The Value of Metrorail and Virginia Railway Express to the Commonwealth of Virginia

Technical Memorandum

NORTHERN VIRGINIA TRANSPORTATION COMMISSION

THE VOICE OF TRANSIT IN NORTHERN VIRGINIA

January
2018

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THE VOICE OF TRANSIT IN NORTHERN VIRGINIA

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EXECUTIVE SUMMARY

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MAJOR FINDINGS

Long credited with fueling economic development in Northern Virginia, Metrorail and Virginia Railway Express (VRE) also provide financial benefits to the state. The additional 85,000 households and 130,500 jobs that the two rail systems make possible in Northern Virginia generate over $600 million each year in sales and income tax revenues that flow to Richmond. For every dollar the state invests in Metrorail and VRE, it receives $2.50 in return. $600 million, or just over 3 percent of general fund revenues, is significant. It is equivalent to Virginia's annual general fund expenditures on state colleges and universities, around $316 million, and state police, about $266 million.

METHODOLOGY

To quantify the value that Metrorail and VRE bring to the Commonwealth of Virginia, NVTC took the current traffic and development in the region, removed Metrorail and VRE from the picture, then moved development out of Northern Virginia to the District of Columbia or Maryland until traffic models showed a return to current levels of peak-period congestion.

Based on the number of jobs and homes moved across the Potomac River, NVTC then estimated how much less the commonwealth would take in from income taxes and the portion of the sales tax that goes directly to the state's general fund.

Part of what distinguishes this study from earlier ones is that it is dynamic, accounting for the level of activity that the regional transportation network can support. NVTC's approach is unique in that it evaluates the interaction between land use and transportation demand.

COROLLARY FINDINGS

The results of the first runs of the transportation model, which removed rail transit in Northern Virginia and held to the existing land use totals, demonstrate rail's importance for commuters in Northern Virginia. With the added congestion, commuters could not travel as far in the same amount of time. Their trip length decreased by about 5 percent, which is significant.

The impacts associated with a lack of rail transit in Northern Virginia are:

- 56,500 more lane miles of congestion on arterial roadways;
- 50 percent fewer transit trips in the peak period;
- 80 percent decrease in jobs accessible by transit for Northern Virginia households; and
- 130,000 fewer transit trips each weekday.

Commuters Riding Transit		
Jurisdiction	**Existing**	**Existing without Rail Modes**
Arlington	49%	28%
Alexandria	38%	24%
Fairfax	17%	6%
Loudoun	4%	2%
Prince William	5%	3%
Northern Virginia Total	18%	8%

Source: Transportation Planning Board V2.3.66 Travel Demand Forecast Model

STUDY SUPPORT

NVTC's report was informed by the expert opinions of others. NVTC engaged its peers in the transportation community in a comprehensive technical review of the study's methodology and assumptions. These groups considered the work plan, technical approach, and findings, and provided comments on the study.

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TECHNICAL MEMORANDUM

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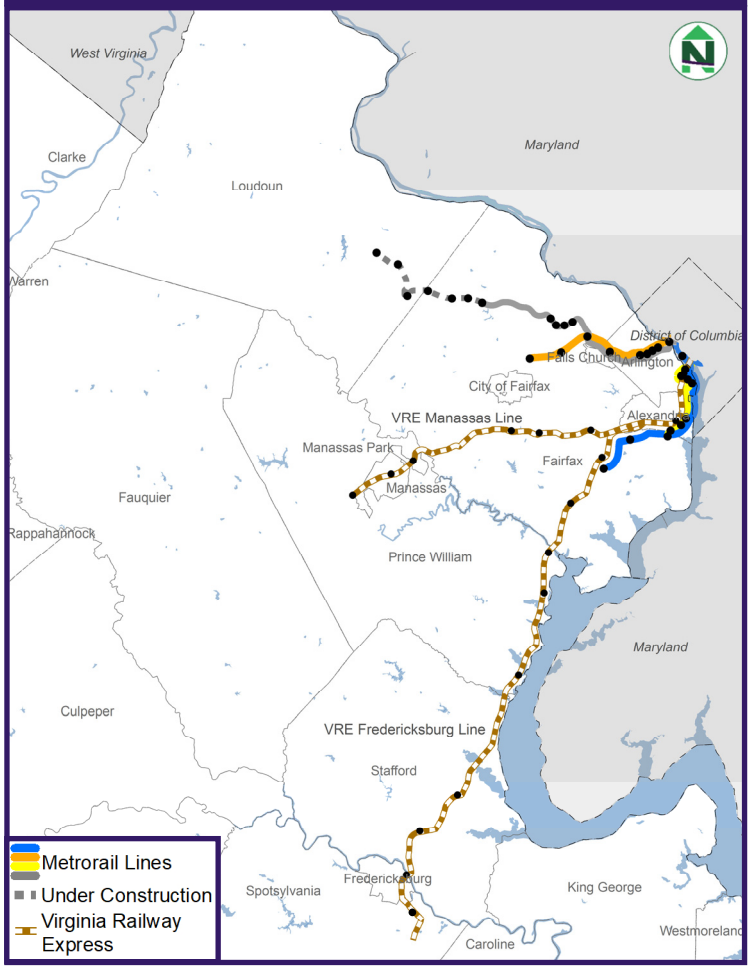
1. INTRODUCTION

Northern Virginia is served by two high capacity transit modes, Metrorail and the Virginia Railway Express (VRE). Metrorail is classified as heavy or urban rail, while VRE is considered commuter rail. VRE is Virginia's only commuter rail system. Metrorail operates throughout the day and stations are relatively close together, between a half mile to a couple of miles apart depending on the density of land development. VRE stations are typically farther apart and service is mainly in the peak direction during commuter travel times. There are a few midday trains.

Metrorail and VRE are the backbone of Northern Virginia's transit system. They move over 290,000 people on an average weekday in Northern Virginia. The National Transit Database lists Metrorail as having approximately 210 directional route miles, of which approximately 37 percent of those miles are in Northern Virginia. There are 91 Metro stations in the greater metropolitan region, 25 of which are in Northern Virginia. VRE operates on 160 directional route miles, serving 17 stations in Virginia. Figure 1-1 is a map showing the high capacity transit modes in Northern Virginia.

Figure 1-1 Metrorail and VRE Service in Northern Virginia



These systems get people to work, help create thriving communities and relieve congestion on roadways. They also support economic development across Northern Virginia. Higher density development clustered around rail stations produces property tax and other revenues that help fund schools, parks, and a range of public services in our communities. Metrorail and VRE also produce significant revenues for the Commonwealth of Virginia. Currently, both Metrorail and VRE have a need for greater capital and operating funding. Decision makers at both the state and local levels need to understand the financial benefits that these systems generate. Given this need, the chairman of the Northern Virginia Transportation Commission (NVTC) requested that staff evaluate the economic value of high capacity transit in Northern Virginia at the state level. The objective of this effort was to quantify how these two high capacity modes financially benefit the commonwealth.

The local economic value of high capacity transit is well studied. This effort differed from previous work in that it looked beyond property tax revenue, which benefit the local jurisdictions. This analysis focused on those revenues that impact the state. In coordination with the Washington Metropolitan Area Transit Authority (WMATA), NVTC assessed the interaction between high capacity transit and the existing

land development that it supports. The objective of the analysis was to quantify the value and worth that high capacity transit operating in Northern Virginia generates in terms of state tax revenues from the land development that these transit modes supports.

To perform this analysis, NVTC used the regional travel demand forecast model to determine the amount of land use and development that could be supported with only the current highway and bus networks. The existing level of highway congestion was quantified and defined as the base scenario. With the base scenario defined, the travel demand model was applied without Metrorail and VRE included in the transportation network. Through an iterative process, land use, both residential and business, was removed until the same level of congestion that existed in the base scenario was reached. Given the dynamics of the modeling process, the regional land use totals were required to be held constant. For the purposes of this exercise, the jobs and households that needed to be removed from Northern Virginia were redistributed to other jurisdictions in the region outside of Virginia. The level of congestion was measured in terms of congested lane miles during the peak period as well as the average commuter trip length distance.

WMATA did a similar study in 2011, but focused on how much additional highway infrastructure would be needed to handle demand if all transit were removed from the network in the entire metropolitan region. This study complements that effort by evaluating the reductions that would be required in land activity and intensity of development. This analysis only removed high capacity transit modes in Northern Virginia. Metrorail remained in the network in Maryland and the District of Columbia, and all existing bus service was included in the model network.

NVTC coordinated with local jurisdictional staff and performed the study in cooperation with WMATA planning staff. Few studies have examined the land use impacts of high capacity transit modes on the economy at the state level. This effort is unique because, not only did it look at the balance of land use and the transportation network, it applied a travel demand forecast model to run scenarios and evaluate policies and economic impacts.

As part of the technical approach, NVTC coordinated with other organizations in the region, as well as a leading consultant in the field. NVTC worked closely with WMATA staff to develop the objectives and goals of the study. WMATA staff also provided review and comment on the technical approach. NVTC worked with WMATA's director of strategic planning in its Office of Long Range Planning and the project manager for the 2011 study that evaluated the impact of transit in the region.

NVTC coordinated its technical approach with and presented its results to modeling staff at the Metropolitan Washington Council of Government's (MWCOG) Transportation Planning Board (TPB). NVTC worked with the director of travel forecasting and his staff to ensure the approach was sound and results were plausible. NVTC staff met several times with MWCOG staff and provided answers to technical questions on the approach and results.

NVTC also reached out to George Mason University's Center for Regional Analysis. Faculty there reviewed the scope and work plan at the beginning of the project. NVTC later coordinated and requested that the Federal Transit Administration's (FTA) lead technical staff review the scope and approach. Transportation specialists in FTA's Office of Planning facilitated review and discussion of NVTC's work with senior technical experts in the Office of Planning.

Over-the-shoulder advice and technical assistance was provided by a nationally recognized expert, Frank Spielberg, PE. Mr. Spielberg has more than 45 years of experience in traffic engineering and transportation planning with an emphasis on public transportation and travel forecasting. He served as chair of the Bus Transit Systems Committee of the National Academy of Sciences' (NAS) Transportation Research Board (TRB) from 2003 to 2009. During his career, he developed and applied travel demand models for transit investment studies in over a dozen cities. In his work as a consultant to the FTA's Office of Planning and Environment, he reviewed New Starts applications and developed the initial guidance for conducting the Congressionally mandated before and after studies. He has conducted transit planning and operational studies throughout the United States in both urban and rural areas.

NVTC reached out to these organizations and individuals to ensure a sound study approach and work plan. The objective was not to get immediate buy-in or approval of the approach, but to generate questions and discussion. The objective of this study was to provide a reasonable assessment of the value of high capacity transit in Northern Virginia in terms of benefits at the state level. The purpose of the coordination was to ensure a sound and creditable approach. NVTC believes that it had a technically sound approach and followed state-of-practice procedures.

The following highlights the analysis and approach:

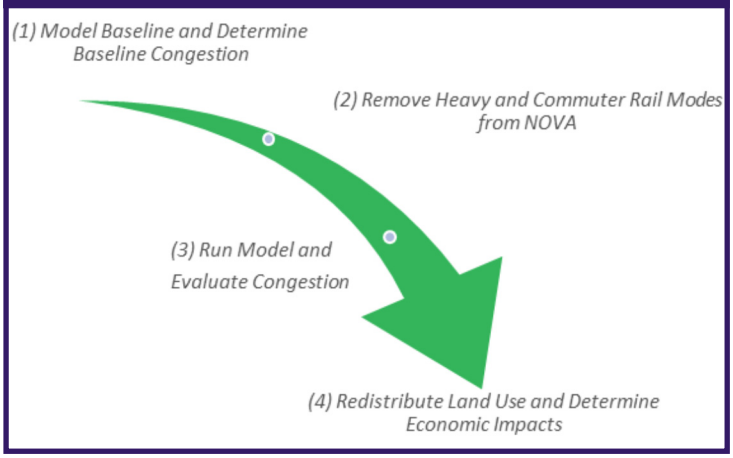
- The goal of the effort was to evaluate the economic value of high capacity transit in Northern Virginia to the commonwealth.
- NVTC focused on how to quantify the value and worth that commuter and heavy rail operating in Northern Virginia brings to the commonwealth.
- This study differed from previous and current work as it looks beyond property tax revenue and emphasizes only those revenues that go directly to the commonwealth.
- NVTC's approach was different than current and past studies because it applied the regional travel demand forecast model to evaluate the network and land use impacts.
- NVTC worked with WMATA planning staff on this effort. This study complements previous work that WMATA did in 2011 that focused on the highway infrastructure needs were there no transit in the region.
- This study built on previous work NVTC did in 1994 and 2005 that showed the economic impacts of heavy rail on regional development.
- While NVTC approached the issues from a different vantage point by evaluating the direct impacts on the transportation system and the interaction between land use and transportation demand, the analysis built on past efforts and studies and coordinated with other ongoing studies at the state and regional level.

2. METHODOLOGY

Overview

This analysis focused on the interaction and balancing of land use and the transportation network. It evaluated how the transportation system responds to network and land use changes. The methodology and approach were based on the concept that commuters have a travel time budget that influences their travel choices in terms of destination and mode. Figure 2-1 provides a schematic overview of the modeling approach applied as part of this analysis. The analysis measured the existing conditions or baseline, and then removed critical elements in the network and measured the impacts. Then the other key input to the modeling process, land use, was

Figure 2-1 Overview Modeling Approach



reduced until the network returned to baseline conditions. The land use was in terms of number of households and jobs. Lost revenue at the state level for these households and jobs was calculated. The result was the total state revenue lost if high capacity transit was not operating in Northern Virginia.

The modeling process requires that land use totals for jobs and households remain constant. The model balances the productions and attractions, both of which are a function of land use. The redistribution of land use was an iterative process and a function of the commuter or home-based work trip length. Commuter trips have the greatest impact on congestion because these trips cover the longest distances and are not discretionary as compared to shopping or recreational trips. Therefore, the focus of this analysis was on these home-based work trips and the morning peak period.

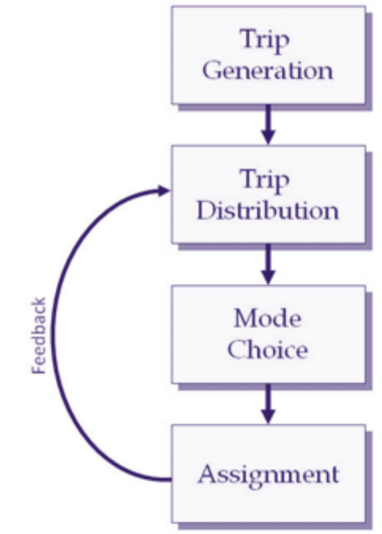
Research has shown and travel demand forecast models are developed around the fact that that for each traveler there is a travel time distribution. This distribution defines a travel time budget for each trip by purpose. The travel time distribution is constant and does not change in the modeling process. It is developed based on survey data. Surveys have shown that in older, mature metropolitan regions the travel time distribution changes little over time. What does change is the distance that can be covered in that time, which is a function of congestion. For this analysis, the average commuter or home-based work trip length was the primary metric in determining the amount of housing and employment to be redistributed. A secondary metric, highway congested lane miles in the morning peak period, was compared by highway facility type.

Modeling

This study used a travel demand forecast model to determine the impacts of the network and land use changes. Travel demand forecast tools with differing levels of complexity and depth are used in the transportation planning process, based on the level and need of the study. This analysis covered a large area and the impacts were regional. Therefore, a travel demand forecast model was used as the primary tool in the analysis. A travel demand forecast model is a series of mathematical relationships linked together in a sequential process that calculates expected travel patterns based on a given land use and transportation system. Changes to land use patterns or the transportation system are reflected in the travel patterns forecasted by the travel demand forecast model. The basic steps in the modeling process answer the following questions:

- Trip Generation: How much travel occurs (and why)?
- Trip Distribution: Where does travel occur?
- Mode Choice: What modes (e.g., automobile, transit, etc.) will be used?
- Trip Assignment: Which path or route is used?

Figure 2-2 Travel Demand Forecasting Model Chain



These questions form a serial process that outlines the general structure of the travel demand forecast model. Though they apply to all levels of transportation planning studies, the application and simplicity of how these elements are determined vary by level of study. Determining how much and where travel occurs is basic to all transportation planning studies. Mode choice addresses the important question of what transportation mode people use, although many lower-level transportation planning studies focus solely on automobiles. The final question of determining the path taken for each trip is important at all levels of the transportation planning process, whether the whole path is traced across a region or a shorter path is traced from exiting a parking lot to the first major signalized intersection.

By answering these questions, travel demand forecast models can estimate traffic levels on roadways and transit systems. In every level of transportation planning study, the impacts are quantified using some type of measure of effectiveness (MOE). The MOE used will depend on the type and scale of the study, desired outcomes of the proposed strategies or projects, and computational capabilities of the selected mod-

eling tool. MOEs are typically used to compare the forecasts associated with different projects or scenarios to determine which will have the best effect on future travel conditions. Common MOEs are volume-to-capacity ratios on roadways, vehicle miles traveled by facility, and mode share. For this study, the focus was on home-based work trip length, and morning peak period congested highway lane miles. Ancillary metrics for this analysis included change in mode share and the number of jobs accessible by transit within defined travel times.

The specific model used for this study was the MWCOG/TPB Version 2.3.66 travel demand forecast model. This is a four-step trip end model. It has five feedback loops and requires a substantial amount of time to complete a run. The model area covers 6,800 square miles and includes 22 of the region's primary jurisdictions spanning the District of Columbia, Northern Virginia, suburban Maryland, and one county in West Virginia. The modeled study area extends well beyond the current TPB member area, which includes 10 of the 22 primary jurisdictions. The TPB member portion of the modeled area is about 3,500 square miles in size or about one half of the modeled study area.

The MWCOG/TPB travel forecasting model requires input data that describe the physical features and operating policies of the region's transportation infrastructure. These data are collectively known as transportation networks. The input networks are used in the travel model to formulate impedances (travel times and costs) between origins and destinations. The model uses these impedances as a basis for estimating the number of person trips that travel between origins and destinations and for allocating those person trips among motorized modes. The inputted land use for this analysis was the MWCOG Cooperative Land Use Forecast Round 9.0 and the networks were based on the fiscal year 2017 Constrained Long Range Plan. The study was only done for the existing year, so the importance of the land use forecast did not play a major role in the findings, but NVTC wanted to use the most recent dataset for the analysis.

Model Application

The first step in the process was to ensure that the model was adequately representing travel in the study area. For this exercise, the study area was determined to be all of the NVTC jurisdictions and Prince William County as well as the cities that are located within these counties' boundaries. Each of the specific sub-models were calibrated to replicate the results of the 2007/2008 Household Travel Survey. The dataset was supplemented with WMATA passenger survey data as well as Census data. The model chain was validated to a supplemental dataset and/or a subset that was held out of the original calibration data, as well as a dataset of transit boardings, and highway traffic counts. This was done at the regional level. To follow best practice, NVTC validated the model for the study area. The validation results are included in the appendices. NVTC found the model to be performing adequately for the defined study region using Federal Highway Administration (FHWA) guidelines.

The primary analysis was to determine the impacts of Metrorail in Northern Virginia. If Metrorail were not operating, it is expected that VRE would attract many of the trips that currently use Metrorail. The system would be overloaded, and the purpose of this analysis was to evaluate high capacity transit. VRE was therefore treated similar to Metrorail in this study. The bus network was not removed and all existing service at the current levels of operation were included in the baseline and test scenarios. The model does not explicitly have a capacity constraint on bus trips. It does have a capacity constraint on Metrorail trips. With the high capacity transit modes (i.e., rail modes) removed from the network in Northern Virginia, the bus network, as expected, was overloaded.

NVTC developed a bus capacity constraint for trips traveling into the higher activity areas in Arlington as well as all routes into Washington, D.C. from Virginia. The capacity was calculated at a macro level by determining the total bus capacity for the peak period. For purposes of this analysis a maximum capacity of 60 people per bus was assumed. Certain vehicles have higher or lower capacity, but this was determined to be the approximate average bus capacity for vehicles in Northern Virginia. For origin and destination pairs that exceeded the bus capacity, the surplus trips were added back into the auto trip tables. The constraint was only applied on the final iteration of the model, post mode choice. Given the limitations of the model structure this was determined to be the best method for addressing the issue. The number of trips

impacted by the bus constraint was small, but it was determined that that there needed to be some type of constraint on the bus trips. There were trips from Northern Virginia that did continue to use Metrorail. These trips would use the buses to access Metrorail outside of Virginia, or drive to Metro stations outside of Virginia. The determination of mode was done in the mode choice model and, even without Metrorail or VRE, some trips still used rail modes. There were no assumptions or manual manipulation of the trip tables other than the application of the bus constraint. The mode share results were a product of the choice models reflecting the travel impedances on the network.

Baseline Congestion Analysis

After the validation, development and testing of the bus constraint application were completed, a baseline model run was evaluated. The baseline run was the same as the final validation run. The baseline evaluation determined the values of the key metrics that guided the redistribution of the land use. The two-primary metrics were average home-based work trip length and lane miles of congested highway during the morning peak period by facility type. For reasonableness, the lane miles of congestion were also reviewed by jurisdiction.

Figure 2-3 shows the average trip length by jurisdiction for both home-based work and non-work trips. Non-work trips would include shopping, recreational, and other trip purposes, and are included as a reference point. The analysis focused on the commuter or home-based work trip. Even though the travel time distribution is approximately the same for each jurisdiction, the impacts of traffic congestion result in different trip lengths. For the inner jurisdictions where the land development is denser and congestion greater, the average trip length is shorter. In the outer jurisdictions, the trip length is approximately double, while the non-work lengths are relative equal. The non-work trips typically are very short and located close to the home end. These trips occur mostly out of the peak period and therefore are less subject to the impacts of heavy congestion. While the commuter or home-based work trip average trip length by jurisdiction ranges from 8 to 17 miles, the average for Northern Virginia is closer to 13.5 miles. It is important to stress that this is the average commuting trip length, where some trips are much farther and other trips are much shorter.

Figure 2-3 Average Trip Length

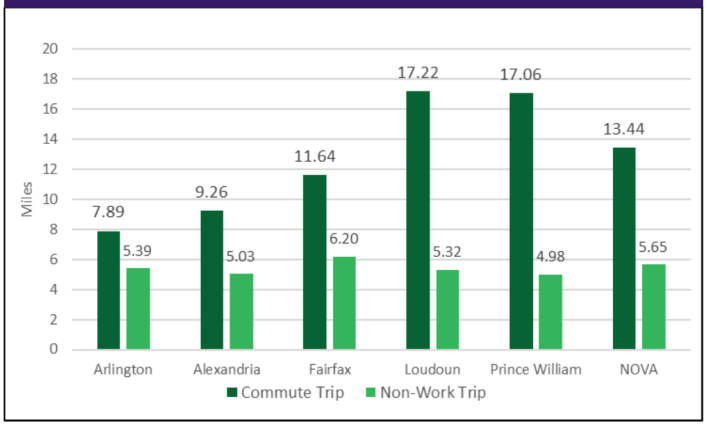
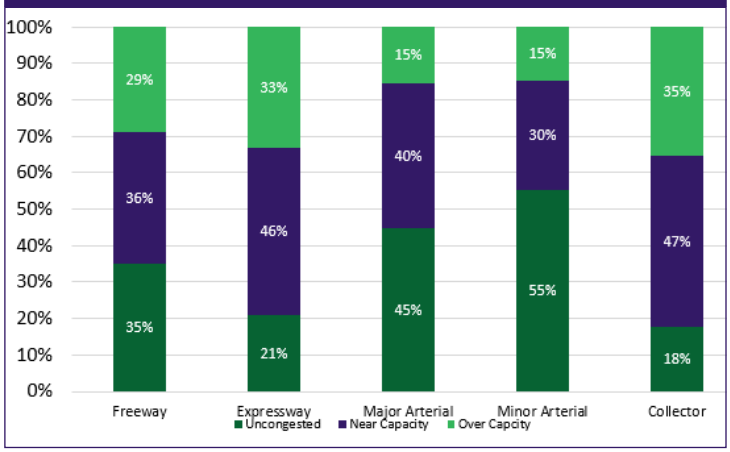


Figure 2-4 Northern Virginia Morning Peak Period Lane Miles of Congestion by Facility Type



The second metric that was used to evaluate the congestion was lane miles of congested highway for the morning peak period. For this analysis congestion was categorized into three levels. The lowest level, uncongested, was determined based on the volume to capacity ratio being less than or equal to 25 percent. Near capacity was defined as a volume to capacity ratio less than 80 percent but greater than 25 percent. Congested was defined as a volume to capacity ratio equal to or greater than 80 percent. Figure 2-4 shows the congested lane miles for the morning peak period by facility type. Facility types are freeway, expressway, major arterial, minor arterial, and collector. Local roads are not explicitly included in the network. Freeways represent all interstate and

highways with restricted access and grade separated interchanges. Expressways are a facility with limited access but some at-grade intersections. A major arterial would be a facility like Lee Highway or Leesburg Pike, while a minor arterial would be a facility like Wilson Boulevard. Collector roads feed into the arterial system and connect to local neighborhood streets.

The primary objective was to match the average trip length by jurisdiction. The secondary objective was to match the distribution of the congested lanes miles of highway by facility type. The average trip length was a measure of mobility across the network, while the congestion was a measure of the usage of network. The congested lane miles include almost all the roads in Northern Virginia. This represents over six million miles of highway lane miles. In the freeway category, HOT lanes are included and these are priced specifically not to incur congestion. HOV facilities, which typically have lower volumes and less congestion, are also included. Arterial facilities have the greatest amount of lane miles. These facilities connect key origins and destinations and are the primary routes into areas of higher activity. Figure 2-5 shows the number of highway miles for aggregated by facility types.

Figure 2-5 Miles of Highway by Facility Type

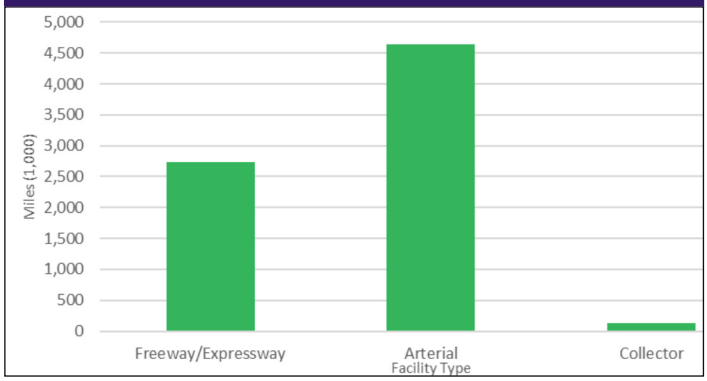
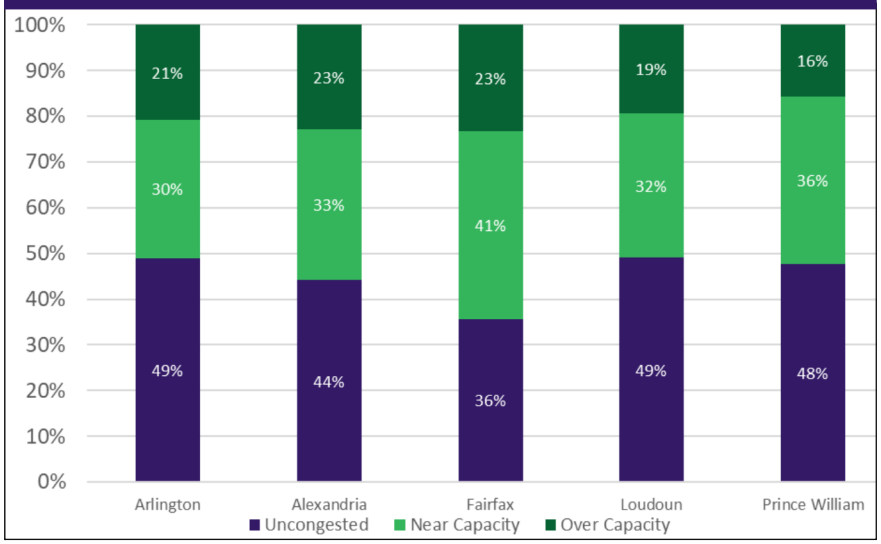


Figure 2-6 Northern Virginia Morning Peak Period Lane Miles of Congestion by Jurisdiction



As part of the baseline analysis, congested lane miles by jurisdiction were evaluated. Figure 2-6 shows the congested lane miles by jurisdiction. Similar to when the miles are calculated by facility type, most of the miles are near capacity followed by congested. The pattern is slightly different at the jurisdictional level. The combination of near capacity and congested miles is always greater than uncongested. Arlington County, the City of Alexandria, and Fairfax County (including all the cities and towns that are located with the boundaries of Fairfax County) show greater miles of congestion than the outer counites of Loudoun and Prince William.

The focus of the analysis was commuter trips. Another metric of importance was the percent of commuter trips using each mode. Table 2-1 shows the mode share by jurisdiction. Arlington County and the City of Alexandria have the highest transit mode shares. There is a correlation between the land development densities and the use of transit. Fairfax County has a more modest transit mode share. It should be noted that even with a lower mode share, Fairfax County, as the largest jurisdiction in Northern Virginia, has the greatest number of residents using transit in the region.

Table 2-1 Existing Commuter Trip Mode Share

Jurisdiction	SOV	HOV	Transit
Arlington	43%	8%	49%
Alexandria	53%	9%	38%
Fairfax	72%	10%	17%
Loudoun	83%	13%	4%
Prince William	82%	13%	5%
NOVA Region	**72%**	**11%**	**18%**

For commuters using transit, only about a quarter of the trips use bus only. Most of the commuters using transit in Northern Virginia, include a rail mode as part of their trip. These trips might walk to a rail station, use bus to access a rail station, or drive to a rail station. There is some bus service into Washington, D.C. from Northern Virginia, as rail modes carry the majority of trips into the District as well as other high employment areas in the core. The importance of including the bus constraint, even if it had limited impact, was good practice in light of the mode shares and use of transit to access the core areas. The existing mode share by jurisdiction also served as a seed value for determining where and how many households to remove from the land use input file for the modeling exercise.

Scenario Testing

The scenario testing involved removing the high capacity rail modes, Metrorail and VRE, and then running the model while redistributing the land use until the existing congestion levels were matched. The first run, after the baseline run, removed Metrorail and VRE from Northern Virginia, but kept the existing levels of land use. The result was a drop in the average commuter trip length from 13.44 miles to 12.96 miles and increase in congested lane miles of approximately 56,000 miles. This was due to the added congestion from lower transit mode share and greater number of single occupant vehicle (SOV) trips on the network. The next model run reduced the number of households and jobs based on the existing mode share data. These two runs constituted the high and low points for the range of households to be removed. Taking the baseline number of home-based work transit trips and equating them to number of households, based on the average number of home-based work trips per household, and then running the model, the average home-based work trip length increased by approximately 4 percent. A series of abbreviated model runs and development of a regression equation served to guide the number of households being redistributed. The model was balanced on productions, so attractions have to equal productions. Productions are a function of households. Therefore, households were the focus of the land use reductions. Employment in terms of the model was an attraction. The attractions were balanced to the productions, therefore the reduction in employment was a function of the household redistribution.

Figure 2-7 shows the iterative process that was applied to the reduction and, then, redistribution of the land use. The land use was reduced and then redistributed to other jurisdictions outside of Virginia. The WMATA 2016 On-Board Passenger Survey provided the locations for the removal of households and jobs, while the MWCOG Cooperative Land Use Forecast provided areas where the households and jobs could be redistributed. Households were redistributed to areas with similar income levels. Household income level is important in the trip generation model. So, households that were removed were added to areas of similar demographics. Households and jobs were redistributed evenly across the other jurisdictions based on the defined growth areas. This removed any bias in the redistribution that might influence congestion levels in Northern Virginia, such as locating them just across the Potomac River to increase congestion on I-495 and the Legion Bridge.

Figure 2-7 Land Use Modification Process

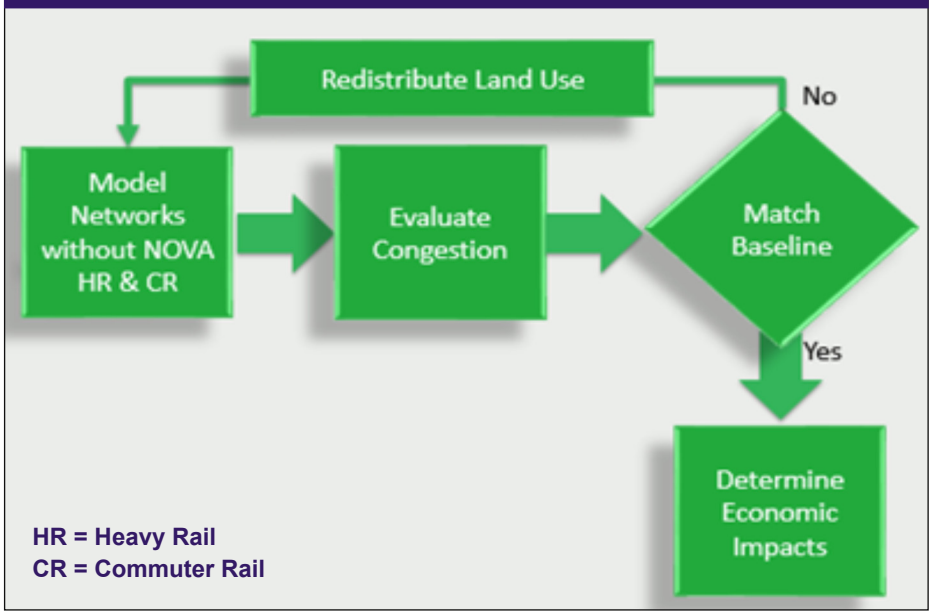
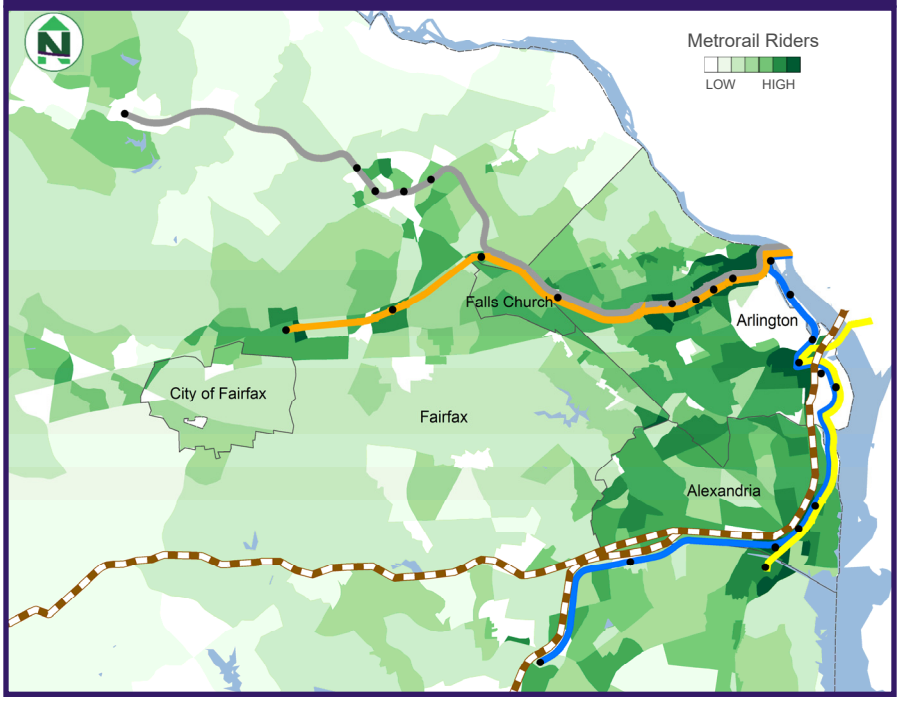


Figure 2-8 Where Metrorail Riders Live in Northern Virginia's Inner Suburbs

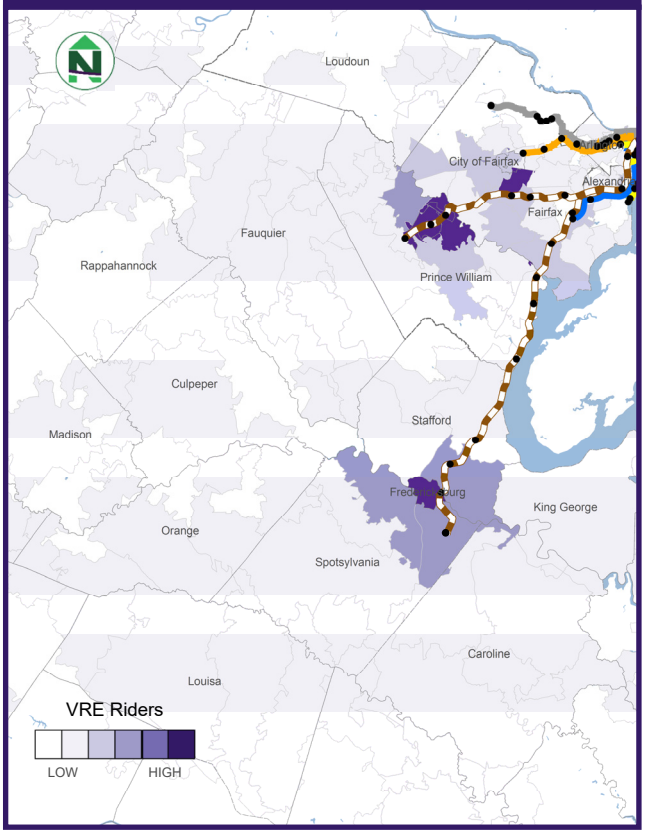


The households were removed based on the WMATA survey. The survey showed that of the approximately 665,000 Metrorail riders per weekday, 30 percent live in Virginia. Figure 2-8 shows the household location for Metrorail riders in Northern Virginia. More than 90 percent of Virginia's average weekday riders come from NVTC jurisdictions. Given the extent of VRE service and other commuter connections, over 13,000 of Metrorail's average weekday riders live in Virginia outside of NVTC jurisdictions. Many of these riders live south and west of the Compact area and use VRE to connect to Metrorail in Virginia or the District of Columbia. About a third of Virginia riders live within a half mile of a Metrorail station.

Thirty-seven percent of Virginia riders are federal employees and 50 percent have household incomes greater than $100,000. There are over 300,000 jobs within a half mile of Virginia Metrorail stations and Metrorail is commonly used by residents of the District, Maryland and Virginia to commute to these jobs.

Figure 2-9 shows the household origin location of VRE's ridership. VRE serves roughly 20,000 trips on an average weekday. As a commuter railroad, VRE's ridership extends farther in the region than Metrorail. Over 60 percent of its riders come from Stafford, Fairfax, Prince William and Spotsylvania counties. The household redistributions were based on the WMATA survey, although VRE service was removed from the network. Many VRE riders transfer to Metrorail, so the WMATA survey provided locations across Northern Virginia jurisdictions to remove trips.

Figure 2-9 Where VRE Riders Live in Northern Virginia



There was a total of 14 model runs. The final runs were guided by the regression analysis of the earlier runs. The analysis used households as the independent variable and trip length as the dependent variable. Regression analysis was done by jurisdiction, as well as Northern Virginia as a region. The regional analysis showed better results with a R^2=0.975, the slope equal to -1.58×10^{-05} and the y-intercept equal to 26.7. The final model run showed an average trip length for commuter trips in Northern Virginia of 13.42 miles and congested lane miles for Northern Virginia at 27 percent.

An estimate of the households to be reduced was calculated based on the regression equation. Then, to

determine the number of jobs to be reduced, productions were calculated for the number of households being reduced. Trip attraction equations for both work and shopping were used to estimate the number of office and retail jobs to be removed. Only office and retail jobs were redistributed. The jobs were removed based on the WMATA survey, so that only the jobs in Northern Virginia that were located near Metro stations were impacted. The jobs were dependent on the productions and were balanced against the productions. Therefore, the estimate of jobs removed was not as critical in the modeling process as the number of households. Additionally, households, and the corresponding income tax, had a greater impact on the revenue estimates than the sales tax receipts.

Revenue Calculations

Once the finalized households and jobs were redistributed in the modeling process, then the corresponding state revenues were calculated. The objective of this analysis was to determine impacts on state revenues. Therefore, the financial analysis focused on state general fund revenues. The largest sources of general fund revenues are the personal income tax at $12.6 billion (69 percent) followed by the sales and use tax at $3.3 billion (18 percent). Given the magnitude of the revenue that these sources provide and because the general fund supports a variety of state programs, this study calculated the number of households and jobs supported by high capacity transit and estimated their contributions to these two revenue sources.

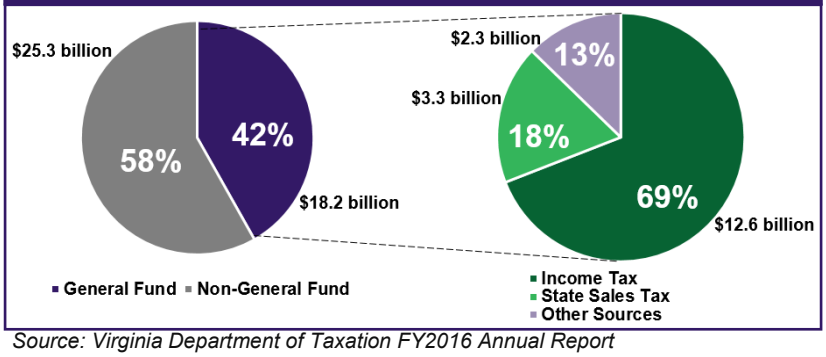
For the income tax, this study used data from the United States Census Bureau and Internal Revenue Service (IRS), and the Virginia Department of Taxation to develop estimates of income tax revenue received by the state from households supported by high capacity transit in Northern Virginia. Income tax revenue estimates were based on income levels as reported in the regional travel demand forecast model. The demographic data for the model aggregated the households into four income quartiles by transportation analysis zone. There were 3,722 zones in the model, with 1,415 zones in the Northern Virginia jurisdictions used for this analysis. The zones were typically defined by major roadways and/or geographical boundaries such as rivers, parks, etc.

For the sales tax calculations, this analysis used the number of retail jobs supported by high capacity transit as a proxy for retail activity. Retail jobs, included in the MWCOG employment forecast, were calculated by local jurisdictions and were considered as proxies for retail activity. The percent reduction in retail jobs for each jurisdiction, as compared to the baseline scenario, was applied to the latest available sales tax data for each jurisdiction to calculate the sales tax value to the Commonwealth. Because this analysis focused on statewide revenues, the analysis only evaluated the portion of the sales tax that is directed to the state general fund.

State Revenue Overview

In fiscal year 2016, the Commonwealth of Virginia collected $43.4 billion in net revenue. This represents revenue received by all departments and for all fund types. State revenues can be divided into general fund revenues and non-general fund revenues. In fiscal 2016, general fund revenues totaled $18.2 billion (42 percent) and non-general fund revenues totaled $25.3 billion (58 percent). Figure 2-10 provides an overview of the general fund. The majority (95.5 percent) of general fund revenues was collected through the Department of Taxation. Other agencies that collected general fund revenue include the Department of Alcoholic Beverage Control, General District and Circuit courts, and the State Corporation Commission. Non-general fund revenues include user fees, fees for service, federal grants, and taxes that are dedicated to certain funds like the Motor Vehicle Sales Tax.

Figure 2-10 Total Revenue and General Fund Revenue Collected



Source: Virginia Department of Taxation FY2016 Annual Report

The individual income and state sales taxes represent over 87 percent of all general fund revenue received by the commonwealth. The income tax is by far the largest contributor to the general fund, generating $12.6 billion (69.1 percent) in revenues in fiscal 2016. The general fund portion of the state sales tax is the second largest contributor, with $3.3 billion (18.1 percent) in revenues in fiscal 2016. The next highest contributor is the corporation income tax, with $765 million (4.2 percent) in revenues in fiscal 2016. Additional general fund sources include the tax on recordation and deeds of conveyance and the insurance premiums license tax. These are smaller amounts and for purposes of this analysis only income and sales tax were calculated.

Income Tax

Background

The income tax is the largest revenue source (69.1 percent) for the Commonwealth's general fund. In fiscal 2016, statewide income tax revenue totaled $12.5 billion. Table 2-2 shows that Virginia's income tax has marginal rates that tax higher incomes at slightly higher levels than lower incomes.

Table 2-2 Total Revenue and General Fund Revenue Collected

Virginia Taxable Income	Tax Calculation
0 - $3,000	2%
$3,001 - $5,000	$60 + 3% of excess over $3,000
$5,001 - $17,000	$120 + 5% of excess over $5,000
Greater than $17,001	$720 + 5.75% of excess over $17,000

Source: Virginia Department of Taxation

In its fiscal 2016 annual report, the Department of Taxation provided income tax liability by locality for taxable year 2014 (the latest year available). Income tax liability is the amount estimated to be owed before any tax credits but after the spouse tax adjustment. While income tax liability is slightly different from net income tax revenue collections, the income tax liability provides a reasonable representation of the percentage of income tax revenues generated by jurisdiction.

Table 2-3 Income Tax Liability by Jurisdiction (Tax Year 2014)

Jurisdiction	Income Tax Liability (Tax Year 2014)	Percent
Arlington County	$649,591,342	5.6%
Fairfax County	$2,758,475,854	23.7%
Loudoun County	$815,692,975	7.0%
Alexandria	$373,709,032	3.2%
City of Falls Church	$43,475,620	0.4%
City of Fairfax	$50,994,815	0.4%
NVTC Jurisdiction Total	$4,691,939,638	40.4%
Prince William County	$601,928,312	5.2%
Manassas	$45,898,746	0.4%
Manassas Park	$14,905,020	0.1%
Study Area	$5,354,671,716	46.1%
State Total	**$11,623,977,320**	**100.0%**

Source: Virginia Department of Taxation FY2016 Annual Report

In tax year 2014, the income tax liability for the entire Commonwealth was $11.6 billion. NVTC jurisdictions contributed nearly $4.7 billion, or 40.4 percent, and the study area contributed $5.4 billion, or 46.1 percent, of this total, as shown in Table 2-4. When the 40.4 percent share was applied to fiscal 2016 net income tax revenues, the income tax contribution from NVTC jurisdictions totaled an estimated $5.0 billion.

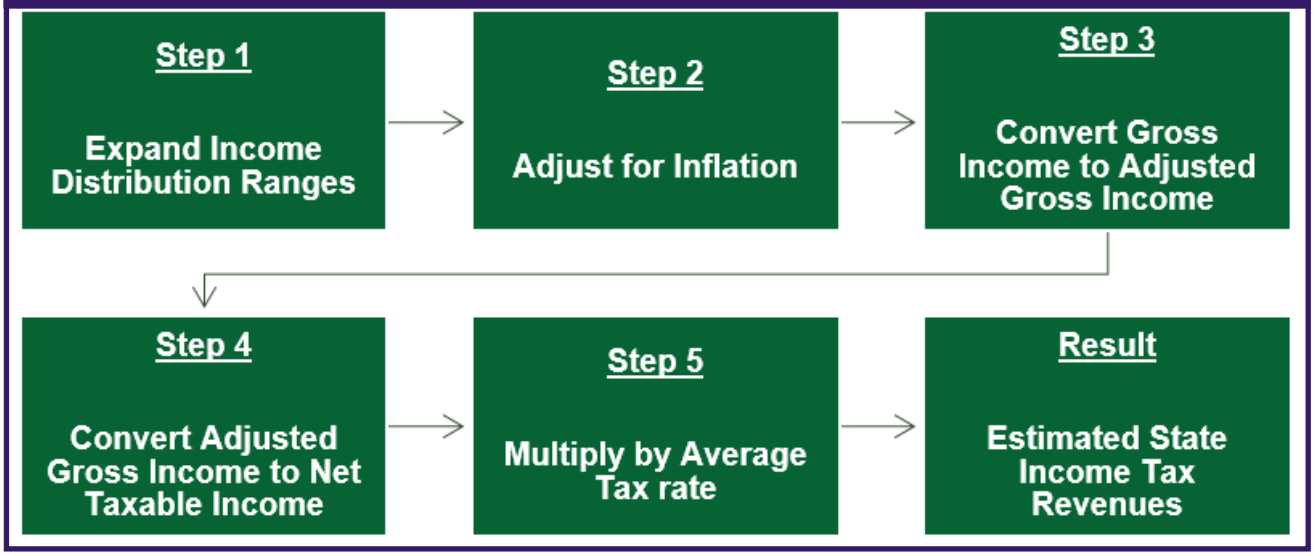
Income Tax Calculation

A unique component of this analysis is the use of the land use and transportation network as an integral input in calculating congestion and then monetizing the value of high capacity transit in Northern Virginia. The modeling for the analysis calculated the existing level of congestion based on today's highway network and the level of congestion that would exist with high capacity transit removed from the network. Through an iterative process, households and jobs were removed from Northern Virginia until the same level of congestion was reached that exists in the baseline or existing scenario. Because of the large numbers of Metrorail riders in Prince William County, this step rebalances land use from NVTC jurisdictions, Prince William County, the City of Manassas and City of Manassas Park to areas with planned growth in Maryland and the District of

Columbia. The number of households and jobs that were redistributed to other areas of the metropolitan region outside of Northern Virginia can be interpreted as the amount of land use supported by high capacity transit in Northern Virginia.

A major land use and transportation input in the model is the number and location of households by income quartile. This is important because households generate travel that is incorporated into the model, and the type and volume of this travel is influenced by household income. Given the number of households by income quartile, the analysis used several data points to derive the estimated income tax revenue received by the Commonwealth. The analysis assumed that each household in the model represented a tax-filing individual. Available state and federal data sources allow for these calculations to be performed for each jurisdiction with metrics that vary per income stratum, where available. The overall objective of the methodology was to convert household income in the model to state income tax revenues. Figure 2-11 provides an overview of the process.

Figure 2-11 Income Tax Revenue Methodology



Process

Step 1: Expand the income distribution ranges from the model

The MWCOG/TPB regional travel model contained households by income quartile by transportation analysis zone (TAZ). A TAZ is a geographic unit used in transportation planning models. Household income was included as a series of ranges, shown in Table 2-4, and was derived from the TPB 2007-2008 Regional Household Travel Survey, wherein respondents indicated their household income. The household travel survey is a valuable component of the regional transportation model because it collects demographic and travel information from a sample of households in the region and is the primary source of observed data used to estimate, calibrate and validate the regional travel demand model.

Table 2-4 Household Income Ranges in Regional Travel Model

Household Income Range
< $50,000
$50,000 - $99,999
$100,000 - $149,000
> $150,000

Source: Regional travel demand forecast model (MWCOG/TPB Version 2.3.66 model).

Given the aggregation of the household income quartiles, additional data was used from the U.S. Census Bureau's American Community Survey. This data is shown in Table 2-5. It provided a greater level of disaggregation and allowed for more precise income tax calculations.

Table 2-5 Household Income (2009 Five-Year American Community Survey)

Model Income Quartiles ($2008)	ACS Income Ranges ($2009)	Arlington County	Fairfax County	Loudoun County	City of Alexandria	City of Fairfax	City of Falls Church	Prince William County	City of Manassas	City of Manassas Park
< $50,000	Less than $10,000	4.3%	2.5%	1.9%	4.1%	1.9%	2.4%	2.2%	3.5%	1.9%
	$10,000 to $14,999	2.1%	1.4%	1.0%	3.0%	2.3%	2.4%	1.5%	3.3%	1.8%
	$15,000 to $24,999	3.7%	3.5%	2.4%	4.8%	3.0%	2.6%	4.1%	3.8%	3.8%
	$25,000 to $34,999	4.8%	4.1%	3.4%	5.9%	3.5%	4.8%	5.0%	8.1%	5.9%
	$35,000 to $49,999	7.8%	8.1%	6.9%	10.9%	9.1%	9.9%	10.0%	12.6%	17.0%
$50,000 - $99,999	$50,000 to $74,999	15.9%	14.5%	13.4%	18.6%	15.3%	12.9%	17.9%	20.8%	26.5%
	$75,000 to $99,999	15.0%	13.6%	14.0%	13.7%	17.7%	8.9%	16.5%	13.9%	12.7%
$100,000 - $149,000	$100,000 to $149,999	20.7%	22.2%	25.5%	19.7%	24.4%	23.2%	21.7%	21.4%	18.1%
> $150,000	$150,000 to $199,999	11.4%	13.3%	15.8%	8.4%	11.8%	14.7%	12.3%	7.2%	8.9%
	$200,000 or more	14.3%	16.7%	15.6%	11.0%	11.0%	18.1%	8.9%	5.5%	3.5%

Source: 2005-2009 American Community Survey, Table S1901, U.S. Census Bureau

The regional household travel survey that informs household incomes in the regional travel model is from 2007-2008 and represents household incomes in 2008 dollars. The 2009 five-year American Community Survey (ACS) household income data that is used to expand the income distribution is in 2009 dollars. This survey represents an estimate of household income and is collected over the entire five-year period. The five-year ACS data has the most reliability, is available for all jurisdictions in the study area, and is the closest survey year to that of the regional household travel survey.

The additional income ranges provided by the ACS allow further division of household income categories in the travel model. For the purposes of calculating income tax, a dollar amount is derived for each income range. The midpoint of the income ranges is shown in Table 2-6. These midpoints are used to calculate estimated income tax yields.

Table 2-6 Household income (2009 Five-Year American Community Survey) and Selected Midpoints

Model Income Ranges	ACS Income Ranges	Midpoint
< $50,000	Less than $10,000	$ 5,000
	$10,000 to $14,999	$ 12,500
	$15,000 to $24,999	$ 20,000
	$25,000 to $34,999	$ 30,000
	$35,000 to $49,999	$ 42,500
$50,000 - $99,999	$50,000 to $74,999	$ 62,500
	$75,000 to $99,999	$ 87,500
$100,000 - $149,000	$100,000 to $149,999	$125,000
> $150,000	$150,000 to $199,999	$175,000
	$200,000 or more	$400,000

Source: 2005-2009 American Community Survey, Table S1901, U.S. Census Bureau

For incomes above $200,000, the lack of an upper limit made it difficult to establish a midpoint, as was done in other income ranges. However, IRS tax return data for the jurisdictions in the study area supported a “midpoint” of $400,000 for this income strata. The IRS provides tax return data for selected income and tax items by county by year, as shown in Table 2-7. The earliest year for which this is available at the

jurisdictional level is tax year 2011. These data were provided by income strata including a category of "$200,000 or more." While this information was shown in AGI, it was comparable to gross income and was the best available data at a jurisdictional level to examine incomes greater than $200,000. For this income stratum, the average AGI per return was $410,984 (in 2011 dollars) across jurisdictions in the study area. Adjusting this by the U.S. Bureau of Labor Statistics' Consumer Price Index (CPI) to 2008 provides a figure of $398,738. This figure is adjusted from 2011 to 2008 to avoid over-inflating the figure in a later step that adjusts 2008 dollars to 2015 dollars. With rounding, the midpoint of the "$200,000" or more range was deemed to be $400,000.

Table 2-7 Income Tax Returns for Adjusted Gross Incomes Greater than $200,000 for Jurisdictions in Planning District 8 (Tax Year 2011)

Jurisdiction	Number of Returns	Adjusted Gross Income	Average AGI per Return
Arlington County	12,590	$5,261,248,000	$417,891
Fairfax County	60,278	$27,015,054,000	$448,174
Loudoun County	18,834	$6,595,442,000	$350,188
City of Alexandria	6,797	$2,789,711,000	$410,433
City of Fairfax	923	$306,257,000	$331,806
City of Falls Church	990	$417,818,000	$422,038
Prince William County	10,620	$3,171,277,000	$297,772
City of Manassas	534	$169,435,000	$312,035
City of Manassas Park	124	$31,086,000	$250,694
Study Area Total	**111,062**	**$45,556,807,000**	**$409,539**

Source: Internal Revenue Service Statistics of Income – County Data, Virginia – Individual Income Tax Returns: Selected Income and Tax Items by State, County, and Size of Adjusted gross income, Tax Year 2011.

Step 2: Adjust for Inflation

The income distribution was expanded using ACS data and multiplied by a midpoint to yield gross incomes by income strata. These incomes were adjusted from 2008 to 2015 dollars (the model base year) using the CPI inflation calculator. The growth of inflation between 2008 and 2015 was calculated as +8.5 percent.

Step 3: Converting Gross Income to Adjusted Gross Income (AGI).

Collectively, the regional household travel survey, census data, and inflation adjustment provide gross household income. To calculate estimated income tax received by the state, gross income needed to be converted into Adjusted Gross Income (AGI). IRS defines AGI as the gross income minus adjustments to income. Using national data provided by the IRS, conversion ratios were established to estimate adjusted gross income. These are displayed by income strata in Table 2-8. The strata are shown in

Table 2-8 Gross Income Compared to Adjusted Gross Income

By Size of Adjusted Gross Income	Total Income (Tax Year 2014, in thousands)	Adjusted Gross Income (less deficit) (Tax Year 2014, in Thousands)	Ratio of AGI to Gross Income
Less than $10,000	$120,067,326	$116,098,218	0.967
$10,000 to $14,999	$157,142,081	$153,830,822	0.979
$15,000 to $24,999	$430,138,129	$423,817,017	0.985
$25,000 to $49,999	$1,280,103,744	$1,263,215,346	0.987
$50,000 to $74,999	$1,207,240,353	$1,191,956,661	0.987
$75,000 to $99,999	$1,124,785,053	$1,111,626,170	0.988
> $100,000	$5,792,198,421	$5,708,181,972	0.985

Source: Internal Revenue Service Statistics of Income, Table 1.4 – All Returns: Sources of Income, Adjustments, and Tax Items, by Size of Adjusted Gross Income, Tax Year 2014 (Filing Year 2015).

AGI. It should be noted that the AGI is close to gross income and determined to be applicable given the wide income strata provided by the American Community Survey. Since income strata were not identical, several categories were collapsed to allow comparison. Tax year 2014 is the latest data available from the IRS and the closest available data to the model base year.

As shown in Table 2-8, dividing the AGI by the total income provided a ratio that allowed conversion from gross income to AGI by income band.

Steps 4 through 6: Converting Adjusted Gross Income into Estimated Tax Revenues.

The AGI, minus deductions and exemptions, yielded the total taxable income. The total taxable income multiplied by a tax rate produced a total estimated tax revenue. The Virginia Department of Taxation's fiscal 2016 annual report provided state level totals for AGI, total taxable income, and the average tax rate by adjusted gross income strata. This information, for tax year 2014, is the latest available and was determined to be adequate for the existing model baseline scenario and testing. After aggregating the income strata, a series of ratios and rates by income stratum to convert between AGI, taxable income, and estimated tax revenue were derived as shown in Table 2-9.

Table 2-9 Adjusted Gross Income, Taxable Income, and Total Tax Liability by Income Class

Income Strata	Total AGI	Total Taxable Income	Taxable Income to AGI	Total Tax Liability/ Estimated Tax Revenue	Avg. Tax Rate
Less than $10,000	$2,819,540,907	$183,441,132	0.065	$4,764,993	2.60%
$10,000 to $14,999	$3,446,741,716	$1,201,853,799	0.349	$42,913,771	3.57%
$15,000 to $24,999	$9,774,258,485	$5,406,150,553	0.553	$224,274,310	4.15%
$25,000 to $34,999	$12,122,612,074	$8,063,225,397	0.665	$368,936,298	4.58%
$35,000 to $49,999	$19,246,895,769	$13,651,658,301	0.709	$665,954,865	4.88%
$50,000 to $74,999	$30,316,794,512	$23,134,325,480	0.763	$1,174,418,065	5.08%
$75,000 to $99,999	$28,177,667,227	$22,743,989,203	0.807	$1,188,418,789	5.23%
$100,000 or more	$163,819,993,856	$143,659,226,733	0.877	$7,954,296,230	5.54%

Source: Virginia Department of Taxation, FY2016 Annual Report, Table 1.2: Virginia Adjusted Gross Income, Total Exemptions, Total Deductions, Total Taxable Income, Total Tax Liability, and Average Tax Rates.

For each income class, the ratios in the table allow conversion from AGI to taxable income and from taxable income to total tax liability. The ratios for AGI to taxable income include assumptions for deductions and exemptions taken directly from state data. The average tax rate includes assumptions for Virginia's income tax scales. The total tax liability, as defined by the Department of Taxation, is the amount of income tax the state is owed before any tax credits and after the spouse tax adjustment. The analysis determined that total tax liability is the same as estimated tax revenue, as assumptions regarding state tax credits were too granular to be included in the revenue model. The objective was to have a more conservative and straightforward approach. Given the taxes paid by household income level and number of households at each income strata, an estimate of the state revenue from income tax was derived.

Sales Tax

Background

The sales tax is the second largest revenue source (18.1 percent) for the Commonwealth's general fund. In fiscal 2016, statewide sales tax revenue contributed $3.3 billion to the state general fund. Virginia's sales tax is directed to several state-wide, regional, and local funds for a wide variety of purposes. This study focuses on the sales tax rate that goes to the state general fund, which is 2.015 percent.

The total state sales tax rate is 5.3 percent. The 5.3 percent rate is broken down into several categories summarized in Table 2-10. In Northern Virginia and Hampton Roads, there is an additional 0.7 percent

sales tax that brings the total rate to 6.0 percent. In jurisdictions that are part of the Northern Virginia Transportation Authority (NVTA), which includes all the jurisdictions in the study area, the added 0.7 percent sales tax rate is dedicated to the NVTA. This analysis evaluated only the portion of the sales tax that was directed to the state general fund.

Table 2-10 Allocation of the Virginia Sales Tax for Jurisdictions within Study Area

Type	Percent
General Fund	2.015%
Local Option	1.000%
Education based on School-Age Population	0.990%
Transportation Trust Fund	0.500%
Public Edu. Standards of Quality/Local Real Estate Property Tax Relief Fund	0.375%
Highway Maintenance Operating Fund	0.275%
Intercity Passenger Rail Fund	0.050%
Commonwealth Mass Transit Fund	0.075%
Northern Virginia Transportation Authority	0.700%
Total	***6.000%**

*Education based on School-Age Population and General Fund portions of the sales tax have a dealer discount of 0.01% each. Including the dealer discount brings the total to 6.0%.

Source: Virginia Department of Taxation

The sales tax does not apply to all purchases in Virginia. It applies to the sale, lease or rental of tangible personal property or the use or consumption of tangible personal property in Virginia. The seller is responsible for collecting the tax from the customer on each taxable sale. Eligible items include most consumer goods. Utilities, healthcare, communications, and motor vehicle sales are examples of purchases that are generally not covered by the sales tax but may be covered by other state taxes. Virginia does apply a sales tax to food but at a reduced rate. Food purchased for home consumption, including most staple grocery food items and cold prepared foods packaged for home consumption, is taxed at a reduced sales tax rate of 2.5 percent, of which 1 percent is allocated to the local option, 1 percent (or 0.99 percent minus the dealer discount) to education based on school-aged population, and 0.5 percent to the Transportation Trust fund.

Sales Tax Methodology

This analysis focused on the land use and transportation network as an integral input in calculating congestion and the value of high capacity transit in Northern Virginia. One of the major land use and transportation inputs in the model is the number and location of households and employment. After defining the baseline congestion, this analysis calculated the number of households and employment that high capacity transit supports by redistributing the land use to other jurisdiction in the metropolitan region until congestion was back to the baseline level.

Cooperative forecast data, which supplies the households and jobs in the model, is generally submitted to MWCOG by each local jurisdiction, and contains several primary inputs: population, households, housing units, and employment. Employment is split into four categories: office, industrial, retail and other. The modeling process of this analysis was an iterative exercise where households and employment were redistributed in the model to areas in the region outside of Virginia. This analysis considered retail employment to be a proxy for physical retail activity and thereby sales tax activity. Retail employment includes all types of retail land uses from shopping malls to restaurants. By comparing the number of retail jobs with recent sales tax information for the region, a ratio of retail jobs to sales tax yield was calculated.

The method utilized in this analysis to calculate the reduction in sales tax revenue accounts for the variability in who buys eligible goods. Sales taxes in any jurisdiction may be generated by resident households, households from neighboring or distant jurisdictions, employees who are also residents, employees from across the region, and tourists or business travelers. Given the volatility regarding who was generating taxable sales, the sales tax calculation required a different methodology from the income tax, which relied on determining households and household income. This analysis assumed that the percent loss of retail jobs in the region would have a proportional percent loss in sales activity in the region. Figure 2-11 presents an overview of the methodology. The analysis focused on jobs in the NVTC jurisdictions because of their proximity to Metrorail stations.

Figure 2-11 Sales Tax Revenue Methodology

Sales Tax Calculation

Process

Step 1: Calculate Retail Jobs by Jurisdiction

Cooperative forecast data, which is utilized in the transportation model, contains employment estimates that are split into four categories: office, industrial, retail and other. The modeling process redistributed the households and employment outside of Northern Virginia based on the congestion levels. The analysis considered retail employment to be a proxy for physical retail activity and thereby sales tax activity. Using MWCOG data, retail jobs are summarized by NVTC jurisdiction for the base year shown in Table 2-11.

Table 2-11 Retail jobs in the MWCOG Forecast by NVTC jurisdiction for Year 2016

Jurisdiction	Retail Jobs
Arlington County	33,150
Fairfax County	93,023
Loudoun County	39,426
Alexandria	22,822
City of Fairfax	4,440
City of Falls Church	4,056
NVTC Total	**196,917**

Source: MWCOG Forecast 9.0

Step 2: Estimate Sales Tax Yield by Jurisdiction

The Department of Taxation collects and distributes the local option 1 percent sales and use tax. This is 1 percent of the total sales tax rate and it is returned to the locality where it is collected. The Department provides information on the actual distributions of the local option 1 percent sales tax (fiscal 2016) for all Virginia jurisdictions. These distributions are based on where the tax is collected and are shown in Table 2-12.

Table 2-12 Local 1 Percent Option Sales Tax Distribution by NVTC Jurisdiction

	Actual FY2016 Local 1% Option Distribution Sales and Use Tax		Estimated Sales Tax Yield to the General Fund
Jurisdiction	**Amount ($)**	**% of state**	
Arlington County	$39,702,349	3.3%	$67,200,196
Fairfax County	$182,857,172	15.4%	$309,504,049
Loudoun County	$74,949,695	6.3%	$126,859,854
Alexandria	$26,504,982	2.2%	$44,862,333
City of Fairfax	$11,395,367	1.0%	$19,287,798
City of Falls Church	$4,282,942	0.4%	$7,249,308
NVTC Total	**$339,692,507**	**28.6%**	**$574,963,537**

Source: Virginia Department of Taxation FY18 Local Estimates and NVTC calculations

In consultation with the Department of Taxation, the sales tax yield to the general fund for NVTC jurisdictions was estimated using the local 1 percent sales tax distribution and enlarging it per its relevant share of the overall sales and food tax rate. The 1 percent distribution includes both food and non-food sales. The

department estimates that roughly 16 percent of the local 1 percent sales tax distribution is collected from food sales.

With this information, the non-food and food portions of the 1 percent distribution can be broken out and used to estimate the overall jurisdictional sales tax contribution to the general fund. To estimate the sales tax contribution to the general fund for non-food sales, the 1 percent distribution is multiplied by 0.84 and then 2.015 (the share of the sales tax that goes to the general fund divided by the share of the sales tax that goes to the local option). Since none of the sales tax on food goes to the general fund, there is no need to estimate the food tax contribution. The resulting value is the total estimate sales tax yield to the general fund for each jurisdiction.

Step 3: Establish Ratios of Retail Jobs to Sales Tax Yield

The total estimated general fund sales tax yield for NVTC jurisdictions ($575 million) divided by the number of retail jobs in the NVTC jurisdictions (196,917) yields a ratio of one retail job for $2,920 in sales tax revenue to the general fund.

Step 4: Estimate State Sales Tax (General Fund) Revenues

Earlier model steps moved jobs, including retail jobs, across the region. The number of retail jobs removed from NVTC jurisdictions multiplied by the above ratio yielded the estimated state sales tax revenue to the general fund from the households that were redistributed from Virginia to other jurisdictions across the region.

3. FINDINGS

In quantifying the value that Metrorail and VRE bring to the Commonwealth, NVTC determined the amount of land use and development that could be supported with only the current roadway and bus networks. The existing level of roadway congestion was defined as the baseline and the modeling process was repeated until the congestion without rail was equal to the baseline. Households and jobs were redistributed from Northern Virginia jurisdictions to Maryland and the District of Columbia until the level of congestion matched the baseline. Congestion was measured by the average home-based trip length and the distribution of congested lane miles of travel by facility type.

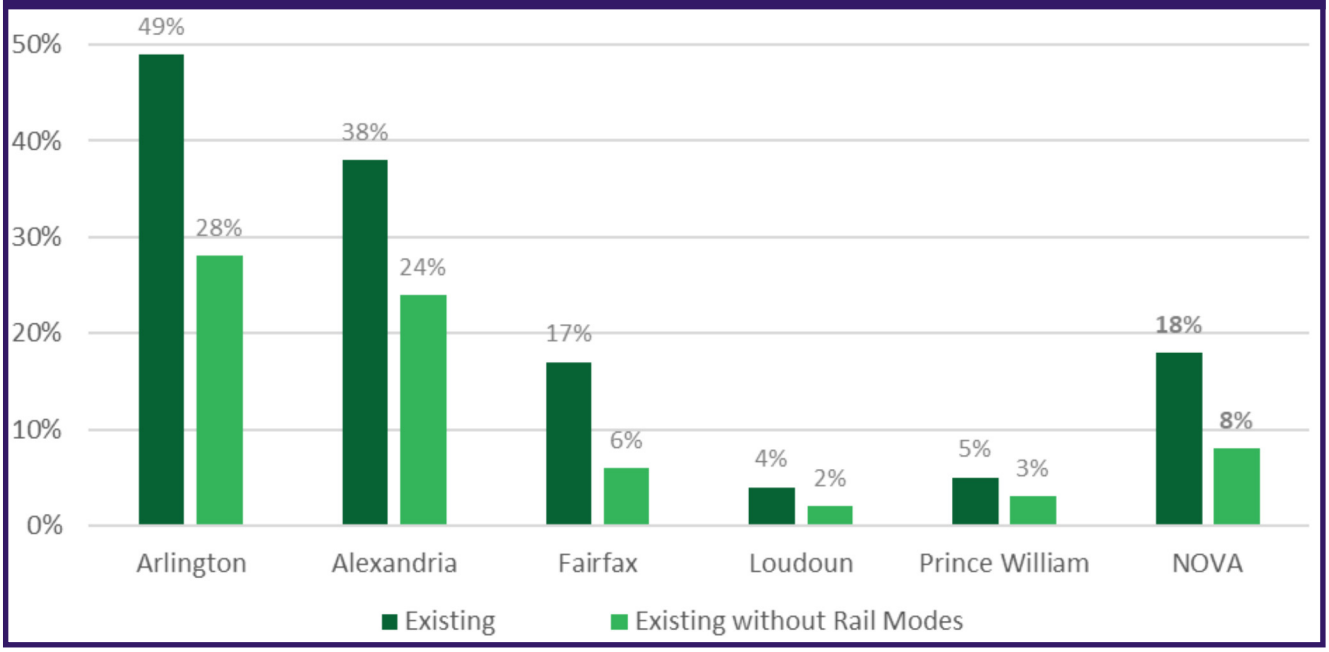
The first model runs removed rail transit in Northern Virginia and held to the existing land use totals. The results of these runs demonstrate the importance of rail in Northern Virginia. With the added congestion, commuters could not travel as far in the same amount of time. Their trip length decreased by about 5 percent, which is significant. By comparison, the trip length decrease projected by MWCOG/TPB in the year 2040 with all funded regional projects was less than 5 percent.

The major impacts associated with a lack of rail transit in Northern Virginia are:

- 56,500 more lane miles of congestion on arterial roadways;
- 50 percent fewer transit trips in the peak period; and
- 80 percent decrease in jobs accessible by transit for Northern Virginia households.

Rail transit is an important option for commuters living inside the Beltway. Nearly half of Arlington County's commuters use transit. That share drops to 28 percent without rail. Just under 40 percent of commuters in the City of Alexandria take transit. That number falls to 24 percent without rail. In Fairfax County, the percentage of commuters using transit drops from 17 to 6. Some of these commuters switch to buses, but the majority switch to automobiles. Without rail transit in Northern Virginia there is a loss of 130,000 daily transit trips. Figure 3-1 shows the decrease in mode share when rail is not included in the network.

Figure 3-1 Change in Mode Share for Home-Based Work Trips



The elimination of Metrorail and VRE from Northern Virginia's transportation network significantly increased traffic congestion. Assuming that the regional total of jobs and households remains constant, achieving current levels of roadway congestion without rail transit required the rebalancing of 85,000 households and 130,500 jobs to Maryland and the District of Columbia. Figure 3-2 shows the location and number of households redistributed, while Figure 3-3 shows the number of jobs redistributed. The reduc-

Figure 3-2 Household Redistribution

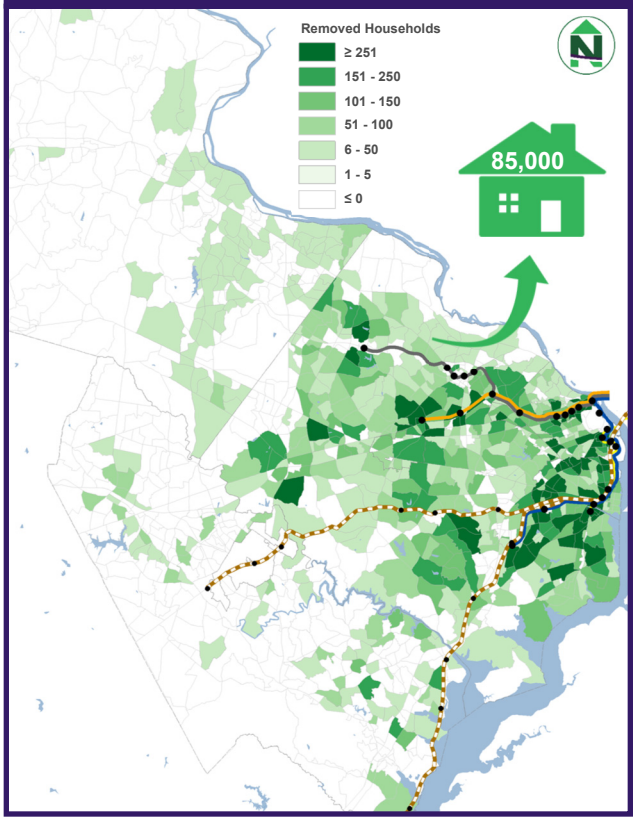
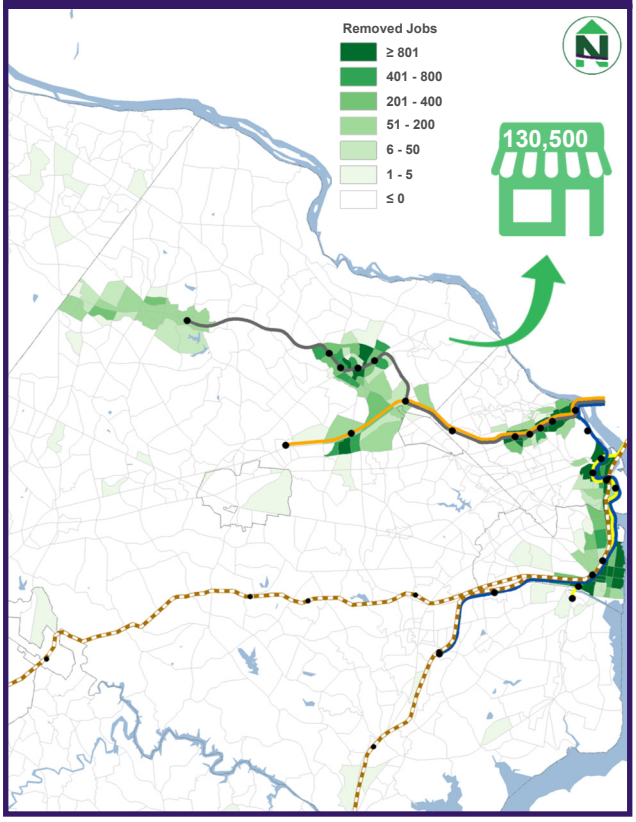


Figure 3-3 Jobs Redistribution



tion of jobs and households was based on WMATA survey data. Jobs were removed for trips that use Metro and therefore were taken from a more limited geography. Households redistributed were more spread across the region.

Figure 3-4 shows the number of households redistributed from Northern Virginia by jurisdiction. The graph also shows the percent of households that are redistributed as compared to the total number of households by jurisdiction. Arlington County had the greatest reduction in households. The outer jurisdictions showed lower reduction in households.

Figure 3-4 Household Reductions by Jurisdiction

Figure 3-5 (see page 23) shows similar data for employment, but the graph is in terms of absolute job numbers. Most of the jobs were redistributed from Arlington and Fairfax counties. Few jobs were reduced from the outer jurisdictions. This was more a function of rounding and balancing the totals, although there are trips that do commute using Metrorail to areas away from the stations. The reduction and redistribution of households and jobs were based on the WMATA 2016 passenger survey. Therefore, areas with higher transit mode resulted in greater reductions.

Figure 3-6 (see page 23) shows the final average commuter or home-based work trip length by jurisdiction. The average trip length for Northern Virginia was 13.44 miles and the final test scenario was 13.42 miles. The challenge in obtaining an exact match might be due to the instability of the equilibrium assignment algorithm and the ability in a congested network to reach convergence. This is a common issue, where the algorithm overall provides a better validation. It can in scenario testing application result in unstable results due the inability to converge in complex congested networks. As part of the scenario testing process, an abbreviated model run was used to develop data for the regression model that predicts the number of households to be redistributed. This short-run model applied an older assignment technique that was stable, but since it was not part of the calibrated and validated model chain it was only used for this limited application. The final model runs were the full model runs.

Figure 3-5 Reduction in Jobs by Jurisdiction

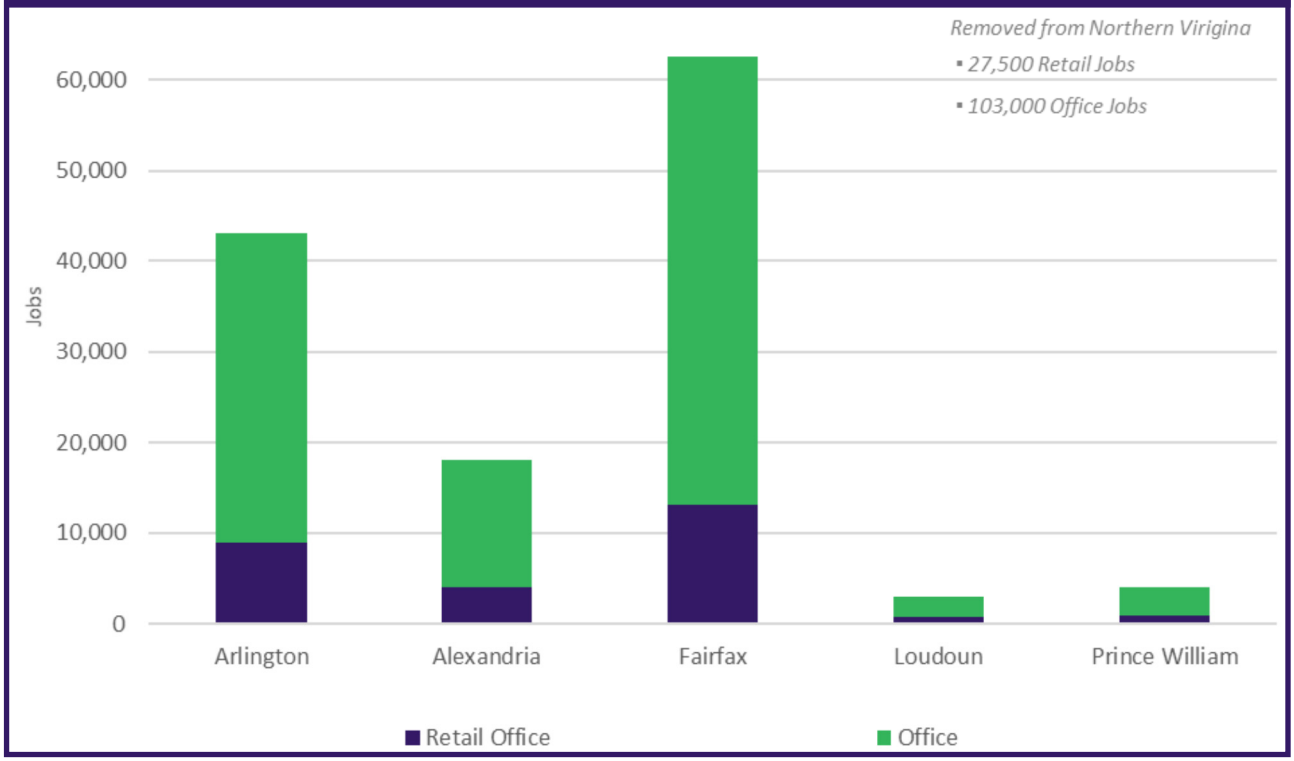
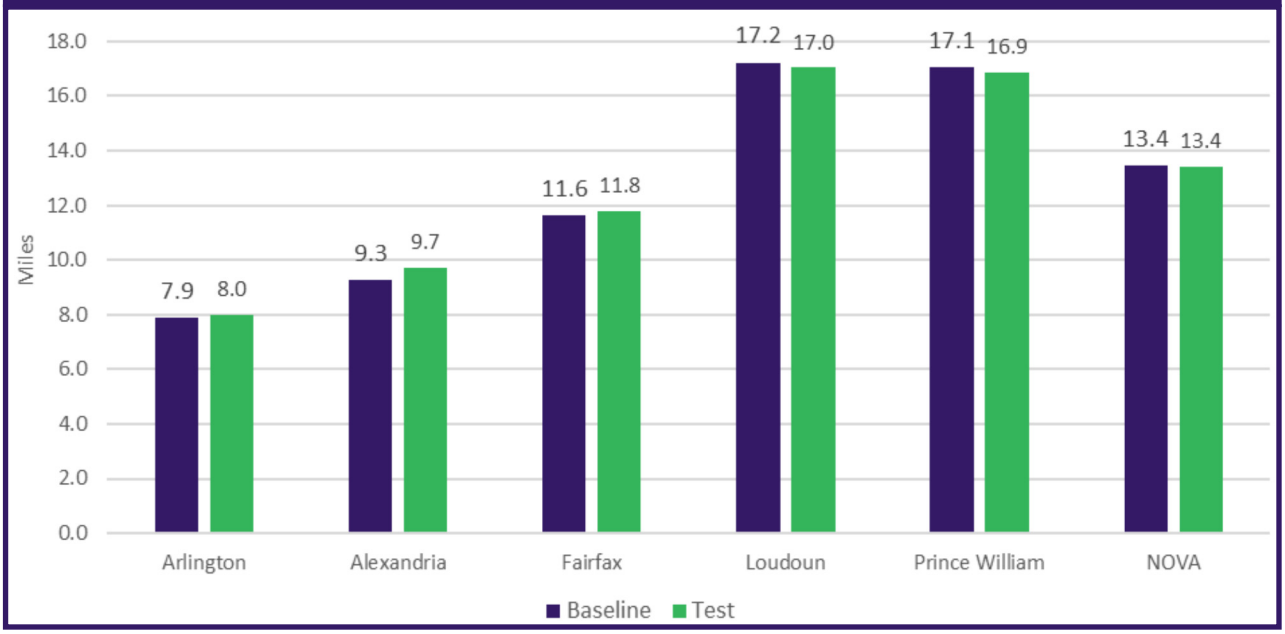


Figure 3-6 Home-Based Average Trip Length



The secondary measure of congestion was the distribution of the congested lane miles by facility type. Figure 3-7 shows the distribution of highly congested lane miles by facility type for Northern Virginia. The final test scenario presented a similar distribution of congestion across facility types. Figure 3-8 shows the amount of highly congested lane miles by facility type and, again, there was a reasonable match with only a 3 percent difference in total lane miles. Given the limitations of the equilibrium assignment algorithm this is considered to be a sufficient match.

Figure 3-7 Percent Distribution by Facility Type of Highly Congested Lane Miles

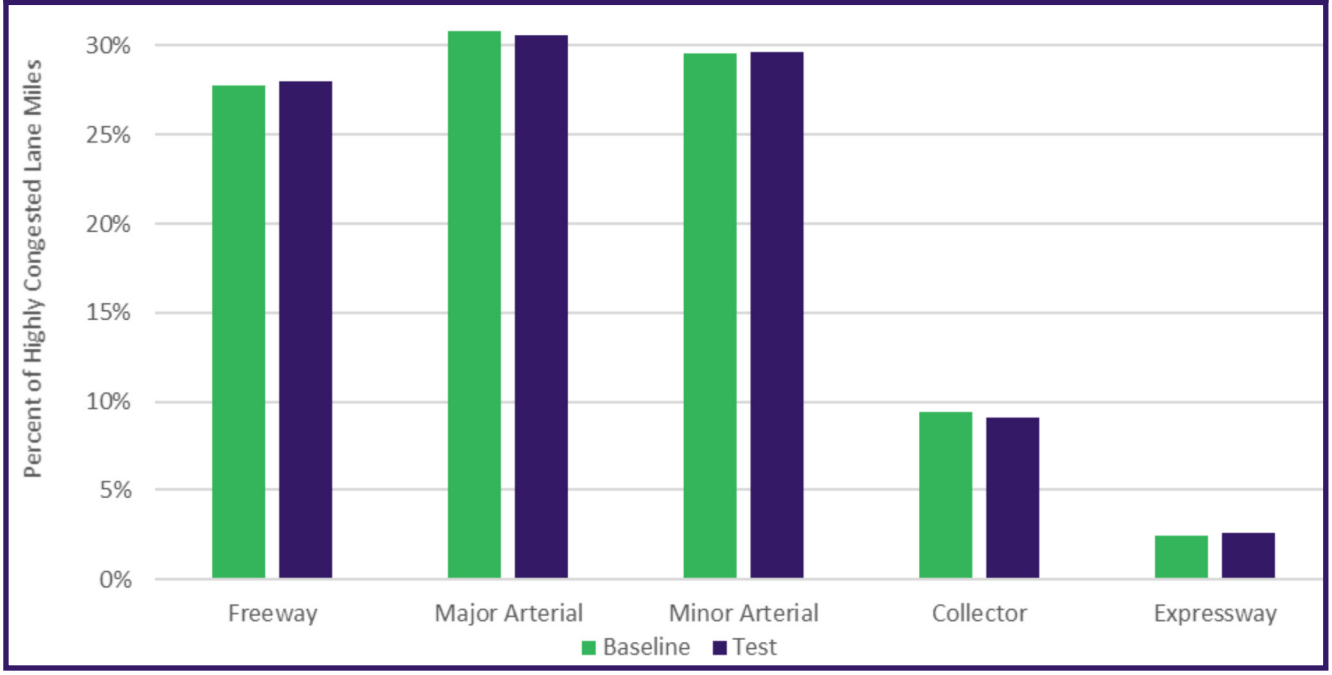
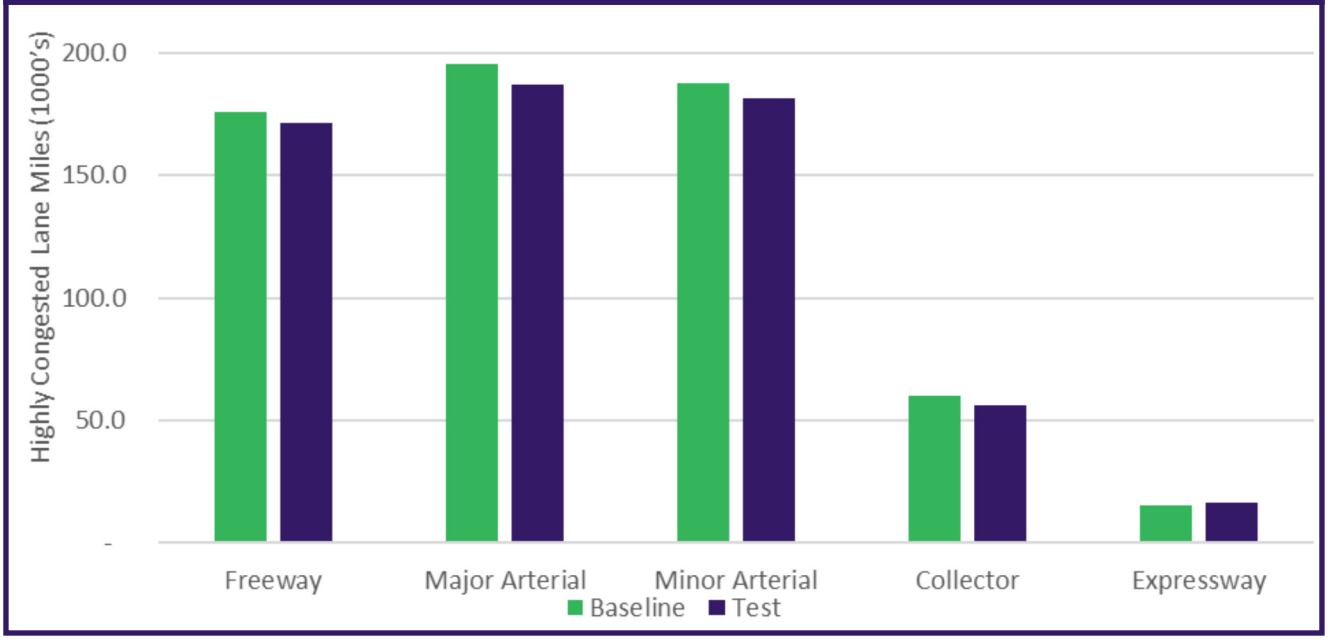


Figure 3-8 Facility Type of Highly Congested Lane Miles



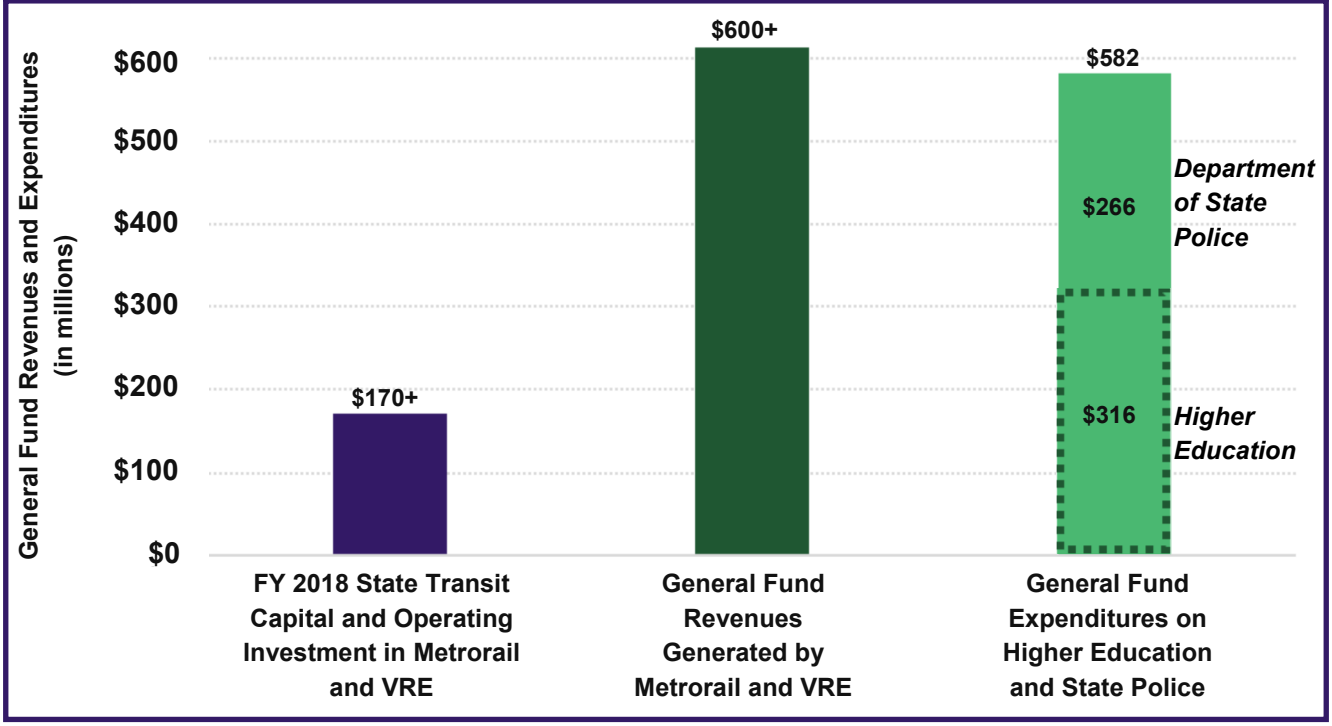
When the state income tax and the sales tax was calculated for the 85,000 households and 130,000 jobs supported by Metrorail and VRE it resulted in over $600 million in general fund revenues for Virginia. This was 3 to 4 percent of the $18.2 billion collected in the state in fiscal 2016. For every dollar the Commonwealth invests in Metrorail and VRE, it received $2.50 in return.

Metrorail and VRE move large numbers of people, relieve congestion and are integral components of local land use and economic development plans. Rail transit attracts jobs and households to Northern Virginia. Whether in new apartment buildings in transit oriented developments near Metrorail stations or in more traditionally suburban locations, these households pay income taxes to the Commonwealth of Virginia.

Figure 3-9 shows Commonwealth Data Point information that provide a frame of reference for understanding the magnitude of $600 million dollars in general fund revenue. Looking at the state's general fund expenditures by agency, this funding can be compared to various agency budgets.

By way of comparison, $600 million is higher than the collective $582 million in general fund spending on higher education and public safety in fiscal 2016. General fund expenditures totaled $316 million for Virginia's universities, community college systems and the State Council for Higher Education and $266 million for the Department of State Police.

Figure 3-9 The Value of Metrorail and VRE to the Commonwealth



Source: NVTC, DRPT, and Commonwealth Data Point

Additional information on state transit funding and general fund expenditures is available in Appendix A.

APPENDIX A: METRORAIL AND VRE FUNDING IN VIRGINIA

This technical appendix provides a detailed background on the revenue and funding components of the methodology of the Economic Value of Metrorail and Virginia Railway Express to the Commonwealth of Virginia study.

Overview of WMATA and VRE Funding in Virginia

In the commonwealth, the funding of WMATA and VRE is ultimately the obligation of the local funding partners. This includes the Virginia members of the WMATA Compact: the cities of Alexandria, Fairfax and Falls Church and the counties of Arlington and Fairfax. Loudoun County will join the other five jurisdictions as the Silver Line Phase 2 becomes operational. Funding for VRE falls to the cities of Alexandria, Fredericksburg, Manassas and Manassas Park and the counties of Arlington, Fairfax, Prince William, Spotsylvania and Stafford. While it does not bear the funding obligation, the commonwealth provides financial support for VRE and WMATA. For WMATA, this financial support currently includes the commonwealth's committed match to federal funds from the Passenger Rail Investment and Improvement Act of 2008 (PRIIA). In addition to state funding, both systems receive federal transit funding, which comprises a significant part of their respective revenues.

WMATA Funding in Virginia

Local governments in Northern Virginia are obligated to fund a portion of WMATA's capital and operating budgets. This is referred to as a jurisdictional subsidy. This arrangement with local governments in the WMATA Compact area also includes the District of Columbia and State of Maryland as the other funding partners. The operating subsidy consists of WMATA's operating expenses, less fare and other revenues. The capital subsidy is the capital needs, less federal and other funding received directly by WMATA. NVTC jurisdictions use a combination of local and regional funds to meet this obligation, with a portion of those funds reimbursed by the commonwealth. Regardless of the availability of state funds, the local jurisdictions in Virginia are responsible for meeting these subsidy requirements.

A 2.1 percent regional gas tax is one tool that NVTC jurisdictions use to pay their WMATA subsidies. The commonwealth collects this tax and remits it to NVTC, where it is held in trust for member jurisdictions' restricted use. Those jurisdictions that are WMATA funding partners, must use the gas tax revenue to help cover their subsidies. In fiscal year 2017, the gas tax produced approximately $28.5 million in revenues for NVTC jurisdictions. Since the gas tax is percentage based and there is no minimum threshold of revenues, the recent decline in the price of gasoline has caused a significant decrease in gas tax collections. In fiscal 2017, gas tax collections were 42 percent less than in fiscal 2012 and fiscal 2013, when gas prices were at their highest levels. Due to the lack of a floor on the regional gas tax, NVTC local jurisdictions lost approximately $17 million in fiscal 2017. As a result, they were forced to use local funds to fill the revenue gap.

Local governments use a combination of general funds, gas tax revenue, general obligation bonds, and their 30 percent funds from the Northern Virginia Transportation Authority to fulfill their WMATA commitments. Most sources of dedicated transportation funding accessible to NVTC jurisdictions cannot be used for WMATA subsidies, as they are generally restricted to expansion projects and/or cannot be used outside of Virginia.

The commonwealth, through the Department of Rail and Public Transportation (DRPT), provides funding as a reimbursement to local jurisdictions for a portion of their WMATA operating and capital subsidy commitments. This assistance is available to all transit systems operating within Virginia. NVTC receives the funds and holds them in trust for the restricted use of the respective jurisdiction. DRPT also provides the $50 million state match under PRIIA that goes directly to WMATA.

Of the $266.5 million in WMATA capital and operating subsidies charged to Virginia localities in fiscal 2017, 8 percent was covered through the regional gas tax. State reimbursements covered approximately 53 percent, and other local funds covered the remaining 39 percent. The state and local percentages have

fluctuated greatly over the years. WMATA's fiscal 2018 adopted budget and fiscal 2018-2023 Capital Improvement Program show significant year-over-year increases in jurisdictional subsidies for capital, as WMATA addresses a backlog of projects to achieve a state of good repair. Based on current state transit funding formulas and funding projections as well as anticipated WMATA subsidies, it is expected that the percentage of local funding will increase significantly in the future.

State Transit Capital and Operating Funding for WMATA

In fiscal 2018, the commonwealth allocated roughly $194 million for WMATA operating and capital needs (Table A-1). This funding is for all three WMATA modes: Metrorail, Metrobus and MetroAccess. Based on DRPT's funding methodologies, the commonwealth's allocated support for transit capital and operating needs for Metrorail is $146 million. This funding comes from DRPT's transit capital and transit operating funds and includes the commonwealth's PRIIA match.

Table A-1 State support for WMATA budgeted for FY2018 (in millions)

Type of Funding	Metrorail	Metrobus/ MetroAccess	Total
Capital	$26.6	$13.1	$39.7
PRIIA Match	$49.5	-	$49.5
Operating	$69.9	$35.5	$105.4
Total	**$146.0**	**$48.6**	**$194.6**

Source: DRPT FY18 Six-Year Improvement Program and NVTC calculations. State support comes from DRPT transit capital and operating funds.

VRE Funding in Virginia

VRE's capital and operating expenditures are funded by a combination of passenger fare payments, federal formula transit and rail funds, commonwealth funds, local jurisdiction contributions, in-kind contributions, regional funds, local matches, and other revenue. The commonwealth's financial support includes funding from DRPT's transit and rail programs and competitive grants from VDOT's SMART SCALE program. According to the Comprehensive Annual Financial Report for the Years Ended June 30, 2016 and 2015, VRE's major sources of revenue in fiscal 2016 consisted of passenger revenue (31.8 percent), federal funds (30.5 percent), state funds (22.3 percent), and payments from member jurisdictions (13.9 percent). The remaining 1.5 percent came from regional and local matches, rentals, interest, and other sources.

State Funding for VRE

State funding for VRE consists of state transit capital and operating funding and other types of funding, which are typically related to rail or transportation expansion projects.

State Transit Capital and Operating Funding for VRE

In fiscal 2018, the commonwealth allocated about $26.3 million in transit operating and capital funding for VRE (Table A-2). This funding comes from DRPT's transit capital and operating funds. VRE is eligible to and has received state funding from DRPT's rail programs and from Virginia's SMART SCALE program for transportation capital expansion projects. These funds are treated as grants and are strictly for transportation expansion projects. Because they are not used for VRE's current capital and operating needs, they are not included in the table below.

Table A-2 State transit support for VRE budgeted for FY2018 (in millions)

Type of Funding	Total
Capital	$16.7
Operating	$ 9.6
Total	**$26.3**

Source: DRPT FY18 Six-Year Improvement Program. State support comes from DRPT transit capital and operating funds.

Other Types of State Funding for VRE

VRE is eligible to and has received state funding from sources other than DRPT's transit capital and operating programs. These DRPT rail funds include the Intercity Passenger Rail Operating and Capital Funds (IPROC) and Rail Enhancement Fund (REF). The IPROC allows funding for continued operations of Amtrak's Virginia-sponsored regional trains, investments in growth and enhancement of intercity passenger rail service in the commonwealth, and matching dollars for federal transportation grants to improve intercity passenger rail and fund high-speed rail. The REF supports the preservation and development of railway transportation facilities in the commonwealth to foster the growth of freight and/or passenger rail

transportation. These funds are not included in the calculation within this study, as they are generally for rail expansion projects and not part of the ongoing annual capital and operating needs of VRE.

Table A-3 summarizes the funding that VRE has received, as shown in the FY 2018 Rail and Public Transportation Improvement Program. Given the overlap offreight, passenger and commuter rail in Virginia, VRE may receive some level of benefit from other rail projects. Since this benefit is difficult to allocate directly to VRE, the table shows funded projects where VRE is the applicant. As it is programmed over multiple years, the rail funding shown is not entirely comparable to annual state transit capital and transit operating funding programmed for fiscal 2018. Nonetheless, this snapshot of state rail program funds provides additional context for the commonwealth's commitment to rail expansion funding in Virginia.

Table A-3 State IPROC and REF Funding for VRE as Shown in the FY18 SYIP

Funding Source	Project	Previous Allocation	FY18	FY19
IPROC	Quantico Station and Track Work	$13,600,000		
REF	Crystal City Station Platform Study		$707,000	
REF	L'Enfant Station Platform Study		$2,226,000	
REF	Brooke, Leeland, and Potomac Shores Stations Expansion Study and Design	$2,821,600		
REF	Brooke, Leeland, and Potomac Shores Stations Expansion and Construction	$4,990,000	$5,292,000	$4,900,000

Source: DRPT FY18 Six-Year Improvement Program. Note: Funds are programmed for more than one year.

VRE is also eligible to receive funding from Virginia's SMART SCALE program. SMART SCALE – which stands for System Management and Allocation of Resources for Transportation: Safety, Congestion Accessibility, Land Use, Economic Development and Environment – is a state program designed to balance transportation needs and prioritize investments for both urban and rural communities throughout the commonwealth. Unlike state transit capital and operating funds, SMART SCALE funding applies to transportation expansion projects. As it is programmed over multiple years, the rail funding from SMART SCALE is not entirely comparable to annual state transit capital and transit operating funding programmed for fiscal 2018. Nonetheless, this snapshot of SMART SCALE funds provides additional context for the commonwealth's commitment to rail and transit expansion in Virginia. Table A-4 shows the SMART SCALE funds VRE was awarded in fiscal 2018.

Table A-4 FY2018 SMART SCALE Funding for VRE

Funding Source	Project	FY18 SMART SCALE Funding
SMART SCALE	Improve Brooke and Leeland VRE Stations, Construct Potomac Shores VRE Station	$22,047,320
SMART SCALE	VRE Fredericksburg Line Capacity Expansion	$70,588,800

Source: FY2018 SMART SCALE Funded Projects Note: Funds are programmed for more than one year.

VRE is also anticipated to receive funding from the Transform 66 Outside the Beltway Concessionaire. As part of the project, the private partner, Express Mobility Partners, has agreed to provide a payment to the Commonwealth of up to $500 million for multimodal projects within the I-66 outside the Beltway corridor. The Northern Virginia Transportation Authority solicited eligible projects and made project recommendations to the Commonwealth Transportation Board (CTB). One of these projects included a VRE project, Manassas Line Capacity Expansion and Real-time Multimodal Traveler Information, for nearly $128.5 million in concessionaire funds. On January 10, 2018, the CTB allocated up to $500 million from the Transform 66 Outside the Beltway Concession Payment Account to a number of projects, including the aforementioned VRE project, and added them to the FY2018-FY2023 Six Year Improvement Program.

State Sources of Revenue for Metrorail and VRE Transit Funding

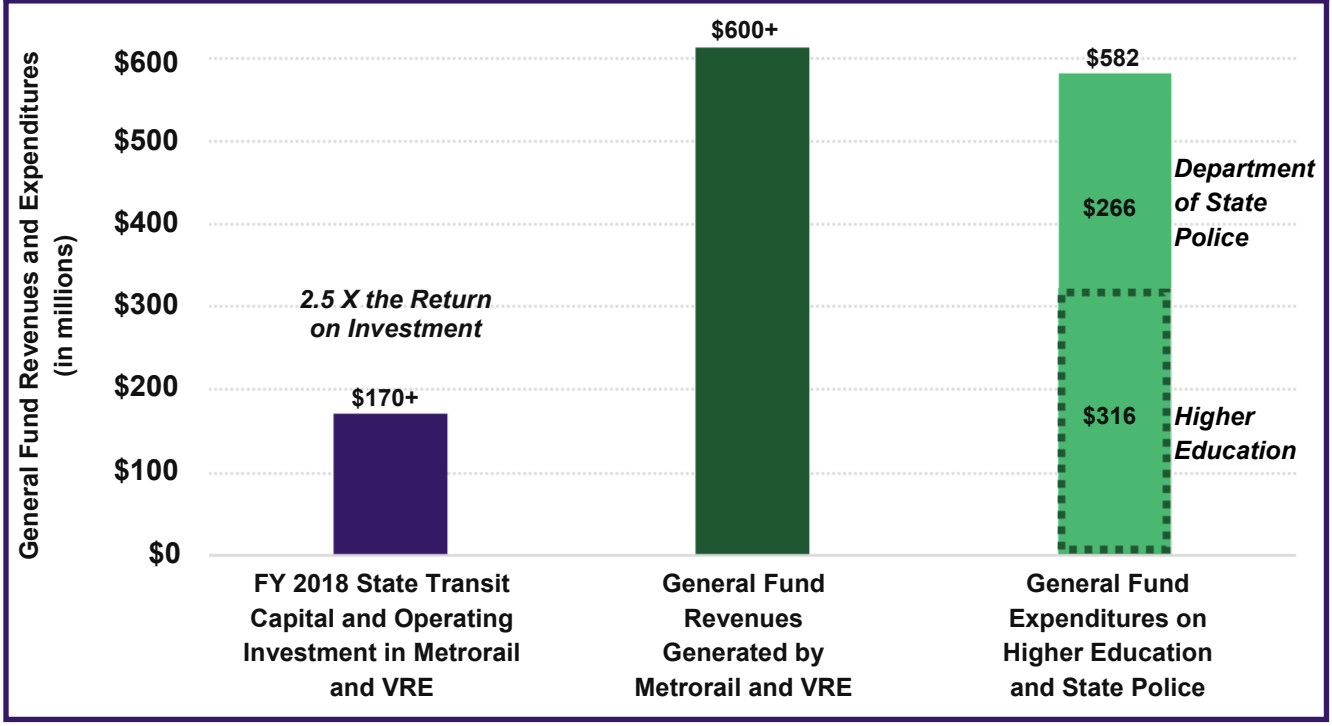
DRPT's state transit capital and operating funds, which total $389 million in fiscal 2018, come from a variety of sources. They include the recordation tax, retail sales and use tax, statewide motor vehicle fuels tax, and 10-year Capital Project Revenue (CPR) bonds. The expected revenue sources for the CPR debt service payments are insurance premium taxes and the statewide motor vehicle fuels tax. DRPT also provides federal Surface Transportation Program funds for VRE track lease and other transit projects, Congestion Mitigation and Air Quality, and federal formula funds for rural systems.

While DRPT's operating assistance funding is stable, Virginia's source of funding for transit capital investments, the transit capital program, faces a pending funding shortfall. In fiscal 2019, $110 million or 44 percent of all program funding will begin to phase out as the 10-year life of the CPR bonds comes to a close. If no action is taken by the General Assembly, this funding shortfall of $110 million per year will apply to all transit agencies in the commonwealth, including NVTC localities, which use this funding as reimbursements for their WMATA capital subsidies. Since the local jurisdictions are responsible for funding WMATA, this revenue gap would have to be filled with local funds. This transit capital funding shortfall would also jeopardize the commonwealth's ability to fund its annual $50 million match, as required under PRIIA.

State General Fund Expenditure Comparisons

The land use supported by Metrorail and VRE generates approximately $600 million in general fund revenues. This is between 3 and 4 percent of the $18.2 billion in general fund revenues collected in Virginia in fiscal 2016. The commonwealth provides approximately $172 million in annual state transit funding for the operating and ongoing capital needs of Metrorail and VRE; $600 million represents 2.5 times the return on investment. Metrorail and VRE move large numbers of people, relieve congestion and are integral components of local land use and economic development plans. High capacity transit attracts jobs and households to Northern Virginia. These households could work in Virginia, the District or Maryland. Whether in new apartment buildings, transit oriented developments near Metrorail stations, or more traditional suburban locations, these households all pay income taxes to the commonwealth.

Figure A-1 The Value of Metrorail and VRE to the Commonwealth



Source: NVTC, DRPT, and Commonwealth Data Point

As this study only estimates general fund revenues from two sources, the personal income tax and a portion of the sales tax, the revenue estimate is likely a conservative approximation of state revenues generated by the land use that Metrorail and VRE support. Exploring the Commonwealth Data Point, a state website that provides transparency of state data and financial figures, offers a frame of reference for understanding the magnitude of $600 million dollars in general fund revenue. By looking at the state's general fund expenditures by agency, the magnitude of funding can be framed against various state agencies.

General fund expenditures of $600 million is slightly higher than the fiscal 2016's $582 million in general fund expenditures on higher education and state police (Figure A-1 on page 29). These examples provide a tangible frame of reference for the value of Metrorail and VRE to state revenues. In fiscal 2016, general fund expenditures totaled $266 million for the Department of State Police and totaled $316 million for Virginia's universities, community college systems, and the State Council for Higher Education in Virginia. Table A-5 details how higher education expenditures were calculated.

Table A-5 Direct General Fund Expenditures on Higher Education (FY2016)

State Agency	Expenditures (FY2016)	State Agency	Expenditures (FY2016)
Blue Ridge Community College	$1,223,927	Rappahannock Community College	$524,220
Central Virginia Community College	$645,400	Richard Bland College	$593,957
Christopher Newport University	$9,506,647	Roanoke Higher Education Authority	$1,215,995
Dabney S. Lancaster Community College	$308,831	Southern Virginia Higher Education Center	$2,468,283
Danville Community College	$1,407,832	Southside Virginia Community College	$1,440,675
Eastern Shore Community College	$297,385	Southwest Virginia Community College	$668,152
George Mason University	$21,839,384	Southwest Virginia Higher Education Center	$1,571,170
Germanna Community College	$1,144,101	State Council Of Higher Education For Virginia	$69,318,761
J. Sargeant Reynolds Community College	$3,779,666	The College Of William And Mary In Virginia	$4,202,011
James Madison University	$17,670,658	Thomas Nelson Community College	$2,799,645
John Tyler Community College	$1,794,926	Tidewater Community College	$8,498,326
Longwood University	$4,409,608	University Of Mary Washington	$6,783,312
Lord Fairfax Community College	$1,500,129	University Of Virginia - College At Wise	$2,505,014
Mountain Empire Community College	$1,097,810	University Of Virginia-Academic Division	$24,504,450
New College Institute	$1,921,344	Virginia Commonwealth University - Academic Division	$31,256,650
New River Community College	$1,039,079	Virginia Highlands Community College	$578,627
Norfolk State University	$8,164,972	Virginia Military Institute	$981,728
Northern Virginia Community College	$8,805,538	Virginia Polytechnic Institute And State	$26,333,848
Old Dominion University	$21,600,781	Virginia State University	$7,382,428
Patrick Henry Community College	$990,716	Virginia Western Community College	$1,928,970
Paul D. Camp Community College	$384,337	Wytheville Community College	$733,703
Piedmont Virginia Community College	$964,231		
Radford University	$9,081,142		
Subtotal	*$119,578,444*	*Subtotal*	*$196,289,925*
TOTAL: $315,868,369			

Source: Commonwealth Data Point

The $316 million in direct general fund expenditures are one component of the commonwealth's total general fund commitment to higher education. A large portion of general fund appropriations for higher education are transferred to and expended from the commonwealth's Higher Education Operating Fund. The same agencies that totaled $316 million in direct general fund expenditures totaled $1.67 billion in general fund adjusted legislative appropriations for higher education in fiscal 2016 (Table A-6 on page 31).

Utilizing Commonwealth Data Point comparisons to other types of state general fund expenditures is possible.

In fiscal 2016, general fund expenditures for the Compensation Board totaled $657 million. The Compensation Board determines a reasonable budget for the commonwealth's contribution toward the cost of office operations for constitutional officers (sheriff's offices and courts) and enhancement of services provided to the citizens of Virginia. Much of this assistance is goes to sheriff's offices and regional jails.

In fiscal 2016, general fund expenditures for the Treasury Board totaled $673 million. The Treasury Board exercises general supervision over all investments of state funds and approves the terms and structure of certain bonds or other financing arrangements paid from state appropriations. This assistance is entirely programmed for bond and loan retirement and redemption.

Table A-6 General Fund Appropriations for Higher Education (FY2016)

Agency Name	FY2016 General Fund Adjusted Legislative Appropriation
Christopher Newport University	$30,680,321
George Mason University	$142,881,281
James Madison University	$81,996,990
Longwood University	$29,395,815
New College Institute	$1,518,753
Norfolk State University	451,211,803
Old Dominion University	$132,697,173
Radford University	$54,275,371
Richard Bland College	$6,465,152
Roanoke Higher Education Authority	$1,122,013
Southern Virginia Higher Education Center	$2,348,360
Southwest Virginia Higher Education Center	$2,012,483
State Council of Higher Education for Virginia	$82,793,038
The College of William and Mary in Virginia	$43,739,360
University of Mary Washington	$27,258,203
University of Virginia's College at Wise	$16,035,000
University of Virginia	$137,099,157
Virginia Commonwealth University	$199,048,008
Virginia Military Institute	$13,605,980
Virginia Polytechnic Institute and State University	$174,543,831
Virginia State University	$38,796,332
Virginia Community College System	$405,711,667
Total	**$1,675,236,091**

Source: Virginia Department of Planning and Budget, Operating Plan for State Agencies. Queried to FY2016 Operating Dollars for General Funds.

The commonwealth provides significant financial support for local school systems. In fiscal 2016, the Department of Education expended over $5.5 billion in general fund revenues on direct aid to public education. The $600 million in general fund revenues attributable to the land use supported by Metrorail and VRE is equivalent to approximately 11 percent of this direct aid to public education, which is received by all localities in Virginia.

In fiscal 2016, general fund expenditures for the Compensation Board totaled $657 million. The Compensation Board determines a reasonable budget for the commonwealth's contribution toward the cost of office operations for constitutional officers (sheriff's offices and courts) and enhancement of services provided to the citizens of Virginia. Much of this assistance is goes to sheriff's offices and regional jails.

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The commonwealth provides significant financial support for local school systems. In fiscal 2016, the Department of Education expended over $5.5 billion in general fund revenues on direct aid to public education. The $600 million in general fund revenues attributable to the land use supported by Metrorail and VRE is equivalent to approximately 11 percent of this direct aid to public education, which is received by all localities in Virginia.

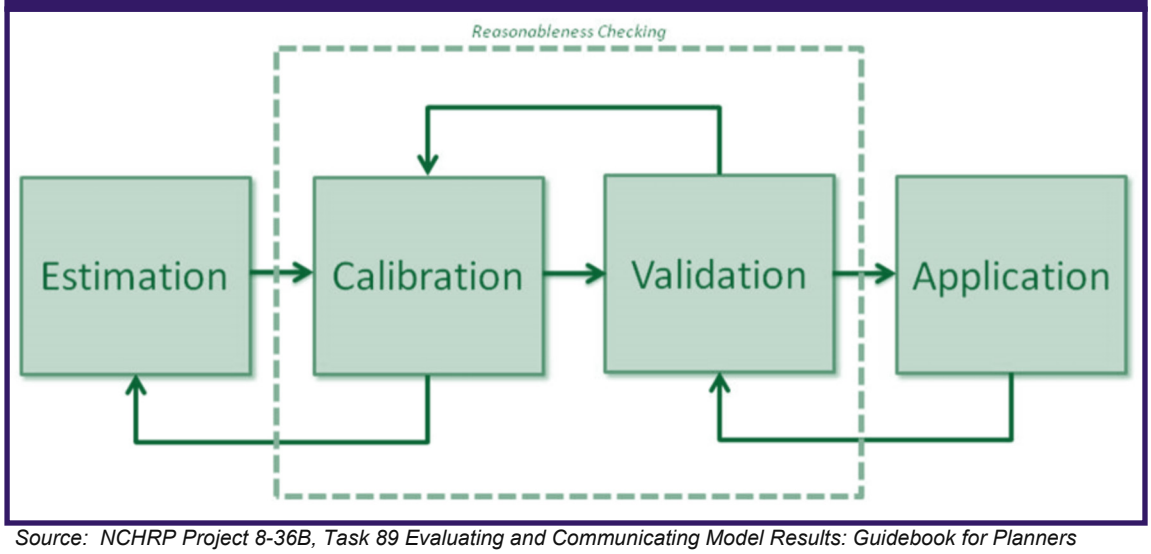
APPENDIX B: MODEL VALIDATION

Travel demand forecast models are a composite of different sub-models linked together in a serial process. The development and construction of a travel demand forecast model is a serial process. The steps in travel demand forecast model development are estimate, calibrate and validate before applying the model (Figure B-1). An effective model is developed based on local data and tested to see how well it replicates base-year travel patterns. First, the sub-models that make up the travel demand forecast model must be estimated. Then the model must be checked and tested for reasonableness in two stages, defined as calibration and validation. After validation is successful, the model is ready for application.

Model Estimation

The first step is using statistical estimation to find the model parameter values that maximize the likelihood of the model fitting the observed travel data. The focus is on specifying the form of the model and determining the statistical significance of the variables used in the model. This step is dependent on the availability of local data. There are cases where local data is not available, and data from nearby regions or national data is substituted. This, however, often leads to challenges later, when calibrating and validating the model set.

Figure B-1 Travel Demand Forecast Model Development Process



Source: NCHRP Project 8-36B, Task 89 Evaluating and Communicating Model Results: Guidebook for Planners

Model Calibration

The second step in the process is model calibration. After the model structure has been defined and the variables estimated, the calibration adjusts the sub-model coefficients and parameters until the predicted outcome matches the observed data. Each sub-model in the travel demand forecast model is calibrated in isolation of the next model. The calibration focuses on adjusting the sub-model estimated equations. The variables are adjusted until the base-year data can be matched by the sub-model. There is interaction between the calibration effort and the model estimation phase. If the model cannot be calibrated, then often the estimation phase must be revisited. The calibration targets and observed data are often grouped by some type of market segmentation, which may include income or geographic area within the region.

Model Validation

The terms validation and calibration are often confused. Validation involves checking the model results against observed data, sometimes at the aggregate level, and adjusting the calibration until the model results fall within an acceptable range of error.

Validation is performed at different levels, corresponding to the needs of the transportation study. For the whole model set, a regional validation effort is done to look at how the model predicts for an entire metropolitan region. For a corridor or sector study, it is best practice for the model to be validated for the study area. In these cases, the same metrics are evaluated for each step in the process. For example, if vehicle miles traveled (VMT) by facility type was used, it would not include all VMT but only those freeway segments at the study area.

Many times, in aggregating the observed data and the modeled results, the values average out. So, there might be an area in the model that is low in VMT on freeways but another area in the model that is high, with the end result being total VMT close to the observed. When drilling down into lower levels of studies, these errors often come out and require recalibration so they won't distort the study outcome. In general, validation of the model set is usually done on both a continuing and project basis, while calibration is only done when new survey data is collected or modifications are made to the models.

Model Application

Depending on the level of study, a validation effort of some scale is needed to ensure that the model is predicting observed trends adequately. There are no set national standards for validation and the level of detail is a function of the application needs, but there are several guides on acceptable practice. It is important to note that the reasonableness of the application results is tied to the validation. Though a travel demand forecast model is estimated and calibrated on observed data, major societal changes affecting travel behavior can change the model estimation and impact the accuracy of the application results.

For this analysis, the MWCOG/TPB Version 2.3.66 model set was used to estimate the impacts of changes to the land use and transportation network. The mode was calibrated and validated at the regional level. Therefore a subarea validation was required to ensure that the model was adequately representing travel patterns in the defined study area. For this analysis, the defined study area was Northern Virginia. This included the following jurisdictions:

- Arlington County
- City of Alexandria
- Fairfax County and all the towns and cities located within the county boundaries
- Loudoun County and all the towns and cities located within the county boundaries
- Prince William County and all the towns and cities located within the county boundaries

The validation effort focused on these jurisdictions. The base year for the model validation was 2010, as there are ample data (e.g., MWCOG Household Travel Survey, 2010 Census, WMATA passenger surveys, etc.) available to review all steps of the travel demand forecast model. The purpose of the validation is to ensure that the model accurately captures travel choices and matches demand in Northern Virginia. The focus of the model validation was work trips and the morning peak period. Since NVTC's analysis primarily looked at work or commuter trips, the morning commuting period was the focus of the analysis.

Trip generation is the amount of travel produced by a specific land use. There are different numbers of trips by trip purpose. In the model, trip ends are defined as either productions or attractions. For this validation, NVTC focused on matching home-based work production trip ends estimated in the model to observed data. The focus was on productions, since the model balances attractions to productions. Table B-1 summarizes the trip generation validation.

The absolute regional percent difference for the home-based work productions was 4.4 percent. For all jurisdictions, except Arlington, the absolute difference was under 10 percent. Arlington was less than 15 percent. Arlington's size and the Department of Defense facilities located in the county could have contributed to the lower than observed productions. Even though attractions are balanced against productions the trip generation validation did look at the observed to estimated home-based work attractions as a reasonableness check. For Northern Virginia, the estimated home-based work attractions were 2.9 percent less than the observed.

Table B-1 Northern Virginia Trip Generation Validation Results for Productions

	HBW Model	HBW Household Travel Survey (adjust 2008 - 10)	Percent Difference
Jurisdictions	**Productions**	**Productions**	**Productions**
Arlington	129,018	149,945	-14.0%
Alexandria	91,963	102,105	-9.9%
Fairfax	673,617	702,263	-4.1%
Loudoun	176,147	167,690	5.0%
Prince William	251,531	260,791	-3.6%
Northern Virginia	**1,322,276**	**1,382,794**	**-4.4%**

In addition to the larger jurisdiction, a subset of key activity areas was reviewed. Table B-2 shows the results for these activity areas. Overall for these areas, the model had reasonable estimates when compared to the observed data. Where the difference was greater than 20 percent, the total number of trip ends was relatively small. For all of the key activity areas, the production estimates were within 15 percent of the observed data and for attractions the estimated trip ends were within 5 percent of the observed. These areas are key employment centers, so the attractions are of greater importance than the productions.

Table B-2 Key Activity Area Trip Generation Validation Results

	HBW Model		HBW Household Travel Survey (adjust 2008 - 10)		Percent Difference	
Activity Areas	**Productions**	**Attractions**	**Productions**	**Attractions**	**Productions**	**Attractions**
Tysons	20,089	109,065	18,178	108,488	10.5%	0.5%
Old Town	14,315	40,877	15,450	48,328	-7.3%	-15.4%
Rosslyn-Ballston Corridor	28,342	124,070	36,612	106,470	-22.6%	16.5%
Crystal City	17,757	80,100	24,243	75,988	-26.8%	5.4%
Total	**80,503**	**354,112**	**94,483**	**339,274**	**-14.8%**	**4.4%**

The trip distribution step in the model process determines the origin and destination for a specific trip. NVTC looked at the flows between jurisdictions in the region with a special focus on core areas, including the District of Columbia and Arlington County. Table B-3 shows the trip distribution for productions and attractions for home-based work trips within the Northern Virginia.

Table B-3 Percent Difference Home-Based Work Production and Attraction Distribution within Northern Virginia

	Home-Based Work Trips	
Jurisdictions	**Productions**	**Attractions**
Arlington	15%	25%
Alexandria	8%	-15%
Fairfax	-6%	-8%
Loudoun	-7%	-6%
Prince William	-3%	-2%
Northern Virginia	-3%	-3%

Table B-4 shows the distribution for key employment centers. Since the focus of the analysis was on home-based work trips, it was important to evaluate trips in high employment

areas. Overall the difference for the distribution to key employment areas was under 25 percent. There were certain interchanges with a high percent difference, but these interchanges have few trips compared to other origin-destination pairs.

Table B-4 Trip Distribution Northern Virginia Jurisdictions to Core Employment Areas

	Model		HTS			
HBW	To ARL Core	To DC Core	To ARL Core	To DC Core	ARL Core	DC Core
Arlington	7,612	37,360	4,141	54,149	84%	-31%
Alexandria	3,467	23,893	2,318	32,173	50%	-26%
Fairfax	14,629	110,057	14,446	114,791	1%	-4%
Loudoun	2,050	12,973	701	7,002	192%	85%
Prince William	2,716	17,419	2,969	19,232	-9%	-9%
Total	**30,474**	**201,702**	**24,575**	**227,347**	**24%**	**-11%**

The mode choice step determines what mode a trip will take given the origin, destination, travel time, and cost. NVTC focused on rail modes and total transit shares for the validation. The validation effort looked at mode share for productions and attractions at the jurisdictional level and at the defined key activity clusters. Table B-5 summarizes the results at the jurisdiction level and Table B-6 shows the results for the key activity areas.

Table B-5 Northern Virginia Mode Share Validation Results

	HBW Transit Model		HBW Transit HTS (adjust 2008-10)		HBW Transit Share Model		HBW Transit Share HTS (adjust 2008-10)	
Jurisdictions	Productions	Attractions	Productions	Attractions	Productions	Attractions	Productions	Attractions
Arlington	60,545	102,360	72,930	89,509	47%	40%	49%	41%
Alexandria	33,798	16,611	39,663	23,391	37%	21%	39%	25%
Fairfax	112,861	27,550	108,289	29,692	17%	4%	15%	4%
Loudoun	5,343	443	3,064	769	3%	0%	2%	1%
Prince William	14,700	1,536	16,065	1,984	6%	1%	6%	1%
NOVA	**227,247**	**148,500**	**240,010**	**145,345**	**17%**	**12%**	**17%**	**12%**

For the key activity, or employment, areas, the attraction end is more important than the production end. Overall the model adequately replicated the mode shares for these areas.

Table B-6 Key Activity Areas Mode Share Validation Results				
	HBW Transit Model		HBW Transit HTS (adjust 2008 - 10)	
Activity Centers	**Productions**	**Attractions**	**Productions**	**Attractions**
Tysons	18%	6%	18%	6%
Old Town	45%	28%	57%	34%
Rosslyn-Ballston Corridor	60%	44%	65%	37%
Crystal City	52%	44%	67%	60%
Total	**45%**	**30%**	**55%**	**31%**

Overall the model was determined to be functioning adequately for this study and no changes were made to the model parameters.

APPENDIX C: REFERENCES & RESOURCES

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THE VALUE OF METRORAIL AND VIRGINIA RAILWAY EXPRESS TO THE COMMONWEALTH OF VIRGINIA

NORTHERN VIRGINIA TRANSPORTATION COMMISSION

THE VOICE OF TRANSIT IN NORTHERN VIRGINIA

APPENDIX D: SEPTEMBER 2017 REPORT

Metrorail and the Virginia Railway Express (VRE), the state's only commuter railroad, are the backbone of Northern Virginia's transit system, moving approximately 293,000 people on an average weekday in Northern Virginia. These systems get people to work, help create thriving communities and relieve congestion on roadways. They also fuel economic development across Northern Virginia. High density development clustered around rail stations produces property tax and other revenues that help fund schools, parks, and a range of public services in our communities. The local economic value of high capacity transit is well studied, yet Metrorail and VRE also produce significant revenues for the Commonwealth of Virginia. In fact, the households and jobs supported by Metrorail and VRE generate over $600 million in state general fund revenues.

Metrorail and VRE Service in Northern Virginia

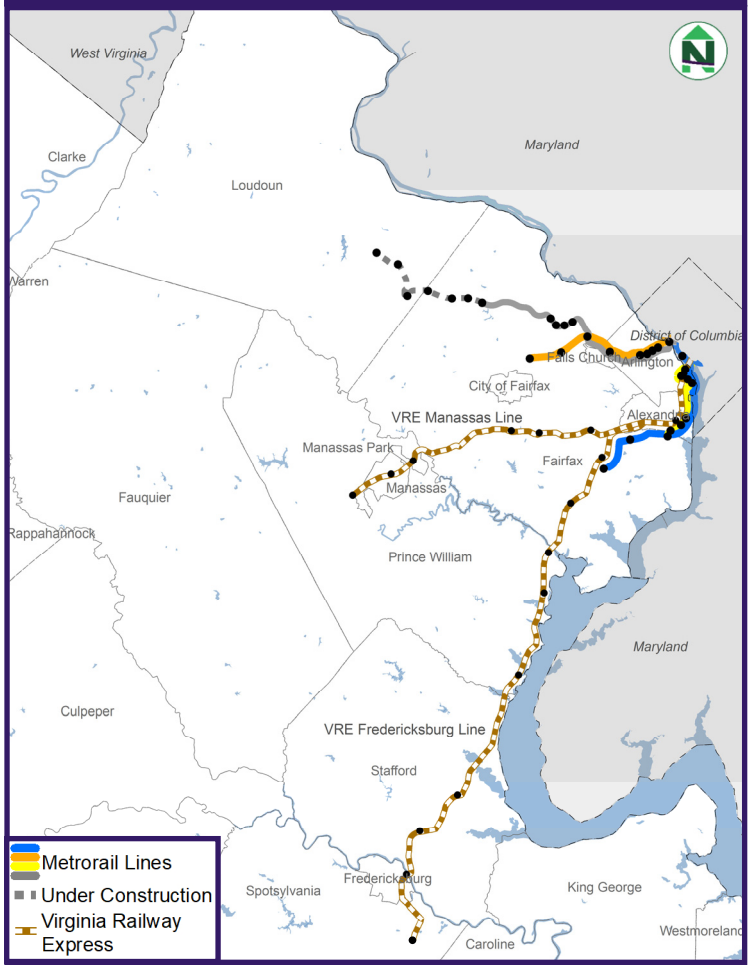

Figure 1 Source: NVTC

OVERVIEW

NVTC's analysis finds that:

- The presence of Metrorail and VRE supports an additional 85,000 households and 130,500 jobs in Northern Virginia.
- Those households and jobs generate more than $600 million annually in sales and income tax revenue that flow to the state's general fund.
- Given Virginia's annual transit operating and capital contribution to Metrorail and VRE (about $170 million budgeted in fiscal year 2018), the return on investment to the Common-wealth exceeds 250 percent.
- $600 million, which represents just over 3 percent of general fund revenues, covers Virginia's annual, general fund expenditures on state colleges and universities (about $316 million) and state police (about $266 million).

BACKGROUND

The benefits that accrue to communities served by rail are well documented. Several studies — including one in 2011 by the Washington Metropolitan Area Transit Authority (WMATA) and another

in 2017 by the Metropolitan Washington Council of Governments (COG) — demonstrate the value of transit to localities in the greater Washington, D.C. region. According to WMATA:

- $235 billion of property value is within a half-mile of Metrorail stations.
- This land generates $3.1 billion annually in property tax revenues.
- This land represents 28 percent of the jurisdictions' property tax base, but only 4 percent of their land.
- Proximity to Metrorail increases property values by 7 to 9 percent.

COG notes that $25 billion of development has occurred near Metro stations over the past eight years.

With Metrorail experiencing track segment shutdowns to handle a backlog of deferred maintenance and as discussions about finding dedicated funding for WMATA gained traction in late 2016, NVTC planners considered whether the economic benefits associated with the rail system extended beyond the property taxes collected by local jurisdictions. The question arose as to what value Metrorail and VRE, which NVTC co-owns, bring to Virginia.

NVTC planners applied a model to determine the additional number of households and jobs that exist in Northern Virginia resulting from rail service. The model used the existing level of roadway congestion as a base and then determined the likely level of congestion and deterioration in travel times were Metrorail and VRE not available. Staff then rebalanced households and jobs in the region until they reached the level of congestion that currently exists on Northern Virginia's roadways.

Part of what distinguishes this study from previous ones, including reports issued by NVTC in 1994 and 2005, is that it is dynamic rather than static, accounting for the level of activity that the regional transportation network can support. NVTC's approach is unique in that it evaluates the interaction between land use and transportation demand. The study found that the presence of Metrorail and VRE alone supports an additional 85,000 households and 130,500 jobs in Northern Virginia, which enhances the amount of sales and income taxes collected by the Commonwealth. The fact is that the entire state reaps dividends — to the tune of approximately $600 million in general fund revenues — from Metrorail and VRE service in Northern Virginia.

Where in Northern Virginia Do Metrorail Riders Live?

Of the approximately 665,000 Metrorail riders per weekday, 30 percent live in Virginia. More than 90 percent of Virginia's average weekday riders come from NVTC jurisdictions – the counties of Arlington, Fairfax and Loudoun and cities of Alexandria, Fairfax and Falls Church. Given the extent of VRE service and other commuter connections, over 13,000 of Metrorail's average weekday riders live in Virginia outside of NVTC jurisdictions. Many of these riders live south and west of the compact area and use VRE to connect to Metrorail in Virginia or the District of Columbia. About a third of Virginia riders live within a half mile of a Metrorail station.

Where Metrorail Riders Live in Northern Virginia

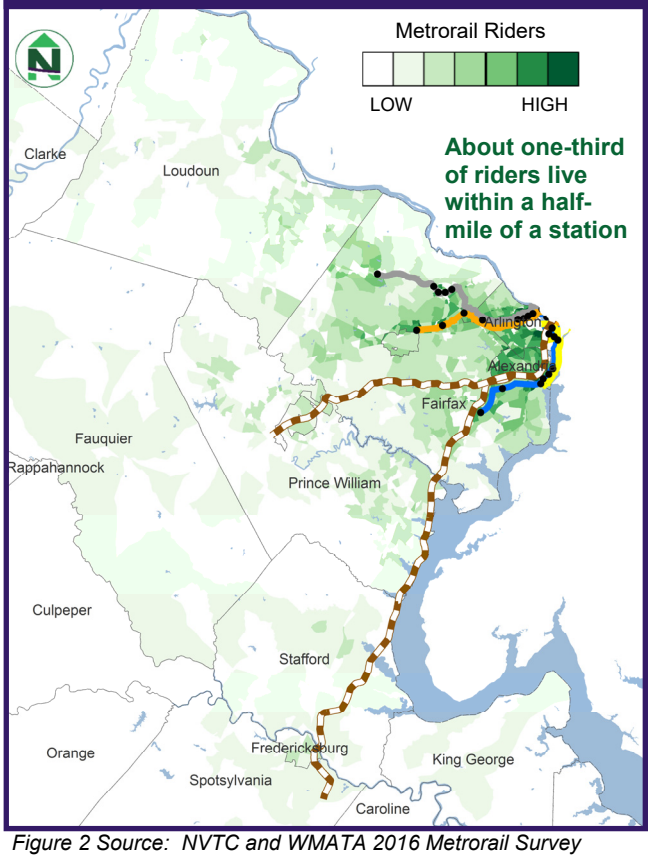

Figure 2 Source: NVTC and WMATA 2016 Metrorail Survey Ridership weighted by population per traffic analysis zone

Who rides Metrorail in Northern Virginia?

Virginians access Metrorail stations by walking (38 percent), taking the bus (27 percent), and driving and parking (21 percent). Thirty-seven percent of Virginia riders are federal employees and 50

percent have household incomes greater than $100,000. There are over 300,000 jobs within a half mile of Virginia Metrorail stations and Metrorail is commonly used by residents of the district, Maryland and Virginia to commute to these jobs.

Where Metrorail Riders Live in Northern Virginia's Inner Suburbs

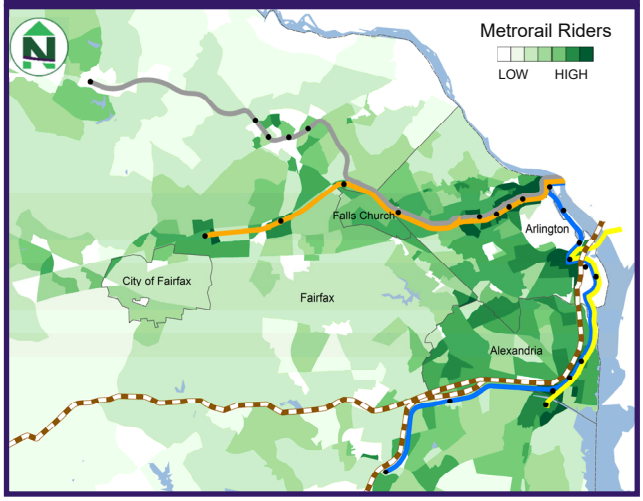

Figure 3 Source: NVTC and WMATA 2016 Metrorail Survey
Ridership weighted by population per traffic analysis zone

Where do VRE riders live in Northern Virginia?

VRE provides roughly 20,000 trips on an average weekday. Given that VRE is a commuter railroad, its ridership extends farther in the region than Metrorail. Over 60 percent of VRE's riders come from Stafford, Fairfax, Prince William and Spotsylvania counties.

How much does the Commonwealth spend on Metrorail and VRE?

Virginia spends about $170 million annually on Metrorail and VRE from its transit capital and operating funds, which total nearly $380 million for all transit in the Commonwealth in fiscal 2018. The revenue for these funds comes from a variety of sources, including the recordation tax, retail sales and use tax, statewide motor vehicle fuels tax and 10-year Capital Project Revenue (CPR) bonds. The expected revenue sources for the CPR debt service payments are insurance premium taxes and the statewide motor vehicle fuels tax.

How is WMATA funded in Virginia?

In Virginia, WMATA is funded by the localities identified in the WMATA Compact: Fairfax and Arlington counties and the cities of Alexandria, Falls Church and Fairfax. Loudoun County will join in supporting Metro as the Silver Line Phase 2

Metrorail Riders in Virginia by Household Income

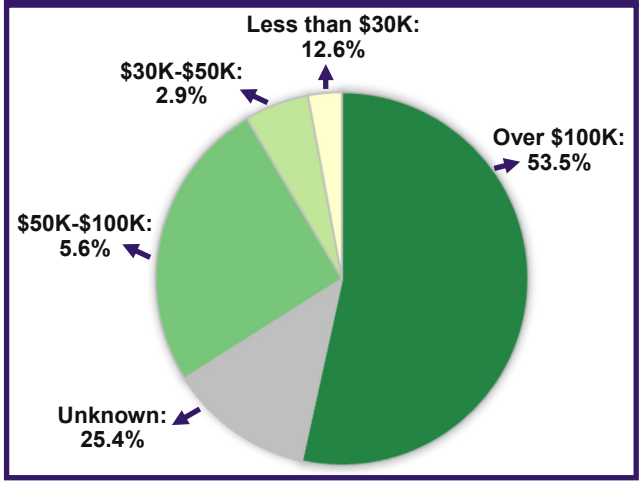

Figure 4 Source: WMATA 2016 Metrorail Survey

becomes operational. NVTC jurisdictions primarily use local funds to meet this obligation, with a considerable portion of expenditures reimbursed by the Commonwealth. Regardless of the availability of state funds, the local jurisdictions are responsible for meeting Metro's financial needs.

Where VRE Riders Live in Northern Virginia

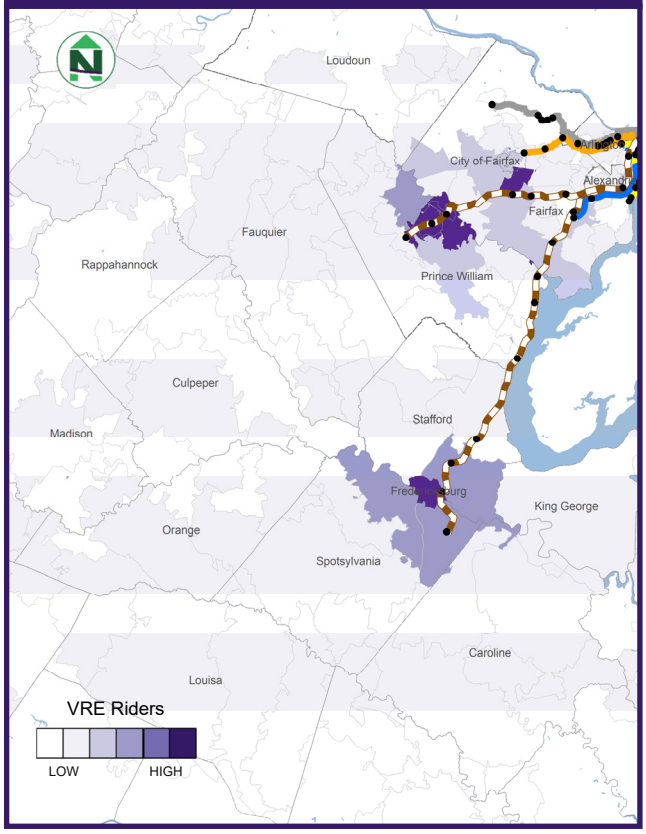

Figure 5 Source: NVTC and VRE 2016
Ridership weighted by population per zip code

Funding sources for local government use include:

- General funds
- General obligation bonds
- Northern Virginia Transportation Authority 30-percent funds
- 2.1 percent regional gas tax revenues

In fiscal 2018, the Commonwealth budgeted about $195 million for WMATA operating and capital subsidies. This funding is for all WMATA modes: Metrorail, Metrobus and MetroAccess. Based on the Department of Rail and Public Transportation's (DRPT) funding methodologies, the commonwealth's budget for Metrorail is $146 million. The funding comes from DRPT's transit capital and transit operating funds.

State Support for WMATA, FY2018 (millions)			
	Metrorail	Metrobus/ MetroAccess	Total
Capital	$ 26.6	$13.1	$ 39.7
PRIIA Match	$ 49.5	-	$ 49.5
Operating	$ 69.9	$35.5	$105.4
Total	$146.0	$48.6	$194.6

Table 1 Source: DRPT FY18 Six-Year Improvement Program and NVTC calculations. State support comes from DRPT transit capital and operating funds.

How is VRE funded in Virginia?

VRE's capital and operating expenditures are funded by a combination of sources, including passenger revenue, federal formula transit and rail funds, Commonwealth of Virginia funds, local jurisdictional contributions, in-kind contributions, regional funding, local matches, and other revenues. In fiscal 2018, the Commonwealth budgeted over $26 million for VRE operating and capital funding from DRPT's transit capital and operating programs. VRE is eligible for and has received funding from DRPT's rail programs and from the Virginia Department of Transportation's SMART SCALE program for capital expansion projects. Because they are not used for VRE's current or ongoing capital and operating needs, these funds are not included in the table below.

State Support for VRE, FY2018 (millions)	
	Total
Capital	$16.7
Operating	$ 9.6
Total	$26.3

Table 2 Source: DRPT FY18 Six-Year Improvement Program and NVTC calculations. State support comes from DRPT transit capital and operating funds.

Threats to Rail Transit Funding in Northern Virginia

Regional Gas Tax

A flaw in the 2.1 percent regional gas tax has led to a more than 40 percent decline in revenues between fiscal 2017 and 2013, when gas prices were at their highest. The regional gas tax – unlike the state tax, which no matter how low the price of gas goes has a fixed minimum – has no bottom threshold. Receipts from the regional gas tax are used by local jurisdictions to support their financial commitment to WMATA.

Transit Capital Funding Shortfall

With the expiration of CPR bonds, the amount available for transit capital investments in Virginia will begin to drop by $110 million or more than 40 percent in fiscal 2019. Legislative action is needed to insure adequate support for all transit agencies in the Commonwealth, including NVTC jurisdictions that rely on these funds for reimbursement of their WMATA capital subsidies. This funding shortfall could jeopardize the Commonwealth's ability to fund its $50 million match required under the federal Passenger Rail Investment and Improvement Act of 2008.

Methodology for Calculating the Value of Metrorail and VRE to the Commonwealth

1) Determine the existing level of roadway congestion

Use the regional land use and transportation model to calculate the existing level of roadway congestion in Northern Virginia.

2) Calculate the households and jobs supported by high capacity transit

Remove Metrorail and VRE from the transportation model in Northern Virginia and recalculate roadway congestion. Rebalance households and jobs across the region until congestion reaches current levels.

3) Estimate state revenues

With the number of households and jobs supported by Metrorail and VRE calculated, estimate the annual contribution to Virginia's general fund from state income and sales taxes.

THE VALUE OF METRORAIL AND VIRGINIA RAILWAY EXPRESS TO COMMUTERS IN THE REGION

In quantifying the value that Metrorail and VRE bring to the Commonwealth, NVTC determined the amount of land use and development that could be supported with only the current roadway and bus networks. The existing level of roadway congestion was used as the base level. The regional travel demand forecast model was then run without Metrorail and VRE to assess the likely level of congestion and deterioration in travel times. Households and jobs were removed to return the level of congestion to what exists today. Congestion was measured by the distance of the average commuter trip and the distribution of congested lane miles of travel.

Commuters have a travel time budget. Based on the congestion level, a specific trip can travel only so far in a given amount of time. Historical data shows little change in average commuter travel times for mature urban areas. The Metropolitan Washington Council of Governments (COG) does regional household travel surveys, which consistently show an average commuter trip travel time of about 30 minutes.

Existing Average Commuter Trip Distance for All Modes by Jurisdiction (miles)

Jurisdiction	Average Commuter Trip Distance
Arlington	7.89
Alexandria	9.26
Fairfax	11.64
Loudoun	17.22
Prince William	17.06
Northern Virginia Combined	13.44

Table 3 Source: Transportation Planning Board V2.3.66 Travel Demand Forecast Model

Following the removal of Metrorail in Northern Virginia and VRE from the model, households and jobs were shifted to Maryland and the district. The model was run iteratively until the average commuter trip distance matched what currently exists. The level of congestion on the roadway network was also matched to the existing level.

Existing Peak Period Congested Roadway Lanes in Northern Virginia (miles)

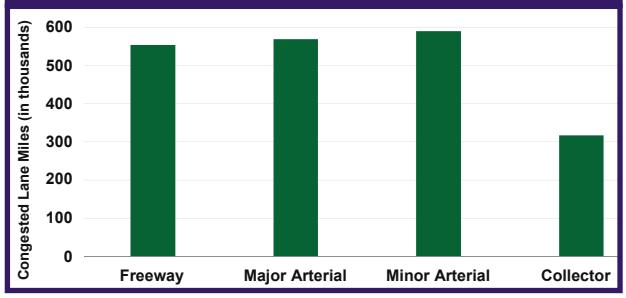

Figure 6 Source: Transportation Planning Board V2.3.66 Travel Demand Forecast Model

The first model runs removed rail transit in Northern Virginia and held to the existing land use totals. The results of these runs demonstrate the importance of rail in Northern Virginia. With the added congestion, commuters could not travel as far in the same amount of time. Their trip length decreased by about 5 percent, which is significant. By comparison, the trip length decrease projected by COG in 2040 with all funded regional projects was less than 5 percent.

The major impacts associated with a lack of rail transit in Northern Virginia are:

- 56,500 more lane miles of congestion on arterial roadways;
- 50 percent fewer transit trips in the peak period; and
- 80 percent decrease in jobs accessible by transit for Northern Virginia households.

Rail transit is an important option for commuters living inside the Beltway. Nearly half of Arlington County's commuters use transit. That share drops to 28 percent without rail. Just under 40 percent of commuters in the City of Alexandria take transit. That number falls to 24 percent without rail. In Fairfax County, the percentage of commuters using transit drops from 17 to 6. Some of these commuters switch to buses, but the majority switch to automobiles. Without rail transit in Northern Virginia there is a loss of 130,000 daily transit trips.

Commuters Riding Transit		
Jurisdiction	**Existing**	**Existing without Rail Modes**
Arlington	49%	28%
Alexandria	38%	24%
Fairfax	17%	6%
Loudoun	4%	2%
Prince William	5%	3%
Northern Virginia Total	18%	8%

Table 4 Source: Transportation Planning Board V2.3.66 Travel Demand Forecast Model

WHAT METRORAIL AND VIRGINIA RAILWAY EXPRESS SUPPORT IN NORTHERN VIRGINIA

The elimination of Metrorail and VRE from Northern Virginia's transportation network significantly increased traffic congestion. Assuming that the regional total of jobs and households remains constant, achieving current levels of roadway congestion without rail transit required the rebalancing of 85,000 households and 130,500 jobs within the region to the areas of Maryland and the district with planned growth.

Households Rebalanced within the Region

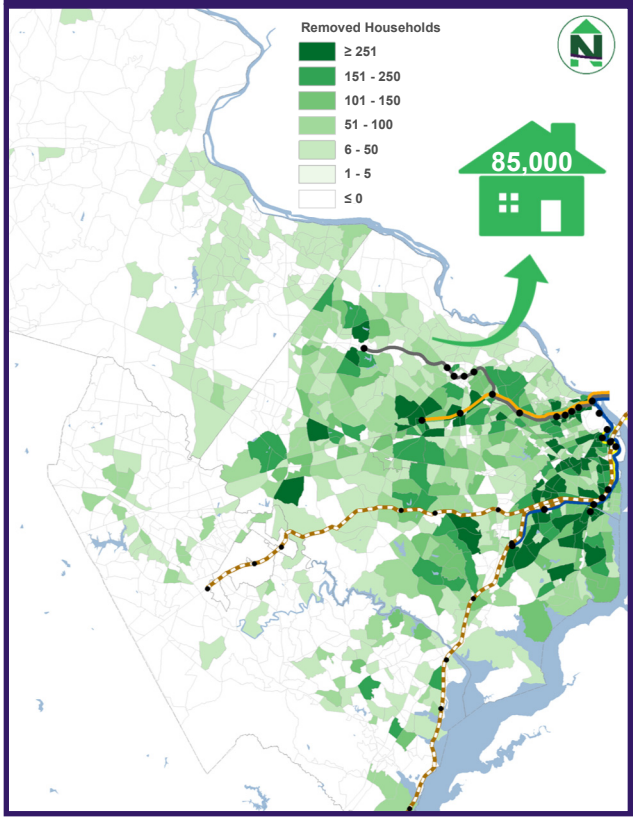

Figure 7 Source: NVTC

Jobs Rebalanced within the Region

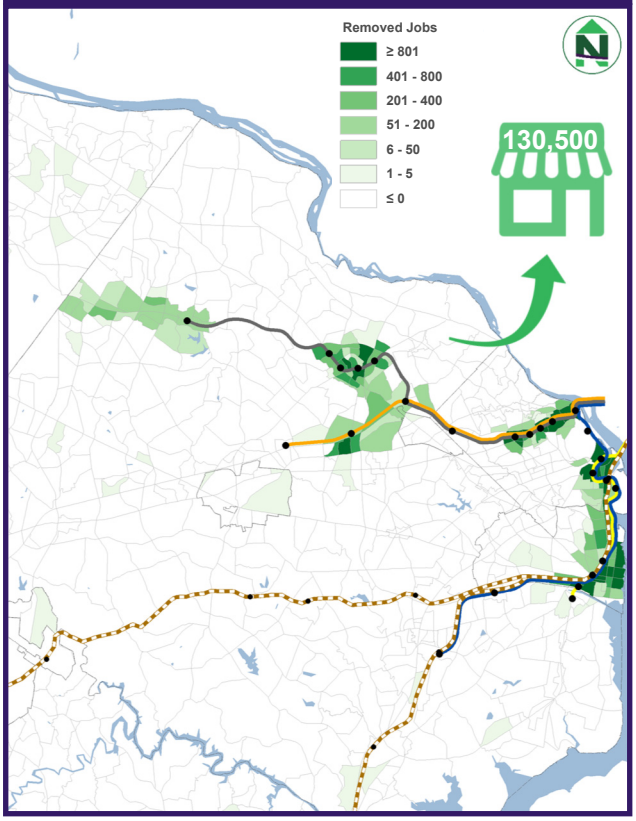

Figure 8 Source: NVTC

THE VALUE OF METRORAIL AND VIRGINIA RAILWAY EXPRESS TO THE COMMONWEALTH

The land use supported by Metrorail and VRE generates over $600 million in general fund revenues for Virginia. This is 3 to 4 percent of the $18.2 billion collected in the state in fiscal 2016. For every dollar the Commonwealth invests in Metrorail and VRE, it receives $2.50 in return.

Metrorail and VRE move large numbers of people, relieve congestion and are integral components of local land use and economic development plans. Rail transit attracts jobs and households to Northern Virginia. Whether in new apartment buildings in transit oriented developments near Metrorail stations or in more traditionally suburban locations, these households pay income taxes to the Commonwealth of Virginia.

Commonwealth Data Point provides a frame of reference for understanding the magnitude of $600 million dollars in general fund revenue. Looking at the state's general fund expenditures by agency, this funding can be compared to various agency budgets.

By way of comparison, $600 million is higher than the collective $582 million in general fund spending on higher education and public safety in fiscal 2016. General fund expenditures totaled $316 million for Virginia's universities, community college systems and the State Council for Higher Education and $266 million for the Department of State Police.

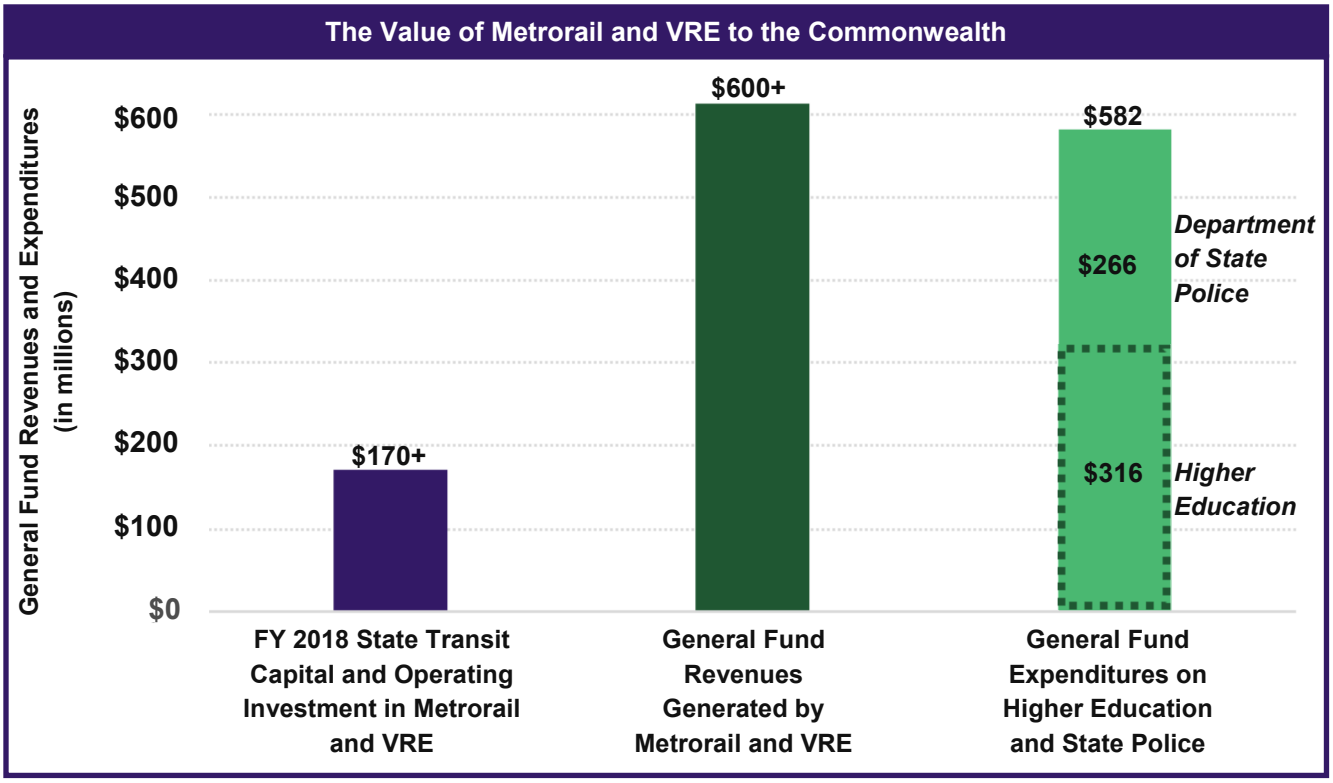

Figure 9 Source: NVTC, DRPT, and Commonwealth Data Point

Technical Review Team

NVTC engaged staff at WMATA, the Transportation Planning Board, the Federal Transit Administration, George Mason University, and other organizations in a comprehensive technical review of the study's methodology and assumptions. These groups reviewed the work plan, technical approach, and findings and provided comments to NVTC on the study.

As the premier transit organization in Northern Virginia, NVTC brings the region together to plan, coordinate, and secure funding for transit systems that are financially sustainable and high performing. NVTC enjoys a special relationship with the Washington Metropolitan Area Transit Authority and Virginia Railway Express (VRE), as it is charged with the funding and stewardship of both. Founded in 1964, in part to represent the interests of the Commonwealth during the establishment of WMATA, NVTC continues to serve as Virginia's voice on the WMATA Board of Directors through its appointments to the panel. Following Metrorail's launch, NVTC began planning for a commuter rail service, VRE, which became operational in 1992. NVTC, as the railway's co-owner, appoints members to the VRE Operations Board. Learn more at www.novatransit.org

Metrorail is the second largest, based on track mileage, and third busiest, based on passenger trips, heavy rail transit system in the U.S. The network includes six lines (four in Virginia), 91 stations (25 in Virginia) and 118 track miles (41 in Virginia). The Silver Line is the largest rail expansion project by route mileage since Metrorail's inception in 1976. Phase 1 opened in July 2014 and Phase 2, which will serve Dulles International Airport and Loudoun County, will open in 2020. Learn more at www.wmata.com.

Virginia Railway Express (VRE) is the eighth largest, based on track mileage, and 10th busiest, based on passenger trips, commuter rail service in the U.S. It is a partnership of NVTC and the Potomac and Rappahannock Transportation Commission. VRE's mission is to provide safe, cost-effective, accessible, reliable, convenient and customer-responsive commuter rail service. It provides over 4.5 million rides annually in Northern Virginia and Washington, D.C. and is based in Alexandria. Learn more at www.vre.org.

This report is a product of
the Northern Virginia Transportation Commission

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