# Virginia Statewide Greenhouse Gas Planning Level Analysis

## *Appendix A. Virginia Statewide Greenhouse Gas and Climate Change Impacts Planning Level Analysis*

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# 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 7.0 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 totaling nearly $1.5 billion in value) included in VDOT's Smart Scale database.

[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.

## Table 1.1 Sample of Major Highway Projects and List of All Major Transit and Rail Projects Included in 2040 Build Scenario

| Project Type | Project/Study | Indicator[1] | 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 |
| | 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 |
| | Commonwealth Railway (CWRY) Marshalling Yard | Change in Ton-Miles (millions) | 18.0 |
| | Shoulders Hill Siding | Change in Ton-Miles (millions) | 3.9 |

1 Ridership 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. Section 5.0 compares emissions effects of two hypothetical major projects.

In addition to describing the statewide GHG analysis, Section 6.0 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 7.0 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 (MWCOG), 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 online 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. 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 a.m. and 4–7 p.m.). Free-flow speeds were assigned to other time periods (9 a.m.–4 p.m. = midday; 7 p.m.–7 a.m. = off-peak).[4] The model

[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.

[4] The model database includes fields for speed and link travel time corresponding to four time periods—AM Peak, Midday, 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.

computes congested speeds using the Bureau of Public Roads formula with coefficients that vary by roadway type.[5]

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. Pollutant ID 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 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.

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5 This formula is: Congested speed = Free flow speed / ( 1 + $\alpha * (\text{Volume / Capacity})^{\mathrm{B}}$ ), where $\alpha$ 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.

### 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 Table 1.1. |
| 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 Table 1.1. |
| 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 Table 1.1. |
| Temp/humidity—zoneMonthHour | Temperature and humidity by month and hour. | Low—mainly affects criteria pollutants. | Use Fairfax County as a representative county. |
| FuelFormulation<br>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

In September 2019, Virginia Governor Ralph Northam announced an Executive Order that calls for the state to produce 30 percent of its electricity from renewable energy by 2030 and 100 percent from carbon-free sources by 2050. Title 45.2 of the state code sets a goal for the Commonwealth to reach net-zero emissions by 2045 in all sectors, including transportation, and a policy to develop energy resources necessary to produce 30 percent of Virginia's electricity from renewable energy sources by 2030 and 100 percent of Virginia's electricity from carbon-free sources by 2040. Virginia has also adopted regulations for a “low-emissions and zero-emissions vehicle program,” consistent with the California Advanced Clean Cars (ACC) program, that would aggressively increase the light-duty vehicle zero-emission vehicles (ZEV) market share beginning in 2025.

Based on this rule, Virginia is expected is ramp up electric vehicle sales requirements between 2025 and 2035, when 100 percent of light duty vehicles sales are anticipated to be electric vehicles. The ramp-up schedule between 2025 and 2035 could vary depending upon a number of factors such as the use of credits. Two possible phase-in schedules were developed by Virginia DEQ. With the more conservative schedule, it is expected that roughly 57 percent of light-duty VMT will be from electric vehicles in 2040. This is based on applying the DEQ phase-in schedule to a fleet activity and turnover model based on data from the Argonne National Laboratory VISION model,[9] to translate sales by year into vehicle fleet and VMT share by year by technology type.

In the statewide analysis, electrification is considered by reducing the emissions output from MOVES in proportion to the electrified share of each respective vehicle type (light-duty vehicles and buses), to simulate the reduction in direct tailpipe emissions from vehicle electrification. Emissions from electricity generation to power future electric vehicles are accounted for separately since they are generated at the powerplant source rather than directly by on-road transportation sources. See Section 2.2 for a discussion of electricity emissions rates used in this analysis.

### *2.1.3 Transit Buses*

Transit bus emissions were estimated using data provided from transit providers to the National Transit Database (2015 reporting year).[10] 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:

- 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.

- 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.[11] This percentage was applied to total WMATA bus VMT to identify the Virginia portion.[12]

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9 https://www.anl.gov/es/vision-model.

10 https://www.transit.dot.gov/ntd.

11 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.

12 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.

- 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.

- 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 MOVES[13] 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.

- Multiply VMT by the MOVES-generated emission factor for buses. Sum to get total emissions.

### No-Build 2040 Emissions

For the baseline 2040 no-build emissions estimate, no change in service levels was assumed compared to 2015. Changes in emissions result from assumed improvements in energy efficiency consistent with Federal standards for heavy-duty vehicles as well as complete electrification of the transit bus fleets and associated VMT operating in the Commonwealth.[14]

### 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

[13] 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.

[14] Electrification of buses is not currently required by any state or Federal regulation.

[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/.

revenue-miles, revenue-hours were used to inflate base year revenue-mile values to a value representing 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 MWCOG 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]

**Vehicle technology**—For the build scenario, similar to the no-build, it was assumed that by 2040 all transit buses operating in the Commonwealth would be electric.

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.** No direct emissions would be produced by transit vehicles given the assumption of 100 percent electrification. To estimate emissions from electricity generation, the amount of new service (vehicle revenue-miles by fuel type) was multiplied by the energy consumption per mile and GHG emissions rate per unit of energy consumed (Section 2.2.2).

- **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, and then reduced to account for the estimated proportion of electric VMT in 2040. 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

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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.

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.

- **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 as discussed in Section 2.2.2, reflecting projected decreases in the carbon intensity of electricity generation.

#### 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.

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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/.

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 EIS[21] to proxy for operating emissions. 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:

- Calculate a Metrorail "emissions-per-rider" factor from 2015 data by dividing the estimated 2015 Metrorail emissions by 2015 ridership.
- 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.
- 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. However, an adjustment was made to these estimates to account for changes in vehicle mix (electrification) and grid emission rates in 2040 to create an updated displacement factor in 2040. Based on increases in vehicle electrification and declining carbon intensity for electricity, WMATA emissions in 2040 would be 115,000 MT CO2 and regional emissions would be 224,000 MT CO2 in the absence of Metro, with an adjusted 2040 displacement factor of 1.95. This displacement factor of 1.95 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.

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

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.

22 WMATA. 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.

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.

### Table 2.2 2015 and 2040 Intercity Rail Emission Rates

| Mode | Units | Energy intensity (BTU/unit): 2015 | Energy intensity (BTU/unit): 2040 | CO2 Intensity (kg CO2/unit): 2015 | CO2 Intensity (kg CO2/unit): 2040 |
|---|---|---|---|---|---|
| Passenger Rail | Per passenger-mile | 1,644 | 1,381 | 0.132 | 0.111 |
| Freight Rail | Per ton-mile | 293 | 246 | 0.023 | 0.019 |

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 percent 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 multiyear period, and assumptions were made to estimate changes for year 2040. The studies and information provided in each are shown in Table 2.3.

### Table 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 | ● | ● | – | – | – |
| Richmond to Raleigh R2R Tier II EIS | – | ● | – | – | – |
| Long Bridge EIS | ● | – | – | – | – |
| Richmond to Hampton Roads R2HR Tier I EIS | – | ● | – | – | – |
| Virginia Railway Express FY20-FY25 Transit Development Plan | – | ● | – | – | – |
| Ettrick Station Improvements | – | – | ● | – | – |
| Staples Mill Station Improvements | – | – | ● | – | – |
| Buckingham Branch Railroad (BBRR) Improvements | – | – | – | – | ● |
| Norfolk International Terminals (NIT) Improvements | ● | – | – | ● | ● |
| Virginia Inland Port (VIP) Improvements | ● | – | – | ● | ● |
| Commonwealth Railway (CWRY) Marshalling Yard | ● | – | – | ● | ● |
| Shoulders Hill Siding | ● | – | – | ● | ● |

#### *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.

[25] Assumption used in DRPT project studies.

- 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.

- 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 model provides both direct and full fuel-cycle emissions estimates accounting for upstream emissions.[26] 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. According to the 2020 Virginia Clean Energy Economy Act (VCEA), all regulated utilities will be required to have carbon-free energy by 2050. An emissions factor of 29.3 grams of $CO_2$ per MJ in 2040 was employed in the analysis, assuming a linear annual reduction in the grid emissions rate between 2018 and 2050.

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 2.4. This assumes that EVs have power and performance characteristics similar to conventional fuel vehicles within a given vehicle type. The energy efficiency of a conventional bus in 2040 is assumed to be 41 percent higher than in 2015, based on the Annual Energy Outlook projections for medium and heavy-duty trucks, which are subject to the same GHG emissions standards as buses.[29]

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.

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 CS analysis of 2019 AEO Reference Case, combining weighted data for medium and heavy trucks showing an increase from 7.1 to 10.1 MPG diesel, using 2016 data to represent 2015 (which is not included in the 2019 AEO).

### Table 2.4 Electric Vehicle Energy Conversion Factors

| Vehicle Type | Conventional Vehicle MPG: 2015 | Conventional Vehicle MPG: 2040 | Electric Energy Efficiency Ratio | EV MPGGE: 2015 | EV MPGGE: 2040 | EV MJ/VMT: 2015 | EV MJ/VMT: 2040 |
|---|---|---|---|---|---|---|---|
| Auto/Light Truck | 22.4 | 36.6 | 3.0 | 67.2 | 109.8 | 1.96 | 1.20 |
| 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 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

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

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 2.5 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 2.5 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. |
| | A default schedule for roadway rehabilitation with a resurfacing event at year 15 and a reconstruction event at year 30. | Facility type (rural interstate, urban arterial, etc.) | |
| | A default schedule for roadway rehabilitation with a resurfacing event at year 15 and a reconstruction event at year 30. | Lane miles (#) | |
| Light Rail and Heavy Rail | None. | 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 | None. | Number of new stations | MWCOG plans |
| | | Facility type (new lane miles, converted/upgraded lane) | MWCOG plans |
| | | Number of lane miles | MWCOG plans |
| Bicycle and Pedestrian Pathways | None. | Project type (new construction, resurfacing) | VDOT |
| | | Facility type (off-street, path, on-street bicycle lane, on-street sidewalk) | VDOT |
| | | Length of project (miles) | VDOT |

# 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 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-19 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. Rapid advancement of light-duty vehicle and transit bus electrification is assumed in this study, consistent with goals and policies of the Commonwealth. Similar goals and policies have not yet been adopted for trucks and other heavy vehicles, however. Emissions would decline even more in 2040 if electrification or other decarbonization technologies are implemented more aggressively for heavy vehicles. Conversely, if decarbonization does not occur at the anticipated rate for light-duty vehicles, emissions in 2040 will be higher than projected. As electrification increases, life-cycle emissions in 2040 will also increasingly depend 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 as a result of transportation improvements (e.g., induced development in areas with new or expanded road service and potential related VMT increases). 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

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

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. 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.

- Carbon sequestration effects are not considered. Existing tools for transportation project or program analysis do not address GHG emissions related to potential direct and indirect impacts from transportation improvements on natural features that currently serve as "carbon sinks," such as wetlands, forests, grasslands, and other vegetation.

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 as well as mode for direct and electricity generation emissions. Table 4.2 displays emissions by source and mode as a percentage of the total emissions for each scenario. Emissions from direct vehicle operations and electricity generation were about 42 million metric tons in 2015, projected to decline to just under 22 MMT in 2040. Including construction, maintenance, and upstream emissions, total emissions are estimated to be nearly 53 MMT in 2015, declining to 27 MMT in 2040. Compared to the 2040 no-build scenario, the 2040 build scenario shows a decrease of about 16,000 tons in direct + electricity emissions and a decrease of 6,000 tons of upstream fuel emissions; however, this is more than offset by an increase in average annual construction and maintenance emissions of 88,000 tons, yielding a net increase of 65,000 tons from all sources.

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. Implicit in this methodology is that latent demand does not effectively replace the VMT and associated emissions from on-road motor vehicles otherwise “lost” to mode shifting.

### Table 4.1 Summary of GHG Emissions (metric tons CO2e) by Source and Mode[1]

| Source by Mode | 2015 | 2040 No Build | 2040 Build | 2040 Build vs. No-Build |
|---|---|---|---|---|
| Onroad Mobile Sources—Direct and Electricity Generation Emissions | 41,130,953 | 20,962,510 | 20,901,622 | (60,888) |
| Onroad Transit Buses[2]—Direct and Electricity Generation Emissions | 92,246 | 21,978 | 29,907 | 7,929 |
| Urban Heavy Rail and Light Rail—Direct and Electricity Generation Emissions | 45,975 | 14,392 | 16,611 | 2,219 |
| Intercity Passenger Rail—Direct and Electricity Generation Emissions | 54,384 | 54,421 | 70,185 | 15,764 |
| Freight Rail—Direct and Electricity Generation Emissions | 575,000 | 570,000 | 588,482 | 18,482 |
| **Subtotal, Direct + Electricity** | **41,898,559** | **21,623,301** | **21,606,807** | **(16,494)** |
| Construction and Maintenance | 1,034,391 | 1,034,391 | 1,122,065 | 87,674 |
| **Subtotal, Including Construction and Maintenance** | **42,932,950** | **22,657,693** | **22,728,872** | **71,179** |
| Upstream Fuel Emissions (Gasoline, Diesel, CNG) | 9,806,500 | 4,509,718 | 4,503,680 | (6,038) |
| **Total Including Upstream, Construction, and Maintenance** | **52,739,450** | **27,167,411** | **27,232,552** | **65,141** |

1 Note that emissions in are reported here in metric tons. Care should be taken to apply the appropriate conversion factor when comparing results to inventories developed using U.S. or short tons (1.102 short tons per metric ton).

2 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 Source and Mode

| Source and Mode | 2015 | 2040 No Build | 2040 Build |
|---|---|---|---|
| Onroad Mobile Sources—Direct and Electricity Generation Emissions | 78.0% | 77.2% | 76.8% |
| Onroad Transit Buses[1]—Direct and Electricity Generation Emissions | 0.2% | 0.1% | 0.1% |
| Urban Heavy Rail and Light Rail—Direct and Electricity Generation Emissions | 0.1% | 0.1% | 0.1% |
| Intercity Passenger Rail—Direct and Electricity Generation Emissions | 0.1% | 0.2% | 0.3% |
| Freight Rail—Direct and Electricity Generation Emissions | 1.1% | 2.1% | 2.2% |
| **Subtotal, Direct + Electricity** | **79.4%** | **79.6%** | **79.3%** |
| Construction and Maintenance | 2.0% | 3.8% | 4.1% |
| **Subtotal, Including Construction and Maintenance** | **81.4%** | **83.4%** | **83.5%** |
| Upstream Fuel Emissions (Gasoline, Diesel, CNG) | 18.6% | 16.6% | 16.5% |
| **Total Including Upstream, Construction, and Maintenance** | **100.0%** | **100.0%** | **100.0%** |

1 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.

Across all scenarios, over three-quarters of emissions originate from on-road mobile sources, with transit and rail emissions representing 1.5 to 2.7 percent of emissions, and construction and maintenance representing between 2 and 4 percent of emissions.[32] Upstream fuel-cycle emissions from gasoline and diesel represent between 16 and 19 percent of total emissions across all scenarios.

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. There is a small (7,100 metric tons 0.03 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 is not fully sensitive to the effects of build projects related to congestion relief, mode shifting, or induced demand, as discussed in Section 3.0.

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, truck, and potentially air travel)[33] as a result of planned transit and rail investments. Since the reduction in displaced auto and truck GHG is larger than the increase in transit and rail GHG, these projects result in a small net decrease in emissions of 9,400 metric tons or 0.04 percent on a statewide basis. The components of the decrease reflected in the "transit and rail build projects" line are shown below the summary line and include new transit and rail service, displaced auto and truck emissions from mode shifting, indirect land use effects, and congestion relief effects.

32 The share of emissions attributed to construction and maintenance appears to increase in the future as the total amount of those emissions remains constant, but emissions from highway vehicles decline. It is likely that emissions per unit of construction or maintenance activity would also decline in the future, but those declines are not projected in the model used in this analysis.

33 One study reviewed—for the DC2RVA intercity rail project—included mode shifting from air as well as automobile. Air emissions are not included in this inventory or forecast. Additional rail travel increased emissions slightly more than the reduction in emissions from diverted auto travel, but the additional consideration of diverted air travel yielded a net decrease in emissions considering average emissions per passenger-mile by mode. Whether this project appears to increase or decrease emissions therefore depends on the accounting framework.

## Table 4.3 Net Effects of Modal Projects[1]

| Project Type | Net GHG Change | % of 2040 No-build |
|---|---|---|
| Highway Build Projects | (7,102) | -0.03% |
| Transit and Rail Build Projects | (9,392) | -0.04% |
| Emissions from new bus service | 7,929 | – |
| Displaced auto emissions from new bus service: Mode shift | (3,484) | – |
| Displaced auto emissions from new bus service: Land use effects | (7,937) | – |
| Displaced auto emissions from new bus service: Congestion relief effects | (10) | – |
| Emissions from new light and heavy rail service | 2,219 | – |
| Displaced auto emissions from new light and heavy rail service[2] | (4,338) | – |
| Emissions from new commuter and intercity passenger rail service | 31,528 | – |
| Displaced auto emissions from new commuter and intercity passenger rail service | (28,719) | – |
| Emissions from new freight rail service | 2,718 | – |
| Displaced truck emissions from new freight passenger rail service | (9,299) | – |

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

2 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 shows emissions by fuel type and scope, including direct, upstream fuel-cycle, and electricity generation emissions. The construction and maintenance emissions represent a combination of all three of those sources, which are not broken out by the tool used to produce these estimates. Electricity generation emissions are small in 2015 but become more significant in 2040 (nearly 2 MMT) when they add about 10 percent to the direct emissions total of 20 MMT or 8 percent to the combined direct and fuel cycle emissions from conventional fuels of 24 MMT. This is still a relatively small contribution given that EVs are projected to represent 57 percent of light-duty VMT and 53 percent of all vehicle VMT in 2040. The small contribution assumes that electricity generation emissions become much cleaner as they continue to decline on a trajectory to meet net zero emissions by 2050.

## Table 4.4 Emissions by Fuel Type and Scope

*Metric Tons*

| Fuel Type and Scope | 2015 | 2040 No Build | 2040 Build |
|---|---|---|---|
| Gasoline, Diesel, CNG—Direct | 41,852,583 | 19,729,914 | 19,708,095 |
| Gasoline, Diesel, CNG—Upstream | 9,806,500 | 4,509,718 | 4,503,680 |
| Electricity Generation | 45,975 | 1,893,388 | 1,898,712 |
| Construction and Maintenance | 1,034,391 | 1,034,391 | 1,122,065 |
| Total, All Fuel Types | 52,739,450 | 27,167,411 | 27,232,552 |

Table 4.5 and Table 4.6, compare the change in VMT, roadway lane miles, and emissions for all sources across the three different scenarios (2040 no-build vs. 2015, 2040 build vs. 2015, and 2040 build vs. 2040 no-build). Compared to 2015, both 2040 scenarios show a total decrease in emissions of nearly 50 percent. With VMT projected to increase by nearly 20 percent under both 2040 scenarios, the decrease in emissions can be attributed to widespread adoption of electric vehicles in the light duty fleet and 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 buses.

Comparing the 2040 build scenario with the no-build scenario, VMT increases by 0.1 percent compared to an increase in lane-miles of 0.8 percent. Total emissions from all sources are marginally higher (roughly 0.3 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 (although latent demand—which was not assessed in the methodology used here—could offset this decrease.) Transit and rail emissions are higher due to expanded service and new projects. Additionally, under the 2040 build scenario, emissions relating to new project construction and maintenance cause average annual construction and maintenance emissions to increase by roughly 8.5 percent compared to the no-build scenario, increasing total emissions by 0.32 percent.

The GHG changes from highway vehicles for the 2040 build vs. no-build scenario are driven by changes in travel speeds from reduced congestion, as well as changes in VMT that result from changes in route choice or other travel parameters considered in the model.

### Table 4.5 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)[1] | 77,741 | 92,660 | 92,725 | 14,918 | 14,984 | 65.3 |
| VMT (medium and heavy truck) (millions)[1] | 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 |

[1] 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 Table 4.1 and Table 4.2, where bus emissions are subtracted from on-road mobile source emissions.

## Table 4.6 Key Indicator Change Between Scenarios

*Percent Change*

| Source | No-build vs. 2015 | Build vs. 2015 | Build vs. No-build |
|---|---|---|---|
| Vehicle Miles Traveled[1] | 19.6% | 19.7%[a] | 0.1%[1] |
| Lane Miles | 0.0% | 0.8% | 0.8% |
| Transit Trips | 0% | 28.0% | 28.0% |
| Intercity Rail Passenger-Miles | 19% | 75.0% | 47.0% |
| Change in Emissions by Source—On-Road Mobile Sources (excluding transit buses)[2] | -49.0% | -49.2% | -0.3% |
| Change in Emissions by Source—On-road Transit (buses) | -76.2% | -67.6% | 36.1% |
| Change in Emissions by Source—Urban Heavy Rail and Light Rail | -68.7% | -63.9% | 15.4% |
| Change in Emissions by Source—Intercity Passenger Rail | 0.1% | 29.1% | 29.0% |
| Change in Emissions by Source—Freight Rail | -0.9% | 2.3% | 3.2% |
| Change in Emissions by Source—Construction and Maintenance | 0.0% | 8.5% | 8.5% |
| **Total Emissions (All Sources)** | **-47.2%** | **-47.1%** | **0.3%** |

[1] 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 Table 4.1 and Table 4.2, and the "change in emissions by source" line, where bus emissions are subtracted from on-road mobile source emissions.

[2] The methodology used here did not account for latent demand, which could effectively offset the decrease in VMT and emissions attributed to on-road mobile sources for mode shifting to rail and transit.

# 5.0 Hypothetical Major Project Amendments

In addition to the statewide 2040 build/no-build comparison, GHG emissions changes were compared in 2040 for the "project" vs. "no-project" situation for two hypothetical major projects:

- Widening approximately 36 miles of a heavily-traveled Interstate highway; and
- Making passenger and freight rail upgrades to support faster and more frequent service in a major rail corridor.

The purpose of these assessments was 1) to identify the approximate upper bound magnitude of GHG emissions changes that might be expected from any one particular project; 2) to compare the magnitude of direct, upstream, and construction and maintenance emissions from individual projects; and 3) to test the utility of the methods applied for the statewide analysis to evaluate the impacts of individual projects.

## 5.1 Highway Widening

This hypothetical project involves the addition of one lane in each direction to approximately 36 miles of the heavily-traveled and congested Interstate 95 (I-95) between Springfield and Fredericksburg. To model this project, roadway links in the statewide model corresponding to this highway section were coded with a capacity increase corresponding to one additional travel lane, compared to the 2040 no-build network.

For context, the percent changes in VMT and emissions from the no-build to the build scenario may reasonably be expected to be comparable to the percent change in lane-miles for a high demand corridor like I-95, as the additional capacity would be heavily utilized during peak periods. Therefore, if the modeled percent changes in VMT and emissions are very small for a major project like widening I-95 compared to the statewide VMT and emissions, but are still in line with the percent change in lane-miles, it is reasonable to conclude that the effect on statewide lane miles, VMT and GHG of any one project, even a major project, would be very small.

In this case, the model run showed no meaningful changes in traffic volumes or speeds as a result of the project. The convergence criteria for the model showed that any changes from the new project run were less than the "noise" for such a large network. Therefore, any difference in VMT with and without the project could not be measured. Similar results might be therefore expected when applying the statewide model to any single project, even a major project, where the effect of the project is very small relative to overall conditions on the statewide network.

## 5.2 Rail Corridor Upgrades

The Washington, D.C. to Richmond, Virginia (DC2RVA) intercity rail project was used as the sample rail corridor project, since GHG impacts of this project were already evaluated in support of the environmental impact statement[34] for this project.

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34 U.S. Department of Transportation, Federal Railroad Administration and Virginia Department of Rail and Public Transportation (2019). DC to Richmond Southeast High Speed Rail: Tier II Final Environmental Impact Statement and Final Section 4(F) Evaluation.

The DC2RVA project is a proposed passenger rail service and rail infrastructure project that spans 123 miles between Washington, D.C. and Richmond, Virginia. The project aims to increase intercity passenger train frequency, increase passenger train speeds from 80 mph to 90 mph, increase rail capacity through an additional track, and improve station areas and roadway crossings.

The preferred alternative for this project, as documented in the final EIS, would add nine new daily intercity passenger round trips (18 total trains per day) to the project corridor, resulting in an increase of up to 854,000 annual rail passenger trips to, from, and through the study corridor in 2025. Up to 2,050 vehicles per day and 250,000 daily vehicle miles (80 million annual VMT) would be removed from the parallel roads of I-95 and U.S. Route 1. The preferred alternative was projected to reduce GHG emissions by 6,518 tons of CO2 per year in 2045 compared to the no-build alternative. This reduction includes reduced air travel. If air travel were excluded (consistent with the boundaries of this statewide analysis), there would be a very small increase in emissions from the net of increased rail and decreased automobile emissions.

According to the project's environmental documentation, emissions changes were calculated by first estimating changes in passenger rail ridership, as well as corresponding changes in automotive, bus, and air travel. Changes in passenger rail ridership were estimated using a nested logit model. A per-passenger mile emissions rate was applied to ridership for each mode to determine the change in emissions as a result of changes in travel behavior. The emission rates were taken from a 2008 American Bus Association (ABA) publication.[35] The EIS did not estimate any potential change in freight energy use as a result of the proposed corridor improvements. The EIS also did not assume any electrification of on-road vehicles.

The EIS also reported construction emissions. Using the FHWA Infrastructure Carbon Estimator, DRPT calculated GHG emissions from construction, estimating that 11,467 tons per year of CO2 would be generated from construction activities over a 25-year period.[36] In comparison, the EIS notes, in 2016, CO2 emissions from large facilities in counties along the DC2RVA corridor were 13.8 million tons (as reported to the U.S. EPA).[37] Therefore, CO2 emissions from DC2RVA construction would be less than 0.1 percent of the total CO2 emissions from large facilities in the DC2RVA corridor (and would be an even smaller percentage of total CO2 emissions for the Commonwealth). DRPT concluded that construction of the project would have a negligible impact on climate change due to GHG emissions.

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35 The 2008 ABA publication is no longer available and has since been superseded by a 2014 version which provides somewhat different modal estimates. See: American Bus Association (2014). Updated Comparison of Energy Use & CO2 Emissions From Different Transportation Modes. Prepared by M. J. Bradley & Associates.

36 This is the same tool used by the CS project team to estimate statewide construction emissions, but version 2.0 was not available at the time the EIS was prepared so version 1.0 would have been used.

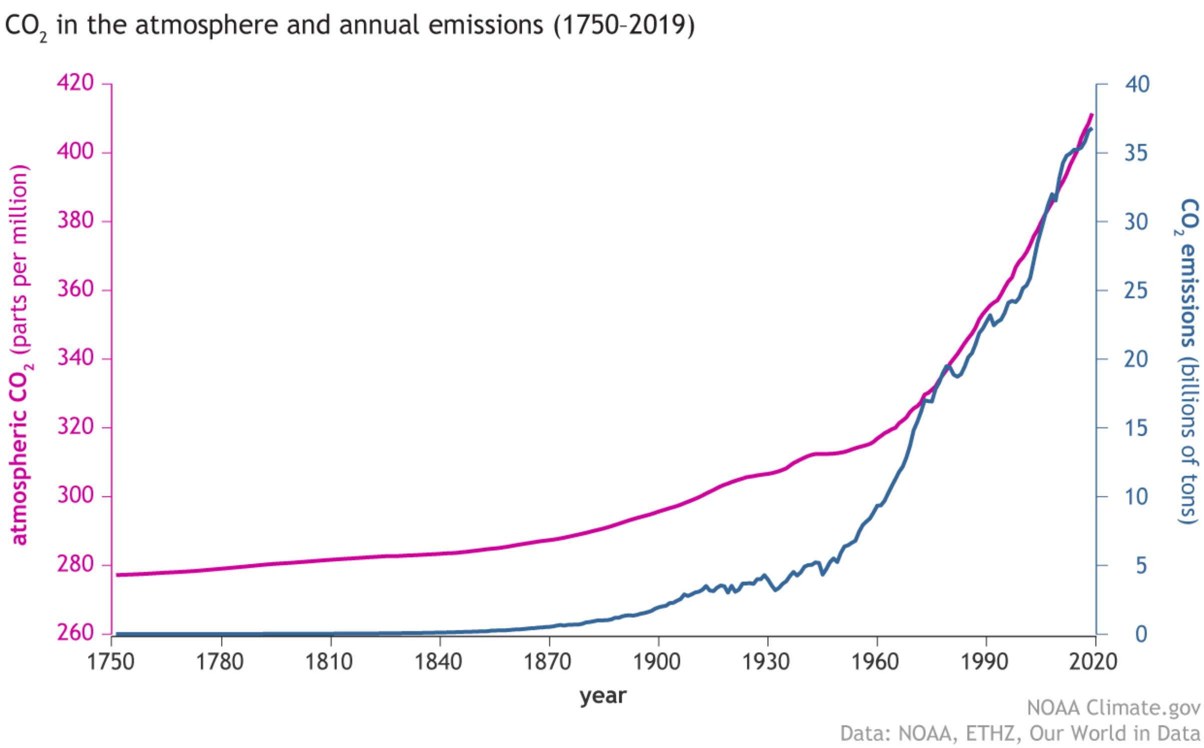
37 According to the EPA's Greenhouse Gas Reporting Program, large facilities typically are facilities that produce more than 25,000 MT CO2e per year, or supply of products would result in over 25,000 metric tons of CO2e emissions if those products were released, combusted, or oxidized. See https://www.epa.gov/ghgreporting/learn-about-greenhouse-gas-reporting-program-ghgrp for more information.

# 6.0 Climate Change Considerations Related to the Affected Environment

## 6.1 Overview of Global and National Climate Change Trends and Projections[38]

Greenhouse gas emissions have accumulated rapidly as the world has industrialized, with concentration of atmospheric $CO_2$ increasing from roughly 300 parts per million in 1900 to over 400 parts per million today (Figure 6.1). 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 6.2).

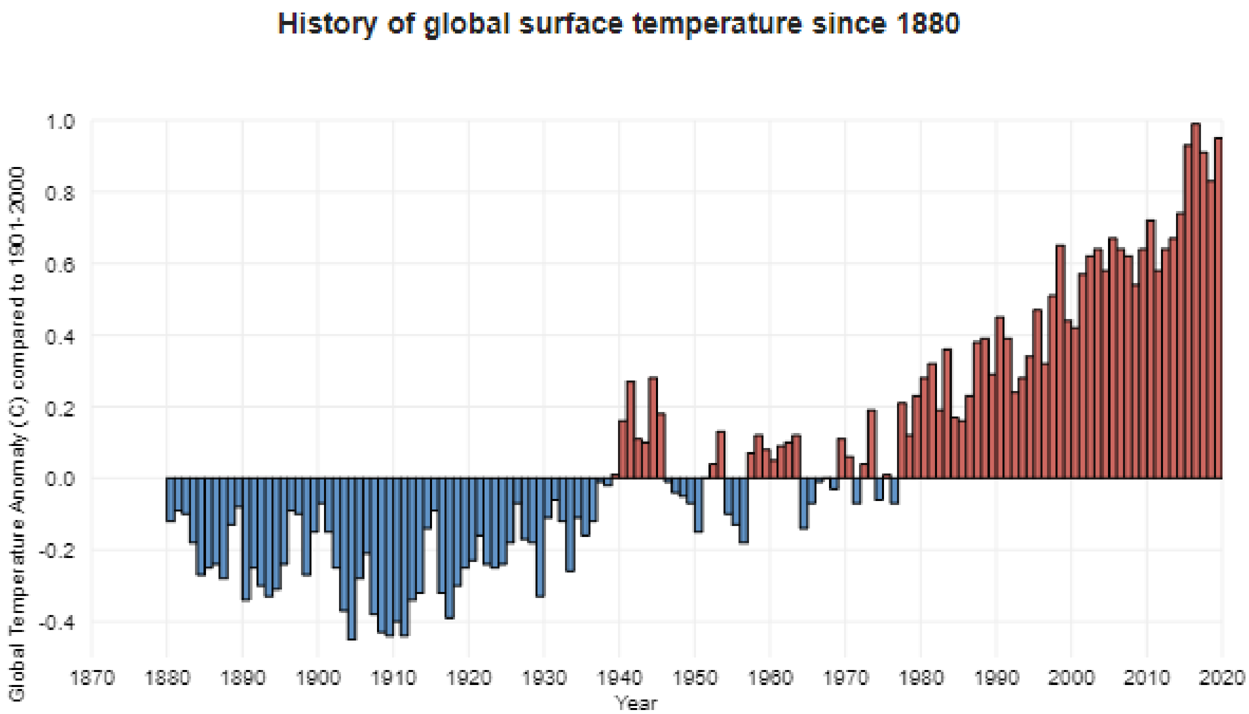
**Figure 6.1 Global Greenhouse Gas Trends**




Source: NOAA.

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

## Figure 6.2 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),[39] 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.[40] However, based on the IPCC assessment, holding temperature increases to below 2.0°C would require net zero $CO_2$ emissions by at least 2055 and significant reduction of non-$CO_2$ GHG emissions by at least 2030.

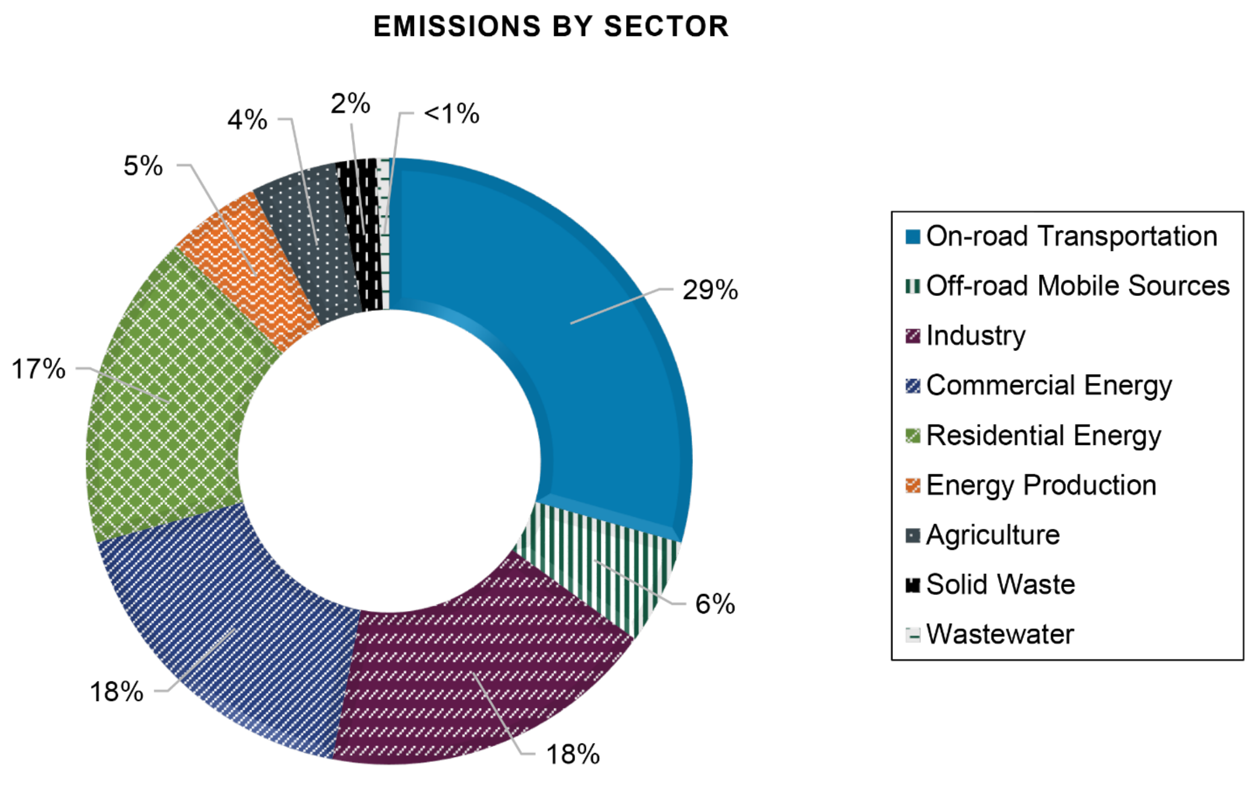
According to the Virginia DEQ's 2018 Greenhouse Gas Inventory, transportation is the largest source of greenhouse gas emissions, with on-road transportation representing 29 percent of emissions (Figure 6.3). In 2018, a total of 141 million metric tons of CO2e were emitted in the Commonwealth.[41]

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

40 Intergovernmental Panel on Climate Change (2018). Special Report: Global Warming of 1.5 ºC. https://www.ipcc.ch/sr15/.

41 Virginia Department of Environmental Quality (2018). Virginia Greenhouse Gas Inventory. https://www.deq.virginia.gov/air/greenhouse-gases.

### Figure 6.3 Sources of Greenhouse Gas Emissions in Virginia in 2018




Source: Virginia Department of Environmental Quality, Virginia Greenhouse Gas Inventory, 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 6.1.

### Table 6.1 Potential Transportation Infrastructure Impacts of Climate Change

| Climate Change | Potential Magnitude | Transportation Infrastructure Impacts |
|---|---|---|
| Sea level rise | 1'–8.2' by 2100 | Flooding and storm surge—<br>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<br>Need for evacuation routes |
| Excessive summer heat | +2.5–2.9 °F by mid century<br>+5.0–8.7 °F by late century | Pavement and rail integrity |
| Prolonged droughts | – | Lower water levels in rivers/shipping channels;<br>Wildfires—Road closures |

Source: USGCRP (2018).

## 6.2 Climate Change Risks to Virginia's Environment

Virginia's transportation infrastructure faces risks from a changing climate including coastal flooding, inland flooding, and extreme heat. Transportation infrastructure can also impact natural resiliency systems such as wetlands, forests, and floodplains.

### 6.2.1 Coastal Flooding

**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)*

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.[42] 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.[43] 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.[44] 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.[45] 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.[46]

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.[47]

Resiliency considerations in the planning and design of transportation infrastructure related to coastal flooding include: building new facilities or relocating existing facilities to areas with minimal risk to the facility; designing new infrastructure that is resilient to potential flooding impacts that could affect its scope, function, and/or performance; enhancing the design of existing infrastructure to increase its resilience to potential flooding impact; and designing facilities that work as part of a coordinated system of flood control measures to protect adjacent and nearby land uses.

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[42] 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.

[43] 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.

[44] 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.

[45] U.S. Global Climate Change Research program (2018). Fourth National Climate Assessment.

[46] Commonwealth of Virginia, Office of the Secretary of Transportation (2020). Vulnerability Assessment.

[47] 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.

### 6.2.2 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).[48] 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.[49]

***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).*

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.

Similar to coastal flooding, resiliency considerations in the planning and design of transportation infrastructure related to inland flooding include: building new facilities or relocating existing facilities to areas with minimal risk to the facility; designing new infrastructure that is resilient to potential flooding impacts that could affect its scope, function, and/or performance; enhancing the design of existing infrastructure to increase its resilience to potential flooding impacts; and designing facilities to minimize their contribution to flooding effects or to help mitigate rather than exacerbate these effects.

### 6.2.3 Extreme Heat

In Virginia, according to the NOAA National Centers for Environmental Information, average annual temperatures have increased by roughly 1.5º F since the beginning of the 20th century.[50] According to data retrieved from the NOAA National Climactic Data Center, daily summer high temperatures as recorded at Richmond International Airport are now 3°F higher on average than they were in the 1960s.[51] 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.[52]

***Transportation Risk: 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).*

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

49 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.

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

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

52 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.

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. Extreme heat combined with drought conditions can also increase the risk of wildfires. Pavements may also contribute to heat island effects in urban locations.

Resiliency considerations in the planning and design of transportation infrastructure related to extreme include: designing pavements and structures to withstand potential levels of extreme heat; measures to protect worker and public safety during heat waves; and using materials or coatings that can minimize contributions to heat island effects.[53]

### 6.2.4 Resiliency Systems

Transportation infrastructure can affect natural resiliency features such as wetlands, forests, and floodplains through direct takings or through indirect effects such as water runoff. Some Federal and state laws and regulations exist to help protect these features, particularly wetlands. For example, Section 404 of the Federal Clean Water Act regulates certain activities that occur in wetlands including dredging, filling, and discharges. The Virginia Water Protection permit program, administered by the DEQ, also regulates activities impacting surface waters such as land clearing, dredging, filling, excavating, draining, or ditching in open water, streams and wetlands. Additional impacts that may need to be considered in the design of infrastructure include loss of forests or other vegetative cover that sequesters carbon, loss of critical wildlife habitat or ecosystem connectivity, and changes in impervious surface or drainage that may increase runoff and flooding risks. These impacts may be mitigated directly through project design considerations, or, if needed, through offsets (e.g., forest or wetland reconstruction in other locations).

[53] Georgetown Climate Center (2012). “Adapting to Urban Heat: A Tool Kit for Local Governments.” https://www.georgetownclimate.org/files/report/Urban%20Heat%20Toolkit_9.6.pdf.

# 7.0 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 7.1 shows the projects listed in VDOT's Smart Scale database; Table 7.2 shows major public-private partnership projects; and Table 7.3 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 7.1 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 Road |
| 18003 | Route 277 Widening and Access Management |
| 69050 | U.S. 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. |

| UPC | Project Title |
|---|---|
| 115241 | Jefferson Ave & Oyster Point Rd Intersection Improvements |
| 115244 | Virginia Beach Blvd Widening—George St to Newtown Rd |
| 115245 | General Booth Blvd/Oceana Blvd Intersection Improvements |
| 115414 | Jude's Ferry Road & Route 60 |
| 115477 | U.S. 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 | U.S. 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 |

| UPC | Project Title |
|---|---|
| 109314 | Nike Park Road Extension from Reynolds Drive to U.S. 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 |
| 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 7.2 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 7.3 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 |

| UPC | Description |
|---|---|
| 11314 | RTE 58—CORRIDOR DEVELOPMENT PROJECT—DEVELOP TO 4 LANES |
| 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 STEVENSBURG 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 |

| UPC | Description |
|---|---|
| 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 |
| 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 DEVELPMENT PROG—4 LANES |
| 17537 | RTE 58—CORRIDOR DEVELOPMENT PROG—4 LANES |

| UPC | Description |
|---|---|
| 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 |
| 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 |

| UPC | Description |
|---|---|
| 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 |
| 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 |

| UPC | Description |
|---|---|
| 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 |
| 78767 | MILNWOOD ROAD—WIDENING AND ADDING SIDEWALKS |
| 78826 | WESTBOUND ACCEL/DECEL LANE FROM GEOMASON 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—REHABILIATE 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 stuc 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 Boulevard PH2 CN Shared Use Path-RVSH 08 |

| UPC | Description |
|---|---|
| 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 |
| 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 Avenue (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 |

| UPC | Description |
|---|---|
| 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 |
| 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 |

| UPC | Description |
|---|---|
| 103072 | Victory Boulevard (Route 171) Multi-Use Path |
| 103073 | U.S. 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 U.S. 29 TO U.S. 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 |
| 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 |

| UPC | Description |
|---|---|
| 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 |
| 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) |

| UPC | Description |
|---|---|
| 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) |
| 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) |

| UPC | Description |
|---|---|
| 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 DEVELPMENT 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 |
| 9783 | RTE 13—8 LANES |