

AIR QUALITY TECHNICAL REPORT

VAN BUREN ROAD EXTENSION

**Route 234 (Dumfries Road) to Cardinal Drive
UPC 118643**

Northern Virginia District

Prepared for:



Environmental Division

Prepared by:



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Executive Summary

The Virginia Department of Transportation (VDOT) is proposing to extend Van Buren Road on new alignment from its existing termini at the intersection with Dumfries Road (Route 234) north for approximately 2.5 miles to a portion of existing Van Buren Road directly south of Cardinal Drive. The project would construct a four-lane divided urban collector roadway.

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. The assessment indicates that the project would meet all applicable federal and state transportation conformity regulatory requirements as well as air quality guidance under the National Environmental Policy Act (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 in attainment of the CO NAAQS, EPA project-level (“hot-spot”) transportation conformity requirements do not apply. As only NEPA applies, a project-specific analysis and/or assessment for CO is not needed under the terms of the Programmatic Agreement between FHWA and VDOT for Project-Level Air Quality Analyses for CO (October 2020). As documented in that agreement, which is based on the analysis and information presented in the Template Programmatic Agreement and Technical Support Document (TSD) developed in the National Cooperative Highway Research Program (NCHRP) 25-25 Task 104 study (2020), the weight-of-evidence shows that it may be reasonably be concluded that the NAAQS for CO will be met.

Mobile Source Air Toxics (MSATs)

Federal Highway Administration (FHWA) guidance¹ (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)². 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 low potential MSAT effects based primarily on the forecast traffic volumes for this project. A qualitative assessment was therefore conducted for the project, following FHWA guidance for projects with low 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

¹ 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/

² See: <https://www.epa.gov/national-air-toxics-assessment>

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 proposed action is relatively minor in scope compared to the larger set of highway, transit and rail projects that were assessed in a statewide build/no-build analysis for the year 2040. The GHG effects of the statewide build scenario compared to the no-build were found to be small (less than 0.2 percent increase) and are much smaller than the forecast 20 percent decrease in GHG emissions between 2015 and 2040 as a result of cleaner and more efficient vehicles.

A project-specific quantitative analysis of GHG impacts was not performed on the proposed project because its potential impacts are expected to be much smaller than the collective impacts of the projects included in the statewide analysis, and the level of effort in quantifying these impacts would be disproportionate to the value of the information provided.

Climate Change: Considerations Relating to the Affected Environment

Greenhouse gas emissions have accumulated rapidly as the world has industrialized. If emissions continue, projected changes in global average temperature could range from 0.4°–2.7°F (0.2°–1.5°C) under a very low emissions scenario, to 4.2°–8.5°F (2.4°–4.7°C) under a higher scenario by the end of the 21st century. Virginia faces three major risks from a changing climate: coastal flooding, inland flooding, and extreme heat, all of which could impact the Commonwealth's infrastructure.

Resiliency is an important consideration for VDOT when planning and designing future infrastructure investments. Resiliency includes both building in areas with minimal risk and designing infrastructure that is resilient to potential impacts that could affect its scope, function, and/or performance. VDOT, and regional and local agency partners in the state, have already engaged in efforts to plan for resiliency, including conducting a statewide vulnerability assessment of the Commonwealth's transportation network. The Van Buren Road Extension project has not been scored for exposure, sensitivity, and adaptive capacity. However, vulnerability to climate change is believed to be low because the project is not located in a coastal area or river valley. Analysis of the project area within the online interactive VTrans Vulnerability Assessment tool did not identify any vulnerabilities based on exposure, sensitivity,

or adaptive capacity for sea level rise, storm surge, or inland/riverine flooding due to effects of climate change.

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, 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.

Regarding the potential for cumulative impacts, the annual regional conformity analysis conducted by the National Capital Region (NCR) Transportation Planning Board (TPB, which is the Metropolitan Planning Organization or MPO for the Washington, D.C. metropolitan nonattainment area for ozone) 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 January 2020, with the most recent Transportation Improvement Program (FY 2021-2024 TIP) which includes this conformity analysis adopted by the TPB on March 18, 2020. The Van Buren Road Extension project was added to the FY 2021-2024 TIP as a Study in an amendment approved by the TPB on April 21, 2021. State approval and FHWA approval of this amendment is pending. 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*.

The Virginia Department of Environmental Quality (VDEQ) provides general comments for projects by jurisdiction. Their comments in part address mitigation. For the Northern Virginia District, VDEQ comments relating to mitigation are “...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.”

Project Status in the Regional Transportation Plan and Program: Federal conformity requirements, including specifically 40 CFR 93.114³ and 40 CFR 93.115⁴, 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))⁵.

The Van Buren Road Extension project (TIP ID 8605) was added to the FY 2021-2024 TIP (adopted March 18, 2020) as a Study in an amendment approved by the National Capital Region Transportation Planning Board on April 21, 2021. State approval and FHWA approval of this amendment is pending. As a study, the project is exempt from Air Quality Conformity Analysis, but it is already included in Visualize 2045. The study is being funded by Prince William County with non-Federal funds, so the project does not impact the financial constraint finding of the Visualize 2045 Financial Plan.

³ See: <https://www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol20/xml/CFR-2014-title40-vol20-sec93-114.xml>

⁴ See: <https://www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol20/xml/CFR-2014-title40-vol20-sec93-115.xml>

⁵ See: <https://www.gpo.gov/fdsys/pkg/CFR-2014-title40-vol20/xml/CFR-2014-title40-vol20-sec93-109.xml>

1.0 Introduction

An air quality assessment was performed for the Van Buren Road Extension project (Route 234 [Dumfries Road] to Cardinal Drive). The proposed roadway extension project was assessed for potential air quality impacts and conformity consistent with all applicable air quality regulations and requirements. All methods and assumptions applied in the analysis were made consistent with those provided or specified in the Virginia Department of Transportation (VDOT) Resource Document. The assessment indicates that the project would meet all applicable air quality requirements of the National Environmental Policy Act (NEPA) and, as applicable, 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 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 in this report.

2.0 Project Background

2.1 Project Purpose & Need

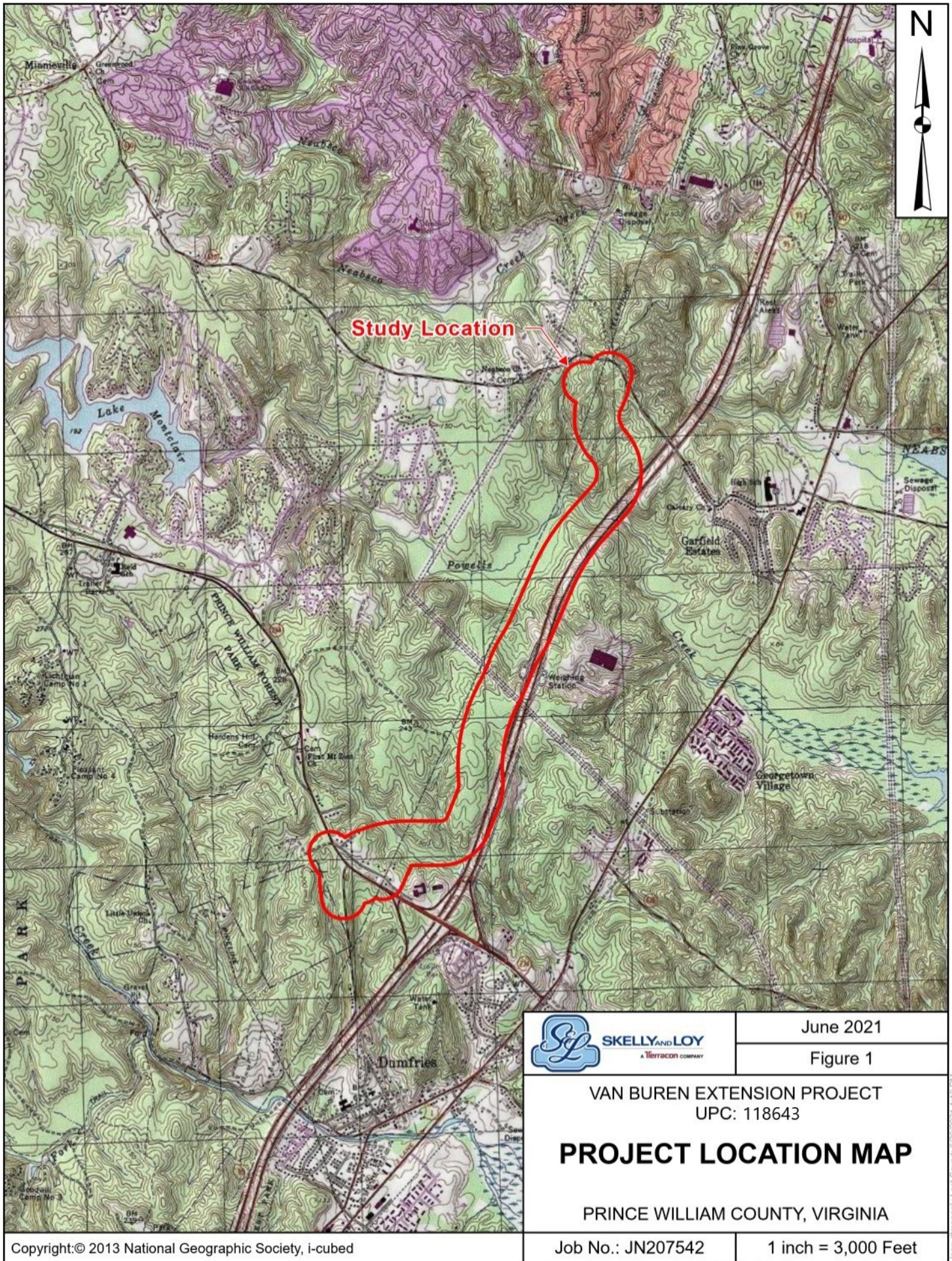
The purpose of the project is to improve local roadway access connections throughout the surrounding area by creating an internal parallel route to I-95 and Route 1 between Dale Boulevard and Route 234. This project would serve to: provide an additional north-south travel corridor and reduce local congestion; provide access to the parcels and proposed developments within the project corridor; improve emergency and state maintenance vehicle access and response time; and improve community access to local schools and adjacent commercial centers.

2.2 Project Description

The project area is located in the southeastern region of Prince William County, Virginia (**Figure 1**). The proposed project will extend Van Buren Road on new alignment from its existing termini at the intersection with Dumfries Road (Route 234) north for approximately 2.5 miles to a portion of existing Van Buren Road directly south of Cardinal Drive. The project would construct a four-lane divided urban collector roadway. Construction of a 10-foot wide shared-use path and a 5-foot wide sidewalk would be included to provide non-motorized transportation alternatives. Van Buren Road would be completed in accordance with Urban Collector Street (GS-7) criteria with a design speed of 40 mph. The typical section for these improvements generally varies from 102 feet to 105 feet along the proposed corridor and includes curb and gutter and a raised median. The project would also include construction of an approximately 235' bridge spanning Powell's Creek perpendicular to the waterway and associated stormwater management facilities. This project is currently being funded by local Northern Virginia Transportation Authority (NVTA) funds. Future utilization of Federal Funds is anticipated for this project.

2.3 Project Area Traffic Volumes

Design year (2040) Average Annual Daily Traffic (AADT) for Van Buren Road is predicted to be 11,180 vehicles per day at the southern end of the roadway, at the intersection of Van Buren



Road and Dumfries Road. An AADT of 8,800 vehicles per day is predicted at the northern end of the roadway, at the intersection of Van Buren Road and Cardinal Drive. No new signalized intersections along the Van Buren Road Extension are being proposed. **Figure 2** presents the existing roadways, the proposed Van Buren Road Extension, existing AADT and peak hour traffic volumes with turning movements for the four signalized intersections that were included in the project's traffic analysis (prepared by Wells + Associates). **Figure 3** presents this same information for the design year 2040 build condition.

3.0 Air Quality Analysis

3.1 Carbon Monoxide (CO)

As the project is located in a region that is in attainment of the CO NAAQS, EPA project-level ("hot-spot") transportation conformity requirements do not apply. As only NEPA applies, a project-specific analysis and/or assessment for CO is not needed under the terms of the Programmatic Agreement between FHWA and VDOT for Project-Level Air Quality Analyses for CO (October 2020). As documented in that agreement, which is based on the analysis and information presented in the Template Programmatic Agreement and Technical Support Document (TSD) developed in the National Cooperative Highway Research Program (NCHRP) 25-25 Task 104 study (2020), the weight-of-evidence shows that it may be reasonably be concluded that the NAAQS for CO will be met for all projects given:

- Continued implementation of effective emission control technology, increasingly more stringent motor vehicle emission and fuel quality standards implemented over the past few decades by the EPA that have had the combined effect of substantially reducing CO emission rates nationwide, resulting in long-term downward trends in emissions and near-road ambient concentrations of CO despite increasing vehicle-miles-travelled (VMT);
- Extensive experience in project-specific modeling for CO for a wide variety of project types, configurations and operating conditions in which compliance with the NAAQS established by EPA for CO is readily demonstrated given the substantially reduced CO emission rates, and despite the use of multiple worst-case assumptions for emission and dispersion modeling that have a compounding effect such that emissions and near-road ambient concentrations are substantially over-estimated;
- Extensive experience in programmatic agreements for project-level agreements for CO that establish ever-increasing thresholds for such analyses given the substantially reduced emission rates; and
- The results of worst-case modeling conducted for this PA for typical highway project types, configurations and operating conditions in which compliance with the NAAQS is readily demonstrated, and by a substantial safety margin.

3.2 Particulate Matter (PM)

The final rule that establishes the transportation conformity criteria and procedures for determining which transportation projects must be analyzed for local air quality impacts in Fine Particulate Matter (PM_{2.5}) nonattainment and maintenance areas was published on March 10,

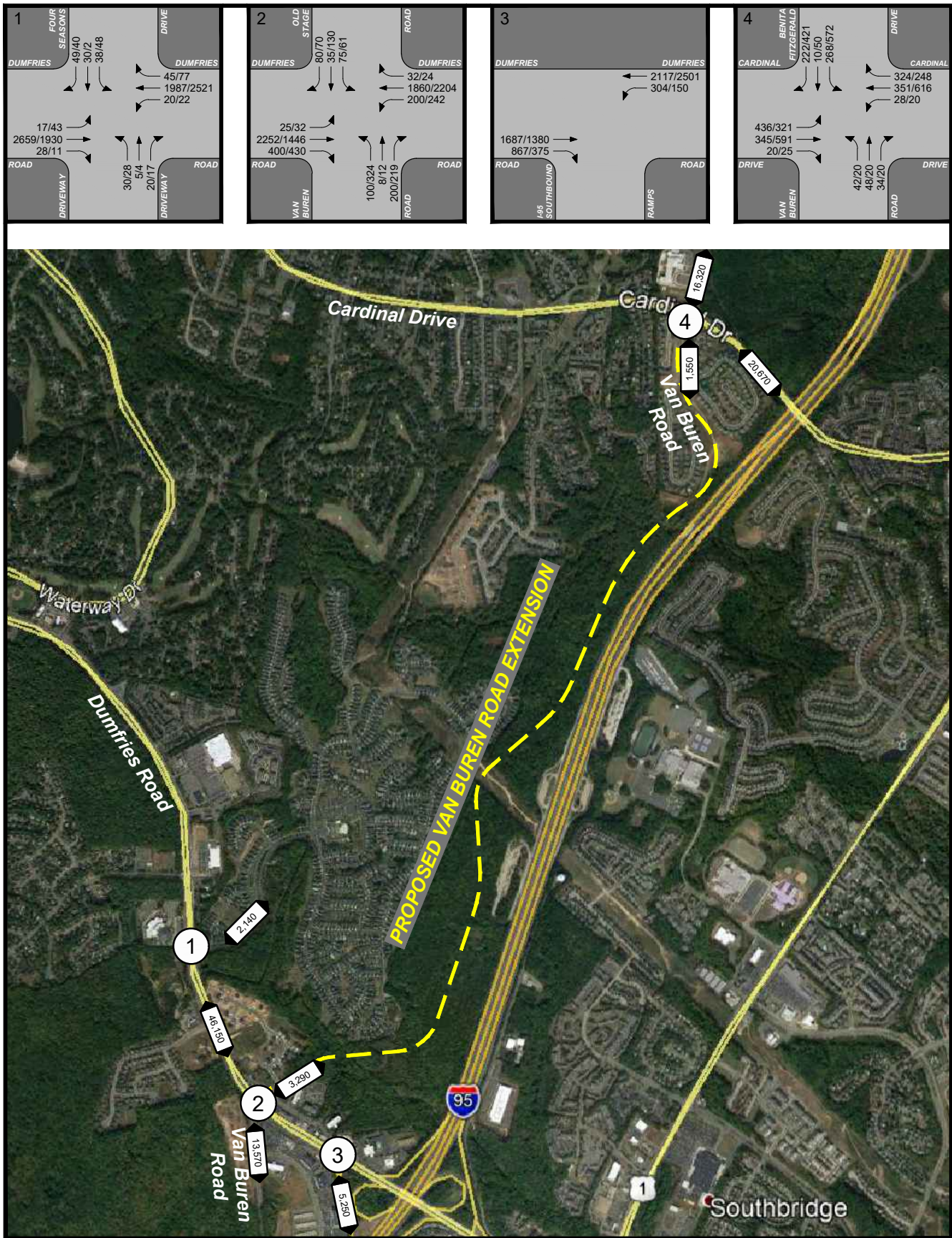


Figure 2
2020 Baseline Volumes

AM PEAK HOUR
PM PEAK HOUR
000 / 000
000/000 AADT



Van Buren Road Extension
Prince William County, Virginia



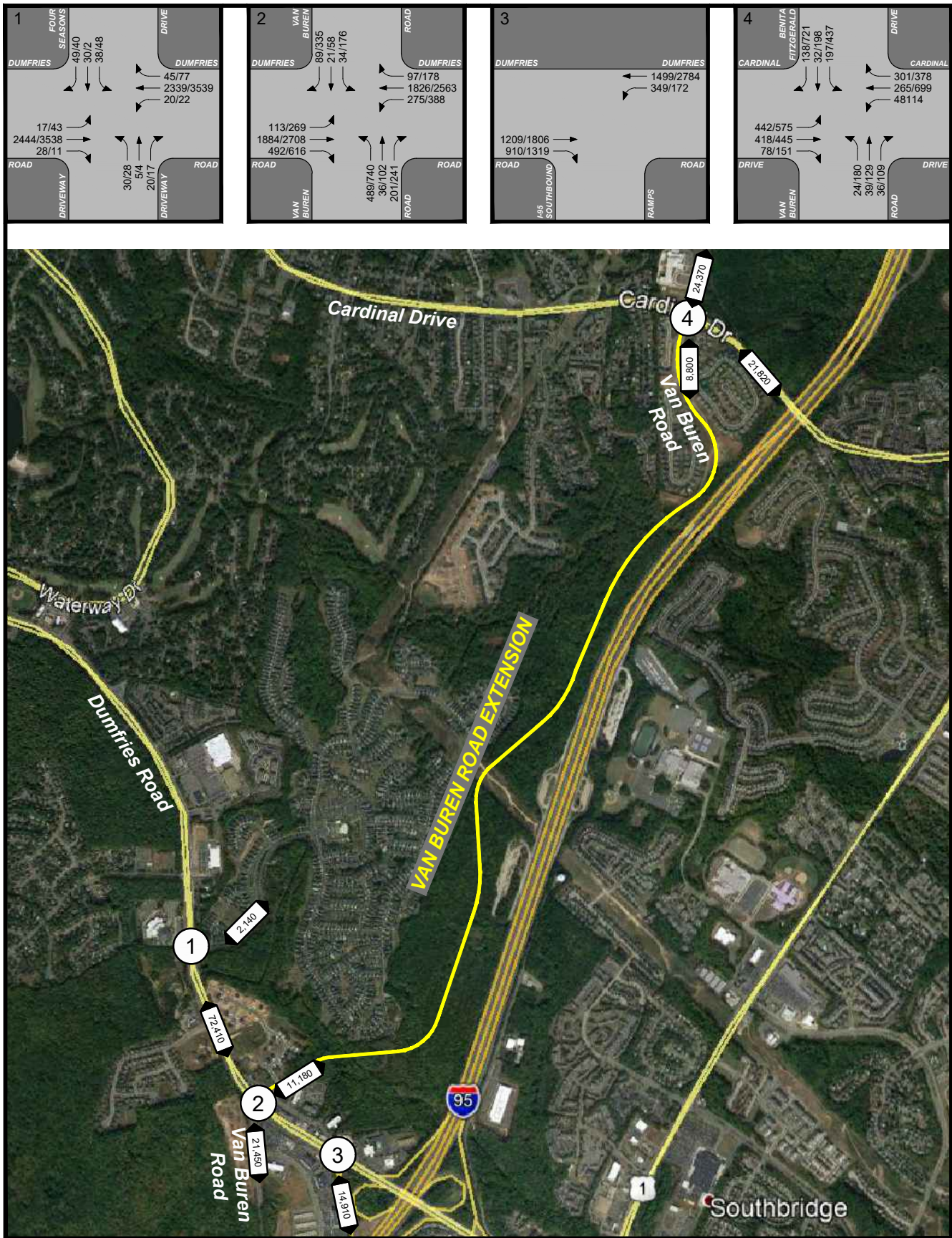


Figure 3
Build Traffic Forecasts (2040)

AM PEAK HOUR
PM PEAK HOUR
000 / 000
000/000 AADT



Van Buren Road Extension
Prince William County, Virginia



2006. This project is located in a PM2.5 attainment area and therefore no further discussion of PM2.5 is necessary.

3.3 Mobile Source Air Toxics (MSATs)

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).

Level of Analysis Determination

As this project involves an EA and is not exempt, it does not qualify as a Tier 1 project under FHWA MSAT Guidance. It also does not meet the criteria for a Tier 3 project in FHWA guidance, as total traffic is forecast to reach only 11,180 ADT for Van Buren Road Extension for the build scenario, which is well below the 140-150 thousand ADT criteria specified in FHWA guidance for Tier 3 projects (i.e., ones for which quantitative analyses for MSATs would be required). Additionally, this project does not involve the creation or alteration of a major intermodal freight facility that has the potential to concentrate high levels of diesel particulate matter in a single location.

This project may therefore be categorized as a Tier 2 project, i.e., one with “Low Potential MSAT Effects”. Projects in this category are addressed with a qualitative analysis, which as FHWA guidance states provides a basis for identifying and comparing potential differences for MSAT emissions, if any, from the various alternatives.

The qualitative assessment presented below follows FHWA guidance. It is derived in part from a study conducted by FHWA entitled “A Methodology for Evaluating Mobile Source Air Toxic Emissions Among Transportation Project Alternatives”, found at:

https://www.fhwa.dot.gov/environment/air_quality/air_toxics/research_and_analysis/mobile_source_air_toxics/msatemissions.cfm.

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 U.S. Environmental Protection Agency (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 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. 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.

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 vehicle miles travelled (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. In the November 2015 MOVES2014a Questions and Answers Guide, 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.

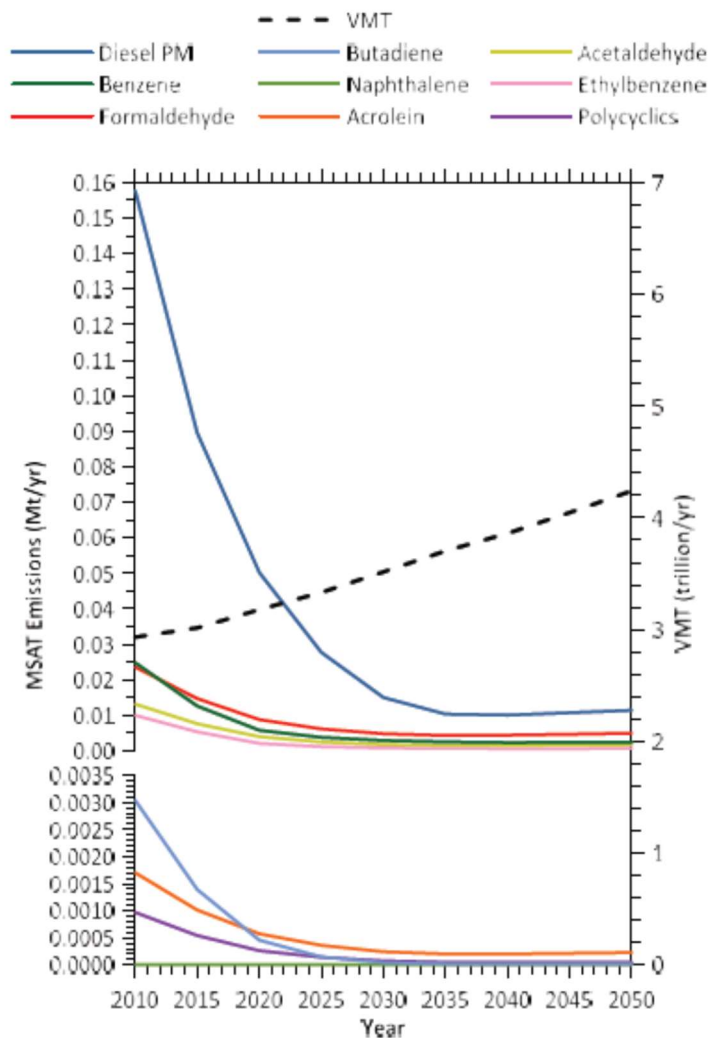
Using EPA's MOVES2014a model, as shown in the figure below, FHWA estimates that even if VMT increases by 45 percent from 2010 to 2050 as forecast, a combined reduction of 91 percent in the total annual emissions for the priority MSAT is projected for the same time period.

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 also 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.

Figure 4
FHWA Projected National MSAT Emission Trends 2010 – 2050
for Vehicles Operating on Roadways Using EPA’s MOVES2014a 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.

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, found at:

https://www.fhwa.dot.gov/environment/air_quality/air_toxics/policy_and_guidance/msat/page04.cfm.

Project-Level MSAT Discussion

The amount of MSATs emitted is proportional to vehicle miles traveled, or VMT, assuming that other variables such as fleet mix are the same for each alternative. The VMT estimated for the Build Alternative therefore may be slightly higher than that for the No-Build Alternative, because the new roadway attracts rerouted trips from elsewhere in the transportation network. This increase in VMT could lead to higher MSAT emissions for the build alternative along the roadway corridor, along with a corresponding decrease in MSAT emissions along the parallel routes. The emissions increase would be offset somewhat by lower MSAT emission rates due to increased speeds; according to EPA's MOVES2014 model, emissions of all of the priority MSATs decrease as speed increases.

There may also be localized areas where VMT would increase and other areas where it would decrease. Therefore, it is possible that localized increases and decreases in MSAT emissions may occur. However, even if these increases do occur, they too will be substantially reduced in the future due to implementation of EPA's vehicle and fuel regulations. Also, regardless of the alternative chosen, emissions will likely be lower than present levels in the design year as a result of EPA's national control programs that are projected to reduce annual MSAT emissions by over 90 percent between 2010 and 2050 (Updated Interim Guidance on Mobile Source Air Toxic Analysis in NEPA Documents, Federal Highway Administration, October 2016). Local conditions may differ from these national projections in terms of fleet mix and turnover, VMT growth rates, and local control measures. However, 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.

Any additional travel lanes contemplated as part of the project may have the effect of moving some traffic closer to nearby homes, schools, and businesses; therefore, there may be localized areas where ambient concentrations of MSATs could be higher for the Build Alternative than for the No-Build Alternative. However, the magnitude and the duration of these potential increases compared to the No-Build alternative cannot be reliably quantified due to incomplete or unavailable information in forecasting project-specific MSAT health impacts.

In sum, the localized level of MSAT emissions for the Build Alternative could be higher relative to the No-Build Alternative, but this could be offset due to increases in speeds and reductions in congestion (which are associated with lower MSAT emissions). In addition, MSAT emissions will be lower in other locations when traffic shifts away from them. However, on a regional basis, EPA's vehicle and fuel regulations, coupled with fleet turnover, will over time cause substantial reductions that, in almost all cases, will cause region-wide MSAT levels to be significantly lower than today.

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 mobile source air toxic (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 Environmental Protection Agency (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 Clean Air Act 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). A number of 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 (Special Report 16, <https://www.healtheffects.org/publication/mobile-source-air-toxics-critical-review-literature-exposure-and-health-effects>). 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>).”

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 Clean Air Act 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

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

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.

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.

3.4 Greenhouse Gases (GHGs)

The proposed action is relatively minor in scope compared to the larger set of highway, transit and rail projects that were assessed in a statewide build/no-build analysis for the year 2040. This statewide analysis is described below⁶. The GHG effects of the statewide build scenario compared to the no-build were found to be small (less than 0.2 percent increase) and are much smaller than the forecast 20 percent decrease in GHG emissions between 2015 and 2040 as a result of cleaner and more efficient vehicles. Details on the methods and findings of the statewide assessment are provided in Appendix A.

A project-specific quantitative analysis of GHG impacts was not performed on the proposed project because its potential impacts are expected to be much smaller than the collective impacts of the projects included in the statewide analysis, and the level of effort in quantifying these impacts would be disproportionate to the value of the information provided.

Statewide Analysis of Direct Operating Emissions from Vehicles

In 2021, Virginia DOT conducted an evaluation of the statewide GHG emissions from highway, transit, and rail vehicles under 2040 build and no-build conditions. The no-build scenario represents the transportation network in its 2015 condition with 2040 levels of travel demand. The build scenario represents all highway projects planned and/or programmed by VDOT and the state's Metropolitan Planning Organizations (MPOs) that are significant enough to be included in the VDOT statewide travel demand model (i.e., they increase capacity) as well as significant planned passenger and freight rail investments and other transit service improvements. The build/no-build comparison therefore represents an upper bound on the GHG impacts that might be seen from any project or projects that are a subset of the 2040 planned network. Compared to the 2040 no-build scenario, the 2040 build scenario includes 1,227 new lane-miles of roadway capacity, increases in bus service, 5 urban transit expansion

⁶ The Statewide GHG analysis is currently being refined by VDOT. Although the Statewide GHG Analysis has not been finalized, it has been reviewed and has received concurrence from FHWA.

projects (bus rapid transit and heavy rail) and 12 commuter and intercity passenger and freight rail projects. A sample of the major highway projects and all of the major transit and rail projects included in the 2040 build scenario, along with an indicator of the scale of each project, is shown in Exhibit 1.

Exhibit 1: Sample of Major Highway Projects and List of Major Transit and Rail Projects Included in 2040 Build Scenario

Project/Study	Indicator ^a	Value
Highway Projects (sample of major projects)		
I-64 Southside Widening and High-Rise Bridge	Miles	9.1
I-64 Capacity Improvements - Segment III		8.4
Rte 7 Corridor Improvements - Phase 1 and Phase 2		6.8
I-264/Witchduck Rd Interchange & Ramp Extension		2.3
I-95 Rappahannock River Crossing		6.0
Rte 58 - Widen to 6-Lane Divided Facility		2.1
Rte 64 - Major Widening		3.9
Rte 10 (Bermuda Triangle Rd to Meadowville Rd)		2.0
I-81 Auxiliary Lanes from Exit 141 to 143		2.0
Urban Transit And Commuter Rail Projects		
10-year Transit Development Plans and Transit System Plans (bus service changes for local operators)	Change in Vehicle Revenue-Hours	1,089,000
Crystal City Transitway: Northern Extension Bus Rapid Transit	Change in Ridership	354,000
Duke Street Transitway - King St Metro to Fairfax County Line		3,300,000
US1 Bus Rapid Transit Huntington to Woodbridge		4,560,000
West End Transitway - Van Dorn Street Metro		2,580,000
Metrorail Silver Line Phase 2		9,707,000
Virginia Railway Express FY20-FY25 Transit Development Plan		3,444,000
Intercity Passenger Rail Projects		
Washington DC to Richmond (DC2RVA) Tier II EIS	Change in Ridership	930,000
Richmond to Raleigh (R2R) Tier II EIS		90,000
Long Bridge EIS		
Richmond to Hampton Roads (R2HR) Tier I EIS		580,000
Ettrick Station Improvements		48,000
Staples Mill Station Improvements		484,000
Freight Rail Projects		
Buckingham Branch Railroad (BBRR) Improvements	Change in Ton-Miles (millions)	15.4
Norfolk International Terminals (NIT) Improvements		46.7
Virginia Inland Port (VIP) Improvements		65.0

Project/Study	Indicator ^a	Value
Commonwealth Railway (CWRY) Marshalling Yard		18.0
Shoulders Hill Siding		3.9

^aRidership and ton-miles annualized based on daily, annual, or multi-year estimates from project studies, using a default annualization factor of 300. “Change in ton-miles” represents freight shifted from truck to rail. Sources: “miles” from VDOT Smart Scale database; transit ridership and freight ton-miles from project studies.

The evaluation found that in both the 2040 build and no-build scenarios, total direct emissions are projected to decrease approximately 20 percent compared to a 2015 baseline. The decrease is due mainly to improvements in vehicle efficiency, which lead to lower per-mile emissions, outweighing projected increases in VMT of 20 percent; along with a modest amount of electrification of vehicles (6.9 percent of the light-duty fleet). Emissions from on-road motor vehicles (except transit buses) decrease by 0.3 percent between the build and no-build scenario due to reduced congestion and mode-shifting to transit and freight rail. Emissions from transit and rail collectively increase by a small amount due to the increased service by these modes. On balance, the net change across all projects is a decrease of about 37,000 metric tons or 0.1 percent of surface transportation emissions. The effects of any individual project or projects would be expected to be much smaller than this.

Statewide Analysis of Construction and Maintenance Emissions

The 2021 statewide GHG analysis also considered the magnitude of emissions from construction and maintenance activities associated with new highway and rail projects. These were estimated using the Infrastructure Carbon Estimator (ICE) tool version 2.0. Total emissions from construction and maintenance activities are estimated to be about 2.3 percent of emissions from surface transportation vehicles in 2040. For the 2040 build scenario, construction and maintenance emissions associated with new projects are projected to increase statewide construction and maintenance emissions by 8.5 percent compared to the no-build scenario.

Considering the net effects of highway traffic, transit and rail projects, and new construction and maintenance activities, the 2040 build scenario increases emissions by about 0.2 percent of the total surface transportation inventory compared to the 2040 no-build, a small effect compared to the net decrease in emissions projected between 2015 and 2040. The effects of any individual project or projects would be expected to be much smaller than this.

Statewide Analysis of Indirect Fuel-Cycle Emissions

In addition to direct emissions from combustion of fuels, vehicles generate indirect emissions from the “upstream” or “fuel cycle” emissions from extraction, refining, and transportation of the fuels. Many of these emissions are generated outside the Commonwealth of Virginia and are accounted for in sectors other than transportation.

The statewide analysis estimated the magnitude of these indirect, fuel-cycle emissions using fuel-specific multipliers. Considering fuel cycle emissions increases direct emissions by

approximately 24 percent overall. This is true in all scenarios, including 2015 and the 2040 build and no-build. Therefore while the magnitude of emissions increases, the relative difference between the build and no-build scenarios is not affected by considering fuel-cycle emissions.

Emissions from electricity generation for electrically powered vehicles (cars, trucks, and rail) are also considered indirect emissions. Virginia is a member of the Regional Greenhouse Gas Initiative, which sets a target of decreasing electricity CO₂ emissions by 2.5 percent per year in the near term. Assuming this rate of improvement continues, emission from electric cars, trucks, and transit vehicles will continue to decrease in the future even for the same level of activity.

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Summary of Emissions Changes

Exhibit 2 provides a summary of total emissions and the change in emissions for the statewide 2040 build vs. no-build scenario, and for the 2040 build vs. 2015 conditions. Emissions changes are shown by source.

Exhibit 2: Statewide Greenhouse Gas Emissions by Scenario and Source (metric tons)

Source	2015	2040 No-build	2040 Build	2040 Build vs. 2015	2040 Build vs. No-build
On-Road Motor Vehicles (non-electric), excluding transit buses	41,130,953	32,430,586	32,326,068	-20.5%	-0.3%
On-Road Motor Vehicles (electric), excluding transit buses	-	391,285	391,561		
On-Road Transit (buses) ^a	92,246	80,146	109,060	18.2%	36.1%
Urban Heavy Rail and Light Rail	45,975	25,051	28,914	-37.1%	15.4%
Intercity Passenger Rail	54,384	54,421	70,185	29.1%	29.0%
Freight Rail	575,000	570,000	588,482	2.3%	3.2%
Subtotal, direct emissions and electricity	41,898,558	33,551,489	33,514,270	-20.0%	-0.1%
Construction and Maintenance	1,034,391	1,034,391	1,122,065	8.5%	8.5%
Total (including construction and maintenance)	42,932,950	34,585,880	34,636,334	-19.4%	0.2%
Fuel Life Cycle	9,870,064	8,137,882	8,151,287	-17.4%	0.2%

Total (including fuel life cycle)	52,803,014	42,723,762	42,787,621	-19.0%	0.1%
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^a"On-road transit" includes buses operated by public transportation agencies. It does not include private transit operators (such as intercity or coach services) or school buses.

Statewide Mitigation Strategies

The 2021 statewide GHG analysis included 16 discrete planned state and regional rail and transit projects that will reduce automobile and truck travel and GHG emissions, as well as increases to existing service. VDOT and the Department of Rail and Public Transportation have also continued to fund other air quality and GHG mitigation strategies. These include bicycle and pedestrian projects, travel demand management (TDM) programs that seek to reduce the amount of commuting in single-occupancy vehicles, and investment in electric vehicles and charging infrastructure. The impacts of those strategies are not reflected in this statewide programmatic assessment.

Climate Change: Considerations Relating to the Affected Environment

Potential Climate Change Impacts

Greenhouse gas emissions have accumulated rapidly as the world has industrialized, with concentration of atmospheric CO₂ increasing from roughly 300 parts per million in 1900 to over 400 parts per million today. Over this timeframe, average temperatures have increased by roughly 1.8 degrees Fahrenheit (1 degree Celsius). If emissions continue, projected changes in global average temperature could range from 0.4°–2.7°F (0.2°–1.5°C) under a very low emissions scenario, to 4.2°–8.5°F (2.4°–4.7°C) under a higher scenario by the end of the 21st century.

Virginia faces three major risks from a changing climate: coastal flooding, inland flooding, and extreme heat.

- Coastal Flooding –Sea level rise is occurring at an accelerating rate, and five Virginia water level stations appear in the nation’s top 20 highest sea level rise trends⁷. In the next 20 to 50 years, Virginia is likely to experience at least 1.5 feet of sea level rise, with the possibility of even greater increases.⁸ Storm surge presents major risks to Virginia’s coastal areas, with over 300 bridges and structures that would face over 2 feet of storm surge inundation from a Category 2 hurricane.⁹ By 2080, 10 percent of the roadway networks in Virginia Beach and Norfolk could be flooded by “king tides” (exceptionally high tide events) with 4 feet of sea level rise.¹⁰

⁷ City of Virginia Beach (2020). Sea Level Wise: Adaptation Strategy.

[https://www.vbgov.com/government/departments/public-works/comp-sea-level-rise/Documents/20200330%20FullDocument%20\(2\).pdf](https://www.vbgov.com/government/departments/public-works/comp-sea-level-rise/Documents/20200330%20FullDocument%20(2).pdf)

⁸ Georgetown Climate Center (undated). “Understanding Virginia’s Vulnerability to Climate Change.” Accessed at <https://www.georgetownclimate.org/files/report/understanding-virginias-vulnerability-to-climate-change.pdf>

⁹ Commonwealth of Virginia, Office of the Secretary of Transportation (2020). Vulnerability Assessment.

¹⁰ Sadler, Jeffer, Nicole Haselden, Kimberly Mellon, and Allison Hackel (2017). Impact of Sea-Level Rise on Roadway Flooding in the Hampton Roads Region, Virginia. *Journal of Infrastructure Systems*. Accessed at:

- Inland Flooding – The southeastern U.S. has experienced an increase in flooding from heavy rainfall and extreme precipitation events. Virginia has seen heavy rainstorms increase by 33 percent in the last 60 years.¹¹ In the future, the southeastern U.S. is expected to see a continued increase in extreme rainfall events.
- Extreme Heat – Heat waves are a leading cause of weather-related deaths.¹² Anticipated more intense heat events pose dangers to human activity and human health.

Project-Level Climate Strategies and Considerations

Resiliency is an important consideration for future infrastructure investments and includes both building in areas with minimal risk and designing infrastructure that is resilient to potential impacts that could affect its scope, function, and/or performance. Resiliency strategies that are cost-effective and can be adopted during the planning, project development, construction, and/or maintenance phases of a given infrastructure project are supported.

VDOT, and some regional and local agency partners in the state, have already engaged in efforts to plan for resiliency. As part of the development of VTrans, Virginia's Long Range Plan, the Office of Intermodal Planning and Investment undertook a vulnerability assessment. Initial work for this assessment conducted in 2019 established a definition of climate change vulnerability and resilience for the agency; created a draft vulnerability assessment methodology to score the state's transportation assets based on exposure, sensitivity to climate change, and adaptive capacity; and performed a review of Virginia's transportation vulnerability assessments. The Office is working to refine the indicators and weighting approach as needed, finalize remaining data collection, and produce a vulnerability rating for each segment of the National Highway System and for each bridge under the state's jurisdiction.

The Metropolitan Washington Council of Governments developed a summary of potential climate change impacts, vulnerabilities, and adaptation strategies in the region. This report describes general impacts of climate change as well as vulnerability and strategies for the transportation sector.¹³

The Van Buren Road Extension project has not been scored for exposure, sensitivity, and adaptive capacity. However, vulnerability to climate change is believed to be low because the project is not located in a coastal area or river valley. Analysis of the project area within the

<https://ascelibrary.org/doi/pdf/10.1061/%28ASCE%29IS.1943-555X.0000397>.

¹¹ Georgetown Climate Center (undated). "Understanding Virginia's Vulnerability to Climate Change." Accessed at <https://www.georgetownclimate.org/files/report/understanding-virginias-vulnerability-to-climate-change.pdf>

¹² Georgetown Climate Center (undated). "Understanding Virginia's Vulnerability to Climate Change." Accessed at <https://www.georgetownclimate.org/files/report/understanding-virginias-vulnerability-to-climate-change.pdf>

¹³ Metropolitan Washington Council of Governments. 2013. "Summary of Potential Climate Change Impacts, Vulnerabilities, and Adaptation Strategies in the Metropolitan Washington Region." <https://www.mwcog.org/documents/2013/07/01/summary-of-potential-climate-change-impacts-vulnerabilities-and-adaptation-strategies-climate-change/>

online interactive VTrans Vulnerability Assessment tool did not identify any vulnerabilities based on exposure, sensitivity, or adaptive capacity for sea level rise, storm surge, or inland/riverine flooding due to effects of climate change.

3.5 Indirect Effects and Cumulative Impacts (IECI)

Indirect effects are defined by the Council on Environmental Quality 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.

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 qualitative 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 annual conformity analysis conducted by the National Capital Region (NCR) Transportation Planning Board (TPB, 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 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 approved conformity analysis was completed in January 2020, with the most recent Transportation Improvement Program (FY 2021-2024 TIP) which includes this conformity analysis adopted by the TPB on March 18, 2020. 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.

4.0 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*. In addition, the following Virginia Department of Environmental Quality (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.

5.0 Project Status in the Regional Transportation Plan and Program

Federal conformity requirements, including specifically 40 CFR 93.114 and 40 CFR 93.115, 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)).

The project (TIP ID 8605) was added to the FY2021-2024 Statewide Transportation Improvement Program (adopted March 18, 2020) as a Study in an amendment approved by the National Capital Region Transportation Planning Board on April 21, 2021. State approval and FHWA approval of this amendment is pending. As a study, the project is exempt from Air Quality Conformity Analysis, but it is already included in Visualize 2045. The study is being funded by Prince William County with non-Federal funds, so the project does not impact the financial constraint finding of the Visualize 2045 Financial Plan.

6.0 Conclusion

The proposed roadway extension project was assessed for potential air quality impacts and compliance with applicable air quality regulations and requirements. 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 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.

Appendix A: Virginia Statewide Greenhouse Gas and Climate Change Impacts Planning Level Analysis

1.0 Overview

This technical appendix describes the methods and findings of a 2021 statewide transportation greenhouse gas (GHG) inventory and forecast developed for the Commonwealth of Virginia. It also provides information on the potential impacts of climate change on Virginia and its infrastructure.¹

In 2021, the Virginia Department of Transportation (VDOT) developed a statewide inventory and forecast of GHG emissions from the surface transportation sector. The inventory and forecast includes:

- Direct operating emissions from system users including highway vehicles and passenger and freight rail vehicles.
- “Lifecycle” or upstream emissions associated with the production and transport of transportation fuels.
- Emissions from highway and rail construction and maintenance activities.

The inventory and forecast provided an estimate of 2015 emissions as well as a forecast of 2040 emissions with no changes to the transportation system (“2040 no-build”), and an estimate of 2040 emissions reflecting the impacts of planned new highway, transit, and rail projects (“2040 build”). Table 1-1 lists a sample of the major highway projects and all of the major transit and rail projects included in the 2040 build scenario, along with an indicator of the scale of each project (a complete listing of highway projects is included in Section 6.0 of this document). In all there are over 500 planned or programmed highway projects representing 1,227 new lane-miles as well as reconstruction and rehabilitation, bicycle and pedestrian facilities, park-and-ride lots, bridge work, geometric realignments, intersection improvements, and other projects. The sample of projects shown here includes the largest value projects (over \$25 million each, collectively totalling nearly \$1.5 billion in value) included in VDOT’s Smart Scale database.

Table 1-1 Sample of Major Highway Projects and List of All Major Transit and Rail Projects Included in 2040 Build Scenario

Project/Study	Indicator ^a	Value
Highway Projects (sample of major projects)		
I-64 Southside Widening and High-Rise Bridge	Miles	9.1
I-64 Capacity Improvements - Segment III	Miles	8.4
Rte 7 Corridor Improvements - Phase 1 and Phase 2	Miles	6.8
I-264/Witchduck Rd Interchange & Ramp Extension	Miles	2.3
I-95 Rappahannock River Crossing	Miles	6.0
Rte 58 - Widen to 6-Lane Divided Facility	Miles	2.1
Rte 64 - Major Widening	Miles	3.9

¹ This appendix was developed by Cambridge Systematics, Inc., under direction from VDOT, with Christopher Porter of Cambridge Systematics as the lead author. Cambridge Systematics is a leading U.S. firm in transportation planning, travel demand modeling and forecasting, transportation energy and emissions analysis, and climate change and resiliency planning. Mr. Porter is the Principal Investigator of National Cooperative Highway Research Program Project 25-56, which developed a guide for State DOTs to estimate and reduce GHG emissions. He has directed or been a major contributor to other major GHG mitigation assessments for agencies including the U.S. DOT, National Renewable Energy Laboratory, and various state and local transportation and environmental agencies.

Project/Study	Indicator ^a	Value
Rte 10 (Bermuda Triangle Rd to Meadowville Rd)	Miles	2.0
I-81 Auxiliary Lanes from Exit 141 to 143	Miles	2.0
Urban Transit And Commuter Rail Projects		
10-year Transit Development Plans and Transit System Plans (bus service changes for local operators)	Change in Vehicle Revenue-Hours	1,089,000
Crystal City Transitway: Northern Extension Bus Rapid Transit	Change in Ridership	354,000
Duke Street Transitway - King St Metro to Fairfax County Line	Change in Ridership	3,300,000
US1 Bus Rapid Transit Huntington to Woodbridge	Change in Ridership	4,560,000
West End Transitway - Van Dorn Street Metro	Change in Ridership	2,580,000
Metrorail Silver Line Phase 2	Change in Ridership	9,707,000
Virginia Railway Express FY20-FY25 Transit Development Plan	Change in Ridership	3,444,000
Intercity Passenger Rail Projects		
Washington DC to Richmond (DC2RVA) Tier II EIS	Change in Ridership	930,000
Richmond to Raleigh (R2R) Tier II EIS	Change in Ridership	90,000
Long Bridge EIS		
Richmond to Hampton Roads (R2HR) Tier I EIS	Change in Ridership	580,000
Ettrick Station Improvements	Change in Ridership	48,000
Staples Mill Station Improvements	Change in Ridership	484,000
Freight Rail Projects		
Buckingham Branch Railroad (BBRR) Improvements	Change in Ton-Miles (millions)	15.4
Norfolk International Terminals (NIT) Improvements	Change in Ton-Miles (millions)	46.7
Virginia Inland Port (VIP) Improvements	Change in Ton-Miles (millions)	65.0
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Shoulders Hill Siding	Change in Ton-Miles (millions)	3.9

^aRidership and ton-miles annualized based on daily, annual, or multi-year estimates from project studies, using a default annualization factor of 300. "Change in ton-miles" represents freight shifted from truck to rail. Sources: "miles" from VDOT Smart Scale database; transit ridership and freight ton-miles from project studies.

This technical appendix describes the methods and findings of the 2021 inventory and forecast. Section 2.0 provides methods and assumptions, with detail for mobile source operating emissions (highway vehicles, buses, and rail); fuel-cycle emissions; and construction and maintenance emissions. Section 3.0 discusses key uncertainties that could affect the findings. Section 4.0 presents a summary of findings on emissions from all sources.

In addition to describing the statewide GHG analysis, Section 5.0 of this appendix provides more information on the potential impacts of climate change on Virginia and its infrastructure, to support considerations relating to the affected environment in project-level environmental documentation. Section 6.0 provides a list of all highway projects included in the 2040 build scenario.

2.0 Methods and Assumptions

2.1 Mobile Source Operating Emissions

2.1.1 Analysis Scope and Approach

The statewide GHG analysis evaluated GHG emissions from on-road mobile sources for the 2015 base year and for the 2040 “build” and “no-build” scenario. A comparison of 2040 no-build to 2015 conditions shows how emissions are expected to change as a result of changes in vehicle-miles traveled (VMT) resulting from population and economic growth; changes in congestion; and improvements in vehicle and fuel technology (more efficient vehicles and low-carbon fuels, including electricity). A comparison of 2040 build to no-build conditions shows the additional changes expected as a result of the VMT and congestion impacts of planned highway improvements.

Emissions from highway vehicles (automobiles, trucks, and buses except for urban transit buses) are estimated using the Virginia statewide travel demand model and the U.S. Environmental Protection Agency’s (EPA) Motor Vehicle Emissions Simulator Model (MOVES). Emissions from transit and rail vehicles are estimated from data found in various sources including the National Transit Database (NTD), the Virginia Statewide Rail Plan, Washington Metropolitan Area Transit Authority (WMATA), the Metropolitan Washington Council of Governments (MWCOCG), and corridor and project-specific studies for transit and rail projects listed in Table 1-1.²

2.1.2 Highway Vehicles

Statewide Travel Demand Model

The Virginia statewide travel demand model was used to estimate and forecast VMT by light-duty cars and trucks, medium and heavy trucks, and buses except for urban transit buses. The Virginia statewide travel demand model is a network-based model used for predicting future travel demand and traffic conditions. It contains information on base year (2015) and future year (2040) households, demographic data, and employment for geographical units known as traffic analysis zones (TAZ). It also contains a set of connected links representing the state’s transportation network. Links have characteristics such as road type, capacity, and free-flow speed. When the model is run, trips generated by households and employment are assigned to the network and traffic conditions (volumes and speeds) on each network link are estimated.

Base year (2015) emissions were estimated based on model runs using the 2015 network and 2015 land use conditions. For the 2040 no-build scenario, the base year (2015) network was used to represent the 2040 no build condition along with 2040 land use. The 2040 network plus 2040 land use represents the 2040 build condition. The 2040 network includes fiscally-constrained roadway improvements (new roads, additional lanes, or changes to speed) that correspond with projects programmed in VDOT’s Six-Year Improvement

² The COVID-19 pandemic of 2020 created unprecedented changes in travel patterns, including high levels of working from home, increased use of other on-line services, and changes in modal preferences due to health and safety concerns. It is not known to what extent these changes might continue in the future, even after economic activity returns to normal levels. The statewide model forecasts, and other forecasts referenced in this protocol, are based on pre-COVID-19 conditions. Future year no-build and build forecasts may need to be revised in the future if long-lasting changes to travel behavior are observed. The effects of increased telework programs as a mitigation strategy may also be considered in project and program-level analysis.

Plan as well as the long-range transportation plans (LRTP) of the state's Metropolitan Planning Organizations (MPO).

Three outputs of the statewide model were required as inputs for emissions modeling using MOVES:

- VMT by vehicle type (auto, medium truck, heavy truck, buses).
- Speed distributions, or the fraction of vehicle-hours of travel (VHT) spent in 16 speed bins.
- Road type distributions, or the fraction of VMT on four road types (rural restricted access, rural unrestricted access, urban restricted access, urban unrestricted access).

Total VMT

Annual VMT was computed by multiplying the daily volume of traffic on each roadway link by the length of the link (in miles), then by an annualization factor. The model estimates total volumes, medium truck volumes, and heavy truck volumes. Light-duty volumes were found by subtracting truck volumes from total volumes. The specific fields and calculations are shown in **Error! Reference source not found..** MOVES also requires motorcycle and bus volumes. These were added to the VMT based on the statewide average percent of all VMT for these vehicle types from FHWA's Highway Statistics (2015) – 2.50 percent for motorcycles and 0.44 percent for buses. Transit bus VMT was estimated separately from National Transit Database data (as described below) and was subtracted from the total model estimate of VMT.

The statewide model is calibrated against weekday traffic volumes on major roadways. Weekday volumes were annualized using a factor of 353.8. For a number of reasons, the model's estimated total VMT did not precisely match the estimated statewide VMT (as reported by the Commonwealth of Virginia to the Federal Highway Administration, or FHWA) based on traffic counts.³ Therefore, total VMT from the model in 2015 (95.8 million) was adjusted to match total statewide VMT as reported in FHWA's Highway Statistics publication for 2015 (82.6 million). This proportionate adjustment (ratio of 0.86) was applied to auto, medium truck, and heavy truck VMT estimates. The same adjustment factor was also applied to the modeled 2040 VMT.

Speed Distributions

The statewide model does not explicitly divide daily traffic into time periods and model peak period congestion. Instead, a single daily volume is forecast. Each roadway link in the model has an associated "free-flow" speed that represents the speed of travel under uncongested conditions. A single "congested speed" for the peak hour is also estimated based on the assumption that 10 percent of daily traffic occurs during the peak hour. For this analysis, that congested speed was assigned to the morning (AM) and evening (PM) peak periods which were assumed to last 3 hours each (7 - 10 AM and 4 - 7 PM). Free-flow

³ For example, local roads and collectors are not explicitly included in the statewide model. Also, weekend traffic is not modeled, so there is uncertainty in the annualization factor. Furthermore, the model is just that – a model, and modeled conditions will not precisely match actual conditions. Finally, it should be noted that VMT estimates based on traffic counts are still estimates as well. Counts are conducted continuously only on a limited sample of roads, and are extrapolated to other roadway segments based on short-term counts and other approximation methods.

(Footnote continued on next page...)

speeds were assigned to other time periods (9 AM – 4 PM = midday; 7 PM – 7 AM = off-peak).⁴ The model computes congested speeds using the Bureau of Public Roads formula⁵ with coefficients that vary by roadway type.

Daily traffic volumes were assigned to the four time periods based on the hourly fraction of volume found in the representative county (Fairfax County) hourly volume distribution file that is also required as input to MOVES. (This file was obtained from the VA Department of Environmental Quality along with other MOVES inputs as described in the next section.) The volume fractions vary by the four MOVES road types and by vehicle type.

Road Type Distributions

The fraction of VMT occurring by road type was determined by summing VMT from each model link by the associated road type, associating model road types with MOVES road types.

MOVES Model

MOVES is the U.S. EPA's official emission factor model. The version used for the 2021 statewide analysis was MOVES3, released in November 2020. PollutantID 98 (CO₂ equivalent) was used, which includes CO₂, methane (CH₄), and N₂O. MOVES3 accounts for Federal fuel economy/GHG, clean fuel, and emissions standards in place as of 2020. This includes light duty and heavy duty GHG standards through Model Year (MY) 2025, reflecting the Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule adopted in March 2020,⁶ which reduced the stringency of the standards compared to a final rule adopted in 2012.⁷ In January 2021 the Biden administration ordered a review of the SAFE rule which may result in a proposal to suspend, revise, or rescind it (thereby reverting to the earlier, more stringent standards which would result in larger GHG reductions in the future).

MOVES was run in inventory mode to provide total emissions. MOVES was run using the county domain scale, where vehicle activity output data from the statewide model are combined with other data for the state or from a representative county.

Table 2-1 shows the source of MOVES inputs for the statewide analysis. The build and no-build vehicle activity inputs were taken from the statewide model as detailed in the previous section. Vehicle age distributions and source type populations are obtained from the Virginia Department of Environmental Quality (DEQ) for the state as a whole. Other inputs were taken for Fairfax County, used as a representative county, as developed by DEQ for the National Emissions Inventory (NEI) and posted on VDOT's online data repository, and consistent with VDOT's Resource Document.⁸ Fairfax County was used as the representative

⁴ The model database includes fields for speed and link travel time corresponding to four time periods – AM Peak, Mid Day, PM Peak, and Off-Peak. These fields are holdovers from the early stage of the model development process, when a time period model was being considered. The period-specific speeds and travel times in the model are not updated after the model is run. In this analysis the period-specific speed and travel time fields were overwritten with peak period and free-flow data computed as described in the text and table.

⁵ This formula is: Congested speed = Free flow speed / (1 + α * (Volume / Capacity)^B), where α is a coefficient ranging from 0.3 to 1.0 and B is a coefficient ranging from 3.0 to 6.0 depending on the roadway type.

⁶ <https://www.nhtsa.gov/corporate-average-fuel-economy/safe>

⁷ U.S. Department of Transportation and Environmental Protection Agency. 2017 and Later Model Year Light-Duty Vehicle Greenhouse Gas Emissions and Corporate Average Fuel Economy Standards; Final Rule. Federal Register 77:199, Monday, October 15, 2012.

⁸ http://www.virginiadot.org/projects/environmental_air_section.asp

county because it has the highest VMT of any county in the state (nearly 12 percent of statewide VMT based on VDOT estimates). In all cases where representative county inputs are used, the effect of these inputs on GHG emissions should be very minor, if any, as these inputs primarily affect pollutants other than CO₂.

Table 2-1 MOVES Inputs

MOVES Input Name	Description	Influence on Emissions	Source for VDOT Statewide
sourceTypeAgeDistribution	Distribution of vehicles by age.	High - Newer vehicles will have lower emission rates as a result of more stringent emissions standards.	Statewide age distribution from 2017 registration data as provided by DEQ.
sourceTypeYear	Population of vehicles by source (vehicle) type.	Low - Mainly affects start emissions, which have a small influence on GHGs.	Statewide source type population from 2017 registration data as provided by DEQ.
HPMSVTypeYear	VMT by vehicle type.	High - VMT is multiplied by rate per mile; different vehicle types will have very different emission rates.	Statewide model – see Error! Reference source not found..
monthVMTFraction	Fraction of annual VMT occurring in each month.	Low – very minor effect on GHG	Use Fairfax County as a representative county.
dayVMTFraction	Fraction of annual VMT occurring on weekdays vs. weekends.	None or very minor.	Use Fairfax County as a representative county.
hourVMTFraction	Fraction of daily VMT occurring within each hour.	Low – very minor effect on GHG	Use Fairfax County as a representative county.
roadTypeDistribution	Fraction of VMT occurring on each MOVES road type.	Moderate – affects operating mode distributions in MOVES.	Statewide model – see Error! Reference source not found..
avgSpeedDistribution	Fraction of VHT occurring within each of 16 speed bins.	High – speed has a significant effect on fuel consumption and GHG.	Statewide model – see Error! Reference source not found..
Temp/humidity - zoneMonthHour	Temperature and humidity by month and hour.	Low – mainly affects criteria pollutants.	Use Fairfax County as a representative county.
FuelFormulation FuelSupply	Characteristics of fuel sold in the region.	Low – mainly affects criteria pollutants.	Use Fairfax County as a representative county.
IMCoverage	Inspection and maintenance program characteristics.	Low – mainly affects criteria pollutants.	Use Fairfax County as a representative county.

Electric and Alternative Fuel Vehicles

The approach of applying MOVES to travel demand model output assumes that virtually all automobiles and trucks in 2040 will continue to be gasoline and diesel powered. This is likely to change in the future. Emissions from electricity generation to power future electric vehicles are accounted for separately in the

statewide inventory since they are generated at the powerplant source rather than directly by on-road transportation sources.

In the statewide analysis, VMT and vehicle (source type) population inputs to MOVES were reduced in proportion to the electrification rate. Future electrification rates by vehicle type are uncertain. This study used the National Renewable Energy Laboratory (NREL) Electrification Futures Study (EFS) Reference Scenario, which is referenced by MWCOC in its 2020 Climate and Energy Action Plan.⁹ NREL projects as a reference case that 6.9 percent of light-duty VMT, 0.6 percent of medium-duty truck VMT, and 0.0 percent of heavy-duty truck VMT will be electrified in 2040.¹⁰ NREL also projects a small amount of VMT from vehicles powered by natural gas or other fuels (less than 2 percent for medium trucks, 1 percent for heavy trucks, and 0.2 percent for light vehicles). Since GHG emissions from natural gas vehicles are not substantially less than for gasoline or diesel vehicles, and these fuels are already used to some degree in the NREL 2015 baseline, these alternative fuel types were not explicitly considered as doing so would have a minimal impact on the overall emissions estimates.

2.1.3 Transit Buses

Transit bus emissions were estimated using data provided from transit providers to the National Transit Database (2015 reporting year).¹¹ To avoid double-counting, transit bus VMT was subtracted from the statewide model output (which was calibrated to match all on-road VMT, including buses).

Baseline 2015 Emissions

Baseline emissions from transit service in 2015, including buses, were estimated using VMT data reported to the NTD by all transit operators in Virginia and emission factors from MOVES. The method applied was as follows:

1. Query the NTD to sum fuel use by type of fuel and total VMT by vehicle type for all transit operators in Virginia, and including all types of transit service offered.
2. For WMATA, which operates service in multiple states, divide the WMATA data so that only the Virginia portion of service is included. Based on WMATA ridership reports, 17 percent of Metrobus riders originate in Virginia.¹² This percentage was applied to total WMATA bus VMT to identify the Virginia portion.¹³

⁹ <https://www.mwcog.org/documents/2020/11/18/metropolitan-washington-2030-climate-and-energy-action-plan/>

¹⁰ National Renewable Energy Laboratory. (2018). Electrification Futures Study: Scenarios of Electric Technology Adoption and Power Consumption for the United States. Golden, CO. <https://www.nrel.gov/analysis/electrification-futures.html>.

¹¹ <https://www.transit.dot.gov/ntd>

¹² Metrobus Monthly Ridership: Bus Line, Sector and Jurisdictional Summary. June 2017 – Preliminary. https://www.wmata.com/initiatives/ridership-portal/upload/201706-JCC-June-2017-Preliminary-Ridership-Rpt_-07092017.pdf

¹³ Diesel commuter rail (CR) and ferry boat (FB) emissions should be included in Section 2.4 with intercity passenger and freight rail. Electric (trolley bus – TB, light rail – LR, heavy rail – HR) emissions should be included in the “fuel cycle” portion of the inventory as described in Section 3.0.

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3. Estimate VMT by fuel type by multiplying total VMT by the fractions of each fuel. These calculations were performed separately for each transit mode. This approach assumes that VMT is proportional to fuel consumption.
4. Obtain MOVES emission factors per bus VMT from the completed MOVES runs for the highway analysis (total GHG emissions for each of four vehicle types output from MOVES¹⁴ divided by total VMT for the vehicle type as input to MOVES). Use vehicle type 40 (bus) for Motor Bus and Commuter Bus (MB, CB) and 20 (light-duty vehicle) for taxi (DT), Vanpool, and Demand Response (VP, DR). For VP and DR, divide the average light-duty vehicle emissions rate by the ratio of “light truck” to “light duty vehicle” stock average MPG from the U.S. Department of Energy (DOE), Annual Energy Outlook (AEO) Reference Case. The 2020 AEO Reference Case shows this ratio as being approximately 0.87 between 2017 and 2040.
5. Multiply VMT by the MOVES-generated emission factor for buses. Sum to get total emissions.

No-Build 2040 Emissions

For the baseline 2040 emissions estimate, no change in service levels was assumed. Therefore, the only changes in emissions result from increasing efficiency of the bus fleet consistent with Federal standards for heavy-duty vehicles. Emission factors for 2040 were applied to the service levels in the 2015 scenario. No electrification of the bus fleet was assumed.

Emissions Under the 2040 Build Scenario

Each of Virginia’s 41 local public transportation agencies must develop and update a Transit Development Plan (TDP) every six years that identifies capital and operating programs and associated budgets. Large public transportation agencies must also develop a Transit Strategic Plan (TSP) outlining desired changes that will improve the provision of transit services throughout each agency’s service area within existing funding structures.

The TDPs and TSPs for the five largest agencies in the state were reviewed for this analysis, including Hampton Roads Transit (HRT), Greater Richmond Transit Company (GRTC), Fairfax County, Blacksburg Transit, and City of Alexandria Transit Company (DASH). These variously project changes in vehicle revenue-miles, revenue-hours, and in some cases ridership over a 10-year period. These agencies collectively represent 50 percent of vehicle revenue-miles of all the 41 operators, based on NTD data. In addition, capital and service plans for WMATA, which operates some service in the Northern Virginia region, were reviewed.¹⁵

Changes to existing service levels – The TDPs and TSPs for the five largest agencies under DRPT’s purview identify baseline and projected vehicle revenue miles, revenue hours, and/or ridership, with baseline years ranging from 2014 to 2019 and out years ranging from 2022 to 2030. For plans that do not project revenue-miles, revenue-hours were used to inflate base year revenue-mile values to a value representing

¹⁴ Light duty: source types 11, 21, 31, 32. Bus: source types 41, 42, 43. Medium truck: source types 51 – 54. Heavy truck: source types 61, 62.

¹⁵ Washington Metropolitan Area Transit Authority (2019). 10-Year Capital Needs Forecast: FY2019-2028. <https://www.wmata.com/initiatives/plans/upload/2019-Capital-Needs-Forecast.pdf>; Metropolitan Washington Council of Governments (2018). Visualize 2045: A Long-Range Transportation Plan for the National Capital Region. <https://www.mwcog.org/visualize2045/document-library/>

2040, based on the ratio of out-year to base-year service. No changes to existing WMATA services were identified in published documents. Emission factors consistent with the no-build analysis were applied to expanded services in the build scenario. The change in emissions was increased by 100 percent assuming that all transit operators change their service levels in the same proportion as the top five operators, to account for the 50 percent of revenue-miles from transit providers not covered in the five largest plans.

New services - The five largest agencies under DRPT's purview did not have any rail investments programmed at the time of the analysis, although some bus transit improvements were planned that are captured in overall ridership increase estimates. For Northern Virginia, four planned bus rapid transit or transitway projects were identified in MWCOC documents. Emissions from these services were estimated by examining project-specific studies that provided data on planned new service levels by vehicle type and/or ridership.¹⁶

For changes to existing services and for new services, the following effects were accounted for in estimating GHG emissions changes:

- **Direct operating emissions from transit vehicles** – The amount of new service (vehicle revenue-miles by fuel type) was multiplied by the MOVES emission factor (grams per mile).
- **Displaced emissions from automobiles** – New passenger-miles were multiplied by an assumed “prior drive” mode share (percent of passengers that would have driven if transit were not available) and by the 2040 automobile GHG emission factor (g/mi). The emission factor was obtained from MOVES output by dividing total emissions for vehicle type 25 (light duty autos and trucks) by total VMT for this vehicle type. These displaced auto emissions were subtracted from the onroad mobile source estimates developed using MOVES in tables showing mode-specific GHG accounting, but were kept with the transit and rail projects in tables showing the net effects of these projects. The prior drive mode share value used was 60 percent.¹⁷

Two other categories of emissions savings associated with transit service based on methods described in a 2009 American Public Transportation Association (APTA) document.¹⁸

- **Emissions savings from congestion relief as a result of less driving.** APTA presents a method using data on fuel savings related to public transportation use from the Texas Transportation Institute's Urban Mobility Report that can be applied to large cities included in the report. This method was applied to changes in service in the Northern Virginia area. Fuel savings generated from the congestion mitigation effects of public transit were scaled down by the ratio of new service to existing service. An emissions factor was then applied to the fuel savings to calculate the emissions savings from congestion relief.

¹⁶ At this time of this writing, overall travel patterns and transit ridership were changing dramatically, at least in the short term, as a result of the COVID-19 pandemic. Long-term effects of this pandemic could lead to changes in transit ridership or highway travel compared to those forecast in pre-COVID studies. Future results could therefore differ from previous findings to some unknown degree.

¹⁷ Estimated by Cambridge Systematics for the Transportation and Climate Initiative region, “urban” and “suburban” area types, from a variety of data sources. Source/documentation pending publication.

¹⁸ APTA Climate Change Standards Working Group (2009). Recommended Practice for Quantifying Greenhouse Gas Emissions from Transit. APTA CC-RP-001-09.

(Footnote continued on next page...)

- **Emissions savings from secondary effects of transit service in supporting more efficient land use patterns (the “land-use multiplier”).** APTA provides a default value of 1.9 (applied to the value of displaced emissions from reduced automobile travel). The land use multiplier is based on statistical analysis of the relationship between transit investment/service and land use patterns to estimate the long-term effects of transit in terms of reducing the need for auto travel through more efficient land use patterns that result in trips that are shorter and/or feasible by walking or bicycling. The most appropriate multiplier can vary substantially based on the type of service and its urban context, with the greatest effect for fixed-guideway services in larger and/or denser metropolitan areas.¹⁹ The use of the 1.9 factor is a first-order approximation. For the statewide analysis, the 1.9 land use multiplier was applied by multiplying direct emissions savings from automobile mode shift by 1.9 to estimate emissions savings from land use patterns.

2.1.4 Light and Heavy Urban Rail

2015 Baseline and 2040 No-Build Emissions

In order to estimate baseline 2015 emissions associated with light rail and urban heavy rail operations in Virginia, fuel data (electricity usage) was queried from the National Transit Database for the light rail (LR) and heavy rail (HR) modes. The vast majority of light and heavy rail operating emissions come from WMATA Metrorail operations in Virginia. Based on ridership reports produced by WMATA, 23 percent of Metrorail ridership can be attributed to stations in Virginia;²⁰ this fraction of electricity usage was attributed to Virginia for the purposes of this inventory. A small fraction of emissions (less than 3 percent of this category) is generated by The TIDE light rail service in Norfolk.

In order to determine the emissions associated with this electricity use, CO₂ emission rates were sourced from EPA’s eGRID, with an average rate for Virginia of 93.6 grams CO₂e per megajoule (g/MJ). This emissions factor was then applied to the electricity use to determine the 2015 baseline emissions.

In the absence of any noted light rail or heavy rail service expansions in recent capital plans, the 2040 No Build scenario assumes electricity consumption will be unchanged from 2015, but applies an updated electricity emissions factor.

Emissions Under 2040 Build Scenario

For the 2040 Build scenario, the change in emissions associated with the completion of the second phase of the Metrorail Silver Line expansion to Dulles Airport was identified. This was the only light or heavy rail project identified in a review of planned projects.

Emissions changes from the Metrorail expansion were broken out into two categories: increased emissions from rail operations, and reduced auto emissions as a result of mode-shifting. Data on daily boardings for the expansion stations were sourced from the Dulles Silver Line Final EIS²¹ to proxy for operating emissions.

¹⁹ TCRP Report 176 (2015). Quantifying Transit’s Impact on GHG Emissions and Energy Use—The Land Use Component; and TCRP Land Use Benefit Calculator. <http://www.trb.org/main/blurbs/172110.aspx>

²⁰ PlanItMetro. Metro Ridership by Station by Month, 2010-20215. <https://planitmetro.com/2016/03/24/data-download-metrorail-ridership-by-station-by-month-2010-2015/>

²¹ Dulles Corridor Metrorail Project. Final Environmental Impact Statement and Section 4(F) Evaluation. 2004. http://www.dullesmetro.com/silverline/assets/File/project_docs/FEIS_I/FTA_FEIS_Chapter_6.pdf

Since daily boardings were only projected out to 2025, these estimates were assumed for the year 2040. In order to calculate operating emissions based on ridership estimates, the following steps were taken:

1. Calculate a Metrorail “emissions-per-rider” factor from 2015 data by dividing the estimated 2015 Metrorail emissions by 2015 ridership.
2. Create a 2040 emissions-per-rider factor by scaling the 2015 factor according to the assumed eGRID emissions factor improvements. Between 2015 and 2040, this represents a roughly 45 percent reduction in electricity emissions intensity.
3. Apply the new 2040 emissions-per-rider factor to the 2040 boarding estimates.

In order to calculate the emissions reductions from mode-shifting (from onroad motor vehicles) as the result of new Metrorail service, a WMATA-specific “displacement factor” was sourced from a recent WMATA sustainability report.²² According to the 2019 report, WMATA’s emissions totaled roughly 367,000 MT CO₂, but in the absence of Metro, the regional emissions would have totaled 667,000 MT CO₂. Therefore, it was inferred that for every metric ton of CO₂ generated by WMATA, 1.82 metric tons of CO₂ are avoided from onroad mobile sources. This displacement factor of 1.82 was applied to the new WMATA Metrorail emissions from the Silver Line Expansion.

2.1.5 Commuter and Intercity Passenger and Freight Rail

Baseline 2015 and 2040 No-Build Emissions

Baseline 2015 emissions were estimated from data in the Virginia Statewide Rail Plan (Virginia DRPT, 2017).²³ Chapter 2 provides estimates of intercity rail passenger-miles (412 million in 2015) and freight rail ton-miles (25 billion in 2015) moved within the state. Baseline emissions were estimated by multiplying these values by average national rates of CO₂ per passenger-mile and rail ton-mile as shown in Table 2-2-22.

Baseline 2040 emissions were also estimated from data in the Statewide Rail Plan. The plan projects a 20 percent increase in passenger boardings and alightings between 2016 and 2040, and a 19 percent increase in rail tonnage.²⁴ These increases were assumed to be proportionate to increases in passenger-miles and ton-miles. The AEO projects that the energy efficiency of freight rail per ton-mile will increase by 16 percent between 2017 and 2040. The analysis assumes that this efficiency improvement applies to both passenger and freight rail and that GHG intensity is proportionate to energy intensity (i.e., no change in fuel sources or the carbon intensity of these sources). The resulting GHG factors for 2040 are also shown in Table 2-2-22.

Table 2-2-2 2015 and 2040 Intercity Rail Emission Rates

Mode	Units	Energy intensity (BTU/unit)		CO ₂ Intensity (kg CO ₂ /unit)	
		2015	2040	2015	2040
Passenger Rail	Per passenger-mile	1,644	1,381	0.132	0.111

²²WMATA. Metro Sustainability Report. 2019. https://www.wmata.com/initiatives/sustainability/upload/2019-Annual-Sustainability-Report_accessible_final.pdf

²³ <http://www.drpt.virginia.gov/rail/reference-materials/virginia-state-rail-plan/>

²⁴ These estimates were made prior to the COVID-19 pandemic. Potential effects of this pandemic on these forecasts, as well as the forecasts included in other studies referenced here, are unknown.

Freight Rail	Per ton-mile	293	246	0.023	0.019
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Sources: Energy intensity – National average for commuter rail or freight rail, from Oak Ridge National Laboratory Transportation Energy Data Book, Edition 38.1. Converted to CO₂ intensity at a rate of 10.21 kg CO₂ per gallon (The Climate Registry) and 127,371 BTU per gallon (Energy Information Administration). 2040 vs. 2015 efficiency improvement of 16% based on AEO projections.

Emissions from diesel commuter rail are included in this section based on diesel fuel consumption reported by transit operators to the National Transit Database.

Emissions Under the 2040 Build Scenario

There is no single source of planned intercity passenger and freight rail service changes. The Statewide Rail Plan provides estimates of emission reductions and economic benefits related to baseline forecast service levels, but does not describe “plan” vs. “no-plan” conditions.

For changes in operating emissions from intercity rail improvements, DRPT identified 12 studies of individual rail corridors or improvement projects. These include a mix of passenger and freight rail projects. Six of these studies provided direct estimates of GHG emission reductions. Four others provided changes in rail ridership and/or auto VMT, from which CO₂ emissions were estimated. One study provided changes in rail ton-miles from which CO₂ emissions changes were estimated. In some cases, the estimates are cumulative over a multi-year period, and assumptions were made to estimate changes for year 2040. The studies and information provided in each are shown in Table 2-2-33.

Table 2-2-3 Rail Corridor or Project Studies Included in 2040 Build Scenario

Study	GHG Change	Rail Ridership Change	Change in Auto VMT	Change in Truck VMT	Change in Rail Ton-Miles
Washington DC to Richmond (DC2RVA) Tier II EIS	X	X			
Richmond to Raleigh R2R Tier II EIS		X			
Long Bridge EIS	X				
Richmond to Hampton Roads R2HR Tier I EIS		X			
Virginia Railway Express FY20-FY25 Transit Development Plan		X			
Ettrick Station Improvements			X		
Staples Mill Station Improvements			X		
Buckingham Branch Railroad (BBRR) Improvements					X
Norfolk International Terminals (NIT) Improvements	X			X	X
Virginia Inland Port (VIP) Improvements	X			X	X
Commonwealth Railway (CWRY) Marshalling Yard	X			X	X
Shoulders Hill Siding	X			X	X

Freight Rail Improvements

For the five freight-focused projects, the change in truck emissions was computed based on the estimated change in truck VMT or ton-miles multiplied by the appropriate emission factor. The change in rail emissions was computed based on the change in rail ton-miles multiplied by the appropriate emission factor.

- Emission factors per truck VMT – From MOVES runs (total GHG emissions from vehicle type 60 divided by total VMT for vehicle type 60).
- Emission factors per truck ton-mile – Ton-miles converted to VMT at a rate of 20.6 ton-miles per VMT.²⁵
- Emission factors per rail ton-mile – Consistent with 2040 no-build analysis.

Passenger Rail Improvements

The Long Bridge environmental impact statement (EIS) and DC2RVA studies reported estimated GHG emissions changes directly. For the other passenger-focused projects, the change in rail emissions was computed by multiplying the change in rail passenger-miles by the average emission factor for commuter or intercity rail.

- The commuter rail factor (for the Virginia Railway Express Transit Development Plan) was computed based on NTD data on energy consumption for existing commuter rail service, multiplied by the appropriate emission factor per unit energy, divided by total passenger miles.
- The intercity rail factor was taken from the Oak Ridge National Laboratory Transportation Energy Data Book (Edition 38, published 2020 was used for this analysis – see Figure 7.01).

If the project study only provides ridership estimates, an average trip length was assumed and multiplied by ridership and GHG emissions per mile to get total emissions. The following sources were used for trip length:

- Commuter rail (e.g., Virginia Railway Express) – Total passenger-miles divided by total passenger-trips on existing service, as reported to the NTD.
- Intercity rail (Amtrak) – Half the length of the project study corridor (this assumes that ridership is evenly distributed across the corridor and trips do not extend beyond the corridor).

The change in automobile emissions was computed by multiplying the change in automobile VMT by the appropriate emission factor.

- Change in auto VMT = change in rail passenger miles of travel multiplied by the prior drive mode share (where “prior drive mode share” is the share of riders who actually drove a car or rode in a single-occupancy taxi or ride-hail service); it does not include private auto passengers. Prior drive mode share was assumed to be 60 percent for urban commuter services as explained above. For intercity rail, change in auto VMT was computed as the change in rail passenger miles divided by the average vehicle occupancy (AVO). An AVO of 1.6 was used for intercity rail, based on 2017 National Household Travel Survey (NHTS) data on vehicle occupancies for all trips.

²⁵ Assumption used in DRPT project studies.

- Emission factor per auto VMT was taken from MOVES runs (total emissions from vehicle type 25 divided by total VMT for vehicle type 25).

The DC2RVA intercity rail project estimated a reduction in GHG emissions from passengers shifted from air travel. Air travel is excluded from the statewide inventory and therefore these reductions are not accounted for in this analysis.

2.2 Fuel Cycle Emissions

2.2.1 Analysis Scope and Approach

The MOVES model only provides estimates of direct, or operating, emissions from on-road mobile sources, produced by the combustion of fuel in the vehicle. GHG inventories may also report “upstream” or full fuel-cycle emissions. Upstream emissions include emissions from the extraction, refining, and transportation of the fuel used in the vehicle. In the case of electricity, upstream emissions include emissions associated with the production of the electricity used by the vehicle. Reporting fuel-cycle emissions provides a fuller picture of the magnitude of emissions impacts and also a more consistent comparison of emissions from petroleum fuels, biofuels, electricity, and other fuel types.

2.2.2 Data Sources

Argonne National Laboratory’s GREET model²⁶ provides both direct and full fuel-cycle emissions estimates accounting for upstream emissions. The version of this model applied in October 2020 provides fuel-cycle multipliers of 1.24 for gasoline, 1.21 for diesel, and 1.29 for compressed natural gas (CNG) (ratio of pump-to-wheel to well-to-wheel GHG emissions). For example, upstream emissions would be 24 percent of operating emissions for gasoline vehicles, and total life-cycle emissions would be 124 percent of operating emissions. Nearly all light-duty vehicles are gasoline powered and nearly all heavy-duty trucks are diesel powered. Medium duty trucks are split with about 65 percent of their energy consumption from diesel and 35 percent from gasoline,²⁷ so a weighted average of the multipliers was applied. The multipliers are: light-duty cars and trucks – 1.24; medium-duty trucks – 1.22; heavy-duty trucks and diesel buses – 1.21; natural gas buses – 1.29.

For electricity generation, the EPA’s eGRID provides estimates of CO₂ emission rates per unit of electricity consumed.²⁸ These rates were applied to any electric vehicle travel included in the base year, no-build, and/or build scenarios, after converting VMT by vehicle type to energy consumption. The average rate for Virginia reported for 2018 was 93.6 grams CO₂e per megajoule (g/MJ). This was used for any electricity emissions in the base year. For 2040, a factor of 51.0 g/MJ was used. This assumes that electricity sector emissions intensities will decline by 2.5 percent per year.²⁹ This rate of decline is consistent with the short-term caps set for the Regional Greenhouse Gas Initiative (RGGI), which Virginia joined in 2021, and assumes the near-term annual rate of reduction set by RGGI is extrapolated out to 2040.

²⁶ <https://greet.es.anl.gov/results>

²⁷ Analysis by Cambridge Systematics, Inc. of 2019 AEO data from table “Freight Transportation Energy Use”.

²⁸ <https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid-questions-and-answers>

²⁹ rggi.org

Electric vehicle VMT was converted to MJ of energy based on assumptions about the ratio of EV to conventional vehicle energy efficiency, as shown in Table 2-42-4. This assumes that EVs have power and performance characteristics similar to conventional fuel vehicles within a given vehicle type.

Emissions associated with electricity used in transit services were calculated directly from the electricity consumed for each electric mode (e.g., Light Rail, Heavy Rail, Trolley Bus) as reported in the NTD.

Table 2-4 Electric Vehicle Energy Conversion Factors

Vehicle Type	Conventional Vehicle MPG		Electric Energy Efficiency Ratio	EV MPGGE		EV MJ/VMT	
	2015	2040		2015	2040	2015	2040
Auto/Light Truck	22.4	36.6	3.0	67.2	109.8	1.96	1.20
Medium Truck	7.8	11.0	3.5	24.6	34.7	5.36	3.80
Transit Bus	3.1	4.4	3.5	9.8	13.9	13.47	9.49

Sources: MPG – 2019 AEO and Alternative Fuels Data Center. Energy efficiency ratio – California Air Resources Board (2017), Battery Electric Truck and Bus Energy Efficiency Compared to Conventional Diesel Vehicles. MJ/VMT converted at a rate of 0.00759 GGE/MJ (<https://www.convertunits.com/>)

2.3 Construction and Maintenance Emissions

2.3.1 Analysis Scope and Approach

Transportation emissions also include emissions associated with the construction and maintenance (C&M) of transportation projects. Emissions relating to C&M can be divided into two categories: direct emissions and upstream emissions. Direct emissions relate to fuel used in construction equipment, as well as the energy used in roadway maintenance, roadway rehabilitation, and pavement preservation. Upstream emissions include emissions from materials extraction, transportation and processing, as well as fuel production and the fuel used in materials transportation.

In order to estimate C&M emissions, this analysis used the Infrastructure Carbon Estimate (ICE) tool, Version 2.0.³⁰ The tool estimates the C&M life-cycle emissions for a broad range of different transportation projects, from roadway and bridge construction and rehabilitation to new rail or bus rapid transit infrastructure. The ICE tool is not a detailed engineering analysis and is “pavement material-neutral,” meaning there are no state-by-state differences in the materials mixtures and associated emissions.

2.3.2 2015 and 2040 No-Build Emissions

The no-build analysis only included annual emissions from maintenance activities related to the existing highway and rail system, as no construction of new projects was assumed in the no-build scenario. The ICE tool provides estimates of maintenance-related GHG emissions per lane-mile and track-mile for different roadway types. The inputs for the 2015 no-build case were obtained from FHWA’s Highway Statistics, which

³⁰ ICE v2.0 was developed through a Transportation Pooled Fund study based on v1.0 of the tool developed by FHWA.

includes data reported by every State on lane-miles by facility class, and from the Statewide Rail Plan for rail trackage.

For the 2040 no-build, the amount of highway and rail infrastructure was assumed to be the same, so the annual maintenance activities are the same.

2.3.3 2040 Build Emissions

C&M emissions were estimated for major projects included in the VDOT Six-Year Improvement Plan, MPO long-range plans, and rail corridor studies. “Major projects” include added capacity (as captured in the statewide model network); transit and rail projects provided by DRPT for which project or corridor studies providing project details have been completed; and bridge, bicycle, pedestrian, and parking projects included in the VDOT Smart Scale database.

Table 2-2-52-5 provides a summary of the ICE tool inputs and assumptions for the major project categories that would be most closely associated with changes in GHG emissions from C&M activities. Data sources for these inputs included the statewide model, VDOT Smart Scale database, DRPT, and MWCOG plans.

Table 2-2-5 ICE Tool Data Needs and Assumptions for New Projects

Project Type	Assumptions	Data Inputs Required	Data Input Source
Roadway Construction and Rehabilitation	A default schedule for roadway rehabilitation with a resurfacing event at year 15 and a reconstruction event at year 30.	Project type (new roadway construction, lane widening, etc.)	Estimates provided by VDOT, based on projects included in statewide model. Project information from SmartScale database and MPO long-range plans. Existing roadway miles provided by FHWA.
		Facility type (rural interstate, urban arterial, etc.)	
		Lane miles (#)	
Light Rail and Heavy Rail		Number of new stations	Estimates for new projects provided by DRPT. Current track miles provided by DRPT State Rail Plan.
		Facility characteristic (at grade, elevated, underground)	
		Track miles (#)	
Bus Rapid Transit		Number of new stations	MWCOG plans
		Facility type (new lane miles, converted/upgraded lane)	
		Number of lane miles	
Bicycle and Pedestrian Pathways		Project type (new construction, resurfacing)	VDOT
		Facility type (off-street, path, on-street bicycle lane, on-street sidewalk)	
		Length of project (miles)	

3.0 Uncertainty in the Estimates

Uncertainties in the modeling of both highway and transit and rail emissions are discussed here. Some of these uncertainties could be large enough to tip the net GHG effect of build vs. no-build conditions to be either positive or negative (most likely in a small amount). However, the general magnitude and direction of forecasted emissions change between 2015 and 2040 appears to be fairly reliable.

3.1.1 2015 vs. 2040 No-build and Build

The main sources of uncertainty for the 2040 no-build vs. 2015 comparison are:

- State population and job growth and demographic and economic changes. The Demographics Research Group at the University of Virginia identifies a projected population growth in Virginia of 17 percent between 2020 and 2040.³¹ This appears reasonably consistent with the statewide model projected VMT increase of 20 percent between 2015 and 2040 (which also includes truck VMT, driven by economic activity as well as population). Slower or faster population and job growth, as well as changes in the amount of passenger or freight travel per unit of population or economic activity, would affect the VMT projections. Other changes in travel behavior (such as long-term post-COVID effects or effects related to vehicle automation) could also change VMT projections significantly.
- Emission rates. The MOVES3 model uses the latest available information on projected vehicle fuel efficiency. Emission rates could, however, vary from this forecast as a result of future changes in Federal standards or other factors (such as fuel prices) driving consumers to purchase more or less fuel-efficient vehicles.
- Electrification. A modest amount of electrification is assumed in this study. Emissions would decline more in 2040 if electrification is implemented more aggressively, and also depending on the rate of improvement in carbon intensity of the electricity generation grid.

3.1.2 2040 No-build vs. 2040 Build

The main sources of uncertainty for the 2040 no-build vs. build comparison are:

- VMT effects of highway capacity expansion projects. Capacity expansion could increase VMT by making it easier to drive, resulting in longer trips, diversion of trips from other modes to auto, or rerouting of trips. There may also be indirect impacts if land use changes (e.g., new developed in areas with new or expanded road service). Land use effects related to capacity expansion are not captured in the statewide model. Trip changes due to capacity expansion may be captured to varying degrees but are limited by the geographic and temporal resolution of the model, which does not explicitly model peak period travel (when congestion reduction effects would be greatest).
- Change in speed distributions for highway traffic. As noted elsewhere the speed estimates are only approximate and consider only a “congested” and “free-flow” speed. This approach may overestimate the amount of travel at low speeds as well as higher speeds, relative to more moderate speeds. The extent to which this affects emissions estimates depends on the ranges in which speeds change.

³¹ <https://demographics.coopercenter.org/virginia-population-projections>

Emissions decrease steadily from lower speeds up to around 30 mph, then are relatively constant until speeds exceed about 65 mph, after which they increase again.

- For transit and rail projects, the amount of mode shifting is a critical assumption. For passenger service this includes not only the ridership increase (often a rough estimate) but also assumptions about the share of new riders that previously drove, and the average trip length of new riders. The methods for estimating ridership, trip length, and displaced auto travel (if estimated) can vary from study to study. For intercity rail projects, some mode shifting may also occur from air travel or from travel outside the state's boundaries, which should not be accounted for in a statewide surface transportation inventory although it may cause a net emissions decrease as a result of the project.
- The actual emissions from new transit and rail service are also usually not estimated, and instead based on an average rate per passenger-mile, which can greatly overstate or understate emissions if ridership is higher or lower than average or an unconventional vehicle technology is used. Similarly, the analysis of freight rail investments reflects uncertain assumptions regarding the actual amount of cargo volume that might be shifted from trucks.
- Project studies that provide actual GHG estimates (for example, the Long Bridge EIS in the 2040 build analysis) have the potential to provide a better GHG estimate by ensuring that project-specific characteristics and impacts are accounted for. However, methodologies and assumptions may differ across studies and may not be consistent. Similarly, for heavy rail the "displacement" factor taken from WMATA study may reflect region-specific conditions but also may reflect a different set of underlying assumptions than the generic land use and congestion effects estimates this study applied to other new urban transit service.
- Transit and rail projects can also have secondary effects related to reduced congestion and land use change which can be difficult to model. Land use change effects are generally highly speculative and difficult to evaluate for individual projects. The 2009 APTA methodology applied to estimate indirect land use effects in this study uses an average multiplier of 1.9 additional indirect tons reduced per direct ton reduced, based on national research. The actual effects will vary depending upon the project characteristics and the land use context, with rail projects in larger or more densely developed urban contexts likely to have larger effects than bus projects or projects in smaller areas. While the land use effect is a very significant assumption relative to direct emissions effects, the congestion effect was found to be very small and can probably be ignored in most cases.
- Construction and maintenance emissions are based on general, planning-level emissions factors rather than a detailed inventory of materials and fuel requirements. They are also provided as a yearly average. The magnitude of construction emissions in particular will vary from year to year depending upon the amount of construction activity in that year.

Overall, new highway projects can show either net increases or decreases in emissions depending upon the specific assumptions about induced travel, speed changes, and construction impacts. Similarly, new transit and rail projects can show either net increases or decreases in emissions depending upon the specific assumptions about transit vehicle technology/efficiency, ridership/mode shifting, land use change, and construction impacts. The relative effect across projects modes will vary based on the characteristics of the project and travel markets served.

4.0 Findings

Table 4-1 displays the emissions estimates for the 2015 baseline, 2040 no-build, and 2040 build scenarios, broken out by emissions source. Table 4-2 displays emissions by source as a percentage of the total emissions for each scenario. In these tables, displaced auto emissions from mode shifting due to passenger rail and transit projects, as well as displaced truck emissions from truck-rail mode shifting due to freight rail projects, are subtracted from other on-road motor vehicle emissions in the motor vehicle line-items. Therefore, the 2040 build scenario shows an increase in emissions from transit and rail sources, and a decrease in emissions from on-road motor vehicles, compared to the 2040 no-build scenario.

Across all scenarios, the majority of emissions (just over 75 percent) originate from non-electric on-road mobile sources, with transit and rail as well as construction and maintenance emissions together representing a small fraction (around 3.5 percent) of emissions. In both 2040 scenarios, emissions from electric vehicles represent just under 1 percent of total emissions, despite representing nearly 7 percent of the light duty vehicle fleet and 6.5 percent of all vehicle VMT. Total fuel life cycle emissions represent between 18 to 19 percent of total emissions across all scenarios. Overall, over 95 percent of emissions for all scenarios are from two sources, namely on-road mobile (non-electric) and fuel life cycle; other emission sources are relatively minor.

Table 4-1 Summary of GHG Emissions (metric tons CO₂e) by Scenario and Source

Source	2015	2040 No-build	2040 Build
On-Road Motor Vehicles (non-electric), excluding transit buses	41,130,953	32,430,586	32,326,068
On-Road Motor Vehicles (electric), excluding transit buses	-	391,285	391,561
On-Road Transit (buses) ^a	92,246	80,146	109,060
Urban Heavy Rail and Light Rail	45,975	25,051	28,914
Intercity Passenger Rail	54,384	54,421	70,185
Freight Rail	575,000	570,000	588,482
Construction and Maintenance	1,034,391	1,034,391	1,122,065
Total	42,932,950	34,585,880	34,636,334
Fuel Life Cycle	9,870,064	8,137,882	8,151,287
Total (including fuel life cycle)	52,803,014	42,723,762	42,787,621

^a "On-road transit" includes buses operated by public transportation agencies. It does not include private transit operators (such as intercity or coach services) or school buses.

Table 4-2 Summary of GHG Emissions (Percent) by Scenario and Source

Source	2015	2040 No-build	2040 Build
On-Road Mobile Sources (non-electric), excluding transit buses	77.9%	75.9%	75.6%
On-Road Mobile Source (electric), excluding transit buses	0.0%	0.9%	0.9%
On-Road Transit (buses)	0.2%	0.2%	0.3%
Urban Heavy Rail and Light Rail	0.1%	0.1%	0.1%
Intercity Passenger Rail	0.1%	0.1%	0.2%
Freight Rail	1.1%	1.3%	1.4%
Construction and Maintenance	2.0%	2.4%	2.6%
Total	81.3%	81.0%	80.9%
Fuel Life Cycle	18.7%	19.0%	19.1%
Total (including fuel life cycle)	100.0%	100.0%	100.0%

Table 4-1 and Table 4-2 show emissions by the mode that produces those emissions. In contrast, Table 4-3 shows the net effects of modal projects. The “highway build projects” line shows the net change in direct highway emissions from auto travel as a result of changes in modeled VMT and speeds from roadway capacity expansion. There is a small (0.02 percent) net decrease on a statewide basis, suggesting that the benefits of increased speeds from reduced congestion outweigh the increased VMT as a result of this reduced congestion. However, the statewide model may not be fully sensitive to the effects of build projects related to induced demand and the speed changes are approximate since the model does not predict travel by time-of-day. The “transit and rail build projects” line item represents the net effects of increased transit and rail operating emissions vs. decreased operating emissions from other modes (auto and truck) as a result of planned transit and rail investments. Since the reduction in auto and truck GHG is larger than the increase in transit and rail GHG, these projects result in a net decrease in emissions of 0.08 percent on a statewide basis. The components of the decrease reflected in the “transit and rail build projects” line include new transit and rail service, displaced auto and truck emissions from mode shifting, indirect land use effects, and congestion relief effects.

Table 4-3 Net Effects of Modal Projects^a

	Net GHG Change	% of 2040 No-build
Highway Build Projects	(8,512)	-0.02%
Transit and Rail Build Projects	(28,708)	-0.08%
Emissions from new bus service	28,913	
Displaced auto emissions from new bus service: mode shift	(6,976)	
Displaced auto emissions from new bus service: land use effects	(24,162)	
Displaced auto emissions from new bus service: congestion relief effects	(15)	
Emissions from new light and heavy rail service	3,863	
Displaced auto emissions from new light and heavy rail service ^b	(7,030)	
Emissions from new commuter and intercity passenger rail service	31,528	
Displaced auto emissions from new commuter and intercity passenger rail service	(48,247)	
Emissions from new freight rail service	2,718	
Displaced truck emissions from new freight passenger rail service	(9,299)	

^a Direct emissions effects, not including upstream (fuel cycle) or construction and maintenance, except for operating emissions for new electric rail transit service.

^b A single “displacement factor” was used per WMATA assumptions, which did not disaggregate the effects into mode shift, congestion relief, and land use.

Table 4-4 and Table 4-5 compare the change in VMT, roadway lane miles, and emissions for all sources across the three scenarios. Compared to 2015, both 2040 scenarios show a total decrease in emissions between 19 and 20 percent. With VMT projected to increase by nearly 20 percent under both 2040 scenarios, the decrease in emissions can be attributed to improved vehicle efficiency standards, which leads to lower per-mile emissions from on-road sources, as well a reduction in the electricity emission factors that lowers emissions from electric-powered transit sources.

Comparing the 2040 build and 2040 no-build scenarios, emissions are marginally higher (roughly 0.15 percent) under the build scenario. Emissions from on-road mobile sources are slightly lower primarily due to mode-shifting resulting from new transit and rail projects. Transit and rail emissions are higher as a result of expanded service and new projects. Additionally, under the 2040 build scenario, emissions relating to new project construction cause annual construction and maintenance emissions to increase by roughly 8.5 percent compared to the no-build scenario. Taken together, emissions changes in 2040 resulting from new highway and transit projects, and the corresponding construction and maintenance, are marginal compared to the 2040 baseline.

Table 4-4 Key Indicators and Change Between Scenarios

Indicator	2015	2040 No-build	2040 Build	No-build vs. 2015	Build vs. 2015	Build vs. No-build
VMT (auto and light-duty truck) (millions) ^a	77,741	92,660	92,725	14,918	14,984	65.3
VMT (medium and heavy truck) (millions) ^a	4,883	6,198	6,194	1,314	1,310	(3.5)
Lane Miles	162,934	162,934	164,161	0	1,227	1,227
Bus Transit Trips (millions)	79.2	79.2	109.6	0	30.4	30.4
Light & Heavy Rail Transit Trips (millions)	64.5	64.5	74.2	0	9.7	9.7
Intercity Rail Passenger Miles (millions)	412	490	719	78	307	228

^a The VMT changes in the build scenario only represent changes as calculated in the statewide model from new roadway projects. Auto and truck VMT changes resulting from transit and rail projects are not subtracted from the VMT totals for the build scenario. Contrast with Tables 4-1 and 4-2 where bus emissions are subtracted from on-road mobile source emissions.

Table 4-5 Key Indicator Change Between Scenarios (Percent Change)

Source	No-build vs. 2015	Build vs. 2015	Build vs. No-build
Vehicle Miles Traveled ^a	19.6%	19.7% ^a	0.1% ^a
Lane Miles	0.0%	0.8%	0.8%
Transit Trips	0%	28%	28%
Intercity Rail Passenger-Miles	19%	75%	47%
Change in Emissions by Source			
On-Road Mobile Sources (excluding transit buses)	-20.2%	-20.5%	-0.3%
On-road Transit (buses)	-13.1%	18.2%	36.1%
Urban Heavy Rail and Light Rail	-45.5%	-37.1%	15.4%
Intercity Passenger Rail	0.1%	29.1%	29.0%
Freight Rail	-0.9%	2.3%	3.2%
Construction & Maintenance	0.0%	8.5%	8.5%
Total Emissions (All Sources)	-19.4%	-19.4%	0.15%

^a The VMT changes in the build scenario only represent changes as calculated in the statewide model from new roadway projects. Auto and truck VMT changes resulting from transit and rail projects are not subtracted from the VMT totals for the build scenario. Contrast with Tables 4-1 and 4-2, and the “change in emissions by source” line, where bus emissions are subtracted from on-road mobile source emissions.

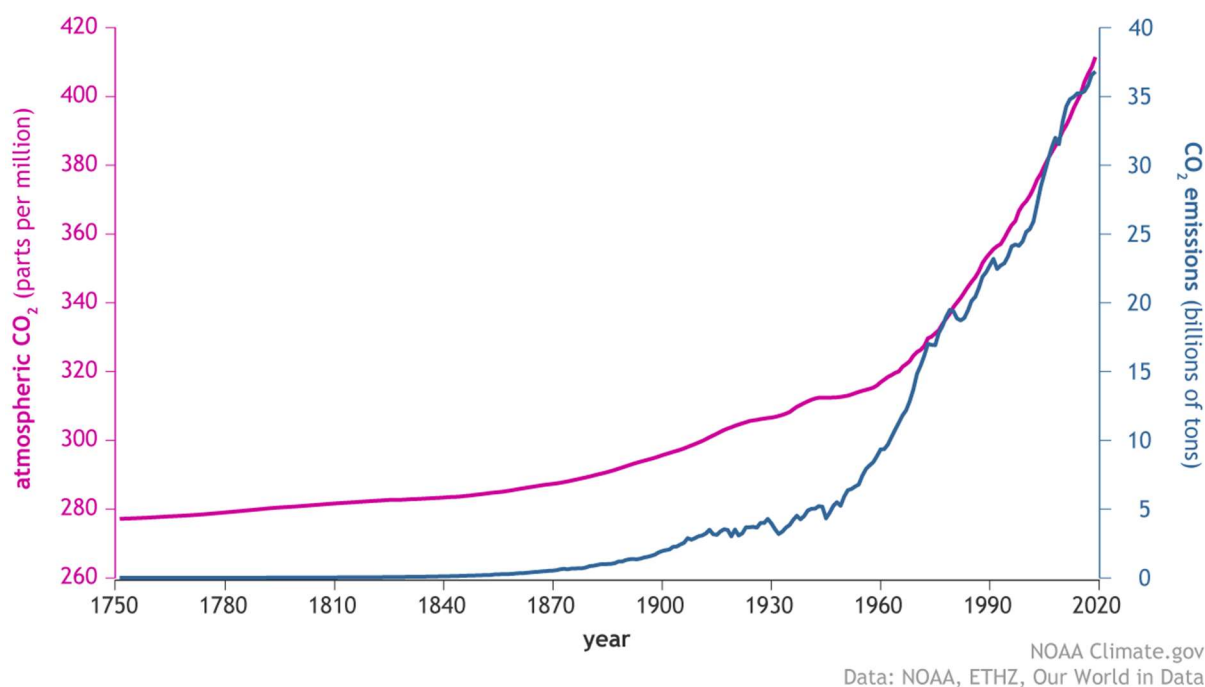
5.0 Climate Change Considerations Related to the Affected Environment

5.1 Overview of Global and National Climate Change Trends and Projections³²

Greenhouse gas emissions have accumulated rapidly as the world has industrialized, with concentration of atmospheric CO₂ increasing from roughly 300 parts per million in 1900 to over 400 parts per million today (Figure 5-1). Over this timeframe, average temperatures have increased by roughly 1.8 degrees Fahrenheit (1 degree Celsius). The most rapid increases in both emissions and atmospheric concentrations have occurred over the past 50 to 60 years, and temperature has also increased steadily over this timeframe (Figure 5-2).

Figure 5-1 Global Greenhouse Gas Trends

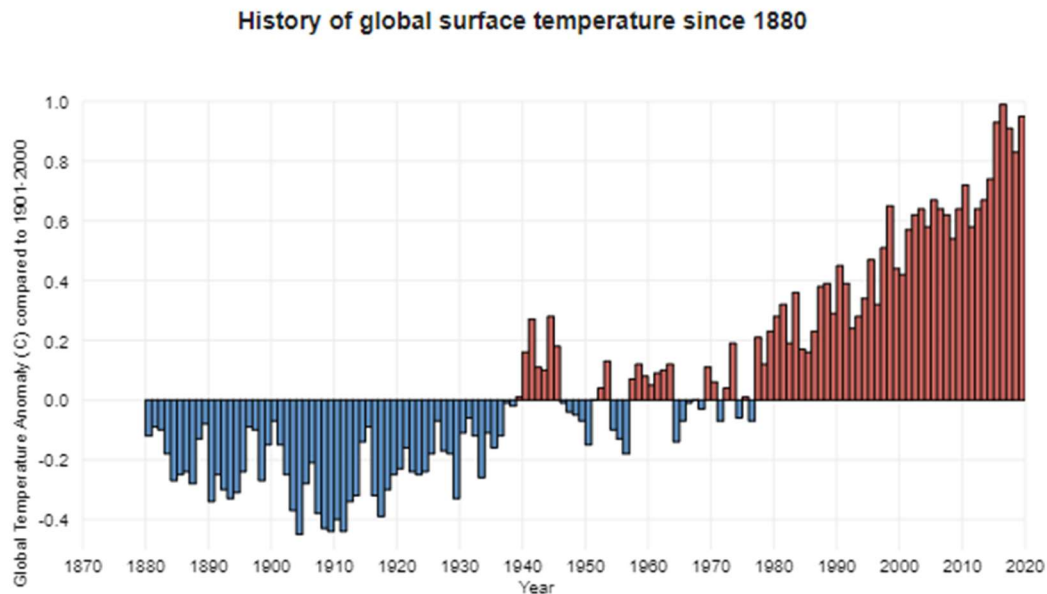
CO₂ in the atmosphere and annual emissions (1750-2019)



Source: NOAA.

³² This section summarizes information in: U.S. Global Climate Change Research program (USGCRP), Fourth National Climate Assessment, 2018.

Figure 5-2 Global Temperature Trends



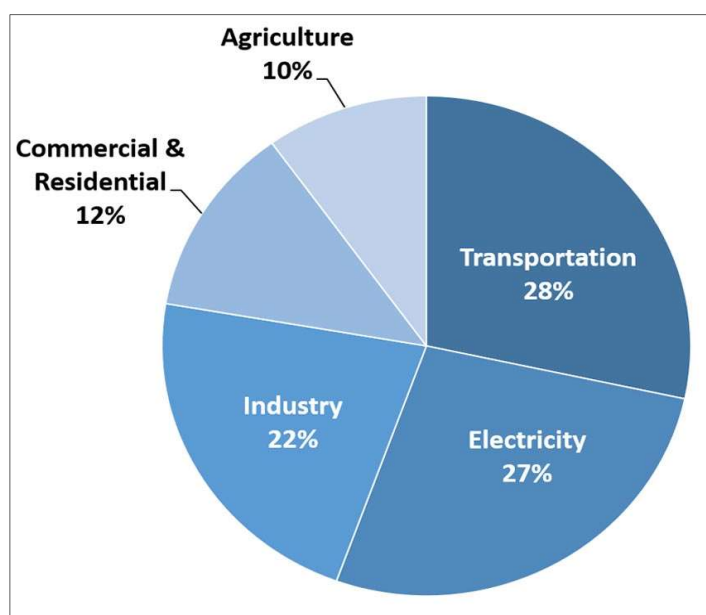
Source: NOAA.

A wide range of future warming scenarios has been projected in the literature depending on changes in technology, economy, policy, and how earth's natural systems react. As summarized by the U.S. Global Climate Change Research Program (USGCRP),³³ even if atmospheric GHG concentrations could be stabilized at their current level, existing levels are projected to result in at least an additional 1.1°F (0.6°C) of warming over this century relative to the last few decades. If emissions continue, projected changes in global average temperature could range from 0.4°–2.7°F (0.2°–1.5°C) under a very low emissions scenario, to 4.2°–8.5°F (2.4°–4.7°C) under a higher scenario by the end of the 21st century. According to the Intergovernmental Panel on Climate Change (IPCC), the global temperature increase must be held below 2.0°C to avoid the most disruptive effects on the human and natural environment.³⁴ However, based on the IPCC assessment, holding temperature increases to below 2.0°C would require net zero CO₂ emissions by at least 2055 and significant reduction of non-CO₂ GHG emissions by at least 2030.

According to the EPA's 2018 Inventory of U.S. Greenhouse Gas Emissions and Sinks, transportation is now the leading source of greenhouse gas emissions nationally, representing 28 percent of emissions (**Error! Not a valid bookmark self-reference.**).

³³ U.S. Global Climate Change Research Program (2018). Fourth National Climate Assessment.

³⁴ Intergovernmental Panel on Climate Change (2018). Special Report: Global Warming of 1.5 °C. <https://www.ipcc.ch/sr15/>

Figure 5-3 National Sources of Greenhouse Gas Emissions in 2018

Source: U.S. EPA, 2018.

At a national level, the potential impacts of climate change to transportation infrastructure under a range of emissions and warming scenarios are shown in Table 5-1.

Table 5-1 Potential Transportation Infrastructure Impacts of Climate Change

	Potential Magnitude	Transportation Infrastructure Impacts
Sea level rise	1'–8.2' by 2100	Flooding and storm surge—coastal transportation facilities
More intense storms	50% to 300% increase in extreme precipitation events by 2100	Overtopping and erosion of roads, bridges, rail lines in river valleys Need for evacuation routes
Excessive summer heat	+2.5–2.9 °F by mid century +5.0–8.7 °F by late century	Pavement and rail integrity
Prolonged droughts		Lower water levels in rivers/shipping channels; Wildfires—road closures

Source: USGCRP (2018).

5.2 Climate Change Risks to Virginia's Environment

Virginia faces three major climate risks: coastal flooding, inland flooding, and extreme heat.

5.2.1 Coastal Flooding

Any significant increase in sea level can pose a threat to coastal communities across the world. As a populated coastal state, Virginia is particularly vulnerable to the threats of sea-level rise and storm surge. Sea level rise is occurring at an accelerating rate, and five Virginia water level stations appear in the nation's top 20 highest sea level rise trends.³⁵ According to the Georgetown Climate Center (GCC), Hampton Roads is the second-most vulnerable region of the country to sea-level rise, with only New Orleans more at risk.³⁶ Over the last century, Sewell's Point tide gauge in Norfolk has recorded more than 18 inches of relative sea level rise, according to the National Oceanic and Atmospheric Administration.³⁷ According to the Fourth National Climate Assessment, Norfolk now faces a fourfold increase in flood risk compared to the 1960s, with businesses, communities, and infrastructure at risk.³⁸

Additionally, storm surge presents major risks to Virginia's coastal areas, with over 300 bridges and structures that would face over 2 feet of storm surge inundation from a Category 2 hurricane, according to Virginia's Secretary of Transportation.³⁹

According to the GCC, in the next 20 to 50 years, Virginia will experience at least 1.5 feet of sea level rise, with the possibility of even greater increases. According to a study by Sadler et al (2017), by 2080, 10 percent of the roadway networks in Virginia Beach and Norfolk could be flooded by "king tides" (exceptionally high tide events) with 4 feet of sea level rise.⁴⁰

Transportation Risk: Coastal Flooding

- Severe flooding during coastal storms and hurricanes.
- Vulnerability to increased wave loads from storm surge for low-clearance bridges.
- Impacts to ports from rising seas, tropical storms, and storm surge.
- Permanent inundation in low-lying areas from increased high tide flooding.
- Flooding and inundation of evacuation routes during coastal storm events.

Source: USGCRP (2018) and Hampton Roads Transportation Planning Organization (2016)

³⁵ City of Virginia Beach (2020). Sea Level Wise: Adaptation Strategy. [https://www.vbgov.com/government/departments/public-works/comp-sea-level-rise/Documents/20200330%20FullDocument%20\(2\).pdf](https://www.vbgov.com/government/departments/public-works/comp-sea-level-rise/Documents/20200330%20FullDocument%20(2).pdf)

³⁶ Georgetown Climate Center (undated). "Understanding Virginia's Vulnerability to Climate Change." Accessed at <https://www.georgetownclimate.org/files/report/understanding-virginias-vulnerability-to-climate-change.pdf>

³⁷ Virginia Office of the Governor (2020). Virginia Coastal Resilience <https://www.governor.virginia.gov/media/governorvirginiagov/governor-of-virginia/pdf/Virginia-Coastal-Resilience-Master-Planning-Framework-October-2020.pdf>

³⁸ U.S. Global Climate Change Research program (2018). Fourth National Climate Assessment.

³⁹ Commonwealth of Virginia, Office of the Secretary of Transportation (2020). Vulnerability Assessment.

⁴⁰ Sadler, Jeffer, Nicole Haselden, Kimberly Mellon, and Allison Hackel (2017). Impact of Sea-Level Rise on Roadway Flooding in the Hampton Roads Region, Virginia. *Journal of Infrastructure Systems*. Accessed at: <https://ascelibrary.org/doi/pdf/10.1061/%28ASCE%29IS.1943-555X.0000397>.

5.2.2 Inland Flooding

The southeastern U.S. has experienced an increase in flooding from heavy rainfall and extreme precipitation events, including a 16 percent increase in extreme rainfall events (those expected to occur only every five years based on the historical record).⁴¹ According to the GCC, Virginia has seen heavy rainstorms (those expected to occur only once a year based on the historical record) increase by 33 percent in the last 60 years.⁴²

In the future, the southeastern U.S. is expected to see a continued increase in extreme rainfall events. According to the 2018 USGCRP National Climate Assessment, under a “higher-emissions” scenario where emissions do not begin to level off until the end of the century, the southeastern U.S. would see a doubling of the number of heavy rainfall events.

Transportation Risk: Inland Flooding

- Increased crash risk and decreased travel reliability from heavy precipitation events.
- Bridge scour and bridge failure as a result of foundation erosion during heavy rainfall and flooding events, which compromise the integrity and stability of scour-critical bridges.
- Increased debris flows from heavy rain events can block culverts and inundate roads.

Source: USGCRP (2018)

5.2.3 Extreme Heat

In Virginia, according to the NOAA National Centers for Environmental Information, average annual temperatures have increased by roughly 1.5° F since the beginning of the 20th century.⁴³ According to data retrieved from the NOAA National Climatic Data Center, daily summer high temperatures as recorded at Richmond International Airport are now 3°F higher

Transportation Risks: Extreme Heat

- Stresses to bridge and rail integrity.
- Accelerated deterioration of materials and structures, especially combined with increased salinity and humidity.
- Increased costs due to material upgrades to accommodate higher temperatures or repair damaged pavement. For example, Virginia DOT has dedicated crews who quickly repair roads during extreme heat events (FHWA, 2013).
- Worker and public safety. Temperature extremes cause vehicles to overheat and tires to shred, while buckled roadway joints can send vehicles airborne. Protocols that govern worker safety limit construction during heat waves.

Source: USGCRP (2018)

⁴¹ U.S. Global Climate Change Research program (2018). Fourth National Climate Assessment.

⁴² Georgetown Climate Center (undated). “Understanding Virginia’s Vulnerability to Climate Change.” Accessed at <https://www.georgetownclimate.org/files/report/understanding-virginias-vulnerability-to-climate-change.pdf>

⁴³ NOAA National Centers for Environmental Information. State Summaries 149-VA. <https://statesummaries.ncics.org/downloads/VA-print-2016.pdf>

(Footnote continued on next page...)

on average than they were in the 1960s.⁴⁴ According to the GCC, heat waves are a leading cause of weather-related deaths, with 12 people in Virginia dying from excessive heat exposure in the summer of 2012 when temperatures regularly exceeded 100°F.⁴⁵

According to the NOAA Center for Environmental Information, under current warming trends, heat waves are projected to become more intense. These extreme heat events pose dangers to human activity and human health. According to the GCC, warmer temperatures also pose increased risks and health concerns to the 163,000 children and 554,000 adults in Virginia who are affected by asthma.

⁴⁴ NOAA National Climatic Data Center, "Climate Data Online." www.ncdc.noaa.gov/cdo-web/search

⁴⁵ Georgetown Climate Center (undated). "Understanding Virginia's Vulnerability to Climate Change." Accessed at <https://www.georgetownclimate.org/files/report/understanding-virginias-vulnerability-to-climate-change.pdf>

6.0 Highway System Projects Included in the 2040 Build Scenario

This section provides a list of all of the highway system projects included in the 2040 build scenario but not in the no-build scenario. Any project that improves capacity was represented in the statewide travel demand model. Table 6-1 shows the projects listed in VDOT's Smart Scale database; Table 6-2 shows major public-private partnership projects; and Table 6-3 shows projects listed in VDOT's Six-Year Improvement Program and projects funded by the I-81 Improvement Program. Projects are shown with their universal project code (UPC) where assigned.

Table 6-1 Smart Scale Database

UPC	Project Title
-23027	I-81 Exit 313 Bridge Capacity Improvement
-19612	Route 670 Connector Road
-19571	Route 7/ Route 690 Interchange
12546	Laskin Road Bridge Replacement
13551	U.S. Route 360/Lee Davis Rd Intersection (UPC 13551)
15829	Indian River Road Phase VII-A
17714	Rte. 624/Happy Creek Rd.
18003	Route 277 Widening and Access Management
69050	US Route 17/Shoulders Hill Intersection (UPC 69050)
99478	Route 7 Widening (Phase I)
101279	Warwick Boulevard over Lake Maury Bridge Replacement
107044	I-64/Northampton Boulevard Interchange Modifications
107796	CI-95/I-64 Overlap: NB I-95 Deceleration Lane to Hermitage
107797	BI-95/I-64 Overlap NB I-95 Belvidere Acceleration Lane
109293	Sudley Road Third Lane
109299	Government Center Parkway Extension
109304	Little Back River Rd Reconstruction w/New Peak Alt-Dir Lane
109309	University Drive Extension
109382	Deep Creek Atlantic Intracoastal Waterway Bridge Replacement
109439	Route 58 Truck Climbing Lane
109519	Route 33 at Route 29 Ruckersville Road Improvement
110911	Richmond-Henrico Turnpike Improvements - Northern Segment
111018	Ironbound Road Phase 2
111362	Southway Regional Business Park Project
113116	RTE 221 - INTERSECTION IMPROVEMENTS.
115124	Rt 3 STARS Study and I-95 off-ramp imp.
115241	Jefferson Ave & Oyster Point Rd Intersection Improvements
115244	Virginia Beach Blvd Widening – George St to Newtown Rd

UPC	Project Title
115245	General Booth Blvd/Oceana Blvd Intersection Improvements
115414	Jude's Ferry Road & Route 60
115477	US 250/Route 20 Intersection Improvement
115504	Warwick Blvd & Oyster Point Rd Intersection Improvements
100200	Skiffes Creek Connector
100822	Mount Cross Road Widening Phase 1
100921	Longhill Road Improvements - Route 199 to Olde Towne Road
100937	U.S. Route 58 Corridor Improvement Project
101020	Route 10 (Bermuda Triangle Rd to Meadowville Rd) Superstreet
101595	UPC 101595 - Rappahannock River Crossing (Southbound)
103320	Construct Auxiliary Lane I77 North Exit 32 onto I81 South
104303	Widen Route 1 to Six Lanes - Marys Way to Featherstone Road
104946	US 501 Passing Lanes and Shoulder Widening
104957	Sliding Hill Road - Widening (UPC 104957)
105309	Lee Highway Widening - Exit 5 Phase 1B
105464	Rt 606 West
105495	Connector Road Phase II
105521	East Spring Street Widening Project (UPC 105521)
105722	1. Stafford - Route 1/Enon Road Intersection and Roadway IMP
105753	Lee Highway Widening - Exit 5 Phase 2
105907	Full Southern Corridor Project
106670	UPC 106670-Widening of Route 639 Ladysmith Road
106692, 108990	I-64 Southside Widening and High Rise Bridge - Phase 1
106917	Route 7 Widening (Phase II)
107061	Route 419 Widening, Safety, and Multimodal Improvements
107140	Rt 17, I95 Bridge to Hospital Blvd
107458	I-64 Widening (I-295 to Exit 205 Bottoms Bridge)
107795	AI-95/I-64 Overlap - SB I-95 Franklin Street Off Ramp
107947/-19576	Neabsco Mills Road Widening w/ Potomac Town Center Garage
108720	Route 28 Widening (PW County Line to Old Centreville Road)
108731	Coliseum Drive Extension
108810	VA 11- South Valley Pike
108826	Transform66 Outside the Beltway
108906	I-81 Northbound Auxiliary Lane from Exit 141 to 143
108909	Route 460 at Franklin Street EB Ramp Construction
109314	Nike Park Road Extension from Reynolds Drive to US Route 17
109322	I-95/Route 10 Interchange Improvements
109376	I-81 Exit 323 Accel/Decel Lane Extension
109377	I-81 Exit 220 and 221 Accel/Decl Lanes

UPC	Project Title
109381	Centerville Turnpike - Phase III
109397	Rio Mills Rd/Berkmar Dr Extended Connection
109478	Rte 3 Passing Lanes Between Potomac Mills and Flat Iron
110329	Route 29 Widening (Union Mill Road to Buckley's Gate Drive)
110803	Cleveland Street Phase IV
110804	Indian River Road Phase VII-B
110914	I-95 Exit 126, Route 1 Southbound onto Southpoint Parkway
111048	Staunton Crossing Street Extension
111054	I-81 Exit 300 Southbound Acceleration Lane Extension
111056	I-81 Exit 315 Northbound Deceleration Lane Extension
111059	I-81 Exit 296 Accel/Decel Lane Extensions
111091	Jefferson Avenue at Yorktown Road Intersection Improvements
111272	Route 58 Truck Climbing Lane Phase II
111373	I-81 Southbound Auxiliary Lane between Exit 143 and 141
115010	Hampton Roads Bridge-Tunnel Widening/I-64 Expansion
115237	J. Clyde Morris Blvd Intersection Improvements
115460	Route 419 and Route 220 Diverging Diamond Interchange
115495	Route 58 WBL from Airport Dr to Kentuck Rd
17630, 57048, 108041, 108042	I-64/I-264 Interchange Improvements
-18039	I-64 Peninsula Widening
-19435	I-95 Auxiliary Lanes (nb & sb) between Rte. 288 and Rte. 10
-19439	BBC Ph 1 - Bailey Bridge Connector, Brad McNeer Connector
-19565	Arcola Boulevard (Route 50 to Route 606)
-19567	Westwind Drive (Loudoun County Parkway to Route 606)
-19664	Route 17 Widening between Route 630 and Route 173
-19667	Route 171 Widening between Route 17 and Route 134
-19841	Laskin Road Phase I-A
-20315	Richmond-Henrico Turnpike Improvements - Southern Segment
4483	Atkinson Boulevard
50100	East Elden Street Widening and Improvements
79923	Interstate 81 Exit 213 Acceleration Lanes
94847	Route 11 North Improvements between Exit 317 and Rt 37

Table 6-2 Public-Private Partnerships

UPC	Description
NA	I-95 Express Lanes Fredericksburg Extension
NA	I-64 Hampton Roads Bridge-Tunnel Expansion
NA	I-495 Express Lanes Northern Extension (495 NEXT) Project

Table 6-3 Six-Year Improvement Program and I-81 Improvement Program

UPC	Description
98	RTE 642 - WIDEN TO 6 LANES
709	TENTH STREET IMPROVEMENTS
1436	CEDAR LEVEL ROAD - 4 LANES
1765	RTE 165 - 6 & 8 LANES
2459	RTE 15 BUSINESS - PARALLEL LANE
2605	RTE 252 (MIDDLEBROOK AVENUE)- 2-LANE ON 4-LANE RIGHT OF WAY
2773	RTE 262 - SOUTHERN ROUTE - 2 LNS ON 4 LN RW ON NEW LOCATION
3475	RTE 614 - RECONSTRUCTION
3793	RTE 63 - RECONSTRUCTION - 2 LANES ON NEW LOCATION
3950	RTE 337 - 4 LANES
4325	RTE 102 - NORFOLK SOUTHERN RWY UNDERPASS - 2 LNS NEW LOC
4412	RTE 271 - RECONSTRUCTION
4579	ELLERSLIE AVENUE - 4 LANES W/CURB, GUTTER & SEWER
5551	RTE 608 - RECONSTRUCT TO 4 LANES
5559	ROLLING ROAD - RTE 638 - WIDEN TO 4 LANES - PE ONLY
8600	RTE 58 - WIDEN TO 8 LANES
8651	RTE 1 - WIDEN TO 6 LANES
8746	RTE 114 - PEPPERS FERRY ROAD - WIDEN TO 4 LANES
8753	RTE 460 - Widen To 3 Lanes w/ Bike Lanes, Curb, Sidewalk
9783	RTE 13 - 8 LANES
9786	RTE 10 - WIDEN TO 3 LANES
9799	RTE 199 - 4 LANES ON NEW LOCATION
9826	RTE 81 - 6 LANE WIDENING & INTCHG IMPROVE AT EXIT 5 (11/19)
9845	RTE 41 - WIDEN TO 4 LANES
9978	RTE 600 - NEW CONSTRUCTION (CONST ONLY ON THIS ID)
10797	RTE 60 - 6 LANES
10798	RTE 603 - NEW LOCATION
11012	TELEGRAPH RD -RTE 611 - WIDEN TO 4-LANES
11314	RTE 58 - CORRIDOR DEVELOPMENT PROJECT - DEVELOP TO 4 LANES

UPC	Description
11679	FAIRFAX COUNTY PARKWAY - CONSTRUCT 4 & 6 LANES
11680	FAIRFAX COUNTY PARKWAY - CONSTRUCT 4 & 6 LANES
11754	BIRDNECK ROAD - WIDEN FROM 2 TO 4 LANES
12379	RTE 64 - WIDENING TO 6 LANES WITH HOV LANES
12537	RTE 1 - 4 LANES
12546	RTE 58 - WIDEN TO 6-LANE DIVIDED FACILITY
12549	LYNNHAVEN PARKWAY - WIDEN TO 6-LANE DIVIDED
12823	RTE 262 - SOUTHERN ROUTE - 2 LANES ON 4 LANE RW ON NEW LOC
12906	RTE 1 - WIDENING
12921	RTE 250-WIDEN TO 6 LANES & INTERSECTION REALIGNMENT
13105	RTE 619 (LINTON HALL ROAD) - UPGRADE TO 4 LANES
13387	RTE 58 ALT - PARALLEL LANE - CORRIDOR DEVLPMNT PROG-PE & RW
13427	RTE 172 - CITY OF POQUOSON - PHASE I
13429	RTE 143 - 6 LANES
13482	RTE 165 - 4 LANES ON 8-LANE RIGHT OF WAY
13496	RTE 60 - RELOCATION & UPGRADING
13497	RTE 105 - CONSTRUCTION OF PARALLEL LANES (WESTBOUND)
13547	RTE 288 - 2 LANES ON NEW LOCATION (PE & RW ONLY)
13551	RTE 360 WIDENING
13714	RTE 620 - CONSTRUCT LTLS AND RTLS AT VARIOUS LOCATIONS
13835	RTE 58 - CLARKSVILLE BYPASS-4 LANES ON NEW LOCATION
14601	RTE 58 - WIDEN TO 6 LANES PHASE II
14603	LYNNHAVEN PARKWAY - WIDENING TO 4 LANES
14607	RTE 210 - LYNCH/MADISON HGHTS BP - INTRCHG AT MADISON HGHTS
14614	RTE 41 - WIDEN TO 4 LANES UNDIVIDED, CURB, GUTTER & SIDEWALK
14627	RTE 1050 - EXTENSION OF FORT EUSTIS BOULEVARD
14643	RTE 29 - FONTAINE AVENUE - 3 LANES
14657	RTE 3 - PARALLEL LANE (EAST OF STEVENSURG TO LIGNUM)
14682	BUILD HOV RAMPS BETWEEN I-95 AND CAPITAL BELTWAY- FAIRFAX CO
14692	RTE 123 - WIDEN TO 6 LANES
14750	RTE 60 - WIDEN TO 4 LANES WITH CURB, GUTTER, SIDEWALK
14791	RTE 256 - 2 LANES ON NEW LOCATION
14833	RTE 29 - CONSTRUCT INTERCHANGE
15130	RTE 642 - WIDEN TO 6 LANES & REPLACE BRIDGE AT POHICK CREEK
15215	RTE 642 - RELOCATION
15292	FAIRFAX COUNTY PARKWAY - ROUTE 7 INTERCHANGE
15428	RTE 1 - WIDEN TO 6 LANES
15675	ROCK ROAD - 2 LANE ON 4 LANE R/W
15811	WIDEN CHURCHVILLE AVENUE FROM TWO TO THREE LANES

UPC	Description
15827	HOLLAND ROAD - UPGRADE TO 4 LANES
15828	ELBOW RD - UPGRADE TO 4 LANES & EXTENSION (PE ONLY IN SYIP)
15829	INDIAN RIVER ROAD - UPGRADE TO 4 LANES (PE ONLY IN SYIP)
15831	RIVER ROAD - 2 LANES
15834	RTE 60 - RECONSTRUCTION
15838	RTE 99 - WIDEN FROM 2 TO 4 LANES
15844	RTE 29 - LYNCHBURG/MADISON HEIGHTS BYPASS - ROUTE 460 INTRCH
15955	RTE 1 - MAJOR WIDENING
15959	RTE 360 - MAJOR WIDENING
16000	RTE 66 - ADD LANES, HOV LANES & INTRCHG UPGRADE-PE & RW ONLY
16093	RTE 58 - REHABILITATE/RECONSTRUCT EBL
16152	RTE 7679 - HUNGARY SPRINGS ROAD - WIDENING
16153	RTE 7555 - LABURNUM AVENUE - WIDENING
16277	RTE 639 - RECONSTRUCTION
16286	RTE 705 - QUIOCCASIN ROAD
16383	Improve existing 2-Lane roadway to a 4-Lane divided facility
16389	RTE 81 - MAJOR WIDENING - ROUTE 460 CONNECTOR
16428	RTE 130 - LYNCH/MADISON HGHTS BP - IMPROVEMENTS - 5 LANES
16446	RTE 340 - WIDEN TO 4 LANES WITH SIDEWALK, CURB & GUTTER
16492	RTE 23 - 4 LANES, CURB, GUTTER & SIDEWALK PE and RW only
16504	RTE 608 - WIDEN TO 4 LANES
16505	RT 638 - WIDEN POHICK RD TO 4-LNS FROM RT 1 TO I-95
16622	RTE 123 - WIDENING FROM 2 LANES TO 4 LANES ON 6 LANE R/W
16627	CONSTRUCT INTERCHANGE AT BARON CAMERON AVENUE
16634	COTTAGE STREET RECONSTRUCTION, TOWN OF VIENNA
16640	RTE 229 - WIDEN FROM 2 LANES TO 5 LANES
17155	RTE 288 - 4 LANES ON 6 LANE RW/ NEW LOCATION (PE & RW ONLY)
17314	RTE 220 - 2 LANES ON 4 LANE RW - RW ONLY
17525	RTE 619 - PE ONLY FOR UPGRADING TO 4 LANES ON 6 LANE R/W
17533	RTE 58 - CORRIDOR DEVELOPMENT PROG - 4 LANES
17534	RTE 58 - CORRIDOR DEVELOPMENT PROG - 4 LANES
17535	RTE 58 - HILLSVILLE BYPASS-CORRIDOR DEV PROG-4 LANES
17536	RTE 58 - CORRIDOR DEVELOPMENT PROG - 4 LANES
17537	RTE 58 - CORRIDOR DEVELOPMENT PROG - 4 LANES
17538	RTE 58 - CORRIDOR DEVELOPMENT PROG - 4 LANES
17541	RTE 257 SOUTH EXTENSION - 2 & 4 LANES, C & G (PE ONLY)
17568	RTE 337 - DEVELOP TO 4 LANE DIVIDED FACILITY
17669	RTE 28 - CONSTRUCT PARTIAL INTERCHANGE FOR SASM - PHASE 3
17682	TOMS CREEK ROAD - INTERCHANGE

UPC	Description
17687	WIDEN RT 15 Phase I
17689	BUILD INTERCHANGE-RT 28/WELLINGTON RD&ELIMINATE @GRADE XING
17692	RTE 220 - SOUTH MAIN STREET - VARIES FROM 2 TO 4 LANES
17723	RTE 45 - RECONSTRUCTION
17747	RTE 58 - CONSTRUCTION INTERCHANGE - PE & RW ONLY
17756	RTE 64/288 - CONSTRUCT 4 LANES ON NEW ALIGN & INTERCHANGES
17768	RTE 360 - WIDENING FROM 4 TO 6 & 8 LANES
17861	RTE 627 - MEADOWBRIDGE ROAD - WIDENING TO 4 LANES
18003	RTE 277 - WIDEN TO 5 LANES
18115	RTE 208-(SPOTSYLVANIA C.H. BYP)-2 LN ON 4 LN R/W (NEW LOCAT)
18122	RTE 627 - MEADOWBRIDGE ROAD - RECONSTRUCTION
18138	ROUTE 95 - WIDEN TO ADD ADDITIONAL LANES
18156	RTE 460 - WIDENING & RELOCATION
18460	RTE 288 - 4 LANES ON NEW LOCATION
18512	RTE 460 - WIDENING & RELOCATION (INCL CONNECTION TO RTE 114)
18591	RTE 337 - WIDEN TO 4 LANES
18749	SOUTH LOUDOUN STREET - PROVIDE 5 LANES DRAINAGE, CURB/GUTTER
18899	RTE 229 - WIDEN TO 4 LANES
18946	RTE 1 - WIDEN TO 6 LANES - PE ONLY
18963	RTE 360 - WIDENING FROM 4 TO 6 LANES
50029	RTE 360 - 6 LANE
50057	RTE 615 - RECONSTRUCT TO 4 LANES
50525	RTE 9999 (THREE CHOPT ROAD) WIDEN TO 4 LANES
50529	RTE 9999 (THREE CHOPT ROAD) WIDEN TO 4 LANES
51919	RTE 610 - RECONSTRUCTION
52077	RTE 174 - WIDEN TO 5 LANES - PE and CN ONLY
52148	WESLEYAN DRIVE - 4 LANE
52172	COURTHOUSE ROAD/BERRY STREET
52299	RTE 208-SPOTSYLVANIA COURTHOUSE BYPASS- 4 LNS NEW LOCATION
52327	RTE 7 - WIDEN TO 6 LANES
52390	RTE 15 - CONSTRUCT 3 LANES
52448	RTE 250 - 4 LANE
52458	RTE 28 - CONSTRUCT INTERCHANGE
52838	RTE 28 - WIDEN TO 6 LANES
53314	RTE 9999 - NUCKOLS ROAD AND COX ROAD
53525	RTE 9999 - CAROLINA AVENUE - RECONSTRUCTION
54384	RTE 340 - RECONSTRUCT TO 4-LANE AT ROUTE 50/17 - PE ONLY
55202	WITCH DUCK ROAD - 6 LANES
56181	RTE 33 - ADD LEFT TURN LANES AT THE INTERSECTION OF RTE 623

UPC	Description
56230	RTE 460 - NEW LOCATION-Phase 2 Construction
56655	PROVIDE 2 LANES, GRADE, DRAIN PE ONLY IN SYP
56939	RTE 3 - WIDENING
57017	ADDING A 4TH LANE IN EACH DIRECTION FROM NEWINGTON TO RT 123
57047	Saunders Road Widening
57167	RTE 7100 - WIDEN FROM 4 TO 6 LANES
57298	RTE 267 - RAMP IMPROVEMENTS
57337	RT 621 (Manakin Rd) - RECONSTRUCTION
57719	RTE 802 - WIDEN FROM TWO TO FOUR LANES
58188	RTE 643 - WIDEN FROM TWO TO FOUR LANES
58599	RTE 7 - CONSTRUCT WB CLIMBING LANE
59094	Construct Shared Use Path along Rt 29 and perform study
60843	RTE 17 - WIDEN FROM 4 TO 6 LANES
60864	STRINGFELLOW ROAD - RTE 645 - WIDEN TO FOUR LANES
60933	RTE 9999 - DABBS HOUSE RD; RECONSTRUCTION
60980	STONE SPRING ROAD - 4 LANE
61407	RTE 337 - WIDEN TO 4 LANES
64177	CHESTER VILLAGE STREETSCAPE - PHASE II
64524	RTE 95 - TELEGRAPH RD & RAMP IMPROV - (PHASE I-CONTRACT VB2)
64647	ERICKSON AVENUE - 4 LANE
65068	RTE 750 - CONSTRUCT LTL ONTO ROUTE 724
65544	RTE 620 - Reconstruction
65655	RTE 337 - 4 LANE
67976	RTE 460 - N. MAIN ST. - RECONSTRUCTION - PE ONLY
68757	WIDEN TO 6-LANES FROM SULLY ROAD (RT 28) TO POLAND ROAD
68820	RTE 15 - WIDEN FROM 2 TO 4 LANES
70043	I66 WIDEN TO 8-LANES FROM RT 234 BYPASS TO RT 29/GAINESVILLE
70542	I-64 - WIDEN FROM 4 TO 6 LANES AND IMPROVE RTE 623 INTERCHNG
70550	RTE 295 - CONSTRUCT INTERCHANGE
71774	RTE 17 - RECONSTRUCTION
72527	PROGRESS STREET EXTENSION / GIVENS LANE
73282	RTE 120-SOUTH GLEBE ROAD/I-395 INTERCHANGE AREA IMPROVEMENTS
75271	ALBEMARLE COUNTY - HISTORIC CROZET STREETSCAPING
75910	Route 11,220,220A Access Management Project at I-81 Exit 150
76244	RTE 659 - RECONSTRUCT TO 4 LANES
77181	RTE 30 - ADD ADDITIONAL THRU LANE EB
77262	EADS STREET EXIT RAMP IMPROVEMENT
77383	RTE 29 - WIDENING & CORRIDOR IMPROVEMENTS
77402	RTE 123 - MAPLE AVENUE IMPROVEMENTS

UPC	Description
78767	MILNWOOD ROAD - WIDENING AND ADDING SIDEWALKS
78826	WESTBOUND ACCEL/DECEL LANE FROM GEO MASON DR TO SYCAMORE ST
78828	WESTBOUND ACCEL/DECEL LN FROM WESTMORELAND ST TO HAYCOCK RD
80463	RTE 262 - Ext. LTL & RTL @ Rte. 11 Int.
80560	DEVELOP NORFOLK AVENUE TO URBAN 3 LANES
81225	CHARLOTTESVILLE MULTI-USE TRAIL
81296	RTE 3000 - CORRECT SUPERELEVATION
81636	RTE 600-Restoration and Rehab
82063	3 R PROJECT -- REHABILITATE ROADWAY
84117	RTE. 81 - Addition of Truck Climbing Lane on I81SB
84243	Robin Hood Rd & Military Hwy Phase 1, link w/ UPC 1765 & 9783
84359	Mount Pleasant Rd - Widen to 4-lanes
84363	I-81 Northbound Truck Climbing Lane
84385	BEACH MILL ROAD - RTE 603 - BR. OVER NICHOLS RUN
85212	CONSTRUCT TEMP. DETOUR FOR RTE. 360 OVER BANISTER RIVER
85708	RTE. 29 (EMMET STREET) / RTE. 250 BYPASS INTERCHANGE
86286	Fed ID 5808 Route 80 over Prater Creek @ Haysi Va struc 1040
86288	Kent Junction Rd over Railroad Va struc 1015
86298	Lee Highway over Norfolk Southern RR Va struct number 1011
86299	Lee Highway over NS Railway Va struct number 1009
86301	Route 670 over S Fork Holston River Va struc 6108
86442	RTE 711 - MAJOR WIDENING (FED ID 13865)
86598	SB&NB 23 over NF Holston R Va struc 1003 & 1108 FED ID 16543
86922	ATLANTIC BLVD 4-LNS - CHURCH RD TO MAGNOLIA RD (RT 28 PPTA)
87019	Greene County - Main Street Streetscaping
87118	Rt 627 (Pole Green) Reconstruct Int. at Rt 642 (Bell Creek)
87145	WIDEN GREENVIEW DRIVE FROM 2 TO 4 LANES
87156	RTE 27 Washington Blvd. PH2 CN Shared Use Path-RVSH 08
87504	Rte. 340 Widen to 4 lanes with sidewalk, curb & gutter
87505	Route 340 Widen to 4 lanes with sidewalk, curb & gutter
87994	CREATE A ROUTE 501 PASSING ZONE BY IMPROVING VSD
88558	ARRA BRAC Ft Belvoir Rte 7100 Ffx Cty Pkwy at EPG Phase III
88699	FALL HILL AVE. BRIDGE & APPROACHES RECONSTRUCTION & WIDENING
88906	RTE. 229 - TOWN OF CULPEPER
89062	Ironbound Road (Rte 615) Improvements - Phase I
90175	South Main Street, Phase III
90176	Rte. 158 over Toms Creek VA Struc. No. 1029 FED ID 19301
90187	Rte. 340 Over Cub Run. VA str. 1012
90188	Rte 39 Over Maury River, VA Str. 1046

UPC	Description
90346	RTE 147 (HUGUENOT RD) - SPOT WIDENING
90972	Relocation of Road
91168	Rte 637 Over Nuby Run VA str. 6045
91257	I81 INTERCHANGE IMPROVEMENTS AT EXIT 7
91688	NORTH KING STREET IMPROVEMENTS
91916	MOUNTAINVIEW ROAD - PHASE 1
92545	PM3K15 AMHERST COUNTY ADDITIONAL PRIMARY PLANT MIX SCHEDULE
92558	RTE. 603 - IRONTO/ELLISTON CONNECTOR
93199	ARRA Charles City/Henrico 5 VA Capital Trail Construction
93209	ARRA Hopewell/Prince George 36 Corridor Improvements
93523	ARRA Rockingham 253 (Port Republic) Reconstruct to 4 Lanes
93530	ARRA Richmond German School Road Widening/C&G/Walks/Drainage
93577	I-66 WIDENING TO RTE 15 (1 HOV+1 SOV EACH DIR)
93974	Princess Anne Street Improvements
94089	ARRA RTE. 581 - at Elm Ave. (Design-Build)
94102	Construction Phase-I (Route 1 Widening only)
94584	PIEDMONT DRIVE LANDSCAPING / MITIGATION PROJECT
94632	RTE 460 AND RTE 29 NO PLAN PROJECT
94818	Widen Riverside Drive from four to six lanes
94844	RTE 33 construct a third lane and improve drainage
94854	ARRA - Goochland 250 Widen to 4 Lanes (Manakin to Hockett)
94855	ARRA - Hanover 95 Ramp Improvements for Lewistown (743)
94904	Rt. 1 Widening from 4-6 lanes
94944	Noise Barriers 13A and 13E on I-495
95159	Rte. 637 Over Ivy Creek, VA Str. 6039
95637	Route 28 Spot Widening
96509	TELEGRAPH ROAD - RTE 611 - WIDEN TO 4 LANES
97529	Route 606 Loudoun County Parkway/ Old Ox Road Reconstruction
97649	Rte. 218 over Machodoc Creek
97687	RTE 360 - WIDENING
97688	RTE 155 - SHARED-USE PATH
97694	RTE 700 - RELOCATION & REALIGNMENT
97715	Wythe Creek Road - Widen to 3 Lanes
98220	RTE. 115, Plantation Rd Corridor Improvements
98236	Rte 638 - Extend Atlee Rd to Connect to Atlee Station Rd
98847	RTE 610 - GARRISONVILLE ROAD - WIDEN TO 6 LANES - PHASE 2
98959	I-95 N & SB ASPHALT MILL & OVERLAY
100426	Route1 North
100427	Prince William Parkway Widening

UPC	Description
100518	Battlefield Parkway Extension
100556	RTE 501 - CONSTRUCT PASSING LANE (CAMPBELL COUNTY)
100566	I-66 / ROUTE 15 INTERCHANGE RECONSTRUCTION
100593	RT 614 (STURGEON POINT RD) - PE STUDY ONLY
100920	FOUR LANE WIDENING FRM LIBRARY TO RT 60
100951	Rte 621 Over Passenger Swamp Va Str. 6031
101022	Rte 360 - Widen to Six Lanes
101204	Improve Alignment Valley Mill Rd at Rt. 7
101216	Widen to 4 lane divided highway
101229	Widen Route 76/ Old Hundred Rd to 4 Lanes
101429	Plant Mix Franklin County û Secondary
102105	WALNEY ROAD - RTE 657 - WIDEN TO 4 LANES
102297	Route 28 at Belfort Park
102437	I-395 AUXILIARY LANE
102458	Emergency Wing Wall Repairs at Rte 7100 & Long Br
102760	Route 83 Buchanan Co. - Va. Str. # 1018 - Fed. Str. # 3790
102763	Meadow Creek Road (Rt. 658) realignment. FY13 RS
102795	FOLLIN LANE SOUTHEAST RECONSTRUCTION
102835	TOWN OF AMHERST - SOUTH MAIN STREET LANDSCAPING
102905	ROLLING ROAD - WIDEN TO FOUR LANES
102952	RTE 10 - WIDEN TO 6 LANES
102959	RTE 60 - WIDEN TO 6 LANES
102994	Suffolk Bypass ITS Improvements
103060	RTE 76 - CONCRETE PATCHING NB and SB
103072	Victory Boulevard (Route 171) Multi-Use Path
103073	US Route 1 Improvements at Fort Belvoir
103100	I-85 - DEEP MILL & OVERLAY
103102	I-85 NB & SB - DEEP MILL & OVERLAY
103316	I-395 CONSTRUCT 4TH SOUTHBOUND LANE
103320	Add lane on I-77 (South) at Exit 80 in Wytheville
103321	ROUTE 28 (CATLETT ROAD) FROM US 29 TO US 17
103456	Rte 58-Reserve Blvd - Safety Improvements
103484	WIDEN MINNIEVILLE ROAD FROM 2 TO 4 LANES DIVIDED
103523	F14 Plant Mix Interstate PM2S-962-F14
103525	F14 Plant Mix Floyd County - Primaries PM2B-031-F14
103887	RTE 50 TRAFFIC CALMING - TOWN OF MIDDLEBURG
103999	WIDEN RTE 15 Phase II
104083	RTE 1107 - WIDENING
104116	RTE 460B - ADD ACCELERATION LANE

UPC	Description
104169	Lakeside Drive Roundabout at Lynchburg College Entrance
104226	Relocate Rte. 610
104292	RTE 625 - WAXPOOL ROAD
104338	I-264 Thin Hot Mix Asphalt Concrete Overlay, (THMACO)
104366	I 64 Environmental Study from I-464 to I-664/264
104374	WELLINGTON ROAD OVERPASS PHASE III
104491	RTE. 288 NB - PATCH AND OVERLAY - CHESTERFIELD CO
104889	RT 10 - WIDENING
104890	RTE 360 - WIDENING
104944	RTE 29-REPL. BR. & APPR. / STAUNTON RV. & NSRR (Fed ID 4159)
105035	F15 Plant Mix Botetourt County - Primaries PM2I-011-F15
105038	F15 Plant Mix Patrick County - Primaries PM2G-070-F15
105042	F14 Recycling Giles County - Primaries PM28-035-F14
105049	F15 District Wide Interstate Latex Schedule LM2A-962-F15
105076	RTE 95 - FIBER DESIGN - NORTH RICHMOND
105307	RTE 522 - POWHATAN STATE PARK
105338	ShaeDawn Parkway - Phase 2 (ARC)
105397	ROUTE 29 WIDENING
105482	Route 28 Study
105501	Fairfax County Parkway Route 286 & Terminal Road Route 3726
105674	RTE 720 - MAJOR WIDENING
105745	FY15 RS - City of Roanoke - Streetscaping - Garden City Blvd
105833	FY15/16: SB BWMT SACCARDO NOZZLE PE
105856	FY15/16: SB ERMT SACCARDO NOZZLE PE
105911	RTE 218 - BUTLER ROAD WIDENING (2 TO 4 LANES)
106232	RTE 288 SB - RESTORE EXIST PAVEMENT
106296	RTE 155 - CONSTRUCT TRAIL
106339	FY 15 Plant Mix Carroll Co. - Primaries PM28-017-F15
106406	Rev Sharing Rt 55 Construct EB RTL and NB LTL on Rt 626
106581	BRADDOCK ROAD PLEASANT FOREST TRAIL
106692	I-64 Southside Widening- Including High Rise Bridge
106770	Dominion Boulevard Widening
106986	HERNDON METRORAIL INTERMODAL ACCESS IMPROVEMENTS PH II
107088	RTE 655 - MAJOR WIDENING
107352	Princess Anne Widening
107611	Rt. 55 Upgrade - Warren County
109370	#SMART18 - (St) RTE. 606 INTER IMPROVEMENTS AT I-81 EXIT 205
113323	RTE 632 (Fairground Road) Extension
101209	Widen Reservoir Street from two lanes to four lanes

UPC	Description
103005	Centerville Turnpike Widening Phase 2
104262	Airport Road and Warrior Drive Extension
105623	Rosemont Road
106320	UR-6056 - D/B WIDEN FROM 2 TO 4 LANES (GREENVIEW DRIVE)
107352	Princess Anne VII
108810	#HB2.FY17 Route 11 S. Valley Pike Roadway Improvements
109376	#HB2.FY17 I-81 Exit 323 SB Accel and NB Decel Lane Extension
109440	#HB2.FY17 I-81 Exit 19 Ramp Improvements
111054	#SMART18 - (St) I-81 EXIT 300 SOUTHBOUND ACCEL LANE EXT.
111059	#SMART18 - (St) I-81 EXIT 296 ACCEL/DECEL LANE EXTENSIONS
111230	#SMART18 - (St) I-81 EXIT 247 INTERCHANGE IMPROVEMENTS
111373	#SMART18 - I-81 SB Auxiliary Lane from Exit 143 to 141
111787	#SMART18 - Route 17 Widening between Rte 630 and Rte 173
111788	#SMART18 - I-264 W Off-Ramp at Ballentine Boulevard
112317	Elbow Road Phase 2C
113259	Oyster Point Access Improvements- Ramps
115181	#SMART20 I-81 Exit 317 Accel/Decel Lane Extensions
115345	#I81CIP EXTEND SB DECELERATION LANE MM 26.7 TO 26.8 (ID #22)
115346	#I81CIP EXTEND SB ACCEL LANE MM 25.9 TO MM 26.1 (ID #23)
115795	#I81CIP EXTEND ACCELERATION LANE EXIT 89 (ID #29)
115801	#I81CIP NB EXIT 205 EXTEND ACCELERATION LANE (ID #42)
115802	#I81CIP NB EXIT 269 EXTEND DECELERATION LANE (ID #45)
115804	#I81CIP SB EXIT 283 EXTEND ACCELERATION LANE (ID #52)
115870	#I81CIP NB EXIT 302 EXTEND DECELERATION LANE (ID #48)
115937	#I81CIP MM139 TO MM141 ADD LANE IN EACH DIRECTION (ID #39B)
116155	#I81CIP NB MM 19.2 DECEL LANE (ID #2)
116158	#I81CIP SB MM 47.4 EXTEND ACCEL LANE (ID #16)
116159	#I81CIP NB MM 38.9 EXTEND DECEL LANE (ID #5)
116160	#I81CIP NB MM 45.5 EXTEND DECEL LANE (ID #6)
116161	#I81CIP NB MM 48.1 EXTEND ACCEL LANE (ID #7)
116162	#I81CIP NB MM 67.3 EXTEND DECEL LANE (ID #8)
116163	#I81CIP NB MM 72.7 EXTEND DECEL LANE (ID #10)
116164	#I81CIP NB MM 73.0 DECEL AND LOOP (ID #11)
116165	#I81CIP SB MM 84.3 EXTEND DECEL LANE (ID #12)
116166	#I81CIP SB MM 81.7 EXTEND DECEL LANE (ID #13)
116167	#I81CIP SB MM 42.8 EXTEND ACCEL LANE (ID #17)
116168	#I81CIP SB MM 73.2 AUX. LANE (ID #14)
116169	#I81CIP SB MM 54.1 EXTEND RAMP TO REST AREA (ID #15)
116170	#I81CIP SB MM 8.1 WIDEN TO THREE LANES (ID #27)

UPC	Description
116171	#I81CIP SB MM 16.6 EXTEND ACCEL LANE (ID #26)
116173	#I81CIP SB MM 38.7 EXTEND ACCEL LANE (ID #20)
116174	#I81CIP MM 39.4 EXTEND DECEL LANE (ID #19)
116175	#I81CIP SB MM 41.6 ADD AUX. LANE (ID #18)
116196	#I81CIP MM 116 TO MM 128 ADDING NB LANE (ID #31)
116197	#I81CIP ADD NB LANE BETWEEN EXIT 128 AND EXIT 137 (ID #32)
116198	#I81CIP EXIT 105 NB ACCELERATION LANE EXTENSION (ID #30)
116199	#I81CIP EXIT 162 NB ACCELERATION LANE EXTENSION (ID #33)
116200	#I81CIP EXIT 94 SB ACCELERATION LANE EXTENSION (ID #38)
116201	#I81CIP MM 144 TO EXIT 150 ADDING NB AND SB LANES (ID #40)
116202	#I81CIP EXTEND LANES AT TROUTVILLE SAFETY REST AREA (ID #37)
116203	#I81CIP MM136 TO MM142 ADD LANE IN EACH DIRECTION (ID #39)
116236	#I81CIP NB EXIT 302 EXTEND ACCELERATION LANE (ID #47)
116243	#I81CIP SB EXIT 279 EXTEND ACCELERATION LANE (ID #53)
116244	#I81CIP SB EXIT 296 EXTEND ACCELERATION LANE (ID #51)
116245	#I81CIP SB EXIT 205 EXTEND ACCELERATION LANE (ID #59)
116246	#I81CIP NB EXIT 188 EXTEND ACCELERATION LANE (ID #41)
116268	#I81CIP SB MM 296 TO 299, 3-LANE WIDENING (ID #50)
116269	#I81CIP NB & SB MM 221 TO 225, 3-LANE WIDENING (ID #61)
116270	#I81CIP NB EXIT 291 EXTEND ACCELERATION LANE (ID #46)
116271	#I81CIP NB MT. SIDNEY EXTEND ACCELERATION LANE (ID #43)
116275	#I81CIP SB MT. SIDNEY EXTEND DECELERATION LANE (ID #56)
116276	#I81CIP SB MT. SIDNEY EXTEND ACCELERATION LANE (ID #57)
116279	#I81CIP SB MM 221 TO 220, AUXILIARY LANE (ID #58)
116280	#I81CIP NB & SB MM 242 TO 248, 3-LANE WIDENING (ID #62)
116281	#I81CIP NB & SB MM 313 TO 317, 3-LANE WIDENING (ID #63)
12546	#HB2.FY17 RTE 58 - WIDEN TO 6-LANE DIVIDED FACILITY
16640	RTE 229 - WIDEN FROM 2 LANES TO 5 LANES
17533	RTE 58 - CORRIDOR DEVELOPMENT PROG - 4 LANES (Laurel Fork)
17534	RTE 58 - CORRIDOR DEVELOPMENT PROG - 4 LANES (Crooked Oak)
17536	RTE 58 - CORRIDOR DEVELOPMENT PROG - 4 LANES (Lovers Leap)
17537	RTE 58 - CORRIDOR DEVELOPMENT PROG - 4 LANES (Vesta)
18003	#HB2.FY17 RTE 277 - WIDEN TO 5 LANES
52077	RTE 174 - WIDEN TO 5 LANES - PE and CN ONLY
53097	RTE 81 - WIDEN FROM 4 TO 8 LANES - PE & RW ONLY
70542	I-64 - WIDEN FROM 4 TO 6 LANES AND IMPROVE RTE 623 INTERCHNG
80561	DEVELOP ORANGE AVENUE TO URBAN 6 LANES
84243	Robin Hood Rd & Military Hwy Phase 1, link w/ UPC 1765 & 9783
88699	FALL HILL AVE. BRIDGE & APPROACHES RECONSTRUCTION & WIDENING

UPC	Description
9783	RTE 13 - 8 LANES