toll Diversion Curves from OP3's consultant, based on existing express lane usage on the Capital Beltway Express Lanes, will also be validated in order to increase confidence in the model and maintain relative consistency between traffic and revenue studies for I-495 in Virginia, and regional planning studies of MDOT's proposed managed lanes system in Maryland.

Travel demand forecasting activity will be coordinated between the traffic and revenue study, and IJR/NEPA effort in order to maintain consistency in forecasting among these efforts to the maximum extent practical. Alterations to the MWCOG travel demand model to improve corridor calibration may include:

- Highway network modifications to better represent study area facilities as they exist and are planned, such as modifications to link facility types. Ramps will be micro-coded to improve forecasts and correlation to the microsimulation process.
- Traffic Analysis Zone (TAZ) splits and centroid connector location changes to improve model loading for all modeled modes of transportation.
- Changes to external trip assumptions to improve consistency with origin-destination data and traffic and revenue evaluations.
- Use of toll diversion methodology to forecast Express Lane trips.

- Changes in the time-of-day distribution to improve forecasting of peak period trips, changes in the Volume Delay Function (VDF) curves, and changes in the default speed and capacity of some facility types.

Future Analysis Scenario Assumptions

The I-495 NEXT traffic analysis will assess operations for a project Design Year of 2045 and Interim Year of 2025. The traffic analysis will account for a No-Build scenario and one Build alternative. Separate travel demand model networks will be developed for each of the future-year scenarios to be used for forecasting traffic volumes.

The travel demand model No-Build networks will include all roadway projects in the most up-to-date regional CLRP. In addition, the No-Build networks will account for the following elements:

- **I-495/Dulles Toll Road Interchange Ramps** – currently unbuilt ramps at the I-495/Dulles Toll Road, including ramps to and from the I-495 Express Lanes and Dulles Airport Access Road, for which preliminary engineering has completed and construction is anticipated prior to the I-495 NEXT project being in place.
- **Auxiliary lanes along I-495** – general-purpose auxiliary lanes to be added along I-495 between the Dulles Toll Road interchange and the Georgetown Pike interchange
- **Express Lanes in Maryland** – the I-495 NEXT team will be coordinating closely with the Maryland Department of Transportation (MDOT) on plans for a network of express lanes in Maryland, including lanes along I-495 and I-270. These plans are currently ongoing, but the I-495 NEXT No-Build and Build networks will contain the same assumptions for the Express Lanes in Maryland:
    - Locations of access and network structure
    - Vehicle types allowed in express lanes, including those which must pay a toll and those which are exempt (if any) – could include HOV2/HOV3+ or trucks

Summary of Travel Demand Modeling Assumptions

Table 1 lists key assumptions associated with the travel forecasting process.

Table 2: Travel Demand Forecasting Model Assumptions

<table>
<tr><th>Model Parameter</th><th>Assumption</th><th>Comments</th></tr>
<tr><td colspan="3">Model</td></tr>
<tr><td>Analysis Years
2018 (Existing)
2025 (Interim Year)
2045 (Design Year)</td><td><u>MWCOG Model</u>
2018 (Validation Year)
2025
2045</td><td>MWCOG travel demand model has model inputs at 5-year increments plus a year 2017 input dataset. Intermediate years can be developed by interpolating input data and modifying networks to represent planned conditions.</td></tr>
<tr><td>Time Periods</td><td>Four time periods are modeled in the forecasts. The sum of the four time periods represents average weekday daily traffic:
<table>
<tr><th>Period</th><th>Hours</th></tr>
<tr><td>AM</td><td>6 a.m. – 9 a.m.</td></tr>
<tr><td>Midday</td><td>9 a.m. – 3 p.m.</td></tr>
<tr><td>PM</td><td>3 p.m. – 7 p.m.</td></tr>
<tr><td>Night</td><td>7 p.m. – 6 a.m.</td></tr>
</table></td><td>Hours split based on MWCOG household survey data (2007/2008).</td></tr>
<tr><td>Speed</td><td>Consistent with current conditions in the HOV and general purpose (GP) lanes.</td><td>Consistent with existing conditions. Same as speed/travel time curves based on MWCOG unless validation suggests modification.</td></tr>
<tr><td>Link Capacity</td><td>Lane capacities are defined consistent with the MWCOG model approach.</td><td>The MWCOG facility and area type capacity tables are used to determine link capacities. Use same speed-flow curves consistent with TPB model unless validation suggests modification.</td></tr>
<tr><td>Peak Factors</td><td>Peak period to peak hour factors:
<table>
<tr><th>Period</th><th>2010</th><th>2025</th><th>2040</th></tr>
<tr><td>AM</td><td>0.417</td><td>0.38</td><td>0.34</td></tr>
<tr><td>PM</td><td>0.294</td><td>0.272</td><td>0.25</td></tr>
</table></td><td>Existing peak period values were derived from the 2007/2008 MWCOG Household Travel Survey. The peak hour factors decline in future years in recognition of the increased congestion expected in the region causing less peaked periods. This assumption spreads the traffic evenly over the entire peak period.</td></tr>
<tr><td>Socioeconomic Data</td><td>MWCOG Round 9.1 socioeconomic data will be used.</td><td></td></tr>
</table>

Table 2: Travel Demand Forecasting Model Assumptions

Model Parameter	*Assumption*	*Comments*
	Network	
Project Description (I-495 Northern Extension)	Two Express Lanes in each direction along I-495 between the Dulles Toll Road (Route 267) and George Washington Memorial Parkway. Specifics to be addressed in the preliminary design effort.	
Project Extent	Dulles Toll Road in Tysons to GWMP near Maryland State Line	
I-495 (Capital Beltway) Express Lanes	Existing: Express Lanes on I-495 between I-95/I-395 and Dulles Toll Road Future: Existing Express Lanes on I-495 plus new Express Lanes in Maryland along I-495 and I-270.	Access, tolling parameters, and vehicle restrictions for I-495 Express Lanes in Maryland to be determined in coordination with MDOT.
HOV	Beginning in 2020, all HOV facilities in the Northern Virginia area are assumed to become HOV-3+.	I-495 and I-95 Express Lanes are free to HOV-3 vehicles currently; HOV lanes along I-66 and Dulles Toll Road are HOV-2 currently. HOV restrictions in Maryland to be determined in coordination with MDOT. See Table 3 for further explanation.
	Toll Assumptions	
Tolling Methodology	Tolling assumptions will be kept consistent with MWCOG's default factors for I-495, I-95/395, and I-66 HOT Lanes in the final assignment iteration.	
Toll Approach	Variable toll rates by roadway segment, based on maintaining Express Lane speed goal of 55 mph.	Adopted to account for varying demand levels along the length of the project.
	Mode Assumptions in I-495 NEXT Express Lanes	

Table 2: Travel Demand Forecasting Model Assumptions

Model Parameter	*Assumption*	*Comments*
Vehicle Class	HOV-3+: Free Other cars and medium trucks: Toll Heavy trucks: Are permitted in the I-495 Express Lanes from the Dulles Toll Road to the project terminus north of the GWMP.	Vehicle class restrictions for I-495 Express Lanes in Maryland to be determined in coordination with MDOT
HOV Vehicles	Use the MWCOG model HOV module. Beginning in 2020, all HOV facilities in Northern Virginia area will be HOV-3+.	The HOV estimates provided are an output of the *mode choice* and *carpool occupancy* models developed by MWCOG.

Table 3. HOV and Tolling Assumptions for Facilities in Study Area

Facility	2018	2025	2045
I-495 (Existing Express Lanes Network)	All vehicles except trucks permitted in barrier-separated express lanes. All vehicles except HOV3+ must pay a toll.		
Dulles Toll Road (SR 267)	HOV2+ vehicles only allowed in left-most lane eastbound (AM peak) and westbound (PM peak)	HOV3+ vehicles only allowed in left-most lane eastbound (AM peak) and westbound (PM peak)	
I-66 (Outside the Beltway)	HOV2+ vehicles only allowed in left-most lane eastbound (AM peak) and westbound (PM peak)	All vehicles (including trucks) permitted in barrier-separated express lanes. All vehicles except HOV3+ must pay a toll.	
I-66 (Inside the Beltway)	All vehicles except trucks permitted. During AM peak eastbound and PM peak westbound, lanes are tolled except for HOV2+ vehicles.	All vehicles except trucks permitted. During AM peak eastbound and PM peak westbound, lanes are tolled except for HOV3+ vehicles.	All vehicles except trucks permitted. During AM peak and PM peak in both directions, lanes are tolled except for HOV3+ vehicles.

Traffic Volume Post-Processing

Post-processing of travel demand model output is necessary to develop traffic volume forecasts for analysis of operations during peak periods/peak hours. Post-processing of travel demand forecasts for vehicular volumes will follow NCHRP 255/765 guidelines for estimating balanced No-Build and Build peak period volumes. Existing balanced volumes will be developed outside of the MWCOG travel demand model using field count data; origin-destination (O-D) routing will be obtained utilizing StreetLight Data or the MWCOG model, and the O-D matrix will be adjusted using VISUM's TFlowFuzzy methodology to match target balanced volumes along the corridor. The O-D matrix will be imported into VISSIM for traffic microsimulation analysis.

Traffic volumes for the traffic operations analysis and air quality and noise analyses for future scenarios will be developed using travel demand model outputs and NCHRP 255/765 guidelines. For future scenario VISSIM microsimulation analysis, O-D routing will again be developed using MWCOG model outputs as a seeding matrix and VISUM's TFlowFuzzy process to create an adjusted O-D matrix that matches target forecast volumes in the study area.

Conclusion

The travel demand model methodology and calibration/validation criteria were reviewed with VDOT staff on a call on July 24, 2018. This methodology will be carried forward for travel demand forecasting for the I-495 NEXT project.

Appendix D: Results of 2025 and 2045 Intersection Operations Analysis

2025 No-Build AM - Intersection Delay

VISSIM RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
6	Route 123 and Tysons Boulevard	NB	1,996	25.5	C	32.6	C
		SB	3,975	29.3	C		
		EB	611	66.8	E		
		WB	427	47.4	D		
4	Westpark Drive and Tysons Connector	NB	634	20.5	C	21.4	C
		SB	343	12.2	B		
		WB	908	25.5	C		
5	Tysons Connector and Express Lanes Ramps	NB	638	17.4	B	13.9	B
		SB	281	12.6	B		
		EB	315	8.0	A		
7	Route 123 and Capital One Tower Drive/ Old Meadow Road	NB	3,110	86.5	F	77.9	E
		SB	2,116	43.4	D		
		EB	100	556.7	F		
		WB	677	75.4	E		
8	Route 123 and Scotts Crossing Boulevard/ Colshire Drive	NB	2,427	55.1	E	74.6	E
		SB	2,421	98.7	F		
		EB	391	51.8	D		
		WB	311	67.7	E		
1	Route 123 and Route 267 Eastbound Off-Ramp/ Anderson Road	NB	1,822	46.8	D	106.8	F
		SB	1,964	150.6	F		
		EB	728	99.0	F		
		WB	375	185.1	F		
3	Route 123 and Lewinsville Road/ Great Falls Street	NB	2,410	88.2	F	136.3	F
		SB	1,529	115.9	F		
		EB	828	53.3	D		
		WB	718	437.1	F		
2	Lewinsville Road and Balls Hill Road	SB	221	138.9	F	22.5	C
		EB	732	18.4	B		
		WB	1,228	4.0	A		
9	Jones Branch Drive and Jones Branch Connector	NB	751	19.2	B	17.6	B
		SB	771	12.9	B		
		WB	908	20.2	C		
10	Jones Branch Connector and Express Lanes Ramps	NB	326	35.8	D	64.7	E
		SB	366	28.1	C		
		EB	829	20.1	C		
29	Jones Branch Drive and Capital One (West)	NB	258	35.7	D	17.0	B
		SB	207	34.5	C		
		EB	931	12.9	B		
		WB	544	8.6	A		
30	Jones Branch Drive and Capital One (East)	NB	63	15.0	B	5.4	A
		SB	114	14.6	B		
		EB	539	3.3	A		
		WB	701	4.7	A		
11	International Drive and Spring Hill Road/ Jones Branch Drive	NB	444	55.3	E	48.3	D
		SB	1,842	39.9	D		
		EB	656	57.9	E		
		WB	375	64.4	E		
12	Spring Hill Road and Dulles Toll Road Eastbound Ramps	NB	552	23.1	C	159.8	F
		SB	1,013	48.0	D		
		EB	1,081	334.5	F		
13	Spring Hill Road and Dulles Toll Road Westbound Ramps	NB	558	16.2	B	31.9	C
		SB	704	21.3	C		
		WB	477	65.7	E		
14	Spring Hill Road and Lewinsville Road	NB	501	65.2	E	54.1	D
		SB	310	82.1	F		
		EB	605	55.2	E		
		WB	651	31.2	C		
23	Georgetown Pike and Helga Place/ Linganore Drive	NB	23	6.2	A	139.6	F
		SB	8	139.6	F		
		EB	1,231	84.7	F		
		WB	670	0.6	A		
20	Georgetown Pike and I-495 Southbound Ramps	SB	683	23.7	C	25.4	C
		EB	1,273	27.9	C		
		WB	535	21.7	C		
19	Georgetown Pike and I-495 Northbound Ramps	NB	445	43.0	D	20.5	C
		EB	1,408	12.9	B		
		WB	841	21.4	C		
18	Georgetown Pike and Balls Hill Road	NB	408	47.4	D	21.1	C
		SB	84	35.4	D		
		EB	892	12.5	B		
		WB	549	13.4	B		
22	Georgetown Pike and Dead Run Drive	NB	104	9.2	A	9.6	A
		EB	636	1.0	A		
		WB	521	0.8	A		

SYNCHRO RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
15	Old Dominion Drive at Spring Hill Road	NB	135	14.7	B	10.9	B
		SB	180	15.2	B		
		EB	870	10.4	B		
		WB	260	7.3	A		
16	Old Dominion Drive at Swinks Mill Road	NB	295	25.3	C	16.2	B
		SB	200	22.8	C		
		EB	785	13.6	B		
		WB	210	6.6	A		
17	Old Dominion Drive at Balls Hill Road	NB	315	120.6	F	101.5	F
		SB	330	115.7	F		
		EB	555	84.6	F		
		WB	255	96.3	F		
21	Route 123 at Old Dominion Drive	NB	1,915	27.7	C	43.7	D
		SB	1,165	24.4	C		
		EB	675	84.2	F		
		WB	690	87.4	F		
24	Georgetown Pike at Swinks Mill Road	NB	640	221.4	F	73.7	F
		SB	0	0.0	A		
		EB	650	0.0	A		
		WB	655	2.2	A		
25	Georgetown Pike at Spring Hill Road	NB	45	18.0	C	1.2	A
		EB	660	0.0	A		
		WB	510	0.7	A		
26	Lewinsville Road at Swinks Mill Road	SB	205	46.7	E	8.9	A
		EB	885	2.7	A		
		WB	555	0.0	A		
27	Route 123 at Ingleside Avenue	NB	1,860	0.4	A	1.0	A
		SB	1,135	0.8	A		
		EB	85	14.0	B		
		WB	45	20.2	C		
28	Douglass Drive at Route 193 (Georgetown Pike)	NB	260	153.7	F	26.4	D
		SB	50	48.5	E		
		EB	595	0.4	A		
		WB	610	1.9	A		

2025 Build AM - Intersection Delay

VISSIM RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
6	Route 123 and Tysons Boulevard	NB	1,992	25.6	C	33.3	C
		SB	4,064	30.7	C		
		EB	612	66.5	E		
		WB	428	46.8	D		
4	Westpark Drive and Tysons Connector	NB	649	19.9	B	22.7	C
		SB	347	11.7	B		
		WB	911	28.9	C		
5	Tysons Connector and Express Lanes Ramps	NB	605	17.8	B	14.1	B
		SB	315	12.4	B		
		EB	329	8.8	A		
7	Route 123 and Capital One Tower Drive/ Old Meadow Road	NB	3,188	100.4	F	83.0	F
		SB	2,132	38.6	D		
		EB	98	548.2	F		
		WB	679	74.0	E		
8	Route 123 and Scotts Crossing Boulevard/ Colshire Drive	NB	2,471	59.2	E	78.4	E
		SB	2,428	100.4	F		
		EB	406	70.9	E		
		WB	317	68.5	E		
1	Route 123 and Route 267 Eastbound Off-Ramp/ Anderson Road	NB	1,842	46.5	D	86.8	F
		SB	1,974	119.3	F		
		EB	725	51.3	D		
		WB	369	183.3	F		
3	Route 123 and Lewinsville Road/ Great Falls Street	NB	2,361	77.0	E	155.0	F
		SB	1,492	180.8	F		
		EB	837	51.9	D		
		WB	720	477.0	F		
2	Lewinsville Road and Balls Hill Road	SB	221	145.2	F	22.0	C
		EB	737	16.3	B		
		WB	1,220	3.1	A		
9	Jones Branch Drive and Jones Branch Connector	NB	750	19.2	B	18.0	B
		SB	778	13.3	B		
		WB	967	20.8	C		
10	Jones Branch Connector and Express Lanes Ramps	NB	371	37.7	D	65.0	E
		SB	395	29.6	C		
		EB	815	20.8	C		
29	Jones Branch Drive and Capital One (West)	NB	262	37.3	D	17.6	B
		SB	213	37.3	D		
		EB	943	13.4	B		
		WB	600	8.8	A		
30	Jones Branch Drive and Capital One (East)	NB	63	16.2	B	5.3	A
		SB	118	13.5	B		
		EB	561	2.9	A		
		WB	725	4.9	A		
11	International Drive and Spring Hill Road/ Jones Branch Drive	NB	447	55.6	E	49.1	D
		SB	2,084	41.9	D		
		EB	659	58.4	E		
		WB	380	64.4	E		
12	Spring Hill Road and Dulles Toll Road Eastbound Ramps	NB	571	24.7	C	150.7	F
		SB	1,017	82.9	F		
		EB	1,342	255.6	F		
13	Spring Hill Road and Dulles Toll Road Westbound Ramps	NB	608	16.3	B	77.1	E
		SB	712	28.8	C		
		WB	475	227.3	F		
14	Spring Hill Road and Lewinsville Road	NB	547	63.3	E	57.6	E
		SB	316	83.5	F		
		EB	603	65.0	E		
		WB	650	33.5	C		
23	Georgetown Pike and Helga Place/ Linganore Drive	NB	19	6.1	A	39.5	E
		SB	8	39.5	E		
		EB	1,114	9.8	A		
		WB	643	0.5	A		
20	Georgetown Pike and I-495 Southbound Ramps	SB	650	25.3	C	23.9	C
		EB	1,147	22.4	C		
		WB	531	25.4	C		
19	Georgetown Pike and I-495 Northbound Ramps	NB	442	32.1	C	20.7	C
		EB	1,264	17.0	B		
		WB	753	20.3	C		
18	Georgetown Pike and Balls Hill Road	NB	386	46.0	D	23.0	C
		SB	76	73.8	E		
		EB	879	13.7	B		
		WB	495	13.9	B		
22	Georgetown Pike and Dead Run Drive	NB	93	8.8	A	9.5	A
		EB	625	1.5	A		
		WB	480	0.8	A		

SYNCHRO RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
15	Old Dominion Drive at Spring Hill Road	NB	135	14.7	B	10.9	B
		SB	180	15.2	B		
		EB	870	10.4	B		
		WB	260	7.3	A		
16	Old Dominion Drive at Swinks Mill Road	NB	295	25.3	C	16.2	B
		SB	200	22.8	C		
		EB	785	13.6	B		
		WB	210	6.7	A		
17	Old Dominion Drive at Balls Hill Road	NB	315	120.6	F	101.5	F
		SB	330	115.7	F		
		EB	555	84.6	F		
		WB	255	96.3	F		
21	Route 123 at Old Dominion Drive	NB	1,885	27.8	C	43.7	D
		SB	1,185	25.1	C		
		EB	675	83.9	F		
		WB	700	85.3	F		
24	Georgetown Pike at Swinks Mill Road	NB	560	101.9	F	33.4	D
		SB	0	0.0	A		
		EB	570	0.0	A		
		WB	635	2.1	A		
25	Georgetown Pike at Spring Hill Road	NB	40	16.7	C	1.1	A
		EB	585	0.0	A		
		WB	495	0.7	A		
26	Lewinsville Road at Swinks Mill Road	SB	205	47.6	E	9.0	A
		EB	890	2.7	A		
		WB	555	0.0	A		
27	Route 123 at Ingleside Avenue	NB	1,835	0.4	A	1.0	A
		SB	1,155	0.7	A		
		EB	85	14.2	B		
		WB	45	19.9	C		
28	Douglass Drive at Route 193 (Georgetown Pike)	NB	1,835	115.3	F	20.7	C
		SB	1,155	45.2	E		
		EB	85	0.4	A		
		WB	45	2.1	A		

2025 No-Build PM - Intersection Delay

VISSIM RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
6	Route 123 and Tysons Boulevard	NB	2,160	324.7	F	174.5	F
		SB	2,532	33.6	C		
		EB	1,228	245.6	F		
		WB	471	58.2	E		
4	Westpark Drive and Tysons Connector	NB	926	13.8	B	11.4	B
		SB	891	7.2	A		
		WB	267	17.3	B		
5	Tysons Connector and Express Lanes Ramps	NB	107	17.0	B	7.6	A
		SB	161	6.7	A		
		EB	1,140	6.8	A		
7	Route 123 and Capital One Tower Drive/ Old Meadow Road	NB	2,255	329.8	F	177.1	F
		SB	2,387	44.4	D		
		EB	500	139.7	F		
		WB	641	163.4	F		
8	Route 123 and Scotts Crossing Boulevard/ Colshire Drive	NB	2,011	111.1	F	76.9	E
		SB	1,940	40.0	D		
		EB	667	69.1	E		
		WB	799	86.9	F		
1	Route 123 and Route 267 Eastbound Off-Ramp/ Anderson Road	NB	2,164	108.7	F	85.9	F
		SB	1,486	36.7	D		
		EB	136	44.7	D		
		WB	448	150.9	F		
3	Route 123 and Lewinsville Road/ Great Falls Street	NB	2,007	43.6	D	116.3	F
		SB	2,005	55.0	D		
		EB	1,033	52.8	D		
		WB	669	615.8	F		
2	Lewinsville Road and Balls Hill Road	SB	196	38.7	D	116.6	F
		EB	934	222.5	F		
		WB	767	7.4	A		
9	Jones Branch Drive and Jones Branch Connector	NB	811	14.7	B	16.2	B
		SB	850	11.7	B		
		WB	643	24.0	C		
10	Jones Branch Connector and Express Lanes Ramps	NB	51	27.9	C	149.3	F
		SB	130	41.9	D		
		EB	896	16.2	B		
29	Jones Branch Drive and Capital One (West)	NB	687	33.0	C	21.0	C
		SB	68	34.4	C		
		EB	598	12.6	B		
		WB	489	12.5	B		
30	Jones Branch Drive and Capital One (East)	NB	230	16.3	B	8.3	A
		SB	144	19.6	B		
		EB	557	3.3	A		
		WB	478	6.7	A		
11	International Drive and Spring Hill Road/ Jones Branch Drive	NB	773	96.9	F	89.0	F
		SB	635	61.8	E		
		EB	828	71.7	E		
		WB	1,092	112.2	F		
12	Spring Hill Road and Dulles Toll Road Eastbound Ramps	NB	1,682	15.1	B	20.2	C
		SB	518	4.6	A		
		EB	316	73.1	E		
13	Spring Hill Road and Dulles Toll Road Westbound Ramps	NB	1,413	37.9	D	61.8	E
		SB	538	29.0	C		
		WB	343	211.3	F		
14	Spring Hill Road and Lewinsville Road	NB	716	121.8	F	75.0	E
		SB	220	75.8	E		
		EB	383	61.7	E		
		WB	818	40.1	D		
23	Georgetown Pike and Helga Place/ Linganore Drive	NB	1	6.2	A	157.9	F
		SB	4	157.9	F		
		EB	787	59.4	F		
		WB	834	1.1	A		
20	Georgetown Pike and I-495 Southbound Ramps	SB	910	75.8	E	61.7	E
		EB	816	45.0	D		
		WB	727	62.9	E		
19	Georgetown Pike and I-495 Northbound Ramps	NB	176	38.7	D	19.9	B
		EB	944	14.9	B		
		WB	1,404	20.9	C		
18	Georgetown Pike and Balls Hill Road	NB	323	184.2	F	65.0	E
		SB	166	41.7	D		
		EB	414	11.9	B		
		WB	1,009	52.5	D		
22	Georgetown Pike and Dead Run Drive	NB	335	55.5	F	58.6	F
		EB	207	0.4	A		
		WB	686	41.1	E		

SYNCHRO RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
15	Old Dominion Drive at Spring Hill Road	NB	270	16.2	B	10.8	B
		SB	110	13.7	B		
		EB	490	8.0	A		
		WB	615	10.2	B		
16	Old Dominion Drive at Swinks Mill Road	NB	305	15.7	B	12.1	B
		SB	165	13.8	B		
		EB	455	9.9	A		
		WB	590	11.5	B		
17	Old Dominion Drive at Balls Hill Road	NB	295	214.1	F	189.4	F
		SB	485	218.6	F		
		EB	370	205.7	F		
		WB	685	149.3	F		
21	Route 123 at Old Dominion Drive	NB	1,995	25.9	C	41.9	D
		SB	1,790	26.7	C		
		EB	510	85.8	F		
		WB	890	86.8	F		
24	Georgetown Pike at Swinks Mill Road	NB	360	23.4	C	6.5	A
		SB	0	0.0	A		
		EB	385	0.0	A		
		WB	875	1.3	A		
25	Georgetown Pike at Spring Hill Road	NB	65	13.3	B	1.7	A
		EB	355	0.0	A		
		WB	755	0.8	A		
26	Lewinsville Road at Swinks Mill Road	SB	225	85.8	F	26.6	D
		EB	755	2.9	A		
		WB	780	0.0	A		
27	Route 123 at Ingleside Avenue	NB	1,895	3.6	A	3.0	A
		SB	1,700	0.4	A		
		EB	135	24.9	C		
		WB	50	18.6	C		
28	Douglass Drive at Route 193 (Georgetown Pike)	NB	170	280.2	F	28.7	D
		SB	30	221.9	F		
		EB	220	0.4	A		
		WB	975	2.3	A		

2025 Build PM - Intersection Delay

VISSIM RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
6	Route 123 and Tysons Boulevard	NB	2,111	333.8	F	177.1	F
		SB	2,559	34.4	C		
		EB	1,274	245.8	F		
		WB	473	64.6	E		
4	Westpark Drive and Tysons Connector	NB	946	12.8	B	10.4	B
		SB	904	6.4	A		
		WB	225	16.4	B		
5	Tysons Connector and Express Lanes Ramps	NB	92	18.4	B	7.4	A
		SB	133	6.4	A		
		EB	1,157	6.7	A		
7	Route 123 and Capital One Tower Drive/ Old Meadow Road	NB	2,296	329.5	F	178.7	F
		SB	2,366	42.7	D		
		EB	378	175.6	F		
		WB	656	142.9	F		
8	Route 123 and Scotts Crossing Boulevard/ Colshire Drive	NB	2,046	109.6	F	71.9	E
		SB	1,932	37.0	D		
		EB	651	32.4	C		
		WB	815	91.4	F		
1	Route 123 and Route 267 Eastbound Off-Ramp/ Anderson Road	NB	2,226	94.7	F	78.7	E
		SB	1,471	35.0	C		
		EB	135	46.1	D		
		WB	451	152.5	F		
3	Route 123 and Lewinsville Road/ Great Falls Street	NB	1,881	42.4	D	113.9	F
		SB	2,013	50.8	D		
		EB	1,036	52.2	D		
		WB	675	596.2	F		
2	Lewinsville Road and Balls Hill Road	SB	197	37.6	D	117.1	F
		EB	939	221.7	F		
		WB	752	7.4	A		
9	Jones Branch Drive and Jones Branch Connector	NB	842	14.6	B	16.6	B
		SB	868	12.1	B		
		WB	641	25.4	C		
10	Jones Branch Connector and Express Lanes Ramps	NB	60	30.7	C	144.7	F
		SB	145	42.8	D		
		EB	959	16.3	B		
29	Jones Branch Drive and Capital One (West)	NB	698	34.1	C	20.5	C
		SB	68	35.0	D		
		EB	615	11.7	B		
		WB	511	10.5	B		
30	Jones Branch Drive and Capital One (East)	NB	233	17.1	B	7.2	A
		SB	147	18.7	B		
		EB	562	3.0	A		
		WB	491	4.0	A		
11	International Drive and Spring Hill Road/ Jones Branch Drive	NB	753	133.9	F	99.8	F
		SB	647	60.0	E		
		EB	833	79.3	E		
		WB	1,121	114.9	F		
12	Spring Hill Road and Dulles Toll Road Eastbound Ramps	NB	1,716	15.9	B	20.1	C
		SB	543	5.1	A		
		EB	299	71.7	E		
13	Spring Hill Road and Dulles Toll Road Westbound Ramps	NB	1,406	37.8	D	39.8	D
		SB	535	25.3	C		
		WB	259	80.4	F		
14	Spring Hill Road and Lewinsville Road	NB	718	120.0	F	76.5	E
		SB	221	77.1	E		
		EB	382	68.0	E		
		WB	822	42.3	D		
23	Georgetown Pike and Helga Place/ Linganore Drive	NB	0	0.0	A	28.0	D
		SB	4	12.8	B		
		EB	514	0.2	A		
		WB	865	0.9	A		
20	Georgetown Pike and I-495 Southbound Ramps	SB	986	36.2	D	42.5	D
		EB	524	22.7	C		
		WB	691	66.5	E		
19	Georgetown Pike and I-495 Northbound Ramps	NB	179	35.6	D	21.5	C
		EB	676	12.8	B		
		WB	1,052	24.7	C		
18	Georgetown Pike and Balls Hill Road	NB	247	55.5	E	35.5	D
		SB	138	34.5	C		
		EB	426	9.9	A		
		WB	769	43.4	D		
22	Georgetown Pike and Dead Run Drive	NB	264	70.3	F	71.5	F
		EB	221	0.3	A		
		WB	528	49.3	E		

SYNCHRO RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
15	Old Dominion Drive at Spring Hill Road	NB	270	16.2	B	10.8	B
		SB	110	13.7	B		
		EB	490	8.0	A		
		WB	615	10.2	B		
16	Old Dominion Drive at Swinks Mill Road	NB	305	15.7	B	12.1	B
		SB	165	13.8	B		
		EB	455	9.9	A		
		WB	590	11.4	B		
17	Old Dominion Drive at Balls Hill Road	NB	295	225.6	F	181.5	F
		SB	485	207.1	F		
		EB	370	197.3	F		
		WB	680	135.7	F		
21	Route 123 at Old Dominion Drive	NB	1,910	24.7	C	41.7	D
		SB	1,790	26.5	C		
		EB	510	85.8	F		
		WB	890	86.8	F		
24	Georgetown Pike at Swinks Mill Road	NB	260	15.8	C	4.4	A
		SB	0	0.0	A		
		EB	280	0.0	A		
		WB	875	1.2	A		
25	Georgetown Pike at Spring Hill Road	NB	50	12.7	B	1.6	A
		EB	265	0.0	A		
		WB	755	0.7	A		
26	Lewinsville Road at Swinks Mill Road	SB	225	87.9	F	27.4	D
		EB	760	2.9	A		
		WB	785	0.0	A		
27	Route 123 at Ingleside Avenue	NB	1,825	3.8	A	3.0	A
		SB	1,700	0.3	A		
		EB	135	24.9	C		
		WB	50	17.8	C		
28	Douglass Drive at Route 193 (Georgetown Pike)	NB	165	144.2	F	18.3	C
		SB	30	83.5	F		
		EB	220	0.4	A		
		WB	850	2.7	A		

2045 No-Build AM - Intersection Delay

VISSIM RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
6	Route 123 and Tysons Boulevard	NB	2,320	29.6	C	45.4	D
		SB	4,130	49.9	D		
		EB	721	67.0	E		
		WB	461	50.1	D		
4	Westpark Drive and Tysons Connector	NB	537	74.6	E	31.8	C
		SB	384	27.6	C		
		WB	1,728	19.4	B		
5	Tysons Connector and Express Lanes Ramps	NB	1,222	23.0	C	24.0	C
		SB	505	29.3	C		
		EB	399	20.3	C		
7	Route 123 and Capital One Tower Drive/ Old Meadow Road	NB	3,667	113.9	F	105.9	F
		SB	2,084	35.8	D		
		EB	294	160.0	F		
		WB	691	251.8	F		
8	Route 123 and Scotts Crossing Boulevard/ Colshire Drive	NB	2,806	37.4	D	55.4	E
		SB	2,281	38.3	D		
		EB	621	132.4	F		
		WB	622	122.5	F		
1	Route 123 and Route 267 Eastbound Off-Ramp/ Anderson Road	NB	1,782	21.9	C	145.6	F
		SB	1,838	275.1	F		
		EB	585	74.7	E		
		WB	280	230.1	F		
3	Route 123 and Lewinsville Road/ Great Falls Street	NB	2,029	44.7	D	211.0	F
		SB	1,426	348.2	F		
		EB	760	71.4	E		
		WB	666	583.5	F		
2	Lewinsville Road and Balls Hill Road	SB	160	1,033.3	F	102.8	F
		EB	674	32.7	C		
		WB	1,015	2.7	A		
9	Jones Branch Drive and Jones Branch Connector	NB	770	26.0	C	19.3	B
		SB	941	14.8	B		
		WB	929	18.4	B		
10	Jones Branch Connector and Express Lanes Ramps	NB	219	41.1	D	100.2	F
		SB	473	31.4	C		
		EB	941	43.2	D		
		WB	763	18.3	B		
29	Jones Branch Drive and Capital One (West)	NB	320	50.7	D	36.1	D
		SB	247	41.3	D		
		EB	1,004	46.4	D		
		WB	787	15.3	B		
30	Jones Branch Drive and Capital One (East)	NB	112	56.3	E	26.0	C
		SB	137	19.3	B		
		EB	717	39.9	D		
		WB	1,091	14.7	B		
11	International Drive and Spring Hill Road/ Jones Branch Drive	NB	546	56.8	E	45.7	D
		SB	1,656	33.7	C		
		EB	641	58.3	E		
		WB	432	59.0	E		
12	Spring Hill Road and Dulles Toll Road Eastbound Ramps	NB	714	18.0	B	123.0	F
		SB	1,163	27.0	C		
		EB	717	383.1	F		
13	Spring Hill Road and Dulles Toll Road Westbound Ramps	NB	652	17.7	B	26.2	C
		SB	810	17.2	B		
		WB	467	53.8	D		
14	Spring Hill Road and Lewinsville Road	NB	682	86.7	F	57.2	E
		SB	332	71.9	E		
		EB	620	37.4	D		
		WB	543	33.7	C		
23	Georgetown Pike and Helga Place/ Linganore Drive	NB	23	6.1	A	231.7	F
		SB	8	231.7	F		
		EB	1,124	122.4	F		
		WB	724	1.1	A		
20	Georgetown Pike and I-495 Southbound Ramps	SB	523	28.4	C	40.2	D
		EB	1,160	40.4	D		
		WB	798	47.6	D		
19	Georgetown Pike and I-495 Northbound Ramps	NB	797	140.4	F	69.1	E
		EB	1,317	38.1	D		
		WB	964	52.5	D		
18	Georgetown Pike and Balls Hill Road	NB	379	151.7	F	59.7	E
		SB	86	66.1	E		
		EB	1,168	24.8	C		
		WB	694	67.6	E		
22	Georgetown Pike and Dead Run Drive	NB	123	13.4	B	14.3	B
		EB	841	1.5	A		
		WB	680	18.4	C		

SYNCHRO RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
15	Old Dominion Drive at Spring Hill Road	NB	170	15.4	B	11.3	B
		SB	205	15.8	B		
		EB	875	10.5	B		
		WB	220	7.0	A		
16	Old Dominion Drive at Swinks Mill Road	NB	235	26.3	C	15.6	B
		SB	210	25.9	C		
		EB	830	12.4	B		
		WB	200	5.5	A		
17	Old Dominion Drive at Balls Hill Road	NB	270	121.5	F	97.1	F
		SB	340	109.7	F		
		EB	590	78.1	E		
		WB	235	98.3	F		
21	Route 123 at Old Dominion Drive	NB	1,975	37.3	D	48.8	D
		SB	1,335	29.7	C		
		EB	615	84.6	F		
		WB	840	86.2	F		
24	Georgetown Pike at Swinks Mill Road	NB	620	187.8	F	56.9	F
		SB	0	0.0	A		
		EB	615	0.0	A		
		WB	830	2.0	A		
25	Georgetown Pike at Spring Hill Road	NB	60	23.9	C	1.9	A
		EB	640	0.0	A		
		WB	665	1.0	A		
26	Lewinsville Road at Swinks Mill Road	SB	175	31.4	D	5.0	A
		EB	835	2.2	A		
		WB	450	0.0	A		
27	Route 123 at Ingleside Avenue	NB	2,025	0.5	A	1.6	A
		SB	1,230	0.9	A		
		EB	170	17.7	C		
		WB	50	22.8	C		
28	Douglass Drive at Route 193 (Georgetown Pike)	NB	215	478.6	F	55.7	F
		SB	75	45.9	E		
		EB	880	0.3	A		
		WB	650	1.1	A		

2045 Build AM - Intersection Delay

VISSIM RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
6	Route 123 and Tysons Boulevard	NB	2,331	27.7	C	29.4	C
		SB	4,121	18.4	B		
		EB	721	74.0	E		
		WB	460	66.8	E		
4	Westpark Drive and Tysons Connector	NB	537	81.4	F	35.5	D
		SB	404	29.3	C		
		WB	1,723	22.6	C		
5	Tysons Connector and Express Lanes Ramps	NB	1,284	25.3	C	26.5	C
		SB	439	31.3	C		
		EB	437	25.3	C		
31	Route 123 and EB DTR/SB I-495 C-D Road	NB	2,233	10.0	B	14.5	B
		SB	3,061	8.9	A		
		EB	1,932	28.4	C		
32	Route 123 and NB I-495 Ramp	NB	2,428	16.9	B	42.4	D
		SB	1,850	10.7	B		
		WB	3,077	81.6	F		
7	Route 123 and Capital One Tower Drive/ Old Meadow Road	NB	3,897	41.6	D	69.1	E
		SB	1,988	42.0	D		
		EB	232	236.6	F		
		WB	676	249.6	F		
8	Route 123 and Scotts Crossing Boulevard/ Colshire Drive	NB	2,852	40.2	D	71.0	E
		SB	2,226	43.2	D		
		EB	659	126.1	F		
		WB	581	265.9	F		
1	Route 123 and Route 267 Eastbound Off-Ramp/ Anderson Road	NB	1,837	20.0	B	82.4	F
		SB	1,641	80.3	F		
		EB	909	161.1	F		
		WB	284	246.1	F		
33	Route 123 & EB DTR Ramps	NB	1,257	2.7	A	150.5	F
		SB	1,737	257.5	F		
3	Route 123 and Lewinsville Road/ Great Falls Street	NB	2,450	46.4	D	231.5	F
		SB	1,204	493.4	F		
		EB	787	82.0	F		
		WB	650	625.5	F		
2	Lewinsville Road and Balls Hill Road	SB	212	554.3	F	89.1	F
		EB	660	71.0	E		
		WB	1,000	2.5	A		
9	Jones Branch Drive and Jones Branch Connector	NB	774	23.8	C	18.5	B
		SB	959	13.6	B		
		WB	950	19.0	B		
10	Jones Branch Connector and Express Lanes Ramps	NB	246	33.4	D	29.2	C
		SB	489	31.6	C		
		EB	986	35.7	D		
		WB	800	18.3	B		
29	Jones Branch Drive and Capital One (West)	NB	327	48.0	D	33.6	C
		SB	250	47.7	D		
		EB	1,081	39.2	D		
		EB	815	16.3	B		
30	Jones Branch Drive and Capital One (East)	NB	109	82.3	F	25.7	C
		SB	144	20.5	C		
		EB	764	37.7	D		
		WB	1,034	11.6	B		
11	International Drive and Spring Hill Road/ Jones Branch Drive	NB	551	58.3	E	45.5	D
		SB	2,023	42.1	D		
		EB	541	55.0	D		
		WB	439	33.4	C		
12	Spring Hill Road and Dulles Toll Road Eastbound Ramps	NB	720	38.1	D	214.6	F
		SB	1,062	98.6	F		
		EB	1,242	416.2	F		
13	Spring Hill Road and Dulles Toll Road Westbound Ramps	NB	716	31.3	C	79.5	E
		SB	669	139.0	F		
		WB	596	70.8	E		
14	Spring Hill Road and Lewinsville Road	NB	730	117.2	F	125.7	F
		SB	333	124.8	F		
		EB	378	223.7	F		
		WB	532	68.5	E		
23	Georgetown Pike and Helga Place/ Linganore Drive	NB	19	0.0	A	86.1	F
		SB	8	86.1	F		
		EB	1,019	20.9	C		
		WB	848	1.3	A		
20	Georgetown Pike and I-495 Southbound Ramps	SB	720	29.2	C	39.7	D
		EB	1,041	44.1	D		
		WB	795	43.6	D		
19	Georgetown Pike and I-495 Northbound Ramps	NB	740	126.7	F	53.9	D
		EB	1,280	32.1	C		
		WB	920	25.7	C		
18	Georgetown Pike and Balls Hill Road	NB	395	45.8	D	24.2	C
		SB	103	41.8	D		
		EB	1,229	15.6	B		
		WB	640	24.5	C		
22	Georgetown Pike and Dead Run Drive	NB	114	13.8	B	14.7	B
		EB	897	2.1	A		
		WB	628	1.6	A		

SYNCHRO RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
15	Old Dominion Drive at Spring Hill Road	NB	255	15.1	B	11.2	B
		SB	55	15.7	B		
		EB	240	10.5	B		
		WB	1,040	7.4	A		
16	Old Dominion Drive at Swinks Mill Road	NB	145	24.5	C	14.6	B
		SB	210	26.6	C		
		EB	840	12.2	B		
		WB	205	5.3	A		
17	Old Dominion Drive at Balls Hill Road	NB	225	108.0	F	87.0	F
		SB	345	91.8	F		
		EB	560	78.7	E		
		WB	245	79.7	E		
21	Route 123 at Old Dominion Drive	NB	225	32.6	C	45.0	D
		SB	345	27.0	C		
		EB	560	85.2	F		
		WB	245	82.0	F		
24	Georgetown Pike at Swinks Mill Road	NB	450	59.3	F	15.8	C
		SB	0	0.0	A		
		EB	585	0.0	A		
		WB	830	2.2	A		
25	Georgetown Pike at Spring Hill Road	NB	65	23.5	C	2.0	A
		EB	610	0.0	A		
		WB	640	0.9	A		
26	Lewinsville Road at Swinks Mill Road	SB	140	19.0	C	2.6	A
		EB	835	1.3	A		
		WB	450	0.0	A		
27	Route 123 at Ingleside Avenue	NB	2,050	0.5	A	1.7	A
		SB	1,210	0.9	A		
		EB	190	18.3	C		
		WB	50	23.2	C		
28	Douglass Drive at Route 193 (Georgetown Pike)	NB	2,050	236.7	F	29.3	D
		SB	1,210	36.9	E		
		EB	190	0.2	A		
		WB	50	1.1	A		

2045 No-Build PM - Intersection Delay

VISSIM RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
6	Route 123 and Tysons Boulevard	NB	2,013	490.2	F	206.0	F
		SB	2,605	42.1	D		
		EB	1,561	169.5	F		
		WB	690	78.1	E		
4	Westpark Drive and Tysons Connector	NB	867	20.9	C	15.8	B
		SB	1,079	9.7	A		
		WB	328	22.3	C		
5	Tysons Connector and Express Lanes Ramps	NB	135	21.3	C	13.8	B
		SB	194	7.1	A		
		EB	1,549	14.0	B		
7	Route 123 and Capital One Tower Drive/ Old Meadow Road	NB	2,803	58.2	E	80.2	F
		SB	2,259	45.8	D		
		EB	458	128.3	F		
		WB	694	249.8	F		
8	Route 123 and Scotts Crossing Boulevard/ Colshire Drive	NB	2,199	41.4	D	80.3	F
		SB	1,694	77.2	E		
		EB	942	113.4	F		
		WB	1,115	133.7	F		
1	Route 123 and Route 267 Eastbound Off-Ramp/ Anderson Road	NB	2,100	59.4	E	192.9	F
		SB	1,329	433.5	F		
		EB	159	47.0	D		
		WB	436	155.6	F		
3	Route 123 and Lewinsville Road/ Great Falls Street	NB	2,005	44.6	D	230.1	F
		SB	1,308	401.7	F		
		EB	1,179	69.3	E		
		WB	487	922.0	F		
2	Lewinsville Road and Balls Hill Road	SB	197	290.7	F	168.7	F
		EB	1,066	228.8	F		
		WB	545	7.2	A		
9	Jones Branch Drive and Jones Branch Connector	NB	647	229.4	F	76.6	E
		SB	1,477	35.9	D		
		WB	1,016	38.7	D		
10	Jones Branch Connector and Express Lanes Ramps	NB	80	73.9	E	132.6	F
		SB	224	497.4	F		
		EB	1,140	188.2	F		
		WB	1,324	26.5	C		
29	Jones Branch Drive and Capital One (West)	NB	730	70.9	E	93.5	F
		SB	104	54.3	D		
		EB	718	211.8	F		
		EB	849	17.6	B		
30	Jones Branch Drive and Capital One (East)	NB	140	431.3	F	72.3	E
		SB	221	64.6	E		
		EB	781	81.9	F		
		WB	1,047	18.9	B		
11	International Drive and Spring Hill Road/ Jones Branch Drive	NB	629	53.8	D	47.6	D
		SB	764	43.8	D		
		EB	672	50.9	D		
		WB	877	44.1	D		
12	Spring Hill Road and Dulles Toll Road Eastbound Ramps	NB	1,309	14.5	B	21.6	C
		SB	628	8.3	A		
		EB	364	70.2	E		
13	Spring Hill Road and Dulles Toll Road Westbound Ramps	NB	1,043	34.2	C	31.6	C
		SB	541	17.2	B		
		WB	207	56.3	E		
14	Spring Hill Road and Lewinsville Road	NB	741	106.3	F	67.2	E
		SB	257	64.9	E		
		EB	433	47.3	D		
		WB	695	38.6	D		
23	Georgetown Pike and Helga Place/ Linganore Drive	NB	1	0.0	A	125.6	F
		SB	4	125.6	F		
		EB	599	27.0	D		
		WB	1,198	3.1	A		
20	Georgetown Pike and I-495 Southbound Ramps	SB	866	22.5	C	24.5	C
		EB	615	38.8	D		
		WB	1,110	18.0	B		
19	Georgetown Pike and I-495 Northbound Ramps	NB	315	305.1	F	60.3	E
		EB	822	45.9	D		
		WB	1,601	19.5	B		
18	Georgetown Pike and Balls Hill Road	NB	284	80.1	F	40.7	D
		SB	145	35.9	D		
		EB	419	9.3	A		
		WB	1,285	42.9	D		
22	Georgetown Pike and Dead Run Drive	NB	345	1.4	A	40.6	E
		EB	229	0.6	A		
		WB	934	56.9	F		

SYNCHRO RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
15	Old Dominion Drive at Spring Hill Road	NB	285	16.2	B	11.0	B
		SB	130	13.8	B		
		EB	455	8.1	A		
		WB	605	10.1	B		
16	Old Dominion Drive at Swinks Mill Road	NB	285	15.4	B	11.7	B
		SB	165	13.7	B		
		EB	470	9.7	A		
		WB	585	11.0	B		
17	Old Dominion Drive at Balls Hill Road	NB	365	225.2	F	209.9	F
		SB	495	233.5	F		
		EB	420	227.3	F		
		WB	675	173.6	F		
21	Route 123 at Old Dominion Drive	NB	1,965	19.9	B	35.2	D
		SB	1,835	21.6	C		
		EB	460	84.9	F		
		WB	655	86.7	F		
24	Georgetown Pike at Swinks Mill Road	NB	290	25.8	D	5.6	A
		SB	0	0.0	A		
		EB	325	0.0	A		
		WB	1,255	0.9	A		
25	Georgetown Pike at Spring Hill Road	NB	60	20.1	C	2.3	A
		EB	325	0.0	A		
		WB	1,135	0.6	A		
26	Lewinsville Road at Swinks Mill Road	SB	195	35.9	E	5.7	A
		EB	725	2.7	A		
		WB	650	0.0	A		
27	Route 123 at Ingleside Avenue	NB	1,760	3.2	A	3.1	A
		SB	1,715	0.3	A		
		EB	160	28.5	D		
		WB	55	17.5	C		
28	Douglass Drive at Route 193 (Georgetown Pike)	NB	255	898.5	F	118.8	F
		SB	55	269.2	F		
		EB	240	0.4	A		
		WB	1,040	1.7	A		

2045 Build PM - Intersection Delay

VISSIM RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
6	Route 123 and Tysons Boulevard	NB	2,020.0	486.4	F	207.4	F
		SB	2,703.0	33.8	C		
		EB	1,356.0	208.3	F		
		WB	684.0	67.9	E		
4	Westpark Drive and Tysons Connector	NB	872.0	27.6	C	19.0	B
		SB	1,121.0	10.9	B		
		WB	348.0	23.5	C		
5	Tysons Connector and Express Lanes Ramps	NB	136.0	23.2	C	13.9	B
		SB	212.0	6.6	A		
		EB	1,629.0	14.0	B		
31	Route 123 and EB DTR/SB I-495 C-D Road	NB	2,375.0	5.0	A	10.1	B
		SB	1,949.0	5.3	A		
		EB	942.0	33.1	C		
32	Route 123 and NB I-495 Ramp	NB	1,924.0	10.4	B	24.1	C
		SB	2,259.0	20.9	C		
		WB	1,466.0	47.2	D		
7	Route 123 and Capital One Tower Drive/ Old Meadow Road	NB	2,721.0	56.9	E	78.1	E
		SB	2,312.0	37.7	D		
		EB	335.0	164.9	F		
		WB	653.0	264.6	F		
8	Route 123 and Scotts Crossing Boulevard/ Colshire Drive	NB	2,057.0	32.5	C	71.9	E
		SB	1,776.0	55.8	E		
		EB	964.0	110.9	F		
		WB	1,103.0	137.4	F		
1	Route 123 and Route 267 Eastbound Off-Ramp/ Anderson Road	NB	2,027.0	45.7	D	86.8	F
		SB	1,259.0	109.8	F		
		EB	477.0	132.0	F		
		WB	418.0	165.3	F		
33	Route 123 & EB DTR Ramps	NB	1,141.0	5.3	A	196.3	F
		SB	1,353.0	357.4	F		
3	Route 123 and Lewinsville Road/ Great Falls Street	NB	2,007.0	43.3	D	253.4	F
		SB	1,140.0	501.7	F		
		EB	1,142.0	76.2	E		
		WB	460.0	995.2	F		
2	Lewinsville Road and Balls Hill Road	SB	191.0	343.4	F	191.5	F
		EB	1,028.0	252.4	F		
		WB	497.0	7.0	A		
9	Jones Branch Drive and Jones Branch Connector	NB	441.0	696.4	F	151.9	F
		SB	1,474.0	68.2	E		
		WB	1,029.0	38.5	D		
10	Jones Branch Connector and Express Lanes Ramps	NB	82.0	51.0	D	139.1	F
		SB	295.0	72.3	E		
		EB	1,060.0	300.0	F		
		WB	1,351.0	32.9	C		
29	Jones Branch Drive and Capital One (West)	NB	729.0	75.8	E	98.3	F
		SB	103.0	54.0	D		
		EB	735.0	220.6	F		
		EB	860.0	18.0	B		
30	Jones Branch Drive and Capital One (East)	NB	149.0	418.0	F	70.8	E
		SB	227.0	58.3	E		
		EB	793.0	77.8	E		
		WB	1,009.0	16.9	B		
11	International Drive and Spring Hill Road/ Jones Branch Drive	NB	658.0	71.6	E	54.1	D
		SB	762.0	42.1	D		
		EB	701.0	52.8	D		
		WB	902.0	52.5	D		
12	Spring Hill Road and Dulles Toll Road Eastbound Ramps	NB	1,412.0	18.3	B	24.3	C
		SB	628.0	11.3	B		
		EB	362.0	70.1	E		
13	Spring Hill Road and Dulles Toll Road Westbound Ramps	NB	1,147.0	40.0	D	39.6	D
		SB	553.0	22.6	C		
		WB	277.0	71.7	E		
14	Spring Hill Road and Lewinsville Road	NB	733.0	118.9	F	70.8	E
		SB	260.0	63.5	E		
		EB	441.0	46.7	D		
		WB	702.0	38.5	D		
23	Georgetown Pike and Helga Place/ Linganore Drive	NB	1.0	0.0	A	13.1	B
		SB	4.0	9.8	A		
		EB	346.0	0.2	A		
		WB	1,268.0	4.1	A		
20	Georgetown Pike and I-495 Southbound Ramps	SB	947.0	21.9	C	21.9	C
		EB	353.0	22.5	C		
		WB	1,110.0	21.6	C		
19	Georgetown Pike and I-495 Northbound Ramps	NB	334.0	319.3	F	63.8	E
		EB	588.0	37.8	D		
		WB	1,303.0	10.1	B		
18	Georgetown Pike and Balls Hill Road	NB	246.0	40.2	D	18.7	B
		SB	131.0	29.6	C		
		EB	473.0	8.7	A		
		WB	1,049.0	16.8	B		
22	Georgetown Pike and Dead Run Drive	NB	289.0	13.6	B	13.8	B
		EB	240.0	0.5	A		
		WB	771.0	1.1	A		

Note : Results reflect updated geometry/signal timings at Georgetown Pike/Balls Hill Road

SYNCHRO RESULTS

#	Intersection	Approach	Volume	Average Approach Delay (sec/veh)	Approach LOS	Intersection Delay (sec/veh)	Intersection LOS
15	Old Dominion Drive at Spring Hill Road	NB	175	14.8	B	9.9	A
		SB	65	13.4	B		
		EB	465	7.6	A		
		WB	590	10.0	A		
16	Old Dominion Drive at Swinks Mill Road	NB	110	13.0	B	10.1	B
		SB	155	13.7	B		
		EB	435	8.5	A		
		WB	575	9.7	A		
17	Old Dominion Drive at Balls Hill Road	NB	230	231.0	F	174.6	F
		SB	525	203.8	F		
		EB	395	179.3	F		
		WB	670	129.5	F		
21	Route 123 at Old Dominion Drive	NB	2,000	21.8	C	36.4	D
		SB	1,800	22.5	C		
		EB	485	85.8	F		
		WB	700	82.2	F		
24	Georgetown Pike at Swinks Mill Road	NB	180	18.1	C	4.0	A
		SB	0	0.0	A		
		EB	200	0.0	A		
		WB	1,260	0.8	A		
25	Georgetown Pike at Spring Hill Road	NB	45	19.6	C	2.1	A
		EB	215	0.0	A		
		WB	1,140	0.6	A		
26	Lewinsville Road at Swinks Mill Road	SB	85	29.1	D	2.1	A
		EB	735	0.9	A		
		WB	700	0.0	A		
27	Route 123 at Ingleside Avenue	NB	1,830	1.4	A	2.0	A
		SB	1,695	0.3	A		
		EB	145	26.1	D		
		WB	55	19.4	C		
28	Douglass Drive at Route 193 (Georgetown Pike)	NB	235	513.1	F	70.4	F
		SB	55	98.0	F		
		EB	260	0.3	A		
		WB	915	1.9	A		

Appendix E: I-495 NEXT Traffic Operations Analysis Framework Memorandum

MEMORANDUM

To: Ivan Horodyskyj, P.E., VDOT NoVA District Traffic Engineer
Abi Lerner, P.E., VDOT Project Manager

From: Rob Prunty, P.E.
Raj Paradkar, P.E.
Anthony Gallo, P.E.
Kimley-Horn and Associates, Inc.

Date: August 29, 2018

Subject: I-495 NEXT Traffic Operations Analysis Framework

Introduction

This memorandum documents the traffic operations analysis framework associated with the I-495 NEXT Project. This memorandum is intended to supplement the overarching I-495 NEXT Project Scoping Framework Document.

The following elements of the traffic operations analysis are laid out in detail in this document:

- Traffic data collection
- Traffic analysis tools and measures of effectiveness (MOEs)
- Traffic simulation model calibration methodology and assumptions

Traffic Data Collection

Traffic Volumes

The following intersection locations will have traffic counts conducted in the year 2018 and be analyzed as part of the traffic operations analysis:

1. Westpark Drive Connector at I-495 Express Lane ramp terminals
2. Westpark Drive Connector at West Park Drive
3. Route 123 at Tysons Boulevard / Entrance to Tysons Mall Ring Road
4. Route 123 at Old Meadow Road / Capital One Tower Drive
5. Route 123 at Scotts Crossing Road / Colshire Drive
6. Route 123 at Anderson Road / Dulles Toll Road Connector ramp terminal
7. Route 123 at Great Falls Street / Lewinsville Road
8. Lewinsville Road at Balls Hill Road
9. Lewinsville Road at Swinks Mill Road
10. Lewinsville Road at Spring Hill Road
11. Spring Hill Road at Dulles Toll Road WB ramp terminals
12. Spring Hill Road at Dulles Toll Road EB ramp terminals
13. Spring Hill Road at International Drive / Jones Branch Drive

14. Jones Branch Drive at Jones Branch Connector
15. Jones Branch Connector at I-495 Express Lane ramp terminals
16. Old Dominion at Spring Hill Road
17. Old Dominion at Swinks Mill Road
18. Old Dominion at Balls Hill Road
19. Georgetown Pike at Dead Run Drive
20. Georgetown Pike at Balls Hill Road
21. Georgetown Pike at NB I-495 GP NB ramp terminals
22. Georgetown Pike at SB I-495 GP NB ramp terminals
23. Georgetown Pike at Linganore Drive / Helga Place
24. Georgetown Pike at Swinks Mill Road
25. Georgetown Pike at Spring Hill Road
26. Georgetown Pike at Douglass Drive
27. Route 123 at Ingleside Avenue
28. Route 123 at Old Dominion Drive

The following interchanges will have traffic counts conducted in the year 2018 and will be analyzed as part of the traffic operations analysis:

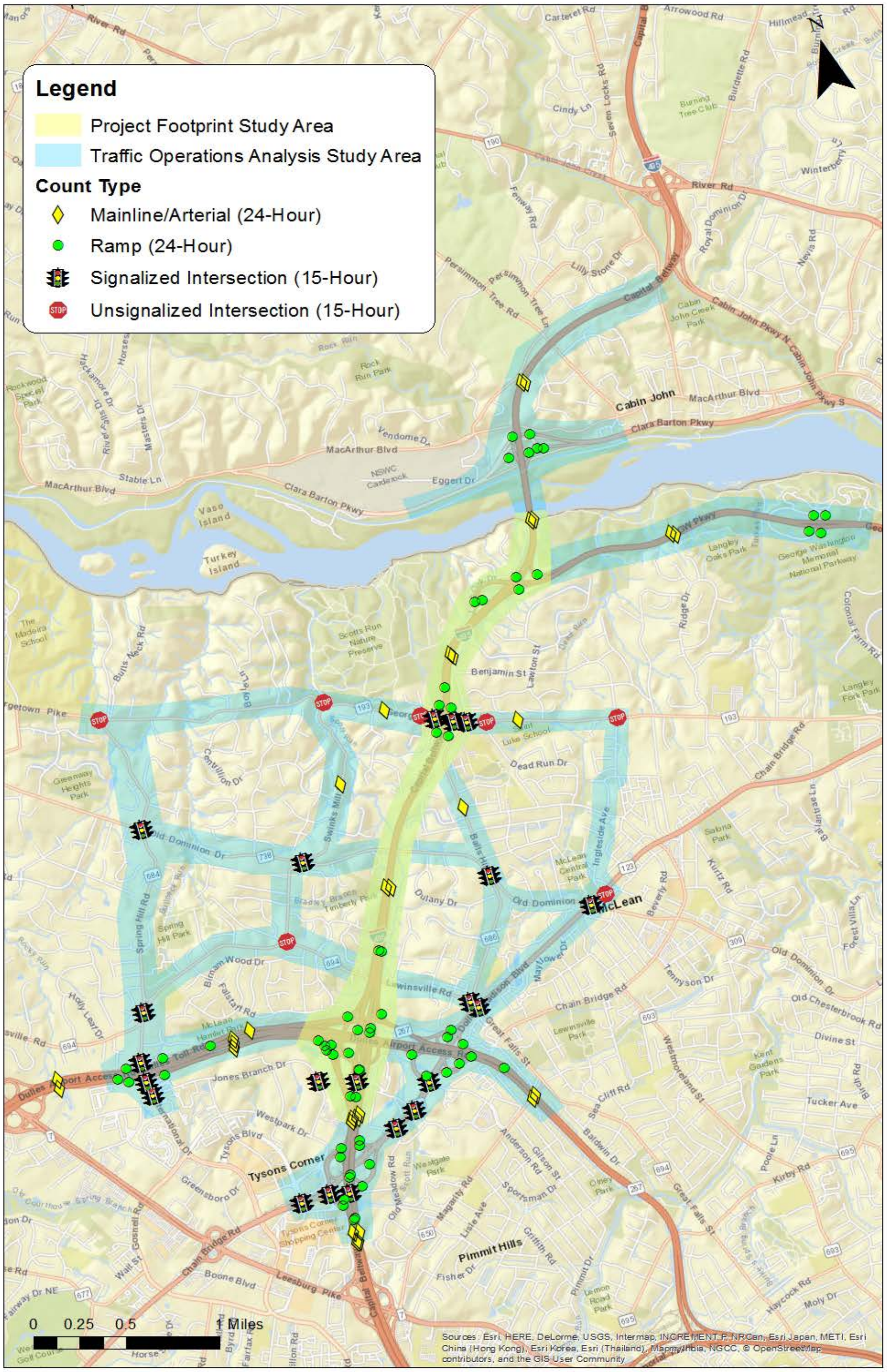
1. I-495 GP at Route 123
2. I-495 Express Lanes at Westpark Drive Connector
3. I-495 Express Lanes at Jones Branch Connector
4. I-495 GP at Dulles Toll Road and Dulles Airport Access Road
5. I-495 Express Lanes at Dulles Toll Road
6. I-495 at Georgetown Pike
7. I-495 at George Washington Memorial Parkway
8. I-495 at Clara Barton Parkway
9. Dulles International Airport Access Highway ramps to / from Dulles Toll Road (VA Route 267), east and west of I-495
10. Dulles Toll Road (VA Route 267) at Spring Hill Road (VA Route 684)
11. Dulles Toll Road (VA Route 267) at Dolley Madison Road (VA Route 123)
12. George Washington Memorial Parkway and Turkey Run Park

Traffic count locations are shown in Figure 1.

Traffic volumes used in the traffic and operations analysis will consist of the following:

- **Existing (2018)** – Developed from field counts (ramps, freeway mainline, and intersection turning movements) conducted in June 2018. Count data will be post-processed and balanced between all adjacent locations in the traffic operations analysis study area.
- **Opening Year (2025)** – No Build and one Build alternative developed through modifications to the MWCOG 2025 travel demand model for the I-495 corridor and post-processed based on 2018 data collection.
- **Design Year (2045)** – No Build and one Build alternative developed through modifications to the MWCOG 2045 travel demand model for the I-495 corridor and post-processed based on 2018 data collection.

Figure 1: Traffic Count Locations



Sources: Esri, HERE, DeLorme, USGS, Intermap, INCREMENT P, NRCan, Esri Japan, METI, Esri China (Hong Kong), Esri Korea, Esri (Thailand), MapmyIndia, NGCC, © OpenStreetMap contributors, and the GIS User Community

Origin-Destination Data

The traffic simulation modeling effort will route vehicles through the traffic network according to origin-destination routing. Origin-destination data will be reviewed from the following sources:

- StreetLight Data, which via a VDOT subscription provides customized origin-destination data with a very high level of spatial accuracy based on aggregated cellular device GPS/location-based services data. StreetLight Data allows for a user to provide custom origins and destinations, such as on- and off-ramps for all freeways in a study area or entry/exit links to a study area. It is anticipated that StreetLight Data will be used as the basis for origin-destination routing for the existing conditions traffic analysis, at the very least for the freeway and ramp segments of the study area.
- MWCOG regional travel demand model, which outputs O-D matrices for various vehicle types between each traffic analysis zone (TAZ) in the Washington, DC, metropolitan area. The travel patterns within the model base year (2017) have been calibrated against 2007/2008 regional household travel survey data, so the travel patterns are somewhat dated. Additionally, this dataset is not as granular as needed to account for freeway weaving proportions. However, given that the travel demand model provides O-D matrices for future years, it is anticipated that these may be used as the basis for vehicle routing in future analysis year scenarios.

Speeds and Travel Times

Floating car travel time runs were conducted in June 2018 during the AM and PM peak periods for the following segments:

Corridor #	Corridor Name
1	I-495 Northbound – From south of Route 123 to River Road CD road;
3	I-495 Southbound – From River Road CD road to south of Route 123;
2	I-495 Northbound to DTR Westbound – From Route 123 to Spring Hill Road;
8	DTR Eastbound to I-495 Southbound – From west of Spring Hill Road to south of Route 123
4	I-495 Southbound to DTR Connector Eastbound from River Road CD road to east of Route 123
10	DTR Westbound Connector to I-495 Northbound – from east of Route 123 to River Road CD road.
5	I-495 Southbound to DTR Westbound – From River Road CD road to Spring Hill Road;
7	DTR Eastbound to I-495 Northbound – From west of Spring Hill Road to River Road CD road;
6	DTR Eastbound – From west of Spring Hill Road to east of Route 123;
9	DTR Westbound – From east of Route 123 to west of Spring Hill Road

In addition, INRIX vehicle probe speed data has been queried for the corridor using the RITIS Congestion Scan tool, which provides a "heat map" of vehicle speeds temporally and spatially along a corridor. This data has been pulled for "average weekdays" (Tuesday, Wednesday, and Thursday) for the 12 most recently available months of data (July 2017 through June 2018).

Queueing Data

Queueing along the freeway segments of the corridor will be provided via the INRIX heat map and verified against Google Maps' typical traffic. Queueing along arterials and ramps will be obtained via screen captures from Google Maps' typical traffic. Targeted spot locations will be verified in the field.

Traffic Operational Analysis Tools and Measures

Traffic Analysis Tools

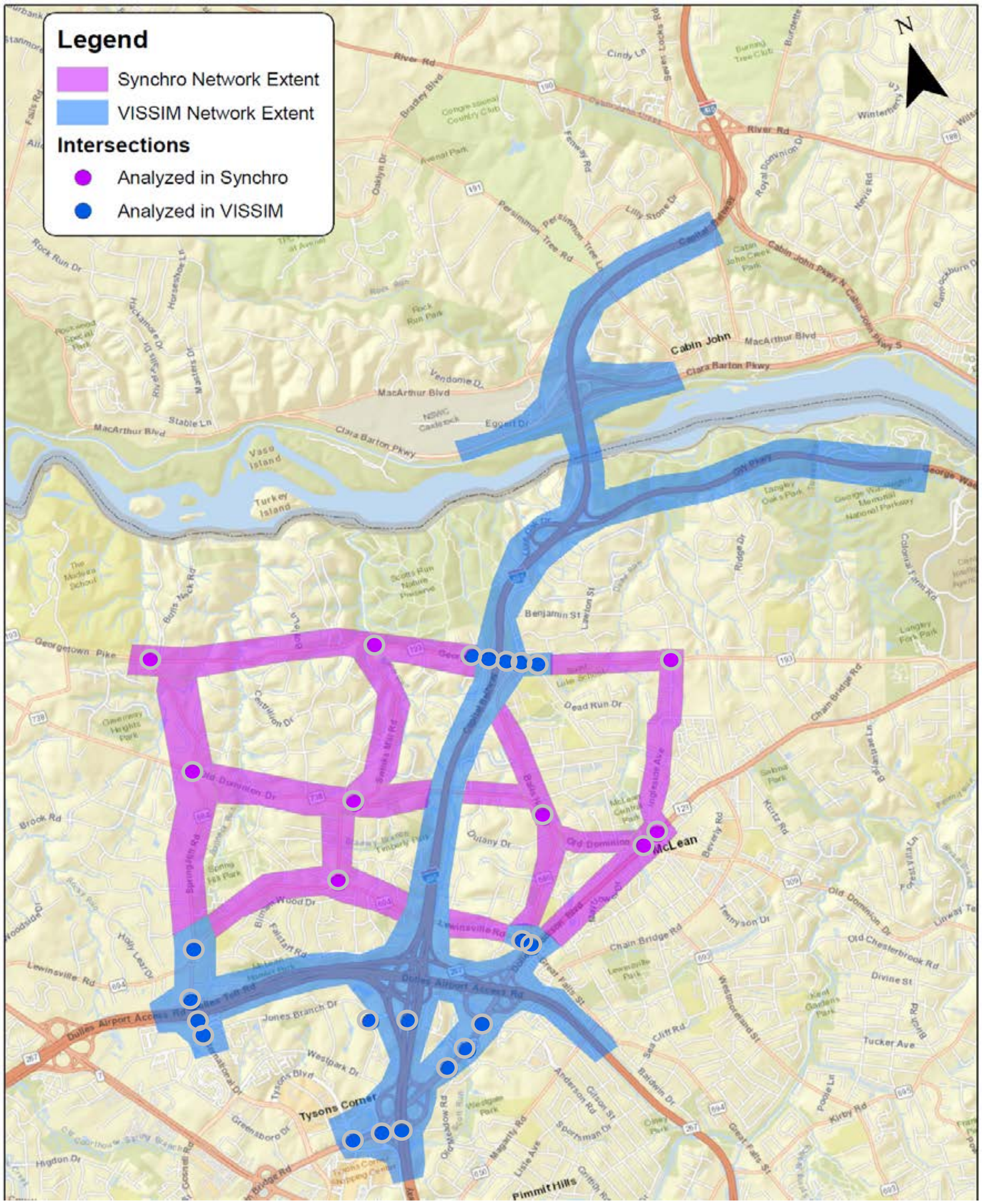
VISSIM Version 9.0 will be used for a comprehensive network traffic analysis for the freeways, interchanges, and adjacent intersections within the traffic operations analysis area limits. (Reference analysis tool selection matrix, *VDOT Traffic Operations and Safety Analysis Manual [TOSAM]* V1.0[1], Appendix D.) Additional calibration, based on simulated volume processed, travel times, queues, and speed profiles, will be performed against 2018 measured field conditions and traffic data.

Surface street intersection operations will be evaluated through a combination of Synchro 10 (in order to develop preliminary optimization for phasing and signal timing) and VISSIM (for microsimulation and analysis). The expanded arterial network beyond intersections immediately adjacent to freeway interchanges in the corridor will be evaluated solely through Synchro. Transit routes and stops will be coded into the study area VISSIM network where they affect or could affect I-495 and related facility operations. The VISSIM and Synchro study areas are shown in Figure 2.

---

[1] http://www.virginiadot.org/business/resources/TOSAM.pdf

Figure 2. I-495 NEXT Traffic Operations VISSIM and Synchro Analysis Areas



Vehicle Classes

The following vehicle classes will be assumed for the traffic operations analysis VISSIM modeling:

- General purpose (non-toll-paying) cars
- HOV3+ cars
- HOT (toll paying) cars
- GP (non-toll-paying) trucks
- HOT (toll paying) trucks

Measures of Effectiveness

The following measures of effectiveness (MOEs) will be used for the operational analysis of the roadway network under existing and future Build and No-Build conditions.

Freeway Performance Measures

- Simulated Average Speed (mph)
- Simulated Average Density (pc/ln/mile, color-coded similar to the equivalent Density-Based LOS Thresholds)
- Simulated Volume (vehicles per hour)

The VISSIM freeway MOEs will be reported for each freeway segment. In addition, the following freeway MOEs also are proposed for reporting in the IJR:

- **Percent of Demand Served.** Simulated Volume (*processed volumes*) divided by Actual Volume (*input volumes*).
- **Simulated Ramp Queue Length.** Reported for 50th and 95th percentiles (feet).
- **Simulated Travel Time.** Reported for select network origin-destination travel paths (seconds).
- **Congestion *Heat Maps*.** Incremental speeds reported for aggregated lanes, by time interval (mph).

Arterial/Intersection Performance Measures

- **Simulated Intersection Level of Service (LOS) and Average Control Delay.** Reported by approach and by intersection (sec/veh, color-coded in similar fashion as the equivalent Highway Capacity Manual (HCM) Delay-Based LOS Thresholds).
- **Simulated Intersection Approach Queue.** Reported by movement (feet).
- **Percent of Demand Served.** Simulated Volume (*processed volumes*) divided by Actual Volume (*input volumes*).

Traffic Modeling Methodology and Assumptions

Calibration Methodology for Base Models

The VISSIM base models will be calibrated based on guidance from *VDOT Traffic Operations and Safety Analysis Manual (TOSAM)*, Version 1. A full review of the criteria and acceptance targets is provided in the attached **I-495 NEXT Traffic Analysis Microsimulation Calibration Methodology Memorandum**. This memorandum was approved and signed by the VDOT NoVA District Traffic

Engineer on July 27, 2018. The following criteria and thresholds are proposed for VISSIM model calibration:

Calibration Item	Basis	Criteria	Target
Simulated Traffic Volume (Intersections)	**By Intersection Approach**	Within ± 20% for <100 vph	At least 85% of all Intersection Approaches
		Within ± 15% for ≥ 100 vph to < 300 vph	
		Within ± 10% for ≥ 300 vph to < 1,000 vph	
		Within ± 5% for ≥ 1,000 vph	
Simulated Traffic Volume (Freeways)	**By Freeway Segment**	Within ± 20% for <100 vph	At least 85% of all Freeway Segments
		Within ± 15% for ≥ 100 vph to < 300 vph	
		Within ± 10% for ≥ 300 vph to < 1,000 vph	
		Within ± 5% for ≥ 1,000 vph	
Simulated Travel Time	**By Route**	Within ± 30% for average travel times on arterials	At least 85% of all Travel Time Routes (Including Segments)
		Within ± 20% for average travel times on freeways	
Maximum Simulated Queue Length	**By Approach for Targeted Critical Locations**	Modeled queues qualitatively reflect the impacts of observed queues	Qualitative Visual Match
Visual Review of Bottleneck Locations	**Targeted Critical Locations**	Speed heat maps qualitatively reflect patterns and duration of congestion	Qualitative Subjective Assessment

The following locations have been proposed for queue length calibration and reporting:

Queue Type	**Location**
Ramp	Ramp from SR 267 EB to I-495 NB GP
Ramp	Ramp from DAAR EB to I-495 NB GP
Ramp	Ramp from SR 267 EB to I-495 SB GP
Ramp	Ramp from SR 267 EB to Route 123 NB
Ramp	Ramp from Georgetown Pike (SR 193) to I-495 NB GP
Ramp	Ramp from George Washington Memorial Parkway NB to I-495 NB GP
Approach	Georgetown Pike (SR 193) EB approaching I-495 NB GP ramps
Approach	Georgetown Pike (SR 193) WB approaching I-495 NB GP ramps

Approach	Balls Hill Rd NB approaching Georgetown Pike
Approach	Spring Hill Rd NB approaching Lewinsville Road
Approach	Route 123 NB approaching Great Falls St
Approach	Lewinsville Road EB approaching Balls Hill Road

Potential Adjustments for Calibration

Adjustments to the VISSIM model during the calibration process will follow guidance from the VDOT TOSAM. These adjustments could include modifications to lane change distance for connectors, driver behavior along freeways and arterials, adjustments to desired speeds for vehicles at the network termini (such as along I-495 northbound leaving the study area), etc. The technical memorandum detailing calibration results will identify any potential deviations from TOSAM guidance.

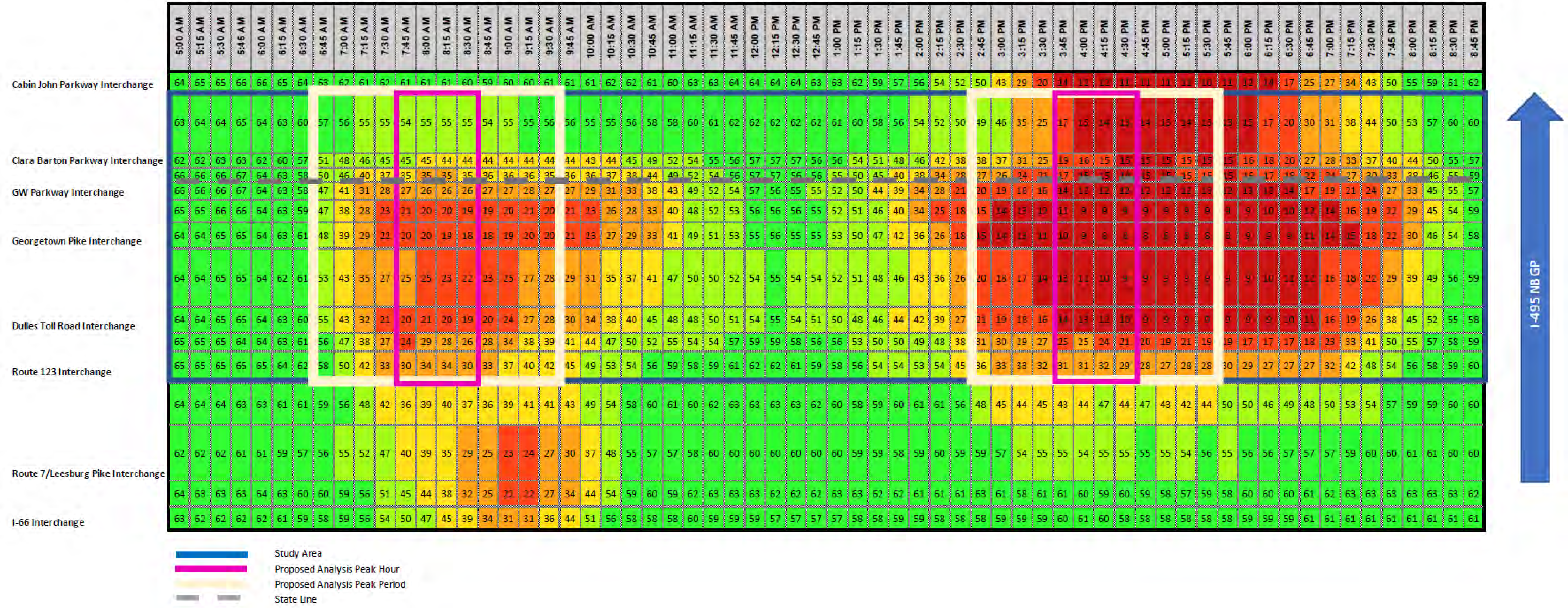
Simulation Time, Seeding Time, and Number of Runs

The I-495 NEXT traffic operations study area is a severely oversaturated network during the weekday AM and PM peak periods, with several hours of congestion in both directions along I-495, especially along I-495 northbound approaching the American Legion Bridge. During these congested periods, traffic volume throughput is constrained due to low speeds and can be much lower than the actual maximum counted volumes along the freeway. Due to the oversaturated conditions, the analysis period was selected based on the heaviest periods of congestion and slowest speeds experienced along the corridor.

Figure 3 shows 15-minute average speeds along the I-495 northbound general purpose lanes through the study area for average weekdays (Tuesday, Wednesday, and Thursday) from July 2017 through June 2018. Note that during both the AM and PM peak periods, speeds along I-495 northbound are slower than speeds along I-495 southbound due to the downstream bottleneck at the American Legion Bridge. Thus, the analysis period and peak hours have been selected specifically based on congestion in the I-495 northbound general purpose lanes.

Figure 3 also show the proposed simulation analysis periods, which were also approved by the VDOT NoVA District Traffic Engineer as documented in the attached memorandum. These analysis periods would each be preceded by a 30-minute seeding period in the VISSIM models:

Figure 3: INRIX 15-Minute Average Speeds Along I-495 Northbound GP and Proposed Simulation Analysis Periods



	5:00 AM	5:15 AM	5:30 AM	5:45 AM	6:00 AM	6:15 AM	6:30 AM	6:45 AM	7:00 AM	7:15 AM	7:30 AM	7:45 AM	8:00 AM	8:15 AM	8:30 AM	8:45 AM
Cabin John Parkway Interchange	64	65	65	66	66	65	64	63	62	61	62	61	61	61	60	59
	63	64	64	65	64	63	60	57	56	55	55	54	55	55	55	54
Clara Barton Parkway Interchange	62	62	63	63	62	60	57	51	48	46	45	45	45	44	44	44
	66	66	66	67	64	63	58	50	46	40	37	35	35	35	35	36
GW Parkway Interchange	66	66	66	67	64	63	58	47	41	31	28	27	26	26	26	27
	65	65	66	66	64	63	59	47	38	28	23	21	20	20	19	19
Georgetown Pike Interchange	64	64	65	65	64	63	61	48	39	29	22	20	20	19	18	18
	64	64	65	65	64	62	61	53	43	35	27	25	25	23	22	23
Dulles Toll Road Interchange	64	64	65	65	64	63	60	55	43	32	21	20	21	20	19	20
	65	65	65	64	64	63	61	56	47	38	27	24	29	28	26	28
Route 123 Interchange	65	65	65	65	65	64	62	58	50	42	33	30	34	34	30	33
	64	64	64	63	63	61	61	59	56	48	42	36	39	40	37	36
Route 7/Leesburg Pike Interchange	62	62	62	61	61	59	57	56	55	52	47	40	39	35	29	25
	64	63	63	63	64	63	60	60	59	56	51	45	44	38	32	25
I-66 Interchange	63	62	62	62	62	61	59	58	59	56	54	50	47	45	39	34

	9:00 AM	9:15 AM	9:30 AM	9:45 AM	10:00 AM	10:15 AM	10:30 AM	10:45 AM	11:00 AM	11:15 AM	11:30 AM	11:45 AM	12:00 PM	12:15 PM	12:30 PM	12:45 PM
Cabin John Parkway Interchange	60	60	61	61	61	62	62	61	60	63	63	64	64	64	64	63
	55	55	56	56	55	55	56	58	58	60	61	62	62	62	62	62
Clara Barton Parkway Interchange	44	44	44	44	43	44	45	49	52	54	55	56	57	57	57	56
	36	36	35	36	36	37	38	44	49	52	54	56	57	57	56	56
GW Parkway Interchange	27	28	27	27	29	31	33	38	43	49	52	54	57	56	55	55
	20	21	20	21	23	26	28	33	40	48	52	53	56	56	56	55
Georgetown Pike Interchange	19	20	20	21	23	27	29	33	41	49	51	53	55	56	55	55
	25	27	28	29	31	35	37	41	47	50	50	52	54	55	54	54
Dulles Toll Road Interchange	24	27	28	30	34	38	40	45	48	48	50	51	54	55	54	51
	34	38	39	41	44	47	50	52	55	54	54	57	59	59	58	56
Route 123 Interchange	37	40	42	45	49	53	54	56	59	58	59	61	62	62	61	59
	39	41	41	43	49	54	58	60	61	60	62	63	63	63	63	62
Route 7/Leesburg Pike Interchange	23	24	27	30	37	48	55	57	57	58	60	60	60	60	60	60
	22	22	27	34	44	54	59	60	59	62	63	63	63	62	62	62
I-66 Interchange	31	31	36	44	51	56	58	58	58	60	59	59	59	57	57	57

	1:00 PM	1:15 PM	1:30 PM	1:45 PM	2:00 PM	2:15 PM	2:30 PM	2:45 PM	3:00 PM	3:15 PM	3:30 PM	3:45 PM	4:00 PM	4:15 PM	4:30 PM	4:45 PM
Cabin John Parkway Interchange	63	62	59	57	56	54	52	50	43	29	20	14	13	12	11	11
	61	60	58	56	54	52	50	49	46	35	25	17	15	14	13	14
Clara Barton Parkway Interchange	56	54	51	48	46	42	38	38	37	31	25	19	16	15	15	15
	55	50	45	40	38	34	28	27	26	24	21	17	15	15	14	15
GW Parkway Interchange	52	50	44	39	34	28	21	20	19	18	16	14	12	12	12	12
	52	51	46	40	34	25	18	15	14	13	12	11	9	9	9	9
Georgetown Pike Interchange	53	50	47	42	36	26	18	15	14	13	11	10	9	8	8	8
	52	51	48	46	43	36	26	20	18	17	14	12	11	10	9	9
Dulles Toll Road Interchange	50	48	46	44	42	39	27	21	19	18	16	14	13	12	10	9
	56	53	50	50	49	48	38	31	30	29	27	25	25	24	21	20
Route 123 Interchange	58	56	54	54	53	54	45	36	33	33	32	31	31	32	29	28
	60	58	59	60	61	61	56	48	45	44	45	43	44	47	44	47
Route 7/Leesburg Pike Interchange	60	59	59	58	59	60	59	59	57	54	55	55	54	55	55	55
	63	63	62	62	61	61	61	63	61	58	61	61	60	59	60	59
I-66 Interchange	57	58	58	59	59	58	58	58	59	59	59	60	61	60	58	58

	5:00 PM	5:15 PM	5:30 PM	5:45 PM	6:00 PM	6:15 PM	6:30 PM	6:45 PM	7:00 PM	7:15 PM	7:30 PM	7:45 PM	8:00 PM	8:15 PM	8:30 PM	8:45 PM
Cabin John Parkway Interchange	11	11	10	11	12	14	17	25	27	34	43	50	55	59	61	62
	15	14	13	13	15	17	20	30	31	38	44	50	53	57	60	60
Clara Barton Parkway Interchange	15	15	15	15	16	18	20	27	28	33	37	40	44	50	55	57
	15	15	15	15	16	17	19	22	24	27	30	33	38	46	55	59
GW Parkway Interchange	12	12	13	12	13	13	14	17	19	21	24	27	33	45	55	57
	9	9	9	9	9	10	10	12	14	16	19	22	29	45	54	59
Georgetown Pike Interchange	8	8	8	8	9	9	9	11	14	15	18	22	30	46	54	58
	9	9	9	9	9	10	11	12	16	18	22	29	39	49	56	59
Dulles Toll Road Interchange	9	9	9	9	9	9	10	11	16	19	26	38	45	52	55	58
	19	21	19	19	17	17	17	18	23	33	41	50	55	57	58	59
Route 123 Interchange	27	28	28	30	29	27	27	27	32	42	48	54	56	58	59	60
	43	42	44	50	50	46	49	48	50	53	54	57	59	59	60	60
Route 7/Leesburg Pike Interchange	55	54	56	55	56	56	57	57	57	59	60	60	61	61	60	60
	58	57	59	58	60	60	60	61	62	63	63	63	63	63	63	62
I-66 Interchange	58	58	58	58	59	59	59	61	61	61	61	61	61	61	61	61

Study Area
Proposed Analysis Peak Hour
Proposed Analysis Peak Period
State Line

- AM peak: 6:45 AM to 9:45 AM (peak hour 7:45 AM to 8:45 AM). This will capture the onset of queueing back from the American Legion Bridge and the start of the dissipation of the queue. The peak hour captures the current worst extent of queueing.
- PM peak: 2:45 PM to 5:45 PM (peak hour 3:45 PM to 4:45 PM). This peak period is intended to capture queue formation from the American Legion Bridge *before the queue from points further north in Maryland spill back and create a single continuous queue*. This can be observed in the figure, as prior to approximately 3:30 PM, congestion in Virginia does not continue into Maryland. By approximately 4:00 PM, a single continuous area of congestion is present from north of the study area through the Route 123 interchange. Between approximately 4:00 PM and 7:00 PM, however, the extent of queueing stays relatively consistent – to the Route 123 interchange. The congestion does not fully dissipate until after 8:00 PM on average – note that the proposed traffic analysis period is not recommended to last until this point. Rather, the proposed traffic analysis period captures the onset of queueing (from when the queue is not due to spillback from Maryland) until it reaches its maximum.

Although the peak period in the afternoon and evening typically extends beyond six hours of congestion, the proposed analysis periods will still capture the onset of congestion and maximum extents of congestion, while allowing for the analysis to proceed in a streamlined manner within the scope and schedule of the project.

Conclusion

The VISSIM calibration criteria and simulation analysis peak hours and peak periods have been reviewed and approved by the VDOT NoVA District Traffic Engineer. The elements of the traffic analysis framework were presented to VDOT staff on July 20, 2018. The analysis tools and framework described in this document will be carried forward for the I-495 NEXT project.

Appendix F: Sample MOVE Run Specification for MSAT Analysis

Sample MOVES2014b Run-Spec

2021 Scenario Run for Diesel PM

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Scenario:  Existing
County:  Fairfax]]></description>
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2021 Scenario Run for MSAT Pollutants without Diesel PM

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Scenario:  Existing
County:  Fairfax]]></description>
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sourcetypename="Transit Bus"/>
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sourcetypename="Combination Long-haul Truck"/>
      <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="61"
sourcetypename="Combination Short-haul Truck"/>
      <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="41"
sourcetypename="Intercity Bus"/>
      <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="32"
sourcetypename="Light Commercial Truck"/>
      <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="54"
sourcetypename="Motor Home"/>
      <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="21"
sourcetypename="Passenger Car"/>
      <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="31"
sourcetypename="Passenger Truck"/>
      <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="51"
sourcetypename="Refuse Truck"/>
      <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="43"
sourcetypename="School Bus"/>
      <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="53"
sourcetypename="Single Unit Long-haul Truck"/>
      <onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="52"
sourcetypename="Single Unit Short-haul Truck"/>
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sourcetypename="Transit Bus"/>
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sourcetypename="Light Commercial Truck"/>
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sourcetypename="Passenger Car"/>
		<onroadvehicleselection fueltypeid="9" fueltypedesc="Electricity" sourcetypeid="31"
sourcetypename="Passenger Truck"/>
		<onroadvehicleselection fueltypeid="5" fueltypedesc="Ethanol (E-85)" sourcetypeid="32"
sourcetypename="Light Commercial Truck"/>
		<onroadvehicleselection fueltypeid="5" fueltypedesc="Ethanol (E-85)" sourcetypeid="21"
sourcetypename="Passenger Car"/>
		<onroadvehicleselection fueltypeid="5" fueltypedesc="Ethanol (E-85)" sourcetypeid="31"
sourcetypename="Passenger Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="61"
sourcetypename="Combination Short-haul Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="32" sourcetypename="Light
Commercial Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="54" sourcetypename="Motor
Home"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="11"
sourcetypename="Motorcycle"/>
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sourcetypename="Passenger Car"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="31"
sourcetypename="Passenger Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="51"
sourcetypename="Refuse Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="43"
sourcetypename="School Bus"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="53" sourcetypename="Single
Unit Long-haul Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="52" sourcetypename="Single
Unit Short-haul Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="42"
sourcetypename="Transit Bus"/>
			</onroadvehicleselections>
			<offroadvehicleselections>
			</offroadvehicleselections>
			<offroadvehiclesccs>
			</offroadvehiclesccs>
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					<roadtype roadtypeid="3" roadtypename="Rural Unrestricted Access"
modelCombination="M1"/>
					<roadtype roadtypeid="4" roadtypename="Urban Restricted Access" modelCombination="M1"/>
					<roadtype roadtypeid="5" roadtypename="Urban Unrestricted Access"
modelCombination="M1"/>
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processname="Running Exhaust"/>
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processname="Crankcase Running Exhaust"/>
		<pollutantprocessassociation pollutantkey="170" pollutantname="Acenaphthene gas" processkey="1"
processname="Running Exhaust"/>
		<pollutantprocessassociation pollutantkey="170" pollutantname="Acenaphthene gas" processkey="15"
processname="Crankcase Running Exhaust"/>
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processname="Running Exhaust"/>
```

```
	<pollutantprocessassociation pollutantkey="70" pollutantname="Acenaphthene particle" processkey="15" processname="Crankcase Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="171" pollutantname="Acenaphthylene gas" processkey="1" processname="Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="171" pollutantname="Acenaphthylene gas" processkey="15" processname="Crankcase Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="71" pollutantname="Acenaphthylene particle" processkey="1" processname="Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="71" pollutantname="Acenaphthylene particle" processkey="15" processname="Crankcase Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="26" pollutantname="Acetaldehyde" processkey="1" processname="Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="26" pollutantname="Acetaldehyde" processkey="15" processname="Crankcase Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="27" pollutantname="Acrolein" processkey="1" processname="Running Exhaust"/>
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	<pollutantprocessassociation pollutantkey="172" pollutantname="Anthracene gas" processkey="1" processname="Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="172" pollutantname="Anthracene gas" processkey="15" processname="Crankcase Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="72" pollutantname="Anthracene particle" processkey="1" processname="Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="72" pollutantname="Anthracene particle" processkey="15" processname="Crankcase Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="173" pollutantname="Benz(a)anthracene gas" processkey="1" processname="Running Exhaust"/>
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	<pollutantprocessassociation pollutantkey="73" pollutantname="Benz(a)anthracene particle" processkey="1" processname="Running Exhaust"/>
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	<pollutantprocessassociation pollutantkey="20" pollutantname="Benzene" processkey="13" processname="Evap Fuel Leaks"/>
	<pollutantprocessassociation pollutantkey="20" pollutantname="Benzene" processkey="15" processname="Crankcase Running Exhaust"/>
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```

```
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	<pollutantprocessassociation pollutantkey="176" pollutantname="Benzo(g,h,i)perylene gas" processkey="1" processname="Running Exhaust"/>
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	<pollutantprocessassociation pollutantkey="118" pollutantname="Composite - NonECPM" processkey="1" processname="Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="168" pollutantname="Dibenzo(a,h)anthracene gas" processkey="1" processname="Running Exhaust"/>
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	<pollutantprocessassociation pollutantkey="68" pollutantname="Dibenzo(a,h)anthracene particle" processkey="1" processname="Running Exhaust"/>
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	<pollutantprocessassociation pollutantkey="41" pollutantname="Ethyl Benzene" processkey="15" processname="Crankcase Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="169" pollutantname="Fluoranthene gas" processkey="1" processname="Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="169" pollutantname="Fluoranthene gas" processkey="15" processname="Crankcase Running Exhaust"/>
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	<pollutantprocessassociation pollutantkey="181" pollutantname="Fluorene gas" processkey="1" processname="Running Exhaust"/>
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```

```
	<pollutantprocessassociation pollutantkey="81" pollutantname="Fluorene particle" processkey="1" processname="Running Exhaust"/>
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	<pollutantprocessassociation pollutantkey="82" pollutantname="Indeno(1,2,3,c,d)pyrene particle" processkey="15" processname="Crankcase Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="185" pollutantname="Naphthalene gas" processkey="1" processname="Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="185" pollutantname="Naphthalene gas" processkey="11" processname="Evap Permeation"/>
	<pollutantprocessassociation pollutantkey="185" pollutantname="Naphthalene gas" processkey="13" processname="Evap Fuel Leaks"/>
	<pollutantprocessassociation pollutantkey="185" pollutantname="Naphthalene gas" processkey="15" processname="Crankcase Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="23" pollutantname="Naphthalene particle" processkey="1" processname="Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="23" pollutantname="Naphthalene particle" processkey="15" processname="Crankcase Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="79" pollutantname="Non-Methane Hydrocarbons" processkey="1" processname="Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="79" pollutantname="Non-Methane Hydrocarbons" processkey="11" processname="Evap Permeation"/>
	<pollutantprocessassociation pollutantkey="79" pollutantname="Non-Methane Hydrocarbons" processkey="13" processname="Evap Fuel Leaks"/>
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	<pollutantprocessassociation pollutantkey="183" pollutantname="Phenanthrene gas" processkey="1" processname="Running Exhaust"/>
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	<pollutantprocessassociation pollutantkey="83" pollutantname="Phenanthrene particle" processkey="1" processname="Running Exhaust"/>
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	<pollutantprocessassociation pollutantkey="184" pollutantname="Pyrene gas" processkey="1" processname="Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="184" pollutantname="Pyrene gas" processkey="15" processname="Crankcase Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="84" pollutantname="Pyrene particle" processkey="1" processname="Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="84" pollutantname="Pyrene particle" processkey="15" processname="Crankcase Running Exhaust"/>
	<pollutantprocessassociation pollutantkey="115" pollutantname="Sulfate Particulate" processkey="1" processname="Running Exhaust"/>
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```
    <pollutantprocessassociation pollutantkey="1" pollutantname="Total Gaseous Hydrocarbons" processkey="1"
processname="Running Exhaust"/>
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processkey="11" processname="Evap Permeation"/>
    <pollutantprocessassociation pollutantkey="1" pollutantname="Total Gaseous Hydrocarbons"
processkey="13" processname="Evap Fuel Leaks"/>
    <pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds"
processkey="1" processname="Running Exhaust"/>
    <pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds"
processkey="11" processname="Evap Permeation"/>
    <pollutantprocessassociation pollutantkey="87" pollutantname="Volatile Organic Compounds"
processkey="13" processname="Evap Fuel Leaks"/>
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            <databaseselection servername="" databasename="va_stage2_input_20161104" description=""/>
      </databaseselections>
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classname="gov.epa.otaq.moves.master.implementation.ghg.internalcontrolstrategies.rateofprogress.RateOfProgress
Strategy"><![CDATA[
useParameters	No

]]></internalcontrolstrategy>
      </internalcontrolstrategies>
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      <uncertaintyparameters uncertaintymodeenabled="false" numberofrunspersimulation="0"
numberofsimulations="0"/>
      <geographicoutputdetail description="COUNTY"/>
      <outputemissionsbreakdownselection>
            <modelyear selected="false"/>
            <fueltype selected="false"/>
            <fuelsubtype selected="false"/>
            <emissionprocess selected="true"/>
            <onroadoffroad selected="true"/>
            <roadtype selected="true"/>
            <sourceusetype selected="true"/>
            <movesvehicletype selected="false"/>
            <onroadscc selected="false"/>
            <estimateuncertainty selected="false" numberOfIterations="2" keepSampledData="false"
keepIterations="false"/>
            <sector selected="false"/>
            <engtechid selected="false"/>
            <hpclass selected="false"/>
            <regclassid selected="false"/>
      </outputemissionsbreakdownselection>
      <outputdatabase servername="localhost" databasename="I495_MSAT_51059_2017_4Seasons_mo"
description=""/>
      <outputtimestep value="24-Hour Day"/>
      <outputvmtdata value="true"/>
      <outputsho value="false"/>
      <outputsh value="false"/>
      <outputshp value="false"/>
      <outputshidling value="false"/>
      <outputstarts value="false"/>
      <outputpopulation value="true"/>
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```
	<scaleinputdatabase servername="localhost" databasename="I495_MSAT_51059_2017_4Seasons_mi"
description=""/>
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	<outputfactors>
		<timefactors selected="true" units="Days"/>
		<distancefactors selected="true" units="Miles"/>
		<massfactors selected="true" units="Grams" energyunits="Million BTU"/>
	</outputfactors>
	<savedata>

	</savedata>

	<donotexecute>

	</donotexecute>

	<generatordatabase shouldsave="false" servername="" databasename="" description=""/>
		<donotperformfinalaggregation selected="false"/>
	<lookuptableflags scenarioid="" truncateoutput="false" truncateactivity="false" truncatebaserates="true"/>
</runspec>
```

Appendix G: Sample MOVE Run Specification for CO Analysis

Sample MOVES2014b Run-Spec

2021 Scenario Run

```xml
<runspec version="MOVES2014b-20181203">
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	<models>
		<model value="ONROAD"/>
	</models>
	<modelscale value="Inv"/>
	<modeldomain value="PROJECT"/>
	<geographicselections>
		<geographicselection type="COUNTY" key="51059" description="VIRGINIA - Fairfax County"/>
	</geographicselections>
	<timespan>
		<year key="2021"/>
		<month id="1"/>
		<day id="5"/>
		<beginhour id="18"/>
		<endhour id="18"/>
		<aggregateBy key="Hour"/>
	</timespan>
	<onroadvehicleselections>
		<onroadvehicleselection fueltypeid="3" fueltypedesc="Compressed Natural Gas (CNG)" sourcetypeid="42" sourcetypename="Transit Bus"/>
		<onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="62" sourcetypename="Combination Long-haul Truck"/>
		<onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="61" sourcetypename="Combination Short-haul Truck"/>
		<onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="41" sourcetypename="Intercity Bus"/>
		<onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="32" sourcetypename="Light Commercial Truck"/>
		<onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="54" sourcetypename="Motor Home"/>
		<onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="21" sourcetypename="Passenger Car"/>
		<onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="31" sourcetypename="Passenger Truck"/>
		<onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="51" sourcetypename="Refuse Truck"/>
		<onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="43" sourcetypename="School Bus"/>
		<onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="53" sourcetypename="Single Unit Long-haul Truck"/>
		<onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="52" sourcetypename="Single Unit Short-haul Truck"/>
		<onroadvehicleselection fueltypeid="2" fueltypedesc="Diesel Fuel" sourcetypeid="42" sourcetypename="Transit Bus"/>
		<onroadvehicleselection fueltypeid="9" fueltypedesc="Electricity" sourcetypeid="32" sourcetypename="Light Commercial Truck"/>
		<onroadvehicleselection fueltypeid="9" fueltypedesc="Electricity" sourcetypeid="21" sourcetypename="Passenger Car"/>
		<onroadvehicleselection fueltypeid="9" fueltypedesc="Electricity" sourcetypeid="31" sourcetypename="Passenger Truck"/>
		<onroadvehicleselection fueltypeid="5" fueltypedesc="Ethanol (E-85)" sourcetypeid="32" sourcetypename="Light Commercial Truck"/>
		<onroadvehicleselection fueltypeid="5" fueltypedesc="Ethanol (E-85)" sourcetypeid="21" sourcetypename="Passenger Car"/>
		<onroadvehicleselection fueltypeid="5" fueltypedesc="Ethanol (E-85)" sourcetypeid="31" sourcetypename="Passenger Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="61" sourcetypename="Combination Short-haul Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="32" sourcetypename="Light Commercial Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="54" sourcetypename="Motor Home"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="11" sourcetypename="Motorcycle"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="21" sourcetypename="Passenger Car"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="31" sourcetypename="Passenger Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="51" sourcetypename="Refuse Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="43" sourcetypename="School Bus"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="53" sourcetypename="Single Unit Long-haul Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="52" sourcetypename="Single Unit Short-haul Truck"/>
		<onroadvehicleselection fueltypeid="1" fueltypedesc="Gasoline" sourcetypeid="42" sourcetypename="Transit Bus"/>
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	<offroadvehicleselections>
	</offroadvehicleselections>
	<offroadvehiclesccs>
	</offroadvehiclesccs>
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		<roadtype roadtypeid="4" roadtypename="Urban Restricted Access" modelCombination="M1"/>
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	</roadtypes>
	<pollutantprocessassociations>
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```

```
				<pollutantprocessassociation pollutantkey="2" pollutantname="Carbon Monoxide (CO)" processkey="15"
processname="Crankcase Running Exhaust"/>
		</pollutantprocessassociations>
		<databaseselections>
				<databaseselection servername="" databasename="MOVES2014_early_NLEV" description=""/>
				<databaseselection servername="" databasename="va_stage2_input_20161104" description=""/>
		</databaseselections>
		<internalcontrolstrategies>
<internalcontrolstrategy
classname="gov.epa.otaq.moves.master.implementation.ghg.internalcontrolstrategies.rateofprogress.RateOfProgressStrategy"><![CDATA[
useParameters		No

]]></internalcontrolstrategy>
		</internalcontrolstrategies>
		<inputdatabase servername="" databasename="" description=""/>
		<uncertaintyparameters uncertaintymodeenabled="false" numberofrunspersimulation="0" numberofsimulations="0"/>
		<geographicoutputdetail description="LINK"/>
		<outputemissionsbreakdownselection>
				<modelyear selected="false"/>
				<fueltype selected="false"/>
				<fuelsubtype selected="false"/>
				<emissionprocess selected="true"/>
				<onroadoffroad selected="true"/>
				<roadtype selected="true"/>
				<sourceusetype selected="false"/>
				<movesvehicletype selected="false"/>
				<onroadscc selected="false"/>
				<estimateuncertainty selected="false" numberOfIterations="2" keepSampledData="false" keepIterations="false"/>
				<sector selected="false"/>
				<engtechid selected="false"/>
				<hpclass selected="false"/>
				<regclassid selected="false"/>
		</outputemissionsbreakdownselection>
		<outputdatabase servername="" databasename="I495_51059_2021_01_05_CO_pmo" description=""/>
		<outputtimestep value="Hour"/>
		<outputvmtdata value="true"/>
		<outputsho value="false"/>
		<outputsh value="false"/>
		<outputshp value="false"/>
		<outputshidling value="false"/><outputstarts value="false"/>
		<outputpopulation value="true"/>
		<scaleinputdatabase servername="localhost" databasename="I495_51059_2021_01_05_CO_pmi" description=""/>
		<pmsize value="0"/>
		<outputfactors>
				<timefactors selected="true" units="Hours"/>
				<distancefactors selected="true" units="Miles"/>
				<massfactors selected="true" units="Grams" energyunits="Million BTU"/>
		</outputfactors>
		<savedata>

		</savedata>

		<donotexecute>

		</donotexecute>

		<generatordatabase shouldsave="false" servername="" databasename="" description=""/>
				<donotperformfinalaggregation selected="false"/>
		<lookuptableflags scenarioid="" truncateoutput="true" truncateactivity="true" truncatebaserates="true"/>
</runspec>
```

Emission Factor Charts

linkID	roadTypeID	linkAvgSpeed	linkDescription	linkAvgGrade (%)	2025	2045	EF Unit
1	5	0	Urban unrestricted queue (idle) link	5	5.4247	1.9233	g/veh-hr
2	5	0	Urban unrestricted queue (idle) link	4	5.4247	1.9233	g/veh-hr
3	5	0	Urban unrestricted queue (idle) link	3	5.4247	1.9233	g/veh-hr
4	5	0	Urban unrestricted queue (idle) link	2	5.4247	1.9233	g/veh-hr
5	5	0	Urban unrestricted queue (idle) link	1	5.4247	1.9233	g/veh-hr
6	5	0	Urban unrestricted queue (idle) link	0	5.4247	1.9233	g/veh-hr
7	5	0	Urban unrestricted queue (idle) link	-1	5.4247	1.9233	g/veh-hr
8	5	0	Urban unrestricted queue (idle) link	-2	5.4247	1.9233	g/veh-hr
9	5	0	Urban unrestricted queue (idle) link	-3	5.4247	1.9233	g/veh-hr
10	5	0	Urban unrestricted queue (idle) link	-4	5.4247	1.9233	g/veh-hr
11	5	0	Urban unrestricted queue (idle) link	-5	5.4247	1.9233	g/veh-hr
12	5	25	Urban unrestricted free flow link	5	4.9648	1.8297	g/mi
13	5	25	Urban unrestricted free flow link	4	3.8881	1.3961	g/mi
14	5	25	Urban unrestricted free flow link	3	3.2845	1.1579	g/mi
15	5	25	Urban unrestricted free flow link	2	2.9175	1.0190	g/mi
16	4	25	Urban unrestricted free flow link	1	2.5684	0.8714	g/mi
17	4	25	Urban unrestricted free flow link	0	2.2031	0.7269	g/mi
18	4	25	Urban unrestricted free flow link	-1	1.9350	0.6321	g/mi
19	4	25	Urban unrestricted free flow link	-2	1.7274	0.5650	g/mi
20	4	25	Urban unrestricted free flow link	-3	1.5753	0.5174	g/mi
21	4	25	Urban unrestricted free flow link	-4	1.3967	0.4571	g/mi
22	4	25	Urban unrestricted free flow link	-5	1.2415	0.4042	g/mi
23	4	35	Urban unrestricted free flow link	5	4.8004	1.8173	g/mi
24	4	35	Urban unrestricted free flow link	4	3.9844	1.4837	g/mi
25	4	35	Urban unrestricted free flow link	3	3.3230	1.2219	g/mi
26	4	35	Urban unrestricted free flow link	2	2.8168	1.0254	g/mi
27	4	35	Urban unrestricted free flow link	1	2.3300	0.8370	g/mi
28	4	35	Urban unrestricted free flow link	0	1.9512	0.6911	g/mi
29	4	35	Urban unrestricted free flow link	-1	1.6535	0.5799	g/mi
30	5	35	Urban unrestricted free flow link	-2	1.4113	0.4900	g/mi
31	5	35	Urban unrestricted free flow link	-3	1.2107	0.4152	g/mi
32	5	35	Urban unrestricted free flow link	-4	1.0399	0.3560	g/mi
33	5	35	Urban unrestricted free flow link	-5	0.9047	0.3104	g/mi
34	5	45	Urban unrestricted free flow link	5	5.3305	2.1100	g/mi
35	5	45	Urban unrestricted free flow link	4	4.3510	1.7167	g/mi
36	5	45	Urban unrestricted free flow link	3	3.4640	1.3578	g/mi
37	5	45	Urban unrestricted free flow link	2	2.7792	1.0789	g/mi
38	5	45	Urban unrestricted free flow link	1	2.2270	0.8521	g/mi
39	5	45	Urban unrestricted free flow link	0	1.7454	0.6561	g/mi
40	5	45	Urban unrestricted free flow link	-1	1.4356	0.5340	g/mi
41	5	45	Urban unrestricted free flow link	-2	1.1912	0.4426	g/mi
42	5	45	Urban unrestricted free flow link	-3	0.9935	0.3690	g/mi
43	5	45	Urban unrestricted free flow link	-4	0.8188	0.3046	g/mi
44	5	45	Urban unrestricted free flow link	-5	0.6888	0.2557	g/mi
45	4	55	Urban restricted free flow link	5	5.6865	2.2890	g/mi
46	4	55	Urban restricted free flow link	4	4.6250	1.8691	g/mi
47	4	55	Urban restricted free flow link	3	3.6985	1.5034	g/mi
48	4	55	Urban restricted free flow link	2	2.8809	1.1654	g/mi
49	4	55	Urban restricted free flow link	1	2.2203	0.8866	g/mi
50	4	55	Urban restricted free flow link	0	1.6834	0.6590	g/mi
51	4	55	Urban restricted free flow link	-1	1.3188	0.5102	g/mi
52	4	55	Urban restricted free flow link	-2	1.0649	0.4119	g/mi
53	4	55	Urban restricted free flow link	-3	0.8770	0.3436	g/mi
54	4	55	Urban restricted free flow link	-4	0.7232	0.2858	g/mi
55	4	55	Urban restricted free flow link	-5	0.5693	0.2245	g/mi

Appendix H: Sample CAL3i Input / Output Files

Sample CAL3QHC Inputs

As generated using the FHWA Cal3i Model

2023 Worst Case Build Scenario

```
'I-495 NEXT'                      60      108      0      0      28      0.3048   1     1
'RCP N Leg E Side - Corner'           58.0     82.0     5.9
'RCP N Leg E Side - 25 m'             58.0    154.0     5.9
'RCP N Leg E Side - 50 m'             58.0    236.0     5.9
'RCP N Leg E Side - Midblk'           58.0    672.0     5.9
'RCP N Leg W Side - Corner'          -58.0     82.0     5.9
'RCP N Leg W Side - 25 m'            -58.0    154.0     5.9
'RCP N Leg W Side - 50 m'            -58.0    236.0     5.9
'RCP N Leg W Side - Midblk'          -58.0    672.0     5.9
'RCP S Leg. E Side - Corner'          58.0    -82.0     5.9
'RCP S Leg. E Side - 25 m'            58.0   -154.0     5.9
'RCP S Leg. E Side - 50 m'            58.0   -236.0     5.9
'RCP S Leg. E Side - Midblk'          58.0   -672.0     5.9
'RCP S Leg. W Side - Corner'         -58.0    -82.0     5.9
'RCP S Leg. W Side - 25 m'           -58.0   -154.0     5.9
'RCP S Leg. W Side - 50 m'           -58.0   -236.0     5.9
'RCP S Leg. W Side - Midblk'         -58.0   -672.0     5.9
'RCP E Leg N Side - 25 m'            130.0     82.0     5.9
'RCP E Leg N Side - 50 m'            212.0     82.0     5.9
'RCP E Leg N Side - Midblk'          648.0     82.0     5.9
'RCP W Leg N Side - 25 m'           -130.0     82.0     5.9
'RCP W Leg N Side - 50 m'           -212.0     82.0     5.9
'RCP W Leg N Side - Midblk'         -648.0     82.0     5.9
'RCP E Leg S Side - 25 m'            130.0    -82.0     5.9
'RCP E Leg S Side - 50 m'            212.0    -82.0     5.9
'RCP E Leg S Side - Midblk'          648.0    -82.0     5.9
'RCP W Leg S Side - 25 m'           -130.0    -82.0     5.9
'RCP W Leg S Side - 50 m'           -212.0    -82.0     5.9
'RCP W Leg S Side - Midblk'         -648.0    -82.0     5.9
'2023 Rt123 & Tysons Blvd'                12       1       0       'c'
1
'N Leg App - FreeFlow'           'AG'    -24.0    0.0    -24.0    1200.0    4920    5.3305    0    67.7
1
'N Leg Dep - FreeFlow'           'AG'     24.0    0.0     24.0    1200.0    4920    5.3305    0    67.7
1
'S Leg App - FreeFlow'           'AG'     24.0    0.0     24.0   -1200.0    4920    5.3305    0    67.7
1
'S Leg Dep - FreeFlow'           'AG'    -24.0    0.0    -24.0   -1200.0    4920    5.3305    0    67.7
1
'E Leg App - FreeFlow'           'AG'      0.0   36.0   1200.0      36.0    7380    5.3305    0    91.7
1
'E Leg Dep - FreeFlow'           'AG'      0.0  -36.0   1200.0     -36.0    7380    5.3305    0    91.7
1
'W Leg App - FreeFlow'           'AG'      0.0  -36.0  -1200.0     -36.0    7380    5.3305    0    91.7
1
'W Leg Dep - FreeFlow'           'AG'      0.0   36.0  -1200.0      36.0    7380    5.3305    0    91.7
2
'N Leg App - Queue'              'AG'    -24.0   72.0    -24.0    1200.0    0    48.0    4
                        120      68      2     4920    5.4247    1900    1    3
2
'S Leg App - Queue'              'AG'     24.0  -72.0     24.0   -1200.0    0    48.0    4
                        120      68      2     4920    5.4247    1900    1    3
2
'E Leg App - Queue'              'AG'     48.0   36.0   1200.0      36.0    0    72.0    6
                        120      68      2     7380    5.4247    1900    1    3
2
'W Leg App - Queue'              'AG'    -48.0  -36.0  -1200.0     -36.0    0    72.0    6
                        120      68      2     7380    5.4247    1900    1    3
1                       0        4     1000    0     'Y'     10     1     36
```

Sample CAL3QHC Output

2023 Worst Case Build Scenario

```
                  *** EPA CAL3QHC Model Run implemented using the FHWA Resource Center CAL3i
graphical user interface

                 CAL3QHC: LINE SOURCE DISPERSION MODEL - VERSION 2.0 Dated 13045
PAGE  1

      JOB: I-495 NEXT                                        RUN: 2023 Rt123 & Tysons Blvd

      DATE : 12/19/19
      TIME : 23:54: 2

         The MODE flag has been set for calculating concentrations for POLLUTANT:  CO

       SITE & METEOROLOGICAL VARIABLES
       -------------------------------
       VS =   0.0 CM/S       VD =   0.0 CM/S       Z0 = 108. CM
        U =  1.0 M/S         CLAS =   4  (D)     ATIM =  60. MINUTES     MIXH =  1000. M   AMB =
0.0 PPM

       LINK VARIABLES
       --------------
         LINK DESCRIPTION     *         LINK COORDINATES (FT)          *    LENGTH  BRG TYPE
VPH    EF      H   W    V/C QUEUE
                              *   X1        Y1        X2        Y2     *     (FT)  (DEG)
(G/MI)  (FT) (FT)       (VEH)
      ------------------------*----------------------------------------*-------------------------
---------------------------------
       1. N Leg App - FreeFlow*    -24.0       0.0     -24.0    1200.0 *    1200.   360. AG
4920.   5.3   0.0 67.7
       2. N Leg Dep - FreeFlow*     24.0       0.0      24.0    1200.0 *    1200.   360. AG
4920.   5.3   0.0 67.7
       3. S Leg App - FreeFlow*     24.0       0.0      24.0   -1200.0 *    1200.   180. AG
4920.   5.3   0.0 67.7
       4. S Leg Dep - FreeFlow*    -24.0       0.0     -24.0   -1200.0 *    1200.   180. AG
4920.   5.3   0.0 67.7
       5. E Leg App - FreeFlow*      0.0      36.0    1200.0      36.0 *    1200.    90. AG
7380.   5.3   0.0 91.7
       6. E Leg Dep - FreeFlow*      0.0     -36.0    1200.0     -36.0 *    1200.    90. AG
7380.   5.3   0.0 91.7
       7. W Leg App - FreeFlow*      0.0     -36.0   -1200.0     -36.0 *    1200.   270. AG
7380.   5.3   0.0 91.7
       8. W Leg Dep - FreeFlow*      0.0      36.0   -1200.0      36.0 *    1200.   270. AG
7380.   5.3   0.0 91.7
       9. N Leg App - Queue   *    -24.0      72.0     -24.0    5372.1 *    5300.   360. AG
33. 100.0   0.0 48.0 1.62 269.2
      10. S Leg App - Queue   *     24.0     -72.0      24.0   -5372.1 *    5300.   180. AG
33. 100.0   0.0 48.0 1.62 269.2
      11. E Leg App - Queue   *     48.0      36.0    5348.1      36.0 *    5300.    90. AG
49. 100.0   0.0 72.0 1.62 269.2
      12. W Leg App - Queue   *    -48.0     -36.0   -5348.1     -36.0 *    5300.   270. AG
49. 100.0   0.0 72.0 1.62 269.2
```

```
PAGE  2
      JOB: I-495 NEXT                                           RUN: 2023 Rt123 & Tysons Blvd

      DATE : 12/19/19
      TIME : 23:54: 2

       ADDITIONAL QUEUE LINK PARAMETERS
       --------------------------------
         LINK DESCRIPTION     *    CYCLE    RED     CLEARANCE  APPROACH  SATURATION   IDLE
SIGNAL   ARRIVAL
                              *    LENGTH   TIME    LOST TIME    VOL     FLOW RATE   EM FAC
TYPE     RATE
                              *     (SEC)   (SEC)    (SEC)      (VPH)      (VPH)    (gm/hr)
      ------------------------*------------------------------------------------------------------
--------------
       9. N Leg App - Queue   *     120       68       2.0      4920       1900       5.42      1
3
      10. S Leg App - Queue   *     120       68       2.0      4920       1900       5.42      1
3
      11. E Leg App - Queue   *     120       68       2.0      7380       1900       5.42      1
3
      12. W Leg App - Queue   *     120       68       2.0      7380       1900       5.42      1
3

       RECEPTOR LOCATIONS
       ------------------
                              *           COORDINATES (FT)          *
         RECEPTOR             *      X          Y          Z        *
     -------------------------*-------------------------------------*
      1. RCP N Leg E Side - C *        58.0       82.0        5.9   *
      2. RCP N Leg E Side - 2 *        58.0      154.0        5.9   *
      3. RCP N Leg E Side - 5 *        58.0      236.0        5.9   *
      4. RCP N Leg E Side - M *        58.0      672.0        5.9   *
      5. RCP N Leg W Side - C *       -58.0       82.0        5.9   *
      6. RCP N Leg W Side - 2 *       -58.0      154.0        5.9   *
      7. RCP N Leg W Side - 5 *       -58.0      236.0        5.9   *
      8. RCP N Leg W Side - M *       -58.0      672.0        5.9   *
      9. RCP S Leg. E Side -  *        58.0      -82.0        5.9   *
     10. RCP S Leg. E Side -  *        58.0     -154.0        5.9   *
     11. RCP S Leg. E Side -  *        58.0     -236.0        5.9   *
     12. RCP S Leg. E Side -  *        58.0     -672.0        5.9   *
     13. RCP S Leg. W Side -  *       -58.0      -82.0        5.9   *
     14. RCP S Leg. W Side -  *       -58.0     -154.0        5.9   *
     15. RCP S Leg. W Side -  *       -58.0     -236.0        5.9   *
     16. RCP S Leg. W Side -  *       -58.0     -672.0        5.9   *
     17. RCP E Leg N Side - 2 *       130.0       82.0        5.9   *
     18. RCP E Leg N Side - 5 *       212.0       82.0        5.9   *
     19. RCP E Leg N Side - M *       648.0       82.0        5.9   *
     20. RCP W Leg N Side - 2 *      -130.0       82.0        5.9   *
     21. RCP W Leg N Side - 5 *      -212.0       82.0        5.9   *
     22. RCP W Leg N Side - M *      -648.0       82.0        5.9   *
     23. RCP E Leg S Side - 2 *       130.0      -82.0        5.9   *
     24. RCP E Leg S Side - 5 *       212.0      -82.0        5.9   *
     25. RCP E Leg S Side - M *       648.0      -82.0        5.9   *
     26. RCP W Leg S Side - 2 *      -130.0      -82.0        5.9   *
     27. RCP W Leg S Side - 5 *      -212.0      -82.0        5.9   *
     28. RCP W Leg S Side - M *      -648.0      -82.0        5.9   *
```

```
       MODEL RESULTS
       -------------

       REMARKS : In search of the angle corresponding to
                 the maximum concentration, only the first
                 angle, of the angles with same maximum
                 concentrations, is indicated as maximum.

 WIND ANGLE RANGE:  10.-360.

 WIND  * CONCENTRATION
 ANGLE *     (PPM)
 (DEGR)*       1       2       3       4       5       6       7       8       9      10      11
12      13      14      15
 ------*-----------------------------------------------------------------------------------------
------------------------------
  10.  *  0.7000  0.7000  0.7000  0.5000  2.2000  2.2000  2.2000  1.9000  2.4000  1.7000  1.4000
1.2000  3.8000  3.2000  2.8000
  20.  *  0.2000  0.2000  0.2000  0.2000  2.0000  2.0000  2.0000  1.9000  1.9000  1.3000  0.9000
0.6000  3.5000  2.9000  2.7000
  30.  *  0.2000  0.1000  0.1000  0.1000  1.9000  1.8000  1.8000  1.8000  1.8000  1.2000  0.8000
0.5000  3.6000  2.7000  2.3000
  40.  *  0.2000  0.1000  0.1000  0.1000  1.7000  1.6000  1.6000  1.6000  1.9000  1.3000  0.9000
0.5000  3.2000  2.5000  2.3000
  50.  *  0.2000  0.1000  0.1000  0.1000  1.6000  1.5000  1.5000  1.5000  2.2000  1.4000  1.0000
0.5000  3.6000  2.6000  2.4000
  60.  *  0.2000  0.1000  0.1000  0.1000  1.5000  1.4000  1.4000  1.4000  2.3000  1.4000  1.0000
0.3000  3.6000  2.6000  2.3000
  70.  *  0.3000  0.0000  0.0000  0.0000  1.5000  1.3000  1.3000  1.3000  2.6000  1.4000  0.9000
0.0000  3.8000  2.7000  2.2000
  80.  *  0.9000  0.1000  0.0000  0.0000  2.2000  1.4000  1.3000  1.3000  2.6000  1.0000  0.6000
0.0000  3.9000  2.5000  1.9000
  90.  *  2.0000  0.5000  0.1000  0.0000  3.3000  1.9000  1.6000  1.4000  1.9000  0.4000  0.1000
0.0000  3.2000  1.8000  1.6000
 100.  *  2.7000  1.0000  0.6000  0.0000  4.1000  2.5000  1.9000  1.3000  0.8000  0.1000  0.0000
0.0000  2.0000  1.4000  1.3000
 110.  *  2.7000  1.4000  0.9000  0.0000  3.8000  2.7000  2.2000  1.4000  0.3000  0.0000  0.0000
0.0000  1.5000  1.3000  1.3000
 120.  *  2.4000  1.4000  1.1000  0.3000  3.6000  2.7000  2.4000  1.6000  0.2000  0.1000  0.1000
0.1000  1.5000  1.4000  1.4000
 130.  *  2.3000  1.4000  1.1000  0.5000  3.5000  2.7000  2.5000  1.9000  0.2000  0.1000  0.1000
0.1000  1.6000  1.5000  1.5000
 140.  *  1.9000  1.3000  1.0000  0.5000  3.2000  2.6000  2.3000  2.0000  0.2000  0.1000  0.1000
0.1000  1.7000  1.6000  1.6000
 150.  *  1.8000  1.2000  0.9000  0.5000  3.6000  2.8000  2.4000  2.2000  0.2000  0.1000  0.1000
0.1000  1.9000  1.8000  1.8000
 160.  *  1.9000  1.4000  0.9000  0.6000  3.6000  3.0000  2.8000  2.4000  0.2000  0.2000  0.2000
0.2000  2.0000  2.0000  2.0000
 170.  *  2.4000  1.8000  1.4000  1.2000  3.7000  3.3000  3.0000  2.6000  0.8000  0.8000  0.8000
0.6000  2.1000  2.1000  2.1000
 180.  *  3.6000  2.6000  2.5000  2.1000  3.5000  2.6000  2.4000  2.2000  1.6000  1.6000  1.6000
1.3000  1.6000  1.6000  1.6000
 190.  *  3.8000  3.2000  2.8000  2.6000  2.4000  1.7000  1.4000  1.2000  2.2000  2.2000  2.2000
1.9000  0.7000  0.7000  0.7000
 200.  *  3.5000  2.9000  2.7000  2.4000  1.9000  1.3000  0.9000  0.6000  2.0000  2.0000  2.0000
1.9000  0.2000  0.2000  0.2000
 210.  *  3.6000  2.7000  2.3000  2.2000  1.8000  1.2000  0.8000  0.5000  1.9000  1.8000  1.8000
1.8000  0.2000  0.1000  0.1000
 220.  *  3.2000  2.5000  2.3000  2.0000  1.9000  1.3000  0.9000  0.5000  1.7000  1.6000  1.6000
1.6000  0.2000  0.1000  0.1000
 230.  *  3.6000  2.6000  2.4000  1.9000  2.2000  1.4000  1.0000  0.5000  1.6000  1.5000  1.5000
1.5000  0.2000  0.1000  0.1000
 240.  *  3.6000  2.6000  2.3000  1.6000  2.3000  1.4000  1.0000  0.3000  1.5000  1.4000  1.4000
1.4000  0.2000  0.1000  0.1000
 250.  *  3.8000  2.7000  2.2000  1.4000  2.6000  1.4000  0.9000  0.0000  1.5000  1.3000  1.3000
1.3000  0.3000  0.0000  0.0000
```

```
 260.  *  3.9000  2.5000  1.9000  1.3000  2.6000  1.0000  0.6000  0.0000  2.2000  1.4000  1.3000
1.3000  0.9000  0.1000  0.0000
 270.  *  3.2000  1.8000  1.6000  1.4000  1.9000  0.4000  0.1000  0.0000  3.3000  1.9000  1.6000
1.4000  2.0000  0.5000  0.1000
 280.  *  2.0000  1.4000  1.3000  1.3000  0.8000  0.1000  0.0000  0.0000  4.1000  2.5000  1.9000
1.3000  2.7000  1.0000  0.6000
 290.  *  1.5000  1.3000  1.3000  1.3000  0.3000  0.0000  0.0000  0.0000  3.8000  2.7000  2.2000
1.4000  2.7000  1.4000  0.9000
 300.  *  1.5000  1.4000  1.4000  1.4000  0.2000  0.1000  0.1000  0.1000  3.6000  2.7000  2.4000
1.6000  2.4000  1.4000  1.1000
 310.  *  1.6000  1.5000  1.5000  1.5000  0.2000  0.1000  0.1000  0.1000  3.5000  2.7000  2.5000
1.9000  2.3000  1.4000  1.1000
 320.  *  1.7000  1.6000  1.6000  1.6000  0.2000  0.1000  0.1000  0.1000  3.2000  2.6000  2.3000
2.0000  1.9000  1.3000  1.0000
 330.  *  1.9000  1.8000  1.8000  1.8000  0.2000  0.1000  0.1000  0.1000  3.6000  2.8000  2.4000
2.2000  1.8000  1.2000  0.9000
 340.  *  2.0000  2.0000  2.0000  1.9000  0.2000  0.2000  0.2000  0.2000  3.6000  3.0000  2.8000
2.4000  1.9000  1.4000  0.9000
 350.  *  2.1000  2.1000  2.1000  1.8000  0.8000  0.8000  0.8000  0.6000  3.7000  3.3000  3.0000
2.6000  2.4000  1.8000  1.4000
 360.  *  1.6000  1.6000  1.6000  1.3000  1.6000  1.6000  1.6000  1.3000  3.5000  2.6000  2.4000
2.2000  3.6000  2.6000  2.5000
 ------*-----------------------------------------------------------------------------------------
-------------------------------
 MAX   *  3.9000  3.2000  2.8000  2.6000  4.1000  3.3000  3.0000  2.6000  4.1000  3.3000  3.0000
2.6000  3.9000  3.2000  2.8000
 DEGR. *    260     190     190     190     100     170     170     170     280     350     350
350      80      10      10
```

```
PAGE  4
      JOB: I-495 NEXT                                         RUN: 2023 Rt123 & Tysons Blvd

       MODEL RESULTS
       -------------

       REMARKS : In search of the angle corresponding to
                 the maximum concentration, only the first
                 angle, of the angles with same maximum
                 concentrations, is indicated as maximum.

 WIND ANGLE RANGE:  10.-360.

 WIND  * CONCENTRATION
 ANGLE *     (PPM)
 (DEGR)*      16      17      18      19      20      21      22      23      24      25      26
27      28
 ------*--------------------------------------------------------------------------------------
---------------
  10.  *  2.6000  0.1000  0.0000  0.0000  0.8000  0.3000  0.0000  1.8000  1.7000  1.7000  2.6000
2.1000  1.7000
  20.  *  2.4000  0.0000  0.0000  0.0000  1.0000  0.5000  0.0000  1.7000  1.7000  1.7000  2.7000
2.3000  1.7000
  30.  *  2.2000  0.1000  0.1000  0.1000  1.1000  0.7000  0.3000  1.7000  1.7000  1.7000  2.6000
2.3000  1.9000
  40.  *  2.0000  0.1000  0.1000  0.1000  1.1000  0.7000  0.3000  1.9000  1.9000  1.8000  2.6000
2.4000  2.1000
  50.  *  1.9000  0.1000  0.1000  0.1000  0.8000  0.6000  0.3000  2.1000  2.1000  2.1000  2.9000
2.7000  2.4000
  60.  *  1.6000  0.1000  0.1000  0.1000  0.8000  0.6000  0.3000  2.2000  2.2000  2.2000  3.1000
2.8000  2.5000
  70.  *  1.4000  0.3000  0.3000  0.3000  1.0000  0.8000  0.5000  2.6000  2.5000  2.3000  3.5000
3.1000  2.9000
  80.  *  1.3000  0.9000  0.9000  0.7000  1.6000  1.3000  1.0000  2.5000  2.5000  2.2000  3.5000
3.3000  3.1000
  90.  *  1.4000  2.0000  2.0000  1.7000  2.8000  2.6000  2.3000  1.9000  1.9000  1.6000  2.8000
2.7000  2.3000
 100.  *  1.3000  2.6000  2.6000  2.3000  3.4000  3.2000  3.0000  0.8000  0.8000  0.6000  1.5000
1.3000  1.0000
 110.  *  1.3000  2.7000  2.6000  2.4000  3.4000  2.9000  2.8000  0.3000  0.3000  0.3000  1.0000
0.8000  0.5000
 120.  *  1.4000  2.3000  2.3000  2.3000  3.0000  2.6000  2.4000  0.1000  0.1000  0.1000  0.8000
0.6000  0.3000
 130.  *  1.5000  2.2000  2.2000  2.2000  2.8000  2.6000  2.3000  0.1000  0.1000  0.1000  0.8000
0.6000  0.3000
 140.  *  1.6000  1.9000  1.9000  1.8000  2.5000  2.4000  2.1000  0.1000  0.1000  0.1000  1.0000
0.7000  0.3000
 150.  *  1.8000  1.7000  1.7000  1.7000  2.5000  2.3000  1.9000  0.1000  0.1000  0.1000  1.0000
0.7000  0.3000
 160.  *  1.9000  1.7000  1.7000  1.7000  2.6000  2.3000  1.7000  0.0000  0.0000  0.0000  0.9000
0.5000  0.0000
 170.  *  1.8000  1.8000  1.7000  1.7000  2.6000  2.1000  1.7000  0.1000  0.0000  0.0000  0.8000
0.3000  0.0000
 180.  *  1.3000  2.2000  2.0000  1.8000  2.2000  2.0000  1.8000  0.3000  0.1000  0.0000  0.3000
0.1000  0.0000
 190.  *  0.5000  2.6000  2.1000  1.7000  1.8000  1.7000  1.7000  0.8000  0.3000  0.0000  0.1000
0.0000  0.0000
 200.  *  0.2000  2.7000  2.3000  1.7000  1.7000  1.7000  1.7000  1.0000  0.5000  0.0000  0.0000
0.0000  0.0000
 210.  *  0.1000  2.6000  2.3000  1.9000  1.7000  1.7000  1.7000  1.1000  0.7000  0.3000  0.1000
0.1000  0.1000
 220.  *  0.1000  2.6000  2.4000  2.1000  1.9000  1.9000  1.8000  1.1000  0.7000  0.3000  0.1000
0.1000  0.1000
 230.  *  0.1000  2.9000  2.7000  2.4000  2.1000  2.1000  2.1000  0.8000  0.6000  0.3000  0.1000
0.1000  0.1000
 240.  *  0.1000  3.1000  2.8000  2.5000  2.2000  2.2000  2.2000  0.8000  0.6000  0.3000  0.1000
0.1000  0.1000
 250.  *  0.0000  3.5000  3.1000  2.9000  2.6000  2.5000  2.3000  1.0000  0.8000  0.5000  0.3000
0.3000  0.3000
```

```
 260.  *  0.0000  3.5000  3.3000  3.1000  2.5000  2.5000  2.2000  1.6000  1.3000  1.0000  0.9000
0.9000  0.7000
 270.  *  0.0000  2.8000  2.7000  2.3000  1.9000  1.9000  1.6000  2.8000  2.6000  2.3000  2.0000
2.0000  1.7000
 280.  *  0.0000  1.5000  1.3000  1.0000  0.8000  0.8000  0.6000  3.4000  3.2000  3.0000  2.6000
2.6000  2.3000
 290.  *  0.0000  1.0000  0.8000  0.5000  0.3000  0.3000  0.3000  3.4000  2.9000  2.8000  2.7000
2.6000  2.4000
 300.  *  0.3000  0.8000  0.6000  0.3000  0.1000  0.1000  0.1000  3.0000  2.6000  2.4000  2.3000
2.3000  2.3000
 310.  *  0.5000  0.8000  0.6000  0.3000  0.1000  0.1000  0.1000  2.8000  2.6000  2.3000  2.2000
2.2000  2.2000
 320.  *  0.5000  1.0000  0.7000  0.3000  0.1000  0.1000  0.1000  2.5000  2.4000  2.1000  1.9000
1.9000  1.8000
 330.  *  0.5000  1.0000  0.7000  0.3000  0.1000  0.1000  0.1000  2.5000  2.3000  1.9000  1.7000
1.7000  1.7000
 340.  *  0.6000  0.9000  0.5000  0.0000  0.0000  0.0000  0.0000  2.6000  2.3000  1.7000  1.7000
1.7000  1.7000
 350.  *  1.2000  0.8000  0.3000  0.0000  0.1000  0.0000  0.0000  2.6000  2.1000  1.7000  1.8000
1.7000  1.7000
 360.  *  2.1000  0.3000  0.1000  0.0000  0.3000  0.1000  0.0000  2.2000  2.0000  1.8000  2.2000
2.0000  1.8000
 ------*-------------------------------------------------------------------------------------
---------------
 MAX   *  2.6000  3.5000  3.3000  3.1000  3.4000  3.2000  3.0000  3.4000  3.2000  3.0000  3.5000
3.3000  3.1000
 DEGR. *     10     250     260     260     100     100     100     290     280     280      70
80      80

 THE HIGHEST CONCENTRATION OF   4.1000 PPM OCCURRED AT RECEPTOR     5.
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Appendix I: Memorandum of the Proposed Air Quality Modeling and Analysis Approach for the VDOT I-495 Northern Extension Project (I-495 NEXT)

Michael Baker
INTERNATIONAL

Innovation Done Right...We Make a Difference

M E M O R A N D U M

To: Jim Ponticello, Air Quality Program Manager – VDOT Environmental Division
Chris Voigt – VDOT Environmental Division

From: Robert d'Abadie, Michael Baker International
John Frohning, Jacobs

Date: September 10, 2019

Subject: Proposed Air Quality Modeling and Analysis Approach for the VDOT I-495 Northern Extension Project (I-495 NEXT)

General Project Overview

The Virginia Department of Transportation (VDOT) is conducting an environmental study regarding plans to extend the 495 Express Lanes by approximately three miles from the I-495 and Dulles Toll Road interchange to the vicinity of the American Legion Bridge.

Virginia's 495 Express Lanes Northern Extension study, also referred to as I-495 NEXT, is being developed as an independent, stand-alone project that will be closely coordinated and compatible with plans for I-495 (Capital Beltway) in Maryland.

The environmental study, specifically an Environmental Assessment or EA, will be completed according to the requirements of the National Environmental Policy Act of 1969 (NEPA), as amended, and 23 CFR Part 771, will evaluate site-specific conditions and potential effects the proposed improvements may have on air quality, noise, neighborhoods, parks, recreation areas, historic properties, wetlands and streams, and other resources. This document focuses primarily on the proposed approach to evaluate the air quality impacts of this project and ensure it is consistent with the air quality goals of the region.

Project Goals and Objectives

VDOT, in coordination with the Federal Highway Administration (FHWA), developed the project's goals and objectives through a comprehensive process that included a review of previous studies and recent or planned projects; an analysis of traffic, environmental, and socioeconomic conditions in the region; and feedback from the public and federal, regional, state, and local agencies through a scoping process.

The project will address the following needs:

- Reduce congestion and improve roadway safety: As population and employment within the Washington, D.C. region continue to grow, the increase in traffic volumes and travel demand along the I-495 corridor will result in increased congestion, delays, and safety concerns. There is a need to address existing and future travel demand and relieve pressure on the general-purpose lanes and the surrounding roadway network.

- Provide additional travel choices: The existing 495 Express Lanes end at Old Dominion Drive, limiting travel choices for HOV and single-occupant vehicles within the study area, with no good options to bypass congestion or bottlenecks. As such, an additional option is needed to allow users to bypass congestion in the general-purpose lanes and to choose a mode that best suits their individual needs.
- Improve travel reliability: Congestion along the I-495 corridor results in highly variable travel speeds and travel times, which are expected to worsen as the population, employment, and traffic volumes in the region increase. Consistent, reliable, predictable travel times are needed for commuters and freight movement.

Development of the Air Quality Approach

The VDOT Project-Level Air Quality Resource Document (Resource Document, December 2018), was used to inform the development of the air quality analysis approach. The Resource Document provides a comprehensive listing of models, methods and assumptions, as well as an associated online data repository for transportation project-level air quality studies to be conducted by or on behalf of the Commonwealth. In December 2015, the draft document and associated data were subjected to inter-agency consultation for conformity (IACC), with a subsequent update in 2018. VDOT also has Programmatic Agreements with FHWA that may be utilized in this air quality evaluation. All these references can be found on the VDOT Air Quality Website[1]. In a review of the preliminary traffic evaluation for this project, it appears all predetermined conditions and thresholds contained within the Resource Document and applicable Programmatic Agreements will be met. The models, methods/protocols and assumptions as specified or referenced in the VDOT Resource Document will be applied without change or without substantive change as defined in that document.

The following sections provide an overview of the proposed approach for assessing the potential for local air quality impacts of the project, addressing all related air quality requirements under the Clean Air Act (CAA) - as amended – specifically the Conformity requirements. Any additional analysis required under the NEPA regulations will also be addressed. Note, for regional conformity, the project is currently included in the most recent regional conformity demonstration approved by the MWCOG Transportation Planning Board, thereby addressing regional conformity requirements. As this is an ongoing effort, VDOT will continue to coordinate with MWCOG to ensure that regional conformity requirements are met.

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[1] https://www.virginiadot.org/projects/environmental_air_section.asp

Air Quality Status

The EPA Green Book[2] lists non-attainment, maintenance, and attainment areas across the nation. It lists the jurisdictions within the area in which the project is located as being in attainment for all the NAAQS except ozone. Specifically, the EPA designated the Metropolitan Washington, DC, (DC-MD-VA) region as 'marginal' non-attainment for the 2015 Ozone Standard effective August 3, 2018. Previously in 2012, EPA designated the Metropolitan Washington, DC, (DC-MD-VA) region as 'marginal' nonattainment for the 2008 Ozone Standard, with a re-designation to attainment-maintenance on August 15, 2019. Having the project explicitly addressed in the most recent regional conformity demonstration by the MWCOG Transportation Planning Board and satisfies project-level Conformity required for this pollutant for both standards under the CAA[3].

Previous designations for Carbon Monoxide (CO) and Fine Particulate Matter ($PM_{2.5}$) pertained to National Ambient Air Quality Standards (NAAQS) that have expired or been revoked[4], respectively. As such Transportation conformity requirements under the CAA no longer apply for these pollutants.

General Note on Air Quality Analysis

It is noted that while the opening year of the project is 2023, traffic forecasting has been done for 2025 to account for the multi-year ramp-up period VDOT has observed on other Express-Toll facilities in the Commonwealth and so the modeling can take advantage of the analysis years native to the MWCOG regional transportation model without alternation. Emissions rates trend downward over time, the higher 2023 emission rates will be combined with higher 2025 traffic forecasts ensure the analysis would be conservative if actual forecast volumes (and not assumed worst-case volumes, which are higher) were to be applied.

Carbon Monoxide Model Evaluation

While the project is not currently subject to transportation conformity under the CAA for CO, NEPA analyses in Virginia requires a project level hot-spot screening analysis for CO. A worst-case approach for modeling CO is proposed consistent with the VDOT Resource Document and EPA guidance. The analysis will include the identified three worst-case intersections as well as, potentially, screening of a nearby worst-case interchange that is technically outside of the project area but included in the traffic study area.

- The three worst case intersections will be selected based on the methodology referenced in the Resource Document and appropriate EPA guidance. The modeling methodology set forth in these documents will be used for this analysis.

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[2] https://www.epa.gov/green-book

[3] This project is included in Visualize2045, the current long-range plan. VDOT will verify that the project as coded reflects best current assumptions sound an update to the conformity determination be necessary. https://www.mwcog.org/visualize2045/document-library/

[4] EPA revoked the applicable PM2.5 annual primary NAAQS effective October 24, 2016 (15 ug/m3). The area is in attainment with the new 2016 Annual Primary $PM_{2.5}$ standard (12 ug/m3).

- Modeling based on the VDOT Resource Document:
    - No exceptions to the models, methods and assumptions/specified in the VDOT Resource Document are planned for this analysis.
    - PM peak hour will be modeled, as higher volumes are generally expected than for the AM peak hour based on preliminary analysis supplied by the traffic team. If this changes the higher of the peak hour volumes will be used.
    - The modeling of any required intersections/interchanges will be conducted using the latest version of EPA's Motor Vehicle Emissions Simulator (MOVES2014b) for emission factors and CAL3QHC for the dispersion modeling.
    - Screening of the worst-case intersections/interchanges will be streamlined by using the FHWA CAL3i tool which generates the input files and executes the selected version of the CALINE3 model (including CAL3QHC) and summarizes the results at the receptor locations it generates.
    - Inputs for MOVES will be based on the available conformity runs for the region made available through the Resource Document. Database conversions may be needed to ensure that the data is in the appropriate format for MOVES2014b.
    - Road grade data will be based on information provided by the traffic team
    - Emission rates will be calculated for the Existing (2018), Opening Year (2023), and Design Year (2045).
    - All other appropriate inputs will be based on the VDOT Project Level Resource Document and applicable guidance.
    - Regarding volumes previous analyses have assumed a volume of 1,900 Vehicles/lane at intersections and 2,200 vehicles/lane on freeways
- Receptor locations will be based on the appropriate EPA/VDOT guidance as set forth in the Resource Document or by the worse-case locations generated by the CAL3i tool. The online data repository accompanying the VDOT Resource Document provides predetermined background concentrations and the 1-hr to 8-hr persistence factor applied to CAL3QHC outputs, which were developed based on ambient air quality monitoring data for the region.

MSAT Evaluation

- Design Year Annual Average Daily Traffic on I-495 is projected to approach or exceed 140,000 to 150,000 vehicles per day and is in close proximity to populated areas. Therefore, a quantitative MSAT analysis will be prepared in accordance with FHWA's Interim Guidance Update on Mobile Source Air Toxic Analysis in NEPA, dated December 6, 2012 and the recommendations contained within Quick Start Guide for Using MOVES for NEPA MSAT Analysis as well as the Resource Document.
- Modeling based on the approach detailed in the VDOT Resource Document:
    - No exceptions to the models, methods and assumptions/specified in the VDOT Resource Document are planned for this analysis.
    - Emission rates will be calculated for the Existing (2018), Opening Year (2023), and Design Year (2045).

- Initially the affected network will be determined using procedures suggested during FHWA NEPA training classes, specifically:
    - Changes of ± 5% or more in AADT on congested highway links of LOS D or worse
    - Changes of ± 10% or more in AADT on uncongested highway links of LOS C or better
    - Changes of ± 10% or more in travel time
    - Changes of ± 10% or more in intersection delay
    - Eliminate obvious modeling artifacts from the selected network
- More recently the FHWA has provided recommendations that the MSAT affected network can coincide with the affected area defined for the project. A comparison to the modeled affected network will be undertaken along with a review on how the affected area used in the remainder of the project was defined. The results will be discussed with VDOT and determination will be made on which network is most suitable.

The online data repository accompanying the VDOT Resource Document provides the input data, current assumptions and pre-approved input datasets for executing MOVES are available, insuring consistency with other air quality planning analyses in the region.

Greenhouse Gas Emissions

In the absence of federal guidance pertaining to transportation-oriented greenhouse gases[5] and given the high-profile of the project, the air quality document will include a qualitative greenhouse gas (GHG) analyses. VDOT has developed a template report for project-level air quality analyses which provides an example of a qualitative analysis for GHGs, and a similar evaluation will be developed for this project.

If you need additional information, please do not hesitate to contact the project team.

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[5] In the absence of applicable federal guidance (following the withdrawal of 2016 guidance issued by the Council on Environmental Quality), Department policy applies.
See: https://www.gpo.gov/fdsys/pkg/FR-2017-04-05/pdf/2017-06770.pdf.