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Hampton Roads Transportation Planning Organization

Hampton Roads Passenger Rail Vision Plan Alternatives Analysis

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Prepared by

TEMS

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Prepared in cooperation with the U.S. Department of Transportation (USDOT), the Federal Highway Administration (FHWA), the Virginia Department of Rail and Public Transportation (DRPT), and the Virginia Department of Transportation (VDOT). The contents of this report reflect the views of the Hampton Roads Transportation Planning Organization (HRTPO). The HRTPO is responsible for the facts and the accuracy of the data presented herein. The contents do not necessarily reflect the official views or policies of the FHWA, VDOT or DRPT. This report does not constitute a standard, specification, or regulation.

These opinions, findings and conclusion are preliminary in nature and do not represent final statements of fact or final projections of high speed and intercity passenger rail service to Hampton Roads. It is anticipated upon completion of a NEPA Service Development Plan and/or TIER I Environmental Impact Statement, these initial study results will be refined to a level that supports the Hampton Roads Vision Plan for High Speed and Intercity Passenger Rail services from Washington D.C. to the Hampton Roads metropolitan area.

NON-DISCRIMINATION

The HRTPO assures that no person shall, on the ground of race, color, national origin, handicap, sex, age, or income status as provided by Title VI of the Civil Rights Act of 1964 and subsequent authorities, be excluded from participation in, be denied the benefits of, or be otherwise subject to discrimination under any program or activity. The HRTPO Title VI Plan provides this assurance, information about HRTPO responsibilities, and a Discrimination Complaint Form.

DISCLAIMER

This report presents alternative high speed and intercity passenger rail proposals that are un-negotiated, un-funded and at a feasibility level of analysis. It is understood that in following detailed environmental and engineering studies, the details of integrating the proposed passenger operations with Norfolk Southern and CSX freight operations will be subject to close coordination and negotiation. The report contains only preliminary data which is subject to review, verification, and approval by both Norfolk Southern and CSX. Findings are not construed to be a commitment on the part of either Norfolk Southern or CSX to operate additional service.

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1. INTRODUCTION

This section provides a description of the background and purpose of the Norfolk-Richmond corridor Phase 2A Data Collection and the Phase 2B Alternatives Analysis studies, the scope of the work, and the organization of the Vision Plan.

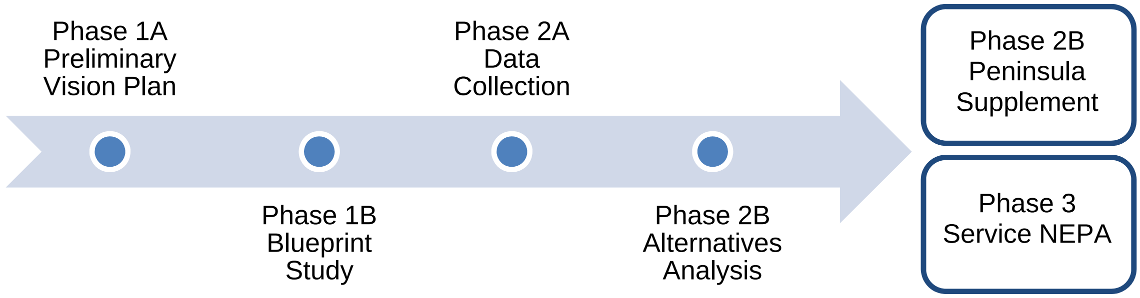
1.1 PURPOSE OF STUDY

The Virginia Department of Rail and Public Transportation (DRPT) developed the Richmond/Hampton Roads Passenger Rail Project Tier I Draft Environmental Impact Statement (EIS) in accordance with the National Environmental Policy Act (NEPA) to develop conventional passenger rail service to the I-64/CSX corridor and the US Route 460/Norfolk Southern corridor. The state's draft NEPA document was released for public review and comment in December 2009. In February 2010, based on the evaluation and public comments received, the Commonwealth Transportation Board selected Alternative 1 as the preferred alternative for enhanced passenger rail service between Richmond and Newport News and higher speed passenger rail service between Petersburg and Norfolk. DRPT has completed the Tier I Final EIS document, which was circulated for public comment in August 2012. The Record of Decision (ROD) was approved by the Federal Railroad Administration (FRA) on December 7, 2012.

The Final Tier 1 EIS proposes 6 trains per day at 90 mph from Norfolk to Richmond and Washington D.C., and 3 trains per day from Newport News to Richmond and Washington D.C. To support and further develop the Commonwealth's efforts, the Hampton Roads Transportation Planning Organization (HRTPO) Board approved a resolution in October 2009 that endorses the designation of a "high speed rail" corridor with ultimate speeds of more than 110 mph along the Norfolk Southern/Route 460 (Norfolk-Richmond) corridor and that enhances the intercity passenger rail service along the CSX/I-64 corridor (Newport News-Richmond).

TEMS was commissioned to develop a Vision Plan for passenger rail service for the Hampton Roads region that implements the HRTPO objectives established by the Board. An initial phase (Phase 1) of work was completed by TEMS in July 2010. Recent and current work on Phase 2A Data Collection and on Phase 2B Alternatives Analysis work is designed to build a database and an evaluation framework for identifying the potential for high speed rail in the Norfolk-Washington D.C. corridor, and for higher speed rail in the Newport News-Washington D.C. corridor. See Exhibit 1-1. The current report describes the data collection process and the evaluation of routes and technology options needed to complete the Norfolk-Richmond Corridor Vision Plan. The Vision Plan includes the analysis needed to support the preparation of a Service Development Plan (SDP) and Service NEPA that are the key documents needed by U.S. Department of Transportation (USDOT) FRA to support further planning work on high speed rail for the Norfolk-Richmond corridor.

Exhibit 1-1 Overview of Study Development Process



1.2 DEVELOPMENT STEPS – NORFOLK-RICHMOND CORRIDOR

Exhibit 1-2 shows the four step process envisaged by DRPT and HRTPO for developing passenger rail service. Development Steps 1 and 2 (79-90 mph) come under the DRPT's focus on conventional passenger rail service, while Steps 3 and 4 reflect the HRTPO's "higher and high speed" rail focus of the HRTPO. In terms of Step 1 and Step 2, DRPT has made good progress in starting an Amtrak 79-mph service to Norfolk. The service was started in December 2012 and provides a daily direct connection from Norfolk to Petersburg, Richmond-Staples Mill, Washington D.C., and connections to the Northeast corridor. Development Step 3 and Step 4 are the focus of the HRTPO planning process to develop high speed rail for the Norfolk-Richmond corridor.

Exhibit 1-2: Proposed System Development Steps for the Norfolk-Richmond Corridor

Steps	Route	Max Speed	No. of Trains	Infrastructure	Station
Step 1	Route 460/ Norfolk Southern**	79 mph	1-3*	Shared Track NS	Staples Mill Only Norfolk
Step 2 (FEIS Opt 1)	Route 460/ Norfolk Southern	79-90 mph	4-6	Shared Track V Line	Main Street Bowers Hill
Step 3	Norfolk-Richmond along Route 460	110 mph	8-12	Dedicated Track V Line	Main Street Bowers Hill
Step 4	Norfolk-Richmond along Route 460	150 mph	12-18	Dedicated Electric Track V Line	Main Street Bowers Hill

* Two additional trains are planned in the near future by DRPT.
** Norfolk Southern (NS) does not permit passenger train maximum authorized speed in excess of 79 mph on any NS track. Where the V-line (former Virginian Railway) has existing freight services, maximum authorized speed for passenger trains will be 79 mph. Along the Algren – Kenyon portion of the V-line (over which NS freight rail service has been formally abandoned); passenger rail planners may consider speeds above 79 mph.

1.3 SCOPE OF THE STUDY

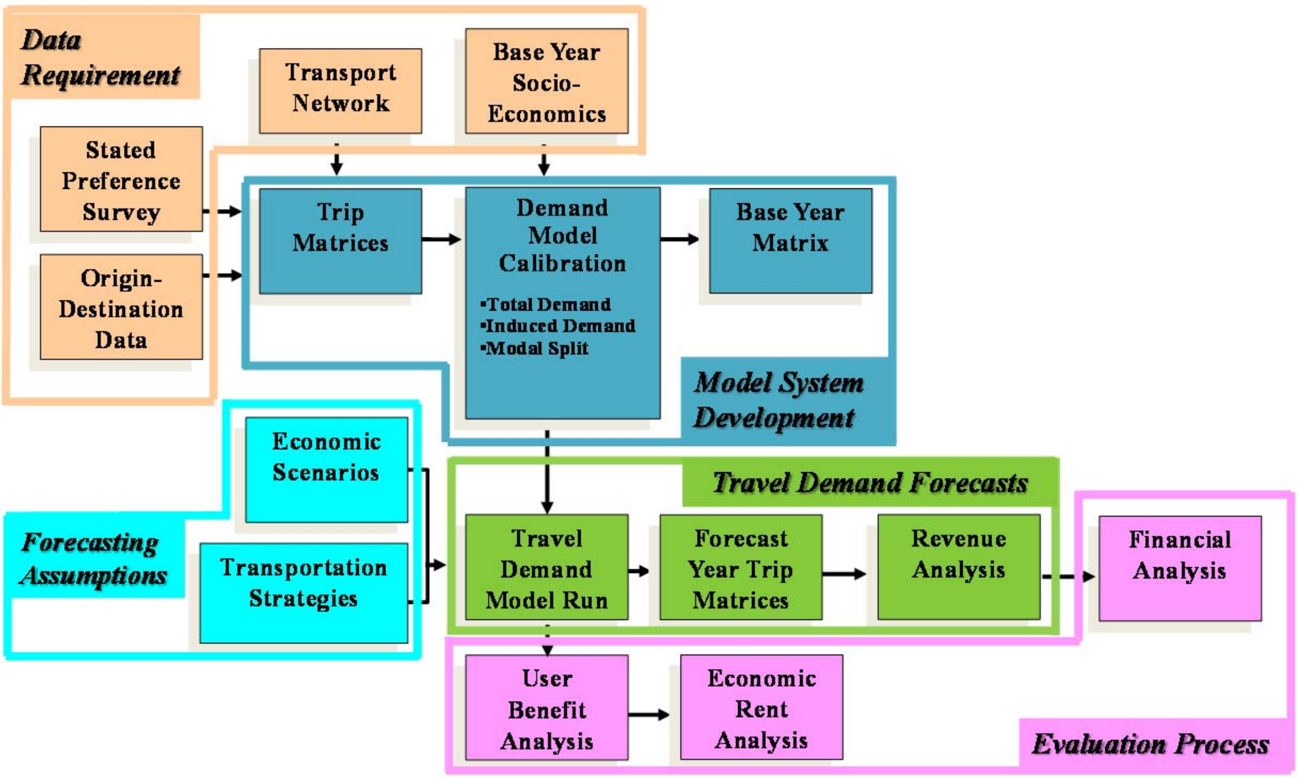
Phases 2A and 2B of this study provide the basic data needed to plan for "high and higher speed" passenger rail service in the Norfolk-Richmond corridor, as well as the analysis of route and technology options that should be considered for the Vision Plan.

The Phase 2A report and study focused on the initial and the most vital stage of high speed passenger rail analysis: Data Collection. For high speed rail planning purposes, databases are required in four key areas:

- Market Database – Hampton Roads to Boston and Charlotte
- Technology Database – National US and International Benchmarks
- Engineering Database – Norfolk to Richmond only
- Environmental Database – Norfolk to Richmond only

A key driver of high speed rail studies is the Market Database. A key factor is to understand the full competitive environment for auto, air, rail and intercity bus travel between Hampton Roads and the Northeast and Southeast corridors. Given the potential competition between the Norfolk-Richmond and Newport News-Richmond rail lines, both corridors are included in the data collection for the Market Database. As such, a thorough understanding of the responsiveness of the region's population and its opportunity to use the proposed high speed rail system provides the critical element in the ability to evaluate and potentially justify the systems. As seen in Exhibit 1-3, the final outcome of demand forecasting analysis is dependent on the socioeconomic, transportation networks, stated preference survey, and the origin destination database.

Exhibit 1-3: Market Database Requirements for *COMPASS*™ Model Ridership and Revenue Analysis

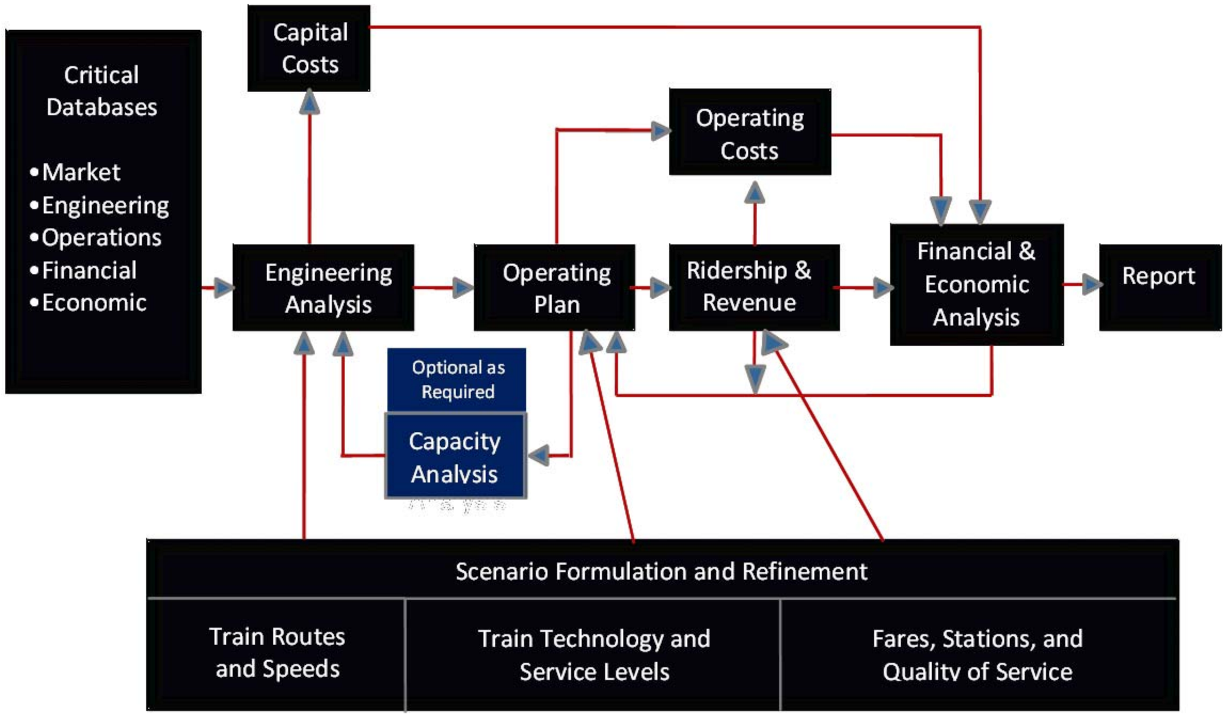


For a comprehensive travel demand model to be developed, data must be collected on the latest socioeconomic data, traffic volumes (air, bus, auto, and rail) by purpose and updated network data (e.g., gas prices) to test likely ridership response to service improvements over time. To develop ridership and revenue demand estimates, using the *COMPASS™* demand modeling system, data is needed on the quality of the service frequencies, travel times, fares, fuel prices, congestion and other trip attributes. Demand Forecasts are made by entering: long term forecasts of the economy (economic scenarios including energy prices) and future rail, and other mode strategies for infrastructure improvements, into the model in order to develop forecasts of high speed rail potential.

The second step in the process, once the existing and future market for rail travel is assessed, is an Interactive Analysis to identify (based on FRA evaluation criteria) the optimum high speed rail system for the market. Exhibit 1-4 shows the interaction of the databases and the Interactive Analysis process needed to develop the critical FRA performance metrics required to show the value of the project[1].

[1] Value of the project will be assessed by financial and economic analysis; this measures the cost benefit ratio and operating ratio.

Exhibit 1-4: Interactive Analysis Process



With respect to the quality of service offered by a high speed rail system, a detailed Interactive Analysis is needed to optimize the potential alignment and the technologies being proposed for the "higher and high speed" rail systems. To effectively model the market, the technology analysis assesses the potential technologies that will be used for both the Norfolk-Richmond and Newport News-Richmond corridors. As a result, the study investigates the interaction between alignments and technologies in order to identify optimum trade-offs between capital investments in track, signals, other infrastructure improvements, and train operating speed. The engineering assessment must include aerial and/or ground inspections of significant portions of track and potential alignments, and of potential station and maintenance base locations for each option. For the purpose of this study, TEMS *TRACKMAN™* is used to catalog the base track infrastructure and improvements, and provides a database that will allow the full range of technology and train service options to be assessed. Once the track data has been collected, the *LOCOMOTION™* train performance program provides the next step in assessing the performance of various train technologies on the track at different levels of investment. The *LOCOMOTION™* program requires that different train operating characteristics (train acceleration, curving and tilt capabilities, etc.) be developed during the technology assessment.

The Technology Database will therefore need to include all the different technologies to be appraised including the existing 79-mph conventional rail, as well as the 110-mph technology associated with "higher" train speed performance and the 150 mph plus technologies associated with true high speed rail operation. The Interactive Analysis can then assess the infrastructure requirements and costs (on an itemized segment basis) necessary to achieve high levels of performance for the train technology options being evaluated.

The Engineering Database includes data on existing and potential rights-of-way and alignments. The data to be assembled in *TRACKMAN™* includes rights-of-way, FRA speeds, curves, speeds, grades, rail and highway crossings, signaling facilities, and potential restrictions such as bridges and track limitations. The database is upgraded by improvements to the track and signaling systems e.g., removing curves or introducing an advanced Positive Train Control (PTC) signaling system, which enforces speed limits and prevents trains from running past red signals. This allows higher train speeds and higher quality service in the corridor.

In terms of an Environmental evaluation, a Service NEPA[2] at the landscape level[3] of documentation is needed for Step 3 and Step 4. (The current Tier I EIS only covers Steps 1 and 2 phases of system development.) This includes the environmental data collection at the landscape level for the envelope of the Study Area. This document is an environmental database provided in preparation of the Service NEPA Environmental Assessment for the Richmond to Norfolk Corridor. The Service NEPA leads to decision whether a Tier 1 EIS[4], an Environmental Assessment (EA)[5], a Finding of No Significant Impact (FONSI), or a Categorical Exclusion is appropriate. This Tier 1 work may be followed by a Tier 2 EA[6] or EIS site specific analysis. Depending on the impact findings, either the EIS is prepared and followed by a ROD in case of Tiered analysis, or an FRA approval is required for a Categorical Exclusion. The process for Environmental Database collection and determining the final outcome are shown in Exhibit 1-5.

[2] Service NEPA as defined in the guidance of FRA is an essential first step for corridors providing an overview of the level of improvements that are needed to implement significantly expanded conventional or high speed rail services. This document provides an environmental database that will be used in preparation of Service NEPA Environmental Assessment for the Petersburg to Norfolk Corridor. The Service NEPA EA typically addresses the broader environmental questions relating to the type of service being proposed, Communities being served, types of operations (speed, electric, or diesel powered), ridership projections and major infrastructure components, improvement alternative being proposed and measures taken to minimize harm to the corridor. http://www.fra.dot.gov/Page/P0262

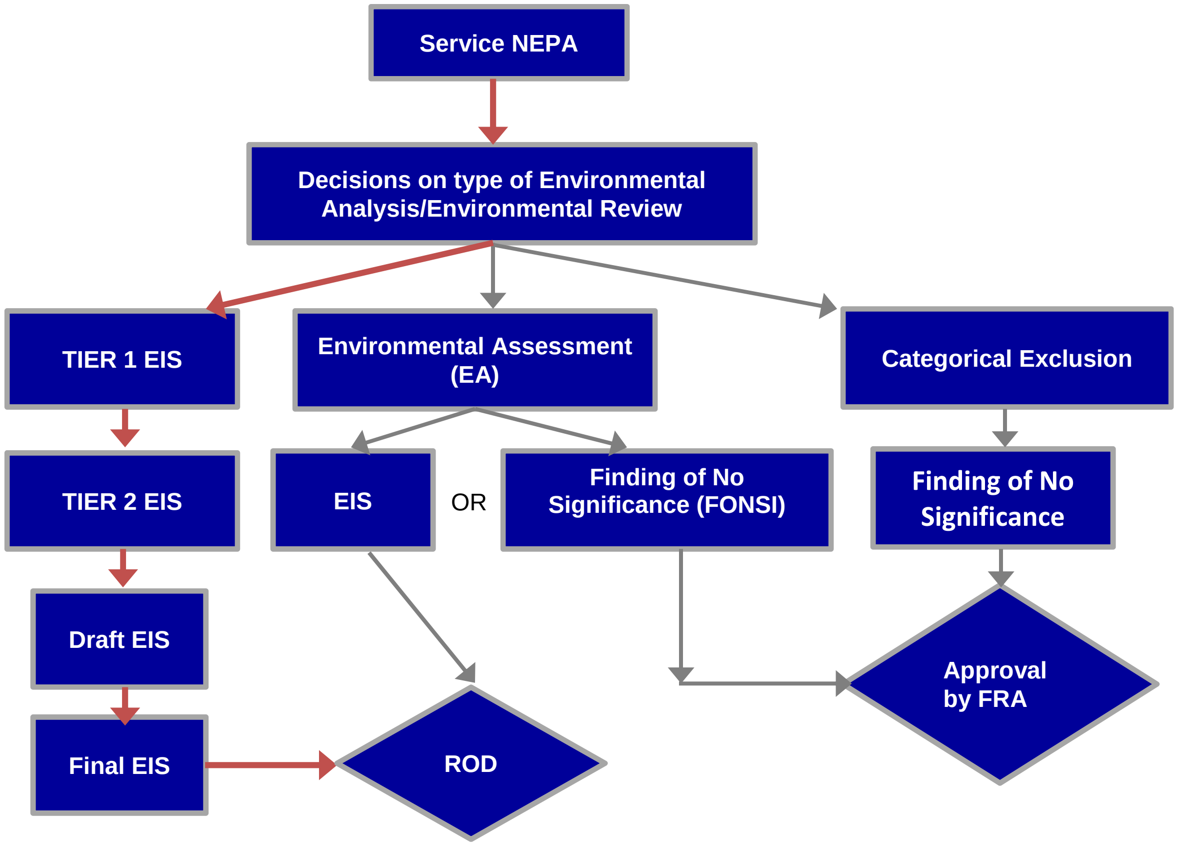
[3] Landscape level in this report refers to preliminary overview of the process i.e., inspection of an area by aerial and on site photographs without any detailed inspection.

[4] TIER 1 would be typical to large expansive projects like for example, EISs that FRA has prepared with the California High Speed Rail Authority for the state's proposed high speed rail project. http://www.fra.dot.gov/Page/P0262

[5] An EA would be appropriate only for a more limited corridor development program where no significant environmental impacts are anticipated. http://www.fra.dot.gov/Page/P0262

[6] TIER 2 or EA would be typically for corridor programs with smaller scope and narrower range of reasonable alternatives. http://www.fra.dot.gov/Page/P0262

Exhibit 1-5 FRA Environmental Process[7]



At this point in time, an environmental study region has been defined and preliminary environmental data has been collected. The detailed environmental work needed to precisely locate prospective alignments within the study area has yet to be completed. These will be more fully developed, with appropriate levels of community input during the Tier 1 EIS.

In the Phase 2B Alternatives Analysis, the market, engineering, technology and environmental data of Phase 2A was used to define the route and technology options to be evaluated.

To meet this need, a number of possible conceptual northern and southern options (north and south of US 460 between Suffolk and Petersburg) were defined, along with a Norfolk Southern (NS) route that would parallel the very straight NS track (route) from Suffolk to Petersburg. The suggested three options (See Exhibits 1-6 and 1-7) are:

- A Northern Greenfield (Option 2A)
- A Southern Greenfield (Option 1A)
- A Richmond Direct (Option 3)

[7] Prepared by TEMS, based on HSIPR NEPA Guidance and Table http://www.fra.dot.gov/Page/P0262

Exhibit 1-6: Option 2A, Northern Greenfield Route and Option 2B, Norfolk Southern Variant

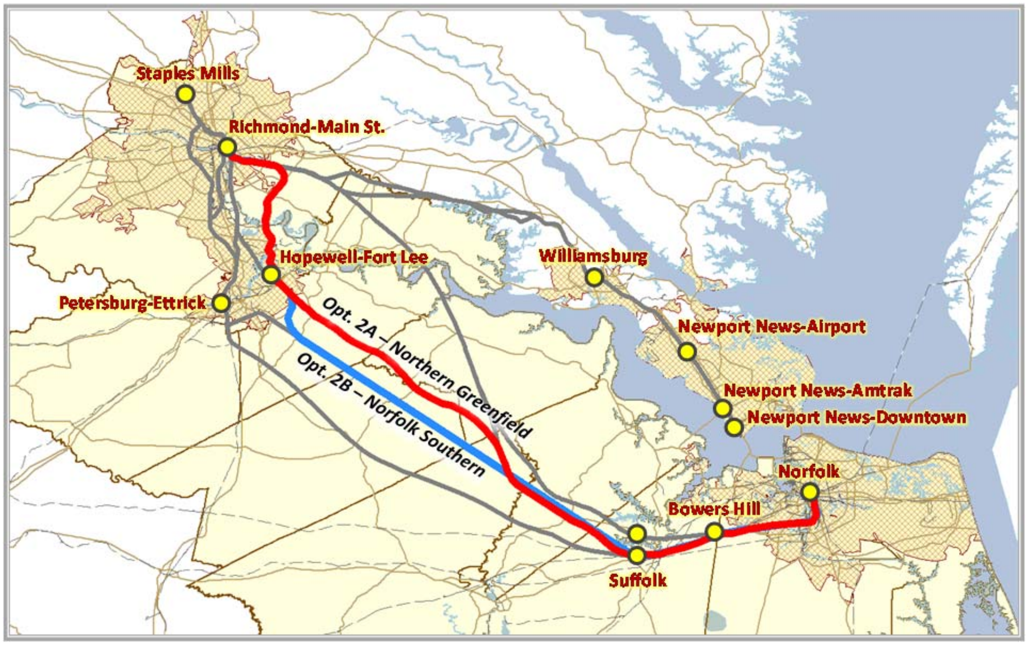
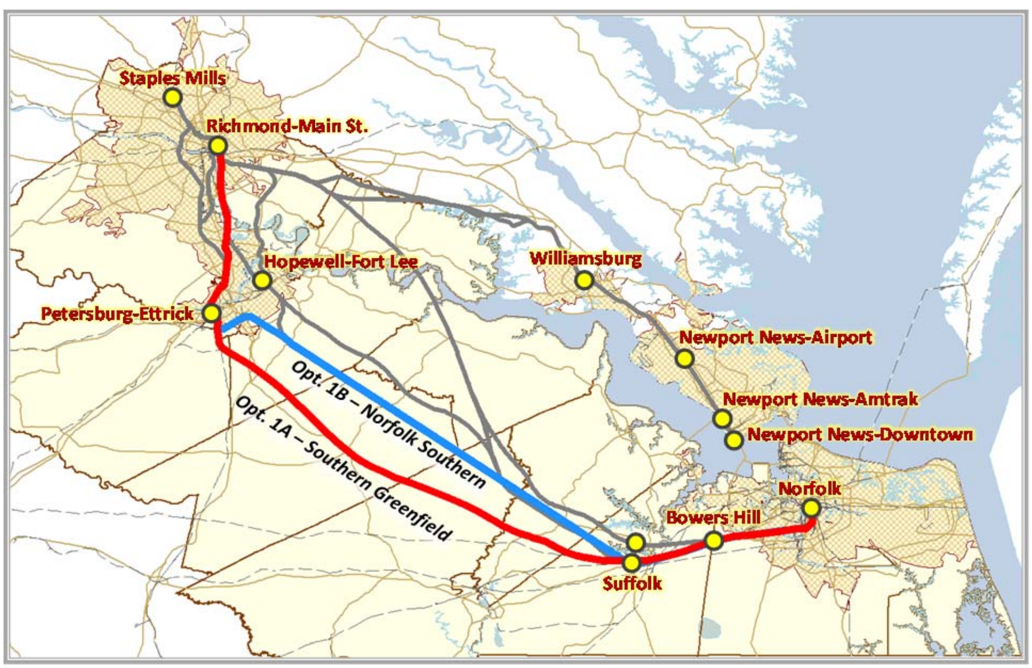
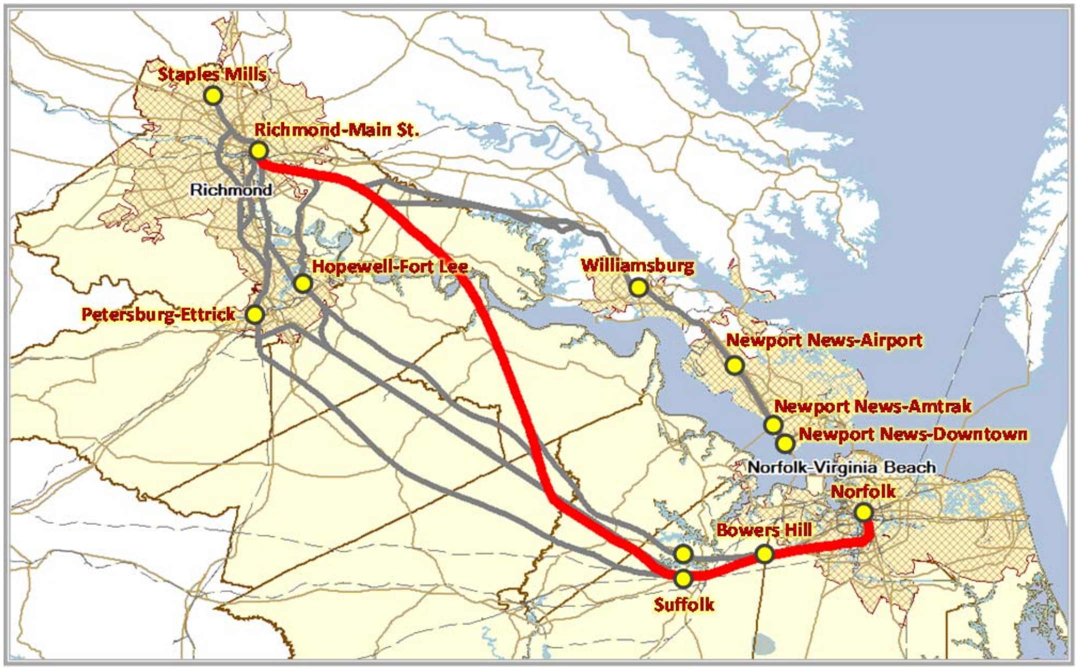


Exhibit 1-7: Option 1A, Southern Greenfield Route and Option 1B, Norfolk Southern Variant



In development of the (Phase 2B) Alternatives Analysis, it became apparent that in addition to the Northern and Southern greenfield routes initially identified, a further more easterly route might be considered that gave a direct route to Richmond from Suffolk. This route was called "Richmond Direct".

Exhibit 1-8: Route Option 3, Richmond Direct



In addition to the Richmond Direct route, it quickly became apparent that it would be difficult to access Petersburg and Richmond from the south or west. As a result, a number of routes were developed that accessed Richmond from the east using suburban bypasses through Hopewell and the Richmond/Petersburg I-295 bypass. See Exhibit 1-8. This created a number of route sub options.

As a result, the Interactive Analysis suggested four main routes be assessed; North and South Greenfield routes, Norfolk Southern route, and a Richmond Direct route.

In terms of technology, the developments in rail technology have been very rapid; and while 150 mph technology was the best commercial speed possible twenty years ago, the latest technology allows speeds up to 220-240 mph. Since the latest 220-mph trains are similar in cost to the 150 mph trains, it was decided to assess 220-mph trains on the new Greenfield routes, and at reduced speed on track shared with freight. In rural areas, Greenfield routes can be developed with only very limited curvature and are thus ideal for the highest speed trains. For higher speed trains, the diesel trains capable of 110 mph can be geared to operating at 130 mph; so a new option for consideration is that of operating diesel trains at 130 mph on Greenfield routes. In urban areas where the track is more curvy, high speed trains are limited to 79-90 mph. As a result, the trains are likely to operate in urban areas at 79-90 mph, with increased speeds of up to 130-220 mph outside the built up urban areas on Greenfield routes.

1.4 Report Organization

This report is organized in the following way:

- **Chapter 1 – Introduction:** Chapter 1 discusses the purpose of the Norfolk-Richmond corridor Phase 2A Data Collection study, the Phase 2B Alternatives Analysis, the scope of the study, and the organization of the report.

- **Chapter 2 – Development of Routes and Technology Options:** This chapter describes the development of route options for analysis, including route options for accessing Richmond via Hopewell versus Petersburg or Direct approaches.

- **Chapter 3 – Route Analysis:** This chapter identifies the speed restrictions including major speed curves, grades, major rail and highway crossings, and other potential speed restrictions and environmental issues associated with the preliminary infrastructure analysis of the existing and proposed route options. This section of the report also discusses the proposed improvements and preliminary infrastructure costs for each of the proposed route options.

- **Chapter 4 – Infrastructure, Rolling Stock and Capital Investment:** This chapter discusses track infrastructure and train technologies, and describes unit capital costs for estimating infrastructure, equipment, and maintenance facility capital costs for each route and technology option.

- **Chapter 5 – Operating Plan and Costs:** This chapter discusses the development of the operating plan, station stopping patterns, frequencies, train times and train schedules for each route and technology option. Operating costs were also calculated for each year the system is planned to be operational using operating cost drivers such as passenger volumes, train miles, and operating hours.

- **Chapter 6 – Market Database:** This chapter is divided into subsections of introduction of the chapter, zone system, socioeconomic data, transportation network data, origin-destination data, stated preference survey process, results and analysis. This chapter describes the steps of developing the market data which includes developing a zone system, socioeconomic database of the Study Area, how the transportation networks were developed, how the origin and destination databases were obtained and validated, methodology used to conducting stated preference survey and analysis of the results.

- **Chapter 7 – Financial and Economic Analysis:** For each route option, a detailed financial analysis was developed, including key financial measures such as Operating Surplus and Operating Ratio. A detailed Economic Analysis was also carried out for each route option using criteria set out by the 1997 FRA Commercial Feasibility Study and including key economic measures such as NPV Surplus and Benefit/Cost Ratio at 3% and 7% discount rates.

- **Chapter 8 – Preferred Option:** In this chapter the impact of integrating the different options assessed in Chapter 7, with two important external factors; Southeast High-Speed Rail and the Newport News – Richmond service.

- **Chapter 9 – Conclusions:** This chapter outlines the key findings of the study, and the next steps that should be taken to move the project forward.

- **Appendices:**
  - Appendix A – Socioeconomic Data
  - Appendix B – Stated Preference Survey Forms
  - Appendix C – *TRACKMAN™* Files
  - Appendix D – Environmental Database

2. DEVELOPMENT OF THE ROUTE AND TECHNOLOGY OPTIONS

For implementation of high speed rail service in the Hampton Roads to Washington corridor, a Tier 1 Alternatives Analysis and Environmental Study will be needed to determine the most appropriate and effective alignment option. The Vision Plan and Environmental Scan is needed to serve as an essential but preliminary Scoping Study for developing the options and estimating the level of effort that will be needed to complete a full environmental analysis. If the USDOT Federal Railroad Administration (FRA) were asked to help fund development of the Tier I environmental study, this analysis could be used to develop the Service Development Plan and "Service NEPA" document to support the funding application. In recent years, inclusion of an Environmental Scan as part of the route and technology evaluation has increasingly become a standard component of rail corridor feasibility studies. This is especially true for high speed studies like this one, which propose to develop extensive segments of new Greenfield alignment. This chapter first covers the requirement for developing the environmental database and definition of the National Environmental Policy Act (NEPA); second, the list of databases such as geographic boundaries, cultural resources, ecology, hazardous material sites, and air quality in the proposed environmental study area; third, the Route Options; and finally, the Train Technology Options.

2.1 PURPOSE OF THE ENVIRONMENTAL ANALYSIS

In developing route options for the study, an initial overview of environmental issues is considered a critical element of National Environmental Policy Act (NEPA) compliance for the development of high speed passenger rail service. Under the Federal Railroad Administration's (FRA) HSIPR program guidance, FRA implements the environmental review process as required by the National Environmental Policy Act (NEPA) together with related laws and regulations, (including Section 106 of the National Historic Preservation Act and 49 U.S.C. 303, which protects public parks, recreation areas, wildlife and waterfowl refuges, and historic sites). The statutory requirement as stated in the *HSIPR NEPA Guidance*[1] is that "NEPA requires that appropriate environmental documentation be available to public officials and citizens *before* decisions are made and actions are taken. *The available information should be relevant to the decision to be made at any particular stage of project development*" (italics added for emphasis) including the decision as to whether or not to launch a detailed environmental study in the first place.

To apply for funding for a high speed rail system, FRA has defined the creation of a Service Development Plan (SDP) as well as a Service NEPA as essential first steps. *It is important to note that neither the "Service NEPA" nor SDP are actually NEPA legal documents; they are only support for an FRA funding application.* A "Service NEPA" has been defined by the FRA as a *landscape level of environmental review that defines from day one the most critical environmental issues before any substantial investments in the corridor are made.* The reason for developing a Service NEPA is to ensure that there are no obvious fatal flaws associated with the proposals being submitted to the FRA, and that due diligence and reasonable consideration have been given to the environmental issues associated with the project.

The *HSIPR NEPA Guidance* states that "Several different approaches are available to accomplish Service NEPA," including for advanced projects, "Tiered NEPA (Tier 1 environmental impact statement (EIS) or environmental assessment (EA) followed by Tier 2 EISs, EAs or categorical exclusion determinations (CE)) or non-Tiered NEPA (one EIS or EA covering both service issues and individual project components)"[1]. A large expansive project such as a high speed rail corridor development would typically be addressed in a Tier 1/2 EIS process requiring several rounds of environmental review, such as the multiple EIS's that have been prepared by the California High-Speed Rail Authority, and the Georgia and

[1] Compliance With The National Environmental Policy Act In Implementing the High Speed Rail Intercity Passenger Rail Program, August 2009. https://www.fra.dot.gov/Elib/Document/2319

North Carolina Departments of Transportation. However, it is clear that SDP's and Service NEPA's can only be developed to a level of detail reflecting the stage of development of each project. As projects advance, more detail is needed to support the progressively increasing funding amounts required. Clearly a Service NEPA associated with a construction application will have more detail than one associated with an application for EIS Tier 1 funds.

This chapter, Chapter 4 and Appendix D, present a high level Environmental Scan that is intended to give insight into the issues that may be associated with a decision to proceed with a detailed Tier 1 EIS. Since the next step will be an application for funding a Tier 1 EIS, the initial "Service NEPA" at this stage should consist of a mapping analysis of environmental factors within the corridors where proposed alignments are likely to be located. A preliminary conceptual analysis is sufficient to show that there are no obvious fatal flaws along the routes that might be developed. Where environmental issues do arise, there should be an understanding of potential mitigation or avoidance strategies. This level of environmental planning ensures that the routes proposed for a Tier 1 EIS are in fact "Reasonable Routes" and that they are likely able to be developed into fully engineered alternatives. Clearly, detailed development of such routes will be part of the Tier 1/2 EIS. Any representative alignments used as the basis of the analysis are highly conceptual and preliminary. The primary reason for considering environmental issues along the corridors is to identify (and avoid if possible) obvious fatal flaws, and to develop an order-of-magnitude assessment of potential impacts.

In the next phase of work, it is expected that this Environmental Scan can serve as a very useful tool for agency outreach to engage discussion and gain concurrence on the list of reasonable routes that need to be screened. In order to secure FRA agreement to scope the Tier I EIS work that needs to follow, it is essential to identify both the number of alternatives that need to be assessed, and to assess the level of detail at which they will likely need to be evaluated to support a screening determination. This is essential so that the Service NEPA can support the funding application and also aid in planning the actual Tier 1 EIS, including estimating of the level of effort that will likely be needed to complete it. This document therefore, serves as the "bridge" between preliminary Feasibility-level planning and the formal NEPA environmental documentation which is still to come.

2.2 List of Data Collection and Mapping Sources

This section identifies the potential list of factors that impact on the community and environment to include transportation, air quality, noise and vibration, energy, land use, socioeconomic factors, community impacts, environmental justice, parklands, farmlands, aesthetics, utilities, contaminated sites, cultural resources, geologic resources, hydrologic and water resources, wetlands, and biological resources (habitats and species). Potential environmental constraints will be reported in the next phase of the study based on the proposed alternatives. A more detailed environmental analysis will be needed once preferred alternatives are assessed in the Tier 1/EA analysis. Exhibit 2-1 provides an overview of the list of data collection elements that will be discussed in the following report sections and in Appendix D, which provides an update to the environmental scan level data presented in the "*Hampton Roads Passenger Rail Study Data Collection – Phase 2A Norfolk – Hampton Roads Corridor*" report submitted by TEMS in March 2013. The following sources provided significant input to the development of this chapter and Appendix D:

- NEPA Guidance: Compliance with the National Environmental Policy Act in Implementing the High-Speed Intercity Passenger Rail Program.
- Service NEPA Environmental Assessment Chicago-Detroit/Pontiac Rail Corridor Improvements From Chicago, Illinois to Pontiac, Michigan by Michigan DOT.

- Route 460 Draft EIS Report.
- Richmond to Hampton Roads Passenger Rail Study, Tier I Environmental Impact Statement, Virginia DRPT.
- Passenger Rail Investment and Improvement Act of 2008 (PRIIA).

Exhibit 2-1: List of Elements and Data Sources

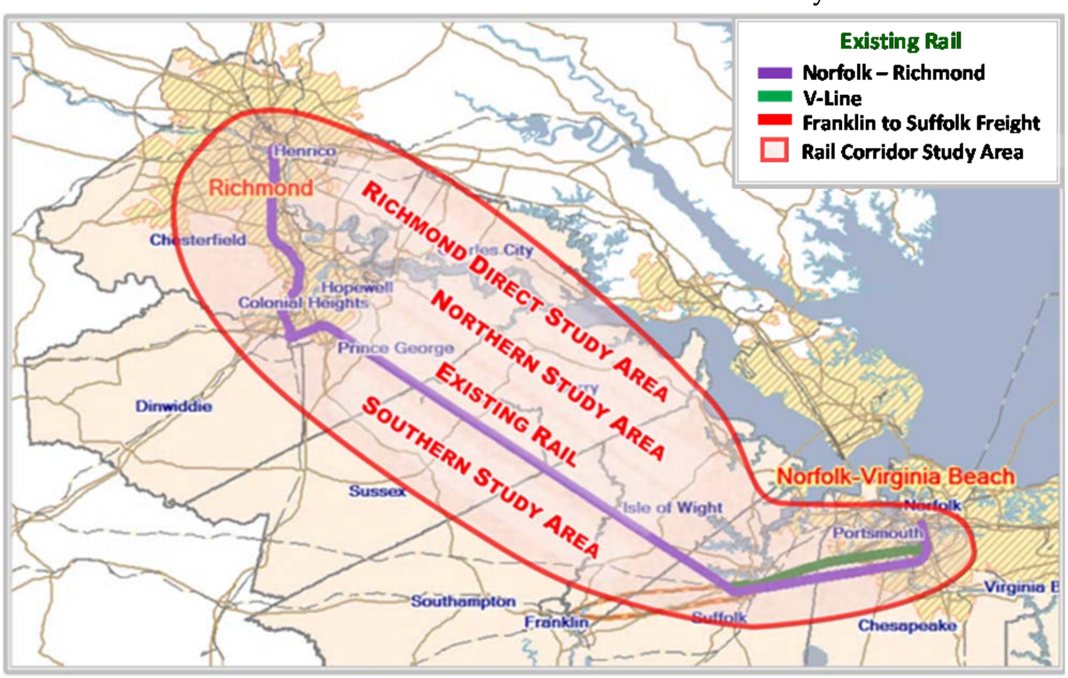
Data Element	Source
Geographic Boundaries: State, County, Census tract, Census Block Group, City, MPO, MSA, Congressional Districts, Community Facilities	US Census Bureau: 2009 TIGER/ Line Shapefiles and Virginia Department GIS, National Transportation Atlas Database (NTAD)
Cultural Resources: Parks, Wildlife Refuge, Heritage preserves, Archaeology resources, Historical resources, Federal lands, etc.	Virginia Department of Conservation and Recreation (DCR), United States Department of Agriculture Forest Service National Park Service U.S. Department of the Interior U.S. Fish and Wild life Service VA DCR: Natural Heritage site Virginia Department of Forestry
Ecology: Wetlands, Hydric Soils, Streams, Waters of US, State waters, Federally protected species, State protected Species, Critical stream habitats, Migratory bird habitat, floodplain encroachment/impacts, coastal zone encroachments	Virginia Department of Game and Inland Fisheries, National Wetlands Inventory, US Fish & Wildlife Service, Virginia Department of Conservation and Recreation: Land Conservation Data Explorer, VA Natural Landscape Assessment (VaNLA)
Hazardous Materials	Virginia Department of Environmental Quality, US EPA
Air Quality	Environmental Protection Agency
OTHER (Satellite Imagery, Street Views, Land Parcel Data, etc.)	Google Earth, Bing Maps, Henrico Co. Parcel Viewer, Richmond Parcel Mapper.
Noise and Vibration,	*High-Speed Ground Transportation Noise and Vibration Impact Assessment*, U.S. Department of Transportation, Federal Railroad Administration, Washington, DC, December 1998 standards, and Richmond to Hampton Roads Passenger Rail Study, Tier I Environmental Impact Statement, Virginia DRPT.
Utilities,	Aerial photographs and mapping available from several internet sites (Google Earth, Bing Maps) site specific photographs, and Richmond to Hampton Roads Passenger Rail Study, Tier I Environmental Impact Statement, and Virginia DRPT.
Environmental Justice,	U.S. Census

Geology and Soil,	U.S. Geological Survey (USGS) maps, Virginia Department of Conservation and Recreation: Land Conservation Data Explorer.
Transportation,	U.S. Census, National Transportation Atlas Database (NTAD)
Land Status, land Use, and Zoning,	U.S. Census, Henrico County Parcel Viewer, Richmond Parcel Mapper (Zoning-City of Richmond)
Socioeconomic Conditions, and	U.S. Census
Public Health and Safety: Railroads grade crossings, Pedestrians and Rail operations	Federal Highway Railroad (FRA) and Federal Highway Administration (FHWA)

2.3 Environmental Study Area and Route Options

The Environmental Study Area is defined by the potential region or area within which potential rail alignments might lie and for which environmental data must be collected. For the preliminary step of data collection in Phase 2(A), the environmental study area from Norfolk to Petersburg was defined and landscape environmental data such as cultural resources, ecology, hazardous materials, air quality, noise and vibration, utilities were collected at a landscape level. For the current Phase 2(B) study, the environmental study area has been expanded to extend from Hampton Roads to Richmond, VA and the data collection and resulting tabulations, have been similarly expanded. Exhibit 2-2 shows the environmental study area that was used as the base for the current study.

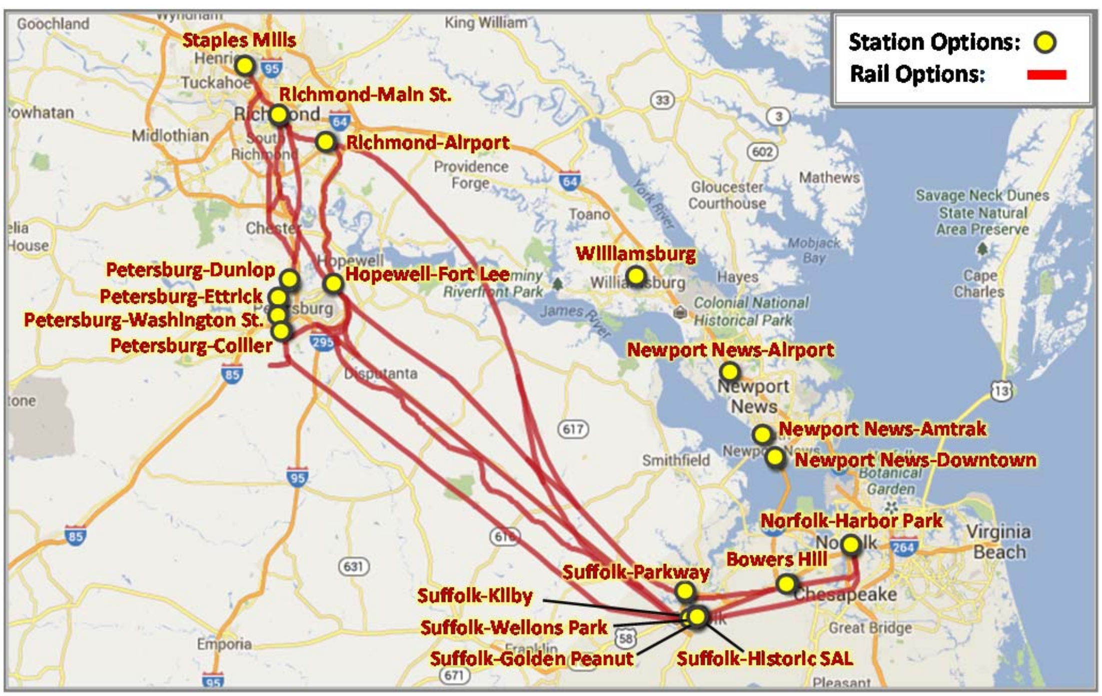
Exhibit 2-2: Norfolk to Richmond Environmental Study Area



The U.S. Census and 2009 TIGER/Line shapefiles provide information on state, county, city, and MPO boundaries for the State of Virginia and these sources were used in specifying boundaries for the current Richmond to Norfolk environmental study. The counties and independent cities considered in the current environmental study area are as follows: Henrico Co., Chesterfield Co., Richmond City, Charles City Co., Colonial Heights (city), Hopewell (city), Petersburg (city), Prince George Co., Dinwiddie Co., Surry Co., Sussex Co., Isle of Wight Co., Southampton Co., Franklin (city), Suffolk (city), Portsmouth (city), Norfolk (city), Chesapeake (city), and Virginia Beach (city). This study area was taken as the base for preparing all environmental database maps[2].

From Norfolk Harbor Park station to the proposed Portsmouth suburban station at Bowers Hill, all options share a common routing over the Norfolk Southern "V"-Line. Alignment options west of Bowers Hill include the possibility of adding track to the existing NS rail corridor, as well as potential Northern, Southern, and Richmond Direct greenfield[3] options. This follows the approach of the US 460 highway study, which in addition to assessing the possibility for improving the existing US 460 highway, also developed one greenfield option north, and one greenfield option south of the existing highway. This level of environmental assessment was considered adequate for locating a new highway and resulted in a Record of Decision, so it was thought that it should be appropriate for locating the rail line as well. However, the current phase of Phase 2B work has refined and developed one additional option (Richmond Direct) based on feedback received through the stakeholder involvement process. Exhibit 2-3 shows all the route and station options that were initially considered in this study. Some options were screened early on, while the surviving options were defined to a greater level of detail.

Exhibit 2-3: Environmental Study Area* – Potential Rail Routes in the Norfolk to Richmond Corridor



**Alignments will not be determined until the Tier II Environmental Process is complete.*

[2] Maps were created in ArcMap 10, TransCAD. And MapWindow GIS
[3] A Greenfield is a brand-new proposed rail line where no rail line ever has existed. This contrasts with upgrades to an existing rail corridor, or the restoration of an abandoned rail corridor, since the locations of existing or abandoned alignments are known for sure. We have identified potential corridors for conceptual Greenfield options both north and south of the existing NS rail line, but have not located the alignments precisely.

From Petersburg to Richmond, Southeast High-Speed Rail (SEHSR) currently plans to add one additional track following the CSX existing “S-Line” rail corridor into Richmond. The current Amtrak “A Line” routing from Petersburg directly to Staples Mill was not considered for this study, since it bypasses downtown Richmond. Adding Norfolk trains to the already planned service using the “S-Line” would probably necessitate adding a second additional track. Since this option has already been well-studied in the SEHSR process, it was not assessed in detail here; but, the current SEHSR plan does allow room for an additional track to be added. Based on stakeholder advice, it is believed that the incremental environmental impacts of doing this would be minimal beyond those impacts that have already been identified for the basic SEHSR improvements. If it were decided to carry this option forward in a Tier 1 NEPA evaluation it would be necessary to coordinate the impacts of adding a Norfolk service with the SEHSR environmental process. However, following the SEHSR into Richmond would limit speeds to 90 mph all the way from Petersburg to Richmond; and as such, would not provide for true high speed service.

Possible rail use of the proposed new US 460 highway corridor, also shown in Exhibit 2-3, was considered. Unfortunately, the curves along the proposed new US 460 are too sharp for passenger trains to effectively use the alignment. Conversely, the grades are too steep for freight trains, particularly at certain highway interchanges where the freeway is planned to overpass local roads. The geometric requirements for adding a freight track could not be accommodated without redesigning those interchanges to reduce grades, by taking local roads over the freeway. As a result, the alternative of using the US 460 highway alignment for either freight or passenger rail was not considered further.

The focus of the current study has been to identify options that could allow for truly high speed (125 mph or greater) service except in densely built up urban areas, where the need to share existing rights of way[4] is likely to constrain speed. Three main route options have been developed utilizing a combination of greenfield and existing rail rights of way: via Petersburg, Hopewell and Richmond Direct.

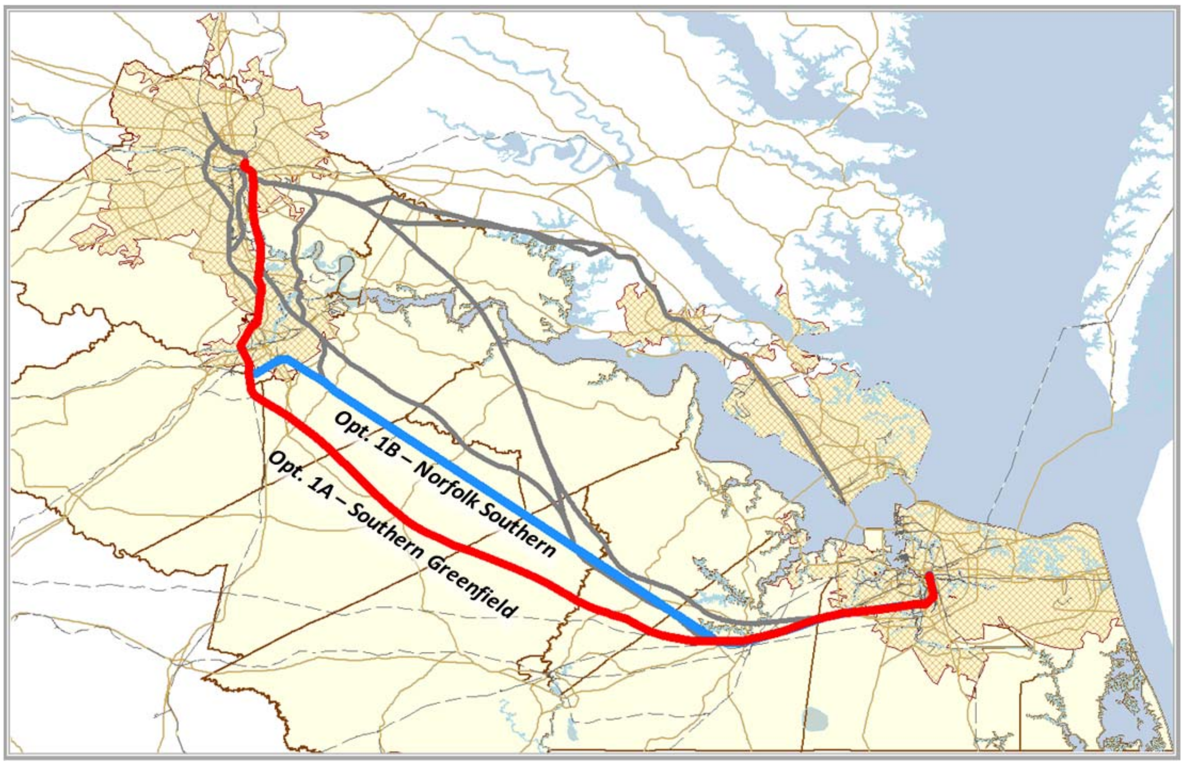
For the Petersburg and Hopewell options, variants have also been developed based on the existing NS rail corridor. Normally, geometric issues would prevent a true high speed service operating along an existing rail alignment, but in this highly unusual situation the existing alignment is arrow-straight from Suffolk to the outskirts of Petersburg. This suggests at least the possibility of developing a high speed service within or close to this right-of-way, so a preliminary assessment has been performed.

Southern Option 1 via Petersburg: As shown in Exhibit 2-4, two route variants were developed from Norfolk to Richmond via Petersburg. Option 1A, a ***Southern Greenfield,*** was developed that could use a portion of the abandoned “Virginian” right-of-way from Suffolk west to the vicinity of Walters, VA, where it would turn northwesterly on new alignment to Petersburg[5]. Option 1B is based on the existing Norfolk Southern rail alignment from Suffolk to Petersburg (Collier). For linking the NS Option 1B over to Petersburg, at Poe there is a need to grade separate both the NS Main Line rail crossing as well as I-295. Implementing this grade separation would likely require either a tunnel or a high level bridge. Continuing from Poe to Collier, residential and commercial development encroaches tightly on the Petersburg Belt line right-of-way; so significant property taking might be needed to widen the corridor. North of Petersburg to Richmond, a high speed option was developed to improve geometry compared to the existing CSX rail corridor. An East

[4] This is characteristic of California’s “Blended” approach http://www.caltrain.com/projectsplans/CaltrainModernization/BlendedSystem.html which has also been typical of the way European high speed systems have been developed, by following existing rail alignments into urban areas.
[5] However, the Country Club of Petersburg and Richard Bland College were seen to both lie across the path of a direct rail alignment. This particular conflict could be eliminated by shifting the option farther south to Burgess. It must be emphasized however, that this Southern routing has not been precisely located. The current analysis only suggests that it may be possible to avoid some obvious obstacles south of the existing rail alignment. It does not suggest any precise location for the alignment.

Shore Greenfield would leave the CSX corridor north of Dunlop, parallel I-95 for a short distance and then cross to the east shore of the James River in the vicinity of Osborne Landing. From there, it would traverse relatively undeveloped farmland on the east shore of the James River, skirting and not directly impacting the Richmond National Battlefield Park, and then rejoin the CSX existing rail alignment (Peninsula Subdivision) in the vicinity of the Fulton Gas Works. From here, the alignment would fly over the CSX tracks to the north side, and approach Richmond Main Street station from the east, rather than from the south. Conceptually, the SEHSR could also choose to share the East Shore Greenfield in lieu of developing the currently planned "S"-Line approach via Centralia.

Exhibit 2-4: Petersburg Rail Options 1A and 1B



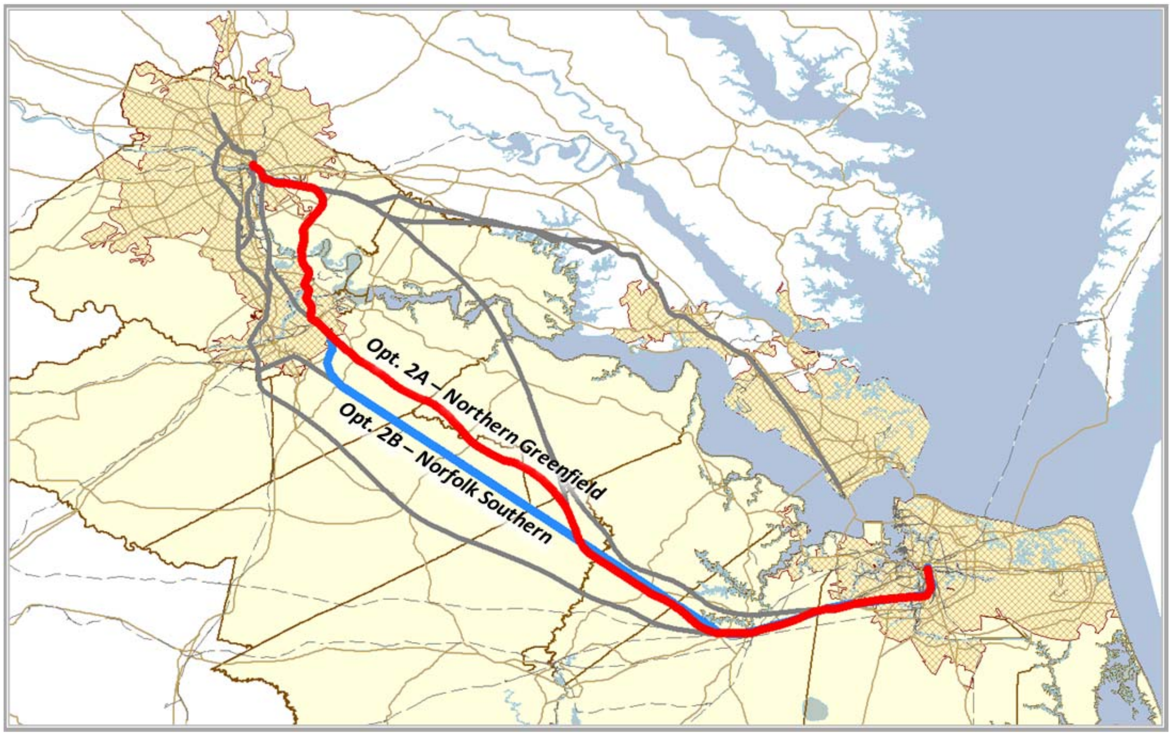
- **Northern Option 2 via Hopewell:** As shown in Exhibit 2-5 two route variants were developed from Norfolk to Richmond via Hopewell. Option 2A, a ***Northern Greenfield,*** was developed that would enter the I-295 median south of Fort Lee.[6]. Option 2B is based on the existing Norfolk Southern rail alignment from Suffolk to Petersburg (Poe). Option 2B would connect to I-295 where the railroad alignment passes under I-295 on the east side of Petersburg.

  From Fort Lee north, it appears that the most practical approach would be to follow I-295 north to where it crosses the CSX Peninsula Subdivision line just east of Richmond Airport. The option

[6] Since most of the Norfolk ridership will be headed north towards Richmond and Washington D.C., a northerly alignment would tend to be shorter and more direct. From Suffolk to Zuni, a new rail alignment could either parallel the existing NS rail line or follow an existing electric utility right-of-way. Beyond Zuni the proposed alignment would cross to the north side of the existing rail alignment and head towards Prince George, VA. The Northern Greenfield would line up with I-295 and follow the highway past Fort Lee. A challenge to the development of any northerly option is how to get through the heavily built-up urban area which covers the whole area from Petersburg to Hopewell on the west shore of James River. However, the I-295 median could provide a possible alternative passageway through the area.

would then parallel the CSX Peninsula Subdivision on the north side into downtown Richmond. The alignment would also approach Richmond Main Street station from the east, rather than from the south. Conceptually, the SEHSR could also share this alternative by constructing a connecting greenfield from Burgess to the junction of I-95 and I-295, then following the I-295 median north.

Exhibit 2-5: Hopewell Rail Options 2A and 2B



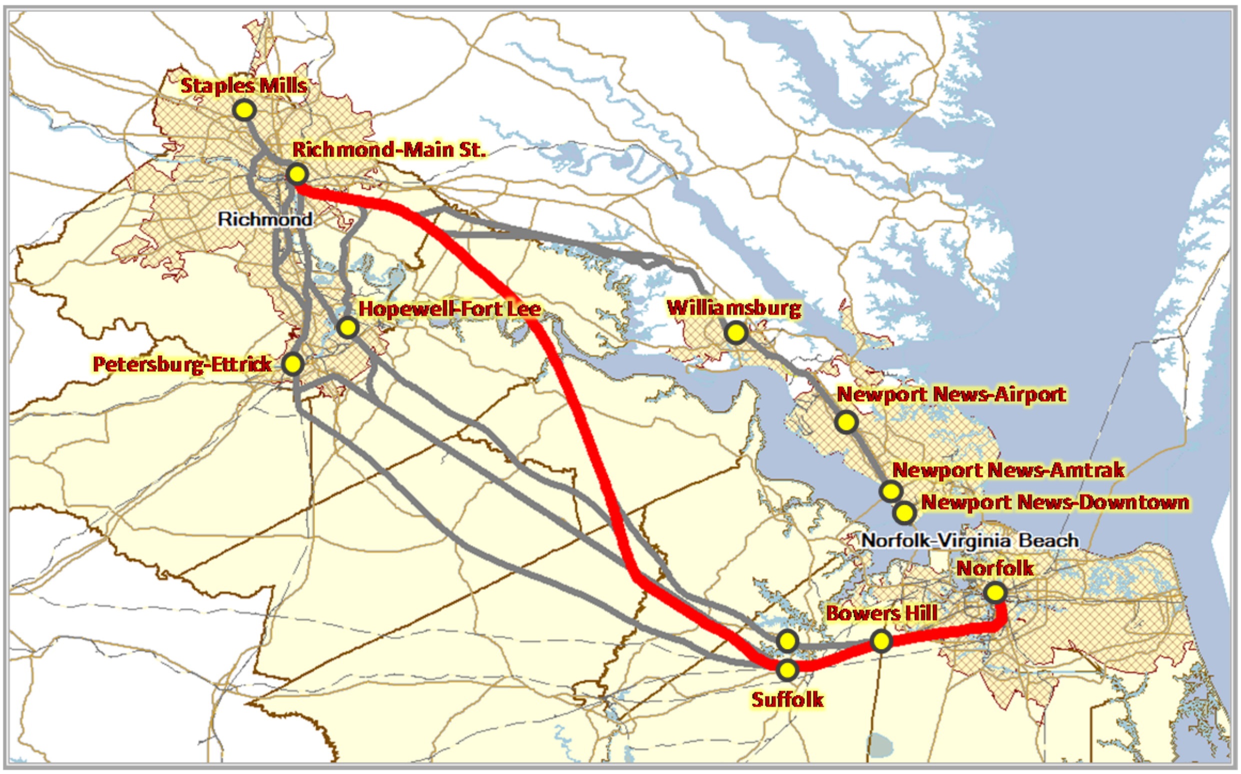
As a result, it can be seen that the Southern Greenfield is logically paired with the East Shore Greenfield in Option 1; while the Northern Greenfield is paired with I-295 in Option 2. The Norfolk Southern variant[7] could pair with either the East Shore Greenfield (via Petersburg) or I-295 (via Hopewell) north to Richmond.

The possibility of constructing a hybrid option "1/2" by pairing the Northern Greenfield with the East Shore Greenfield was considered. Making this connection would require construction of a high speed rail alignment directly across the Fort Lee grounds, which are used for active military training. It is not clear that crossing Fort Lee is even feasible, and a preliminary review of this option does not show any clear environmental or operational advantages to doing this. Bringing this option back would only appear to make sense if some fatal flaw were found in the I-295 opportunity. Given the difficulties associated with crossing the Fort Lee grounds, it is likely that this hybrid option of linking the Northern Greenfield to the East Shore Greenfield will be screened early in the Tier 1 NEPA evaluation.

[7] From Suffolk to Petersburg, a Norfolk Southern variant of Options 1 and 2 was considered. The key element of this analysis was a sensitivity analysis of the adoption of various corridor widths or "footprints" for adding passenger tracks to the existing rail corridor. This suggested the technical possibility of squeezing up to four tracks within a 100' wide right-of-way, with a 30' minimum separation between active freight and passenger tracks, or a 120' wide right of way with a 50' minimum separation. A key finding was that footprints wider than 120' would result in excessive property taking and significant wetland impacts. These would produce an uncompetitive environmental profile as compared to available greenfield options. As a result it is not likely that any "wide footprint" options will survive preliminary screening in a NEPA evaluation. However, the analysis also suggests that a "tight footprint" option up to 120 feet wide for the NS existing rail corridor could produce an environmental profile that is competitive to greenfield alternatives, so this option was retained.

- **Option 3 – Richmond Direct:** shown in Exhibit 2-6 foregoes the benefit of serving intermediate markets at Petersburg and Hopewell, but it also avoids the high costs and environmental issues associated with developing urban infrastructure and sharing either the SEHSR (CSX rail) or I-295 (highway) alignments through Petersburg or Hopewell. The ***Richmond Direct*** option instead relies on the planned SEHSR service to serve Petersburg. Bypassing this area with its potentially high development cost could potentially offer the fastest, most direct and most cost effective way to connect south Hampton Roads to Richmond and the large cities of the Northeast Corridor. Doing this also maximizes potential synergies with development of Peninsula service to Newport News, which could utilize the high speed alignment for access to downtown Richmond.

Exhibit 2-6: Option 3 - Richmond Direct



From Suffolk to Zuni, the representative alignment would follow the same route as the Northern Greenfield: a new rail alignment could either parallel the existing NS rail line or follow an existing electric utility right-of-way[8]. Beyond Zuni the alignment would cross to the north side of the existing rail alignment and head straight towards Richmond. Crossing the James River in the vicinity of Charles City, the alignment would gently curve west to line up with the CSX Peninsula subdivision east of Richmond Airport. From here, crossing under I-295 and paralleling the CSX

[8] As part of the Richmond Direct or Northern Greenfield options, a possible alternative around the north side of Suffolk was also considered. Heading west from the proposed Bowers Hill rail station, instead of following the CSX Portsmouth Subdivision into downtown Suffolk, a "Suffolk Bypass" would head straight west across the Dismal Swamp, skirt the Suffolk Regional Landfill and follow US-13 around the northern outskirts of Suffolk. This is attractive because it could potentially allow an electric train to accelerate directly to 220-mph upon leaving the Bowers Hill station. However, because of extensive wetland impacts and to avoid significant property taking, it is likely that a significant portion of this alignment would need to be constructed on elevated structure. Stakeholders did not consider it to be fatally flawed, but an alternative utilizing the CSX Portsmouth Subdivision through downtown Suffolk will likely be much more cost effective. It is expected that the Suffolk Bypass will likely be screened early on in a Tier I NEPA evaluation because of right-of-way issues, wetland impacts and the high cost of the elevated structures that will likely be required.

Peninsula Subdivision on the north side into downtown Richmond, the alignment would approach Richmond Main Street station from the east, rather than from the south.

2.4 TRAIN TECHNOLOGY OPTIONS

The key element for developing an operating plan is the technology selection from a range of alternative technologies available. In the case of the slower speed alternatives (79-110 mph), the most effective option is using existing railroad rights-of-way and where the volume of freight rail traffic is limited, to share tracks with freight traffic. As speeds and frequency of passenger rail service increase, the ability to share tracks with freight becomes more limited, although if wide enough the right-of-way may still be shared. For very high speeds the ability to even use existing railroad rights-of-way is typically lost. Of course, sharing track or using freight rail right-of-way may still occur (at lower speeds) in urban areas to gain access to downtown stations, but away from the urban area true high speed service is likely to require a greenfield route – since high speed rail operations need long stretches of straight track and very gentle curves to achieve high speed. Even sharing Interstate highway right-of-way may not be possible since they frequently have curves that are too tight for the faster trains. In general, faster systems have fewer stops. A compromise may be needed to ensure all key communities are served, but this results in a trade-off between end-to-end speed and connecting communities. Each station stop takes three to seven minutes (including deceleration, stop time and acceleration back to speed) so multiple stops soon dramatically increase end-to-end running times.

A key study assumption that determines transit time is a passenger car's "tilt" or "non-tilt" design. The track in curves is typically banked (super-elevated) up to six degrees (6° or 6"), which results in designation of a balance speed for each curve (at which speed a vehicle occupant would feel no sideways force in the curve). However, up to four degrees (4° or 4") of imbalance (cant deficiency) is acceptable for passenger comfort. Beyond this, onboard hydraulic systems (active tilt) or car suspension designs (passive tilt) can permit even higher speeds, by lowering the centrifugal forces felt inside cars.

True high speed trains typically do not include tilting mechanisms, because the allowable cant deficiency reduces to only 2.5 degrees (2.5° or 2.5") at 220 mph[9]. This limitation on cant deficiency at the wheel-rail interface eliminates the benefit of tilt for true high speed rail. It should be noted that the geometric standards for interstate highway alignments generally allow speeds of 125-150 mph, which are in the effective range for tilting trains, but the curves are usually too sharp to support true high speed trains (186 mph+). As a result, high speed trains need very gentle curves, which are typically only obtained through development of new "greenfield" alignments. Tilting capability may still be beneficial to high-speed trains however, on shared segments of existing line on urban approaches, or for extended operations beyond the limits of the high speed territory.

Another key issue for determining the suitability of train technology is compliance with FRA safety requirements. The FRA Tier I safety requirements allow speeds up to 125 mph. More stringent Tier II requirements are applied to passenger trains operating with speeds 125-150 mph. The FRA Railroad Safety Advisory Committee (RSAC) recently announced "Alternative Tier I" compliance standards[10] that could make it easier to adapt European train designs to meet United States requirements.

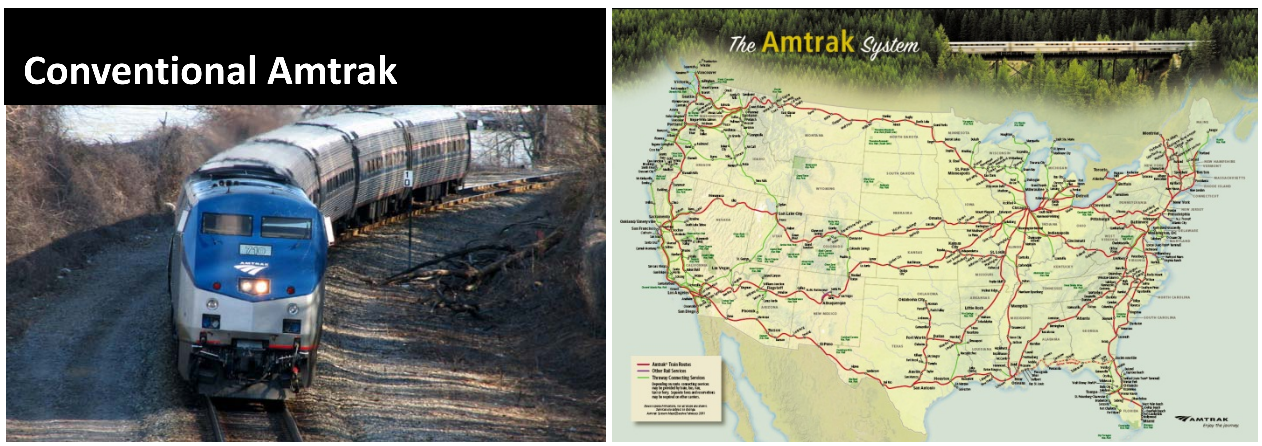
[9] *See: http://www.scribd.com/doc/24548877/High-Speed-Railway-Lines-en*
[10] Railway Track and Structures, http://www.rtands.com/index.php/track-maintenance/off-track-maintenance/rsac-recommends-passenger-rail-crashworthiness-standards-to-accommodate-hsr.html

Conventional Rail – 79 mph or less: Conventional trains, as shown in Exhibit 2-7, typically operate at up to 79 mph on existing freight tracks. 79 mph represents the highest speed at which trains can legally operate in the United States without having a supplementary cab signaling system on board the locomotive. The key characteristics of these trains are that they:

- Are designed for economical operation at conventional speeds
- Can be diesel or electric powered
- Are non-tilting for simplified maintenance

Conventional rail is used for example by Amtrak in corridors across the country outside the Northeast corridor. Such trains do operate at up to 110 mph in developing corridors in Illinois and Michigan, but they need an extra locomotive in order to attain satisfactory acceleration or braking performance. The high center of gravity of the P-42 locomotive limits its safe speed around curves, as compared to higher speed trainsets, which are designed to have a lower center of gravity.

Exhibit 2-7: Conventional Rail – Representative Trains and Corridor Service



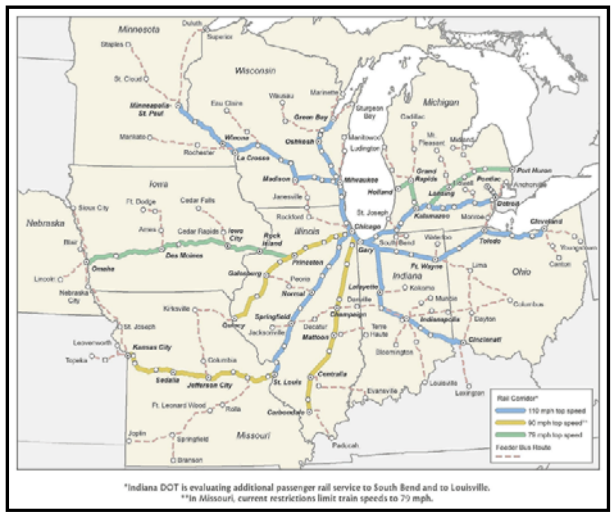
Higher Speed Rail - 110-130 mph: A 110 to 130-mph service can often be incrementally developed from an existing conventional rail system by improving track conditions, adding a supplementary Positive Train Control safety system, and improving grade crossing protection. Tilt capability, built into the equipment can be used to allow trains to go around curves faster, and has proven to be very effective for improving service on existing track, often enabling a 20-30 percent reduction in running times. Trains operating at 110 mph, such as those proposed for the Midwest, Ohio Hub and New York State systems (See Exhibit 2-8), have generally been found to be affordable, produce auto-competitive travel times, and are able to generate sufficient revenues to cover their operating costs.

Higher speed trains:

- Are designed for operation above 110 mph on existing rail lines and diesel trains can attain sustained speed of 130 mph on dedicated grade separated rights of way.
- Can be diesel or electric powered.
- Are usually tilting unless the track is very straight.

In the United States, 110-mph service has been seen to provide a low cost infrastructure option by using existing railroad rights-of-way, and quad-gating crossings, which are relatively low cost options. However, it may contradict some existing freight railroad passenger principles unless additional improvements are made. For example, while Norfolk Southern's passenger principles do not prohibit the operation of higher speed tilting trains, they do prohibit speeds above 79 mph on Norfolk Southern-owned rights of way. CSX policies have generally prohibited operations above 90 mph. To reach 110-mph speeds or higher an alternative arrangement, such as the purchasing of a parallel strip of right way, or right-of-way easement and separate ownership of the track may be needed to comply with the requirements of the freight railroads.

Exhibit 2-8: High Speed Rail Shared Use (Diesel) – Representative Trains and Corridor Service



High Speed Rail - 130-220 mph: The costs of grade separation for 125 mph can easily double the capital cost of a project, as the number of public and private crossings can be as many as two per mile. This is why true high speed rail is typically twice the cost per mile of higher speed rail. Once full grade separation has been accomplished however, speeds can be pushed up to 220 mph by electrification and the use of Electric train systems. This will tend to improve further the economic return on capital investment.

Representative trains include the Amtrak Acela Electric locomotive hauled train as well as the proposed California trainset shown in Exhibit 2-9. While initially the Acela speed was limited to 150 mph, it is now being tested at speeds of 160 mph. However, this concept has been superseded by the joint equipment procurement by Amtrak and the California High-Speed Rail Authority, as well as Amtrak's cancellation of its own intended Acela fleet expansion for the Northeast Corridor. Instead, California and Amtrak intend to collaborate on the purchase of a common fleet of high speed electric trains[11]. It should be noted that in the last twenty years electric high speed train technology has evolved rapidly from 150 mph maximum speed to 220 mph maximum speed. This revolution in train capabilities has been due to rapid advances in the design of the propulsion system of modern electric trains. It is assumed that new electric trains based on the new standards will be able to operate up to 220 mph on dedicated alignment and still be able to comingle with freight trains on the same tracks as needed, at speeds under 125 mph. Both Amtrak and California have produced feasibility and business plans showing the advantage of moving to 220-mph technology.

[11] See: http://www.amtrak.com/ccurl/620/710/Amtrak-CHSRA-Joint-RFI-HSR-Train-Sets-ATK-13-012.pdf

Exhibit 2-9: High Speed Rail Shared Use (Electric) – Representative Trains and Corridor Service

2.5 OTHER ROLLING STOCK AND OPERATIONAL ASSUMPTIONS

Consistent with the assumptions customarily made in feasibility-level planning and Tier I EIS studies, the following general assumptions are proposed regarding operating requirements for the rolling stock:

- Trains will be reversible for easy push-pull operations (able to operate in either direction without turning the equipment at the terminal stations);
- Trains will be accessible from low-level station platforms for passenger access and egress, which is required to ensure compatibility with freight operations;
- Trains will have expandable capacity for seasonal fluctuations and will allow for coupling two or more trains together to double or triple capacity as required;

- Train configuration will include galley space, accommodating roll-on/roll-off cart service for on-board food service. Optionally, the trains may include a bistro area where food service can be provided during the entire trip;
- On-board space is required for stowage of small, but significant, quantities of mail and express packages, and also to provide for an optional checked baggage service for pre-arranged tour groups;
- Each end of the train will be equipped with a standard North American coupler that will allow for easy recovery of a disabled train by conventional locomotives;
- Trains will not require mid-route servicing, with the exception of food top-off. Refueling, potable water top-off, interior cleaning, required train inspections and other requirements will be conducted at night, at the layover facilities located at or near the terminal stations. Trains would be stored overnight on the station tracks, or they would be moved to a separate train layover facility. Ideally, overnight layover facilities should be located close to the passenger stations and in the outbound direction so a train can continue, without reversing direction, after its final station stop; and
- Trains must meet all applicable regulatory requirements including:
  - FRA safety requirements for crash-worthiness,
  - Requirements for accessibility for disabled persons,
  - Material standards for rail components for high speed operations, and
  - Environmental regulations for waste disposal and power unit emissions.

2.6 Route and Technology Options

The three main route options described above (including the two variant options that utilize the Norfolk Southern alignment), have been assessed at two maximum train speeds: 130 mph and 220 mph, consistent with the capabilities of modern diesel and electric train technologies. As a result, the following Exhibit (2-10) shows the five routes and two technology/speed combinations have been assessed in this study, leading to a total of ten options:

Exhibit 2-10: Study Options Assessed

OPTION	VARIANT	SPEED
Southern Option 1 – via Petersburg	Southern Option 1A - Greenfield	130 / 220 mph
	Southern Option 1B - Norfolk Southern	130 / 220 mph
Northern Option 2 – via Hopewell	Northern Option 2A - Greenfield	130 / 220 mph
	Northern Option 2B - Norfolk Southern	130 / 220 mph
Option 3 – Richmond Direct	----	130 / 220 mph

To avoid biasing the analysis, the same capabilities have been assumed for all segments of alignment, so train speeds are limited by only equipment capabilities and track geometric restrictions. For comparative purposes, all alignments are assumed to be double tracked and fully grade separated. As a result, a top speed of 130 mph was assumed for diesel trains in all options, and 220 mph for electric trains.

In terms of the "B" options that involve segments of Norfolk Southern right-of-way between Suffolk and Petersburg, these have been assessed on an equitable basis based on geometry, since the existing rail alignment is arrow-straight between Suffolk and Poe, on the outskirts of Petersburg.

In the short term these Norfolk Southern options may be easier to develop on an incremental or phased basis, assuming that the agreement of the freight railroad can be gained to install the incremental improvements. However, care must be taken in pursing incremental development of the existing rail corridor west of Suffolk to ensure that the speed capability is in fact, ultimately extendable to support the ultimate 220 mph build-out of the system, if it were decided to pursue such incremental options.

3. ROUTE ANALYSIS

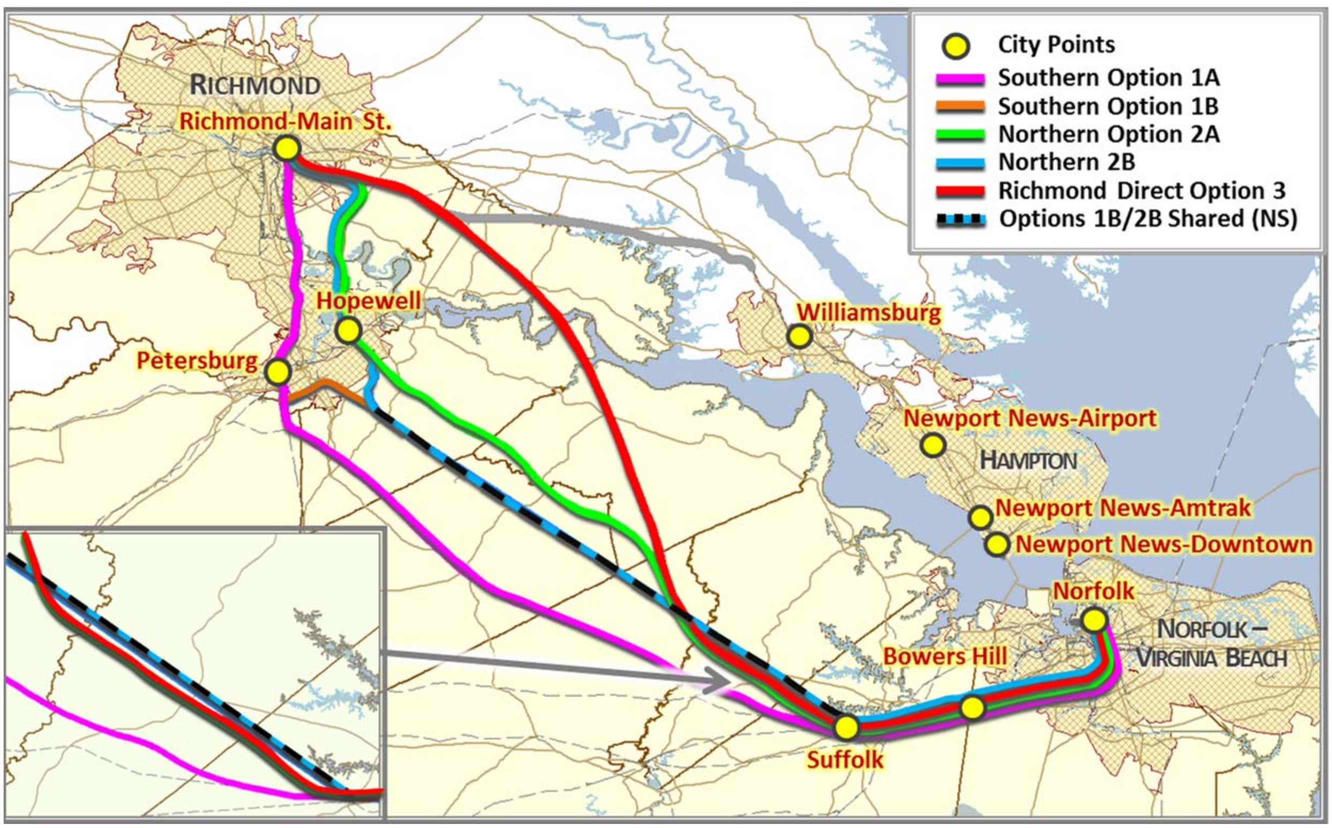
Route options have been developed at a conceptual level based on a mapping analysis of the routes. Particularly for new greenfield alignments, environmental considerations not only determine where an alignment might go, but also directly drive the capital costs in terms of unavoidable consequences and mitigation costs. Particular attention has been paid to crossings of highways and other rail lines, required property takings, river bridges and wetland crossings since these are key capital cost drivers. This route analysis focuses primarily on the factors that directly impact capital cost and develop the key environmental and engineering findings, upon which the preliminary capital cost development for each option will be based.

3.1 ROUTE OPTIONS

Chapter 2 proposed three conceptual options for linking Norfolk to Richmond on a new high speed alignment. These are routes via: Petersburg, Hopewell, or Richmond Direct. The Petersburg and Hopewell options have two variants: where the “A” variant is a new greenfield alignment, and the “B” variant would utilize the existing Norfolk Southern rail corridor from Suffolk to Petersburg.

This makes five route options in total (see Exhibit 3-1), which are called 1A, 1B, 2A, 2B and 3, respectively. However, the 1B and 2B options share the Norfolk Southern segment from Suffolk to Petersburg. This option for developing a dedicated track along the Norfolk Southern Suffolk to Petersburg line will be developed only once, for both options.

Exhibit 3-1: Route Options Assessed for the Engineering Analysis



Because of this overlap, *four* route segments will be developed in this chapter:

1A– Southern Greenfield via Petersburg would link Kilby to Burgess, south of CSX's Collier Yard in Petersburg. From Burgess the alignment would follow the SEHSR through Petersburg to Woods Edge Road. There, the alignment would leave the CSX rail corridor, parallel I-95 for a short distance, cross the James River and enter a possible "East Shore Greenfield" through open land to Richmond.

2A – Northern Greenfield via Hopewell would link Kilby to Hopewell, then follow I-295 north to Richmond. The alignment would leave I-295 where it crosses the CSX Peninsula Subdivision, and parallel the CSX rail line into Richmond Main Street Station

3–Richmond Direct Greenfield would head directly to Richmond on the shortest practicable routing through open land. It would cross the James River near Charles City and line up with the CSX Peninsula Subdivision just east of the I-295 crossing. From here it would parallel the CSX rail line into Richmond.

1B and 2B *(Common Segment from Suffolk to Petersburg)* – Dedicated Tracks Along the Existing Rail Corridor would develop dedicated infrastructure closely following the Norfolk Southern mainline to Poe, on the eastern outskirts of Petersburg. From Poe, the corridor would either follow the Belt Line to Collier and connect to the planned Southeast High-Speed Rail (SEHSR) through Petersburg; or else it would follow the I-295 highway median north via Hopewell to Richmond.

All options would share a common segment using the existing "V-Line" rail alignment from Norfolk Harbor Park to a rail junction called "Kilby" on the west end of the City of Suffolk. Beyond Kilby, the new Greenfield options 1A, 2A and 3 have been developed, to offer an alternative to options 1B and 2B that would develop a dedicated track paralleling the Norfolk Southern rail right-of-way, and also to address the issue of how to connect the high speed alignment north to Richmond. These high speed rail options include two segments in urban areas, where the tracks would be shared with freight trains at reduced speeds. These are:

- Norfolk Harbor Park to Kilby on NS and CSX
- Burgess to Dunlop on CSX (enhanced SEHSR plan)

These two segments are based on existing rail alignments and have been subject to previous Environmental studies, so the assumptions for these segments can be spelled out in some detail. However, some of the earlier engineering assumptions may need to be adjusted for supporting the higher service intensities that are associated with high speed rail operation, particularly the need for adding double dedicated tracks. Any implementation based on existing rail lines might be phased to develop infrastructure improvements incrementally, provided the initial planning accommodates the ultimate capacity need. Such infrastructure could be added over time as the service develops.

3.1.1 FREIGHT RAILROAD PRINCIPLES

Any shared use of freight rail corridors or tracks must respect the need for continued safe and economical rail freight operations. At a minimum, it is intended that the freight railroads must be able to operate their trains as effectively as they could if passenger service did not exist. Beyond this, it is desirable to actually create benefits for freight rail service if possible while developing the infrastructure needed to support passenger services. This has been done in Virginia, for example through development of the Heartland Corridor. This project was justified based on its economic and job creation benefits. Freight railroads must retain their ability not only to handle current traffic, but also to expand their own franchises for future traffic growth.

As such, both CSX and Norfolk Southern have established "Letters of Principle" to provide guidance to passenger rail planners. The purpose of the principles is to protect the safety of railroad employees and communities, service to freight customers, and the right -of -way and land needed to fulfill the railroads' freight transportation mission. However, Norfolk Southern acknowledges that each passenger proposal is unique, so NS' application of the principles to particular proposals will often be unique as well.

The following discussion will focus on Norfolk Southern's principles since CSX's are very similar. With regard to high speed rail (HSR) service and corridors, the following special considerations are necessary:

- Norfolk Southern will work with planners to insulate high speed rail corridors from interference with and from NS freight corridors.
- Passenger trains operating in excess of 79 mph require their own dedicated tracks. Those operating in excess of 90 mph require their own private right -of -way.
- Where higher -speed trains share tracks with conventional freight trains, those high speed trains will not be able to exceed 79 mph. Where shared track is concerned higher speed trains must meet the same safety standards as conventional freight trains.

Norfolk Southern requested that this draft report make clear (See Appendix E) that all high speed (above 90 mph) portions of the route would be constructed off of Norfolk Southern right -of -way, and any high speed route should assume at least a 50 -foot separation between high -speed and Norfolk Southern freight tracks. As a result, in this study where speeds greater than 90-mph have been proposed, it has been assumed that a public entity would either the purchase a strip of land parallel to the existing rail right of way, or else purchase the needed rail right of way outright while maintaining freight rights of access – as was recently done in Michigan – subject, of course, to successful conclusion of negotiations with the freight railroad.

At present the passenger proposals laid out here are still un-negotiated, un-funded and at a feasibility level. The required capacity analysis for shared track segments has yet to be done. As a result, the work is not yet at a detailed enough level to satisfy the needs of the freight railroads. It is understood that in following detailed engineering and environmental studies, the details of integrating the proposed passenger operations with freight operations will be subject to close negotiations with the railroads. This will include detailed engineering and operation studies. The final capital plan and capital costs for shared segments will eventually need to be worked out in negotiations with the freight railroads.

In the meantime, this report contains preliminary data which is subject to review, verification and approval by both CSX and Norfolk Southern Railroad. As of the date of this report, this review process has not taken place. Findings are not to be construed as a commitment on the part of either CSX or Norfolk Southern to operate additional service.

3.2 SEGMENT BY SEGMENT ANALYSIS

The following subsections will address environmental and engineering conditions existing along each route segment. The Norfolk Harbor Park to Suffolk segment is common to all alternatives. After that, individual segments are assembled to develop the full route for each of the developed Options 1A, 1B, 2A, 2B and 3.

3.2.1 NORFOLK HARBOR PARK TO SUFFOLK - EXISTING RAIL SEGMENT

This segment of existing urban rail corridor is common to all options. Although the existing rail alignment is fairly straight, it does include some speed restrictions as well as proposed station stops at Bowers Hill and Suffolk that will limit train speeds. From the Harbor Park station through South Norfolk to the lift bridge over the south branch of the Elizabeth River, a 79 mph design standard will suffice and produces the best compatibility with shared freight operations. For the dedicated segment from the Elizabeth River lift bridge to Kilby (west of Suffolk), it is suggested that the alignment be developed to 110 mph standards which is still compatible with shared freight operations and allows grade crossings.

For speeds up to 110 mph, special highway grade crossing treatment (quad gates) are needed, but grade separations are not required. This does not preclude consideration of grade separations for this segment, but since they are not required by regulation, each grade separation should be individually reviewed and justified on its own merits.

NORFOLK HARBOR PARK TO SOUTH NORFOLK

From Norfolk to South Norfolk, the proposed alignment follows the existing Norfolk Southern double tracked main line. The recommendation would be to add one track to the existing right-of-way, so the line would be completely triple tracked from Harbor Park to the junction of the "V-Line" at South Norfolk. These tracks could all be shared with freight trains, but in fact the westernmost track would be primarily dedicated to passenger trains; while the two eastern tracks would maintain the capacity of the existing freight line. This 2.2 mile segment would be operated at 79 mph or less and due to right-of-way restrictions, should be constructed on conventional 14'-15' track centers. It has 6 grade crossings.

Norfolk Southern bridges 5 and 5A cross the east branch of the Elizabeth River just south of the Harbor Park station. Bridge 5 carries the two current Norfolk Southern main tracks across the river. Beside it, Bridge 5A is currently out of use but according to the DRPT Hampton Roads EIS has been maintained in serviceable condition, and could be reactivated just by reconnecting the tracks. No special maintenance issues have been noted in previous studies regarding this bridge. This should be assessed in the next phase of work to ensure not only safety, but also reliable operation of the bridge after it is restored to service. Starting just east (north) of the Harbor Park station, a third track would be added along the east side of the right-of-way, crossing Bridge 5A. This new track would become the new eastbound freight track; the existing tracks on Bridge 5 would be used for westbound freight and passenger trains, respectively.

Old track charts suggest at one time a former third track across Bridge 5A continued south to "NS Junction" where the Norfolk Southern main connects to the Norfolk & Portsmouth Belt line, about 1.4 miles south of Harbor Park station, directly underneath the US-460 highway overpass. A section of this former third track still remains as a short siding just north of "NS Junction." It is assumed that this siding would be subsumed into the 3rd track restoration along the east side of the right-of-way. From Harbor Park to "NS Junction," this section will be estimated as 1.4 miles of new track on existing roadbed and also includes the base cost for one station. (This provides an allowance for expanding the capacity of the existing terminal station at Harbor Park.)

South from "NS Junction" to the V-Line at South Norfolk, a distance of 0.8 miles, the corridor passes through a densely built up urban residential area on a narrow right-of-way. Based on the position of fence lines, it would appear that the existing double track is positioned within an approximate 90' wide right-of-way, but some existing buildings come right up to the edge of the property line. As shown in Exhibit 3-2, it appears that existing tracks are not quite centered within the right-of-way, rather they seem to be shifted a little closer to the east side of the right-of-way. As a result, south of the US-460 overpass, there is more room to add a new track on the west side than on the east side. There is no evidence that a third track ever existed in this area, so it will be costed as 0.8 miles of new track on new roadbed (15' fill height) on 14-15' track centers. This new track added on the east side would connect directly into the "V-Line" at South Norfolk.

Exhibit 3-2: Norfolk Southern Asymmetrical Right-of-Way between NS-Junction and South Norfolk

SOUTH NORFOLK TO SUFFOLK SPUR

Suffolk Spur is the rail junction just east of Suffolk, where the Commonwealth Railway to Craney Island, and a short remnant of another CSX branch line, pass over and connect with the CSX Portsmouth Subdivision. From South Norfolk to Suffolk Spur the alignment follows a combination of former Virginian "V-Line" and CSX Portsmouth Subdivision right-of-way[1]. At this location, a CSX industrial spur also connects south to several industries and provides a possible connection to the Norfolk Southern main line. The distance from South Norfolk to Suffolk Spur is 17.2 miles. The segment has 22 grade crossings and includes the cost for one station at Bowers Hill.

From South Norfolk the alignment follows the "V-Line" west through a residential neighborhood on an approximate 100' right-of-way. It passes under US-460 and I-464 and emerges into an industrial and wetland area on the east bank of the south branch of the Elizabeth River. Crossing the Norfolk & Portsmouth Belt branch line at grade, the alignment spans the Elizabeth River on a large single track lift bridge (Exhibit 3-3). No special maintenance issues have been noted in previous studies in regard to this

[1] A potential alternative rail routing between South Norfolk and Suffolk could ollow the existing Norfolk Southern main line. Existing Amtrak service uses this line, but studies dating back at least as far as 2002 have argued that the "V-Line" offers a better opportunity to develop a dedicated passenger rail alignment. Using the "V-Line" avoids a major rail freight yard at Portlock, and also avoids the need for adding tracks to Norfolk Southern's main line across the Dismal Swamp. DRPT's Hampton Roads Tier I EIS assumed that the "V-Line" would be used, and this recently was granted an FRA Record of Decision. However, even while the "V-Line" does presents an obvious opportunity to develop a dedicated passenger alignment, it is still necessary to ensure that a sufficient level of environmental documentation exists to support the formal screening of the Norfolk Southern existing rail alternative. It is recommended that this issue be discussed with FRA to determine what level of analysis will suffice to withstand any potential legal challenges. This will also be very useful to serve as public outreach material to document the case for developing the "V-Line" as a dedicated passenger rail corridor.

bridge. This should be assessed in the next phase of work to ensure not only safety, but also reliable operation of the bridge in daily service.

Exhibit 3-3: "V" Line Lift Bridge over the South Branch of the Elizabeth River

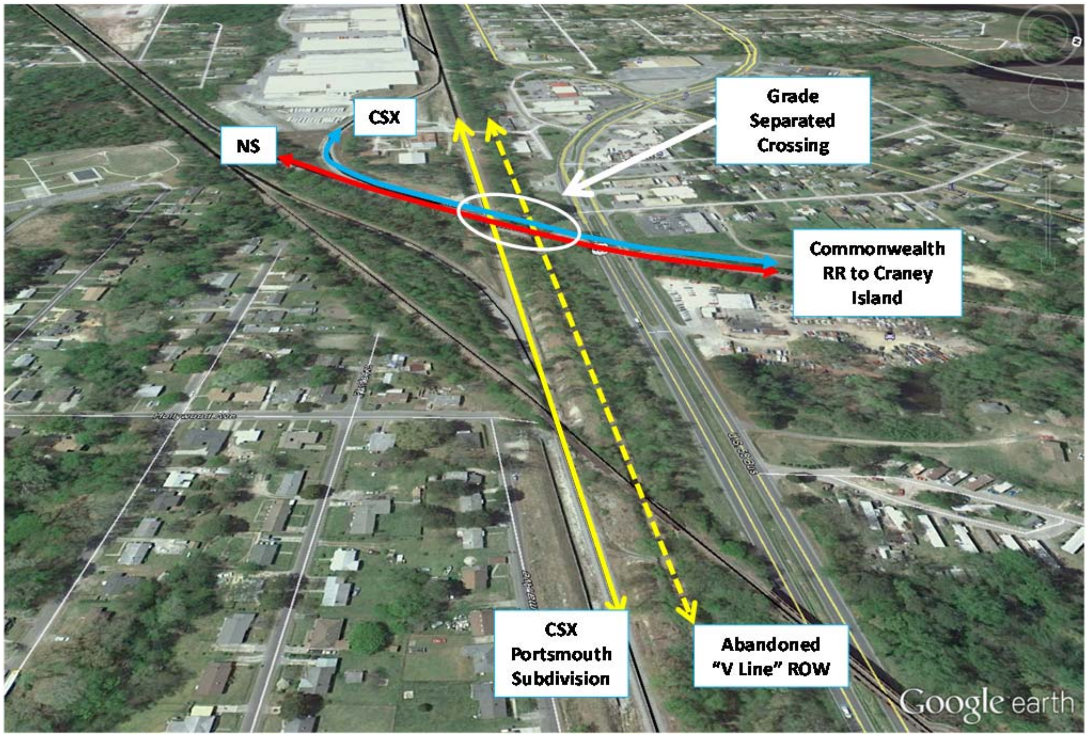
The distance from South Norfolk across the bridge to the west bank of the Elizabeth River is 1.9 miles. Because of the relatively short length of this segment, single tracked bridge structure, freight train sharing, curves and urban environment, it is assumed that the line will be operated at 79 mph and remain single track from South Norfolk to the river bridge. It will be estimated as 1.9 miles of single new track on existing roadbed.

On the west bank of the Elizabeth River, Norfolk Southern serves a Giant Cement import pier[2]. This pier has a permitted throughput capacity in excess of 450,000 tons, or approximately 4,000 railcars annually. The "V" line continues west in active service for another 4.5 miles beyond this cement facility to the Cavalier Industrial park, but carries only very light industrial traffic. Beyond the industrial park, the "V"-line tracks remain in place but out of service for another 3.9 miles to Algren, the junction with the CSX Portsmouth Subdivision. There is a section of about 0.6 miles along Old Virginia Road, and 1.9 miles along Denver and Taft drives where residential development tightly hugs the rail right-of-way and will likely need sound wall protection. The proposed Bowers Hill station lies in the middle of this out-of-service segment. Beyond Algren the distance is 6.9 miles along the CSX Portsmouth Subdivision to Suffolk Spur.

For high speed passenger rail service, it is proposed that this 15.3 mile section from the Elizabeth River Bridge to Suffolk Spur (see Exhibit 3-4) be double-tracked and upgraded for operation at 110 mph.

[2] See http://www.prnewswire.com/news-releases/giant-cement-holding-inc-acquires-deepwater-import-terminal-in-portsmouth-va-74506237.html

Exhibit 3-4: Commonwealth Rail Crossing at Suffolk Spur



From the Elizabeth River Bridge to Algren, some portions of "V Line" right-of-way appear to be wide enough and already graded for double track. However, there is no evidence from the historical track charts that double track ever existed along this section of "V Line." Therefore the "V Line upgrades will be estimated as 8.4 miles of single track on existing roadbed, and a second new track on new roadbed with approximately 15' average fill height. It will include 2.5 miles of sound wall protection for the adjoining residential development.

From Algren to Suffolk Spur, the abandoned "V-Line" right-of-way closely parallels the CSX Portsmouth subdivision (about 100' on the north side.) The first 4.5 miles west from Algren cross the Dismal Swamp with wetlands areas close along the CSX right-of-way on the south side. Beyond the Dismal Swamp there is an industrial siding serving an asphalt and concrete ready-mix facility, also on the south side of the CSX tracks. From this point the CSX and "V-Line" right-of-way continue to parallel one another for the remaining 2.4 miles to Suffolk Spur. Housing development spreads north from Washington Street, adjoining the CSX alignment on the south side for the last mile into Suffolk.

Because of the wetland areas, ready mix plant and housing development all on the south side of the existing CSX track, it would appear that any new track should be added on the north side. In this area, the parallel "V-Line" right-of-way already exists and is graded on the north side. As a result, would appear to make sense to reclaim the "V-Line" right-of-way, so this segment will be estimated as 6.9 miles of double track on existing roadbed. It will include 1.0 miles of sound wall protection for adjoining residential development on the east end of Suffolk.

SUFFOLK SPUR TO KILBY

The optimal routing through the City of Suffolk needs to be determined by a separate, more detailed study. Since the existing Amtrak service could also use the Suffolk to Norfolk improvement, any upgrades made from Suffolk to Norfolk would have independent utility.

Previous studies including the DRPT Tier I EIS have all assumed that passenger trains would use the CSX Portsmouth Subdivision, rather than the Norfolk Southern main line through Suffolk to Kilby, on the west end of town, a distance of 3.9 miles. At Kilby, it has been assumed that a new track connection would be built to connect the Portsmouth Subdivision to the Norfolk Southern main line to Petersburg. However, if it were decided to develop a new Greenfield alternatives west of Suffolk, such a connection would not be needed. The key issues that still need to be resolved are:

- CSX Freight train routings through Suffolk
- Passenger train routing through Suffolk, and related station location

As background -- with the closing of the Portsmouth Marine Terminal[3], container operations have been shifted to a new port at Craney Island. Both Norfolk Southern and CSX access this port over the Commonwealth Railway, which joins the CSX and NS main lines at Suffolk Spur. While CSX still has substantial local freight business in Portsmouth, this shift has *removed* the main flow of container "stack" trains from the Portsmouth subdivision east of Suffolk Spur. However, due to the Panama Canal expansion and CSX's own National Gateway project, CSX double stack traffic has *increased* through downtown Suffolk, west of the junction at Suffolk Spur. Recently, for consolidating blocks of on-dock rail traffic, CSX added a small support yard at Kilby[4], just west of Suffolk.

The 2002 *Richmond to South Hampton Roads High-Speed Rail Feasibility Study*[5] predates this port development. It suggests that the CSX Portsmouth subdivision be developed for rail passenger service but assumes only a single track line, shared with freight trains. However, given the recent increase in CSX double stack traffic, as well as the higher frequencies of passenger trains now envisaged, it may not be realistic to assume that passenger trains can use the Portsmouth Subdivision without adding enough capacity for CSX double stack trains to operate to/from the port in in unfettered manner.

One way for doing this may be to shift CSX stack trains away from the Portsmouth Subdivision altogether, onto Norfolk Southern's parallel line between Suffolk and Franklin. Doing this could allow abandonment of the Portsmouth Subdivision between Suffolk and Franklin, but it would require constructing a new rail connection in Franklin. Alternatively, CSX freight could be shifted onto the Norfolk Southern main line through Suffolk, possibly by adding a third track (if needed) along the north side of the existing rail corridor. This consolidated freight corridor concept was earlier proposed by the Suffolk Rail Impact Study[6] as a possible grade crossing mitigation measure. Either way, by shifting the freight trains to a different line, the CSX Portsmouth Subdivision through Suffolk could be developed into a dedicated passenger alignment free of freight train interference, as shown in Exhibit 3-5.

[3] See: http://hamptonroads.com/2011/11/fate-portsmouth-marine-terminal-depends-other-deals-jelling
[4] See: http://www.nationalgateway.org/projects/project/548
[5] See: http://www.drpt.virginia.gov/studies/files/SHRExecutiveSummary.pdf

[6] See: http://www.hrtpo.org/uploads/docs/SuffolkRailReport.pdf

Exhibit 3-5: Possible Consolidated Freight and Passenger Routings through Suffolk

Exhibit 3-5 assumes a "balloon" track connection between the Norfolk Southern main line and CSX's Portsmouth Subdivision at Kilby. This is in the opposite quadrant from the "balloon" connection that the DRPT EIS proposed for passenger trains. This would enable CSX trains to reenter their own line while staying on the north side of the Norfolk Southern alignment, without needing to cross any of the Norfolk Southern main tracks. At the same time, rather than continuing on the Portsmouth Subdivision west of Constance Road (US 58), it may be beneficial to shift the passenger alignment to the former Virginian right-of-way. Doing this would avoid any conflicts with the CSX track connection at Kilby, since CSX would use the existing Portsmouth Subdivision bridge under the Norfolk Southern main line, while the passenger service could use the former Virginian underpass.

While these proposals could develop an essentially dedicated infrastructure for passenger trains between Suffolk and Norfolk, the engineering design should not preclude operation of freight trains.[7] Therefore it is recommended that the infrastructure from Kilby to Norfolk Harbor Park should accommodate freight railroad clearance and other engineering requirements. For example, if electric catenary were installed, the 20' 6" freight railroad clearance envelope should be respected, so as not to preclude the operation of double stacked trains under the wire east of Suffolk. See Exhibit 3-6.

[7] For example, CSX will want to continue to serve its customers on the Portsmouth Subdivision in downtown Suffolk, will probably want to retain rights to operate some trains through downtown Suffolk, will want to be able to continue accessing its customers and port facilities in Portsmouth, and its interchange with the Norfolk & Portsmouth Belt Railroad. Similarly, Norfolk Southern will want to continue serving its customers on the "V-Line," and may also benefit from the ability to divert freight trains onto the "V-Line" if any emergency or blockage were to affect its main line.

Exhibit 3-6: CSX Double Stack Train under SEPTA Catenary at West Trenton, NJ[8]

It is clear that a full resolution of these freight mitigation issues will require a collaborative effort between CSX, NS, HRTPO, the Port Authority, and the City of Suffolk to develop effective solutions. This requires a level of detail and analysis that is beyond the scope of the current study, but should be addressed in the follow up Tier 1 Analysis.

Suffolk freight mitigation needs will be addressed by including a $50 million placeholder in the cost estimate for this segment. Based on developing the CSX Portsmouth Subdivision into a double tracked, dedicated passenger alignment from Suffolk Spur to Kilby, it is assumed that this segment will be developed to 110-mph standards. It will be estimated as 3.9 miles of new single track on existing roadbed, and the second track on new roadbed with approximately 15' average fill height. The cost for one station at Suffolk will also be included in the cost for this segment.

3.2.2 SUFFOLK TO PETERSBURG – DEDICATED TRACK ALONG NORFOLK SOUTHERN (OPT 1B AND 2B)

The possibility for adding dedicated high speed tracks to the existing Norfolk Southern alignment has been considered from Suffolk to Petersburg as part of Options 1B and 2B.

Normally, geometric issues would prevent operating a true high speed service along an existing rail right-of-way, but in this highly unusual case the existing alignment is arrow-straight from Suffolk to the outskirts of Petersburg. This suggests at least the conceptual possibility for developing a high speed rail service, so a preliminary assessment has been developed. This option is considered as a "Greenfield" alternative, since it is characterized as a dedicated segment of all-new, 220 mph capable high speed rail alignment which may or may not be co-located within an existing railroad right-of-way.

[8] See: http://www.railpictures.net/viewphoto.php?id=346306&nseq=6

KILBY TO BAKERS POND

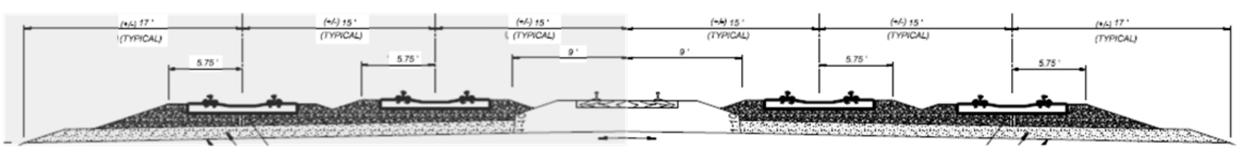
For option 2B, a possible connection from Norfolk Southern to I-295 would diverge at Bakers Pond -- approximately 0.3 miles east of the Route 156 grade crossing, about halfway between Poe and Disputanta. The distance from Kilby to Bakers Pond south of Route 156 is 46.1 miles. Continuing along the NS main line and Petersburg Belt Line, the distance from Bakers Pond to the junction of the Collier connection south of Petersburg is 9.3 miles.

In terms of the potential feasibility of a high speed option following the Norfolk Southern rail corridor, for development of reasonable alternatives planners will be constrained by the National Environmental Policy Act (NEPA), particularly Council of Environmental Policy guidance[9] which states:

> *If a proposed action is to be located in a wetland or significantly encroaches upon a floodplain, a finding must be made that there is no practicable alternative to the wetland take or floodplain encroachment. Any alternative that does not meet the need for the action is not practicable. If the action's purpose and need are not adequately addressed, specifically delineated, and properly justified, resource agencies, interest groups, the public, and others will be able to generate one or possibly several alternatives that avoid or limit the impact and "appear" practicable. A well-described justification of the action's purpose and need may prevent long and involved negotiations or additional analyses demonstrating that an alternative is not practicable.*

It is clear in terms of alternatives being developed, that minimizing wetland impacts as well as property takes will be key to the environmental competitiveness of any alternative. For development of a Norfolk Southern corridor alternative, it became apparent that only a "Narrow Footprint" option could be economically and environmentally competitive to the other Greenfield options. This assumes placement of four tracks within a 100'-120' right-of-way footprint, as shown in Exhibit 3-7, with nominal track centers of 15', two passenger tracks would be separated from the two freight tracks by a 30'-50' track center spacing. Norfolk Southern has requested the wider spacing of 50'. This footprint leaves enough space for a fifth or sixth track in the middle, and three feet buffer on each edge of right-of-way.

Exhibit 3-7: 100' Right-of-Way Footprint for a Passenger and Freight Rail Corridor



The potential viability of the narrow footprint option derives directly from the issue of wetlands. According to the GIS Wetland Shapefiles in Exhibit 3-8, there is an already existing corridor along the Norfolk Southern tracks within which the wetland areas have already been compromised. This corridor appears to vary in width from 75' to 150.' A detailed on-the-ground survey, which was beyond the scope of the current study, would be needed to development a more accurate measurement of the actual conditions.

The two existing Norfolk Southern tracks require a physical footprint of approximately 50'. However, the existing tracks are not generally placed directly at ground level through wetland areas, rather they are on a fill structure with culverts underneath the track. A minimal 12.5' fill with a 2:1 slope would expand the Right-of-Way footprint to 100' as shown in Exhibit 3-9. A 17.5' fill would expand the Right of Way

[9] See: http://environment.fhwa.dot.gov/projdev/tdmalts.asp

footprint to 120'. If the fill were higher, the footprint would be wider. ***However, by adding retaining walls, the same footprint could accommodate the added passenger tracks without needing to claim any wetlands***. This shows how the proposed four track configuration with a 30' separation could be accommodated within a 100' footprint with a 30' spacing, or a 120' footprint with a 50' spacing, ***so this configuration would appear to require only a minimal need for additional wetland taking.***

Exhibit 3-8: 75'-150' Wetland Corridor along the Norfolk Southern at Zuni

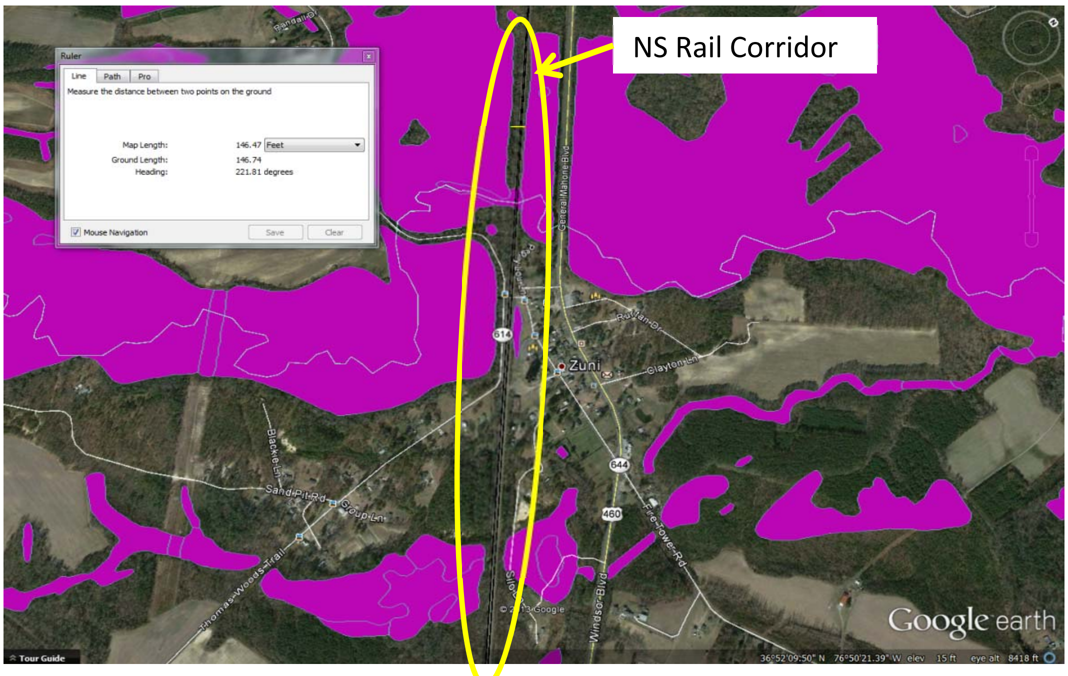
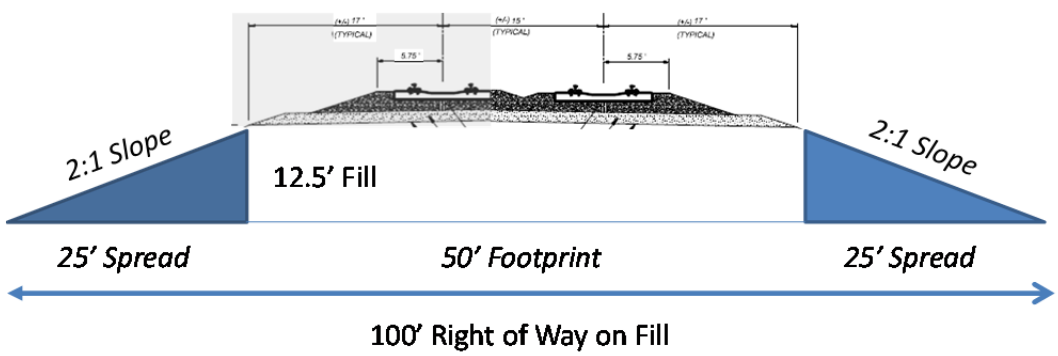
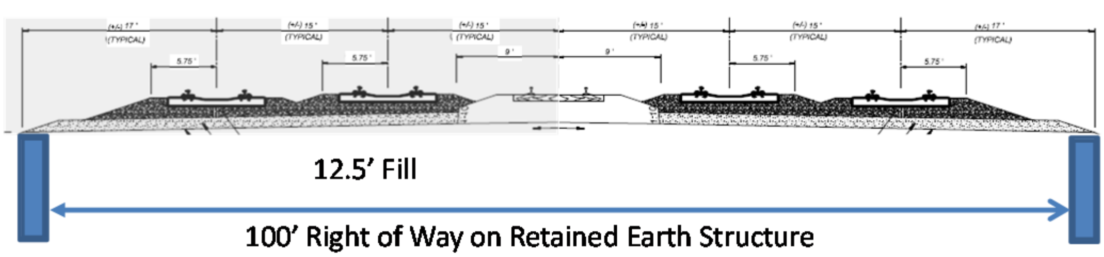


Exhibit 3-9: Fill versus Retained Earth Structure for a 100' Footprint

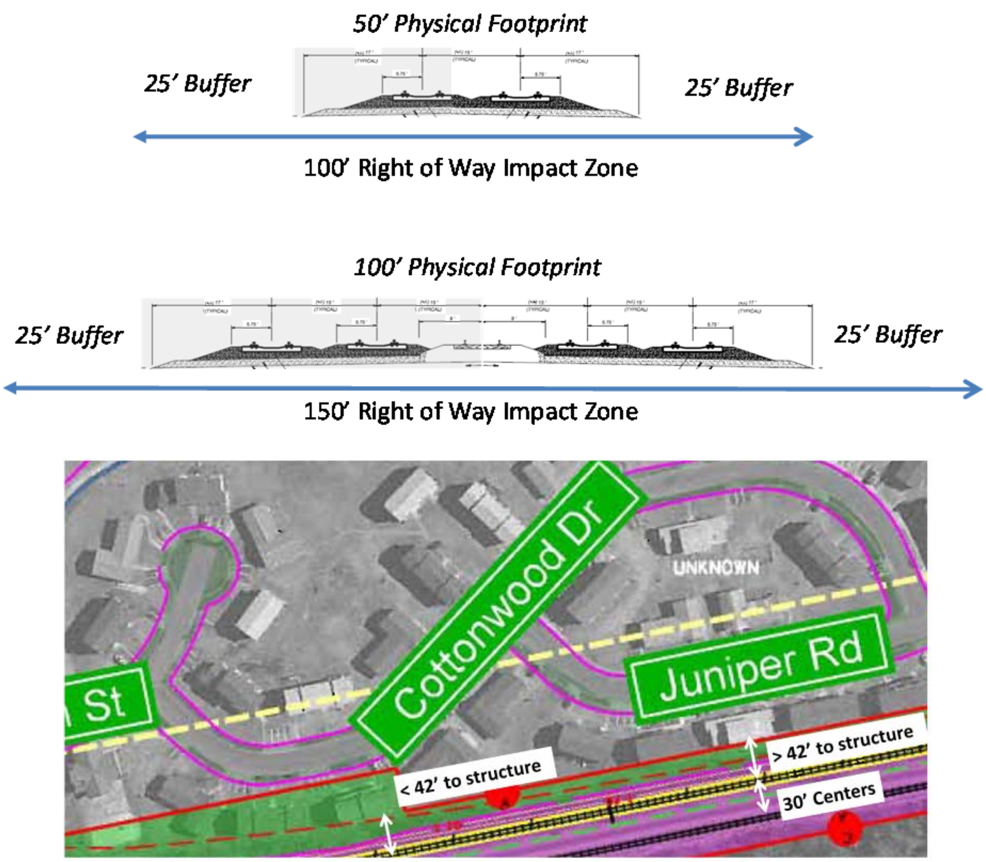




For a “Narrow Footprint” as shown in Exhibit 3-9, it has been estimated that approximately 3 miles of retained earth structure would be needed for areas where the Norfolk Southern corridor passes through wetlands. It is not possible to assess the difference between a 30’ and 50’ track spacing at the current level of study since this difference is well within the error margin of the available data. A more detailed engineering assessment will be needed to ascertain the difference. In contrast, if a 100’ separation were required between the tracks, this would clearly place the new tracks within wetland areas: 6 to 9 miles of bridges may be needed.

The number of property takes depends on the right-of-way width. For consistency in evaluating route alternatives, as shown in Exhibit 3-10, the distance is 17’ from the center of the outside track to the edge of the right-of-way, which is part of the minimum 50’ footprint. Beyond this, a 25’ buffer has been included.

Exhibit 3-10: Impact Zone for Property Taking Assessment



With a 25’ buffer, the minimum distance from the outside track center to the nearest structure is 42’.

- For a new double track line on Greenfield alignment, the physical footprint is 50’, but the right-of-way width is 100’, consistent with industry standards.[10] This provides a clear buffer zone of 25’ on each side of the track.

[10] This is consistent with what California is using for its High Speed rail development project, see http://www.hsr.ca.gov/docs/programs/eir-eis/statewide_techrpt_Ag_farmlands_rpt.pdf, page 3

- For a greenfield double track parallel to existing track on a 30' center, the physical footprint is 100', so the right-of-way width must be expanded to 150' to provide the same 25' clear buffer zone on each side of the track. For a 50' center the physical footprint is 120', so the right of way width must be expanded to 170'.[11]
- This right-of-way standard also appears to be consistent with what the SEHSR assumed for its property taking criteria, as shown on the alignment plates through Petersburg.

For a 30' separation between the freight and passenger tracks, approximately 87 property takes would be needed to widen the right-of-way to 150' including a 25' buffer zone on both sides of the track. By comparison, for a 100' separation between freight and passenger tracks, approximately 153 residential or commercial property takes would be needed for a 220' right of way. It can be seen that the wide footprint option results in considerably more wetland impact as well as more residential and commercial property impact than would a narrower 30'-50' spacing between the freight and passenger tracks. At the extreme, the level of wetland and property take impacts needed for a 100' track spacing along the existing rail corridor would be enough to render this option uncompetitive with greenfield alternatives from an environmental point of view, whereas it appears likely that an environmentally competitive alternative could be developed based on a 30'-50' track spacing.

Summarizing, the overall segment is 46.1 miles long, of which 3.0 miles is assumed to be new double track on 15' retained earth structure and the balance 43.1 miles double track on new roadbed with approximately 15' average fill height. There are no wetland takes, and 87 property takes. There are 47 grade crossings or existing highway bridges which would all be replaced with new grade separations, averaging approximately one grade separation and 1.9 property takes per mile.

BAKERS POND TO COLLIER CONNECTION

From Bakers Pond, continuing along the Norfolk Southern corridor to CSX connection track at Collier for Option 1B is a distance of 9.3 miles. If the new passenger tracks were constructed on the north side of the alignment, it should be possible to get around the auto facility at Poe without interfering with operations of the auto terminal. However two challenges still remain, as shown in Exhibit 3-11: At the I-95 crossing, the issue is how to get through the rail junction on the north side, without cutting off Norfolk Southern's access to its former main line through Petersburg[12]. Beyond this, residential development tightly hugs the rail right-of-way for the next two miles along the Petersburg Belt Line.

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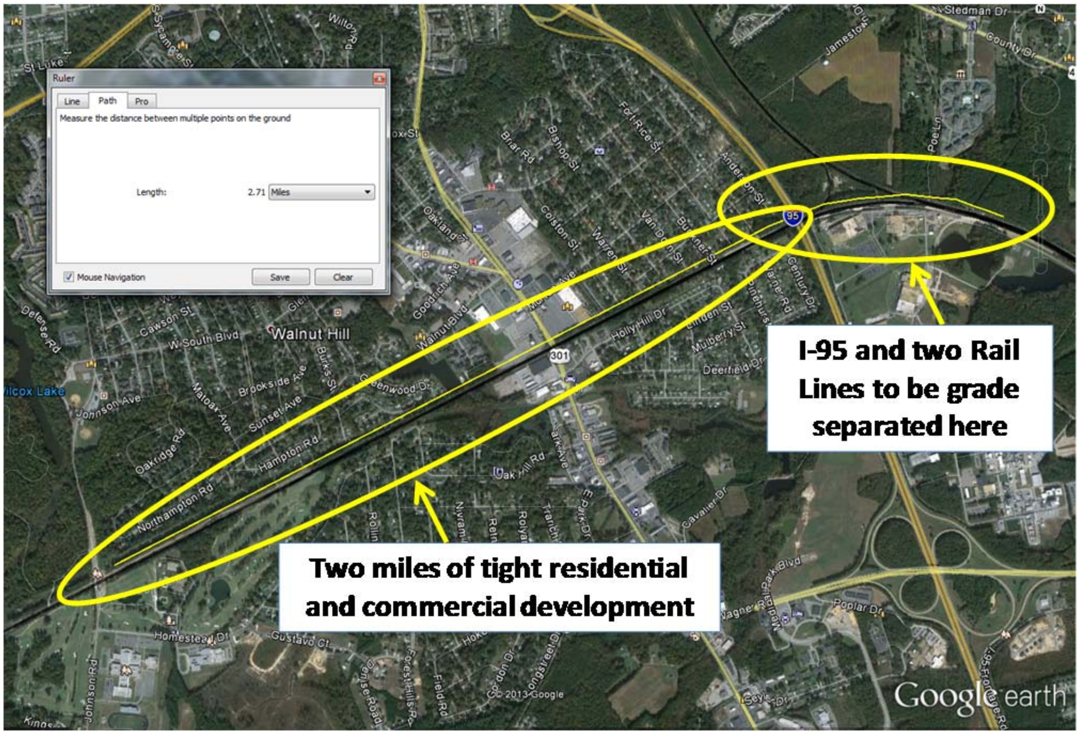
[11] The width of the current Norfolk Southern right of way is not known for sure nor is it necessarily the same everywhere. It is assumed however, that Norfolk Southern already owns at least the 50' of right-of-way that are occupied by its existing tracks, so the land acquisition is 100' width to be added to the corridor. The land acquisition therefore is considered the same as for a new Greenfield corridor on separate right of way.

[12] The old main line through Petersburg and Belt Line are single tracked, paired and directionally operated to create a double tracked mainline through the area. There are three possible ways for dealing with this issue:

- One alternative might be to replace the capacity of the Old Main Line by double tracking the entire Petersburg Belt Line; but this would exacerbate the right-of-way issues since four tracks (two freight and two passenger) would be needed east of Collier.
- The conflict could be eliminated by tunneling under the rail and highway junction. The length of tunnel could be short (0.5 miles) with a short box tunnel to get under the east leg of the railroad wye, and a slightly longer tunnel to get under the west leg of the rail wye and I-95. Between the two legs of the wye and on each end of the tunnel depressed open cut structures would be needed on the approaches to the tunnel portals.
- The third alternative would be to fly over the junction on a high elevated structure. The structure would need to be 60' tall to get over I-95, using a 4% maximum gradient the flyover structure would need to be at least 3,000' long. However an additional 1,800' would be needed to cross over the east leg of the railroad wye at Poe.

Exhibit 3-11: Challenges along the Petersburg Belt Line



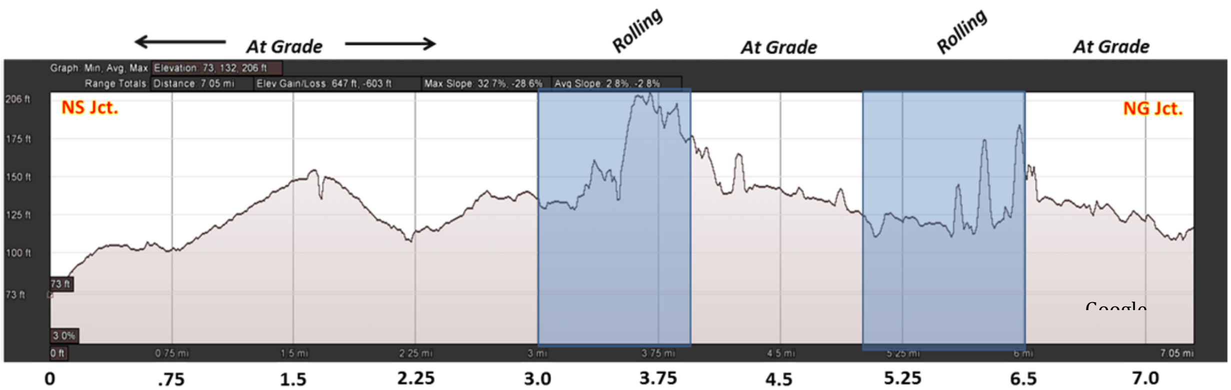
Any of these three alternatives are likely to be expensive. In round dollars a placeholder cost of $100 million (including soft costs and contingency) is likely appropriate for dealing with the combined rail and interstate highway crossing. For a 100' rail corridor footprint, 25 property takings have been estimated over this 9.3 mile stretch. All 9.3 miles are estimated as double track on new roadbed with approximately 15' average fill height. There are no wetland takes, but there are 4 highway crossings that would have to be grade separated in addition to the $100 million placeholder for a rail and highway grade separation at I-95.

Beyond Collier, the alignment would connect to the proposed Southeast High-Speed Rail (SEHSR) improvements through Petersburg to Richmond. The continuation of this route to Richmond will be further discussed as part of the Southern Greenfield alternative 1A.

BAKERS POND TO I-295 VA 646 OVERPASS

Another alternative is to follow I-295 north to Richmond. For option 2B, a 7.2 mile greenfield connection would diverge from the Norfolk Southern right-of-way near Bakers Pond and would head 4.5 miles across open countryside, to enter the I-295 median. It would then continue another 2.7 miles in the I-295 median to the common point where the Northern Greenfield would enter I-295 just south of the VA-646 highway overpass. Exhibit 3-12 shows the elevation profile for this section.

Exhibit 3-12: Elevation Profile, Norfolk Southern to I-295 Connector



As shown in Exhibit 3-12, the cost of the greenfield segment of this connector track is based on 4.5 miles of new double track; 0.4 miles of which are on bridge structure over wetlands and flood plains, 1 mile of which is graded in rolling terrain, and the balance of 3.1 miles at grade. It has 13 roadway crossings, the estimated wetland taking is 0.65 acres, and a 100' right-of-way would require 7 property takings.

Upon reaching I-295, transitioning a rail line into a median strip requires a shallow angle of entry. If the rail line goes over the highway, a long approach structure is needed on either side with a straddle-bent crossing. Putting the rail line over the highway can cost $100 million for a double track rail structure. It is usually less expensive to raise one set of highway lanes to let the railroad pass underneath, as the New Mexico Rail Runner project did as shown in Exhibit 3-13.

Exhibit 3-13: Rail Line Transition to Interstate Highway Median (near Los Cerrillos, NM)

A short box tunnel over the tracks about 0.1 miles long is needed to let the highway lanes pass over. This can be built for $25-50 million. Because of the need for maintaining traffic on the highway it will be estimated at the higher figure of $50 million. The I-295 section is estimated as 2.7 miles of double track on new roadbed, since I-295 is already graded plus a $50 million placeholder for the median strip transition.

It includes an allowance for a additional double tracked rail bridge where the I-295 median crosses over VA-634. The continuation of this route beyond the VA-646 overpass to Richmond will be further discussed as part of development of the Northern Greenfield alternative 2A.

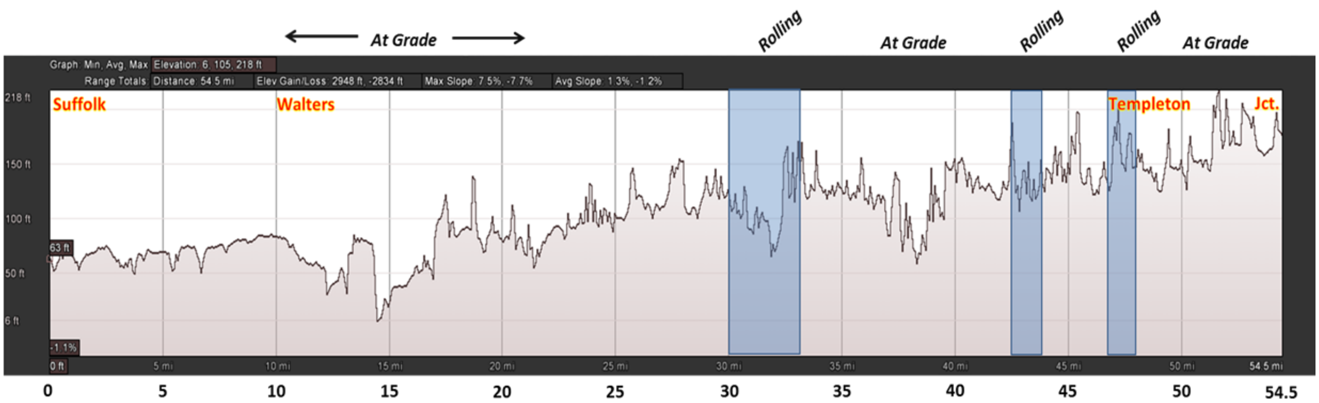
3.2.3 Suffolk to Richmond via Petersburg– Southern Greenfield (OPT 1A)

As previously described, the Southern Greenfield would link Kilby to Burgess, south of CSX's Collier Yard in Petersburg. From Burgess the alignment would follow the SEHSR through Petersburg to Dunlop. At Woods Edge Road, the alignment would leave the CSX rail corridor, cross the James River and utilize an "East Shore Greenfield" through open land to Richmond.

Kilby to Collier

This proposed Greenfield alternative would head west across fairly open countryside 52.3 miles from Kilby to Burgess, where it would join to the proposed SEHSR alignment. It would then follow the SEHSR alignment 2.2 miles north to Collier where the existing Norfolk Southern rail line joins the corridor. Exhibit 3-14 shows the elevation profile for this section.

Exhibit 3-14: Elevation Profile, Southern Greenfield



As shown in Exhibit 3-14, the cost from Kilby to Burgess is based on 52.3 miles of new double track; 2.9 miles of which are on bridge structure over wetlands and flood plains, 5 miles of which are graded in rolling terrain, and the balance of 44.4 miles at grade. There are 100 roadway crossings requiring grade separations. The estimated wetland taking is 25.1 acres, and a 100' right-of-way would require 63 property takings.

The cost for the 2.2 mile section that is shared with SEHSR from Burgess to Collier is based on double tracking the existing SEHSR plan, by utilizing the 30' right-of-way reservation that will already have been provided as shown in the current alignment plates. One additional track would be added between the current SEHSR (single) track and the two existing CSX "A-Line" tracks. Accordingly, 2.2 miles of single track would be added to the existing SEHSR plan. This is estimated as single track on existing roadbed. There are no additional wetland, property taking, or crossing impacts since the SEHSR would provide a fully grade separated alignment and the proposed additional track would be accommodated within the existing planned SEHSR footprint[13].

[13] It should be noted that CSX policy allows for co-mingling of freight and passenger trains up to 90-mph on shared track -- and the geometry of this track section won't effectively allow for train speeds much above this 90-mph limit anyway. Therefore as has been discussed previously with DRPT, it is assumed that this existing track can be added within the currently planned SEHSR footprint.

COLLIER TO WOODS EDGE ROAD

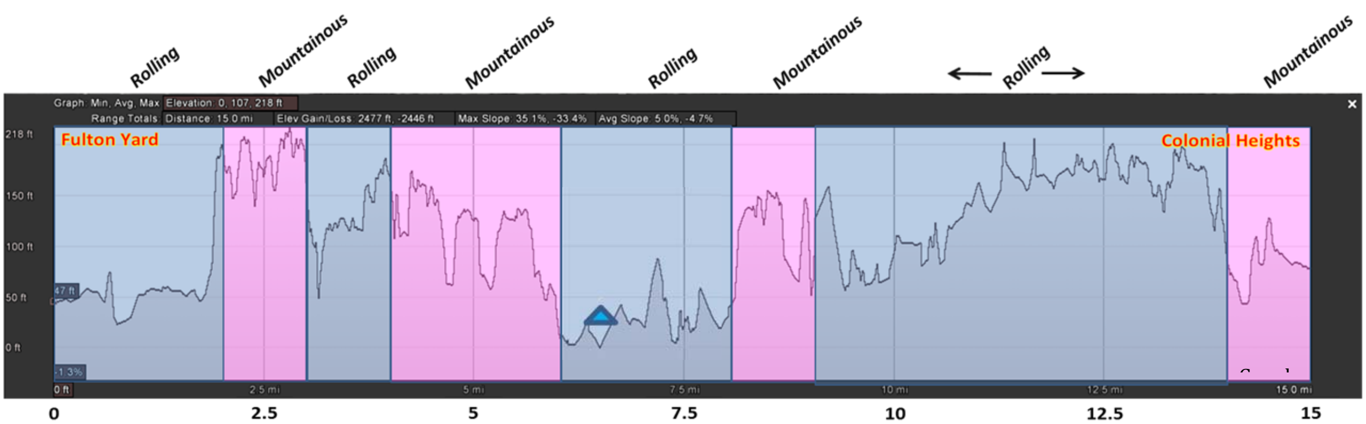
This segment of proposed alignment would share 9.4 miles of right-of-way with SEHSR from Collier to about 0.3 miles north of Woods Edge Road, where the proposed alignment would leave the CSX right-of-way and continue straight onto the East Shore Greenfield. The costing assumptions for this segment are very similar to those for Burgess-Collier since they would utilize the footprints of the improvements that are already planned by SEHSR. In particular, 9.4 miles of single track would be added to the existing SEHSR plan, estimated as additional single track on existing roadbed. There are no additional wetland, property taking, or grade crossing impacts.

The most important added cost along this segment would be the need for a double-tracked Appomattox River bridge, rather than only single track as currently planned by SEHSR. The current Appomattox River bridge is a roughly 1,300 foot long single tracked structure. By comparison, in 2009 the Union Pacific rebuilt the Kate Shelley High Bridge[14], a double-tracked structure that is almost twice as long and twice as high as the Appomattox River bridge, for $50 million. A placeholder of $25 million is being included in the cost of this segment for the added cost of double tracking the Appomattox River bridge instead of only single tracking the new bridge. A $20 million placeholder is also included here for the development of a high speed rail station at Petersburg.

EAST SHORE GREENFIELD: WOODS EDGE ROAD TO FULTON GAS WORKS

The East Shore Greenfield extends for 14.9 miles from just north of Woods Edge Road on the CSX "A" Line north of Petersburg, to the Fulton Gas Works on the CSX Peninsula Subdivision just east of downtown Richmond. Heading north from Woods Edge Road, it parallels I-95 for about 3½ miles, then follows an existing CSX branch rail line for another mile or so before the entering new alignment through an industrial area. After crossing the James River it traverses undulating, but relatively open terrain in open land on the east shore of the River to the Fulton Gas Works. Exhibit 3-14 shows the elevation profile for this section.

Exhibit 3-15: Elevation Profile, East Shore Greenfield



From the elevation profile shown in Exhibit 3-15, it is clear that significant grading would be required for constructing the East Shore Greenfield. The cost from Woods Edge Road to the Fulton Gas Works is based on 14.9 miles of new double track; 0.8 miles of which are on bridge structure over wetlands and flood plains, 0.7 miles on a high level bridge crossing the James River, 5 miles of which are graded in mountainous terrain, and the balance of 8.4 miles in rolling terrain. None of the alignment is flat so there

[14] See: http://www.uprr.com/newsinfo/attachments/media_kit/regional/northern/kate_shelley/fast_facts.pdf

are zero miles at grade. A placeholder cost of $350 million is assumed for the high level James River crossing.[15] There are 24 roadway crossings requiring grade separations. Reflecting the relatively rugged nature of the terrain on the east shore of the James River, the estimated wetland taking is only 2.92 acres, and a 100' right-of-way would require only 2 property takings. These savings in right-of-way and wetland impacts may help offset some of the higher grading costs for developing this segment of the alignment.

FULTON GAS WORKS TO RICHMOND MAIN STREET

This section of 1.5 miles length would be entirely elevated as it parallels CSX's viaduct from Fulton Yard west to Main Street station. Since the East Shore greenfield approaches from the south and Main Street Station is on the north side of the CSX tracks, the first challenge would be to develop a high level elevated flyover crossing the CSX tracks. Coming down from this flyover, the passenger alignment would land on the north side of the existing CSX viaduct. To avoid the challenges associated with building a bridge structure directly over an active rail freight yard, most likely the flyover would need to be located just west of Fulton yard.

Having transitioned the passenger trains over to the north side of the CSX alignment, if a new structure were actually continued on the north side, this would place the new elevated structure directly over Dock Street. To avoid impacting the historic area, from Fulton Yard to Rivanna Junction it might make more sense to construct a new elevated structure instead on the *south* side of CSX's existing structure, then shift freight trains onto the new structure. Passenger trains could then use CSX's existing viaduct into Main Street station. Doing this would reduce the impact on the historic area.

Double track would be restored on the curving section of viaduct from Rivanna Junction through Main Street station. The limited number of CSX freight trains that run over the Piedmont Subdivision or up to Acca Yard could share the short segment of restored double track on the Piedmont subdivision line. As described previously, the rail infrastructure in this area such as overhead catenary height and platform tracks must be designed to accommodate this requirement for shared freight and passenger use. By doing this it is expected that impacts to wetlands and Richmond historical structures can be avoided.

- For approaching from the East Shore Greenfield, this 1.5 miles will be estimated at the standard rate for elevated double track structure, with an additional $50 million for adding a high level flyover from the south to the north side of the rail alignment.
- For the Richmond Direct and I-295 approaches into Richmond no flyover crossing is needed, so the standard rate for elevated double track structure can used.

3.2.4 SUFFOLK TO RICHMOND VIA HOPEWELL– NORTHERN GREENFIELD (OPT 2A)

As previously described, the Northern Greenfield would link Kilby to I-295. From Kilby past Zuni the proposed alignment would follow an existing electric utility corridor south of the existing Norfolk Southern tracks[16]. At Zuni, the alignment would swing north across the Norfolk Southern main line to

[15] The Varina-Enon Bridge over the James River near Hopewell cost only $36 million to build in 1990. See http://newsgroups.derkeiler.com/Archive/Misc/misc.transport.road/2008-01/msg02557.html The Vietnam Veterans Memorial Bridge on the Pocohontas Parkway cost $111 million in 1996, see http://en.wikipedia.org/wiki/Vietnam_Veterans_Memorial_Bridge_(Richmond).Amtrak's Susquehanna River bridge replacement is currently estimated to cost up to $850 million but would provide *two* parallel double tracked bridges, including a fixed high level bridge. See http://www.nec-commission.com/cin_projects/susquehanna-river-bridge-replacement

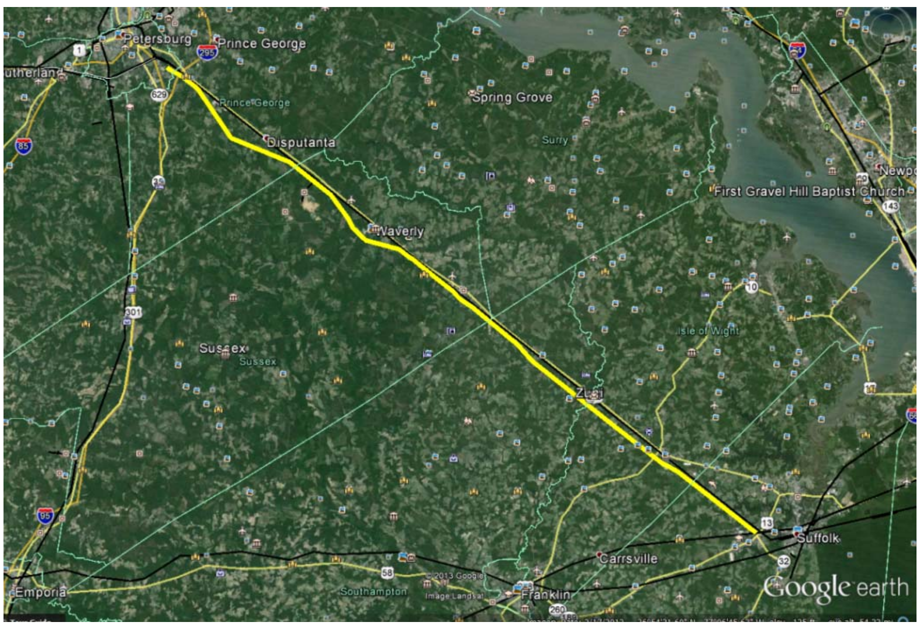
[16] The initial concept was to develop one greenfield alignment completely south and one completely north of the existing US-460 corridor. For the Northern greenfield, an early concept was based on the idea of heading from Bowers Hill straight across the Dismal Swamp, following US-58

Proctors Bridge Road where the proposed Richmond Direct alternative would diverge. From Proctors Bridge Road to I-295 at Hopewell, the Northern Greenfield alignment to Hopewell would head northwest staying on the north side of US 460. Lining up with I-295, it would enter the I-295 median just south of the VA-646 highway overpass, then continue in the I-295 median to Richmond.

KILBY TO PROCTORS BRIDGE ROAD

As an alternative to using the Norfolk Southern rail corridor between Kilby and Zuni, as shown in Exhibit 3-16 an electric power line right-of-way was seen to extend on a mostly straight alignment all the way from Kilby to Disputanta.[17] Aside from the fact that it already exists and is mostly straight, this electric utility corridor bypasses the small towns (Windsor, Wakefield, etc.) along the way. Using the utility right-of-way instead of the Norfolk Southern rail corridor could provide a way to avoid the property takings that would otherwise be needed for widening the rail right-of-way through the towns.

Exhibit 3-16: Electric Utility Right-of-Way Paralleling the Norfolk Southern Rail Corridor



around the north side of Suffolk and then heading west to join I-295 at Hopewell. The main advantage of the Suffolk Bypass is that trains heading west from Bowers Hill could immediately accelerate to 220-mph. The alternative was developed to the point of preliminary discussions with Virginia DOT regarding its feasibility. However, some problems with this concept soon became apparent. Local trains that stop at a suburban Suffolk station along US-58 would not save any time, and a northern Suffolk Bypass was seen to require extensive elevated structure because of extensive wetlands and highway right-of-way restrictions. While the alternative was not considered fatally flawed, it was apparent that this segment would be very expensive to develop. Because two other options for following existing rail alignments through Suffolk could likely be developed at a much lower cost, it was considered that a northern Suffolk Bypass would likely be screened early in any prospective environmental evaluation. As a result a downtown Suffolk alternative to Kilby as previously described, was developed instead.

[17] For the purposes of this study only the segment from Kilby to Zuni is included in the rail option. The extended use of this electric utility corridor all the way from Kilby to Disputantia could however, be developed as an additional option during the Tier I environmental study, if desired.

Beyond this however, another benefit potentially associated with using the utility right-of-way is that the environmental GIS shape files show that, in many cases, the right-of-way associated with the electric power line has already been compromised. As shown in Exhibit 3-17, the power line right-of-way can be seen to cut a swath through some existing wetlands just as railroads or highways do. As a result, there is an opportunity to reduce wetland impacts by co-locating a rail line inside the existing electric power corridor.

Exhibit 3-17: Electric Utility Right-of-Way Cuts through Wetlands

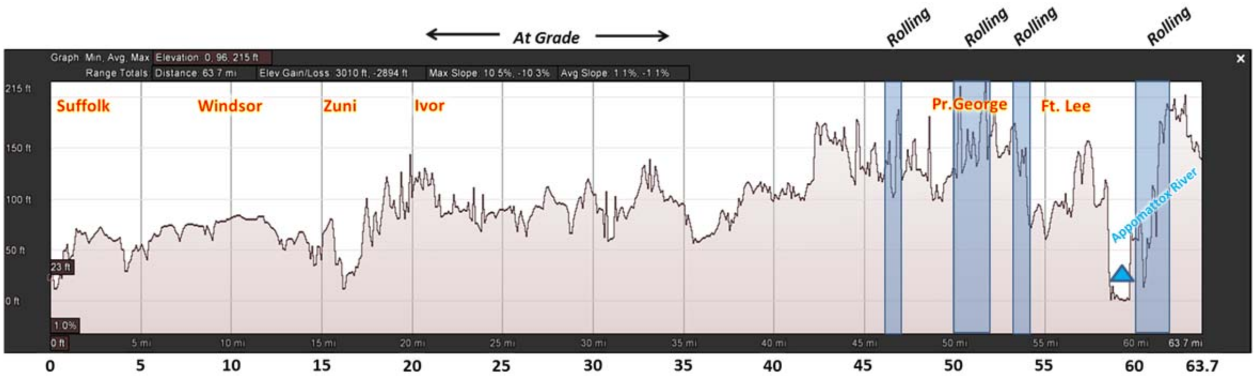
Although there are some engineering issues associated with adding a rail line to an electric utility right-of-way, such use is not unprecedented. It would also provide a clear benefit to electrification of the rail line, since the necessary power source would be directly overhead. Exhibit 3-18 shows an existing rail line co-located with two electric power lines along Hiawatha Boulevard in Minneapolis, MN. Closer to home, Exhibit 3-19 shows the CSX Phoebus branch in Hampton, VA which shares its right-of-way along Pembroke Avenue with a high voltage electric transmission line.

The Kilby to Proctors Bridge Road segment of the Northern Greenfield extends for 20.6 miles from just west of Kilby to the vicinity of Proctors Bridge Road, north of Ivor. Passing underneath the Norfolk Southern rail bridge at Kilby, the alignment turns northwesterly across open countryside to parallel the electric line and finally join and share its right-of-way. It follows the utility line right-of-way for about 10 miles, past Zuni, before crossing to the north side of the US 460 highway alignment. Exhibit 3-20 shows the elevation profile for the Northern Greenfield. (Please note that this profile extends from Suffolk all the way through Fort Lee to a possible connection with the East Shore Greenfield near Moore Lake.)

Exhibit 3-18: Rail Line Co-located with Electric Power Lines in Minneapolis, MN

Exhibit 3-19: Rail Line Co-located with Electric Power Lines in Hampton,VA

Exhibit 3-20: Elevation Profile, Northern Greenfield



From Exhibit 3-20, it can be seen that the first 20.6 miles west from Suffolk past Ivor are all across level terrain, but there are also significant wetland issues in this stretch. The cost from Kilby to Proctors Bridge Road is based on 20.6 miles of new double track; 2.4 miles of which are on bridge structure over wetlands and flood plains, and the balance of 18.2 miles at grade. The alignment has 32 roadway crossings. The estimated wetland taking is 12.96 acres, and assuming that utility power line towers can be avoided, 14 property takings are needed for a 100' right-of-way.

PROCTORS BRIDGE ROAD TO I-295 VA 646 OVERPASS

Beyond Ivor, the proposed Northern Greenfield alternative passes through open countryside north of US 460 but must curve gently to avoid wetlands and minimize impacts. Since it is a high speed alignment curves are limited to a maximum of 15-minutes rotation per 100 feet of distance, so it is not always possible to cross wetlands at right angles. Nonetheless, an effort has been made to avoid as many wetlands as possible. According to the Virginia Natural Landscape Assessment (VaNLA, see Appendix D Section 4), this segment traverses significant stretches of contiguous natural habitat, to avoid fragmentation the need for wildlife overpasses and underpasses along this stretch of track will have to be carefully addressed, in the next phase of environmental planning.

The cost from Proctors Bridge Road to the I-295 VA 646 Overpass is based on 33.4 miles of new double track; 0.4 miles of which are on bridge structure over wetlands and flood plains, 4 miles of which are in rolling terrain, and the balance of 29 miles are at grade. The alignment has 68 roadway crossings. The estimated wetland taking is 10.71 acres, and 32 property takings are needed for a 100' right-of-way. It also includes a $50 million placeholder (per discussion of Exhibit 3-13) for the transition into the I-295 median.

I-295 VA 646 OVERPASS TO OAKLAWN BOULEVARD

This critical 2.3 mile segment of I-295 passes through the Hopewell conurbation from the south to the north; based on consultation with Virginia DOT, it is assumed that the rail alignment will be able to utilize this section of I-295 median at grade. This section is costed as 2.3 miles of double track on new roadbed, since the I-295 median is already graded. A $20 million placeholder is also included here for the development of a high speed rail station at Hopewell.

Beyond Oaklawn Boulevard there is a possible option for heading across Fort Lee to connect with the East Shore Greenfield near Moore Lake. This section would have some rolling terrain issues and also an Appomattox River crossing. However, since Fort Lee is an active military training reservation, it is not clear that this connection would be allowed, and a tunnel option would not be cost effective. The I-295 median provides alternative to building this connection across Fort Lee, so it is assumed that the Northern Greenfield alternative will be paired with I-295 north to Richmond, rather than with the East Shore Greenfield.

OAKLAWN BOULEVARD TO RICHMOND AIRPORT

From Oaklawn Boulevard, the rail alignment will remain on I-295 to the Pocahontas Parkway interchange, a distance of 14.8 miles. From this interchange a greenfield connection would leave the I-295 median and fly over to the north side of the CSX Peninsula Subdivision rail line, a distance of 2.2 miles.

The I-295 section is costed as 13.8 miles of double track on new roadbed, since the I-295 median is already graded. To avoid double counting of costs, this backs out a mile for the length of the Appomattox and James River bridges, which are accounted for by placeholders: $50 million for a double tracked Appomattox River bridge, and $350 million for a new high level James River crossing parallel to the current Varina-Enon Bridge[18]. The alignment has 3 roadway crossings that need short bridges.

The greenfield section that connects over to the CSX rail line is estimated as 2.2 miles of new double track, 1.5 miles of which is graded on rolling terrain and 0.7 miles of bridge structure over wetlands and flood plains. The alignment has 3 roadway crossings and one rail line crossing that need short bridges. The estimated wetland taking is 5.98 acres, and 1 property taking is needed to obtain a 100' right-of-way for this connection. It also includes a $50 million placeholder for the transition out of the I-295 median.

RICHMOND AIRPORT TO THE FULTON GAS WORKS

From the Richmond Airport to the Fulton Gas Works, the proposed high speed alignment would parallel the CSX Peninsula Subdivision on the north side. At the Gas Works to gain access to Main Street station, the alignment would connect into the viaduct structure previously described.

This greenfield section is costed as 5.2 miles of new double track on, 4.7 miles of which is on level terrain and 0.5 miles of bridge structure over wetlands and flood plains. The alignment has 8 roadway crossings but no wetland taking. Only 1 property taking is needed to obtain a 100' right-of-way for this section. In conjunction with the Fulton Gas Works to Richmond Main Street segment described earlier, this completes the description of the Northern Greenfield section.

3.2.5 RICHMOND DIRECT (OPT 3)

The final remaining segment is the Richmond Direct alternative, from the Northern Greenfield at Proctors Bridge Road north of Ivor to Richmond Airport, from where it shares a common entry into Richmond with the I-295 alternative. The Richmond Direct alignment bypasses Hopewell and Petersburg, instead heading directly to Richmond over the shortest practicable route.

PROCTORS BRIDGE ROAD TO RICHMOND AIRPORT

From Ivor, the Richmond Direct alternative heads directly towards Richmond, crossing the James River just south of Charles City at a point where the river is approximately ¾ mile wide. After this it bridges several wetland areas and crosses over the CSX Peninsula Subdivision, landing on the north side of the existing track. The alignment then follows CSX on the north side to Richmond Airport. Just like the other greenfields proposed in this study, a prospective Richmond Direct alignment was laid out on the principle

[18] The Øresund Bridge linking Denmark and Sweden carries a four lane highway and a double tracked railway, and like the Varina-Enon Bridge, it is also of Cable Stayed design. It is possible that by widening and strengthing the Varina-Enon Bridge a rail alignment could be added to it for less cost than building a parallel new high level rail bridge. See: http://en.wikipedia.org/wiki/%C3%98resund_Bridge

of minimizing wetland impacts, while altogether avoiding protected parks and battlefields. Exhibit 3-21 shows the elevation profile for the original Richmond Direct option that includes the Suffolk Bypass. Exhibit 3-22 shows the elevation profile for the Ivor to Dendron (Proctors Bridge Road) connector that links the Northern Greenfield alignment with the Richmond Direct alignment. (East of Ivor the Northern and Richmond Direct Greenfields are the same.)

Exhibit 3-21: Elevation Profile, Richmond Direct Option from Suffolk to Richmond

Exhibit 3-22: Elevation Profile, Richmond Direct Connector from Ivor to Dendron

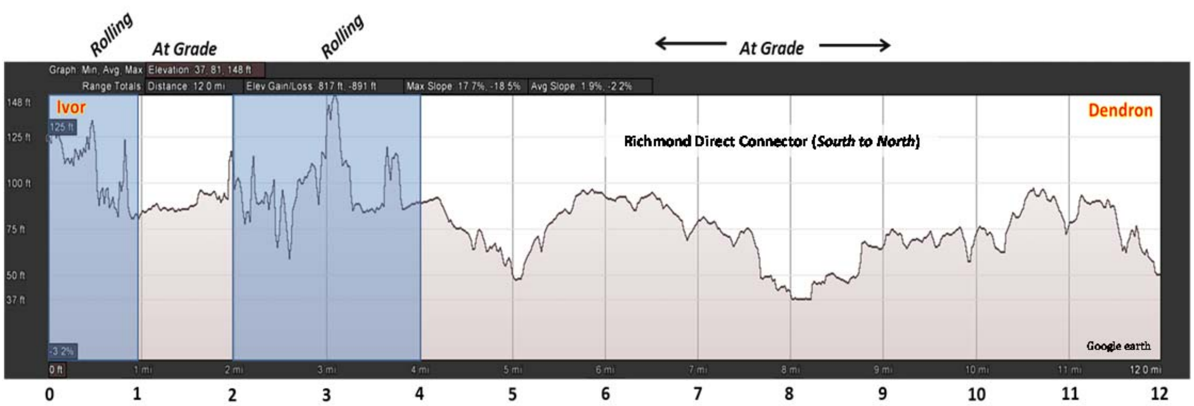


Exhibit 3-21 shows the elevation profile for the Richmond Direct option if the bypass around the northern outskirts of Suffolk were used. With this option there are no terrain issues at all until the north side of the James River, where three miles of alignment are classified as rolling terrain. Exhibit 3-22 shows the elevation profile for the alignment section connecting the Northern Greenfield at Ivor to the Richmond Direct option at Dendron. This identifies three additional miles of rolling terrain to make the connection between the Northern Greenfield (east of Ivor) and the Richmond Direct alignment (west of Dendron.)

The cost from Proctors Bridge Road to Richmond Airport is based on 49.6 miles of new double track; 4.6 miles of which are on bridge structure over wetlands and flood plains, 0.7 miles on a high level bridge crossing the James River, 0.6 miles on a low level bridge across Upper Chippokes Creek, 6 miles are graded in rolling terrain, and the balance of 37.7 miles at grade. A placeholder cost of $350 million is assumed for the high level James River crossing and $50 million for the low level crossing of Upper Chippokes Creek. Most of the wetland issues occur north of the James River. According to the Virginia Natural Landscape Assessment (VaNLA, see Appendix D Section 4), this segment traverses significant stretches of contiguous natural habitat, to avoid fragmentation the need for wildlife overpasses and underpasses along this stretch of track will have to be carefully addressed. Some of these landscape fragmentation issues could also be addressed by minor alignment shifts in the next phase of environmental planning.

The segment has 76 roadway crossings and 35.24 acres of wetland taking. 23 property takings are needed to obtain a 100’ right-of-way.

Costs and statistics for the overall Options 1A, 1B, 2A, 2B and 3 have been developed on an overall route basis by adding the individual segment costs together. These summary results by route option will be reported in Chapter 5.

4. ENGINEERING ANALYSIS

This chapter is divided into six subsections: an introduction describing the content of the work; the TRACKMAN™ database defining the speed curves, grades, rail and highway crossings, and other potential speed restrictions associated with different routes; a preliminary infrastructure analysis of the existing rail right-of-way and the proposed Environmental Study Area (Envelope) to be considered in the analysis for potential greenfield[1] routes; a presentation of the unit capital costs to be used to develop study costs for the Norfolk-Richmond Corridor; and development of Capital Cost estimates, based on detailed information presented in Chapter 4 and elsewhere in the report.

4.1 INTRODUCTION

One of the key elements in evaluating higher and high speed intercity passenger rail service for the Norfolk to Richmond Corridor is the review of the existing rail infrastructure, along with the development of an understanding of the potential corridor constraints and opportunities for improvements for supporting high speed and intercity passenger rail service. Additionally, a field survey for understanding the general topographic, demographic and environmental conditions along potential Greenfield corridors was undertaken. For the purpose of a preliminary analysis, this assessment was accomplished by using the following process:

- Gathering of information from a route review of the existing rail corridor from Norfolk – Suffolk – Petersburg – Richmond area, and to understand the existing conditions along corridors that might include potential new Greenfield alignments.
- Gathering of information from prior Engineering analyses of the Norfolk – Richmond – Washington, DC and Newport News – Richmond – Washington, DC rail corridors and Preliminary Vision Plan including a review of available right-of-way documentation and cost data.
- Identification of typical corridor infrastructure issues and constraints.
- Identification of the design standards typically applied for the various classes of passenger rail service.
- Development of an initial conceptual capital cost estimate of rail improvements to support the implementation of high speed passenger rail service.

It should be noted that for the purposes of this preliminary analysis no detailed corridor mapping or route specific inspection of the potential Greenfield rail corridors was completed, since exact alignments for the prospective Greenfield routes has yet to be determined.

This chapter documents the Engineering Database that includes the *TRACKMAN*™ databases, and the preliminary infrastructure data that was collected for the high speed and intercity passenger rail assessment. It presents an overview of existing conditions between Petersburg/Richmond and the Norfolk area, typical design standards used for the development of the various speeds of passenger rail service and the preliminary unit costs that have been used to estimate the costs for implementing high speed passenger rail service in the Norfolk-Richmond corridor.

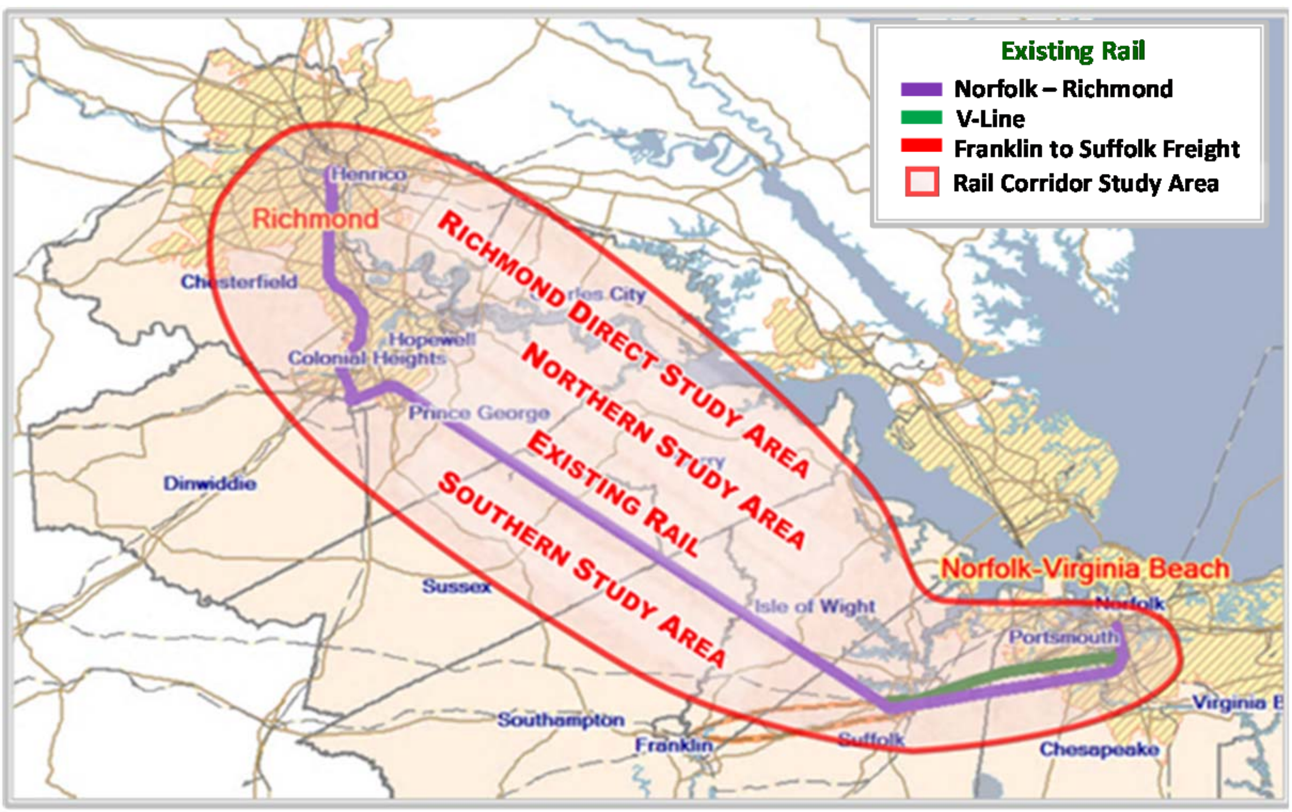
[1] A Greenfield is a brand-new proposed rail line where no rail line ever has existed. This contrasts with upgrades to an existing rail corridor, or the restoration of an abandoned rail corridor, since the locations of existing or abandoned alignments are known for sure. We have identified potential corridors for conceptual Greenfield alignments both north and south of the existing NS rail line, but have not located the alignments precisely.

4.2 Potential High Speed Routes

To support the data collection effort, it was clear that at least a preliminary definition of the Environmental Study Area would be needed. The Environmental Study Area is considered to be the potential region or envelope within which potential rail alignments might lie. This contrasts with a broader "Study Area" or Zone System that is used for ridership forecasting. Because of the ability to use auto as an access mode as well as connecting rail service, the "Ridership Study Area" encompasses a much larger territory than does the "Environmental Study Area." The Environmental Study Area defines the geographic boundaries of the area within which engineering and environmental data must be collected and reviewed. This Environmental Study Area is shown in Exhibit 4-1.

These options allow a great deal of flexibility for locating the final alignments between Richmond and the west end of Suffolk within a broad envelope. All options assume that the existing "V-line" right-of-way will be used through downtown Suffolk to Norfolk. As seen in Exhibit 4-1 an envelope has been created to define the Environmental Study Area. The engineering, environmental databases are focused within this envelope. The major areas of concern along the existing rail alignment are Disputanta, Waverly, Wakefield, Ivor, Zuni and Windsor. These areas are discussed in the following sections.

Exhibit 4-1: Norfolk to Richmond Environmental Study Area



*Alignment will not be determined until the Tier II Environmental Process is complete.

Clearly, one possible option is to develop a high speed rail service paralleling the existing Norfolk Southern tracks. Presumably the existing tracks would not be used because they are needed for the current freight service, and Norfolk Southern has a policy of not permitting speeds above 79 mph on tracks they own. Therefore, the task is to assess the corridor in close proximity, either within the existing right-of-way or closely paralleling the right-of-way, for the ability to add high speed tracks to the corridor. In a general sense, since the existing rail alignment is straight, geometry is not the challenge, but there are a number of instances (particularly in small towns) where adjacent development closely hugs the right-of-way. The need for potential property displacement is a definite challenge for the development of this alignment – although any greenfield alignments will also require displacements.

4.3 *TRACKMAN™* DATABASE

The *TRACKMAN™* Track Management System was used in this analysis to provide a milepost-by-milepost record of the rail gradients and track geometry of the existing right-of-way. The data that has been compiled from existing sources includes railroad timetables, track charts, ordinance survey maps, and land stat photometry for the existing NS alignment and will be complied for the possible greenfield alignments to be developed in the next phase of the study. The following has been assessed for the NS route alignment and will similarly be used to assess the other possible corridor options:

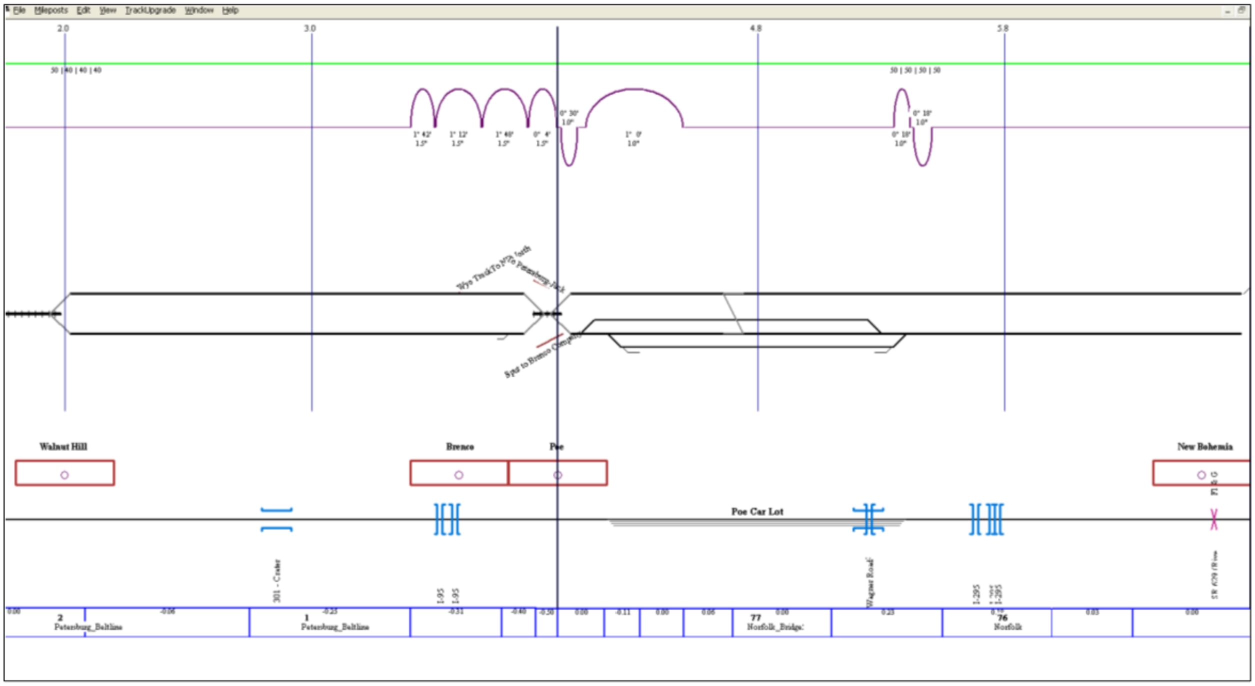
- Potential track upgrades
- Improvements for different passenger rail speeds
- Operations

The possible alternatives will be derived from the preliminary analysis of the environmental data and engineering standards required for each technology. The options are at the conceptual landscape level of route assessment and will serve as preliminary options. However, entirely new options could be selected in the Tier I Environmental Alternative Analysis in the Analysis Phase of the project.

Engineering notes were developed and entered into the *TRACKMAN™* program, which is used to maintain the database, to provide a clear understanding of basic track conditions, and the upgrades needed to support higher passenger rail speeds. *LOCOMOTION™* and *MISS-IT™* are used for operation simulations.

A sample output from *TRACKMAN™* is given below in Exhibit 4-2. The full *TRACKMAN™* file for the existing Norfolk Southern rail route is given in Appendix C.

Exhibit 4-2: Sample NS Petersburg Data



4.4 PRELIMINARY INFRASTRUCTURE ANALYSIS

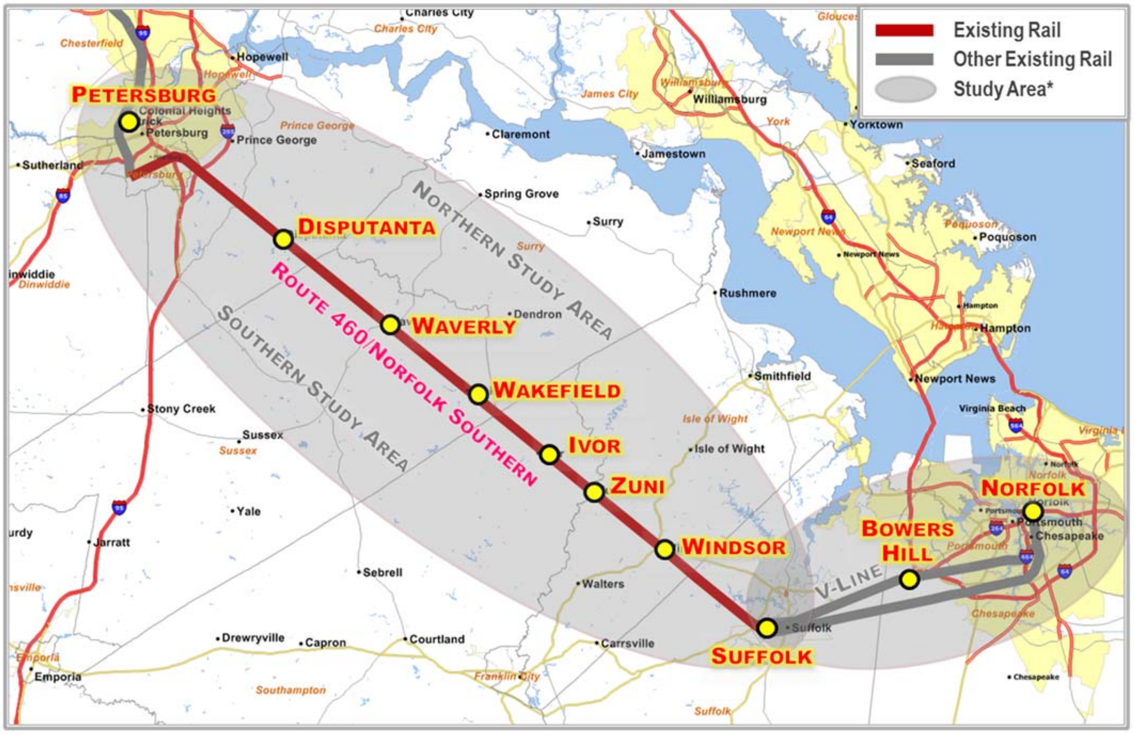
In the earlier phase of the study of the preliminary Vision Plan, existing passenger rail conditions were examined for the Norfolk Southern and the CSX Transportation (CSXT) rail lines between Richmond and the Hampton Roads area along with field review of the section of the Richmond to Petersburg rail lines south of the Amtrak Staples Mill Station. In this phase of the study, possible greenfield options from the Richmond area to Norfolk were added. The earlier inspection of the existing NS corridor from Norfolk to Petersburg was updated and a thorough inspection (as is possible from publicly accessible locations) was conducted. The existing conditions review was completed by a survey of the potential rail corridors together with detailed Google mapping. The existing conditions review was accomplished by driving to access crossing (intersecting streets, overpasses) of the rail lines and seeing the rail corridors at these access points.

The following photos provide an overview of the existing conditions along the rail corridor alternatives between Norfolk and Petersburg. In addition, Harbor Park Station in Norfolk was reviewed.

4.4.1 NORFOLK SOUTHERN EXISTING RAILROAD– SUFFOLK TO PETERSBURG

From Petersburg to Suffolk, one alternative is to follow the existing NS rail alignment. (See Exhibit 4-3) As part of Step 1 this has been recently upgraded to allow 79-mph passenger rail from Petersburg to Norfolk.

Exhibit 4-3: NS Existing Alignment from Suffolk to Petersburg



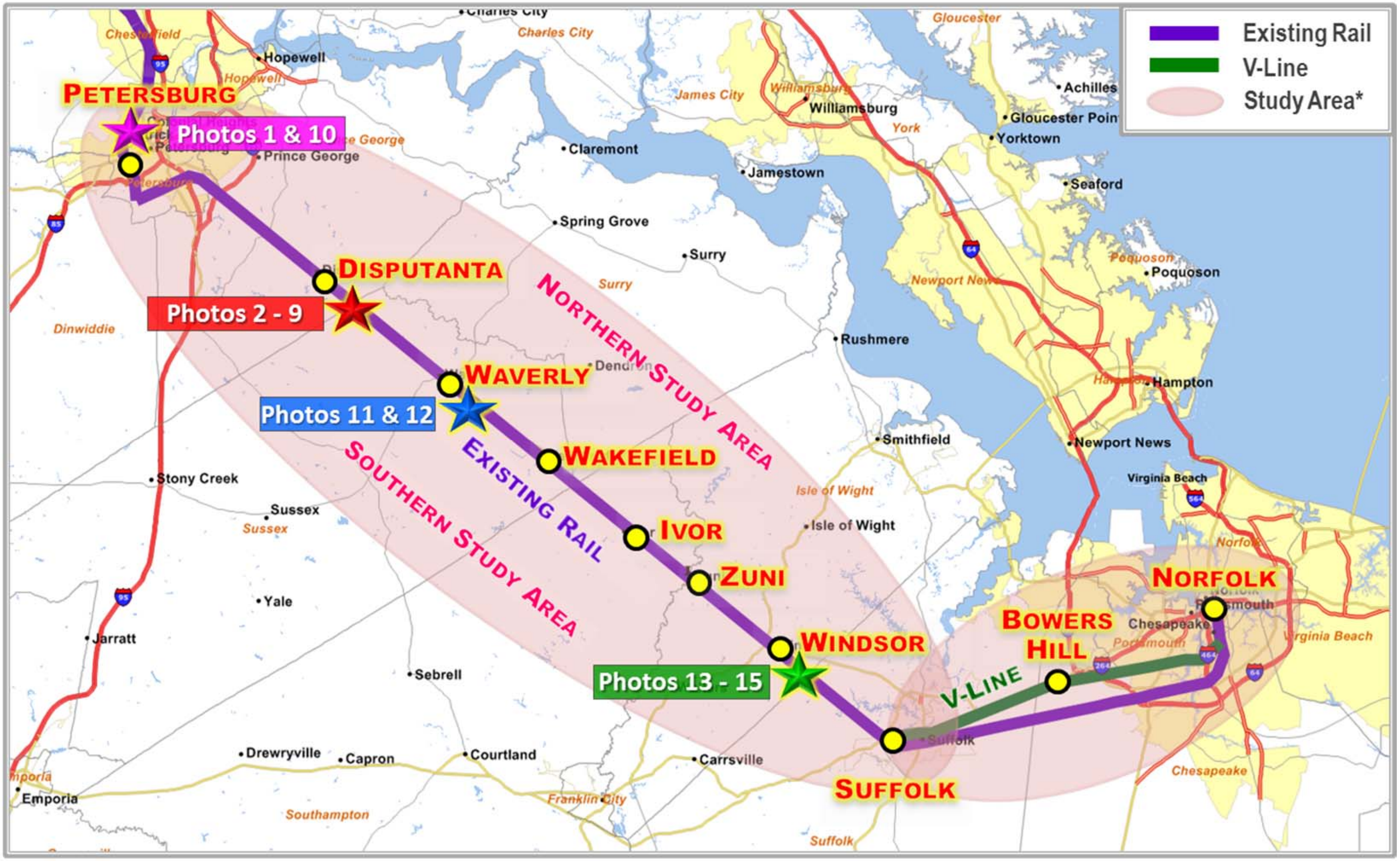
*Alignment will not be determined until the Tier II Environmental Process is complete.

The improvements that have been made from the new connection at Collier (in south Petersburg) to Norfolk include:

- New bidirectional signaling system
- New crossovers
- Track speed improvements

Some of the improvements can be seen in Photos 1 and 2 below that show the new CSXT/NS connection at Collier, and the new bidirectional signaling system.

Exhibit 4-4: Photo Locations along NS Existing Alignment from Suffolk to Petersburg



*Alignment will not be determined until the Tier II Environmental Process is complete.

Photo 1: New Collier connection near Halifax Road south of Petersburg.

Photo 2: New Bi-directional signaling system at Disputanta, VA.

The assumption is that in order to run high speed service at least one or two new tracks must be added to the corridor separate from the existing rail lines. Norfolk Southern's policy does not allow trains with speeds greater than 79 mph[2]. The Federal Railroad Administration (FRA) only requires 14 feet of track separation but according to *Adjacent Track Rule*[3] the track separation should be at least 25 feet to avoid interference with track maintenance operations. Increased spacing even beyond 25 feet will be considered where practical.

For adding track to the rail corridor, photos 3 through 15 (also located in Exhibit 4-4) show the area adjacent to the NS existing track with major areas of concerns being Disputanta, Waverly, Wakefield, Ivor, Zuni, and Windsor.

[2]Norfolk Southern to increase maximum speeds for Amtrak trains between Norfolk and Petersburg.
http://www.nscorp.com/nscportal/nscorp/Media/News%20Releases/2012/ns_amtrak_speed.html
[3] http://www.gpo.gov/fdsys/pkg/FR-2011-11-30/pdf/2011-30250.pdf

Some of the environmental issues noted along the existing NS tracks were:

- The presence of small towns with residential property, historic places
- Presence of wetlands very close to the existing NS tracks
- Presence of over and under bridges which narrow downs the track separation distance, or else requires replacement of the bridges
- Highway crossing to develop grade separations for a high speed rail
- Access to private lands across tracks must be maintained
- Rail-served industry access must be maintained
- Rail access to connecting lines and junctions must be maintained

Photo 3: Railroad crossing at Disputanta, VA would require grade separation.

Photo 4: Industrial development near tracks at Disputanta, VA

Photo 5: Overhead rail bridge on Golf Course Drive at Disputanta, VA would have to be widened or replaced.

Photo 6: On south side of the NS Tracks Prince George Golf Course entrance at Disputanta, VA.

Photo 7: On south side of the NS tracks Bakers Pond at Disputanta, VA.

Photo 8: Private grade crossing at Disputanta, VA.

Another track may be added under the bridge, which should be at least 25 feet away according the FRA adjacent track rule for not interfering with freight operations.

Photo 9: Bridge at Disputanta, VA allows room for one track at 14 feet center, but not two tracks or wider separation. This bridge may have to be replaced to allow room for additional tracks.

Photo 10: Junction to Old NS Mainline at Poe, near Petersburg. Room for new track on the south side here would not interfere with the junction on the north side.

Photo 11: Old building in close proximity to tracks at Waverly, VA.

Photo 12: Room to add track north of existing rail alignment at Waverly, VA.

Photo 13: Industrial access at Windsor, VA.

Photo 14: Streets on both sides of tracks at Windsor, VA.

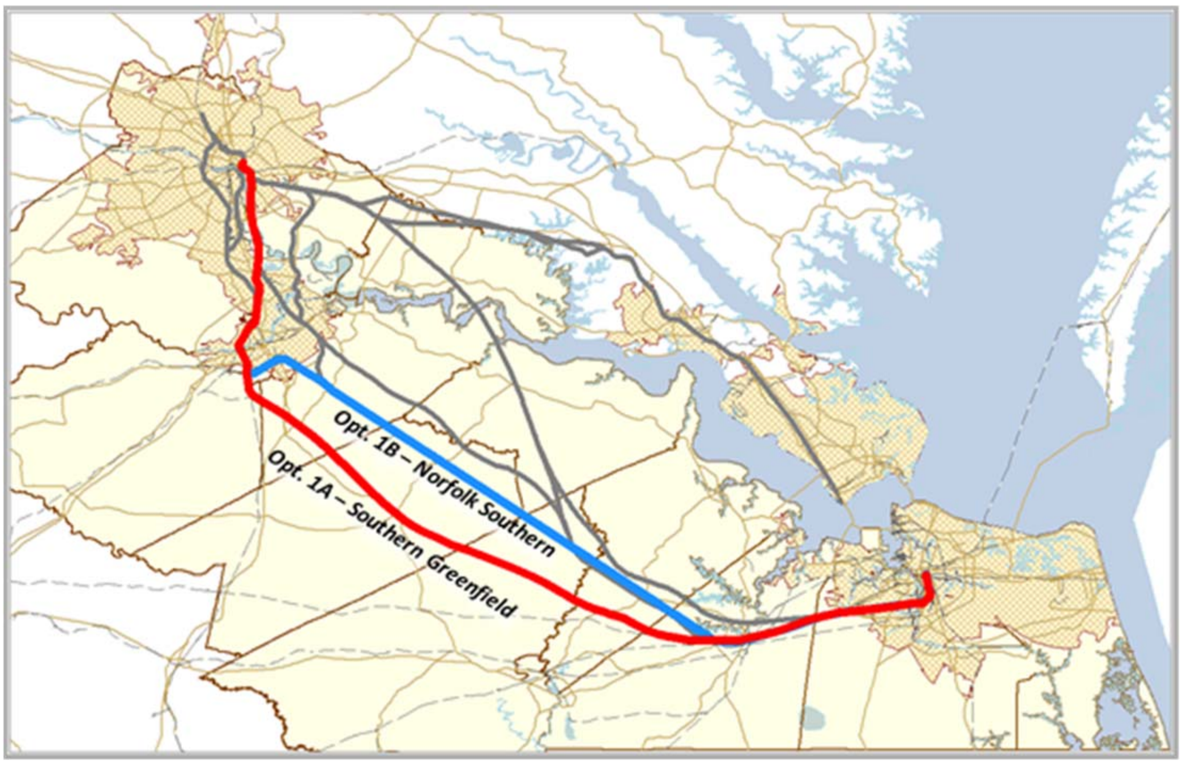
Photo 15: Railroad crossover at Windsor, VA.

The purpose of this inspection effort was to provide data for use in the preliminary engineering and environmental work for developing a capital cost estimate for improving the existing rail corridor. The example photographs show the specific kinds of measures that will be needed to implement high speed rail service while avoiding interference with existing freight operations.

4.4.2 POSSIBLE SOUTHERN GREENFIELD – SUFFOLK TO PETERSBURG OPTION 1A

The Suffolk to Petersburg segment of Option 1A, otherwise known as the Southern Greenfield, has also been reviewed (See Exhibit 4-5). The original concept was to follow the abandoned Virginian right-of-way as far as possible, to the vicinity of Walters. From Walters a new greenfield would head straight towards Collier to meet CSX. But this has two problems: at the east end, this would pass through the middle of the town of Walters. At the west end, Photo 16 shows a residential community and Photo 17 shows Richard Bland College which lie along this direct path between Walters and Collier. However, these obstacles can be avoided by shifting the conceptual option. The revised greenfield would pass north of Walters, rather than directly through it. At the west end, the option is shifted south to meet CSX at the south end of Collier Yard, (near the SEHSR's[4] Burgess Connection) rather than at the north end. This eliminates any conflicts with the college and golf course community. See Exhibit 4-6 for photo locations within the possible southern greenfield study area.

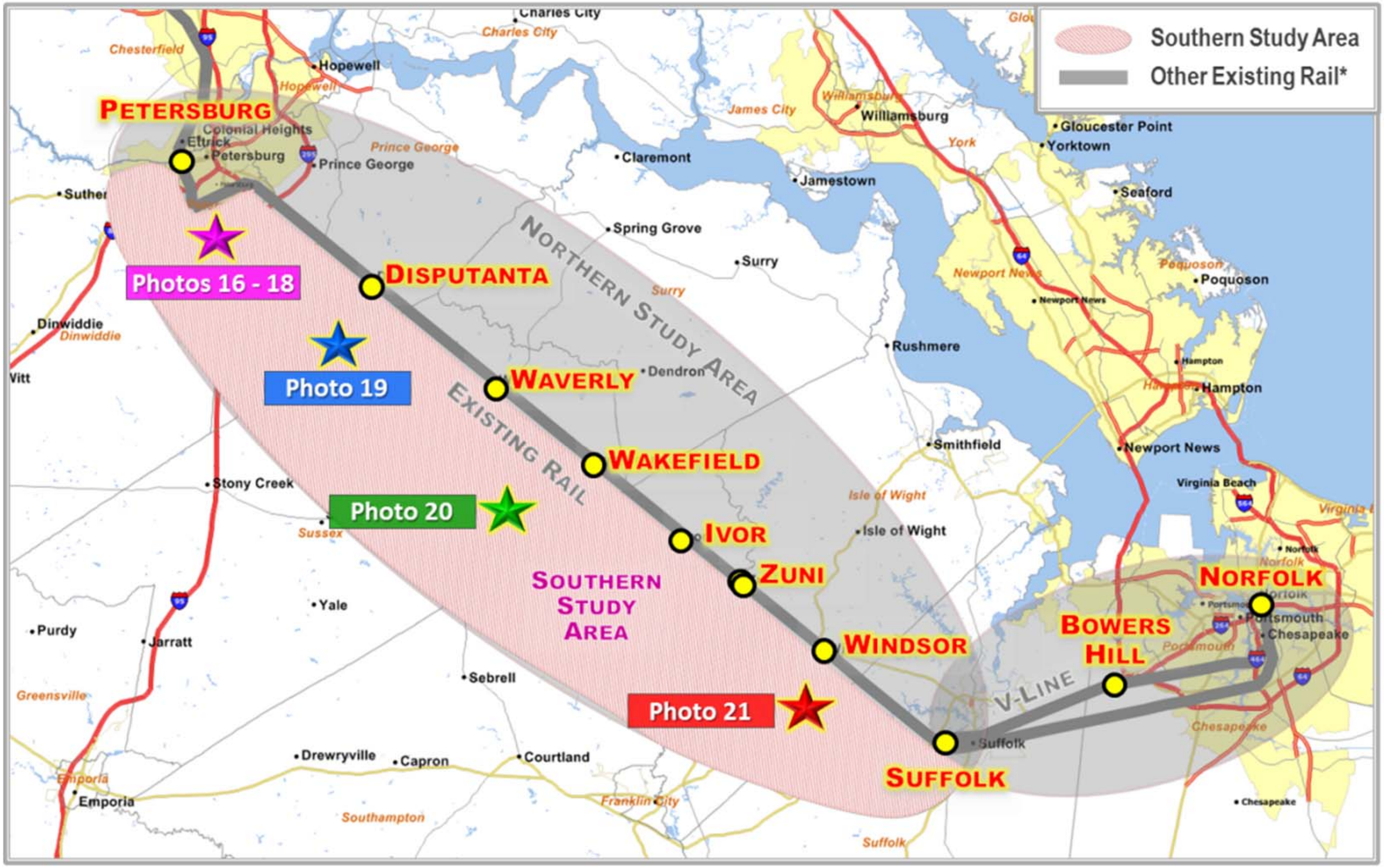
Exhibit 4-5: Southern Greenfield Option 1A from Suffolk to Petersburg



*Alignment will not be determined until the Tier II Environmental Process is complete.

[4] SEHSR – Southeast High Speed Rail

Exhibit 4-6: Photo Locations along Possible Southern Greenfield Option 1A from Suffolk to Petersburg



*Alignment will not be determined until the Tier II Environmental Process is complete.

Photo 16: Golf course and residential community at Halifax Road near Petersburg.

Photo 17: Richard Bland College at Petersburg

From Burgess north to Petersburg, the SEHSR and Norfolk services could share a dedicated passenger track around Collier yard. From Burgess, the southern high speed line would head southeast towards Suffolk, Photo 18 shows the open countryside looking east from Burgess. Photos 19 through 21 show open country side along the southern alignment, which would connect the south end of the Collier Yard to the western outskirts of Suffolk.

The greenfield right-of-way would skirt the Warwick Swamp heading through generally open countryside (cotton fields and scrub forest) to meet the abandoned “Virginian” rail right-of-way somewhere in the vicinity of Walters, VA. The alignment would then continue along the abandoned “V-Line” right-of-way into downtown Suffolk.

Photo 18: Open country side looking east, from the south end of Collier Yard.

Photo 19: Pine Scrub Forest territory to be traversed near Disputanta.

Photo 20: Cotton field in general area to be traversed near Wakefield.

Photo 21: Section of abandoned "Virginian" railroad right-of-way from Suffolk to Walters.

4.4.3 POSSIBLE NORTHERN GREENFIELD – SUFFOLK TO HOPEWELL – OPTION 2A

A northern greenfield from Petersburg to Suffolk (see Exhibit 4-7) might roughly parallel route 10 from south of James River Bridge near Hopewell to Zuni and then parallel the utility line and NS rail line from Zuni to Suffolk. Photos 22-25 show the bridge over James River on I-295 near Hopewell, the Median on Interstate I-295 near Prince George which has room to add track, Tucker Swamp which was identified as a potential environmental concern, and the utility line which is parallel to NS alignment/US Route 460. These photos are identified in Exhibit 4-8. The generic Greenfield would be located by identifying and avoiding the Tucker Swamp area, and utilizing the I-295 median to pass through the Petersburg/Hopewell community.

Exhibit 4-7: Northern Greenfield from Suffolk to Hopewell

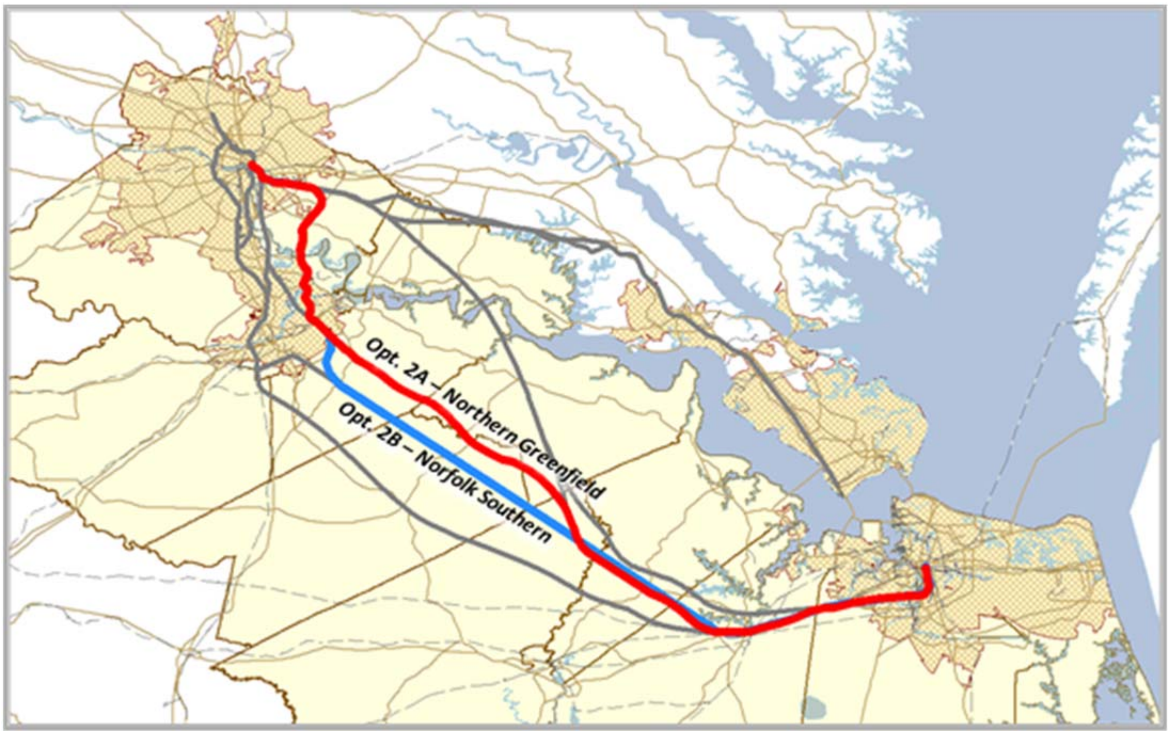
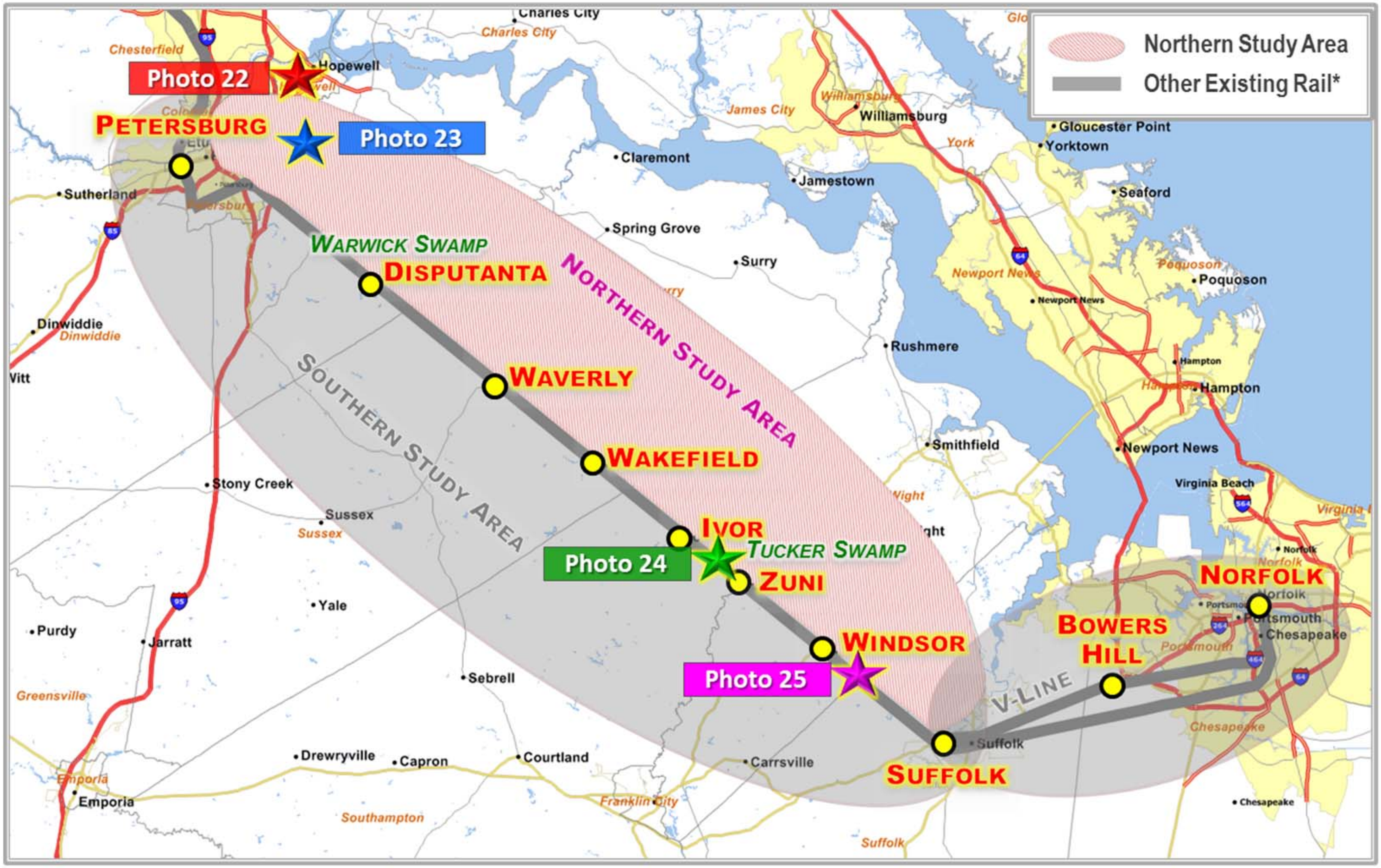


Exhibit 4-8 Photo Locations along Northern Greenfield from Suffolk to Hopewell



*Alignment will not be determined until the Tier II Environmental Process is complete.

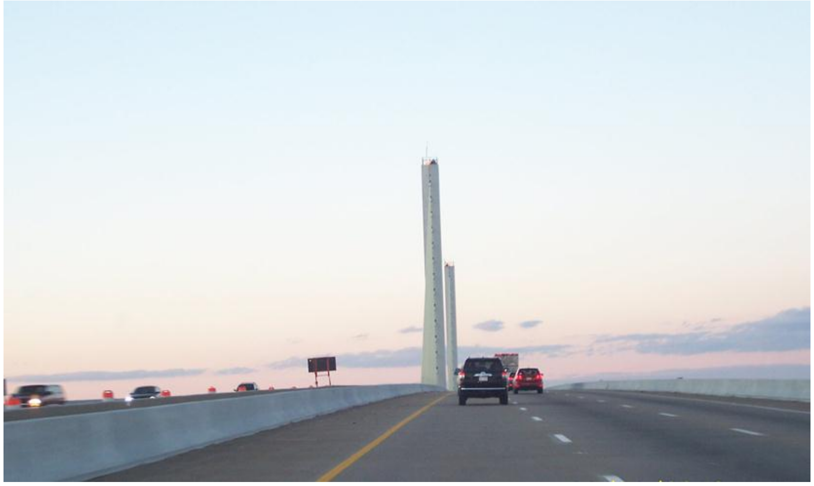


Photo 22: Bridge on I-295 near Hopewell James River.

Photo 23: Median on I-295 near Prince George.

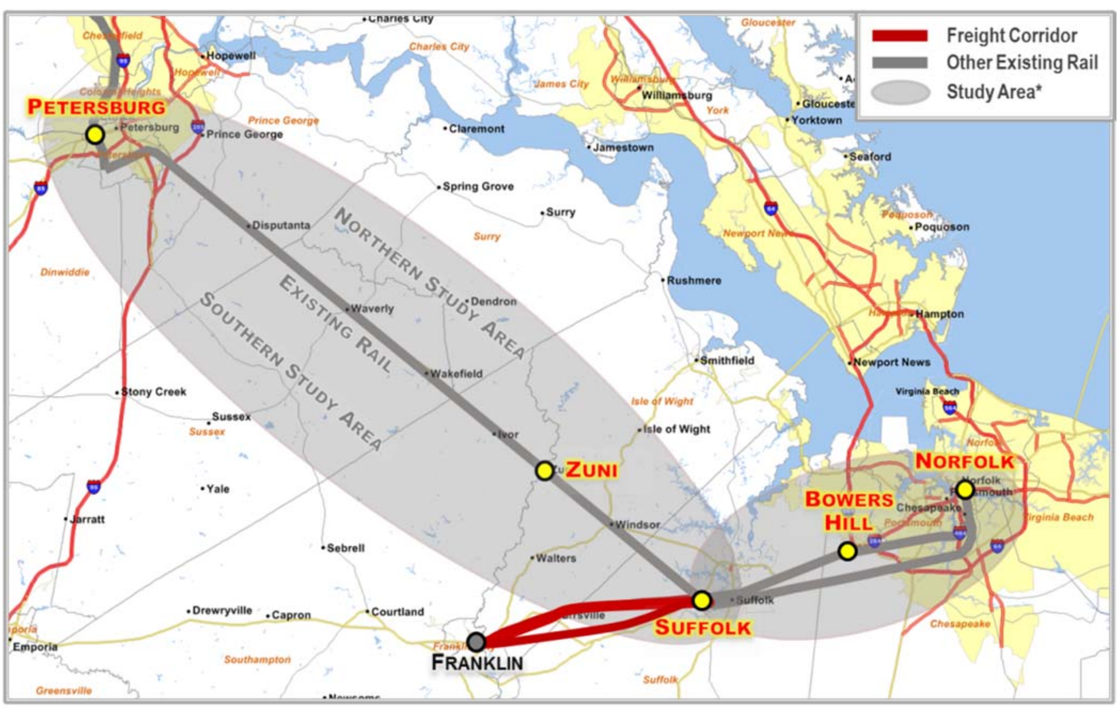
Photo 24: Tucker Swamp at the NS alignment.

Photo 25: Northern greenfield - utility line corridor at Windsor.

4.4.4 EXISTING RAIL – FRANKLIN TO SUFFOLK, AND DOWNTOWN SUFFOLK

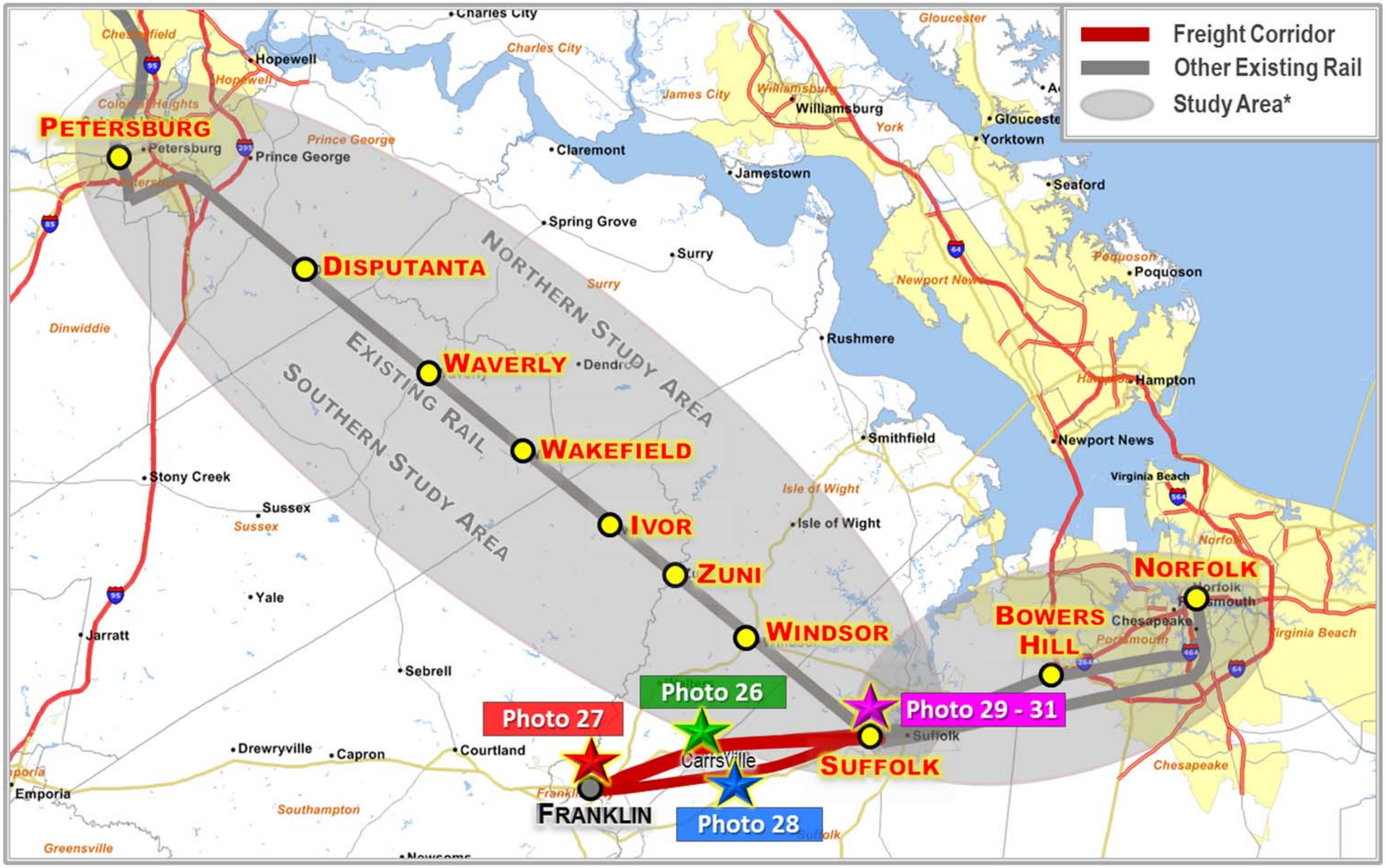
A possible freight rail alternative for developing a dedicated passenger line through downtown Suffolk could alleviate potential conflicts with CSXT double track container trains that now use the CSX Portsmouth subdivision through downtown Suffolk on their way to VPA container port. It is intended for the development of an alternative rail access for CSXT container trains, to avoid conflict with passenger trains through downtown Suffolk on the proposed "V-Line alignment". The existing CSXT and NS freight lines from Franklin to Suffolk (See Exhibit 4-9) have been reviewed in the following photos from 26 through 28. These photos show that the NS line is in good condition, and could be a practical alternative to the CSXT line through downtown Suffolk. Exhibit 4-10 shows the location of these photos along the existing rail line Franklin to Suffolk and downtown Suffolk.

Exhibit 4-9: Franklin to Suffolk Freight Alternative



*Alignment will not be determined until the Tier II Environmental Process is complete.

Exhibit 4-10: Photo Locations along Franklin to Suffolk Freight Alternative



*Alignment will not be determined until the Tier II Environmental Process is complete.

Photo 26: CSXT Portsmouth subdivision near Franklin. This is current route for CSXT double stack trains.

Photo 27: NS Bridge over CSXT in Franklin.

Photo 28: Welded rail on NS line from Franklin to Suffolk.

Photo 29 shows the roadway that has displaced about 0.8 miles of railroad right-of-way in downtown Suffolk. It extends from the junction of W Constance road/Prentis Street to the Suffolk Seaboard Station. This was a recently constructed roadway which can be seen in Photo 30. In the vicinity of this old seaboard Suffolk station, there is a development on the other side of the CSXT tracks while there is more room to add track if necessary, on the station side. This suggests that the station be shifted back from its current place to make room for added tracks if the CSXT freight traffic cannot be relocated.

Photo 29: Rail right-of-way taken over by Highway close to Suffolk Old Station.

Photo 30: Seaboard Suffolk Old Station.

To implement the Franklin to Suffolk rerouting of CSXT trains, a grade separation may be needed at the rail junction in downtown Suffolk, as shown in Photo 31.

Photo 31: Part of Franklin to Suffolk freight reroute.

4.4.5 "V" LINE EXISTING RAIL – NORFOLK TO SUFFOLK

The corridor from Norfolk to Suffolk is heavily built up, and there are only a limited number of ways of getting between the two cities because of the significant environmental obstacles as well, particularly, the Dismal Swamp.

- Currently NS has a double tracked mainline from Suffolk to Norfolk which carries heavy freight traffic and additionally, the Virginia Department of Rail and Public Transportation (DRPT) has purchased up to three slots for operating Amtrak passenger service over this line into downtown Norfolk.
- However, NS also has a parallel, partially abandoned line, the "V Line" which could provide a dedicated passenger access route into downtown Norfolk separate from the current freight line. DRPT's Hampton Roads Tier I FEIS has selected this route.

As a result, this analysis assumes that the "V" line alternative will be followed, for the following reasons. The "V" line alternative follows the US Route 460 alignment north of the Dismal Swamp, whereas the existing NS mainline goes directly across the swamp. Adding tracks to the existing NS alignment would either entail filling parts of the swamp – unlikely to be environmentally acceptable – or else bridging the swamp, which would be very expensive. It is likely that the Dismal Swamp issue alone would be sufficient to environmentally disqualify such an alternative. There are additional operational issues along the NS mainline at Portlock Yard which would also be bypassed by using the proposed "V Line" alignment.

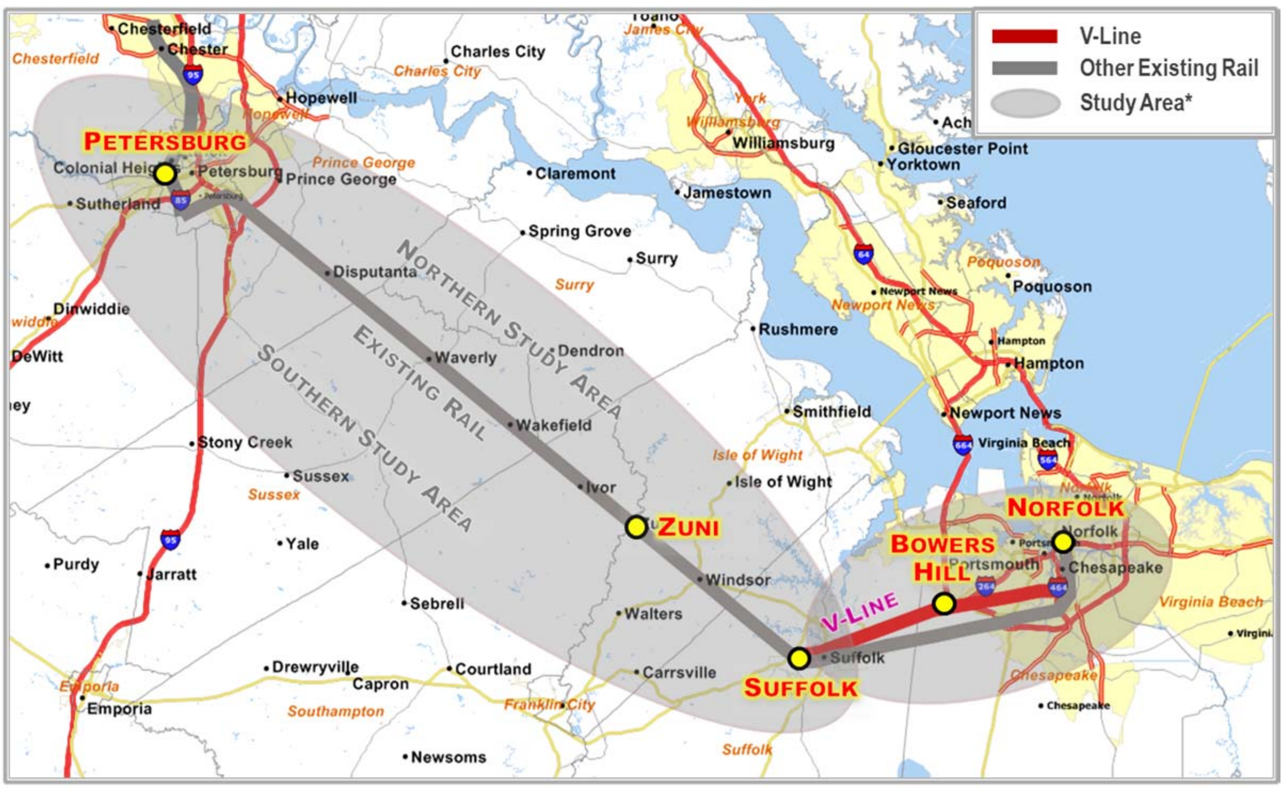
However, development of the "V Line" option is not without some challenges:

- At Algren on the west side of Suffolk, a new connection track may be needed to link the Norfolk Southern mainline to the CSXT Portsmouth subdivision through Suffolk.
- From Algren through Suffolk, passenger trains may need to share tracks with CSXT double stack trains to a connection with the Commonwealth Railway, which provides access to the Portsmouth Marine Terminal at Craney Island. As already described, the right-of-way is highly restricted through downtown Suffolk, since the abandoned former Virginian right-of-way has been converted into a city street (Prentis Street) occupying the land that would be needed to develop a separated passenger alignment through this area.
- Beyond the Commonwealth Railway, the CSXT Portsmouth subdivision is lightly-used to its junction with the abandoned "V-Line" in the vicinity of the Hampton Roads Executive Airport.

- The tracks are in place, but the "V-Line" is out of service from the Hampton Roads Executive Airport to the Cavalier Industrial Park, just west of Cavalier Boulevard.
- From the Cavalier Industrial Park, crossing the Western Branch of the Elizabeth River on a lift bridge, to NS Main Line junction north of Portlock Yard (Seaboard Avenue and Richmond Streets in South Norfolk in Chesapeake) the "V-Line" is lightly used for industrial traffic.
- From the "V" Line junction into the Harbor Park train station (Seen in Photo 36), passenger trains must share right-of-way with the NS main line. This section includes a second major bridge crossing the Southern Branch of the Elizabeth River just south of the Harbor Park station. In this area, an out-of-service former Virginian Railroad bascule bridge is proposed to be rehabilitated and restored to service so as not to displace freight capacity of the existing NS main line.

These challenges will be shown in the following photos 32 through 36 covering Portsmouth, Chesapeake, and Norfolk following the V-line track from Norfolk to Suffolk (as shown in Exhibit 4-11). The location of these photos are shown in Exhibit 4-12.

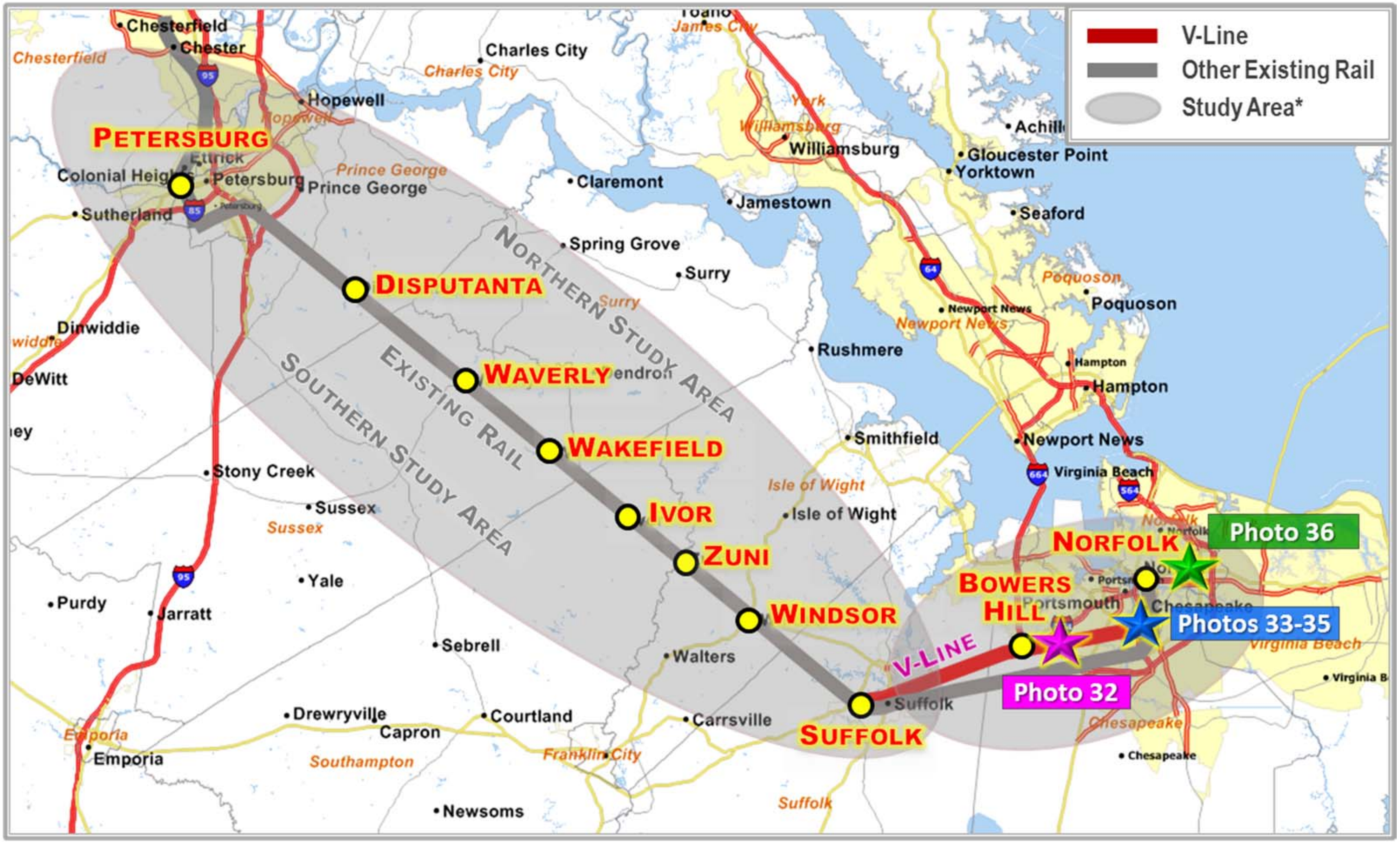
Exhibit 4-11: Existing V-line from Norfolk to Suffolk



*Alignment will not be determined until the Tier II Environmental Process is complete.

The following photos from 32 through 36 show abandoned tracks near I-64 and I-664, railroad crossings in Portsmouth, the humped railroad crossing at Chesapeake, tracks that requires roadwork and the improved Harbor Park station in Norfolk (See Exhibit 4-12 for location of these photos).

Exhibit 4-12: Photo Locations along Existing V-line from Norfolk to Suffolk



*Alignment will not be determined until the Tier II Environmental Process is complete.

Photo 32: Abandoned V-Line under the Bridge at Rotunda under I-664 and I-64.

Photo 33: Railroad crossing at Chapin Road in Portsmouth.

Photo 34: V-line joining the NS Main Line in South Norfolk, at the north end of Portlock Yard.

Photo 35: Humped Railroad Crossings at Park Avenue in Portsmouth.

Photo 36: Harbor Park Station in Norfolk.

4.5 INFRASTRUCTURE UNIT COSTS

In addition to the Engineering Assessment, a capital costing methodology was developed to identify infrastructure rolling stock (equipment) costs and land costs. Land costs are presented separately, as a placeholder for access to railroad rights-of-way and for procurement of additional privately owned property where required to construct new passenger rail infrastructure.

The Engineering Assessment for the Vision Plan is being conducted at a feasibility level of detail and accuracy. Exhibit 4-13 highlights the levels of accuracy associated with typical phases of project development and engineering design. A 30% level of accuracy is associated with the evaluation of project feasibility; while the level of accuracy of 10% is achieved during final design and production of construction documents. This phase of the study is only the first step in the project development process. As shown in Exhibit 4-13, the cost estimate is intended to be a mid-range projection with equal probability of the actual cost moving up or down.

Exhibit 4-13: Engineering Project Development Phases and Levels of Accuracy Development

Development Phases	Approximate Engineering Design Level*	Approximate Level of Accuracy**
Feasibility Study	0%	+/- 30% or worse
Project Definition/Advanced Planning	1-2%	+/- 25%
Conceptual Engineering	10%	+/- 20%
Preliminary Engineering	30%	+/- 15%
Pre-Final Engineering	65%	+/- 15%
Final Design/Construction Documents	100%	+/- 10% or better

The first step in the Engineering Assessment is to divide each corridor into segments. Route segments for existing railroad rights-of-way generally begin and end at major railroad control points or rail stations. For greenfield alignments, segments begin and end at stations or junction points. Typical corridors are divided into three to five route segments. These segments are discussed and defined in Chapter 4. A systematic engineering planning process has been used to conduct the Engineering Assessment using the five basic costing elements:

- Guideway and Track Elements
- Structures – Approaches, Flyovers, Bridges and Tunnels
- Systems
- Crossings
- Stations and Maintenance Facilities

Three auxiliary costing elements have been defined in the chapter as follow:

- Right-of-Way and Land
- Vehicles
- Professional Services & Contingencies

The Engineering Assessment will be based on these eight costing elements. In addition to the field inspections and extensive work with GIS and railroad track charts, the assessment will include a thorough review of the alignment studies and estimate the costs.

4.5.1 INFRASTRUCTURE CAPITAL COSTS DEVELOPMENT

The infrastructure capital costs are summarized in this section of the chapter were similar to that presented in Preliminary Vision Plan and have been updated to 2012 dollars. The unit cost data base and corridor infrastructure costs are appropriate for a Vision Plan Feasibility Study. The costs will be further refined in future phases of work when the Alternatives Analysis for the Tier 1 and Tier 2 EIS work is undertaken.

The infrastructure capital unit costs used in the development of the preliminary capital cost estimates were developed from TEMS library of HSR unit costs. Peer panels, freight railroads and construction contractors have reviewed these costs. In addition, a summary validation was completed comparing the

TEMS unit costs with unit costs used in regional rail studies around Virginia. Capital cost categories include:

- Land and right-of-way
- Sub-grade, structures and guideway
- Track
- Signals and communications
- Electrification
- Demolition
- Stations
- Maintenance and facilities
- Highway and railroad crossings
- Fencing and corridor protection

In addition to the engineering assessment, the capital costing methodology identifies rolling stock (equipment) costs and land costs. Land costs are presented separately, as a placeholder for access to railroad rights-of-way and for procurement of additional privately owned property where required to construct new passenger rail infrastructure.

Using the Engineering News Record Construction Cost Index (ENR CCI) Indices, unit costs used in this preliminary/initial portion of the Vision Plan study were adjusted for geographic region and annual escalation. Unit Prices will be adjusted to Regional Conditions and Escalate from 2009 to 2012. The following adjustment will be made:

- Unit Prices were based on the recent Rocky Mountain Rail Authority Business Plan for Denver region which was developed in 2009 dollars.
- From ENR CCI Analysis, the Denver to Hampton Roads adjustment is 97 percent, as the benchmark prices are slightly higher in the Denver area than they are in Hampton Roads.
- According to ENR CCI, National Cost Indices cost increases from 2009 to 2012 is the ratio of ENR CCI for 2012 divided by that of 2009[5] which is 1.085.

With the Regional Adjustment Factor of 0.97, and inflation of 1.085, the Escalation Factor from the Denver regional study of 2009 to Hampton Roads 2012 costs is the product of 0.97 * 1.085, which is 1.05.

The unit costs in the following section were estimated by applying this adjustment factor to the previous developed representative unit costs in previous TEMS work for the Midwest Regional Rail Authority high-speed rail studies and for the Rocky Mountain Rail Authority High-Speed Rail studies (as discussed earlier in Preliminary Vision Plan report).

[5] http://www.cahighspeedrail.ca.gov/assets/0/152/302/314/288d8ea6-bf10-4e14-80fc-fc92bd4ba48a.pdf and methodology based on Unit Price Regional & Escalation Analysis Rocky Mountain Rail Authority (RMRA), High Speed Rail Feasibility Study http://rockymountainrail.org/documents/RMRA_HSRBP_Appendix_F_03.2010.pdf

4.5.2 RAIL CAPITAL UNIT COSTS

The base set of unit costs addresses typical passenger rail infrastructure construction elements including: roadbed and trackwork, systems, facilities, structures, and grade crossings. In the tables below, only a subset of the costs were actually used in Capital Cost development. Those costs are highlighted in yellow.

TRACKWORK AND LAND ACQUISITION

The FRA requires that passenger trains operating on the general railroad system comply with stringent crashworthiness standards. For the purposes of defining requirements necessary to proceed with the study and in order to develop planning level capital costs, it has been assumed that highway traffic and adjacent high speed trains will be separated by concrete barriers. On tangent highway and track segments, there exists a small probability that automotive vehicles will leave the highway. Thus, protection against highway traffic incursions into the high speed rail median would be provided using NCHRP Report 350 Level 5 highway concrete barrier walls. In curved median segments, where accidents are more likely, we have planned for NCHRP Level 6 barriers. It is anticipated that high speed rail systems will be separated from the freight rail corridors by at least 25 feet between track centers where practicable. Chain link fencing will be provided throughout the system in all corridors to prevent the intrusion of trespassers and animals. These planning assumptions may be subject to modification as a result of federal or state rule making.

Land acquisition costs for right-of-way owned and controlled by the railroad industry is always an issue when attempting to introduce new passenger rail service. Since its inception, Amtrak has had the statutory right to operate passenger trains over freight railroad tracks and rights-of-way. When using freight tracks, Amtrak is required to pay only avoidable costs for track maintenance along with some out-of-pocket costs for dispatching.[6]

Amtrak's payments do not include any access fee for the use of a railroad's tracks or its rights-of-way. Amtrak's federal statutory right-of-access has never required such a payment, and therefore, Amtrak avoids paying a fee or "rent" for occupying space on privately held land and facilities.

However, this study assumes a cost for access based on estimated across-the-fence land values would be included as part of the up-front capital expense, and would be used to purchase the rights to use the underlying railroad rights-of-way for the passenger service. It is assumed that railroads would receive this compensation in cases where the construction of a dedicated high speed passenger track is on their property. If new track cannot be constructed within the existing railroad rights-of-way, then this cost would fund the possible acquisition of adjacent property.

Elsewhere land will need to be purchased directly from land owners. Where highway rights-of-way are proposed, the study assumes that right-of-way or air rights access would be granted by appropriate authority at no cost to the rail system.

The outright purchase of land is not the only method whereby railroads could receive compensation for access to railroad rights-of-way. Commuter rail development provides examples of various types of

[6] However, these payments do not cover all of the freight railroads' incremental costs associated with dispatching Amtrak's passenger trains. Railroad costs increase due to delays caused by Amtrak's tightly scheduled trains. Track capacity constraints and bottlenecks create unreliable conditions where train delays often become unavoidable. While federal regulations give passenger trains dispatch priority, railroad dispatchers often encounter congestion where it becomes difficult to control traffic and adhere to Amtrak's timetables. In some cases, Amtrak will offer the railroads a payment to provide on-time passenger train performance. On heavily used line segments, however, these incentive payments only partially compensate a railroad for the costs of increased delay, and some railroads simply refuse to accept incentive payments. On lightly used lines, the economic rationale for making these payments is questionable since passenger trains cause very little delay on such tracks.

payments for access rights. Some of these projects involved the purchase of the railroad rights-of-way while others provide up-front capital improvements in return for access to a railroad's tracks. The actual methods of payment remain to be determined during negotiation, and may depend on the importance of the track to the freight railroad as well as the level of capital to be invested by the passenger rail authority.

One area of possible concern is the freight railroads' ability to retain operating control over their rights-of-way. Whenever transit systems have paid full price to acquire a freight rail line, as on some commuter rail projects, the transit agencies have assumed operating control over the property. However, this study has assumed that the freight railroads would retain dispatching control over these rights-of-way. The railroads would have the right to use the increased capacity provided by the passenger system for its high speed freight services.

A 100-foot right-of-way will be assumed for the greenfield, except where the alignment falls within an existing publicly-owned right-of-way, such as a highway or street alignment, no cost to the project for that particular right-of-way has been assumed. Where the geometric requirements take the alignment outside of the public right-of-way, impacted parcels will be evaluated and a square foot quantity calculated. A unit cost per acre was developed in conjunction with other studies. Exhibit 4-14 shows the unit costs used for trackwork and land acquisition.

Exhibit 4-14: Unit Capital Costs, Trackwork in $2012.

Item No.	Description	Unit	Unit Cost (Thousands of $2012)
1.1	HSR on Existing Roadbed (Single Track)	per mile	$1,246.11
1.2	HSR on Existing Roadbed (Double Track)	per mile	$2,492.42
1.3	HSR on New Roadbed & New Embankment (Single Track)	per mile	$1,872.29
1.31	HSR Single Track 15' offset added to existing corridor on 15' fill	per mile	$2,532.29
1.4	HSR on New Roadbed & New Embankment (Double Track)	per mile	$3,355.65
1.41	Greenfield Double Track at Grade	per mile	$3,355.65
1.42	Greenfield Double Track Rolling Terrain	per mile	$3,713.65
1.43	Greenfield Double Track Mountainous Terrain	per mile	$4,785.65
1.44	HSR Double Track 15' offset added on 15' fill	per mile	$4,807.82
1.45	HSR Double Track 30' offset added on 15' fill	per mile	$5,599.85
1.46	HSR Double Track 30' offset added on 15' Retained Earth fill	per mile	$17,724.11
1.5	HSR New Double Track on 15' Retained Earth Fill	per mile	$17,724.11
1.6	Timber & Surface w/ 33% Tie replacement	per mile	$278.62
1.7	Timber & Surface w/ 66% Tie Replacement	per mile	$415.33
1.8	Relay Track w/ 136# CWR	per mile	$444.29
1.9	Freight Siding	per mile	$1,144.50
1.10	Passenger Siding	per mile	$1,726.77
1.11	NCHRP Class 6 Barrier (on curves)	lineal ft.	$1.38
1.12	NCHRP Class 5 Barrier (on tangent)	lineal ft.	$0.21
1.13	Fencing, 4 ft. Woven Wire (both sides)	per mile	$63.95
1.14	Fencing, 6 ft. Chain Link (both sides)	per mile	$191.97
1.15	Fencing, 10 ft. Chain Link (both sides)	per mile	$219.65

1.15a	Sound Wall Fencing	per mile	$1,350.00
1.16	Decorative Fencing (both sides)	per mile	$494.45
1.17	Drainage Improvements (cross country)	per mile	$82.83
1.18	Drainage Improvements in Median or along highway	per mile	$662.56
1.19	Land Acquisition Urban and Resort (100' of ROW)	per mile	$410.35
1.20	Land Acquisition Rural (100' of ROW)	per mile	$136.82
1.21a	Land Acquisition Rural US-460 Corridor	per acre	$35.00
1.21b	Property Takes (overall average per take)	each	$161.00
1.21c	Wetland Mitigation	per acre	$150.00
1.21	#33 High-Speed Turnout	each	$712.73
1.22	#24 High-Speed Turnout	each	$564.67
1.23	#20 Turnout Timber	each	$155.59
1.24	#10 Turnout Timber	each	$86.55
1.25	#20 Turnout Concrete	each	$312.45
1.26	#10 Turnout Concrete	each	$148.06
1.27	#33 Crossover	each	$1,425.56
1.28	#20 Crossover	each	$625.76
1.28a	Interlockings and Crossovers every 10 miles	Per mile	$265.00
1.29	Elevate & Surface Curves	per mile	$72.76
1.30	Curvature Reduction	per mile	$493.18
1.31	Elastic Fasteners	per mile	$102.88

4.5.3 STRUCTURES: APPROACHES, FLYOVERS, BRIDGES, AND TUNNELS

A complete inventory of bridges has been developed for each existing rail route from existing track charts. For estimating the cost of new bridges on either green field alignments or along existing rail beds, conceptual engineering plans will be used for a bridge to carry either single or double tracks over highways, streams, valleys, and rivers. Some bridges require rehabilitation on the abutments and superstructure. This type of work includes pointing of stone abutment walls, painting of bridges, and replacement of bearings. Many of the major bridge cost estimates will be estimated only as placeholders, which will be subject to more detailed engineering analysis in the future. Tunneling costs lie within the $20-73 thousand per linear foot range, where the higher cost was from the long undersea English Channel tunnel; but the estimates in Exhibit 4-15 were considered as benchmarks for the probable cost of tunnels and these costs will be used in this study.

Exhibit 4-15: Unit Capital Costs, Structures in $2012

Item No.	Description (Bridges-under)	Unit	Unit Cost (Thousands of $2012)
2.1	Four Lane Urban Expressway (Rail over Highway)	each	$6,067.52
2.2	Four Lane Rural Expressway (Rail over Highway)	each	$5,051.03
2.3	Two Lane Highway (Rail over Highway)	each	$3,832.50
2.4	Rail (New Rail over Existing Rail)	each	$3,832.50
2.5	Minor river	each	$1,016.48
2.6	Major River	each	$10,162.30
2.7	Double Track High (50') Level Bridge	per LF	$15.27
2.8	Rehab for 110	per LF	$17.61
2.9	Convert open deck bridge to ballast deck (single track)	per LF	$5.83
2.10	Convert open deck bridge to ballast deck (double track)	per LF	$11.77
2.11	Single Track on Flyover/Elevated Structure	per LF	$5.30
2.12	Single Track on Approach Embankment w/ Retaining Wall	per LF	$3.71
2.13	Double Track on Flyover/Elevated Structure	per LF	$8.48
2.13a	Greenfield Double Track on Low Bridge	per LF	$8.90
2.14	Double Track on Approach Embankment w/ Retaining Wall	per LF	$6.89
2.15	Ballasted Concrete Deck Replacement Bridge	per LF	$2.65
2.16	Land Bridges	per LF	$3.29
2.17	Four Lane Urban Expressway (Highway over Rail)	each	$3,675.64
2.18	Four Lane Rural Expressway (Highway over Rail)	each	$2,619.06
2.19	Two Lane Highway (Highway over Rail)	each	$2,388.06
2.20	Rail (Existing Rail over New Rail)	each	$7,667.55
2.21	Two Bore Long Tunnel	route ft.	$46.67
2.22	Single Bore Short Tunnel	lineal ft.	$26.52

4.5.4 SYSTEMS

The capital cost estimates for this study include costs to upgrade the train control and signal systems. Unit costs for system elements are shown in Exhibit 4-16. Under the 110 mph or higher speed scenarios, the signal improvements include the added costs for a vital Positive Train Control (PTC) signal system. The FRA "Cab signal rule" requires that wayside signals be displayed within the engine cab for any speeds of 80 mph or high. The PTC system would do this. However it should be noted that NS policy prohibits exceeding 79 mph on its tracks. For this study PTC would only need to be applied only to new dedicated tracks and not the existing NS freight tracks.

Most US railroads that allow or provide passenger and freight service operate under manual control with wayside signals. Centralized traffic control (CTC) signaling is provided on busy corridors including Amtrak's Northeast Corridor. FRA requires that passenger service exceeding 79 mph operate with cab signaling/automatic train protection or automatic train stop to provide protection against operator errors. In addition, FRA is currently sponsoring demonstration projects to develop a universal communications based train control system, known as positive train control or PTC. New high speed passenger service will include sophisticated signal systems to comply with FRA mandates and provide safe, reliable operations. Such signal systems include train borne components and wayside equipment such as track circuits, switch operators, and wayside detectors for protection against intrusion, high water, hot bearings and dragging equipment.

Modern signal systems rely on digital communication systems for data transmission using radio, fiber optic cables or a combination or the two. In addition, the communication system provides radio for operations, supervisory control and data acquisition for power systems, passenger station public address, etc. Wayside space must be provided for ducts and enclosures to house signal and communication components.

Electrified high speed rail options require traction power substations and distribution facilities. Electric utility is expected to provide substations, transmission equipment and connections to the utility network with such costs covered in the utilization charges. As such, it is assumed that the electric utility would amortize the costs for bringing power to the substations, so the costs of modifications to the utility's grid are not included in the electrification cost estimate. Typical requirements for electrification include substations at 25 mile intervals and distribution conductors. In the case of electrified rail systems, overhead catenary conductors provide power to the train pantograph and the rails serve as return conductors. The catenary conductors are supported by poles and cross arms spaced at roughly 100-150 foot intervals. The catenary system contact wire is generally located 17.5 to 23 feet above the top of the rail. Additional electrical clearance or high voltage insulation is required to overhead bridge structures.

Exhibit 4-16: Unit Capital Costs, Systems, in $2012

Item No.	Description	Unit	Unit Cost (Thousands of $2012)
3.1	Signals for Siding w/ High-Speed Turnout	each	$1,591.23
3.2	Install CTC System (Single Track)	per mile	$229.62
3.3	Install CTC System (Double Track)	per mile	$376.52
3.4	Install PTC System	per mile	$181.36
3.5	Electric Lock for Industry Turnout	each	$129.29
3.6	Signals for Crossover	each	$878.39
3.7	Signals for Turnout	each	$501.98
3.8	Signals, PTC, Communications & Dispatch (Double Track)	per mile	$1,602.00
3.9	Electrification and Power Supply (Double Track)	per mile	$5,482.00

4.5.5 CROSSINGS

The treatment of grade crossings to accommodate 110-mph operations on existing rail is a major challenge to planning a high speed rail system. Highway/railroad crossing safety plays a critical role in future project development phases. A variety of devices were considered to improve safety including roadway geometric improvements, median barriers, barrier gates, traffic channelization devices, wayside horns, fencing and the potential closure of crossings. Greenfield routes were developed with grade separations at street and roadway crossings. Exhibit 4-17 details the unit costs for highway and railroad grade crossings.

Exhibit 4-17: Unit Capital Costs, Crossings, in $2012

Item No.	Description	Unit	Unit Cost (Thousands of $2012)
4.1	Private Closure	each	$104.15
4.2	Four Quadrant Gates w/ Trapped Vehicle Detector	each	$617.38
4.3	Four Quadrant Gates	each	$361.45
4.4	Convert Dual Gates to Quad Gates	each	$188.26
4.5	Conventional Gates single mainline track	each	$208.30
4.6	Conventional Gates double mainline track	each	$257.30
4.7	Convert Flashers Only to Dual Gate	each	$62.79
4.8	Single Gate with Median Barrier	each	$225.91
4.9	Convert Single Gate to Extended Arm	each	$18.77
4.10	Precast Panels without Roadway Improvements	each	$100.44
4.11	Precast Panels with Roadway Improvements	each	$188.26

4.5.6 Station/Maintenance Facilities

Passenger stations and parking facilities include platforms, escalators/elevators and other circulation elements, passenger ticketing and waiting facilities, lighting security, and station administration facilities.

The terminal stations may require four tracks for passenger boarding, train layover and light maintenance.

A maintenance facility with sufficient capacity to service the fleet is required. The facility must provide space and equipment to service the rolling stock and maintain the track structure and systems. Storage tracks can be expanded as the fleet grows. Sophisticated component repair may be subbed out to contract shops. It is anticipated that the maintenance facility for a non-electrified system will be less sophisticated than that of an electrified rail system. Exhibit 4-18 shows the unit costs for types of stations, terminals, and maintenance facilities.

Exhibit 4-18: Unit Capital Costs, Railroad Station/Maintenance Facilities, in $2012

Item No.	Description	Unit	Unit Cost (Thousands of $2012)
5.1	Full Service - New - Low Volume - 500 Surface Park	each	$5,303.03
5.2	Full Service - Renovated - Low Volume- 500 Surface Park	each	$4,242.42
5.3	Terminal - New - Low Volume - 500 Surface Park	each	$7,954.55
5.4	Terminal - Renovated - Low Volume - 500 Surface Park	each	$6,363.64
5.5	Full Service - New- High Volume - Dual Platform - 1000 Surface Park	each	$10,606.06
5.5a	High-Speed Rail Station	each	$12,019.23
5.6	Terminal - New- High Volume - Dual Platform - 1000 Surface Park	each	$15,909.09
5.7	Heavy Maintenance Facility (non-electrified track)	each	$84,848.48
5.8	Heavy Maintenance Facility (electrified track)	each	$106,060.61
5.9	Layover Facility	lump sum	$10,606.06

4.5.7 OTHER COSTS

Please note that contingency and professional service allowances are added for infrastructure capital costs only. They are not added for land acquisition, property taking, wetland remediation or placeholder costs since these factors are the results of benchmarking rather than engineering cost comparisons..

CONTINGENCY

Contingency costs will be added as an overall percentage of the total construction cost. Contingencies are an allowance added to the estimate of costs to account for items and conditions that cannot be realistically anticipated. The contingency is expected to be needed as the project develops. The contingency is estimated at 30 percent of the construction cost elements. This contingency included 15%+ for design contingency and 15%+ for construction contingency.

PROFESSIONAL SERVICES AND ENVIRONMENTAL

The project elements included in the Professional Services category are design engineering, program management, construction management and inspection, engineering during construction, and integrated testing and commissioning. For a project of this size, an overall program manager with several section designers is needed to provide conceptual engineering, preliminary engineering, environmental studies, geotechnical engineering, final engineering and engineering during construction. Field and construction management services and integrated testing services and commissioning of various project elements also are required. Professional services and other soft costs required to develop in this study have been estimated as a percentage of the estimated construction cost and are included in the overall cost estimates as a separate line item. Overall this category adds 28% on top of the base cost and contingency. These costs include, as a percentage of construction cost:

- Design engineering and related studies 10%
- Insurance and Bonding 2%
- Program Management 4%
- Construction management and inspection 6%
- Engineering services during construction 2%
- Integrated Testing and Commissioning 2%
- Erosion Control and Water Quality Mgmt 2%

PLACEHOLDERS

The capital costs include allocation for special elements (placeholders) as conservative estimates for large and/or complex engineering projects that have not been estimated on the basis of unit costs and quantities. Placeholders provide lump sum budget approximations based on expert opinion rather than on an engineering estimate and are shown in the unit costs as lump sum items. Placeholders are used where detailed engineering requirements are not fully known. These costs will require special attention during the project development phase.

4.5.8 CAPITAL COST SUMMARY

The capital cost for developing a high speed 220-mph rail link between Norfolk, VA and Washington, DC has been estimated. The estimate shown in Exhibit 4-19 consists of several components:

1. Equipment cost was estimated as $590 million, for 14 high speed (220-mph) electric trains at $42.14 million each. This equipment cost benchmark is consistent with what has been assumed for the cost of high speed trains in the Atlanta-Charlotte Tier I EIS Study.
2. The cost for the Richmond to Washington DC segment is based on a highly conceptual greenfield between those points. This cost was drawn from the earlier 2010 Hampton Roads Progress Report C (Exhibit C-3 on page C-40) and was increased 5% for inflation. It should be noted that the original cost of $2.129 billion reflected a 65% allocated share of the total cost. For this update however, it has been assumed that the Hampton Roads corridor would bear 100% of the cost of developing the greenfield so the cost used was $2.129 / 0.65 * 1.05 = $3.439 billion.
3. The cost for Newport News to Richmond was zero, reflecting the Step 2 3 trains per day at 90-mph scenarios that were evaluated in the DRPT EIS. The scenarios assumed that the Peninsula service would not be upgraded beyond the currently planned level of 3 Round Trips according to the DRPT DEIS. This assumption is not necessarily optimal or appropriate in view of planned service improvements to other parts of the Hampton Roads-Washington Corridor. Nevertheless, it is what the study team was tasked to evaluate at this stage. It is expected that this assumption will be revised in future phases of work.
4. The cost for Norfolk to Richmond was based on a feasibility level engineering assessment of the options, as detailed in Chapter 4. Although Richmond Direct appears to be the most cost effective alternative (because it avoids the high cost of developing urban infrastructure through Petersburg) costs in the $3.1-3.3 billion range the results for all five options are very close, well within the error range of the estimates. By comparison, the original 2010 Progress Report C estimate if increased by 5% inflation to $2.87 billion is very close to this new $3.1-3.3 billion figure, which is based on a much more detailed environmental and engineering assessment than was possible in the earlier study. This difference in costs can be largely explained by the added cost of a high level James River Bridge in the five new options, which was not anticipated in the earlier 2010 cost estimates.
5. The total cost for the Hampton Roads-Washington Corridor for each option were also very similar with the total cost of Option 2A Northern Greenfield being $7.35 billion while that for Option 3 Richmond Direct is $7.15 billion. This is a cost of $35-37 million per mile, which is much less expensive than major new interstate highway construction costs which in urban and suburban areas typically fall in the $100-200 million per mile range.[7].Based on these benchmarks it can be seen that the proposed new US-460 highway costing only $25.4 million per mile[8] is indeed a bargain– because it is built only through rural lands, whereas the rail system includes several urban areas where highway development would be much more expensive, if it could be undertaken at all. In contrast the cost of the rail project is held down by sharing existing rail rights of way, for example the largely abandoned "V-Line" corridor through urban areas. Although development of the rail corridor all the way to Washington D.C. would be a large project, it would have correspondingly large benefits. Its costs and affordability are not out of line with comparable highway benchmarks.

[7] The new Fluor express toll lanes widening I-495 around Washington D.C. cost $138 million per mile: $1.93 Billion for 14 miles, see http://tollroadsnews.com/news/how-fluor-lane-widened-the-495-capital-beltway-from-8-to-12-lanes-interview The Intercounty Connector in Maryland (MD-200) cost $183 million per mile: $2.56 Billion for 14 miles, see http://en.wikipedia.org/wiki/Maryland_Route_200
[8] The new US-460 highway through open countryside is projected to cost $25.4 million per mile --$1,396 million for 55 miles, seehttp://www.fhwa.dot.gov/ipd/project_profiles/va_route_460_improvements.htm..

Exhibit 4-19 below breaks down the Capital Costs for a 220-mph electrified rail system from Norfolk to Washington D.C.

Capital Costs for the 130-mph diesel service were scaled based on the 220-mph estimates. At a minimum there would be some cost savings by not installing the electrification and purchasing lower cost diesel trains. If train frequencies were reduced it may be possible to single track some portions of the corridor although this was not included in the current cost estimate for 130-mph diesel service. It could be possible to save additional money by reducing the maximum speed to 110 mph and installing level grade crossings rather than grade separations. Again this was not included but if this approach were applied in the development of a diesel option, it could reduce the initial costs of developing the infrastructure.

The cost for the 130-mph diesel service was estimated by applying a factor of 73% to the 220-mph costs shown below. This factor was based on the ratio of costs calculated for 130-mph vs 220-mph service on an identical greenfield alignment by the Atlanta-Charlotte Tier I EIS Study.

It should be noted that Option 3 – Richmond Direct is the least expensive of all the High Speed options since it avoids the cost associated with urban infrastructure in Petersburg or Hopewell. However costs for all routes will be subject to further refinement as a part of the Tier I NEPA process. Track spacing requirements may impact the cost for options 1B and 2B that would follow part of the existing Norfolk Southern alignment. However, the Greenfield options 1A, 2A and 3 are not affected since these options do not make any use of the Norfolk Southern alignment west of Suffolk. As a result, Richmond Direct is likely to remain the most cost effective option.

Exhibit 4-19: 220-mph Norfolk, VA to Washington, DC Capital Costs by Option, in $2012 (thousands)

OPTION	1A- Southern GF/Petersburg	1B- NS via Petersburg	2A- Northern GF/Hopewell	2B- NS via I295/Hopewell	3- Richmond Direct
Equipment	$590,000	$590,000	$590,000	$590,000	$590,000
Richmond to Washington DC	$3,439,910	$3,439,910	$3,439,910	$3,439,910	$3,439,910
Newport News to Richmond	$0	$0	$0	$0	$0
Norfolk to Richmond	$3,318,834	$3,261,481	$3,320,923	$3,235,350	$3,121,971
TOTAL	***$7,348,743***	***$7,291,391***	***$7,350,832***	***$7,265,260***	***$7,151,881***
SEGMENT INFRASTRUCTURE COST:					
Harbor Park to Kilby	$548,552	$548,552	$548,552	$548,552	$548,552
NS- Killby to Bakers Pd	$0	$1,256,279	$0	$1,256,279	$0
NS- Bakers Pd to Collier	$0	$308,389	$0	$0	$0
NS- Bakers Pd to I295	$0	$0	$0	$261,039	$0
SG- Kilby to Collier	$1,622,021	$0	$0	$0	$0
SG- Collier to Woods Edge	$179,444	$179,444	$0	$0	$0
ESG- Woods Edge to Fulton GW	$833,161	$833,161	$0	$0	$0
Fulton to Main St Station	$135,656	$135,656	$135,656	$135,656	$135,656
NG-Kilby to Proctors Bridge Rd	$0	$0	$648,346	$0	$648,346
NG-Proctors Bridge Rd to I295	$0	$0	$954,545	$0	$0
NG- I295 through Hopewell	$0	$0	$60,970	$60,970	$0
I295 Oakland Blvd to RIC Apt	$0	$0	$827,843	$827,843	$0
RICHMOND Apt to Fulton GW	$0	$0	$145,011	$145,011	$145,011
RICH DIR- Proctor Br Rd to RIC Apt	$0	$0	$0	$0	$1,644,407
Norfolk to Richmond Subtotal . . .	***$3,318,834***	***$3,261,481***	***$3,320,923***	***$3,235,350***	***$3,121,971***

5. OPERATING PLAN AND COSTS

This chapter describes the development of an operating plan for each route, the mechanism for estimating operating cost and gives the final operating cost for each option.

5.1 OPERATING PLAN

5.1.1 INTERACTIVE ANALYSIS PROCESS

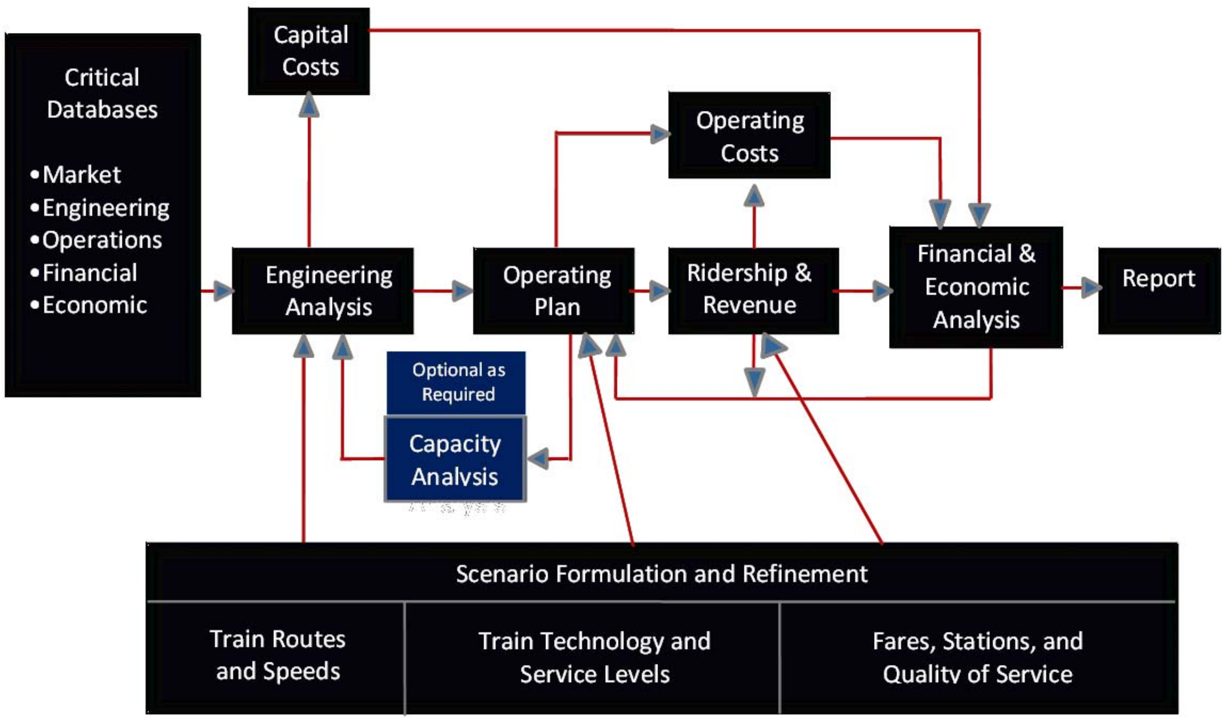
A key element for developing an operating plan is the technology selection from the range of alternative technologies available. In the case of the slower speed alternatives (79-110 mph), the most effective option is using existing railroad rights-of-way and where the volume of freight rail traffic is limited, to share tracks with freight traffic. As speeds and frequency of passenger rail service increase, the ability to share tracks with freight becomes more limited, although if wide enough the right-of-way may still be shared. For very high speeds the ability to even use existing railroad rights-of-way is typically lost. Of course, sharing track or using freight rail right-of-way may still occur (at lower speeds) in urban areas to gain access to downtown stations, but away from the urban area true high speed service is likely to require a greenfield route – since high speed rail operations need long stretches of straight track and very gentle curves to achieve high speed. Even sharing Interstate highway right-of-way may not be possible at full speed since highways frequently have curves that are too tight for the faster trains. In general, faster systems have fewer stops. A compromise may be needed to ensure all key communities are served, but this results in a trade-off between end-to-end speed and connecting communities. Each station stop takes three to seven minutes (including deceleration, stop time and acceleration back to speed) so multiple stops soon dramatically increase end-to-end running times.

Given that reasonable high speed rail routes can be developed then the key issue is the technology to be used. In the earlier Chapter 2, the representative routes are discussed. This chapter focuses on the following issues for speeds greater than 90 mph:

- Generic technology categories,
- *LOCOMOTION™* equipment database that was collected for the generic trains

As seen in Exhibit 5-1 of the interactive analysis process, train routes and speeds; technology and service levels; and fares; stations; and quality of service are all critical inputs in the operating plan process. *LOCOMOTION™* is the software used to calculate train travel times, train schedules for train alternatives, and to recommend train technology and rail system operating strategies. A key requirement for the analysis is to adjust the train size and frequency levels to appropriately match demand, providing enough capacity while still producing acceptable load factors, and respecting the financial constraints on the operation of the system. The results of the interactive analysis are then used to identify the system operating costs.

Exhibit 5-1: Interactive Analysis Process



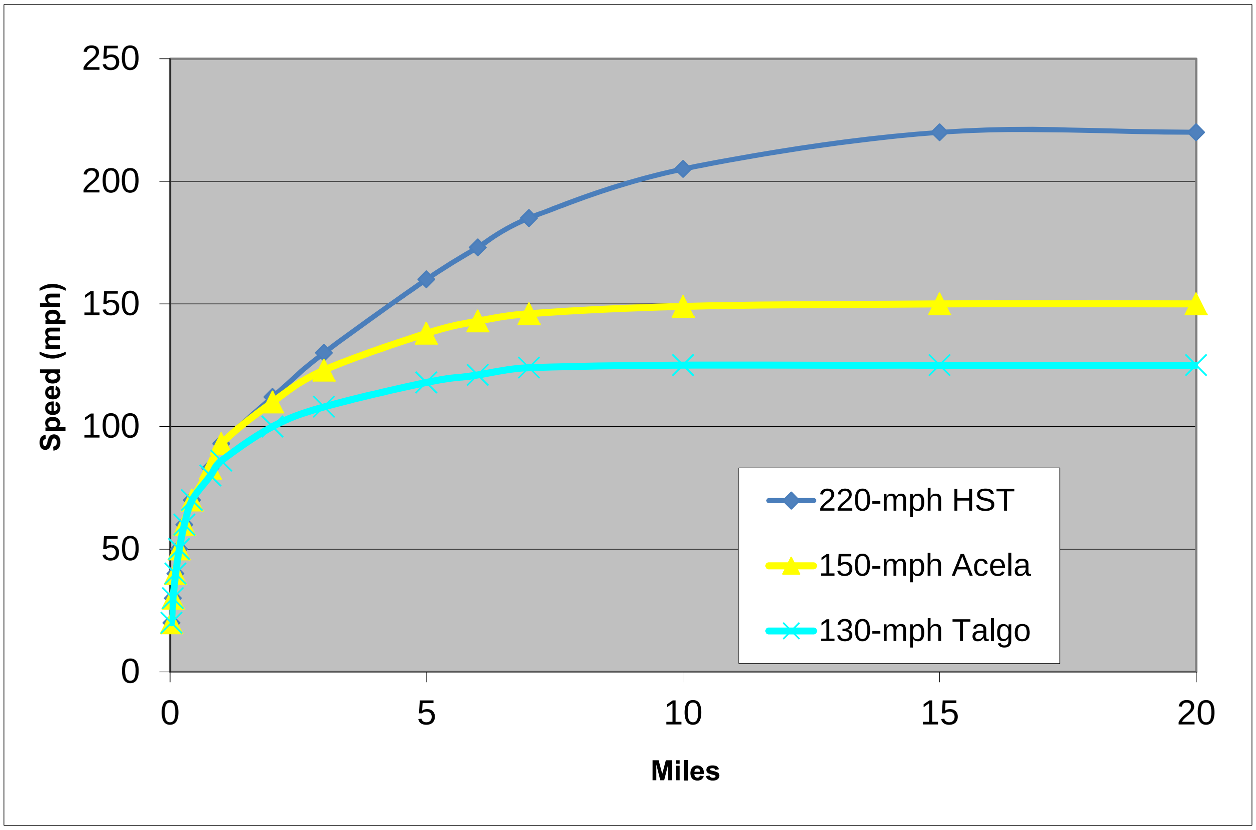
5.1.2 TRAIN TECHNOLOGY OPERATING CHARACTERISTICS

In terms of assessing rail technologies, there are two main criteria that need to be considered: type of propulsion and source of power:

- **Type of Propulsion: Trains can be either locomotive-hauled or self-propelled.** Self-propelled equipment has each individual railcar powered whereas conventional coaches rely on a separate locomotive to provide the power.
- **Source of Power: Trains can be either diesel or electrically-powered.** Diesel or electric power can be used with either the locomotive hauled or self-propelled equipment options. (Turbine power has also been considered for high speed trains, but does not offer any clear advantage over diesel at this time.)

As a rule, diesel locomotives are heavier than electric locomotives, because of the weight of the engine and also of the fuel. Electric equipment also can be more powerful since it is not limited by the on-board generating capacity of the engine. Train performance curves for representative equipment types are shown in Exhibit 5-2. The curves reflect the acceleration capabilities of three rail technologies with speed 130 mph, 150 mph and 220 mph.

Exhibit 5-2: Comparative Train Acceleration Curves[1]



Purpose-built diesel higher-speed trains, such as the Talgo T21, can offer considerably improved performance over conventional diesel trains that are based on freight-derived designs. Conventional locomotive-hauled diesel trains have a practical top speed of about 100 mph, whereas purpose-built high speed diesel trains can achieve 125 mph to 135 mph and can accelerate much faster than a conventional diesel train. For speeds above 135 mph, electrified trains are needed. Some European diesel-powered 125-mph trains offer up to 500 seats, but if U.S. safety regulations were applied, the added vehicle weight (10-15 percent) would likely reduce the practical capacity of such trains down to 400-450 seats.

Up to its current top speed of 150 mph, Exhibit 5-2 shows that the Acela accelerates as fast as a TGV due to its very high power to weight ratio. This implies that the Acela could go even faster if it were given a straight enough track to run on. Acela's weight penalty however, expresses itself in terms of a higher operating cost and lower revenue generating capacity than a comparable TGV. However, this is not a serious problem in the special environment in which the Acela operates (i.e., limited capacity and a very high level of demand.

The following train technologies are described in Exhibit 5-2:

[1] Source: TEMS LOCOMOTION™ Equipment Database showing typical technology performance parameters, as developed and validated over the course of previous rail studies.

- **130-mph Talgo T21:** the technical characteristics are hauled (non-powered) axles equipped with independent wheels to prevent hunting movement and to reduce wheel-track interaction; Permanently steered axles by means of robust guiding bars that keep the wheels parallel to the track at all times; high-comfort tilting suspension, with natural car body tilting toward the interior of curves; Articulated couplings between adjacent cars with anti-overturning and anti-vertical hunting mechanisms; and maximum commercial speed of 140 mph[2].
- **160-mph Acela:** Acela express with standard gauge of 1,435 mm (4 ft 8 1/2 in) and maximum operating speed 160 mph (256 km/h). However since Amtrak decided not to order any more Acela equipment and instead will purchase new trains in a joint procurement with California, this category of trains will not be used here. Instead, the 220-mph category of electric train will be used.
- **220-mph AGV:** The trains that are certified to run 220-mph speed include Siemens Valero, Bombardier Zefiro, and Alstom AGV. Chinese HST are even faster with speeds up to 240 mph. The trains are constructed from units comprising three cars, each with one transformer and two traction electronics packages located underneath the cars, and from single-car trailers. A 7-car unit has two 3-car modules separated by one trailer and seating for around 245, an 11-car unit has three 3-car modules with two trailer cars with seating for around 446. The maximum commercial speed is 360 km/h (220 mph)[3].

Exhibit 5-3 below summarizes the train characteristics.

Exhibit 5-3: Train Characteristics Table

Conventional	Higher Speed	High Speed	
▪ 79 mph	▪ 110 mph	▪ 160 mph	▪ 220 mph
▪ Diesel	▪ Diesel	▪ Electric	▪ Electric
▪ Non-Tilting	▪ Tilting	▪ Tilting	▪ Non-Tilting
▪ Amtrak Regional NEC	▪ Acela Express	▪ Talgo T21	▪ AGV

The key tool used for development of pro-forma train schedules is the *LOCOMOTION™* Train Performance Calculator. *LOCOMOTION™* works in conjunction with a *TRACKMAN™* infrastructure database to estimate train speed given various types of track geometry, curves, gradients and station-stopping patterns. The *TRACKMAN™* database captures all the details of grades, curves, superelevation, speed limits and station locations along the line. *LOCOMOTION™* then calculates the train running time for each route segment and sums the running times to produce a timetable. *LOCOMOTION™* assumes a train will accelerate to a maximum possible speed and will only slow down for stations or speed restrictions due to curves, crossings, tunnels or civil speed restrictions such as grade crossings and sensitive urban areas.

The inputs for *LOCOMOTION™* consist of milepost-by-milepost data (as fine as 1/10th of a mile) defining gradient and curve conditions along the track. For this study, these data were derived from a condensed

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[2] http://www.talgo.com/pdf/TXXIen.pdf
[3] http://en.wikipedia.org/wiki/Automotrice_%C3%A0_grande_vitesse

profile for existing rail alignments and the use of field inspection data along with satellite photography and GIS mapping to develop the geometry for new routes.

In addition, *LOCOMOTION™* includes a train technology database that defines the acceleration, top speed, and braking characteristics of each train technology type. The database includes many train types with varying performance characteristics, ranging from heavy freight trains all the way up through very high speed rail options.

Train timetables are determined from running times and are used to calculate rolling stock requirements. Train frequencies and the number of cars required per train are determined via an interactive process using the demand forecast *COMPASS™* model.

The results taken from *LOCOMOTION™* will be faster than the actual times, since they are based on optimized performance of trains under ideal conditions. While it is assumed that passenger trains will have dispatching priority over freight, practical schedules still need to allow 5-10 percent slack time in case of any kind of operating problem, including the possibility of freight or commuter train interference, depending on the degree of track sharing with freight. Slack time is included in the train timetables and in the input provided to the *COMPASS™* model.

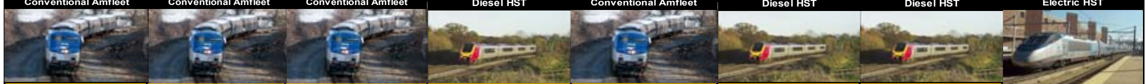
5.1.3 TRAIN TIMETABLES

As background, Exhibit 5-4 shows the train schedule objectives that were developed for Hampton Roads service, as Exhibit B-6 on page B-13 of the earlier 2010 study ***Progress Report B***. The detailed update performed here has validated this earlier work since the newest schedules are still consistent with these earlier results. However, this study has only updated Steps 3 and 4 for the Richmond to Norfolk segment – the two cells highlighted in yellow in Exhibit 5-4 below. Please note that the diesel train top speeds in Steps 3 and 4 have subsequently been raised from 110 mph to 130 mph in the current study; electric train speeds in Step 4 raised from 150 mph to 220 mph. All other train schedule assumptions have been carried forward from the previous study.

Two speed options: 130 mph and 220 mph, have been developed for each of the five route options 1A, 1B, 2A, 2B and 3. A key output of the Operations Planning process has been the operational train schedules, based on an assumed train frequency, stopping patterns and running times. These key results are presented in Exhibit 5-5 through 5-14. These exhibits summarize the key train scheduling assumptions that were using as a direct input to the ridership forecasting process.

For implementation of both conventional and high speed rail to be efficient, it is essential to improve train schedules and frequencies in a balanced way. Typically as speeds increase, the market expands and both train size and frequency also need to be increased. The proposed implementation steps do add train frequency as speeds increase in a manner that is reflective of the growth in market demand, and also equitably scaled to the relative size of the north and south side demographic bases.

Exhibit 5-4: Schedule Objectives for Hampton Roads Service from Phase 1 Progress Report B

	Step 1		Step 2		Step 3		Step 4	
	Conventional Amfleet	Conventional Amfleet	Conventional Amfleet	Diesel HST	Conventional Amfleet	Diesel HST	Diesel HST	Electric HST
	79-mph	79-mph	79-mph	90-mph	90-mph	110-mph	110-mph	150-mph
Washington to Richmond	2:45[1]	2:15[2]	2:20[3]	2:05	2:20	1:30	1:30	1:05
Richmond to Norfolk		1:48		1:48[5]		1:10		0:55
Richmond to Newport News	1:25		1:25		1:13		0:52	
Total	4:10	4:03	3:45	3:53	3:33	2:40	2:22	2:00[4]

[1] 2:45 current Amtrak time to Main Street, 1:35 to Newport News
[2] 2:15 current Amtrak time to Staples Mill Road Station only, does not go to Main Street
[3] 2:20 to Main Street, train operates at 90 mph north of Richmond
[4] 2:00 proposed schedule objective for HSR electric service
[5] 1:38 using 79 mph south of Petersburg

In the 2010 study, schedule times were based on the train types shown and assume expected levels of infrastructure upgrade associated with each Step. Train times in Step 1 are consistent with current Amtrak schedules and with the Richmond/Hampton Roads Passenger Rail Project DEIS projection for 79-mph Richmond to Norfolk service. Times in Step 2 are consistent with the DEIS.

Washington to Richmond times for Norfolk service in Step 2 does reflect an improvement from 2:20 down to 2:05 assuming the use of high speed diesel trains[4] rather than conventional Amtrak equipment. This is consistent with the capabilities of locomotive hauled passive tilt trains using a very conservative 6" Cant deficiency assumption. The time is also sufficient to allow a reasonable amount of slack for co-mingled operation on shared infrastructure with freight trains.

DRPT has defined a schedule objective of 1:30 for Washington-Richmond service on existing CSXT tracks[5]. Preliminary performance modeling suggests that this might be possible, but it would require the use of very aggressive 9" of Cant Deficiency and allows for very little slack time in the schedule. A ninety-minute schedule may be theoretically possible for a DMU with active tilt, but would certainly require a dedicated track not only to minimize the possibility of freight train delays, but also to support the kind of precision track maintenance and curve geometry that such high deficiency operations will require. A

[4] This does not contradict the DEIS, since it must be recognized that Amtrak's current Amfleet coaches are already 35 years old and beyond their mid-life refurbishment. See: http://en.wikipedia.org/wiki/Amfleet. This equipment is already considered commercially obsolete and have been rejected by California, Washington and Oregon who purchased new equipment for their state-supported trains. Modern High-Speed Diesel trains are well able to satisfy the performance parameters of the DEIS offering similar or better environmental performance. Given DRPT's expected project development timeframes, the Amfleet equipment will approaching 50 years of age by the time the project is implemented. Although Amfleet has been used to characterize the performance capabilities of existing trains, the DEIS certainly does not appear to exclude the possibility of actually purchasing new trains for the service by the time it is implemented.
[5] See: http://www.drpt.virginia.gov/studies/files/WashingtonD.C.StudyDetails.pdf

1:30 schedule over existing tracks appears to be barely achievable and may not ultimately be deliverable in practice.

In contrast, the 1:30 schedule objective shown for 110-mph high speed diesel trains is comfortably achievable by assuming a Greenfield segment from Lorton to Doswell, using very conservative train performance assumptions. If grade crossings were fully grade separated, high speed diesel trains could attain 130 mph instead of just 110 mph, and would achieve timings faster than 1:30. The 1:05 electric schedule assumes a Greenfield segment that allows the train to reach its design potential. Coupled with a short Greenfield segment south towards Petersburg and the excellent geometry of the proposed Greenfield alignments leads to a potential 2:00 schedule for Norfolk to Washington D.C. It should be pointed out since this would be all-electric service that it would also eliminate the 20-30 minutes delay typically now incurred for a locomotive change in Washington, so the time savings to NEC points north of Washington would be even greater.

The rail service assumptions developed for Steps 3 and 4 by this study are as follows:

- Washington D.C. to Richmond, 109 miles (Current Time 2:00, 79 mph):
    - Assumes a new conceptual greenfield due to capacity and geometric limitation of existing Right-of-Way
    - 130-mph diesel could easily achieve 1:30 on a greenfield – an aggressive tilt train could achieve this time on the existing CSX alignment
    - 220-mph electric could achieve 0:55 based on a high quality greenfield from Lorton to Richmond
- Richmond to Norfolk, 97-105 miles (Current Time 2:00, 79 mph):
    - 13 daily round trips at 130 mph; 1:00 to 1:10 schedule times
    - 22 daily round trips at 220 mph; 0:45 to 0:55 schedule times
- Richmond to Newport News, 75 miles (Current Time 1:25, 79 mph):
    - 3 daily round trips at 79 mph; 1:25 schedule time

Overall, the impact of the proposed improvements would be to cut the Norfolk-Washington D.C. Time in half: from over 4 hours today at 79 mph, to 2 hours at 220 mph once the high speed rail concept has been fully implemented. From Richmond to Washington D.C. the assumed running times are as shown in Exhibit 5-5:

Exhibit 5-5: Proposed Richmond to Washington D.C. Running Times

130-mph Diesel

Station	Super Express	Express	Local
Richmond Main St	0:00	0:00	0:00
Ashland			0:12
Fredericksburg		0:40	0:45
Quantico			1:08
Alexandria	1:20	1:25	1:35
Washington Union	1:30	1:35	1:45

220-mph Electric

Station	Super Express	Express	Local
Richmond Main St	0:00	0:00	0:00
Ashland			0:10
Fredericksburg		0:25	0:30
Quantico			0:45
Alexandria	0:43	0:48	0:58
Washington Union	0:53	0:58	1:08

These Richmond to Washington D.C times are consistent with the Step 3 and 4 times of 1:30 and 1:05 for Diesel and Electric options, respectively, from 2010 Progress Report B as shown in Exhibit 5-4. The 1:30 Diesel time can be achieved on the CSX alignment using aggressive tilt technology. The 220-mph electric times are based on conceptual Greenfield route options between Richmond and Washington DC.

OPTION 1 VIA PETERSBURG

Two conceptual options 1A and 1B have been defined in Chapter 2 via Petersburg. Option 1A has been defined as a "Southern Greenfield" whereas Option 1B would utilize the existing Norfolk Southern rail alignment. However, since both alignments are essentially straight and about the same length, the running times for the two route variants are extremely close – within a minute of one another – so the train schedule for either variant is the same. Schedules for the Petersburg Option 1 are shown in Exhibit 5-6, and the 130-mph and 220-mph *LOCOMOTION™* speed profiles for the two train simulations are shown in Exhibit 5-7 and 5-8.

Exhibit 5-6: Proposed Norfolk to Washington D.C. -- Option 1 Times via Petersburg

130-mph Diesel

Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00
Bowers Hill	0:12	0:12	0:12
Suffolk			0:17
Petersburg		0:53	0:58
Richmond Main St	1:04	1:09	1:14
Washington Union	2:36	2:46	3:01

220-mph Electric

Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00
Bowers Hill	0:10	0:10	0:10
Suffolk			0:15
Petersburg		0:40	0:45
Richmond Main St	0:50	0:55	1:00
Washington Union	1:45	1:55	2:10

** Allowing 2 minutes for Richmond Station Stop*

Exhibit 5-7: Norfolk to Washington D.C. -- Option 1 via Petersburg – 2:08:25 at 130 mph

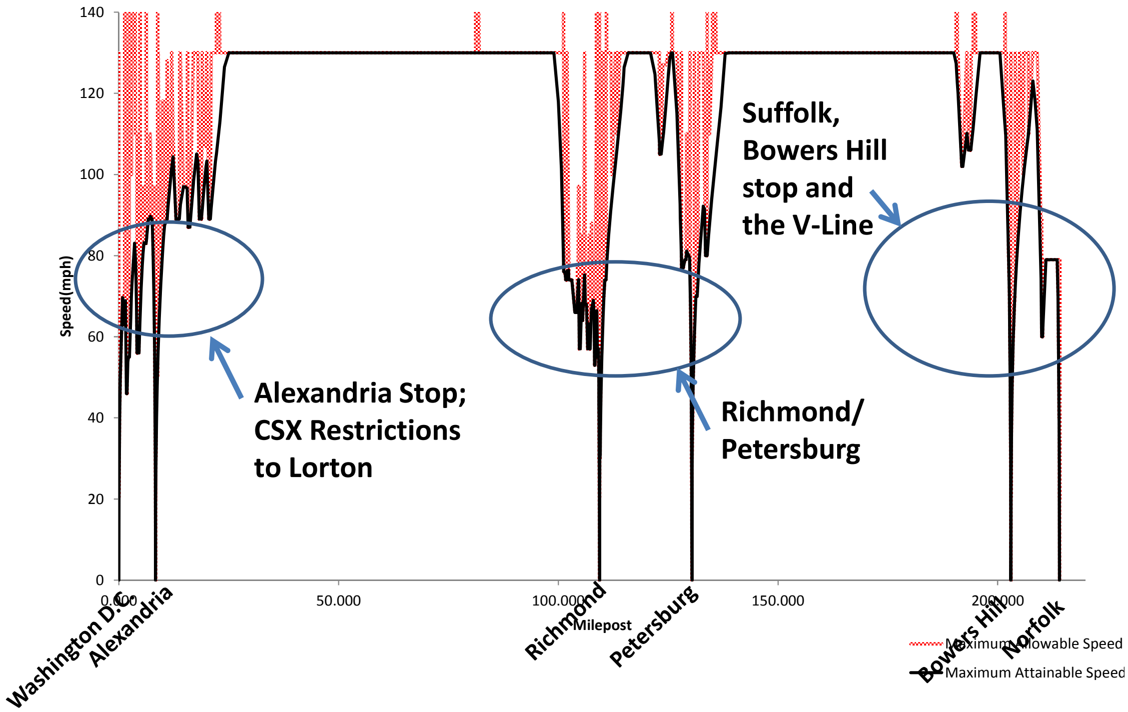
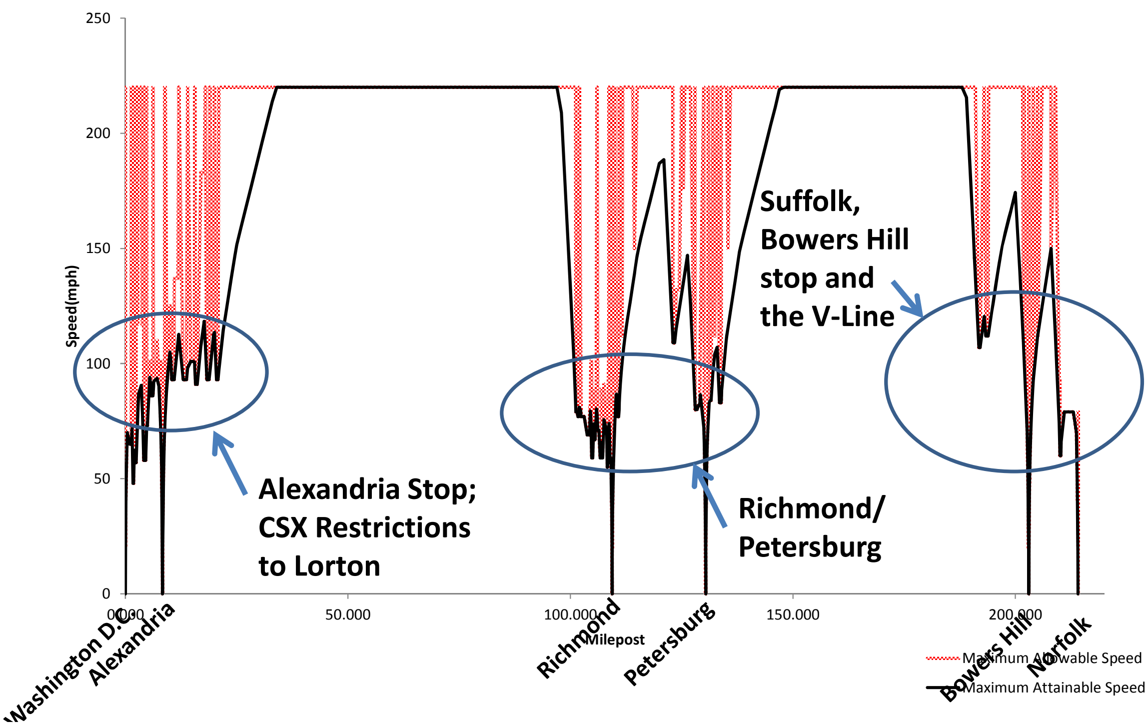


Exhibit 5-8: Norfolk to Washington D.C. -- Option 1 via Petersburg – 1:40:36 at 220 mph



OPTION 2 VIA HOPEWELL

Two conceptual options 2A and 2B have been defined in Chapter 2 via Hopewell. Option 2A has been defined as a "Northern Greenfield" whereas Option 2B would utilize the existing Norfolk Southern rail alignment. However, since both alignments are essentially straight and about the same length, the running times for the two route variants are extremely close – within a minute of one another – so the train schedule for either variant is the same. Schedules for the Hopewell Option 2 are shown in Exhibit 5-9, and the 130-mph and 220-mph *LOCOMOTION™* speed profiles for the two train simulations are shown in Exhibit 5-10 and 5-11.

Exhibit 5-9: Proposed Norfolk to Washington D.C. -- Option 2 Times via Hopewell

130-mph Diesel

Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00
Bowers Hill	0:12	0:12	0:12
Suffolk			0:17
Hopewell		0:50	0:53
Richmond Main St	1:04	1:09	1:14
Washington Union	2:36	2:46	3:01

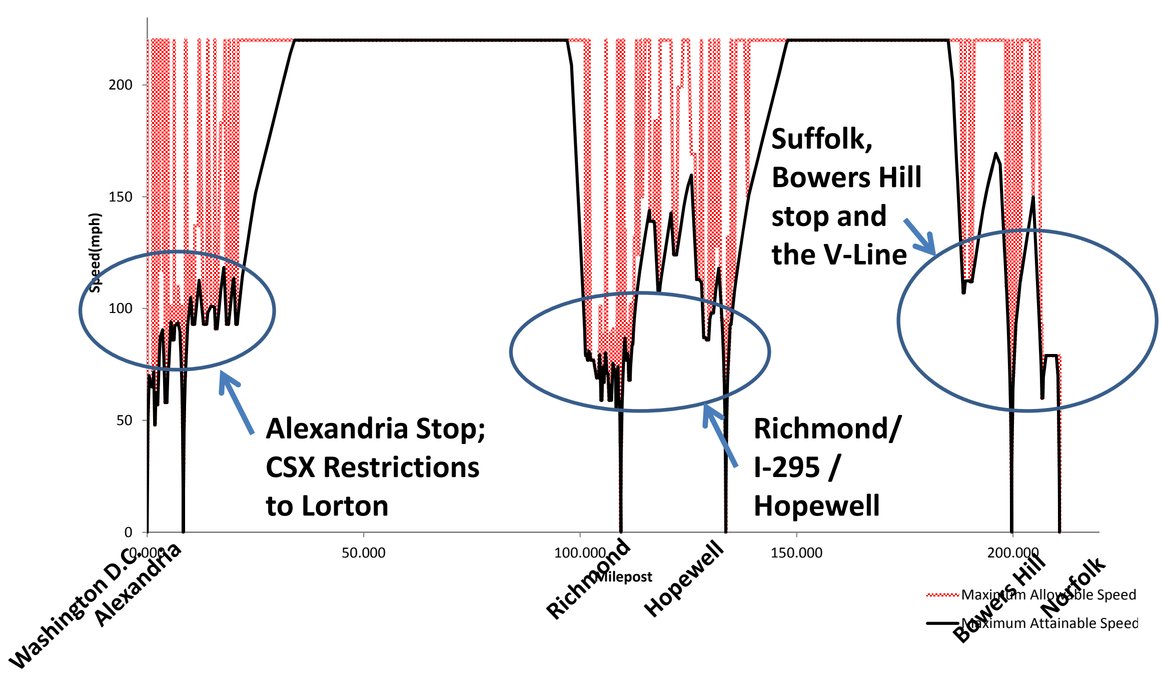
220-mph Electric

Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00
Bowers Hill	0:10	0:10	0:10
Suffolk			0:15
Hopewell		0:37	0:42
Richmond Main St	0:50	0:55	1:00
Washington Union	1:45	1:55	2:10

** Allowing 2 minutes for Richmond Station Stop*

Exhibit 5-10: Norfolk to Washington D.C. -- Option 2 via Hopewell – 2:07:19 at 130 mph

Exhibit 5-11: Norfolk to Washington D.C. -- Option 2 via Hopewell – 1:40:30 at 220 mph



OPTION 3 RICHMOND DIRECT

Schedules for the Richmond Direct Option 3 are shown in Exhibit 5-12, and the 130-mph and 220-mph *LOCOMOTION™* speed profiles for the two train simulations are shown in Exhibit 5-13 and 5-14. The Richmond Direct option is about five minutes faster than going via Petersburg or Hopewell for an express train; as compared to a stopping train, Richmond Direct is about 10 minutes faster

Exhibit 5-12: Proposed Norfolk to Washington D.C. -- Option 3 Times Richmond Direct

130-mph Diesel

Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00
Bowers Hill	0:12	0:12	0:12
Suffolk			0:17
Richmond Main St	0:59	0:59	1:04
Washington Union	*2:31*	*2:36*	*2:51*

220-mph Electric

Station	Super Express	Express	Local
Norfolk	0:00	0:00	0:00
Bowers Hill	0:10	0:10	0:10
Suffolk			0:15
Richmond Main St	0:43	0:43	0:48
Washington Union	*1:38*	*1:43*	*1:58*

** Allowing 2 minutes for Richmond Station Stop*

Exhibit 5-13: Norfolk to Washington D.C. -- Option 3 Direct – 2:07:19 at 130 mph

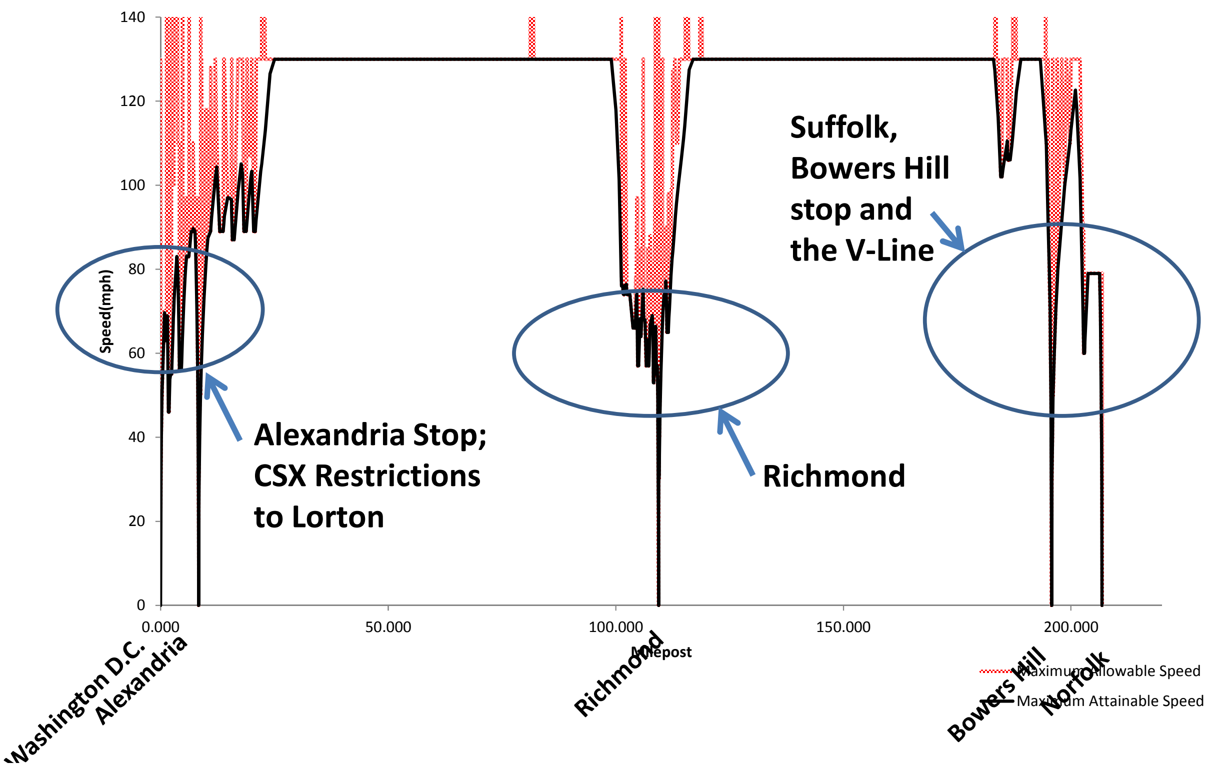
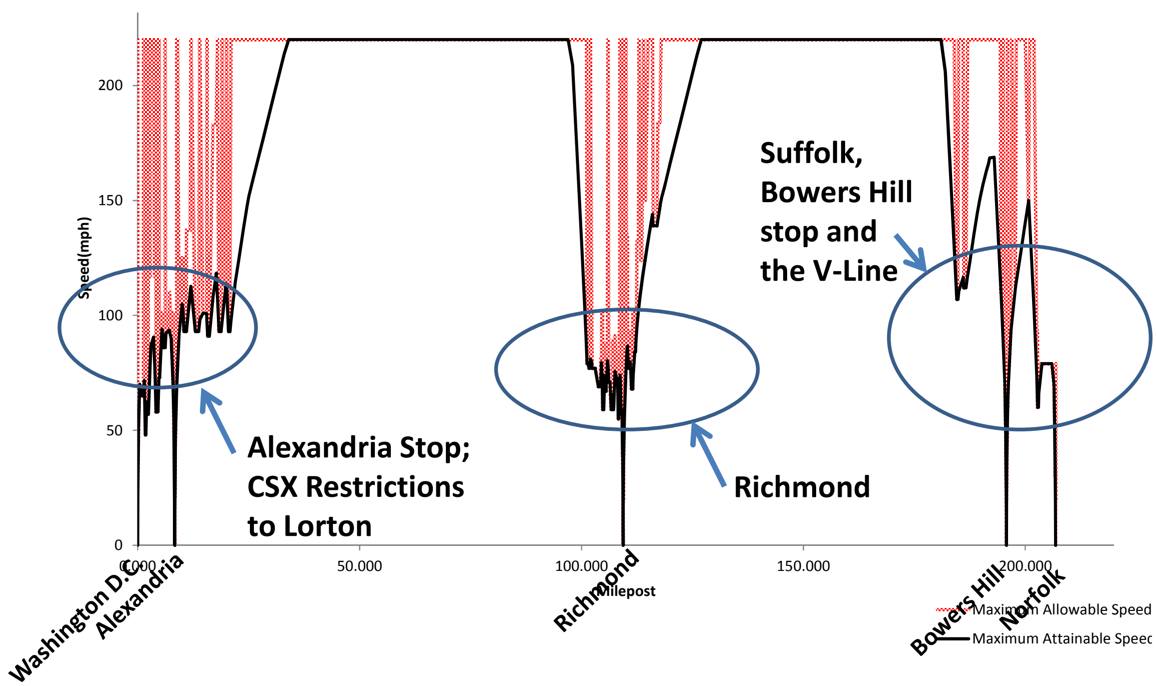


Exhibit 5-14: Norfolk to Washington D.C. -- Option 3 Direct – 1:40:30 at 220 mph



SCHEDULE SUMMARY

The result of this operational analysis along with recommended train frequencies for the two speed options are summarized in Exhibit 5-15. As can be seen, the overall running times via Petersburg and Hopewell are essentially the same; Richmond Direct is five to ten minutes faster.

Exhibit 5-15: Norfolk to Washington D.C. – Schedule Results Summary

Stations	Super Express	Express	Local
Norfolk	√	√	√
Bowers Hill	√	√	√
Suffolk	–	–	√
Petersburg/Hopewell*	–	√	√
Richmond Main St	√	√	√
Ashland	–	–	√
Fredericksburg	–	√	√
Quantico	–	–	√
Alexandria	√	√	√
Washington Union	√	√	√
130-mph Total Trains	4 trains	5 trains	4 trains
130-mph Time via Petersburg/Hopewell	2:36	2:46	3:01
130-mph Time Richmond Direct	2:31	2:36	2:51
220-mph Total Trains	5 trains	10 trains	3 trains
220-mph Time via Petersburg/Hopewell	1:45	1:55	2:10
220-mph Time Richmond Direct	1:38	1:43	1:58

* Stations Bypassed by Richmond Direct

The performance of the 130-mph and 220-mph options both depend on the characteristics of the option that is ultimately developed between Richmond and Washington D.C.

- The 130-mph diesel would likely operate between 1:05 and 1:30
- The 220-mph electric would likely operate between 0:55 and 1:30

In Exhibit 5-15, "Super Express" trains stop only at the main urban stations. "Express" trains add stops in Petersburg and Fredericksburg. Local trains make all stops. The schedule times of all four route options are very close. The results of this more detailed assessment support the findings of the earlier 2010 study, Progress Report B. Petersburg and Hopewell route options have the same times. These route options are 5 minutes slower than Richmond Direct, plus an additional 5 minutes if they add a stop.

Although every minute of time savings attracts more riders, the time difference between options is not enough to drive significant differences in ridership between the options. Going via Petersburg or Hopewell would add ridership from this intermediate market but the added time would reduce ridership from Norfolk and Bowers Hill. As a result, the route selection will likely be made based on cost, environmental factors and synergies with other routes, including the relative degree of benefit to the Peninsula and SESHR services and the degree to which the Peninsula and SEHSR ridership is responsive to such benefits.

5.2 OPERATING AND MAINTENANCE COSTS

5.2.1 OPERATING AND MAINTENANCE COSTS METHODOLOGY

This section describes the build-up of the unit operating costs that have been used in conjunction with the operating plans, to project the total operating cost of each corridor option. A costing framework originally developed for the Midwest Regional Rail System (MWRRS) was adapted for use in this study. Following the MWRRS methodology[6], nine specific cost areas have been identified. As shown in Exhibit 5-16, variable train-mile driven costs include equipment maintenance, energy and fuel, and train and onboard (OBS) service crews. Passenger miles drive insurance liability, while ridership influences marketing, and sales. Fixed costs include administrative costs, station costs, and track and right-of-way maintenance costs. Signals, communications and power supply are included in the track and right-of-way costs.

This framework enables the direct development of costs based on directly-controllable and route-specific factors, and allows sensitivity analyses to be performed on the impact of specific cost drivers. It also enables direct and explicit treatment of overhead cost allocations, to ensure that costs which do not belong to a corridor are not inappropriately allocated to the corridor, as would be inherent in a simple average cost-per-train mile approach. It also allows benchmarking and direct comparability of HRTPO costs with those developed by other high speed rail studies across the nation, including those with which the proposed corridor route would connect.

Exhibit 5-16: Operating Cost Categories and Primary Cost Drivers

Drivers		Cost Categories
Train Miles	→	Equipment Maintenance Energy and Fuel Train and Engine Crews Onboard Service Crews
Passenger Miles	→	Insurance Liability
Ridership and Revenue	→	Sales and Marketing
Fixed Cost	→	Service Administration Track and ROW Maintenance Station Costs

For development of costs, since there are a number of different corridor and technology options, it is essential to maintain consistency of the costing basis across all options. For developing a fair comparison:

- Unit Costs that depend on the propulsion/speed should reflect legitimate differences between technologies and routes; and

6 Follow the links under "Midwest Regional Rail Initiative (MWRRI)" at http://www.dot.state.mn.us/planning/railplan/studies.html

- Unit Costs that do not depend on propulsion/speed should remain the same across all technologies and routes.

Operating costs can be categorized as variable or fixed. As described below, fixed costs include both Route and System overhead costs. Route costs can be clearly identified to specific train services but do not change much if fewer or additional trains were operated.

- Variable costs change with the volume of activity and are directly dependent on ridership, passenger miles or train miles. For each variable cost, a principal cost driver is identified and used to determine the total cost of that operating variable. An increase or decrease in any of these will directly drive operating costs higher or lower.
- Fixed costs are generally predetermined, but may be influenced by external factors, such as the volume of freight tonnage, or may include a relatively small component of activity-driven costs. As a rule, costs identified as fixed should remain stable across a broad range of service intensities. Within fixed costs are two sub-categories:
  - Route costs such as track maintenance, train control and station expense that, although fixed, can still be clearly identified at the route level.
  - Overhead or System costs such as headquarters management, call center, accounting, legal, and other corporate fixed costs that are shared across routes or even nationally. A portion of overhead cost (such as direct line supervision) may be directly identifiable but most of the cost is fixed. Accordingly, assignment of such costs becomes an allocation issue that raises equity concerns. These kinds of fixed costs are handled separately.

Operating costs have been developed based on the following premises:

- Based on results of recent studies, a variety of sources including suppliers, current operators' histories, testing programs and prior internal analysis from other passenger corridors were used to develop the cost data. However, as the rail service is implemented, actual costs will be subject to negotiation between the passenger rail authority and the contract rail operator(s).
- Freight railroads will maintain track and right-of-way that they own, but ultimately, the actual cost of track maintenance will be resolved through negotiations with the railroads. For this study, a track maintenance cost model will be used that reflects actual freight and passenger railroad cost data.
- Maintenance of train equipment will be contracted out to the equipment supplier.
- Train operating practices follow existing work rules for crew staffing and hours of service. Average operating expenses per train-mile for train operations, crews, management and supervision were estimated through a bottoms-up staffing approach based on typical passenger rail organizational needs.

The MWRRS costing framework was developed in conjunction with nine states that comprised the MWRRS steering committee and with Amtrak. In addition, freight railroads, equipment manufacturers and others provided input to the development of the costs. However, the costing framework has been validated with recent operating experience based on publicly available data from other sources, particularly the Midwest 403B Service trains Northern New England Passenger Rail Authority's (NNEPRA) Downeaster costs and data on Illinois operations that was provided by Amtrak. It has been brought to a $2012 costing basis and additional cost categories not included in the original MWRRS study, such as for electrification, have been added into the framework.

The original concept for the MWRRS was for development of a new service based on operating methods directly modeled after state-of-the-art European rail operating practice. Along with anticipated economies of scale, modern train technology could reduce operating costs when compared to existing Amtrak practice. In the original 2000 MWRRS Plan, European equipment costs were measured at 40 percent of Amtrak's costs. However, in the final MWRRS plan that was released in 2004, train-operating costs were significantly increased to a level that is more consistent with Amtrak's current cost structure. However, adopting an Amtrak cost structure for financial planning does not suggest that Amtrak would actually be selected for the corridor operation. Rather, this selection increases the flexibility for choosing an operator without excluding Amtrak, because multiple operators and vendors will be able to meet the broader performance parameters provided by this conservative approach.

5.3 Variable Costs

These costs include those that directly depend on the number of train-miles operated or passenger-miles carried. They include train equipment maintenance, train crew cost, fuel and energy, onboard service, and insurance costs.

Train Equipment Maintenance

Equipment maintenance costs include all costs for spare parts, labor and materials needed to keep equipment safe and reliable. The costs include periodical overhauls in addition to running maintenance. It also assumes that facilities for servicing and maintaining equipment are designed specifically to accommodate the selected train technology. This arrangement supports more efficient and cost-effective maintenance practices. Acquiring a large fleet of trains with identical features and components, allows for substantial savings in parts inventory and other economies of scale. In particular, commonality of rolling stock and other equipment will standardize maintenance training, enhance efficiencies and foster broad expertise in train and system repair.

The MWRRS study developed a cost of $9.87 per train mile for a 300-seat train in $2002. This cost was increased to $12.70 per train mile in $2012. Available evidence suggests that the maintenance cost for a conventional electric train should be about 9 percent cheaper per equivalent seat-mile than that of a diesel train leading to a unit cost of $11.27 per mile for a 150-mph locomotive hauled electric train. However, high speed electric trains have a more than proportional increase in power: a typical 130-mph diesel train has about 18 kw/Seat; the 220-mph Alstom AGV has 24 kw/ Seat[7] while the 160-mph Acela is rated at 30kw/Seat. However, the Acela needs this much power due to the high weight of the steel coaches and low seating capacity of the train. As a result, the maintenance cost per mile for the 220-mph electric train benchmarked only slightly higher than that for the 130-mph diesel of equivalent capacity; a cost of $14.08 per mile was assumed for the 220-mph electric train. The 79-mph conventional Amtrak train benchmarked at a higher cost of $15.43 due primarily to a lack of economies of scale associated with typical lighter density Amtrak corridors.

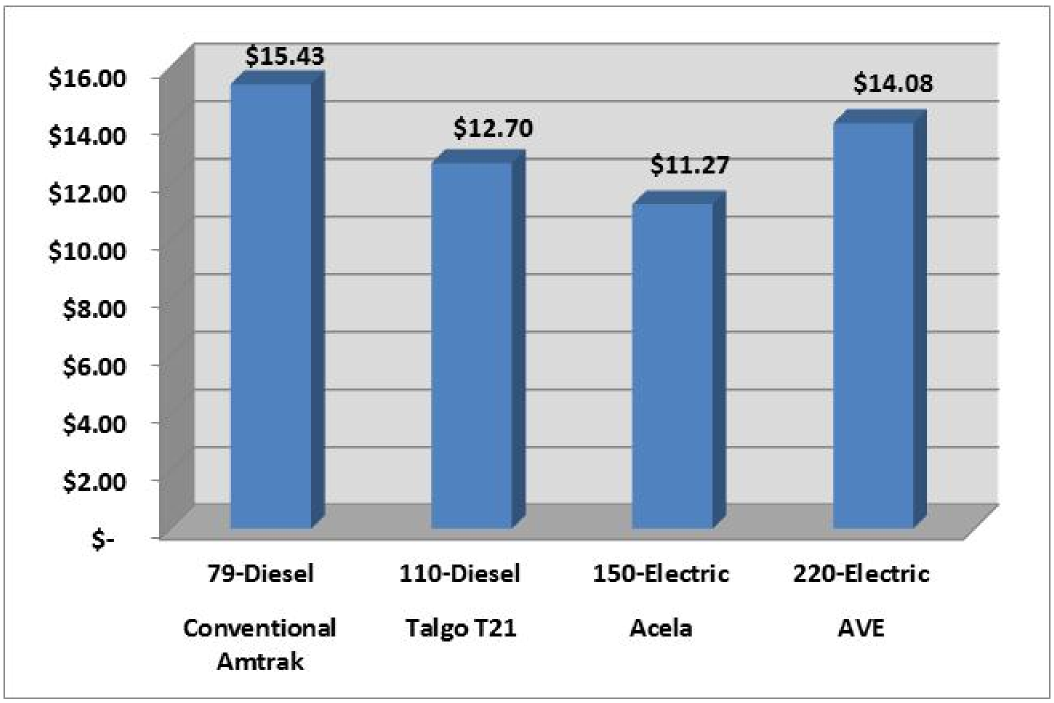
[7] See: http://en.wikipedia.org/wiki/Automotrice_%C3%A0_grande_vitesse

For this study:

- A $15.43 cost will be assumed for low frequency 79-mph options. These are characteristic of the current Amtrak service to Norfolk and Newport News, but were not part of any options assessed in this study.
- The intermediate $12.70 cost will be assumed for the 130-mph diesel options.
- A lower $11.27 level of cost would be assumed for electric trains running at 150 mph maximum. As a result, the extra power and traction motors are not needed, so the lower maintenance cost could be assumed. However, these trains were not used in any options assessed in this study.
- The highest $14.08 cost will be used for the 220-mph electric train operating on a Greenfield.

These costs are summarized in Exhibit 5-17.

Exhibit 5-17: Equipment Maintenance Cost per Mile ($2012)



TRAIN AND ENGINE CREW COSTS

The train operating crew incurs crew costs. Following Amtrak staffing policies, the operating crew would consist of an engineer, a conductor and an assistant conductor and is subject to federal Hours of Service regulations. Costs for the crew include salary, fringe benefits, training, overtime and additional pay for split shifts and high mileage runs. An overtime allowance is included as well as scheduled time-off, unscheduled absences and time required for operating, safety and passenger handling training. Fringe benefits include health and welfare, FICA and pensions. The cost of employee injury claims under FELA is also treated as a fringe benefit for this analysis. The overall fringe benefit rate was calculated as 55 percent. In addition, an allowance was built in for spare/reserve crews on the extra board. Costing of train crews was based on Amtrak's 1999 labor agreement, adjusted for inflation to 2012.

Crew costs depend upon the level of train crew utilization, which is largely influenced by the structure of crew bases and any prior agreements on staffing locations. Train frequency strongly influences the amount of held-away-from-home-terminal time, which occurs if train crews have to stay overnight in a hotel away from their home base. Since a broad range of service frequencies and speeds have been evaluated here, a parametric approach was needed to develop a system average per train mile rate for crew costs. Such an average rate necessarily involves some approximation, but to avoid having to reconfigure a detailed crew-staffing plan whenever the train schedules change, an average rate is appropriate for the current feasibility level study. A more specific and detailed level of assessment would be appropriate for a Tier 2 EIS. For this study:

- An intermediate value of $4.92 per train mile was assumed for the high frequency 130-mph diesel options. This is a moderate level of crew cost that includes the need for some away-from-home layover.
- 79-mph service would cost $6.59 per train-mile because of poor crew utilization in these very low-frequency scenarios. With trains operating less frequently there is less opportunity to return crews to their home base on the same day, leading to more split shifts and overnight layovers. However, these trains were not part of any options assessed in this study.
- The 220-mph Greenfield scenario used $4.60 per train mile, reflecting operating efficiencies related both to higher speeds and more frequent trains in this scenario only, both of which tend to reduce the need for away-from-home layovers.

FUEL AND ENERGY

An average consumption rate of 2.42 gallons/mile was estimated for a 110-mph 300-seat train, based upon nominal usage rates of all three technologies considered in Phase 3 of the MWRRS Study. Assuming $3.60 a gallon in late 2012 for diesel fuel according to Energy Information Administration (EIA)[8], this translates into a cost of $8.71 per train mile, more than tripling (375%) the cost of diesel fuel that was prevalent at the time of the earlier MWRRS study. During the same time period however, electricity costs did not rise nearly so much. For example, Virginia electric power costs rose only by 46%.

However, electric traction has an advantage over diesel since it can be powered from any energy source, not just petroleum-based fuel. Even taking typical peaking demands into account, electricity is typically cheaper than diesel fuel. As a result, the rapid rise of petroleum costs over the past ten years has tipped the cost advantage towards electrification.

However, there is a large regional variation in electricity and peak usage rate structures. For example, electric power has in the past been more expensive than diesel traction in the northeastern United States. But the southeast enjoys lower average electricity rates than do northeastern states:[9] in 2010, for example, Virginia electric power for transportation averaged only 7.7¢ per kWH as compared to 11.9¢ per kWH in New Jersey. The actual price paid is also driven by the peak hour surcharges that can more than double a railroad's electric energy bill.

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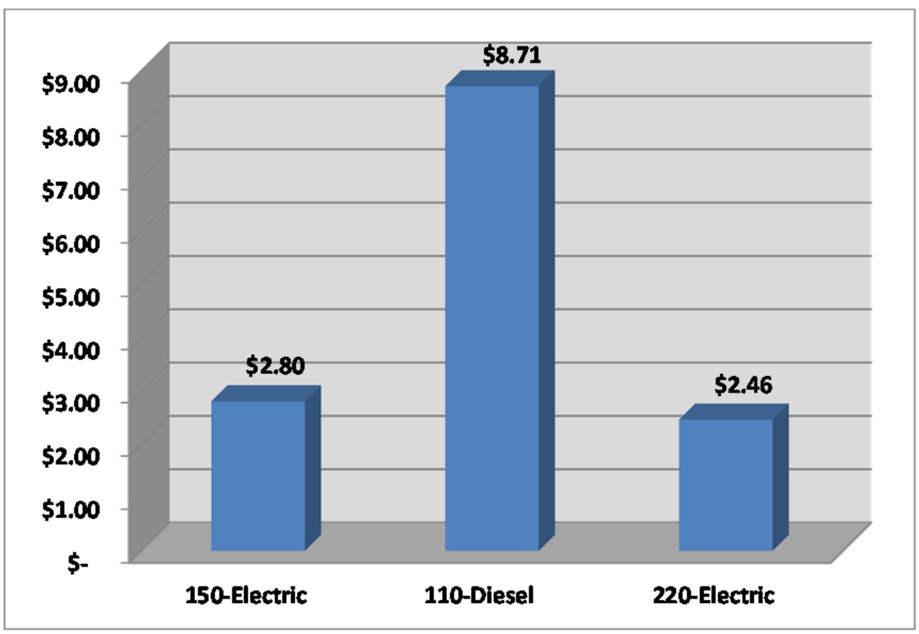
[8] EIA diesel retail price in 2012 excluding the taxes http://www.eia.gov/petroleum/gasdiesel/
[9] See http://www.eia.gov/electricity/state/

However, by employing power smoothing techniques such as onboard and wayside energy storage, as well as by regenerating electric power while braking, the rail operator might reduce the level of fluctuation in its energy usage so it pays closer to the base average kilowatt-hour power generation charge. Given the high cost associated with electric power purchases, the issue of demand smoothing is an issue that should receive careful attention in the train equipment procurement, as well as in the design of the electric traction system. The structure of peak usage charges should be negotiated with the electric utilities to ensure that the operator can purchase the power it needs at the lowest possible cost.

As shown in Exhibit 5-18, and including the Peak Usage charge, the comparable electric cost for an Acela 150-mph locomotive-hauled electric train is just $2.80 per train mile as compared to $8.71 for the diesel 130-mph train. But because it weighs less than the Acela, the 220-mph electric multiple unit is even more efficient at $2.46 per train mile. Also, the 220-mph electric train on a greenfield needs to accelerate and brake less than a train operating over an existing rail or highway alignments would. This results in a more uniform electric load which should lead to a more favorable utility rate negotiation.

On the other hand, the 220-mph electric train does go faster. This speed increases its energy consumption, largely offsetting the weight improvement. As a result, all diesel options assume a 2012 fuel cost of $8.71 per train mile, and all electric options assume an electric cost of $2.80 per train mile. These energy costs are then adjusted each year in line with the relevant Energy Information Administration forecasts.

Exhibit 5-18: Fuel and Energy Cost per Mile ($2012)



ONBOARD SERVICES (OBS)

Onboard service (OBS) costs are those expenses for providing food service onboard the trains. OBS adds costs in three different areas: equipment, labor and cost of goods sold. Equipment capital and operating cost is built into the cost of the trains and is not attributed to food catering specifically. Small 200-seat trains cannot afford a dedicated dining or bistro car. Instead, an OBS employee or food service vendor would move through the train with a trolley cart, offering food and beverages for sale to the passengers.

The goal of OBS franchising should be to ensure a reasonable profit for the provider of on-board services, while maintaining a reasonable and affordable price structure for passengers. In previous studies, it has been found that the key to attaining OBS profitability is selling enough products to recover the train mile related labor costs. For example, if small 200-seat trains were used, given the assumed OBS cost structure, even with a trolley cart service the OBS operator will be challenged to attain profitability. However, the expanded customer base on larger 300-seat trains can provide a slight positive operating margin for OBS service. 400-seat electric trains should usually provide a comfortable positive profit margin for the OBS operator.

Because the trolley cart has been shown to double OBS revenues, it can result in profitable OBS operations in situations where a bistro-only service would be hard-pressed to sell enough food to recover its costs. While only a limited menu can be offered from a cart, the ready availability of food and beverages at the customer's seat is a proven strategy for increasing sales. Many customers appreciate the convenience of a trolley cart service and are willing to purchase food items that are brought directly to them. While some customers prefer stretching their legs and walking to a bistro car, other customers will not bother to make the trip.

The cost of goods sold is estimated as 50 percent of OBS revenue, based on Amtrak's route profitability reports. Labor costs, including costs for commissary support and OBS supervision, have been estimated at:

- An intermediate value of $2.56 per train mile was assumed for the 130-mph diesel options. This is a moderate level of crew cost that includes the need for some away-from-home layover.
- Existing rail 79-mph scenarios would cost $3.66 per train-mile because of poor crew utilization in these very low-frequency scenarios. With trains operating less frequently there is less opportunity to return crews to their home base on the same day, leading to more split shifts and overnight layovers. However, these trains were not part of any options assessed in this study.
- The 220-mph Greenfield scenario used $2.41 per train mile, reflecting operating efficiencies related both to higher speeds and more frequent trains in this scenario only, both of which tend to reduce the need for away-from-home layovers.

These costs are generally consistent with Amtrak's level of wages and staffing approach for conventional bistro car services. However, this Business Plan recommends that an experienced food service vendor provide food services and use a trolley cart approach. A key technical requirement for providing trolley service is to ensure the doors and vestibules between cars are designed to allow a cart to easily pass through. Since trolley service is a standard feature on most European railways, most European rolling stock is designed to accommodate the carts. Although convenient passageways often have not been provided on U.S. equipment, the ability to support trolley carts is an important equipment design requirement for the planned service.

INSURANCE COSTS

Liability costs were estimated at 1.4¢ per passenger-mile, the same rate that was assumed in the earlier MWRRS study brought to $2012. Federal Employees Liability Act (FELA) costs are not included in this category but are applied as an overhead to labor costs.

The Amtrak Reform and Accountability Act of 1997 (§161) provides for a limit of $200 million on passenger liability claims. Amtrak carries that level of excess liability insurance, which allows Amtrak to fully indemnify the freight railroads in the event of a rail accident. This insurance protection has been a key element in Amtrak's ability to secure freight railroad cooperation. In addition, freight railroads perceive that the full faith and credit of the United States Government is behind Amtrak, while this may not be true of other potential passenger operators. However, a General Accounting Office (GAO) review10 has concluded that this $200 million liability cap applies to commuter railroads as well as to Amtrak. If the GAO's interpretation is correct, the liability cap may also apply to potential franchisees. If this limitation were in fact available to potential franchisees, it would be much easier for any operator to obtain insurance that could fully indemnify a freight railroad at a reasonable cost. It is recommended that Virginia DOT seek qualified legal advice on this matter.

5.4 FIXED ROUTE COSTS

This cost category includes those costs that, while largely independent of the number of train-miles operated, can still be directly associated to the operation of specific routes. It includes such costs as track maintenance, which varies by train technology, and station operations.

TRACK AND RIGHT-OF-WAY COSTS

Currently, it is industry practice for passenger train operators providing service on freight-owned rights-of-way to pay for track access, dispatching and track maintenance. Rates for all these activities are ultimately based upon a determination of the appropriate costs that result from negotiations between the parties. The purpose here is to provide estimates based on the best available information; however, as the project moves forward, additional study and discussions with the railroads will be needed to further refine these costs.

To accommodate passenger trains, the Norfolk Southern existing rail corridor would need a substantial increase in capacity or else a new Greenfield alignment would need to be constructed. Once built, these improvements would need to be maintained to FRA standards required for reliable and safe operations. The costing basis assumed in this report is that of incremental or avoidable costs[11] for shared tracks. The passenger operator, however, must take full cost responsibility for maintaining any tracks that it must add to the corridor either for its own use, or for mitigating delays to freight trains. The following cost components are included within the Track and Right-of-Way category:

- **Track Maintenance Costs**. Costs for track maintenance were estimated based on Zeta-Tech's January 2004 draft technical monograph Estimating Maintenance Costs for Mixed High-Speed Passenger and Freight Rail Corridors.[12] Zeta-Tech costs have been adjusted for inflation to $2012. However, Zeta-Tech's costs are conceptual and subject to negotiation with the freight railroads.
- **Dispatching Costs and Out-of-Pocket Reimbursement.** Passenger service must also reimburse a freight railroad's added costs for dispatching its line, providing employee efficiency tests and for

[10] See: http://www.gao.gov/highlights/d04240high.pdf

[11] Avoidable costs are those that are eliminated or saved if an activity is discontinued. The term incremental is used to reference the change in costs that results from a management action that increases volume, whereas avoidable defines the change in costs that results from a management action that reduces volume.

[12] Zeta-Tech, a subsidiary of Harsco (a supplier of track maintenance machinery) is a rail consulting firm who specializes in development of track maintenance strategies, costs and related engineering economics. See a summary of this report at http://onlinepubs.trb.org/onlinepubs/trnews/trnews255rpo.pdf. The full report is available upon request from the FRA.

performing other services on behalf of the passenger operator. If the passenger operator does not contract a freight railroad to provide these services, it must provide them itself. As a result, costs for train dispatching and control are incurred on dedicated as well as shared tracks and are now shown under a separate "Operations and Dispatch" cost category.

- **Costs for Access to Track and Right-of-Way**. Access fees, particularly train mile fees incurred as an operating expense, are specifically excluded from this calculation. Any such payments would have to be calculated and negotiated on a route-specific and railroad-specific basis. Such a calculation would have to consider the value of the infrastructure improvements made to the corridor for balancing up-front capital with ongoing operating payments.[13]

Exhibit 5-19 shows the conceptual relationship between track maintenance cost and total tonnage that was calibrated from the 2004 Zeta-Tech study. It shows a strong relationship between tonnage, FRA track class (4 through 6, corresponding to a 79-mph to 110-mph track speed) and maintenance cost. At low tonnage, the cost differential for maintaining a higher track class is not very large, but as tonnage grows, so too does the added cost. For shared track, if freight needs only Class 4 track, the passenger service would have to pay the difference, called the "maintenance increment", which for a 25 MGT line as shown in Exhibit 5-19, would come to about $22,000 per mile per year (in $2002), including capital costs[14]. The required payment to reimburse a freight railroad for its added cost would be less for lower freight tonnage, more for higher freight tonnage.

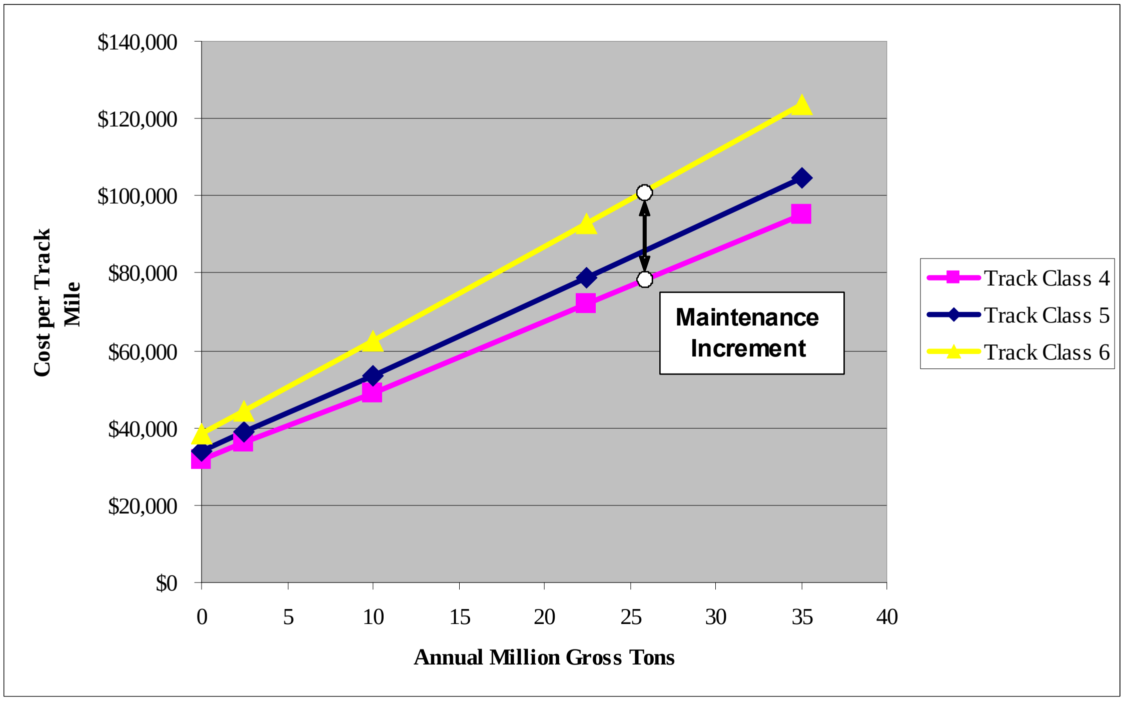
Exhibit 5-19 also breaks out the operating versus total track maintenance cost, showing that capital (the difference between total and operating cost) is a significant share of the total cost. For track maintenance:

- ***Operating costs*** cover expenses needed to keep existing assets in service and include both surfacing and a regimen of facility inspections.
- ***Capital costs*** are those related to the physical replacement of the assets that wear out. They include expenditures such as for replacement of rail and ties, but these costs are not incurred until many years after construction. In addition, the regular maintenance of a smooth surface by reducing dynamic loads actually helps extend the life of the underlying rail and tie assets.

[13] For 110-mph service, the level of infrastructure improvements to the corridor called for in this study should provide enough capacity to allow superior on-time performance for both freight and passenger operations

[14] Calculated as $38,446 - $31,887 + ($2.440 – $1.810) * 25 = $22,309 per year. Note that the yellow highlighted cells in the table correspond to the three lines shown on the graph.

Exhibit 5-19: Zeta-Tech 2004 Calibrated Track Class vs. Tonnage Total Cost Function ("Middle Line" Case, in $2002)



TOTAL	LOW		MIDDLE		HIGH	
	Intercept	Slope	Intercept	Slope	Intercept	Slope
Class 3[1]	$17,880	$0.917	$21,683	$1.231	$25,487	$1.548
Class 4	$26,294	$1.348	$31,887	$1.810	$37,481	$2.277
Class 5	$28,072	$1.509	$33,937	$2.020	$39,801	$2.530
Class 6	$31,714	$1.837	$38,446	$2.440	$45,178	$3.035

OPER	LOW		MIDDLE		HIGH	
	Intercept	Slope	Intercept	Slope	Intercept	Slope
Class 3	$6,558	$0.579	$8,216	$0.726	$9,873	$0.872
Class 4	$9,644	$0.852	$12,082	$1.067	$14,519	$1.283
Class 5	$11,283	$0.997	$14,135	$1.249	$16,987	$1.501
Class 6	$14,640	$1.293	$18,371	$1.623	$22,101	$1.953

Exhibit 5-19 shows that the cost of shared track depends strongly on the level of freight tonnage, since passenger trains are relatively lightweight and do not contribute much to the total tonnage. In fact, following the Zeta-Tech methodology, the “maintenance increment” is calculated based on freight tonnage only, since a flat rate of $1.56 per train mile as used in the Zeta- Tech report (in $2002) was already added to reflect the direct cost of added passenger tonnage regardless of track class. This cost, which was developed by Zeta-Tech’s TrackShare® model, includes not only directly variable costs, but also an allocation of a freight railroad’s fixed cost. Accordingly, it complies with the Surface Transportation Board’s definition of “avoidable cost.” Inflated to $2012 (an approximate 52% increase, a higher rate of inflation than CPI, reflecting the energy-intensity of construction materials) this avoidable cost allocation would come to $2.37 per train mile. It should be noted that Norfolk Southern policy does not allow for upgrading shared freight tracks above 79-mph. Accordingly, this $2.37 per train mile is the rate that would be assumed for shared use of Norfolk Southern freight tracks. The “maintenance increment” as described earlier is not relevant to this case since it is assumed that the tracks are not upgraded beyond what are needed for freight use.

On top of this, an allowance of 39.5¢ per train-mile (in $2002) was added by Zeta-Tech for freight railroad dispatching and out-of-pocket costs. Inflated to $2012 based on the Consumer Price Index (approx. 29% increase) this dispatching and out-of-pocket cost now comes to 50.8¢ per train mile, which is applied both to dedicated and shared tracks. This cost is now separated from track maintenance under the “Operations and Dispatch” category.

The same cost function shown in Exhibit 5-19 can also be used for costing dedicated passenger track. With dedicated track, the passenger system is assumed to cover the entire operating cost for maintaining its own track. (Freight may then have to reimburse the passenger operator on a car-mile basis for any damage it causes to the passenger track.) Because passenger train tonnage is very low however, it can be seen that the cost differential between Class 4, 5 and 6 track is very small. Adjusting Zeta-Tech’s $2002 costs shown in Exhibit 5-19 up to $2012:

- The Total cost per track-mile for maintaining dedicated Class 4 track is about $48,468; the cost for Class 6 track rises to $58,438. For a shared-use scenario, this assumes that Norfolk Southern would require this level of support each year for maintaining the additional tracks that it must add to its existing rail corridor, for supporting the needs of passenger rail service.
- The Operating cost per track-mile for maintaining dedicated Class 4 track is about $18,365; the cost for Class 6 track rises to $27,924.
- The Capital cost per track-mile for maintaining dedicated Class 4 track reflects the difference of about $30,103; similarly for Class 6 track is $30,514. The capital cost for maintaining Class 4 versus Class 6 track under light tonnage density is not much different; most of cost differential is in operating cost needed to maintain the more precise alignment of the higher class track.
- Adding $26,859 per track-mile for overhead electric catenary, the overall operating maintenance cost for electrified dedicated track rises to $27,924 + $26,859 = $54,783 per track mile per year. We do not account for separate capital cost replacement for catenary, since the $26,859 per track-mile estimate accounts for both operating and normalized capital power system maintenance.

Reducing axle loads as is a common design practice for 220-mph high speed equipment. This helps keep guideway maintenance costs low and in line with the above assumed costs. French experience[15] showed that the maintenance cost of a dedicated high speed track was actually lower (just 55%) of the cost of a conventional track with equivalent traffic. According to the French railways, the justification for such a difference was due basically to three causes: the uniformity of TGV rolling stock, the reduced axle loading (17 metric tons) and the strict quality conditions imposed during the construction of the line. Table 6 of this same report showed that the mixture of traffic operated over a line influences track maintenance cost much more than does the top speed. This finding is consistent with United States experience as shown in Exhibit 5-19. As a result, considering the maintenance of a 220-mph dedicated track costs as equivalent to that of a Class 6 line shared with freight trains is, if anything, conservative.

While operating costs are needed every year, capital maintenance costs for dedicated tracks are gradually introduced using a table of ramp-up factors provided by Zeta-Tech, see Exhibit 5-20.

Exhibit 5-20: Capital Cost Ramp-Up Following Upgrade of a Rail Line

Year	% of Capital Maintenance	Year	% of Capital Maintenance
0	0%	11	50%
1	0%	12	50%
2	0%	13	50%
3	0%	14	50%
4	20%	15	75%
5	20%	16	75%
6	20%	17	75%
7	35%	18	75%
8	35%	19	75%
9	35%	20	100%
10	50%		

A fully normalized capital maintenance level is not reached until 20 years after completion of the rail construction program. This is used for calculating "Cyclic Maintenance" in the Benefit Cost Analysis. But because Cyclic Maintenance is not an Operating Cost under GAAP accounting methodology, it is not normally included in the Operating Ratio calculation.

STATION OPERATIONS

A simplified fare structure, heavy reliance upon electronic ticketing and avoidance of a reservation system will minimize station personnel requirements. Station costs include personnel, ticket machines and station operating expenses.

- Staffed stations will be assumed at major stations. All stations will be assumed open for two shifts. The cost for the staffed stations includes eight positions at each new location, costing $644,640 per year, as well as the cost of utilities, ticket machines, cleaning and basic facility maintenance.

[15] See Maintenance Costs of High-Speed Lines in Europe: State of the Art, Transportation Research Record, Railways 2008: http://trb.metapress.com/content/gg76453p458327qr/?genre=article&id=doi%3a10.3141%2f2043-02

- The cost for unstaffed stations covers the cost of utilities, ticket machines, cleaning and basic facility maintenance, costing $80,580 per year. (These costs are also included in the staffed station cost.) Volunteer personnel such as Traveler's Aid, if desired could staff these stations.

Costing of the Richmond Direct option assumes 9 staffed stations, and the Petersburg/Hopewell option is based on 10 staffed stations.

5.5 SYSTEM OVERHEAD COSTS

The category of System Overhead largely consists of Service Administration or management overheads, covering such needs as the corporate procurement, human resources, accounting, finance and information technology functions as well as call center administration. A stand-alone administrative organization appropriate for the operation of a corridor system was developed for the MWRRS and later refined for the Ohio Hub studies. This organizational structure, which was developed with Amtrak's input and had a fixed cost of $8.9 million plus $1.43 per train-mile (in $2002) for added staff requirements as the system grew. Inflated to $2012, this became $11.45 million plus $1.84 per train mile. However, the Sales and Marketing category also has a substantial fixed cost component for advertising and call center expense, adding another $2.9 million per year fixed cost, plus variable call center expenses of 70.9¢ per rider, all in $2012.[16] Finally, credit card (1.8% of revenue) and travel agency commissions (1%) are all variable.

Therefore, the overall financial model for a Stand-alone organization therefore has $14.35 million ($11.45 + $2.9 million) annually in fixed cost for administrative, sales and marketing expenses. In addition, the system operator was allowed a 10 percent markup on certain direct costs as an allowance for operator profit.

5.6 RESULTS/TABLES

Exhibit 5-21 summarizes the Unit Cost factors used for developing Operating costs for each alternative. Following the original MWRRS methodology, those costs marked with an asterisk (*) are subject to the 10% Operator Profit markup.

[16] In the MWRRS cost model, call center costs were built up directly from ridership, assuming 40 percent of all riders call for information, and that the average information call will take 5 minutes for each round trip. Call center costs, therefore, are variable by rider and not by train-mile. Assuming some flexibility for assigning personnel to accommodate peaks in volume and a 20 percent staffing contingency, variable costs came to 57¢ per rider. These were inflated to 66¢ per rider in $2008 and now 70.9¢ per rider in $2012.

Exhibit 5-21: Unit Operating and Maintenance Costs

Unit Cost	Driver	Shared 79-mph diesel	Shared 110-mph diesel	Greenfield 130-mph diesel	Greenfield 220-mph electric
Equipment Maintenance	Train-Miles	$15.43	$15.43	$12.70	$14.08
Train Crew *	Train-Miles	$6.59	$6.59	$4.92	$4.60
Fuel or Energy *	Train-Miles	$8.71	$8.71	$8.71	$2.80
On Board Services (Labor) *	Train-Miles	$3.66	$3.66	$2.56	$2.41
On Board Services (Goods Sold) *	% of OBS Revenue	50%	50%	50%	50%
Insurance	Passenger-Mile	1.4¢	1.4¢	1.4¢	1.4¢
Track (Shared)	Train-Miles over Shared Track	$2.37	$2.37	N/A	N/A
Track and Electrification (Dedicated)	Dedicated Track Miles	$48,468	$58,438	$27,924 plus Cyclic Capital	$54,783 plus Cyclic Capital
Operations and Dispatch *	Train-Miles	50.8¢	50.8¢	50.8¢	50.8¢
Stations * - Staffed	Per Station	$644,640	$644,640	$644,640	$644,640
Stations* - Unstaffed	Per Station	$80,580	$80,580	$80,580	$80,580
Administration and Management (Fixed) *	Fixed	$14.35 mill	$14.35 mill	$14.35 mill	$14.35 mill
Administration and Management (Variable Train-Mile) *	Train-Miles	$1.84	$1.84	$1.84	$1.84
Administration and Management (Call Center: Variable Riders) *	Riders	70.9¢	70.9¢	70.9¢	70.9¢
Credit Card and Travel Agency Commissions *	Percent of Revenue	2.8%	2.8%	2.8%	2.8%
Operator Profit Markup	Selected (*) Costs	10%	10%	10%	10%

Exhibit 5-22 shows the Operating Costs for each rail route and speed option. It can be seen that each of the 130 mph options cost between $130-135 million in 2025 while the 220-mph options cost between $175-179 millions in the same year. As a result it can be seen that the 220-mph options only cost an extra $40 million per year despite operating more train miles as a result of the increased frequency offered at higher speed.

Exhibit 5-22: 2025 Operating and Maintenance Costs Results

Financial 2025(mill. 2012$)	Southern Option 1 - Via Petersburg				Northern Option 2 - Via Hopewell				Option 3 - Richmond Direct	
	Southern Option 1A -		Southern Option 1B -		Northern Option 2A -		Northern Option 2B -			
	130 mph	220 mph	130 mph	220 mph	130 mph	220 mph	130 mph	220 mph	130 mph	220 mph
COSTS										
Train Crew	$10.83	$15.67	$10.83	$15.67	$10.71	$15.26	$10.71	$15.26	$11.10	$15.69
OBS	$13.42	$21.45	$13.42	$21.45	$13.21	$20.90	$13.21	$20.90	$13.88	$21.59
Equipment	$27.96	$47.95	$27.96	$47.95	$27.65	$46.72	$27.65	$46.72	$28.65	$48.03
Fuel	$19.57	$8.92	$19.57	$8.92	$19.35	$8.69	$19.35	$8.69	$20.06	$8.94
Track	$11.95	$23.45	$11.95	$23.45	$11.78	$23.12	$11.78	$23.12	$11.56	$22.68
Insurance	$7.40	$11.44	$7.40	$11.44	$7.32	$11.15	$7.32	$11.15	$7.58	$11.46
Call Ctr Variable	$2.65	$3.82	$2.65	$3.82	$2.62	$3.71	$2.62	$3.71	$2.77	$3.94
T-Agent and CC Comm	$5.45	$9.27	$5.45	$9.27	$5.35	$9.03	$5.35	$9.03	$5.67	$9.36
Stations	$6.45	$6.45	$6.45	$6.45	$6.45	$6.45	$6.45	$6.45	$5.91	$5.91
Admin and Mgt	$18.40	$20.62	$18.40	$20.62	$18.36	$20.46	$18.36	$20.46	$18.50	$20.63
Operation & Dispactch	$1.09	$1.70	$1.09	$1.70	$1.07	$1.67	$1.07	$1.67	$1.05	$1.64
Operator Profit 10% selected items	$7.79	$8.79	$7.79	$8.79	$7.71	$8.62	$7.71	$8.62	$7.89	$8.77
Total Cost	**$132.95**	**$179.51**	**$132.95**	**$179.51**	**$131.57**	**$175.77**	**$131.57**	**$175.77**	**$134.63**	**$178.63**

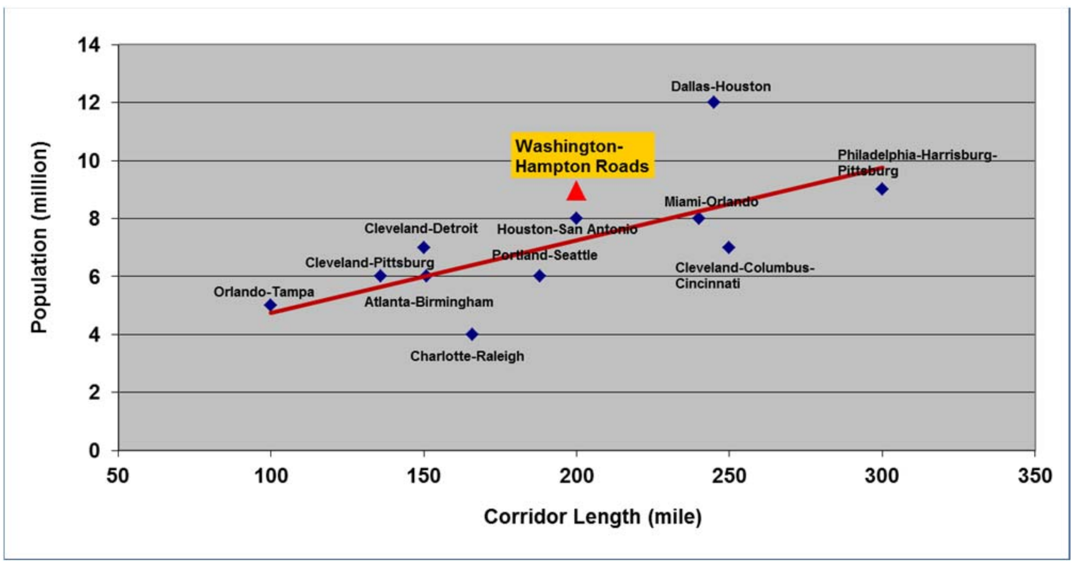
6. MARKET ANALYSIS

The Market Analysis provides an assessment of the overall travel market and its comparison with other US high speed rail corridors. It describes the development of the very high quality travel demand model, its zones, and data sources used to develop forecasts. The socioeconomic growth projections and transport conditions for the corridor are also provided. A key input to the demand model was the Stated Preference Survey that estimated the responsiveness of the community to their travel options. Finally, the forecasts of ridership and revenue are described for each of the route and technology options.

6.1 OVERVIEW OF EXISTING TRAVEL MARKET

The Hampton Roads-Richmond-Washington Corridor is one of the top intercity corridors in the U.S. being comparable with Florida's Miami-Orlando, Ohio's Cleveland-Columbus-Cincinnati, Pennsylvania's Philadelphia-Harrisburg-Pittsburgh, and Texas's Houston-Dallas, and much stronger than many Southeast High-Speed rail corridors like Atlanta-Charlotte or Charlotte-Raleigh and Raleigh-Richmond (Exhibit 6-1). As such, the corridor has independent utility as a high speed corridor.

Exhibit 6-1: Corridor Comparison



In addition to this corridor having independent utility in its own right, it should be recognized that is really the southern extension of the Northeast corridor and a logical part of the "East Coast Mega Region" that stretches from Boston to New York to Philadelphia to Washington and on to Richmond and Hampton Roads. The impact of being linked to this Mega Region is to effectively double the volume of trips that the corridor would have as a freestanding corridor, and thus significantly enhances its potential for High Speed and Enhanced Intercity Passenger Rail.

Like many intercity passenger rail corridors the demand for travel in the corridor is strong. In 2012 the Hampton Roads – Richmond - Washington Corridor had a population of nearly ten million. The corridor also hosts large number of finance and business services, research and high-tech industry, government agencies and military bases. In 2012 the total employment in the corridor was over six million and per capita income was $39,648. Projections indicate that the corridor's demographic and economic growth will continue over the next several decades, the population is projected to be over 12 million in 2040, employment will be 8.5 million in 2040, and per capita incomes will grow to $53,227 in 2040 in 2012 dollars. As a result, the Hampton Roads – Richmond – Washington Corridor has a high level of business and commuter travel between its urban areas together with significant social and tourist travel. The total annual intercity one-way trips in the corridor is estimated to be 59 million in 2012. This means the average resident takes 6.6 one way or 3.3 round intercity trips per year.

6.2 BASIC STRUCTURE OF THE COMPASS™ TRAVEL MARKET FORECAST MODEL

For the purpose of this study, the ridership and revenue forecast will be produced using the COMPASS™ Travel Demand Model. The COMPASS™ Multimodal Demand Forecasting Model is a flexible demand forecasting tool used to compare and evaluate alternative passenger rail network and service scenarios. It is particularly useful in assessing the introduction or expansion of public transportation modes such as air, bus or high speed rail into markets. Exhibit 6-2 and 6-3 show the structure and working process of the COMPASS™ Model. As shown, the inputs to the COMPASS™ Model are base and proposed transportation networks, base and projected socioeconomic data, value of time and value of frequency from Stated Preference surveys, and base year travel data obtained from government agencies and transportation service operators.

The COMPASS™ Model structure incorporates two principal models: a Total Demand Model and a Hierarchical Modal Split Model. These two models are calibrated separately. In each case, the models are calibrated for origin-destination trip making in the study area. The Total Demand Model provides a mechanism for replicating and forecasting the total travel market. The total number of trips between any two zones for all modes of travel is a function of (1) the socioeconomic characteristics of the two zones and (2) the travel opportunities provided by the overall transportation system that exists (or will exist) between the two zones. Typical socioeconomic variables include population, employment and income. The quality of the transportation system is measured in terms of total travel time and travel cost by all modes, and the induced demand is estimated by considering the change in quality of travel offered by all modes.

The role of the COMPASS™ Modal Split Model is to estimate relative modal shares of travel given the estimation of the total market by the Total Demand Model. The relative modal shares are derived by comparing the relative levels of service (as estimated by generalized costs) offered by each of the travel modes. Four levels of binary choice were used in this study (see Exhibit 6-3). The first level separates two routes from Hampton Roads area to other areas in the corridor by rail. The second level separates rail services from bus services. The third level of the hierarchy separates air travel, the fastest and most expensive mode of travel, from surface modes of rail and bus services. The fourth level separates auto travel with its perceived spontaneous frequency, low access/egress times, and highly personalized characteristics, from public modes (i.e., air, rail and bus). The model forecasts changes in riders, revenue and market share based on changes travel time, frequency and cost for each mode as measured by the generalized costs for each mode. A more detailed description of the COMPASS™ Model is given in Appendix 2.

Exhibit 6-2: Structure of the COMPASS™ Model

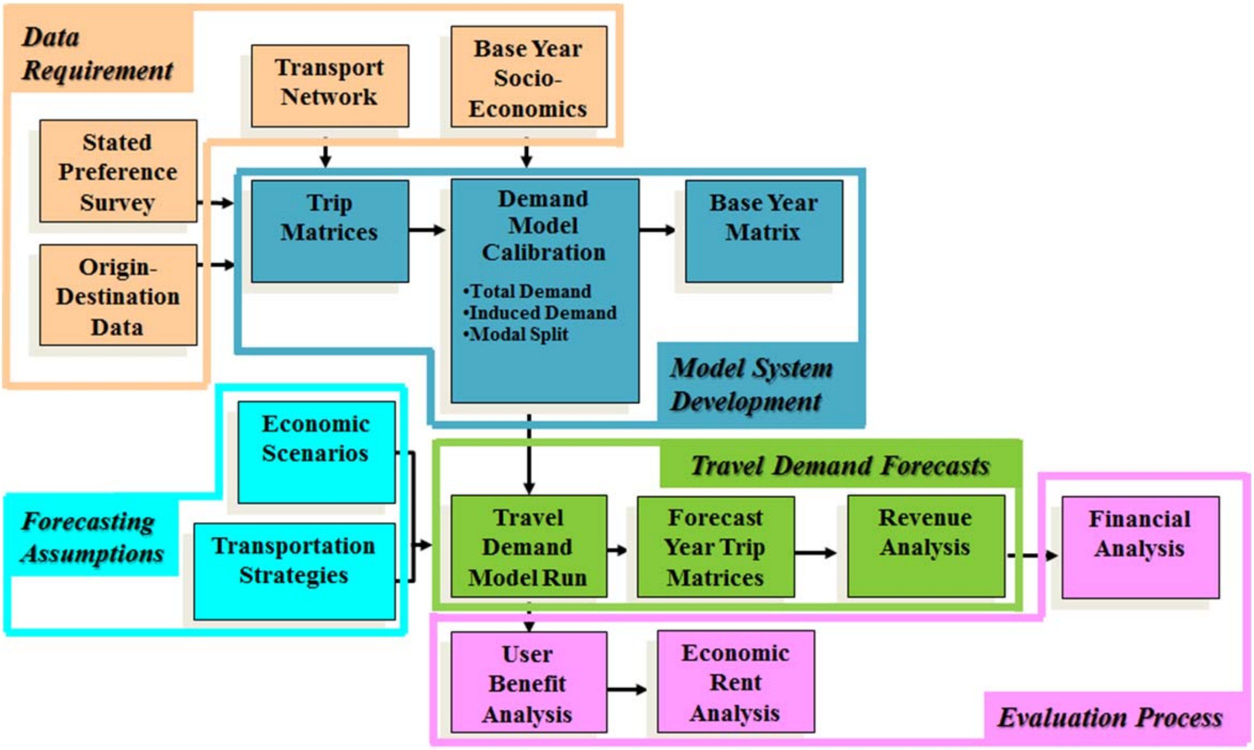
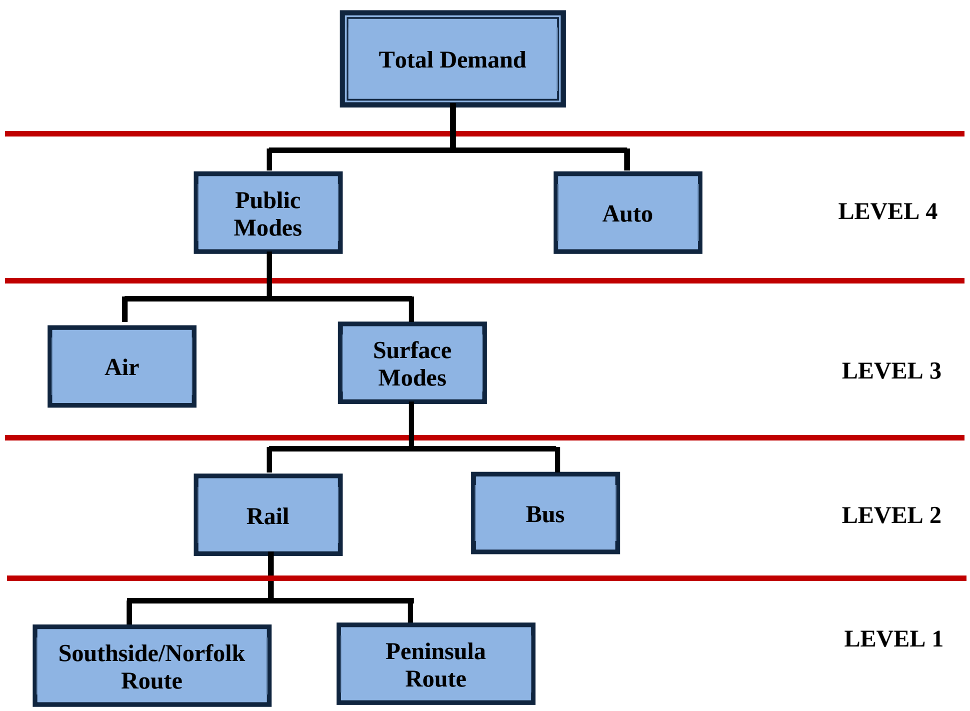


Exhibit 6-3: Hierarchical Structure of the Modal Split Model



A key element in evaluating passenger rail service is the comprehensive assessment of the travel market in the corridor under study, and how well the passenger rail service might perform in that market. For the purpose of this study, this assessment was accomplished using the following process:

- Building the zone system that enables more detailed analysis of the origin-destination travel market and the development of base year and future socioeconomic data for each zone.
- Compiling information on the service levels (times, fares, frequency, costs) in the corridor for auto, air, bus, and the proposed passenger rail travel.
- Identifying and quantifying factors that influence travel choices, including values of time, frequency and access/egress time.
- Developing strategies that quantify how travel conditions will change, including future gas price, future vehicle fuel efficiency improvement, and highway congestion.
- Developing and calibrating total travel demand and modal split models for travel demand forecasting.
- Forecasting travel, including total demand and modal shares.

The following sections document the modeling process and the forecasting results.

6.3 Zone Definition

The zone system provides a representation of the market areas among which travel occurs from origins to destinations. For intercity passenger rail planning, most rural zones can be represented by larger areas. However, where it is important to identify more refined trip origins and destinations in urban areas, finer zones are used. The travel demand model forecasts the total number of trip origins and destinations by mode and by zone pair. Because Hampton Roads – Richmond - Washington Corridor is closely related to the Northeast Corridor and Southeast Corridor, a zone system is needed that incorporates all areas that are part of the Northeast and Southeast corridors. To meet this need, a 333-zone system was developed for the whole study area based on aggregation of the 2010 census tracts and traffic analysis zones (TAZs) of local transportation planning agencies. Exhibit 6-4 shows the zone system for the whole study area. Exhibit 6-5 shows the zones in the Hampton Roads area.

Exhibit 6-4: Study Area Zone System

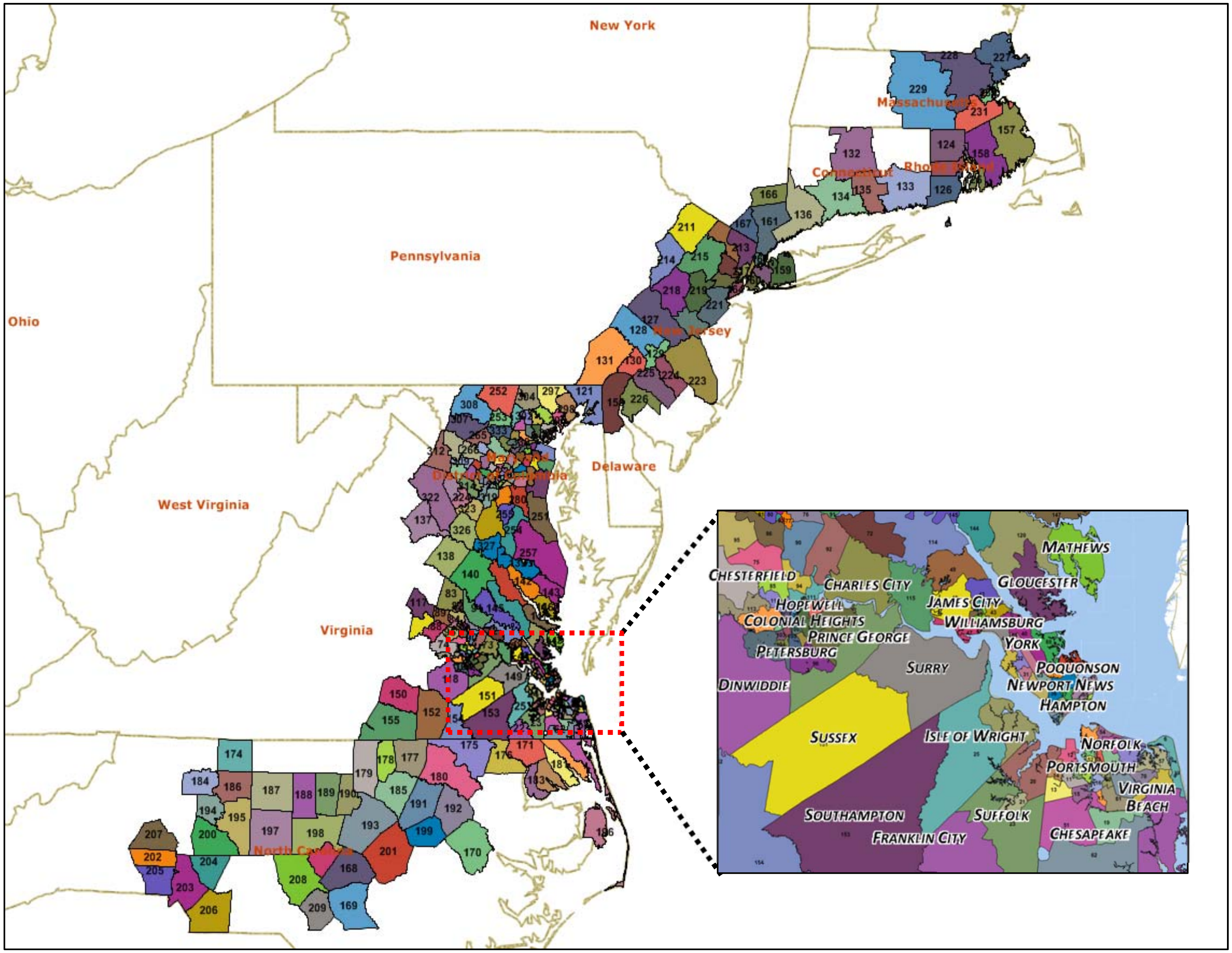
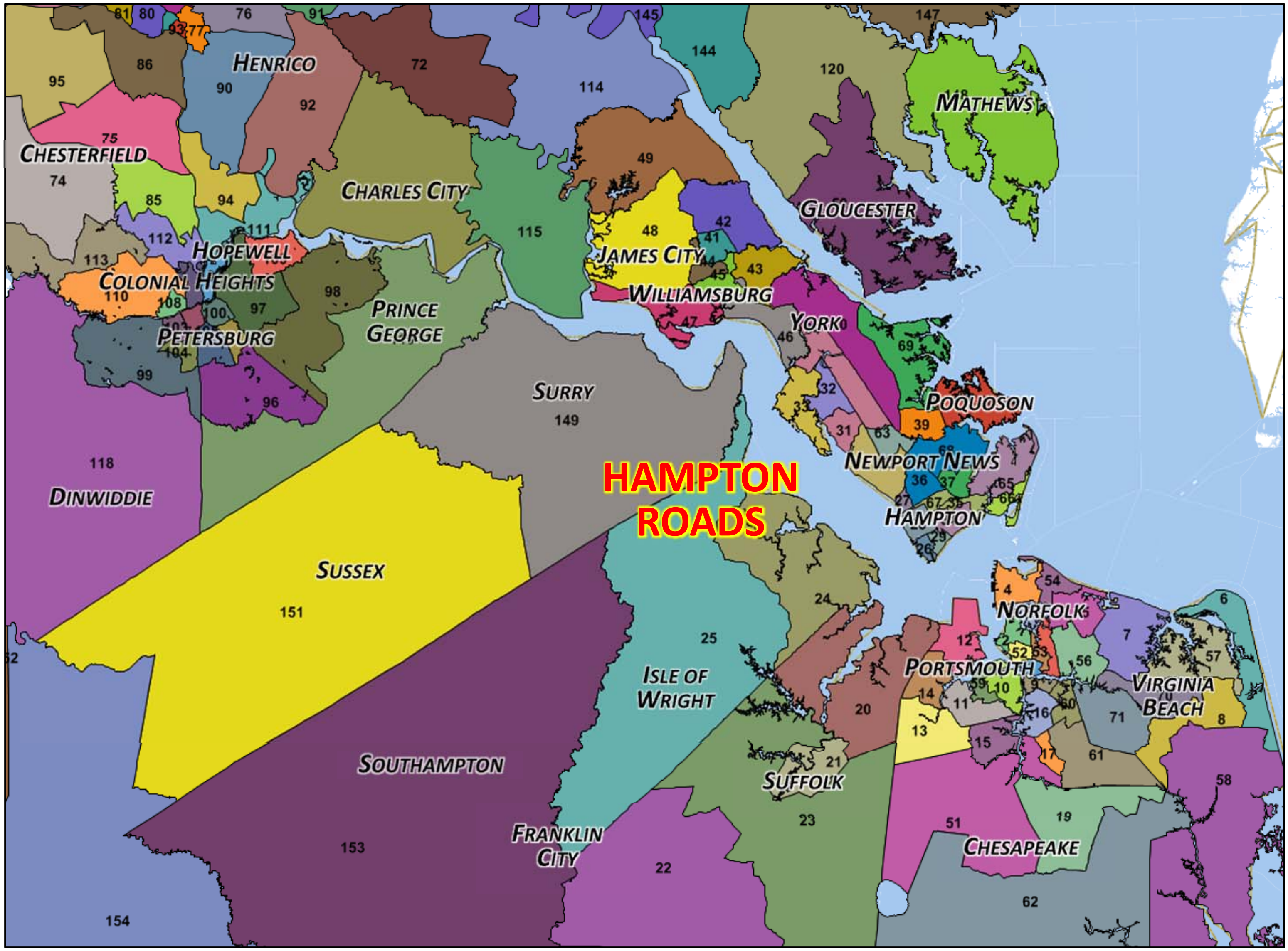


Exhibit 6-5: Hampton Roads Area Zones



6.4 Socioeconomic Baseline and Projections

The travel demand forecasting model requires base year estimates and future growth forecasts of three socioeconomic variables of population, employment and per capita income for each of the zones in the study area. A socioeconomic database was established for the base year (2012) and for each of the forecast years (2015-2050). The data was developed at five-year intervals using the most recent data from the following sources:

- U.S. Census Bureau
- Hampton Roads Planning District Commission
- Richmond Regional Planning District Commission
- Crater Planning District Commission
- Virginia Employment Commission
- Metropolitan Washington County of Governments
- Baltimore Metropolitan Council
- Bureau of Economic Analysis
- Woods & Poole Economics, Inc.

Exhibit 6-6 shows the base year and projected socioeconomic data for the whole study area including Northeast and Southeast corridor regions. According to the data developed from these sources, the population will increase from 50.62 million in 2012 to 64.36 million in 2050, the total employment of the study area will increase from 30.99 million to 46.2 million in 2050, and per capita income will increase from $35,611 in 2012 to $52,304 in 2050 in 2012 dollars.

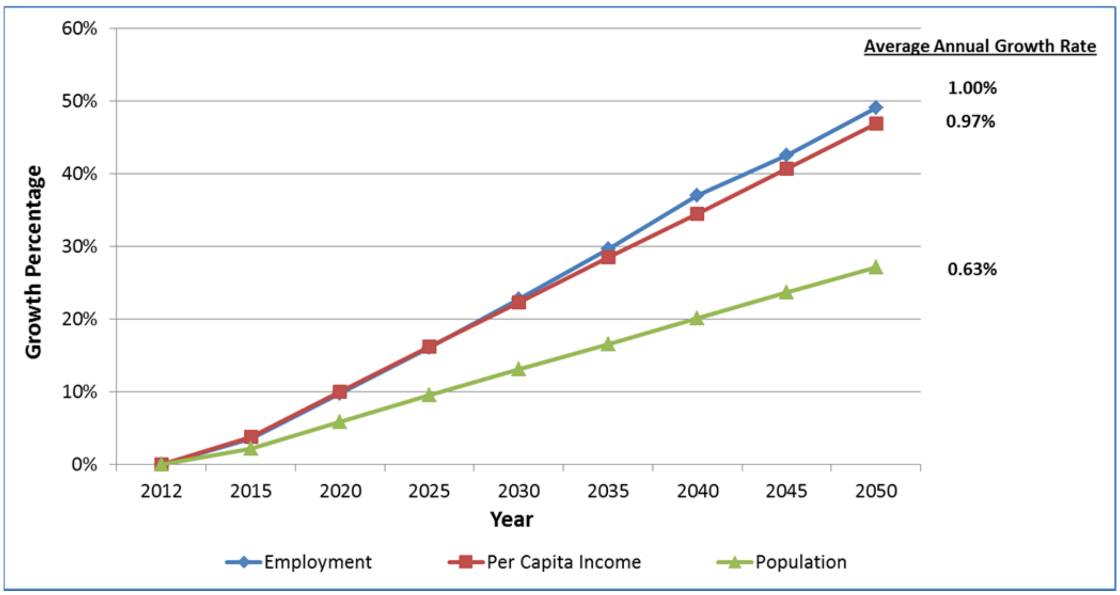
Exhibit 6-6: Base and Projected Socioeconomic Data for the Whole Study Area that Extends from Boston to Charlotte

Year	2012	2015	2020	2025	2030	2035	2040	2045	2050
Population	50,618,637	51,715,458	53,583,628	55,434,004	57,232,413	59,012,616	60,811,800	62,596,572	64,364,454
Employment	30,986,211	32,082,878	34,008,141	35,986,164	38,044,681	40,173,357	42,443,934	44,161,365	46,196,616
Per Capita Income (2012$)	35,611	36,957	39,176	41,378	43,567	45,745	47,889	50,120	52,304

Exhibit 6-7 shows the socioeconomic growth projections for the study area. The exhibit shows that there is higher growth of employment and income than population. Furthermore, travel increases are historically strongly correlated to increases in employment and income, in addition to changes in population. Therefore, travel in the corridor is likely to continue to increase faster than the population growth rates, as changes in employment and income outpace population growth, and stimulate more demand for traveling.

The exhibits in this section show the aggregate socioeconomic projection for the whole study area. It should be noted that in applying socioeconomic projections to the model, separate projections were made for each individual zone using the data from the listed sources. Therefore, the socioeconomic projections for different zones are likely to be different and thus may lead to different future travel sub-market projections. A full description of socioeconomic data of each zone can be found in the Appendix 1.

Exhibit 6-7: Socioeconomic Growth Projection for the Whole Study Area that extends from Boston to Charlotte



6.5 EXISTING TRAVEL MODES

In transportation analysis, travel desirability/utility is measured in terms of travel cost and travel time. These variables are incorporated into the basic transportation network elements that provide by mode the connections from any origin zone to any destination zone. Correct representation of the existing and proposed travel services is vital for accurate travel forecasting. Basic network elements are called nodes and links. Each travel mode consists of a database comprised of zones and stations that are represented by nodes, and existing connections or links between them in the study area. Each node and link is assigned a set of travel attributes (time and cost). The network data assembled for the study included the following attributes for all the zone pairs.

For public travel modes (air, rail, bus):

- Access/egress times and costs (e.g., travel time to a station, time/cost of parking, time walking from a station, etc.)
- Waiting at terminal and delay times
- In-vehicle travel times
- Number of interchanges and connection times
- Fares
- Frequency of service

For private mode (auto):

- Travel time, including rest time
- Travel cost (vehicle operating cost)
- Tolls
- Parking Cost
- Vehicle occupancy

The transportation travel attribute or service data of different modes available in the study corridor were obtained from a variety of sources and coded into the COMPASS™ networks as inputs to the demand model. The major sources are as follows.

The highway network was developed to reflect the major highway segments within the study area. The sources for building the highway network in the study area are as follows:

- State and Local Departments of Transportation highway databases
- National Highway System (NHS) database

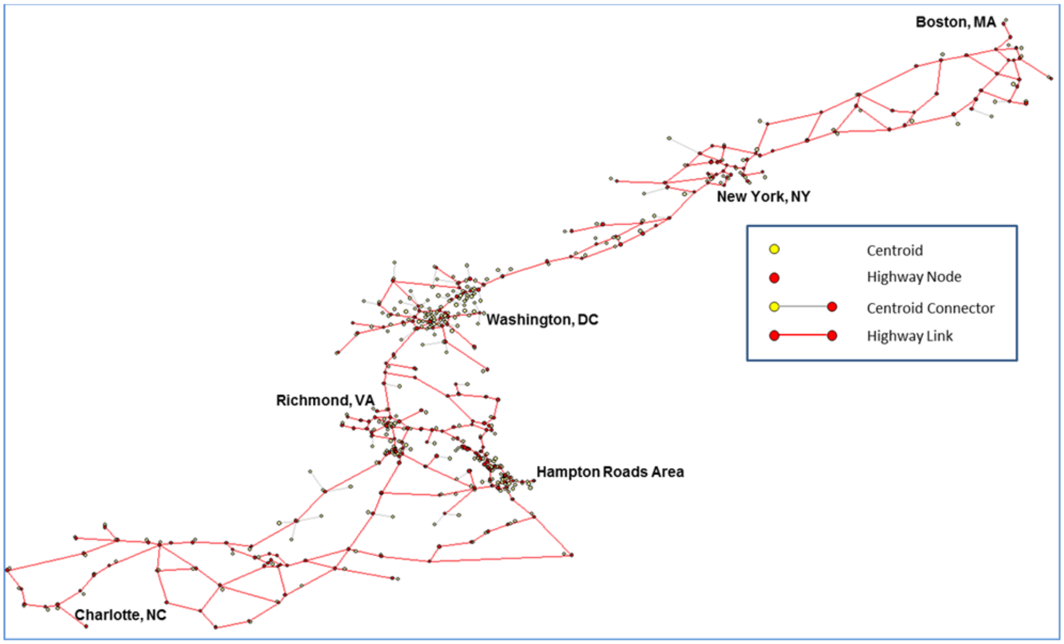
The main roads included in the highway network are shown in Exhibit 6-8

Exhibit 6-8: Major Roads in the COMPASS™ Highway Network

Highway Description	Segment Description
Interstate-64	Norfolk to Richmond
US 460	Suffolk to Richmond
Interstate-95	Richmond to Boston
Interstate-295	Petersburg to Richmond

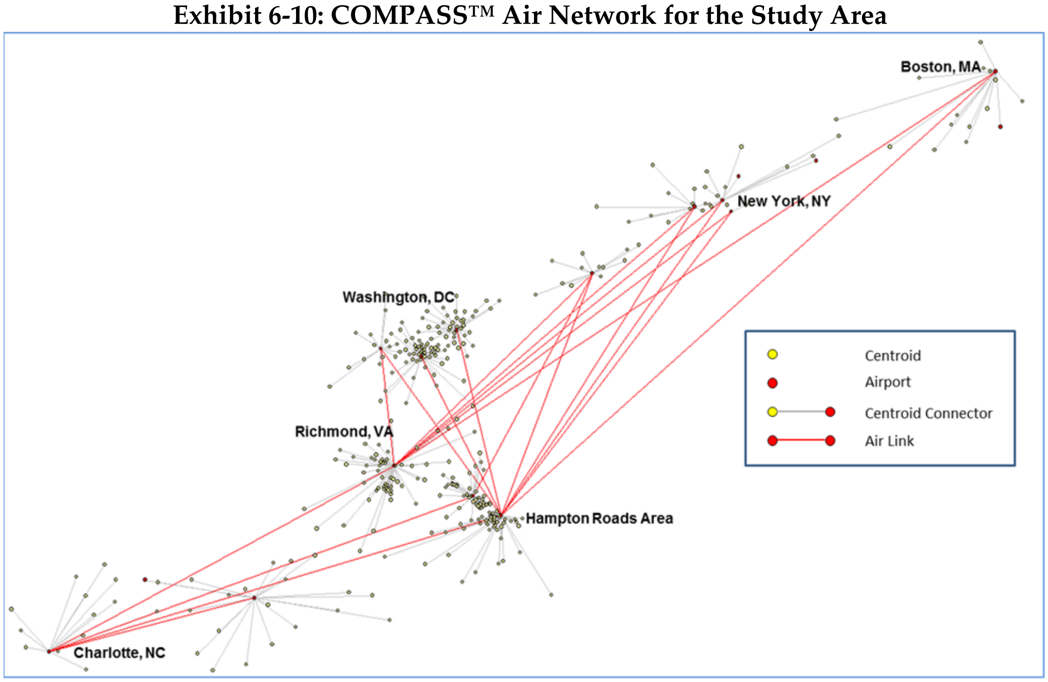
The highway network of the corridor area coded in COMPASS™ is shown in Exhibit 6-9.

Exhibit 6-9: COMPASS™ Highway Network for the Study Area



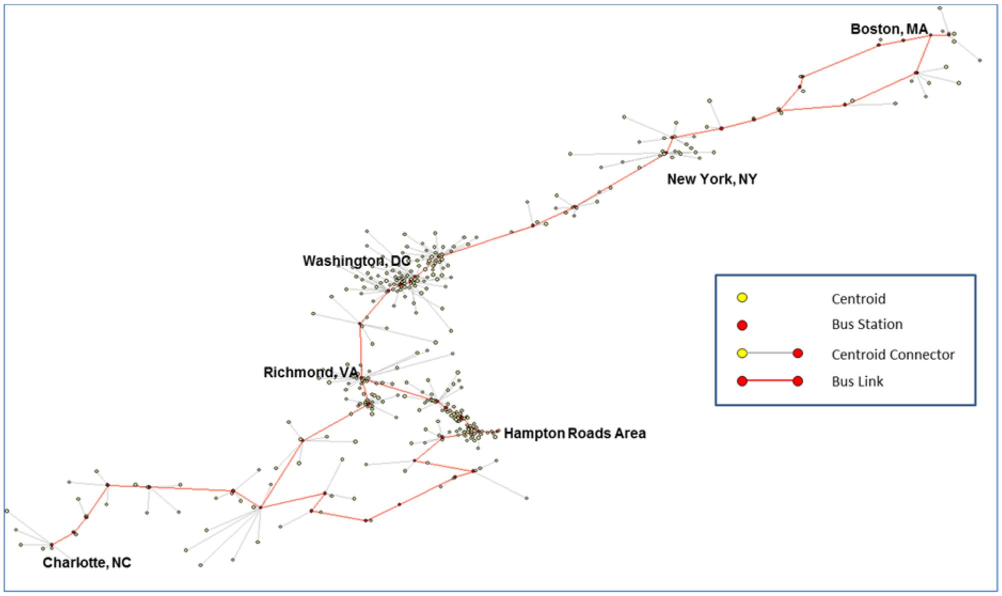
Air network attributes contain a range of variables that include time and distance between airports, airfares, and connection times. Travel times, frequencies and fares were derived from official airport websites, websites of the airlines serving airports in the study area, and the BTS 10% sample of airline tickets. Exhibit 6-10 shows the air network of the study area coded in COMPASS™.

Exhibit 6-10: COMPASS™ Air Network for the Study Area



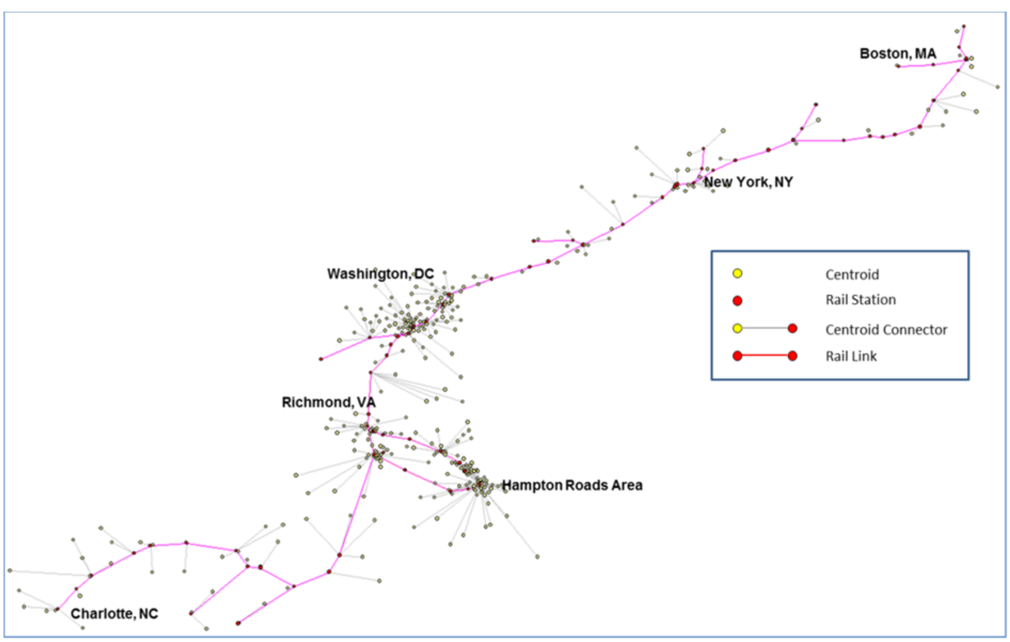
Bus travel data of travel time, fares, and frequencies, were obtained from official schedules of Greyhound and MegaBus. Exhibit 6-11 shows the bus network of the study area coded in COMPASS™.

Exhibit 6-11: COMPASS™ Bus Network for the Study Area



Current passenger rail travel data of travel time, fares, and frequencies, were obtained from official schedules of Amtrak. Exhibit 6-12 shows the passenger rail network of the study area coded in COMPASS™.

Exhibit 6-12: COMPASS™ Passenger Rail Network for the Study Area



6.6 ORIGIN-DESTINATION TRIP DATABASE

The multi-modal intercity travel analyses model requires the collection of base year 2012 origin-destination (O-D) trip data describing annual personal trips between zone pairs. For each O-D zone pair, the annual personal trips are identified by mode (auto, air, and bus) and by trip purpose (Business and Non-Business). Because the goal of the study is to evaluate intercity travel, the O-D data collected for the model reflects travel between zones (i.e., between counties, neighboring states and major urban areas) rather than within zones.

TEMS extracted, aggregated and validated data from a number of sources in order to estimate base travel between origin-destination pairs in the study area. The data sources for the origin-destination trips in the study are:

- The Airline Origin and Destination Survey (DB1B) Air Ticket Database
- T-100 Air Market and Segment Database
- Greyhound and Megabus Schedules
- Previous travel origin-destination surveys
- State department of transportation (Virginia, Maryland, Washington, DC, North Carolina, Delaware, Pennsylvania, New Jersey, New York, Connecticut, Rhode Island and Massachusetts) highway traffic volume Average Annual Daily Traffic (AADT) data
- Amtrak passenger rail ridership data
- Amtrak station volume data
- TEMS 2012 Virginia Travel Survey

The travel demand forecast model requires the base trip information for all modes between each zone pair. In some cases this can be achieved directly from the data sources, while in other cases the data providers only have origin-destination trip information at an aggregated level (e.g., AADT data, station-to-station trip and station volume data). Where that is the case, a data enhancement process of trip simulation and access/egress simulation needed to be conducted to estimate the zone-to-zone trip volume. The data enhancement process is shown in Exhibit 6-13.

For the auto mode, the quality of the origin-destination trip data was validated by comparing it to AADTs and traffic counts on major highways and adjustments have been made when necessary. For public travel modes, the origin-destination trip data was validated by examining station volumes and segment loadings.

Exhibit 6-13: Zone-to-Zone Origin-Destination Trip Matrix Generation and Validation

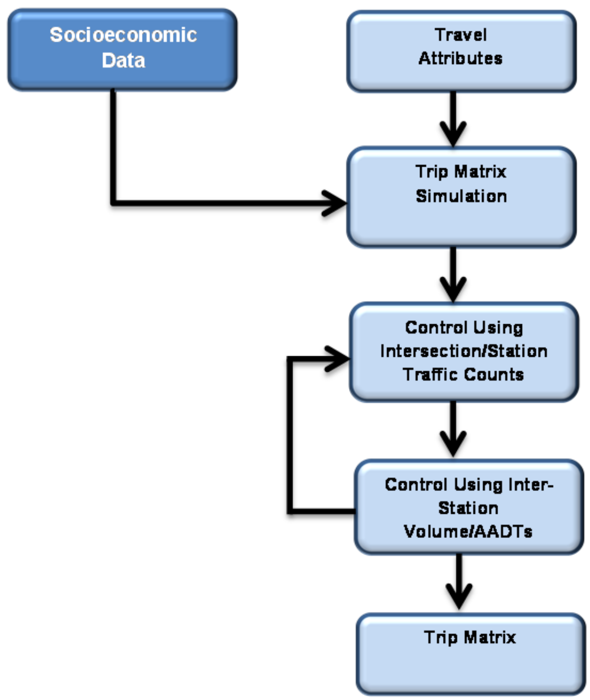
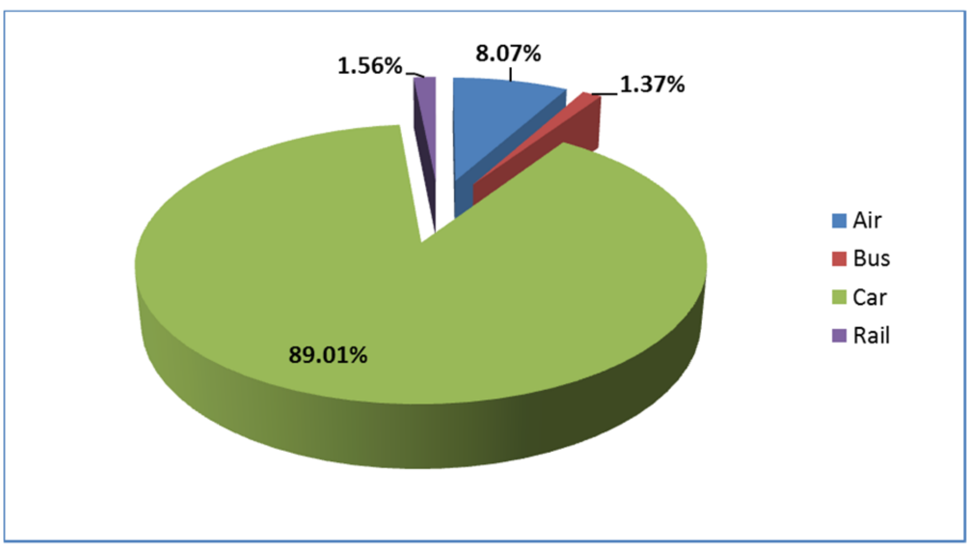


Exhibit 6-14 shows the base 2012 travel market share of rail, air, bus, and auto modes. It can be seen that auto mode dominates the travel market with 89 percent of market share. Public modes have 11 percent of travel market share.

Exhibit 6-14: 2012 Base Travel Market Share by Mode



6.7 STATED PREFERENCE SURVEY

The Stated Preference Analysis was based on results from a broad range of collected stated preference survey forms. Stated Preference Survey method uses a quota sampling approach as a fast and effective way of gathering consumer information on the importance of different travel decisions. This includes such issues as how travelers value travel time (for auto and transit modes) and how they value frequency of service and access time (for transit modes). A quota survey, as opposed to a random survey or a focus group study, is particularly effective in ensuring that all the important travel attributes are measured for the whole population at minimum cost. The quota survey, which has been widely adopted for public opinion surveys, is based on the development of representative "quotas" of the traveling public. The TEMS analysis requires that, two sets of data be collected: (1) the data that define the "travel behavior" quota and (2) the data that define the "personal profile" quota for the individuals surveyed. This allows the data to be stratified by such factors as trip length, income, and group size.

This section describes the stated preference survey process including the methodology used, sample size, survey forms, target locations, and dates of survey deployment along with survey results and analysis.

6.7.1 SURVEY PROCESS

The essence of the stated preference technique is to ask people making trips in the corridor to make a series of trade-off choices based on different combinations of travel time, frequency and cost. Stated preference analysis has been used extensively by TEMS to assess new travel options relating to time, fares, frequency, comfort and reliability for rail, air, and bus services. Tests of the technique in a series of before and after evaluations in North America have produced exceedingly good results. In particular, these tests found that the use of "abstract mode" questions in conjunction with "trade-off analysis" produced reliable results.

Two specific trade-offs were analyzed and used for this study:

- Choices between travel times and travel costs to derive incremental Values of Time for all modes
- Choices between headway times (frequency of service) and travel costs to derive incremental Values of Frequency for transit users.

One part of the survey contains revealed preference questions while the other part contains questions that aim on defining the travel behavior of the surveyed individuals. The revealed preference questions which are the profile data collected from the surveys are used in conjunction with origin-destination and census data to ensure that the stated preference survey can be effectively expanded to properly represent the total population. The collected travel behavior data provides the critical part of the data needed to estimate the generalized cost of travel.

Generalized cost of travel between two zones estimates the impact of improvements in the transportation system on the overall level of trip making. It is typically defined in travel time (i.e., minutes) rather than dollars. Costs are converted to time by applying appropriate conversion factors, as shown in Equation 1. The generalized cost (GC) of travel between zones i and j for mode m and trip purpose p is calculated as follows:

Equation 1:

$$GC_{ijmp} = TT_{ijm} + \frac{TC_{ijmp}}{VOT_{mp}} + \frac{VOF_{mp} * OH * \exp(\alpha * F)}{VOT_{mp} * \alpha * F^2{}_{ijm}}$$

Where,

TT_{ijm} = Travel Time between zones i and j for mode m (in-vehicle time + station wait time + connection wait time + access/egress time + interchange penalty), with waiting, connect and access/egress time multiplied by a factor (greater than 1) to account for the additional disutility felt by travelers for these activities[1]

TC_{ijmp} = Travel Cost between zones i and j for mode m and trip purpose p (fare + access/egress cost for public modes, operating costs for auto)

VOT_{mp} = Value of Time for mode m and trip purpose p

VOF_{mp} = Value of Frequency for mode m and trip purpose p

F_{ijm} = Frequency in departures per week between zones i and j for mode m

α = Frequency damping factor

OH = Operating hours per week

Value of time is the amount of money (dollars/hour) an individual is willing to pay to save a specified amount of travel time, the value of frequency is the amount of money (dollars/hour) an individual is willing to pay to reduce the time between departures when traveling on public transportation, and the value of access is the amount of money (dollars/hour) an individual is willing to pay for the access time to a mode (e.g. the airport, HSR station, railroad station, bus station) to gain easier access to someplace (e.g., an airport). Station wait time is the time spent at the station before departure and after arrival. On trips with connections, there would be additional wait times incurred at the connecting station. Wait times are weighted higher than in-vehicle time in the generalized cost formula to reflect their higher disutility as found from previous studies.

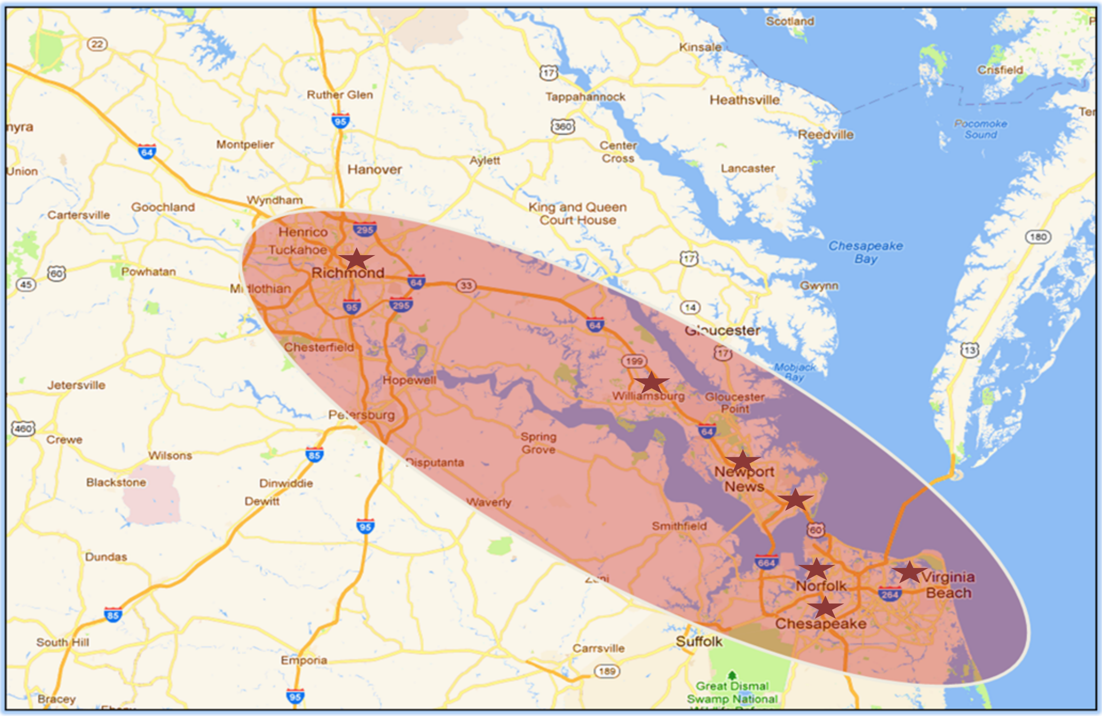
In terms of the size of the survey for each of the quota groups identified - usually up to 12 primary groups. It has been shown that a sample as small as 20 individuals[2] is statistically significant to define the behavioral choices of each group. These primary groups are based on 4 mode groups - auto and transit (that includes air, rail and bus) to 3 purpose groups commuter, business, and other (that includes shopping and social). To improve statistical reliability, TEMS typically seeks 40 to 100 respondents per quota. This means that between 500 and 1,500 surveys are needed for a stated preference survey analysis. The minimum of 1,200-2,000 surveys was set as a goal.

[1] Travel time includes the rest time if travel is by private auto.

[2] According to Stirrings Approximation where the ratio of the actual value (n) and its factorial (n!) is closer to 1.

A very important part of the survey process is to identify the desirable survey locations. Exhibit 6-15 shows the Stated Preference Survey locations map covering Richmond, Williamsburg, Newport News, Hampton, Norfolk, Chesapeake, and Virginia Beach. The surveys were conducted both electronically and also in the field. The main aim of the surveys was to target all 12 quota groups (i.e., Business, Commuters, and for other purpose such as shopping and other social events for both auto and transit users).

Exhibit 6-15: Survey Area



The field Stated Preference Survey captured:

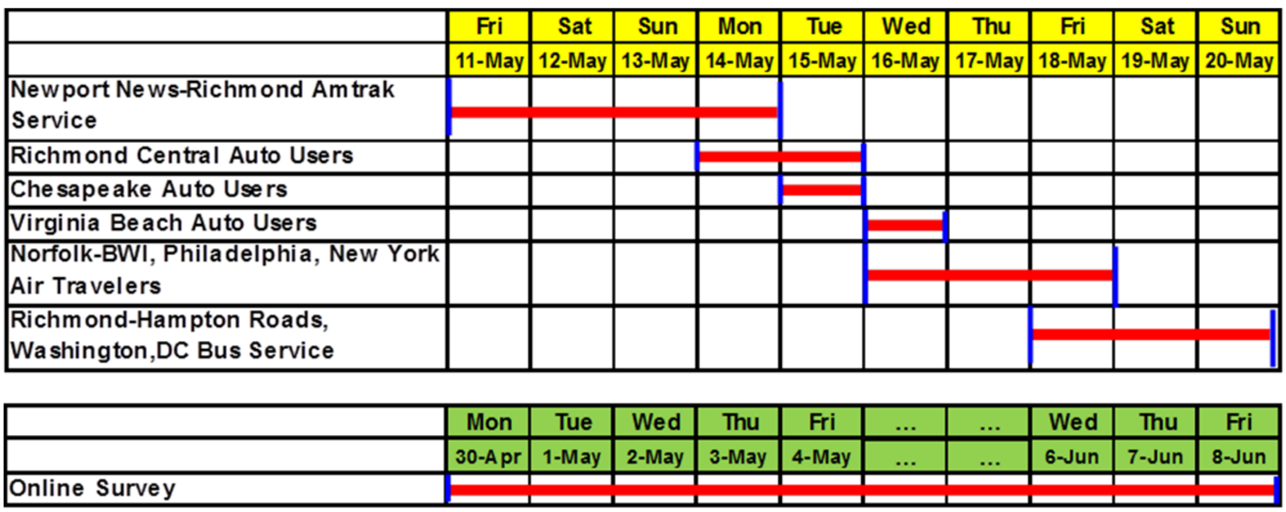
- Rail Users: With the help of Amtrak officials approval, a survey was conducted inside the train station at Richmond, VA capturing both boarding and departing passengers from Newport News to Richmond Amtrak service users and vice versa. The boarding passengers were captured while they were waiting for the train arrivals and departing passengers were captured while they were waiting for their ride;
- Auto Users: With the help of the Virginia Department of Motor Vehicles authority, a survey was conducted at their facilities located at Richmond central, Chesapeake, and Virginia Beach. Patrons were interviewed at these facilities by approaching only those who were seated and were waiting to be called;
- Air Mode Users: With the help of Norfolk International Airport Authority, the air travelers from Norfolk to BWI (Baltimore –Washington Area), to Philadelphia and to New York were interviewed at the baggage claim areas, lobby and outside the security clearance areas;
- Bus Users: With the help of Megabus officials, bus passengers traveling from Richmond to Hampton Roads and Richmond to Washington, DC were interviewed; and

- All Four Mode Users: With the help of Public and Private Organizations such as Virginia Beach Vision, Inc., Greater Williamsburg Chamber & Tourism, Hampton Roads Economic Development Alliance (HREDA) and U.S. NAVY, online survey responses were collected from individuals located in Hampton Roads area, Williamsburg and Newport News area.

Pilot surveys were also conducted prior to actual field and online surveys to test the survey questionnaire. This provided a validation of the survey design and helped the scaling of the stated preference questions so that respondents did “trade” time and cost when filling in the survey forms. Minor adjustments to wording of questions and format were made to improve the readability of the forms. The surveys were kept to one-page, one-side only. Most interviewees filled out the form themselves in 5-10 minutes.

Field and online survey deployment are shown in Exhibit 6-16 The survey was conducted in May 2012 with interviews between May 11, 2012 and May 20, 2012 TEMS collected 2,736 surveys, and exceeded their target range and these results will be discussed in the following section.

Exhibit 6-16: On-Site Survey Team Actual Deployment & Online Survey



6.7.2 SURVEY RESULTS AND ANALYSIS

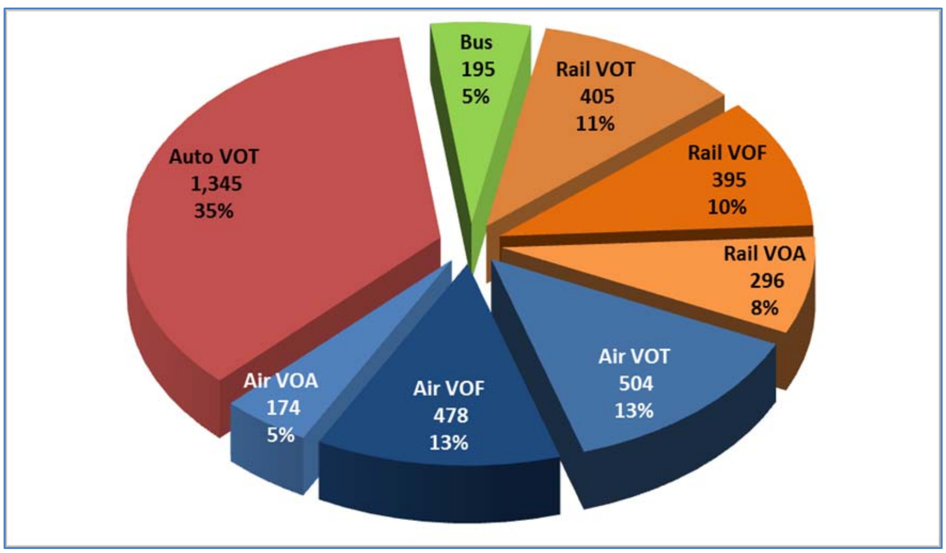
TEMS collected 2,736 surveys, and exceeded their target of 1,900 as shown in Exhibit 6-17 showing exceeded actual survey counts against the survey targets for each location except for bus locations, which almost achieved the target.

Exhibit 6-17: Target vs. Actual Survey Count per Location

Location	Survey Target	Field + Online Count (Actual)
DMV	800	1,377
Airport	500	573
Amtrak	500	690
Bus	100	96
Total	**1,900**	**2,736**

Behavioral attributes reflect the behavior of the respondent when travel conditions change. For the purpose of this study, stated preference surveys collected the information necessary to identify the Value of Time (VOT)[3] for all travelers, the Value of Frequency (VOF)[4] and the Value of Access (VOA)[5]. There were separate forms for each mode and questions were unique for VOT, VOF and VOA. Exhibit 6-18 shows that a total of VOT, VOF and VOA responses for all modes were 3,792.

Exhibit 6-18: VOT, VOF, VOA Counts per Mode[6]



[3] Value of Time (VOT) is the amount of money (dollars/hour) an individual is willing to pay to save a specified amount of travel time.
[4] Value of Frequency (VOF) is the amount of money (dollars/hour) an individual is willing to pay to reduce the time between departures when traveling on public transportation.
[5] Value of Access (VOA) is the amount of money (dollars/hour) an individual is willing to pay for the improved access time to a mode (e.g. the airport, HSR station, railroad station, bus station) to gain easier access to someplace (like airport).
[6] This total count of VOT, VOF and VOA per mode equals 3,792 and these counts are not equal to total survey counts as each transit respondent (most of them) filed out two stated preference questionnaires.

The responses captured by the revealed part of the questionnaire, show that 9% of responses were from commuters and travel to/from school, 14% from business travelers, 77% response was from leisure travelers for all modes as shown in Exhibit 6-19. Other as indicated by the respondents include visit family, friends, graduation, baseball game, etc.

Exhibit 6-19: Purpose of Travel Responses

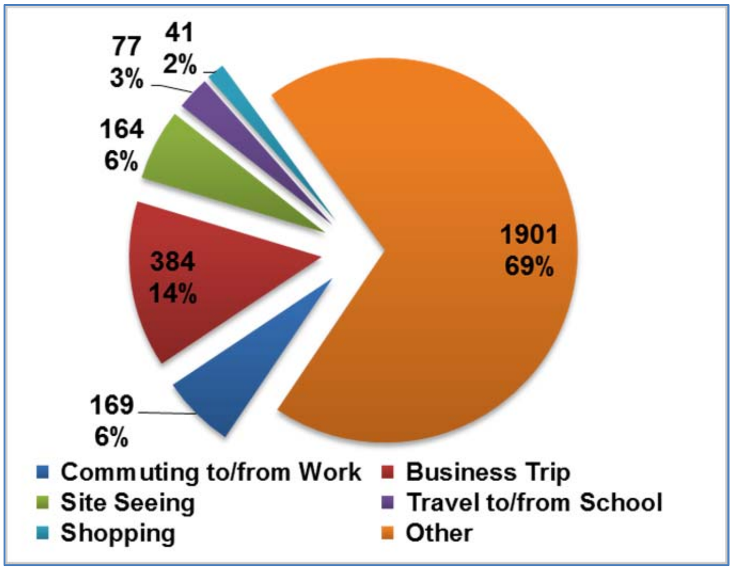
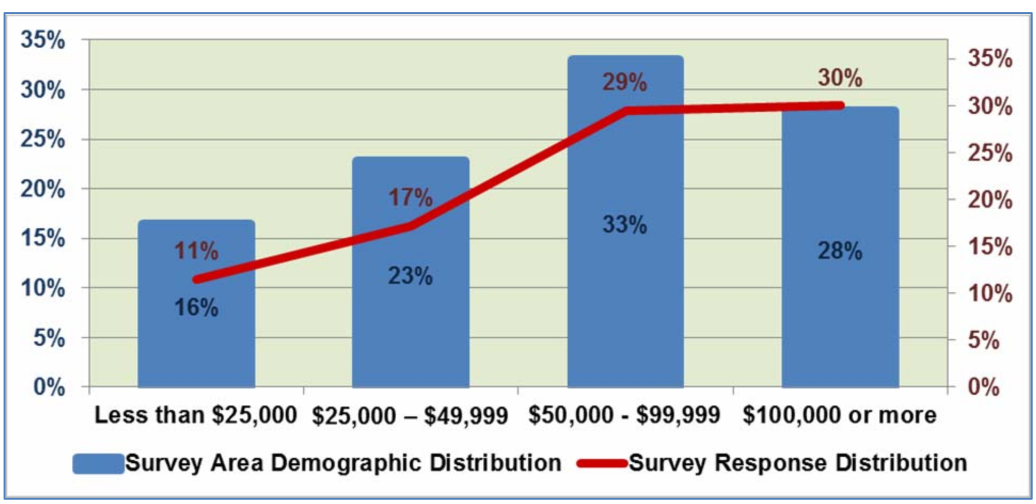


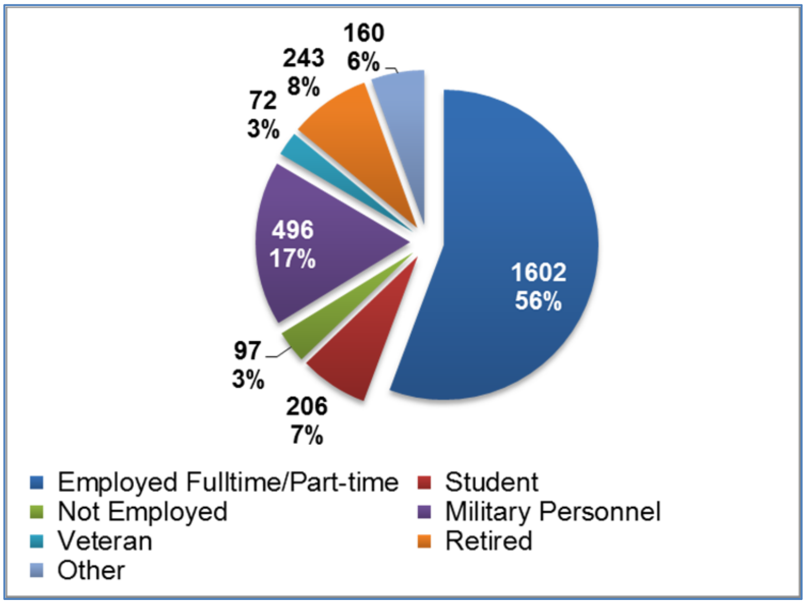
Exhibit 6-20 illustrates distribution of average number of household by income groups along the Survey Study Area corridor in comparison with statistical and survey data. It is seen in the Exhibit that survey responses closely followed most of the demographic distribution with a very slight increase of greater than $100,000 income group. This shows that the survey responses were effectively represented, and the margin of error is only ±6%.

Exhibit 6-20: Distribution of Average Number of Households by Income



The employment type responses from the survey as shown in Exhibit 6-21 was that 56% of the responses were from employed individuals, 17% were from military personnel's, 8% were from retired individuals, 7% were from students, 3% were from veterans, 3% were from unemployed individuals, and 6% were from other where other as indicated by individuals were home-maker, self-employed, etc.

Exhibit 6-21: Employment Type Responses[7]



6.7.3 BEHAVIORAL ATTRIBUTES

Each of these three variables (VOT, VOF and VOA) has been analyzed using the "trade-off' method. The Trade-Off Analysis identifies how individuals choose between time and money in selecting travel options. Two trade-off analysis methods, Binary Logit Method and Direct Comparison Method, were employed to analyze the Attitudinal Survey Data and determine Values of Time (VOT's), Values of Frequency (VOF's), and Values of Access (VOA's).

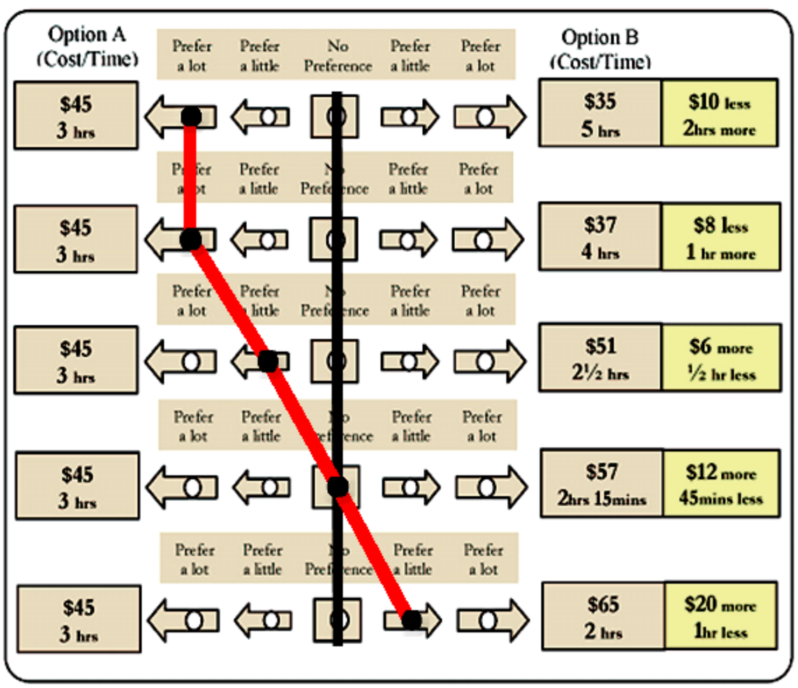
In the Comparison Method, the trade-off choices made by individuals are ranked in descending or ascending (VOT, VOF or VOA) order, along with the individual's choice between time and money and the degree of preference the individual had for that specific trade-off choice. The individual's VOT, VOF or VOA is then determined by identifying the point of inflection, or the point at which an individual changes from spending more time to save money or preferring to spend more money to save time in making a given journey. The Comparison Method provides a clear and detailed understanding of how travelers react to the series of binary choice trade-off questions. Once the individual trade-off values are determined, the results are averaged to give overall population values.

[7] The total count in Exhibit 2-19 is 2,876 which is more than the actual survey count. The reason being respondents with more than one response were counted separately. For example, student respondents who are employed are counted twice.

The Binary Logit Method uses a logit curve to calculate the coefficients of the time and cost variables. The individual's VOT, VOF or VOA is derived as the ratio of time and cost coefficients. While this method is a less subjective and more automatic process than the Comparison Method, the statistical rigidity of the Binary Logit Method frequently provides less understanding of travel behavior and less ability to interpret behavior effectively. Furthermore, because this method cannot incorporate the results for individuals who quite rationally do not make a trade-off (preferring time or money options consistently over the whole range of trade-off choices), the Binary Logit Method can only be used at most aggregate level.

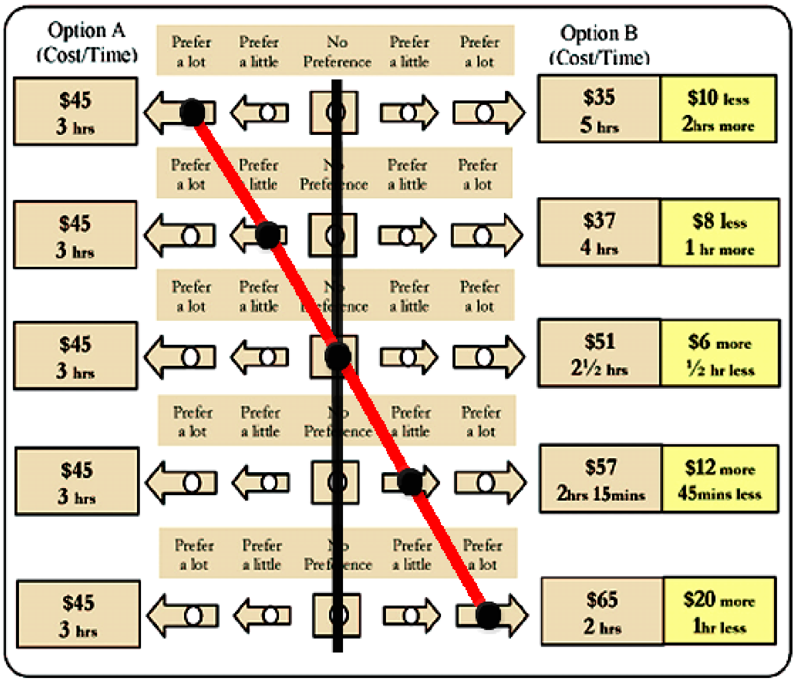
Exhibit 6-22 and 6-23 provides an example of the respondent's trading behavior and illustrates how VOT is calculated using 'trade-off' method. Exhibit 6-23 provides an example of the respondent's non trading behavior[8]. The VOT is calculated for the 'neutral point' located in the intersection between the line indicating 'no preference' and the line connecting the points indicated by the respondent. As seen in Exhibit 6-22 the neutral point or no preference line is located at the fourth row indicating that the respondent is willing to spend $12 more for 45 minutes less. This implies the respondent is willing to spend $16 more for one hour of time saving. Thus, the respondent has a VOT value of $16 per hour.

Exhibit 6-22: VOT calculation based on "Trade-Off" Method: "Trading Behavior"- Example #1



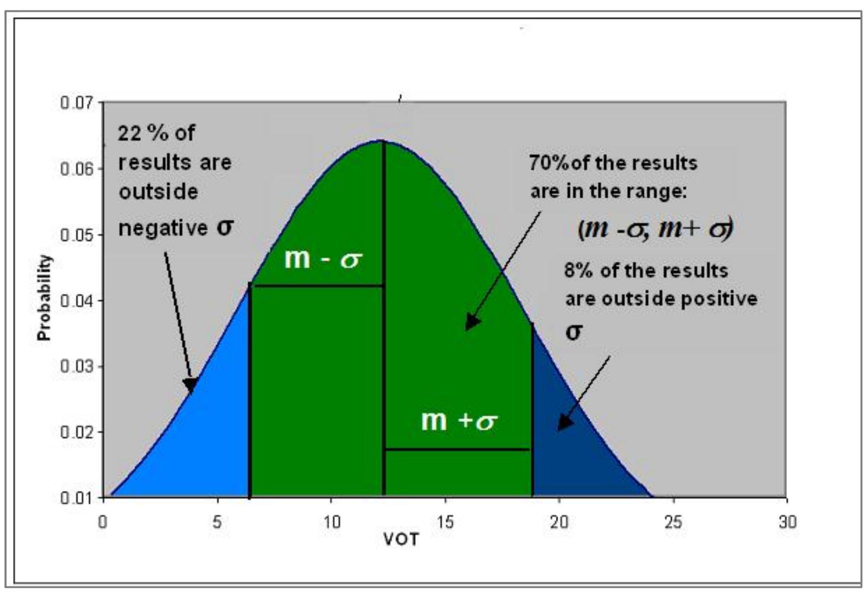
[8] These examples (Exhibit 1-22, 1-23, and 1-25) are drawn from previous TEMS Stated Preference Surveys, and are designed to show how travelers 'trade-off' or 'do not trade-off' between time and cost options.

Exhibit 6-23: VOT calculation based on "Trade-Off" Method: "Trading Behavior" - Example # 2



Not all survey respondents illustrated perfect trading behavior (similar to those shown in Exhibit 6-22 or 6-23). For the data collected, about 30% of the respondents were identified as 'non-traders'. This is shown in Exhibit 6-24, where the 30% (i.e. 22% of very low values of time and 8% of very high values of time) non-traders are equally proportioned between individuals with either very high values of time or very low values of time. The survey is intended to obtain VOT's from the 70% in the middle (i.e., one standard deviation). This is illustrated in Exhibit 6-24.The 30% non-trading behavior example is shown in Exhibit 6-25.

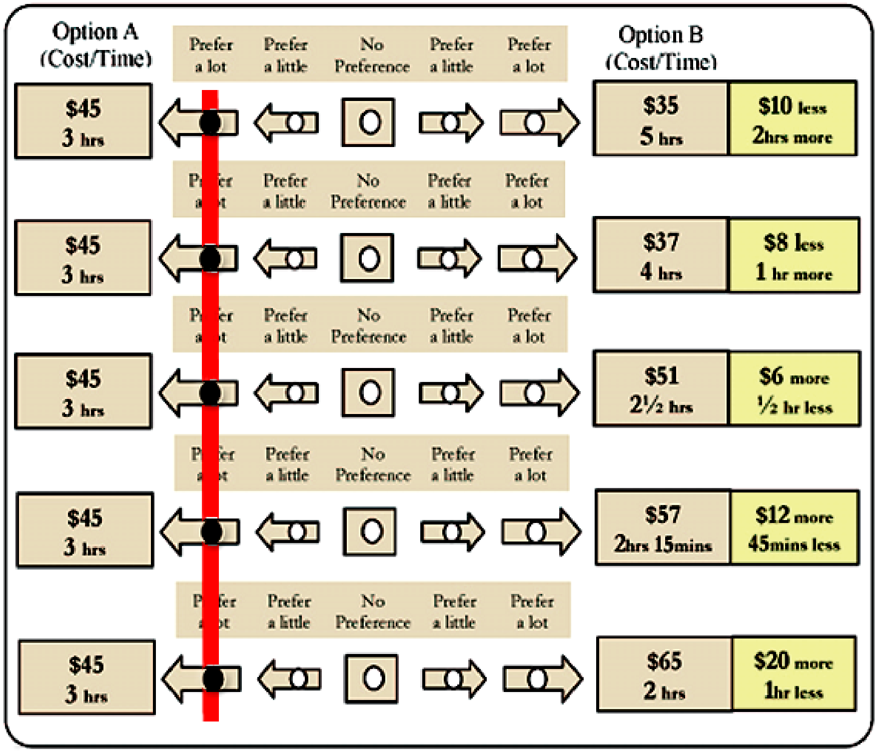
Exhibit 6-24: Distribution of the Non Respondent Error in the Trade-off Analysis of the Collected Survey Data[9]



[9] Normal distribution with one standard deviation above the mean.

VOT calculated based on the example shown in Exhibit 6-25 is assumed to be $45 for three hours ($15 per hour) or less as there is no trading, and the individual is showing a preference to spend time rather than money.

Exhibit 6-25: VOT calculation based on '"Trade-Off" Method: "Non Trading Behavior"



The Stated Preference Survey results of VOT, VOF and VOA calculated for four modes (auto, rail, bus, and air) and three types of purpose (commuter, business and other) are presented in Exhibits 6-26 through 6-28. Based on the calculations, the following observations were made:

- The hierarchical order of VOT is higher for Air access, rail, auto and then bus users., which is the typical trend;
- Business trips have larger VOT, VOF and VOA values than commuter and other trips;
- The VOT, VOF and VOA values are consistent with those of previous studies (e.g., Bay Bridge Travel Survey, 2006, Rocky Mountain Rail Authority (RMRA), 2008) after adjusting to 2012 dollars for similar trip length
- Intercity value of time is larger than intraurban value of time due to longer trip length, this explains why commuters have lower value of time, which have more intraurban trips than other trip purposes

Exhibit 6-26: VOT values by Mode and Purpose of Travel

Value of Time VOT	Business	Commuter	Social
Auto	$19.42	$14.80	$16.88
Bus	$11.07	$7.15	$8.54
Rail	$22.51	$18.80	$17.88
Air	$44.45	-	$31.76

Exhibit 6-27: VOF values by Mode and Purpose of Travel

Value of Frequency VOF	Business	Commuter	Social
Bus	$7.33	$6.50	$7.75
Rail	$18.58	$13.67	$16.13
Air	$28.81	-	$26.28

Exhibit 6-28: VOA values by Mode and Purpose of Travel

Value of Access VOA	Business	Commuter	Social
Bus	-	$8.89	$10.77
Rail	$42.73	$29.15	$37.66
Air	$62.91	-	$47.94

6.8 Future Travel Market Strategies

6.8.1 Fuel Price Forecasts

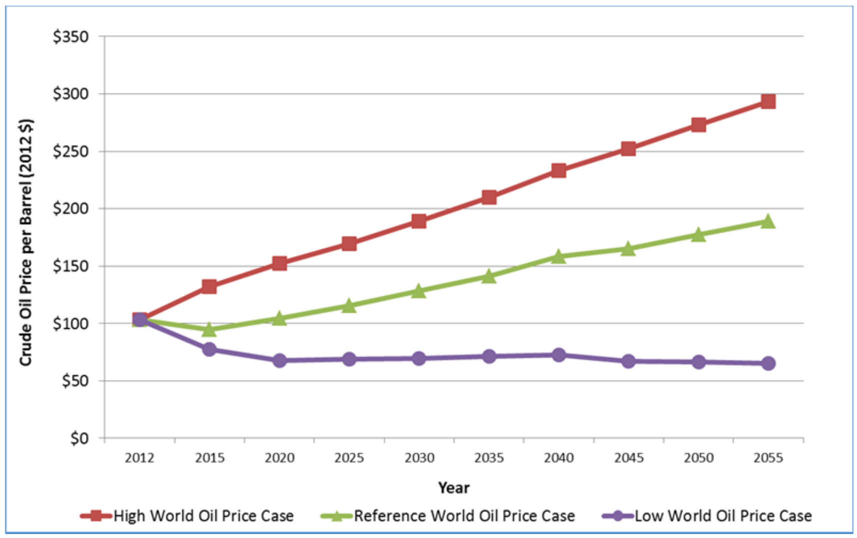
An important factor in the future attractiveness of passenger rail is fuel price. Exhibit 6-28 shows the Energy Information Agency (EIA)[10] projection of crude oil prices for three oil price cases, namely high world oil price case that is aggressive oil price forecast, reference world oil price case that is moderate and is also known as the central case forecast, and the conservative low world oil price case. In this study, the reference case oil price projection was used to estimate transportation cost in future travel market. EIA projects oil price to 2040, the oil price projections after 2040 were estimated based on historical prices and EIA projections. The EIA reference case forecast suggests that crude oil prices are expected to

[10] EIA periodically updates historical and projected oil prices at www.eia.gov/forecasts/aeo/tables_ref.cfm

be $116 per barrel (2012$) in 2025 and will remain at that high level and will increase to $142 per barrel (2012$) in 2035.

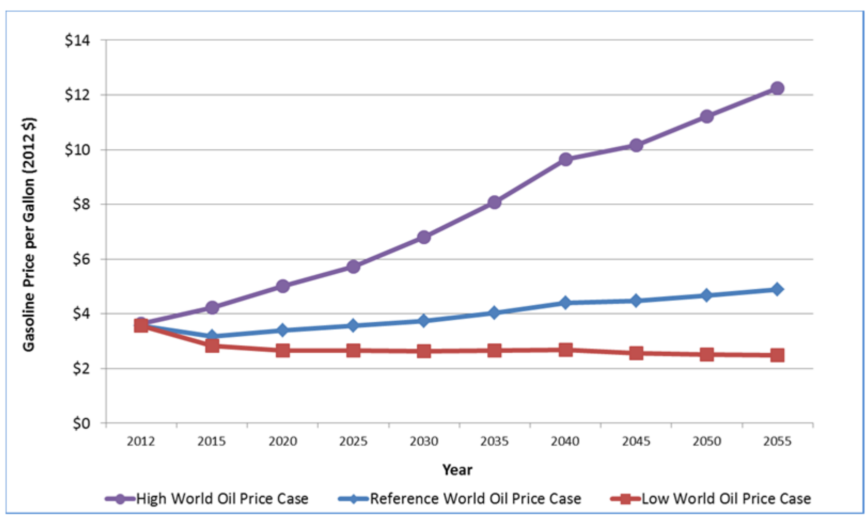
EIA has also developed a future retail gasoline price forecast, which is shown in Exhibit 6-29. The implication of this is a reference case gasoline price of $3.6 per gallon (2012$) in 2025, with a high case price of $5.7 per gallon and a low case price of $2.7 per gallon. Since 2012 annual average gas price of Midwest region is about $3.6[11] per gallon in a weak economy environment, $4~5 per gallon once the economy starts to grow again seems likely.

**Exhibit 6-28:
Crude Oil Price Forecast by EIA**



*EIA projections go to 2040, projections beyond 2040 were extrapolated

**Exhibit 6-29:
U.S. Retail Gasoline Prices
Forecast by EIA**



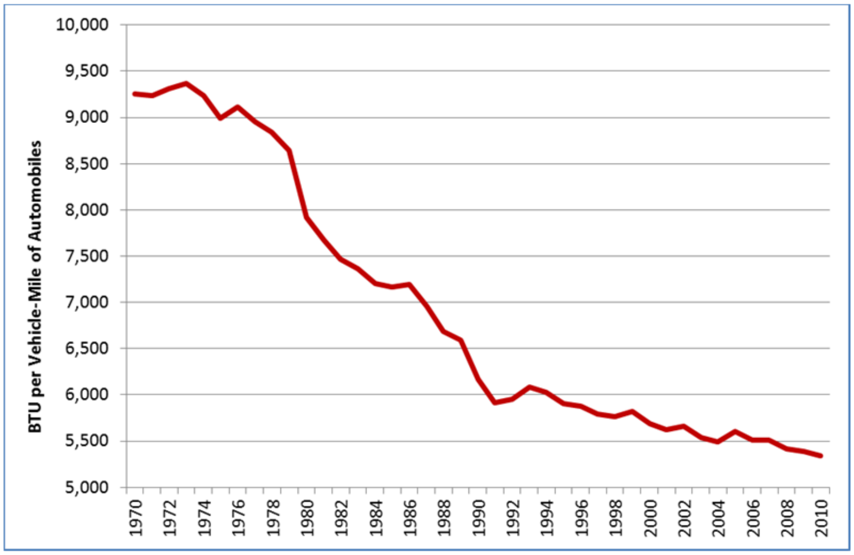
*EIA projections go to 2040, projections beyond 2040 were extrapolated

[11] Weekly Retail Gasoline and Diesel Prices from EIA http://www.eia.gov/dnav/pet/pet_pri_gnd_a_epmr_pte_dpgal_a.htm

6.8.2 VEHICLE FUEL EFFICIENCY FORECASTS

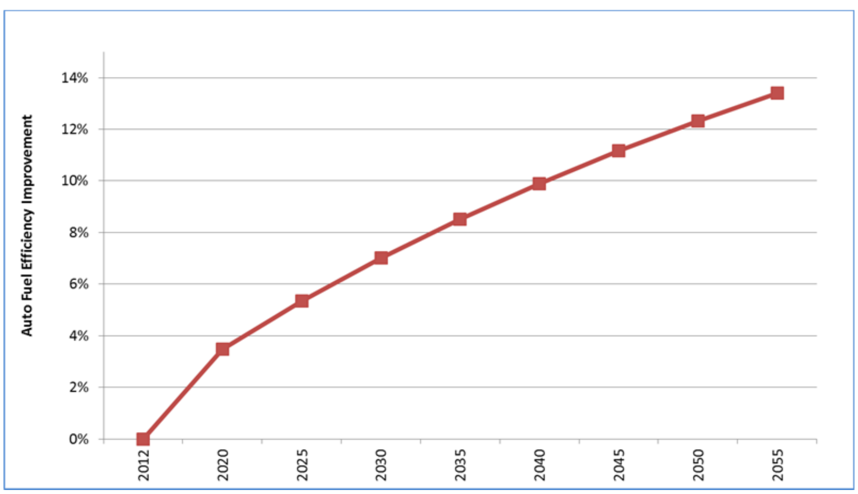
Future improvement in automobile technology is likely to reduce the impact of high gas prices on automobile fuel cost with better fuel efficiency. The Oak Ridge National Laboratory (ORNL) Center for Transportation Analysis (CTA) historical automobile highway energy intensities data has the historical Btu (British thermal unit) per vehicle-mile data for automobiles since 1970 as show in Exhibit 6-30.

Exhibit 6-30: ORNL Historical Highway Automobile Energy Intensities Data



From Exhibit 6-31 it can be seen that automobile fuel efficiency has been improving gradually during the past few decades but the improvement has slowed down in recent years. Future automobile fuel efficiency improvement that was projected and shown in Exhibit 6-31 was based on the historical automobile fuel efficiency data. It shows that the automobile fleet fuel efficiency is expected to improve by nearly 13 percent by 2055.

Exhibit 6-31: Auto Fuel Efficiency Improvement Projections



6.8.3 HIGHWAY TRAFFIC CONGESTION

The average annual travel time growth in the corridor is estimated with the projected highway traffic volume data and the BPR (Bureau of Public Roads) function that can be used to calculate travel time growth with increased traffic volumes:

$$T_f = T_b * [1 + \alpha * \left(\frac{V}{C}\right)^{\beta}]$$

where

T_f is future travel time,

T_b is highway design travel time,

V is traffic volume,

C is highway design capacity,

α , β are calibrated coefficients.

The future highway link volumes are forecasted based on the historic Annual Average Daily Traffic (AADT) from VDOT[12]. Exhibit 6-32 shows historic AADTs and annual average growth rate (AAGR) for six segments on two major highway corridors of the study areas: Interstate 64 and Route 460. As shown in the exhibit, the traffic growth in these two corridors since 2000 is strong. Without significant improvement on these two corridors or building new alternatives, the congestions on these highways will become more and more serious.

Exhibit 6-32: Historic AADT of I64 and Route 460

Route	From	To	2011	2010	2009	2005	2000	AAGR
I64	I-295	New Kent County Line	69,000	68,000	69,000	67,000	62,000	1.0%
I64	SR 33 Eltham Rd	James City County Line	52,000	53,000	54,000	47,000	39,000	2.6%
I64	SR 238 Yorktown Rd	SR 105 Ft Eustis Blvd	88,000	88,000	83,000	86,000	71,000	2.0%
Rte. 460	I-295	74-629	14,000	15,000	16,000	16,000	13,000	0.7%
Rte. 460	Windsor East County Line	Suffolk West County Line	17,000	14,000	14,000	16,000	11,000	4.0%
Rte. 460	Suffolk East County Line	I-664	67,000	67,000	68,000	67,000	55,000	1.8%

[12] http://www.virginiadot.org/info/ct-TrafficCounts.asp

Exhibit 6-33 shows the estimated travel time growths in 2025 for two city pairs in the study area due to increasing highway traffic volumes.

Exhibit 6-33: Highway Travel Time Projections for Two City Pairs

	2012 Travel Time	2025 Estimated Travel Time
Norfolk, VA - Richmond, VA	1Hour40Min	1Hour55Min
Norfolk, VA - Petersburg, VA	1Hour35Min	1Hour43Min

The projected travel times in Exhibit 6-33 are calculated by applying BRP function with forecasted link volumes and capacity. The key assumptions of parameter are same as used in 2004 HRTPO Roads Travel Demand Model[13]. For example, suburban Interstate has the following parameters

- α = 0.15
- β = 4
- Lane capacity = 1875
- Highway link capacity does not change with time

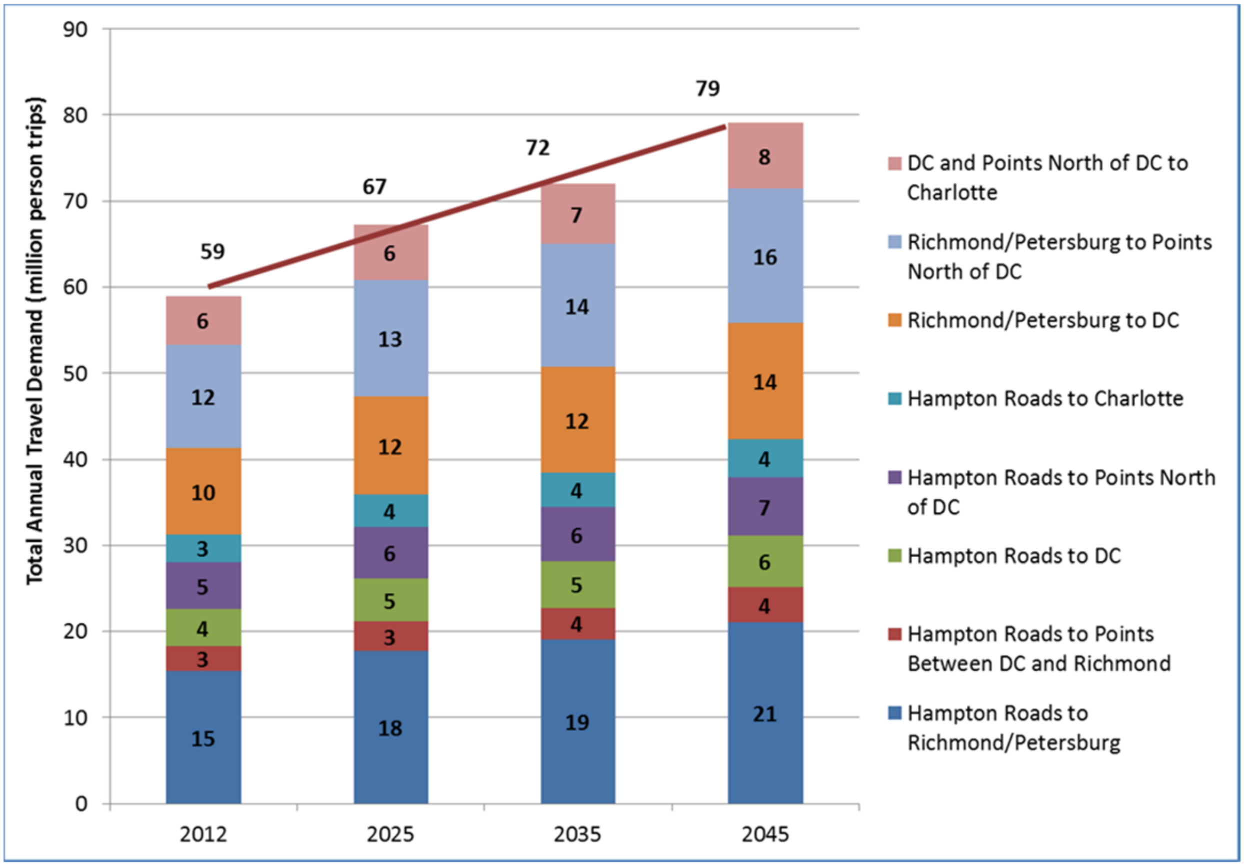
For example, a highway segment around on I64 has seen a traffic volume increase from 39,000 vehicles per day to 85,500 vehicles per day from 2011 to 2025. By applying the BPR function while assuming same route is used between these two cities in the future, it can be calculated that travel time on this highway segment will increase by about 0.5% per year with the BPR function.

6.9 Corridor Total Travel Market Demand Forecast

This section presents the Hampton Roads – Richmond - Washington Corridor Total Travel Demand Forecast produced from the results of the *COMPASS*™ Total Demand Model application. While the COMPASS™ analysis considers intercity travel from Boston to Charlotte (See Exhibit 6-4) but is presenting in this section only the demand in the Hampton Roads – Richmond – Washington Corridor. Exhibit 6-34 shows the Hampton Roads – Richmond - Washington Corridor total travel demand forecasts for 2025, 2035, and 2045. It can be seen that the corridor travel demand will increase to 67 million in 2025, to 72 million in 2035, and increases to 79 million in 2045. The average annual corridor travel market growth rate is 0.9 percent, which is in line with the socioeconomic growth within the corridor.

[13] 2000 Hampton Roads Model Validation Memorandum, Virginia Department of Transportation, May 2004

Exhibit 6-34: Study Area Travel Market Forecast – Annual Person Trips for the Whole Study Area that Extends from Boston to Charlotte



6.10 CORRIDOR TRAVEL MARKET FORECASTS FOR PASSENGER RAIL

The specific ridership and revenue is dependent on the level of train service proposed. Exhibit 6-35 presents the summary of passenger rail service assumptions (strategies) for the passenger rail ridership and revenue forecast. The rail service plan includes station stopping pattern number, train running times for 130 mph and 220 mph options.

Exhibit 6-35: Norfolk to Washington High Speed Train Stopping Pattern

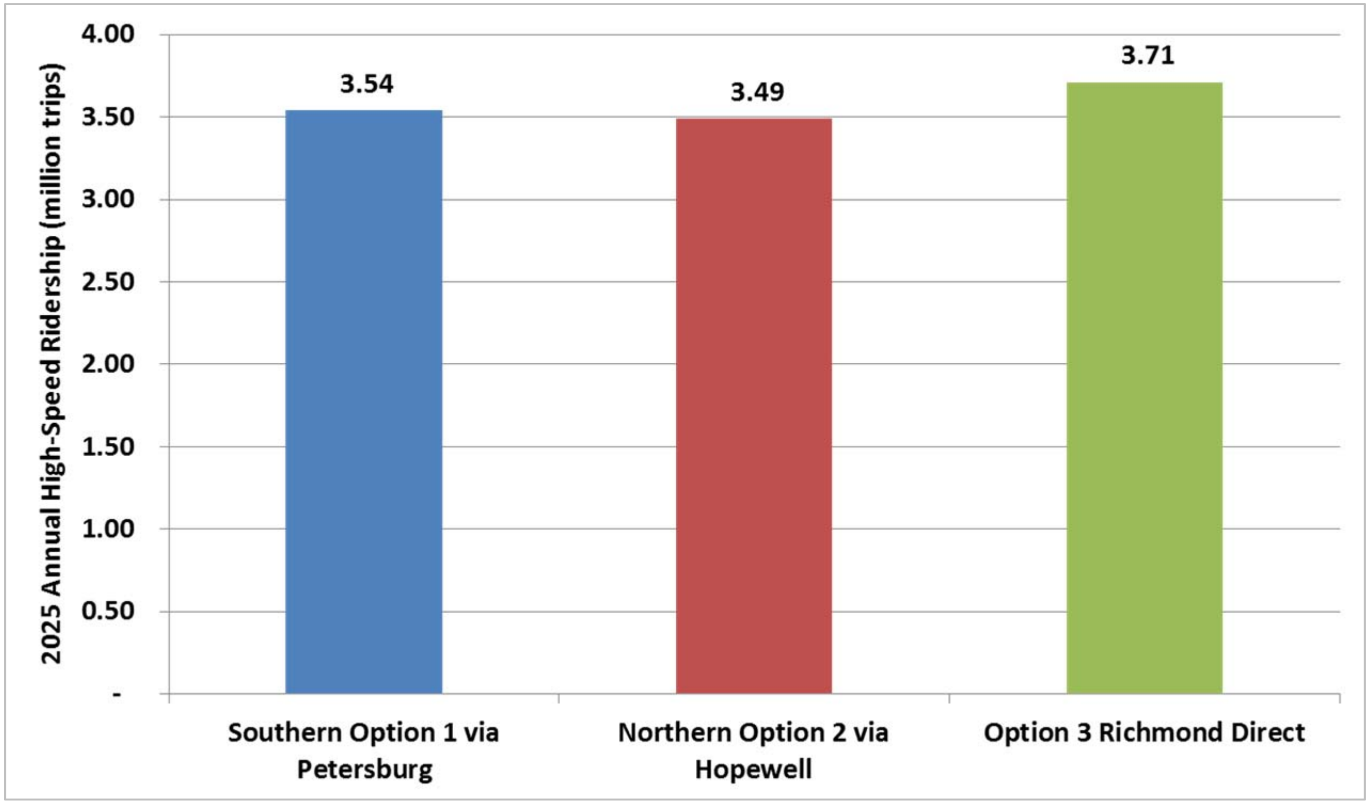
Stations	Super Express	Express	Local
Norfolk	√	√	√
Bowers Hill	√	√	√
Suffolk	–	–	√
Petersburg/Hopewell*	–	√	√
Richmond Main St	√	√	√
Ashland	–	–	√
Fredericksburg	–	√	√
Quantico	–	–	√
Alexandria	√	√	√
Washington Union	√	√	√
130-mph Total Trains	4 trains	5 trains	4 trains
130-mph Time via Petersburg/Hopewell	2:36	2:46	3:01
130-mph Time Richmond Direct	2:31	2:36	2:51
220-mph Total Trains	5 trains	10 trains	3 trains
220-mph Time via Petersburg/Hopewell	1:45	1:55	2:10
220-mph Time Richmond Direct	1:38	1:43	1:58

* Stations Bypassed by Richmond Direct

Using different route and train service plans, Exhibits 6-36 and 6-37, present the passenger rail ridership forecasts for the Hampton Roads – Richmond – Washington Corridor for 2025. The passenger rail system generates 3.66 to 3.73 million trips in 2025 for 130-mph options. For 220-mph options, the ridership ranges from 5.28 to 5.38 million trips. A trip is defined as a passenger making a one-way trip and a round trip generates two one way trips.

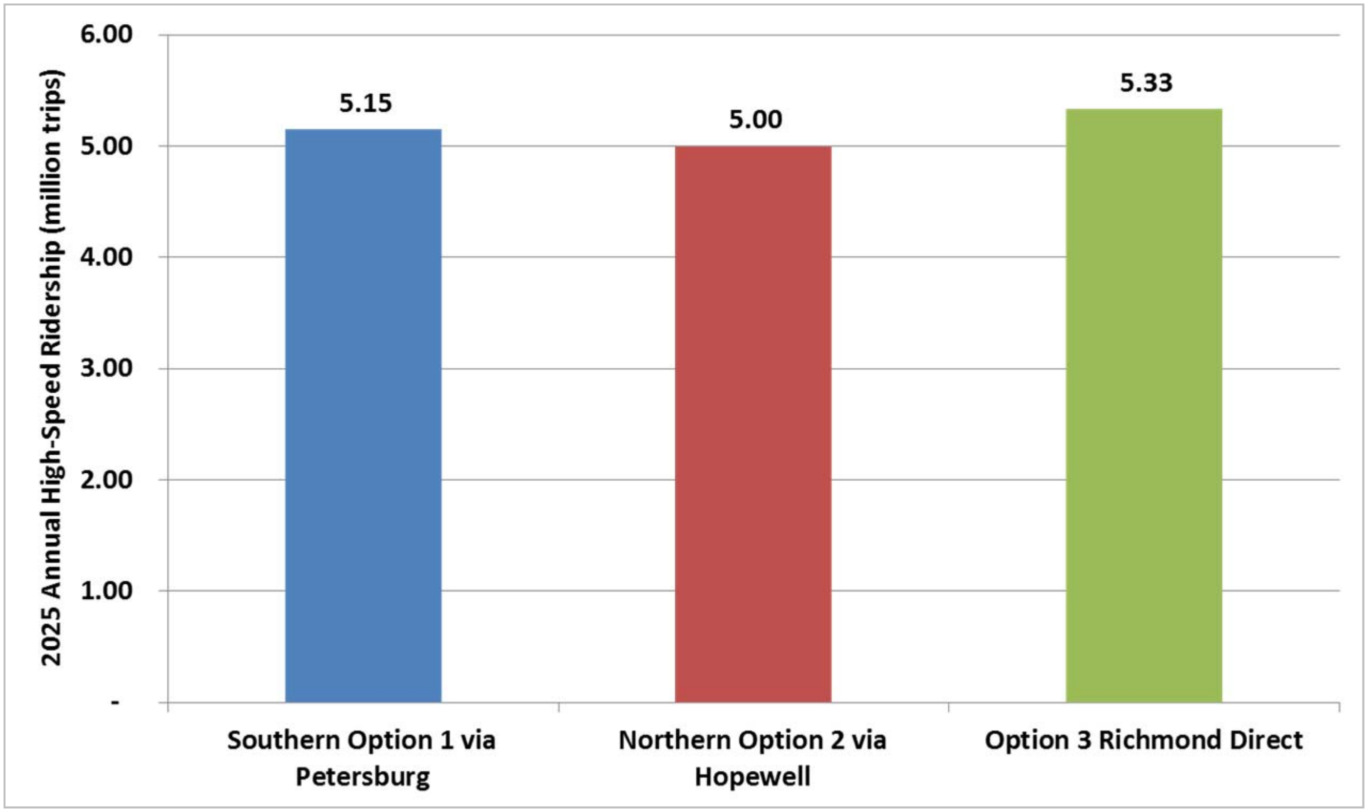
Exhibits 6-38 and 6-39 shows the annual fare-box revenue for years 2025. It can be seen that the annual revenue of 2025 is $185 to 195 million for the 130-mph options and is 316 to 331 million for 220-mph options. All revenue forecasts are presented in 2012 dollar values.

Exhibit 6-36: 130-mph High Speed Passenger Rail Ridership Forecast-Annual Person Trips for the Southside Option that Extends from Boston to Charlotte



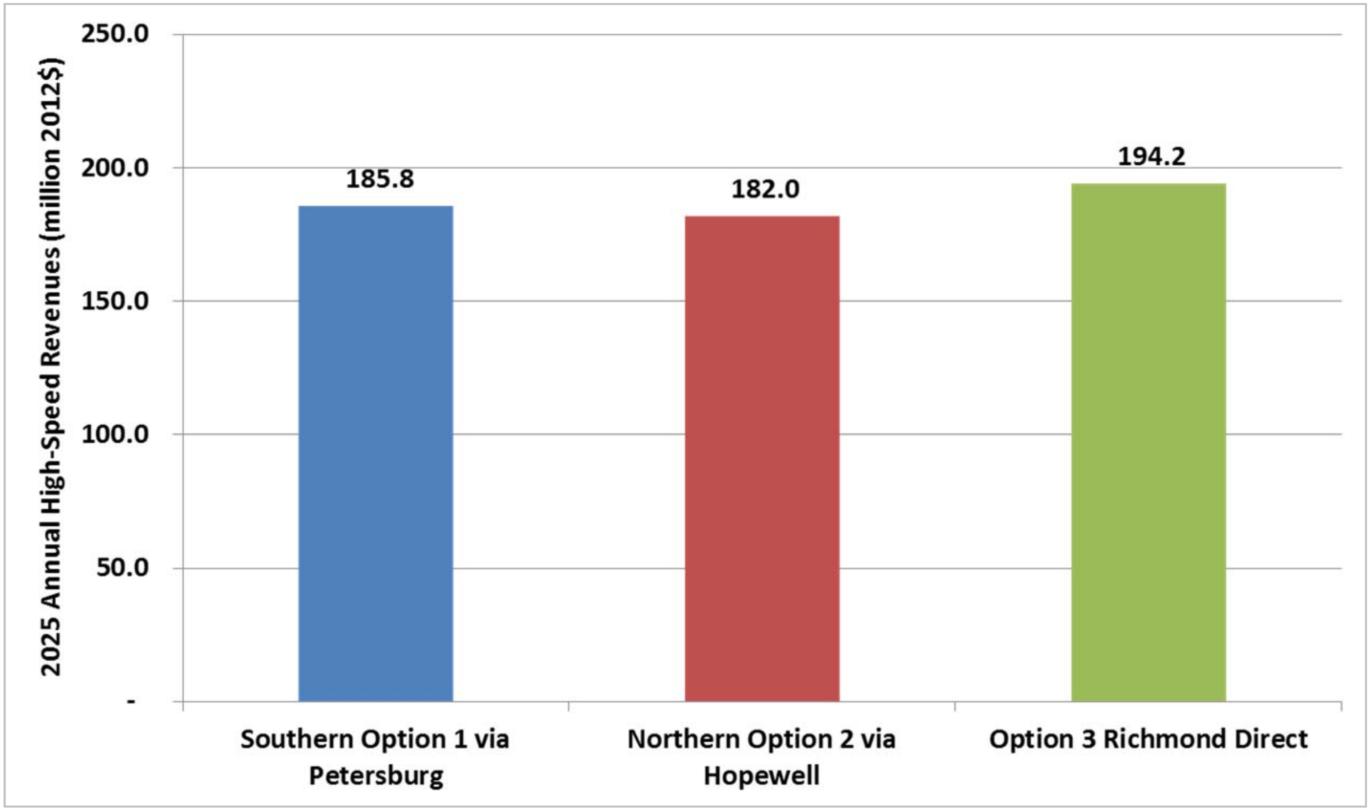
	Southern Option 1 via Petersburg	Northern Option 2 via Hopewell	Option 3 Richmond Direct
Hampton Roads to Richmond/Petersburg	0.30	0.29	0.33
Hampton Roads to points between DC and Richmond	0.47	0.47	0.59
Hampton Roads to DC	0.69	0.69	0.82
Hampton Roads to points North of DC	0.28	0.28	0.32

Exhibit 6-37: 220-mph High Speed Passenger Rail Ridership Forecast-Annual Person Trips for the Southside Option that Extends from Boston to Charlotte



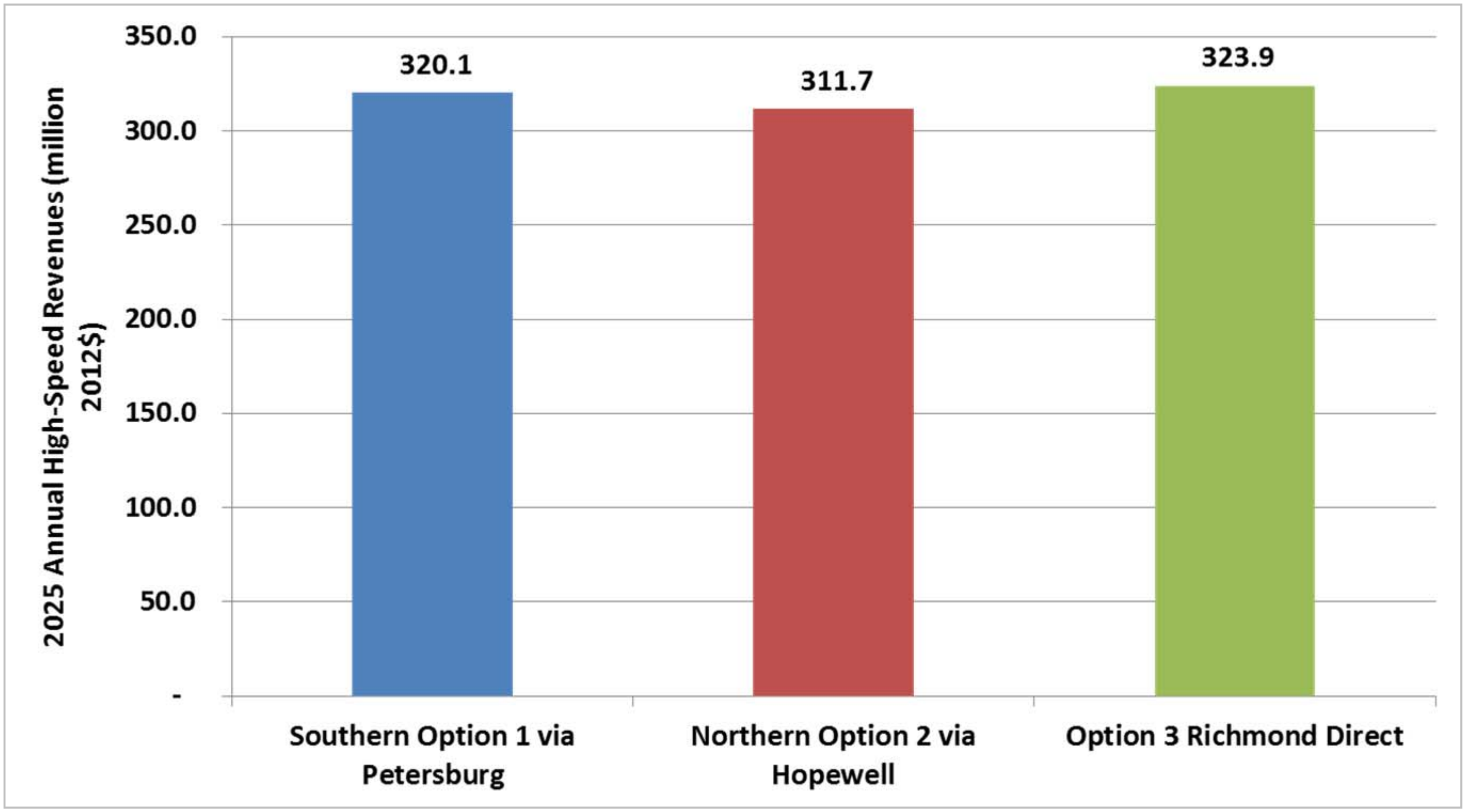
	Southern Option 1 via Petersburg	Northern Option 2 via Hopewell	Option 3 Richmond Direct
Hampton Roads to Richmond/Petersburg	0.45	0.45	0.50
Hampton Roads to points between DC and Richmond	0.87	0.87	1.01
Hampton Roads to DC	1.13	1.13	1.27
Hampton Roads to points North of DC	0.55	0.55	0.62

Exhibit 6-38: 130-mph High Speed Passenger Rail Revenue Forecast-Annual Revenue for the Southside Option that Extends from Boston to Charlotte



	Southern Option 1 via Petersburg	Northern Option 2 via Hopewell	Option 3 Richmond Direct
Hampton Roads to Richmond/Petersburg	7.52	7.47	8.36
Hampton Roads to points between DC and Richmond	34.56	34.54	40.83
Hampton Roads to DC	58.42	58.39	66.36
Hampton Roads to points North of DC	22.31	22.33	24.50

Exhibit 6-39: 220-mph High Speed Passenger Rail Revenue Forecast-Annual Revenue for the Southside Option that Extends from Boston to Charlotte

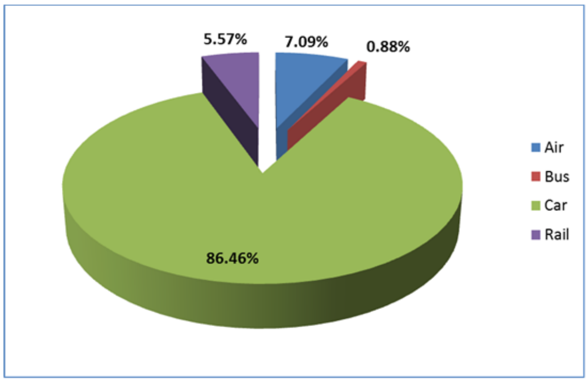


	Southern Option 1 via Petersburg	Northern Option 2 via Hopewell	Option 3 Richmond Direct
Hampton Roads to Richmond/Petersburg	14.54	14.45	15.81
Hampton Roads to points between DC and Richmond	69.17	69.09	75.85
Hampton Roads to DC	102.15	102.06	108.41
Hampton Roads to points North of DC	49.33	49.05	53.47

The corridor transportation mode market share forecasts in 2025 are shown in Exhibits 6-40 thru 6-42. The auto mode continues to demonstrate its dominance in the corridor maintaining a market share above 84 percent in 2025. Rail market share will increase to more than five percent for 130-mph options, and will be around eight percent for 220-mph options. Air market share will be around seven percent. Bus market share will remain less than one percent.

Exhibit 6-40: Intercity Travel Market Share Forecast – Southern Option 1 via Petersburg 2025

130 MPH



220 MPH

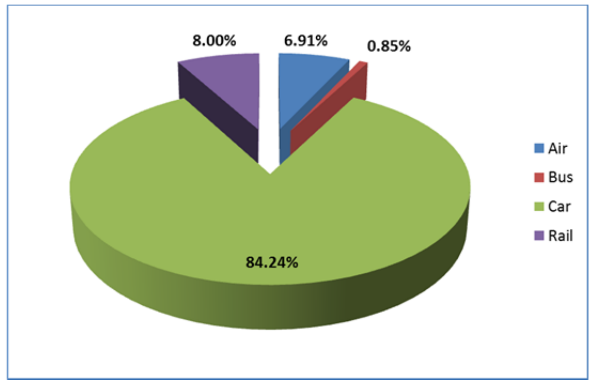
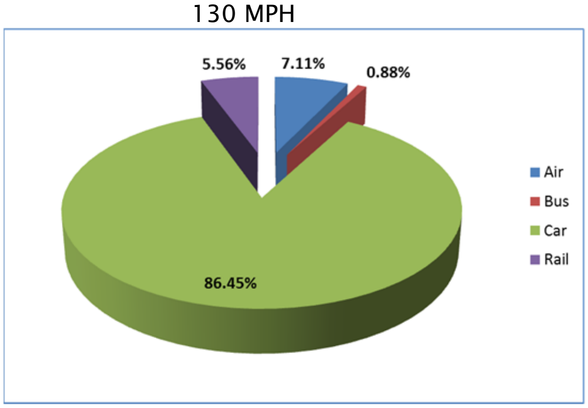


Exhibit 6-41: Intercity Travel Market Share Forecast – Northern Option 2 via Hopewell 2025

130 MPH



220 MPH

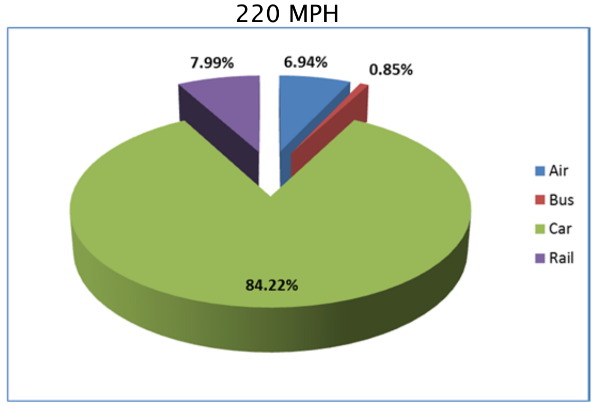
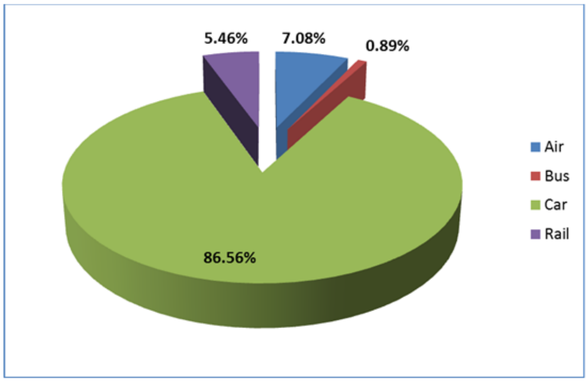
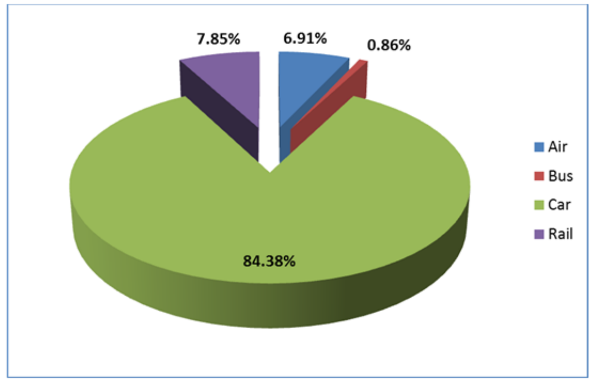


Exhibit 6-42: Intercity Travel Market Share Forecast – Option 3 Richmond Direct 2025

130 MPH



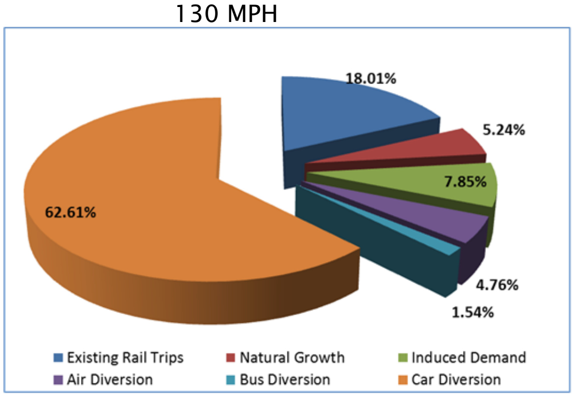
220 MPH



Exhibits 6-43 thru 6-45 illustrate the sources of the rail trips. The trips diverted from other modes-primarily auto, are the most important source of rail trips, which accounts for 68 to 73 percent of overall rail travel market. Induced travel demand in the corridor as result of the new passenger rail service is 7.8 to 11 percent of the rail travel market. As for the diverted trips from other modes, more than 90 percent trips are from auto mode, but the auto driving still dominates future travel market, as this is still a very effective option for shorter trips in the current Hampton Roads – Richmond – Washington Corridor.

Exhibit 6-43: Sources of HSR Trips- Southern Option 1 via Petersburg 2025

130 MPH



220 MPH

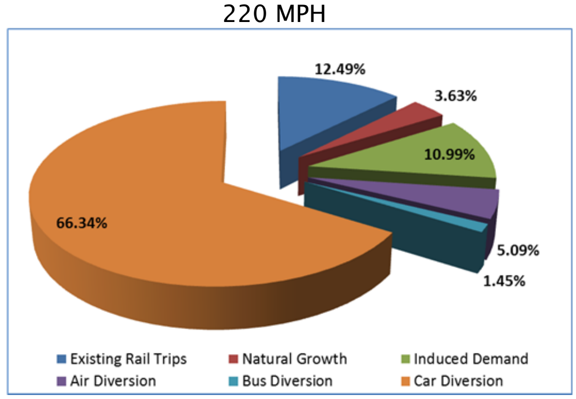
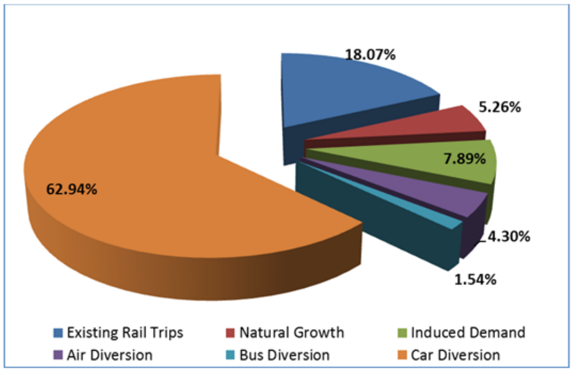


Exhibit 6-44: Sources of HSR Trips- Northern Option 2 via Hopewell 2025

130 MPH



220 MPH

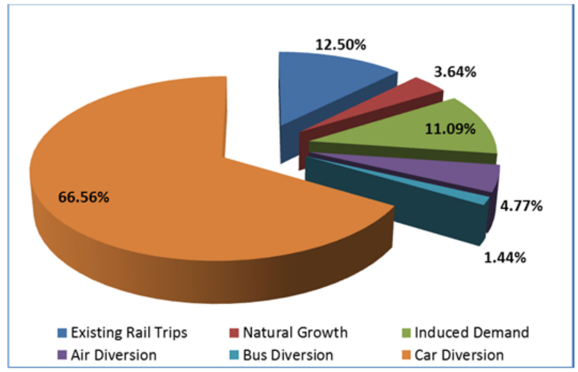
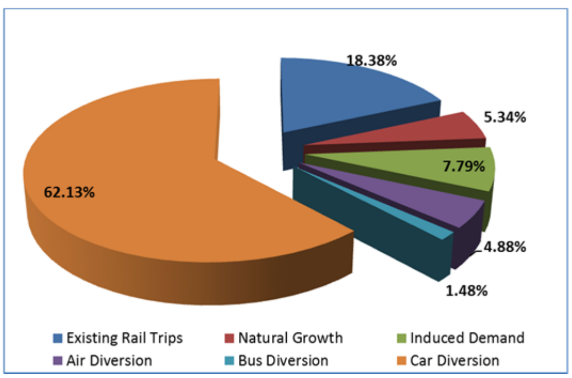
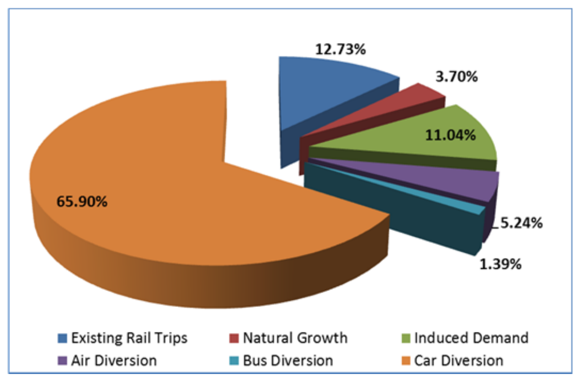


Exhibit 6-45: Sources of HSR Trips- Option 3 Richmond Direct 2025

130 MPH



220 MPH



7. Financial and Economic Analysis

The Financial and Economic Analysis describes the USDOT FRA criteria used to assess the route and technology options. It defines the criteria and describes the process used to estimate the financial and economic benefits of the system. It provides both the financial and economic results for each option.

7.1 Evaluation of Alternatives

7.1.1 Study Objectives

This analysis uses the same criteria (updated to include Tiger Grant criteria) and structure as the 1997 FRA Commercial Feasibility Study. This study set out criteria for establishing a public-private partnership between the Federal government, State and local communities, and the private sector for intercity rail projects. The study described two conditions that were considered essential for receiving Federal funding support for proposed intercity passenger rail projects:

- An operating cost ratio of at least 1.0, defined as a pre-condition for an effective public/private partnership, so that once the system has been constructed, a private operator could operate the system on a day-to-day basis without requiring an operating subsidy, and
- A benefits/cost ratio greater than 1.0, to ensure that the project makes an overall positive contribution to the economy, at both the regional and national levels.

The Commercial Feasibility Study makes it clear that "federal consideration of specific High-Speed Ground Transportation project proposals could apply additional criteria that could differ from, and be much more stringent than, this report's threshold indicators for partnership potential."

Operating ratios are usually expressed on a year-by-year basis, but they can also be expressed as a Present Value of Revenue / Present Value of Operating Cost over the lifetime of a project.

Benefit Cost ratios are usually expressed as a Present Value of Total Benefit / Present Value of Total Cost over the lifetime of a project.

At a feasibility level of study, analysis is based on a number of assumptions that are needed to carry out the analysis. These assumptions include such factors as: rate of socioeconomic growth, rate of demographic growth, rate of energy price increase and the capital cash flows in accordance with a multi-year, implementation plan. Once more detailed assessments are made and more specific information on the rate of ridership and revenue growth and a system implementation plan detailing the capital cash flows become available, then that information can be included to further refine the initial estimates of the Financial Return and Benefit Cost ratio.

This chapter describes the process by which the alternatives were evaluated and how this analysis lead to the identification of a number of feasible options based on the economic and financial criteria adopted.

7.2 Financial and Economic Objectives

For each alternative being evaluated, measures of financial and economic efficiency were calculated. These measures were determined from assessments integrating the forecasted capital, operating and maintenance costs with the forecasted revenue projections over the lifetime of the project. Specifically, the analysis was based on the following components:

- Operating and implementation plans for the alternative passenger rail service options
- Cost estimates for operations, infrastructure and acquisition of rolling stock
- Ridership and revenue estimates based on projected travel demand. These forecasts include assumptions regarding fare levels and oil prices, highway congestion and the responsiveness of the air industry to the introduction of the Diesel 130-mph and Electric 220-mph Alternatives.
- Cash flow analysis that includes statements of revenues and expenses for each alternative.

Two measures, net present value (NPV) and Benefit Cost ratio were used to evaluate the economic returns of the system. Similar measures, net present value (NPV) and Operating ratio, were used to evaluate the financial returns and the potential for franchising the operations

Both measures require the development of a project's year-by-year financial and economic returns, which are then discounted to the base year to estimate present values (PV) over the lifetime of the project. For this analysis, a 25-year project life from 2025 to 2050 was assumed, with a ten year implementation period from 2015-2024. Revenues and cost cash flows were discounted to the 2012 base year using two discount rates: 3 percent and 7 percent. The 3 percent discount rate reflects the real cost of money in the market as reflected by the long term bond markets, and the 7 percent discount rate reflects the Federal government's desire to establish a benchmark comparison by discounting long term benefits at a greater rate than the market for public securities.

The operating ratios reported here in this chapter, follow a commercial criteria definition; but are different from the commercial operating ratio calculations that are typically presented by freight railroads and intercity bus companies. For the current analysis, the selected feasibility criteria were as follows:

- The Operating Ratio as calculated here includes direct operating costs only. The operating ratio calculations presented here do not include capital costs, depreciation or interest. The costs used are incremental costs.
- The Operating Ratio presented here is defined as Revenues/Costs. It should be noted that freight railroads and intercity bus companies typically define it as the reciprocal Costs/Revenues.

As defined by this analysis, a positive operating ratio does not imply that a passenger service can attain full financial profitability by covering its capital costs, but it does allow the operation to be franchised and operated by the private sector. The definition puts passenger rail on the same basis as other passenger transportation modes, such as intercity bus and air, where the private sector operates the system but does not build or own the infrastructure it uses. It does, however, pay access fees to the freight railroads where they own the track. In the case of passenger rail, these would include track access costs. All calculations are performed using the standard financial formula, as follows:

Financial Measure:

$$\text{Operating Ratio} = \frac{\text{Financial Revenues}}{\text{Operating Costs}}$$

Economic Measures:

Net Present Value = Present Value of Benefit – Present Values of Costs

$$\text{Benefit Cost Ratio} = \frac{\text{Present Value of Revenues}}{\text{Present Value of Costs}}$$

Present Value is defined as:

$$PV = \sum_t \frac{C_t}{(1+r)^t}$$

Where:

PV = Present value of all future cash flows

C_t = Cash flow for period t

r = Discount rate reflecting the opportunity cost of money

t = Time

In terms of Economic Benefits, a positive NPV and Benefit Cost Ratio imply that the project makes a positive contribution to the economy. For this analysis, revenues and cost cash flows were discounted to the 2012 base year using two discount rates: 3 percent and 7 percent. The 3 percent discount rate reflects the real cost of money in the market as reflected by the long term bond markets, and the 7 percent discount rate reflects the Federal government's desire to establish a benchmark comparison by discounting long term benefits at a greater rate than the market for public securities. Consistent with standard practice, Benefit Cost ratios are calculated from the perspective of the overall society without regard to who owns particular assets receives specific benefits or incurs particular costs.

7.2.1 KEY ASSUMPTIONS

The analysis projects travel demand, operating revenues and operating and maintenance costs for all years from 2015 through 2050. The financial analysis has been conducted in real terms using constant 2012 dollars. Accordingly, no inflation factor has been included and a real discounting rate of 3 to 7 percent was used. Revenues and operating costs have also been projected in constant dollars over the time frame of the financial analysis. A summary of the key efficiency measure inputs are presented below.

RIDERSHIP AND REVENUE FORECASTS

Ridership and revenue forecasts were prepared for 2025, 2035 and 2045. Revenues in intervening years were projected based on interpolations, reflecting projected annual growth in ridership. Revenues included not only passenger fares, but also onboard service revenues. Because of this, the revenues are slightly higher than those that were forecasted in Chapter 3.

CAPITAL COSTS

Capital costs include rolling stock, track, freight railroad right-of-way purchase or easement fees, bridges, fencing, signaling, grade crossings, maintenance facilities and station improvements. The capital cost projections are based on year-by-year projections of each cost element and include all of the capital costs, plus some selected elements of additional costs as needed to support year-by-year capacity expansion of the system. A year-by-year implementation plan was developed which detailed the Capital cash flows and funding requirements. Using this information, the Benefit Cost calculations were able to be assessed.

OPERATING EXPENSES

Major operating and maintenance expenses include equipment maintenance, track and right-of-way maintenance, administration, fuel and energy, train crew and other relevant expenses. Operating expenses were estimated in 2012 constant dollars so that they would remain comparable to revenues. However, these costs do reflect the year-by-year increase in expense that is needed to handle the forecasted ridership growth, in terms of not only directly variable expenses such as credit card commissions, but also the need to add train capacity and operate either larger trains, or more train-miles every year in order to accommodate anticipated ridership growth.

Operating costs are included as a cost, whereas system revenues are included as a benefit in the discounting calculation over the life of the system. In this way they directly offset one another in the Net Present Value calculation and are also reflected in the Benefit Cost calculation. It can be seen that a system that requires an operating subsidy, e.g., where costs exceed revenues, will tend also to reflect this in the Benefit Cost ratio. This is why slow speed options such as conventional Amtrak services often fail on both the Operating Ratio and Benefit Cost ratio criteria.

IMPLEMENTATION PERIOD

According to the implementation plan, the planning and construction period for this corridor will take up to ten years with the start-up of full system operations not occurring until 2025. This represents a very slow and conservative planning process. If the start-up can be achieved earlier, say 2020 then both the financial and economic returns would be enhanced.

7.2.2 ESTIMATE OF ECONOMIC BENEFITS

A key requirement is the need for public capital investment to be supported by the economic benefit that will be generated by the rail system. Calculation of the economic benefit includes both consumer surplus and revenues generated by the system and environmental and external mode benefits; while costs include both capital and operating costs. Similar to the way most highway projects are justified, the primary justification for intercity rail projects relies on time savings multiplied by the user's value of time. The consumer surplus term equates to the passenger user's value of time savings as being the benefit an individual receives over and above the fare charged for using the system.

Calculation of benefit cost ratios requires a detailed, year-by-year forecast to support the calculation of Net Present Values for all the costs and benefits associated with the project. Specifically, a year-by-year estimate of system revenues, consumer surplus, operating costs, capital costs, and external benefits is needed to develop the Benefit Cost Analysis.

In line with Federal, State and Municipal projections, the rate of population growth, the increasing price of oil, and the increasing congestion on Virginian highways (e.g., I-95, I-64), means that there is a gradual increase in rail users over the life of the project. This has several consequences for the correct calculation of Benefit/Cost ratios for the project –

- It would be inappropriate to increase the ridership and revenue of the system in future years, without also reflecting the added operating and capital costs that will be needed to accommodate this growth in traffic.
- The result is a steady improvement in the system financial performance that reflects improved economies of scale over the 30-year life of the system. While the Benefit Cost ratios calculated do take this forecast growth into account, they also add the additional capital cost for providing the capacity needed to handle it. The economic benefits to be used in the analysis include two main categories:
    - User Benefits (Consumer Surplus)
    - Other Mode and Resource Benefits

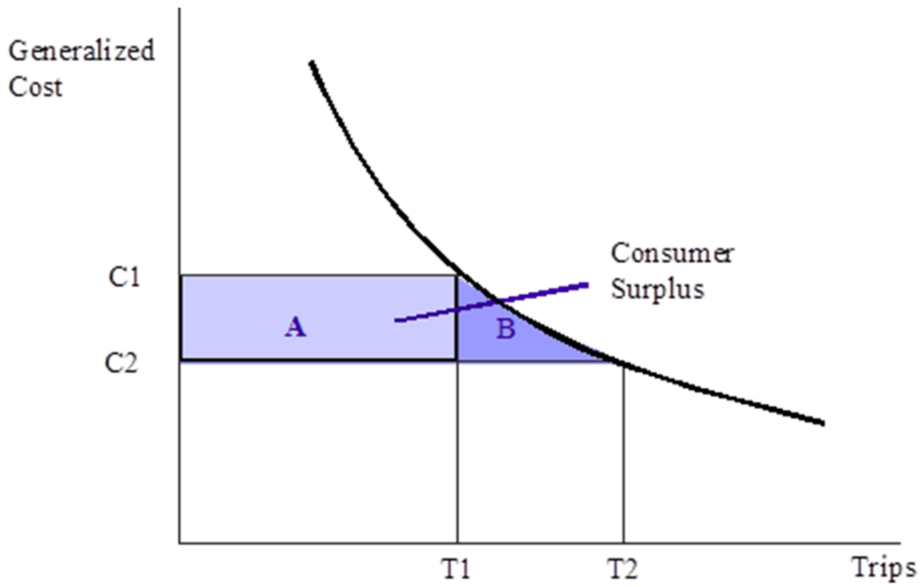
USER BENEFITS

The analysis of user benefits for this study is based on the measurement of Generalized Cost of Travel, which includes both time and money. Time is converted into money by the use of Values of Time. The Values of Time (VOT) used in this study were derived from stated preference surveys conducted in previous study phases of work and used in the COMPASS™ multimodal demand model for the ridership and revenue forecasts. These VOTs are consistent with previous academic and empirical research and other transportation studies conducted by TEMS.

Benefits to users of the rail system are measured by the sum of system revenues and consumer surplus. Consumer surplus is used to measure the demand side impact of a transportation improvement on users of the service. It is defined as the additional benefit consumers (users of the service) receive from the purchase of a commodity or service (travel), above the price actually paid for that commodity or service. Consumer surpluses exist because there are always consumers who are willing to pay a higher price than that actually charged for the commodity or service, i.e., these consumers receive more benefit than is reflected by the system revenues alone. Revenues are included in the measure of consumer surplus as a proxy measure for the consumer surplus forgone because the price of rail service is not zero. This is an equity decision made by the USDOT to compensate for the fact that highway users pay zero for use of the road system (the only exception being the use of toll roads). The benefits apply to existing rail travelers as well as new travelers who are induced (those who previously did not make a trip) or diverted (those who previously used a different mode) to the new passenger rail system.

The RENTS™ financial and economic analysis estimates passenger travel benefits (consumer surplus) by calculating the increase in regional mobility, traffic diverted to rail, and the reduction in travel cost measured in terms of generalized cost for existing rail users. The term generalized cost refers to the combination of time and fares paid by users to make a trip. A reduction in generalized cost generates an increase in the passenger rail user benefits. A transportation improvement that leads to improved mobility reduces the generalized cost of travel, which in turn leads to an increase in consumer surplus. Exhibit 7-1 presents a typical demand curve in which Area A represents the increase in consumer surplus resulting from cost savings for existing rail users and Area B represents the consumer surplus resulting from induced traffic and trips diverted to rail.

Exhibit 7-1: Consumer Surplus Concept



The formula for consumer surplus is as follows –

Consumer Surplus = $(C_1 – C_2)$*T1 + $((C_1 – C_2)*(T_2 – T_1))/2$

Where:

C_1 = Generalized Cost users incur before the implementation of the system

C_2 = Generalized Cost users incur after the implementation of the system

T_1 = Number of trips before operation of the system

T_2 = Number of trips during operation of the system

The passenger rail fares used in this analysis are the average optimal fares derived from the revenue-maximization analysis that was performed for each alternative. User benefits incorporate the measured consumer surplus, as well as the system revenues, since these are benefits are merely transferred from the rail user to the rail operator.

OTHER MODE BENEFITS

Other Mode and Resource Benefits: In addition to rail-user benefits, travelers using auto or air will also benefit from the rail investment, since the system will contribute to highway congestion relief and reduce travel times for users of these other modes. For purposes of this analysis, these benefits were measured by identifying the estimated number of auto passenger trips diverted to rail and multiplying each by the updated monetary values derived from previous stated preference studies updated to 2012.

Highway Congestion: The highway congestion delay savings is the time savings to the remaining highway users that results from diversion of auto users to the rail mode. To estimate travel time increase within the corridor, historical highway traffic volumes were obtained from the State DOTs and local planning agencies. The average annual travel time growth in the corridor was estimated with the historical highway traffic volume data and the BPR (Bureau of Public Roads) function that can be used to calculate travel time growth with increased traffic volumes.

The Airport Congestion Delay Savings: The Airport Congestion Delay Savings were based 1997 FRA Commercial Feasibility Study and updated to 2012 value. The Airport Congestion Delay Savings includes the airport operation delay saving and air passenger delay saving.

Auto Operating Cost (Non Business): Vehicle operating cost savings for non-business travelers have been included in the current analysis as an additional resource benefit. This reflects the fact that social/leisure travelers do not accurately value the full cost of driving when making trips. As a result, the consumer surplus calculation for commuters, social, leisure and tourist travelers has not fully reflected the real cost of operations of an automobile, but only the cost of gas. The difference between the cost of gas and the full cost of driving reflects a real savings that should be included in a Benefit Cost analysis.

Emissions: The diversion of travelers to rail from the auto mode generates emissions savings. The calculated emissions savings are based on changes in energy use with and without the proposed rail service. This methodology takes into account the region of the country, air quality regulation compliance of the counties served by the proposed rail service, the projection year, and the modes of travel used for access/egress as well as the line-haul portion of the trip. Highway Reduced Emissions were estimated from the vehicle miles traveled (VMT) and flight reductions derived from the ridership model. The assumption is that a reduction in VMT or flights is directly proportional to the reduction in emissions. The pollutant values were taken from the latest TIGER III Grant Benefit-Cost Analysis (BCA) Resource Guide[1].

Public Safety Benefits: Public Safety is calculated from the diverted Vehicle-Miles times the NHTSA[2] fatality and injury rate per Vehicle mile and then times the values of fatality and injury from the latest TIGER III Grant Benefit-Cost Analysis (BCA) Resource Guide[1]. This was calculated for 2025, 2035 and 2045 then extrapolated for all other years.

7.3 FINANCIAL RESULTS

The financial evaluation was completed for the three route options (1, 2 and 3) being assessed in the Route Analysis. Options 1 and 2 each included two route variants and two technology options for each route, reflecting different access routes into Richmond and are defined as sub-options. Specifically, the five sub-options are as follows:

- Southern Option 1A – Greenfield via Petersburg
- Southern Option 1B – Norfolk Southern (NS) via Petersburg
- Northern Option 2A – Greenfield via Hopewell
- Northern Option 2B – Norfolk Southern (NS) via Hopewell
- Option 3 – Richmond Direct

For each route, two technology options were developed for the 130-mph diesel technology, and the 220-mph electric technology. The Financial Analysis methodology followed typical financial cash flow analysis and USDOT-Tiger Grant guidelines, as well as OMB discount procedures for the economic analysis.

[1] http://www.dot.gov/sites/dot.dev/files/docs/TIGER_BCA_RESOURCE_GUIDE.pdf
[2] http://www.nhtsa.gov/

There are two key operating financial performance factors for the system, which are the key drivers of the financial evaluation:

- **System Revenues:** These include the fare box revenues and revenues from onboard sales. Revenues were derived from the Ridership and Revenue Analysis.
- **Operating Costs:** These are the operating and maintenance costs associated with running the train schedules and include onboard service costs. The operating costs for the system were developed using the methodology.

The **Operating Surplus**, which is defined as Revenues minus Operating Cost, is a critical factor in the overall business case as it determines the ability to franchise the operation.

- **If the operating surplus is positive**, the system will not require any operating subsidy, and it will even be able to make a contribution towards its own Capital cost. In addition because the system is generating a positive cash flow, a Private-Public Partnership or other innovative financing methods can be used to construct and operate the system. This absolves the local entity of any need for providing an operating subsidy but more than this, it is not uncommon for the operating cash flow to be sufficient to cover the local match requirement as well.
- **If the operating surplus is negative**, the system will not only require a grant of capital to build the system, but in addition it will also require an ongoing operating subsidy. An operating subsidy not only prevents the project from being a Public Private Partnership, but casts doubt on the efficiency of the system and the reason for the project. In addition, a subsidy will reduce the economic performance of the system as it will actually offset part of the economic benefits of the system (e.g. Consumer Surplus, Environmental Benefits). This will depress the Benefit Cost ratio. If the subsidy is not too great and the capital cost is not too high, in some cases it may still be possible to maintain a positive Benefit Cost ratio. But the larger the subsidy and the higher the capital cost, the harder it is to show a positive Benefit Cost ratio. It is not uncommon for slow passenger rail systems to fail both FRA's Operating Ratio and Benefit Cost criteria.

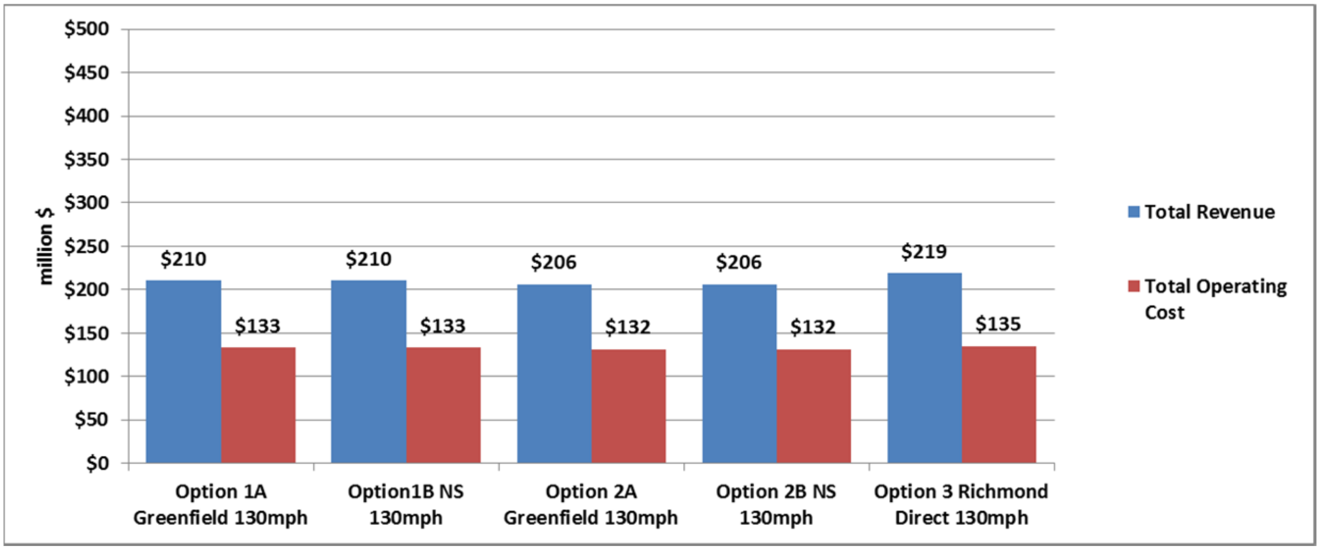
7.3.1 OPERATING RATIOS

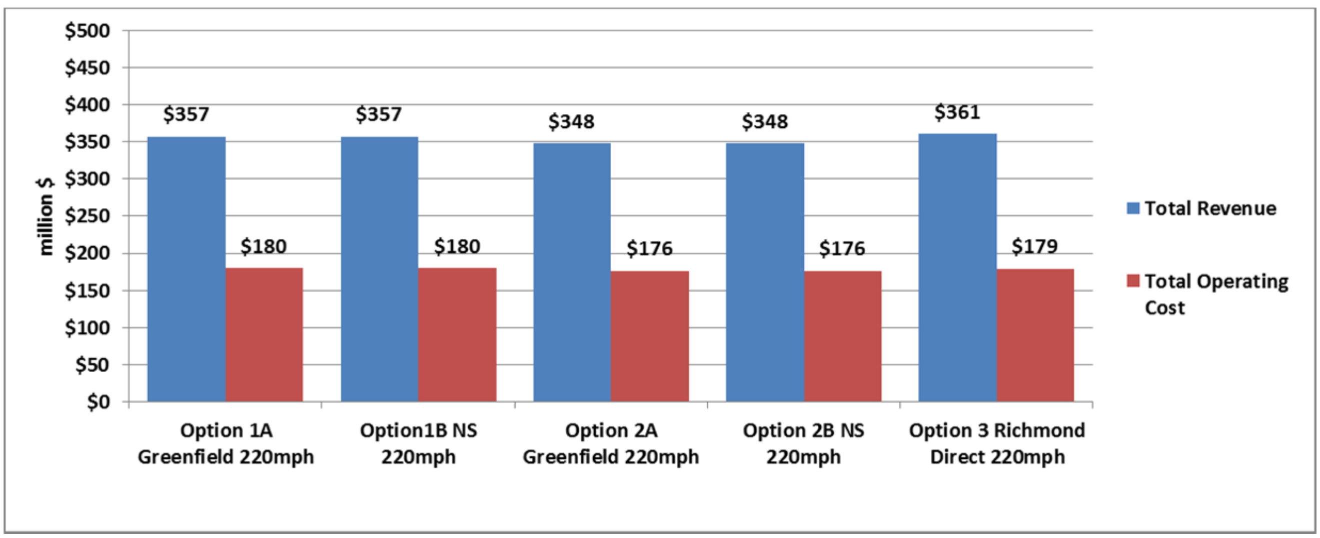
Exhibit 7-2 shows the revenues, operating costs and operating ratios for each route option variant for year 2025. Exhibit 7-3 displays bar charts that compare revenues and operating costs for 130-mph vs 220-mph technology options.

Exhibit 7-2: Years 2025 Revenues and Operating Ratios for all HRTPO Rail Options

Financial 2025(mill. 2012$)	Southern Option 1 - Via Petersburg				Northern Option 2 - Via Hopewell				Option 3 - Richmond Direct	
	Southern Option 1A - Greenfield		Southern Option 1B - Norfolk Southern		Northern Option 2A - Greenfield		Northern Option 2B - Norfolk Southern			
	130 mph	220 mph	130 mph	220 mph	130 mph	220 mph	130 mph	220 mph	130 mph	220 mph
REVENUE										
Ticket Revenue	$194.73	$330.95	$194.73	$330.95	$190.90	$322.52	$190.90	$322.52	$202.58	$334.25
OBS Revenue 8%	$15.58	$26.48	$15.58	$26.48	$15.27	$25.80	$15.27	$25.80	$16.21	$26.74
Total Revenue	**$210.30**	**$357.43**	**$210.30**	**$357.43**	**$206.17**	**$348.32**	**$206.17**	**$348.32**	**$218.79**	**$360.99**
COSTS										
Train Crew	$10.83	$15.67	$10.83	$15.67	$10.71	$15.26	$10.71	$15.26	$11.10	$15.69
OBS	$13.42	$21.45	$13.42	$21.45	$13.21	$20.90	$13.21	$20.90	$13.88	$21.59
Equipment	$27.96	$47.95	$27.96	$47.95	$27.65	$46.72	$27.65	$46.72	$28.65	$48.03
Fuel	$19.57	$8.92	$19.57	$8.92	$19.35	$8.69	$19.35	$8.69	$20.06	$8.94
Track	$11.95	$23.45	$11.95	$23.45	$11.78	$23.12	$11.78	$23.12	$11.56	$22.68
Insurance	$7.40	$11.44	$7.40	$11.44	$7.32	$11.15	$7.32	$11.15	$7.58	$11.46
Call Ctr Variable	$2.65	$3.82	$2.65	$3.82	$2.62	$3.71	$2.62	$3.71	$2.77	$3.94
T-Agent and CC Comm	$5.45	$9.27	$5.45	$9.27	$5.35	$9.03	$5.35	$9.03	$5.67	$9.36
Stations	$6.45	$6.45	$6.45	$6.45	$6.45	$6.45	$6.45	$6.45	$5.91	$5.91
Admin and Mgt	$18.40	$20.62	$18.40	$20.62	$18.36	$20.46	$18.36	$20.46	$18.50	$20.63
Operation & Dispactch	$1.09	$1.70	$1.09	$1.70	$1.07	$1.67	$1.07	$1.67	$1.05	$1.64
Operator Profit 10% selected items	$7.79	$8.79	$7.79	$8.79	$7.71	$8.62	$7.71	$8.62	$7.89	$8.77
Total Cost	**$132.95**	**$179.51**	**$132.95**	**$179.51**	**$131.57**	**$175.77**	**$131.57**	**$175.77**	**$134.63**	**$178.63**
Operating Surplus	**$77.35**	**$177.92**	**$77.35**	**$177.92**	**$74.60**	**$172.55**	**$74.60**	**$172.55**	**$84.16**	**$182.36**
Operating Ratio	**1.58**	**1.99**	**1.58**	**1.99**	**1.57**	**1.98**	**1.57**	**1.98**	**1.63**	**2.02**

Exhibit 7-3: Year 2025 Revenues vs Operating Costs Diesel 130-mph and Electric 220-mph Rail Technologies





It can be seen that all route variants have positive operating surpluses and positive operating ratios in year 2025, with the Electric 220-mph options having better results due to higher ridership and revenues despite the higher operating costs. The results of this analysis also show that all of the proposed route options are franchisable with a positive cash flow that is greater than the system operating costs. However, Option 3, the Richmond Direct route using 220-mph technology, has slightly better cash flows than the other options, although they are all very comparable to each other.

7.4 ECONOMIC RESULTS

The Demandside Economic Analysis was completed using data derived from the Ridership and Revenue Analysis, the Infrastructure Analysis, and the Operating Analysis. This provided:

- **System Revenues -** Fare box and onboard revenue
- **Operating Costs -** Operating and maintenance costs
- **Capital costs** - Infrastructure costs

In addition, the Economic benefits of the system to be assessed for the analysis include –

- **Consumer Surplus** – benefit to system users
- **Revenues**
- **Highway Congestion Savings** – benefits to road users of less congestion
- **Airport Delay Savings** – benefits to air travelers
- **Safety Benefits** – benefit of less accidents
- **Reduced Emissions** – benefit of lower emissions levels
- **Highway Resource Savings**

7.4.1 Cost Benefit Ratios and Net Present Value

The economic results for all options and technology variants are shown in exhibit 7-4. The exhibit shows the NPV break down of benefits, costs and the resulting Benefit/Cost ratio at the 3% and 7% discount rates. Exhibit 7-5 compares of the total benefits vs total costs for each of the route technology options at 3% and 7% discount rates.

Exhibit 7-4: Comparing the Benefit-Cost and NPV Surplus results at the 3% and 7% Discount rates for all route and technology variants

Southern Option 1 - Via Petersburg

	3% Discount				7% Discount			
million $	Option 1A Greenfield 130mph	Option 1A Greenfield 220mph	Option1B NS 130mph	Option1B NS 220mph	Option 1A Greenfield 130mph	Option 1A Greenfield 220mph	Option1B NS 130mph	Option1B NS 220mph
System Passenger Revenues	$3,034	$4,985	$3,034	$4,985	$1,221	$2,019	$1,221	$2,019
OBS	$243	$399	$243	$399	$98	$162	$98	$162
Users Consumer Surplus	$2,458	$3,067	$2,458	$3,067	$1,006	$1,256	$1,006	$1,256
Highway Congestion Savings	$1,631	$2,328	$1,631	$2,328	$632	$907	$632	$907
Airport Delay Saving	$262	$413	$262	$413	$103	$162	$103	$162
Safety Benefits	$550	$868	$550	$868	$223	$354	$223	$354
Highway Reduced Emissions	$117	$185	$117	$185	$47	$74	$47	$74
Total Benefits	**$8,295**	**$12,245**	**$8,295**	**$12,245**	**$3,330**	**$4,934**	**$3,330**	**$4,934**
Capital Cost	$3,942	$5,452	$3,911	$5,410	$2,690	$3,720	$2,669	$3,691
O&M Costs	$1,980	$2,575	$1,980	$2,575	$802	$1,051	$802	$1,051
Cyclic Mtn	$75	$75	$75	$75	$25	$25	$25	$25
Total Costs	**$5,997**	**$8,102**	**$5,966**	**$8,060**	**$3,517**	**$4,797**	**$3,496**	**$4,768**
NPV(Surplus)	**$2,298**	**$4,143**	**$2,329**	**$4,185**	**($187)**	**$137**	**($166)**	**$166**
Benefit/Cost Ratio	**1.38**	**1.51**	**1.39**	**1.52**	**0.95**	**1.03**	**0.95**	**1.03**

Exhibit 7-4: Comparing the Benefit-Cost and NPV Surplus results at the 3% and 7% Discount rates for all route and technology variants (cont)

Northern Option 2 - Via Hopewell

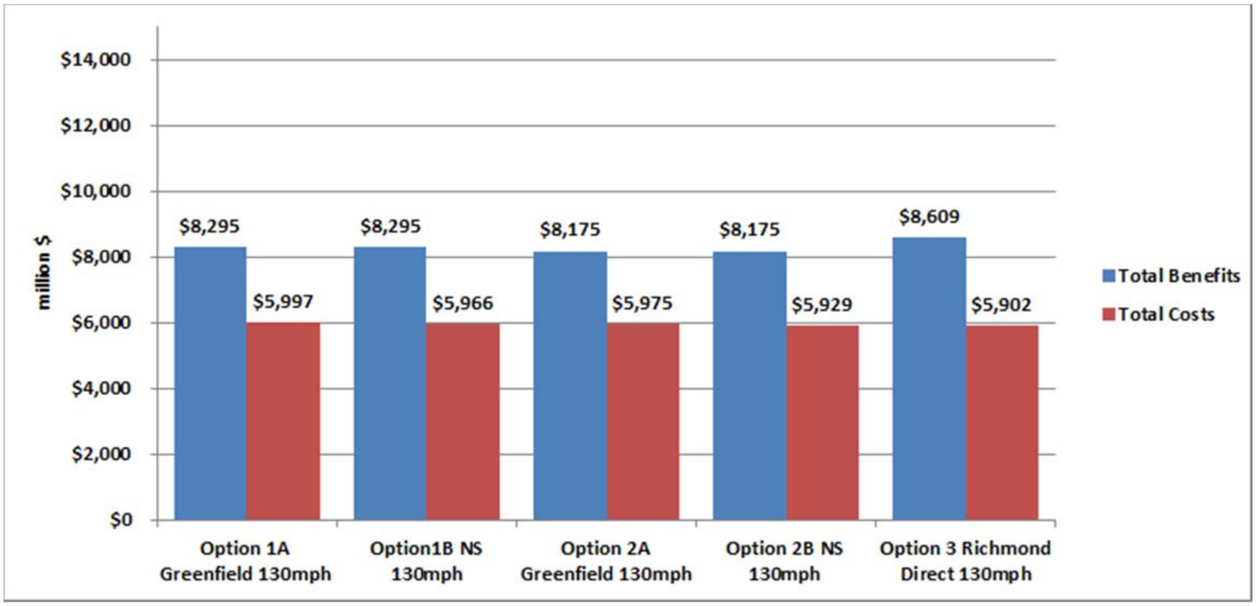
million $	3% Discount				7% Discount			
	Option 2A Greenfield 130mph	Option 2A Greenfield 220mph	Option 2B NS 130mph	Option 2B NS 220mph	Option 2A Greenfield 130mph	Option 2A Greenfield 220mph	Option 2B NS 130mph	Option 2B NS 220mph
System Passenger Revenues	$2,972	$4,889	$2,972	$4,889	$1,196	$1,978	$1,196	$1,978
OBS	$238	$391	$238	$391	$96	$158	$96	$158
Users Consumer Surplus	$2,433	$2,987	$2,433	$2,987	$996	$1,222	$996	$1,222
Highway Congestion Savings	$1,615	$2,292	$1,615	$2,292	$626	$893	$626	$893
Airport Delay Saving	$261	$372	$261	$372	$103	$146	$103	$146
Safety Benefits	$541	$855	$541	$855	$219	$348	$219	$348
Highway Reduced Emissions	$115	$182	$115	$182	$46	$73	$46	$73
Total Benefits	**$8,175**	**$11,969**	**$8,175**	**$11,969**	**$3,282**	**$4,819**	**$3,282**	**$4,819**
Capital Cost	$3,943	$5,454	$3,897	$5,390	$2,690	$3,722	$2,659	$3,678
O&M Costs	$1,958	$2,532	$1,958	$2,532	$794	$1,033	$794	$1,033
Cyclic Mtn	$74	$74	$74	$74	$25	$25	$25	$25
Total Costs	**$5,975**	**$8,060**	**$5,929**	**$7,996**	**$3,509**	**$4,780**	**$3,477**	**$4,736**
NPV(Surplus)	**$2,199**	**$3,910**	**$2,245**	**$3,973**	**($227)**	**$39**	**($196)**	**$82**
Benefit/Cost Ratio	**1.37**	**1.49**	**1.38**	**1.50**	**0.94**	**1.01**	**0.94**	**1.02**

Richmond Direct Option 3

million $	3%		7%	
	Option 3 Richmond Direct 130mph	Option 3 Richmond Direct 220mph	Option 3 Richmond Direct 130mph	Option 3 Richmond Direct 220mph
System Passenger Revenues	$3,121	$5,034	$1,258	$2,039
OBS	$250	$403	$101	$163
Users Consumer Surplus	$2,543	$3,193	$1,041	$1,306
Highway Congestion Savings	$1,750	$2,400	$679	$936
Airport Delay Saving	$264	$420	$104	$165
Safety Benefits	$561	$870	$228	$355
Highway Reduced Emissions	$119	$185	$48	$74
Total Benefits	**$8,609**	**$12,503**	**$3,460**	**$5,037**
Capital Cost	$3,836	$5,306	$2,617	$3,621
O&M Costs	$1,993	$2,564	$808	$1,047
Cyclic Mtn	$73	$73	$24	$24
Total Costs	**$5,902**	**$7,943**	**$3,450**	**$4,692**
NPV(Surplus)	**$2,707**	**$4,560**	**$9**	**$345**
Benefit/Cost Ratio	**1.46**	**1.57**	**1.00**	**1.07**

Exhibit 7-5: Comparing the total benefits vs costs for each of the route technology options at 3% and 7% discount rates

Diesel 130 mph Technology Options at 3% Discount Rate



Electric 220 mph Technology Options at 3% Discount Rate

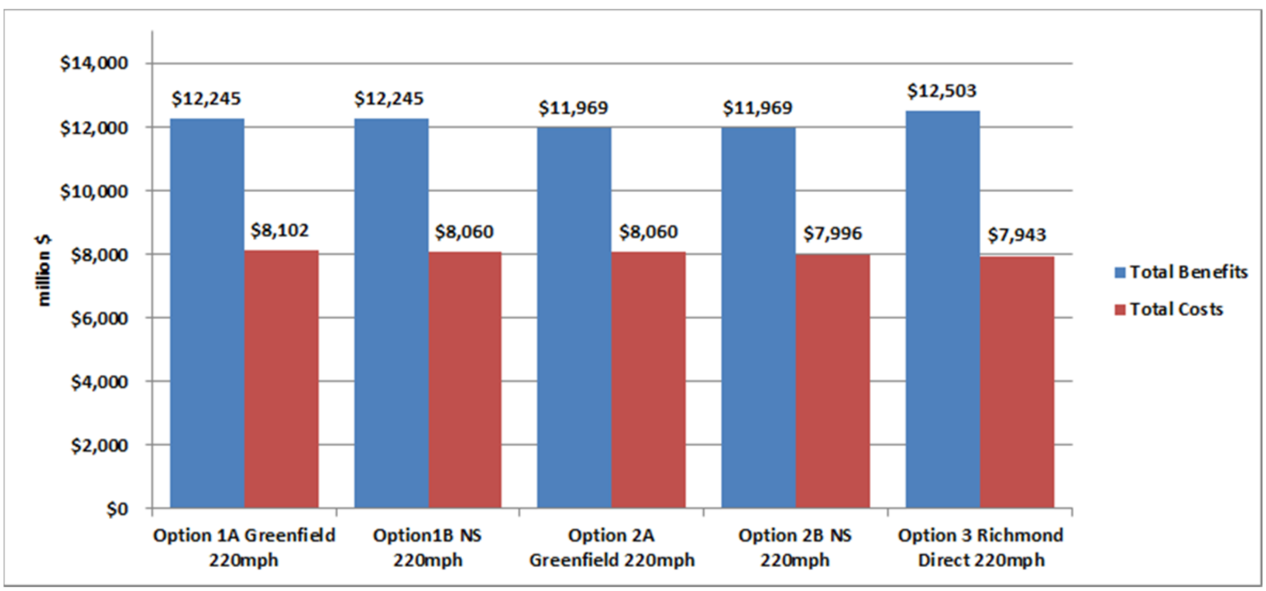
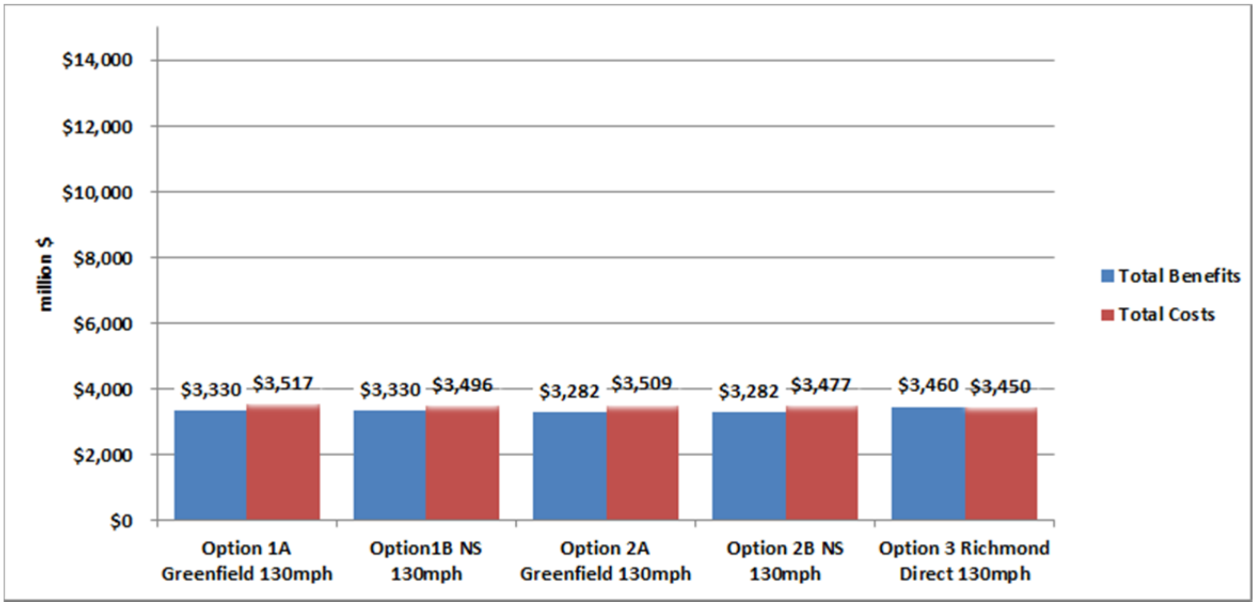
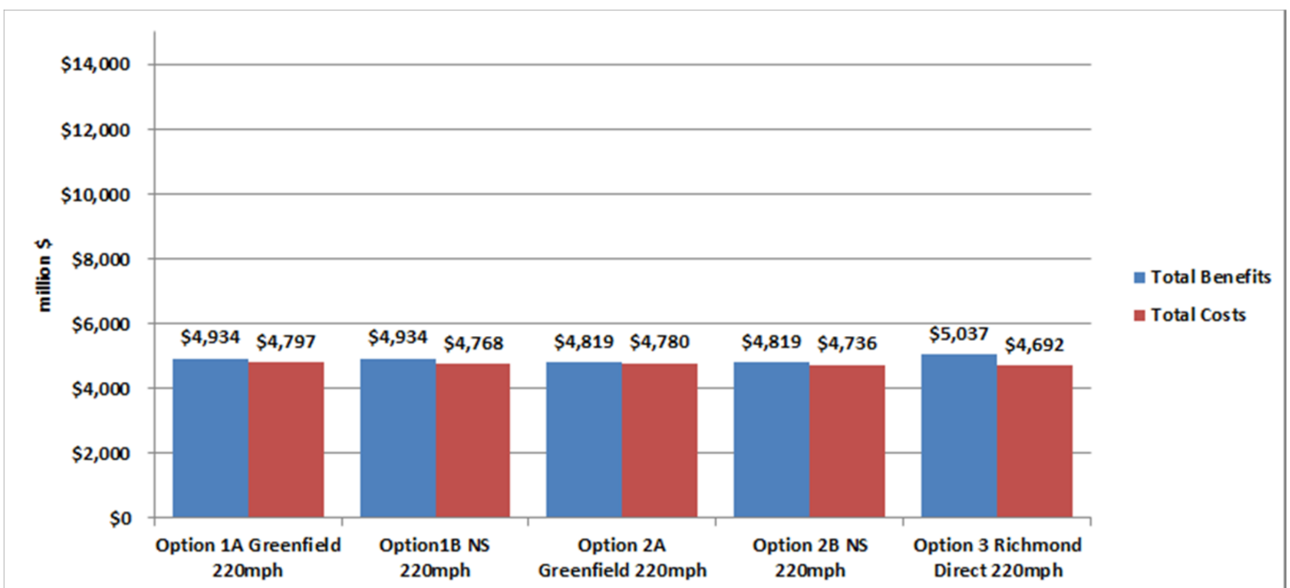


Exhibit 7-5: Comparing the total benefits vs costs for each of the route technology options at 3% and 7% discount rates (cont)

Diesel 130-mph Technology Options at 7% Discount Rate



Electric 220-mph Technology Options at 7% Discount Rate



As can be seen in the exhibits, all route options show positive benefit/cost ratios with Option 3 (Richmond Direct) using 220-mph technology showing the best results of all options at the 3% discount level (B/C: 1.57). However, all options have results that are comparable to each other at both the 3% and 7% discount rates. Also, all route options using the 220-mph electric train technology have better financial results vs the options that use 130-mph diesel technology, although with much lower gains at the 7% discount rates. NPV Surpluses, in particular, are higher for all route options using the 220-mph electric technology with surpluses being much greater at the 3% discount rate vs the 7% discount rate. In fact, 130-mph technology options 1A, 1B, 2A and 2B have negative NPV values at the 7% discount rate. NPV surpluses for the 220-mph technology options are greater despite their higher costs due to the increases in ridership and overall benefits that using a more efficient higher speed rail technology would bring. In conclusion, the results show that all options and technology variants are viable at the 3% discount rate; however, only Option 3 Richmond Direct remains viable at the 7% discount rate for all technology variants. Based on these results, the most viable route option is Option 3 Richmond Direct using electric 220-mph train technology. However, for this option an initial 130-mph implementation step is possible given that 130-mph technology is viable at a 7% discount rate.

8. PREFERRED OPTION DEVELOPMENT

In this chapter the concept of a preferred option is explored considering how external factors of the Southeast High-Speed Rail and a Peninsula Connection can impact the results for the basic options considered in Chapter 7. The assessment is a sensitivity analysis of how the external factors affect the Financial and Economic results.

8.1 INTRODUCTION

One of the characteristics of the Financial and Economic Analysis is that all the routes evaluated for the Norfolk to Richmond corridor are very comparable and the decision on which route to select may well be determined by two external factors. These are:

Southeast High-Speed Rail (SEHSR) – The Southern Greenfield Option 1A and Option 1B can easily be integrated with the SEHSR service being planned, and as a joint service with the SEHSR, the Southern Greenfield options may be able to share some capital costs with the SEHSR. The Northern Greenfield options are also possible (although more difficult) to integrate with SEHSR by building a connecting train from Burgess over to the I-95/I-295 interchange, and then following the I-295 median north. Sharing alignments would reduce the capital cost of the segment from Petersburg to Richmond and Washington; and as such, would produce a higher Cost Benefit Result. The initial assumption of the Phase 1 Vision Plan work was that this could save 35% or approximately $1.2 Billion of the infrastructure cost based on the assumed share of train frequency estimated for each service. This would improve the Benefit-Cost Ratio for the Option 1 and Option 2 Petersburg and Hopewell, 220-mph options from 1.5 to 1.8. This is clearly a very good result for both options.

Peninsula Connection – The Richmond Direct option swings quite far to the east to access Richmond. This leaves open the possibility of services from the Peninsula using the Richmond Direct route from near Roxbury to Richmond, a distance of some 20 miles. This would allow Peninsula trains to operate on a portion of the Norfolk-Richmond segment and would provide an increase in Peninsula train speed to 130 mph going from Roxbury to Richmond and to Washington, DC. Such a connection would also dramatically increase Peninsula traffic to a level to a level beyond just 3 trains per day.

Given this potential synergy of the Richmond Direct Route with the Peninsula, an evaluation was made of developing a high speed connection towards Newport News. This evaluation of a high speed connection considered the geography, topology, and environment along the Peninsula corridor between Roxbury and Newport News. As a preliminary estimate, it was decided that a short (20 mile) connection going from the Richmond Direct route at Roxbury to Toano just outside Williamsburg, would be the most effective option. The terrain for these twenty miles is rural and the development of the connection would face similar issues to those faced by Richmond Direct, Option 3.

It is possible that the high speed route could be extended all the way to Newport News new station, but that would require a preliminary environmental assessment similar to what has already been done for Norfolk to ensure no fatal flaw. Furthermore, the improvement of the train service to the Peninsula by extending the route to Toano, could be achieved by a relatively low increase in capital costs; whereas, the further extension of the route would be much more expensive per mile through the urbanized areas of Williamsburg and Newport News. To fully understand this trade-off, more detailed work is needed.

As a result, the preliminary route analysis suggests an extension to Toano just outside Williamsburg as being feasible and further extensions may be possible. This is a distance of 40 miles from Richmond and would allow high speed operation from just outside Williamsburg to Washington at 130 mph. This option was identified as the Richmond Direct Improved alternative, Option 4. A preliminary sensitivity analysis was performed for this option.

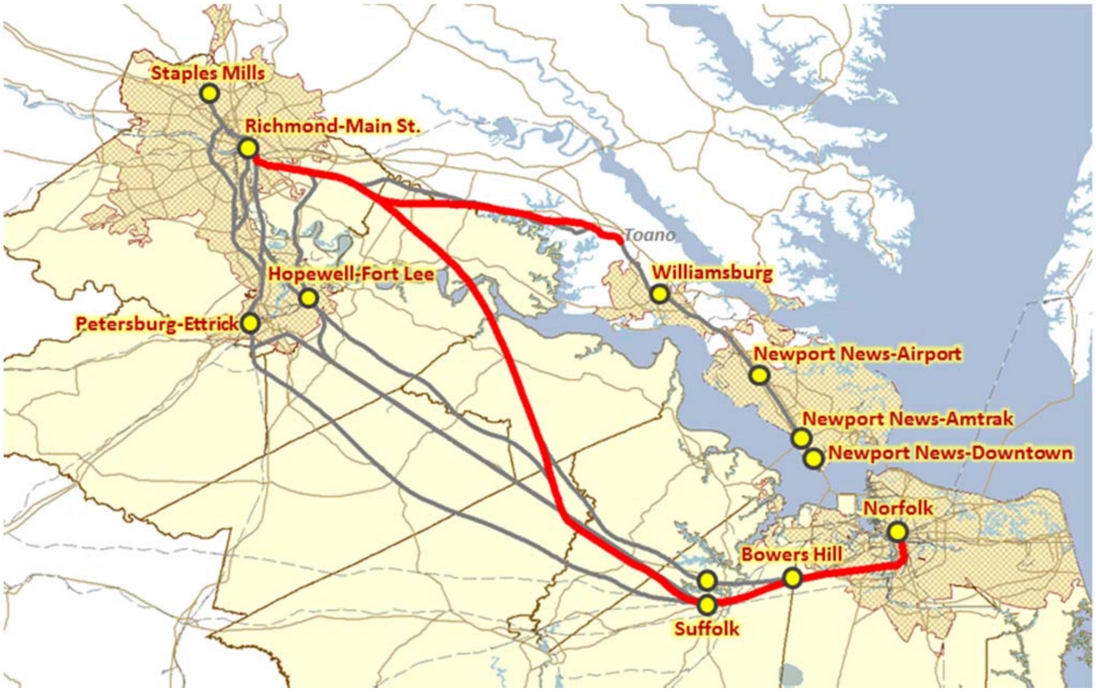
8.2 Option 4, Richmond Direct Improved

The Option 4, Richmond Direct Improved was assessed as a preliminary sensitivity without the benefit of detailed operating, engineering and environmental work. Further work is needed to bring the analysis up to the level of the Phase 2 analysis of this report.

To develop the sensitivity analysis of the Option 4, Richmond Direct Improved, a conceptual high speed connection was envisaged from Roxbury to the existing CSX line near Toano (Exhibit 8-1). This connection is only an additional 20 miles in length but would provide the Peninsula some 140 miles of high speed operation from just outside Williamsburg to Washington. It provides a very low cost connection that improves speeds to a level that would significantly increase demand and would require a train service of 8-10 trains per day. This is comparable with what was envisaged by the HRTPO Board Objective of Enhanced Passenger Rail Service for the Peninsula. Because it would use 130-mph high speed train technology, this connection would provide a two hour connection from Newport News to Washington, and a 1 ½ hour schedule from Williamsburg to Washington.

This schedule is very close to the schedule outlined for the Peninsula Enhanced Passenger Rail Service in Step 4 of the passenger rail development program set out by HRTPO and DRPT. The reason for this is that the Step 4 development program assumed 79-mph operation in the urban areas of Newport News and Williamsburg, 110-mph operation from Williamsburg to Richmond, and 130-mph operation from Richmond to Washington. For the Richmond-Washington segment, the train would use the same tracks as the true high speed option from Norfolk. As a result, the high speed diesel train could operate at a top speed of 130-mph. Option 4 provides for 79-mph operation in urban areas and 130-mph running from Williamsburg north. As such, Option 4 has a slightly better train time than that proposed in the original development program Step 4.

Exhibit 8-1: Option 4, Richmond Direct Improved



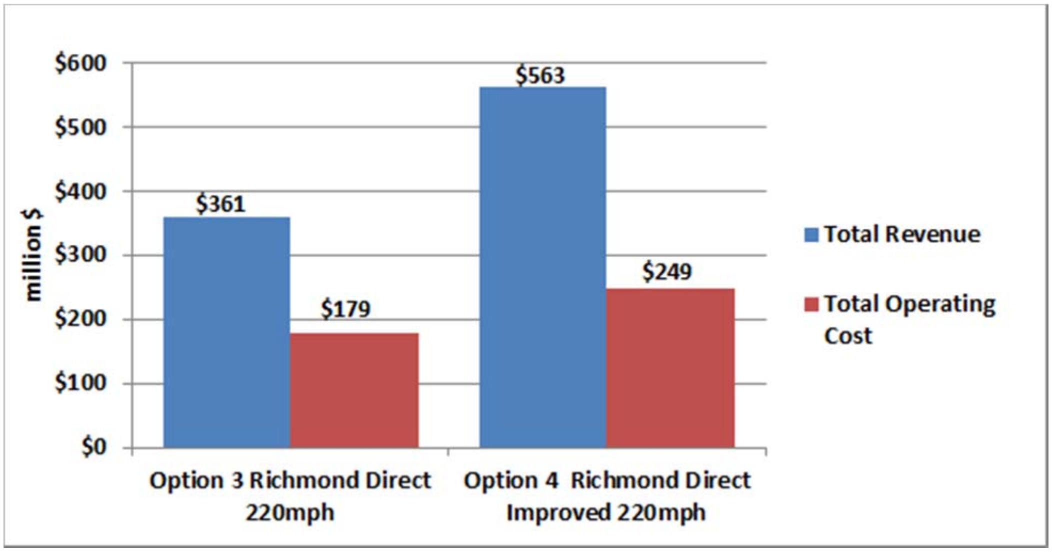
8.3 Option 4, Richmond Direct Improved: Financial Analysis

Exhibit 8-2 compares the revenues, operating costs and operating ratios for Richmond Direct Improved, Option 4 with the best of the original options, Richmond Direct, Option 3 for year 2025. Exhibit 8-3 provides a bar chart comparison of revenues and operating costs for Option 4 Richmond Direct Improved and Option 3 Richmond Direct.

Exhibit 8-2: Option 3, Richmond Direct vs Option 4 Richmond Direct Improved Comparison of Year 2025 Financial Results

Year 2025 Operation (million 2012$)	Option 3 Richmond Direct 220mph	Option 4 Richmond Direct Improved 220 mph
Ticket Revenue	$334	$521
On Board Service Revenue	$27	$42
Total Revenue	**$361**	**$563**
Total Operating Cost	**$179**	**$249**
Operating Surplus	**$182**	**$313**
Operating Ratio	**2.02**	**2.26**

Exhibit 8-3: Bar Chart Comparing Total Revenue and Operating Cost for Option 3 Richmond Direct vs Option 4, Richmond Direct Improved (Year 2025)



It can be seen that the Operating Ratio is considerably higher for Option 4, increasing from 2.02 to 2.26. This considerably improves the case for a public private partnership and/or franchising the system, as it shows a higher level of profitability so the system could contribute a higher share of its own capital cost. Exhibit 8-2 and 8-3 show that the proposed Option 4 significantly improves revenues over costs, due to better service of 8-10 trains per day in the Peninsula corridor. These extra trains are required to service the extra demand that the connection to the Richmond Direct route generates. In addition, there are operating cost synergies associated with running Peninsula trains on the Richmond Direct route. These include signal and track maintenance, station staffing, marketing administrative and management costs.

8.4 Option 4, Richmond Direct Improved: Economic Analysis

Exhibit 8-4 shows a comparison of the economic results for Option 4 Richmond Direct Improved vs Option 3 Richmond Direct. Exhibit 8-5 and 8-6 compare total benefits vs total costs for Option 4 and Option 3 at the 3% and 7% discount rates. It can be seen that the economic Net Present Value and the Cost Benefit Ratio is enhanced for Option 4. At 3% discount rate, Option 4 has close to a return of twice the capital and operating cost, and even at 7% discount rate it has a significantly higher than 1.0 Cost Benefit Ratio. This is essentially the same high rate of economic return that was developed by the earlier 2010 Preliminary Vision Plan assessment that included both Peninsula and Norfolk service[1].

[1] July 2, 2010, HRTPO Board Presentation, Slide 27

Exhibit 8-4: Comparison of Economic Results at 3% & 7% Discount Rates for Option 3 Richmond Direct vs Option 4 Richmond Direct Improved

	3% discount Rate		7% discount Rate	
Discount (million 2012$)	Option 3 Richmond Direct 220mph	Option 4 Richmond Direct Improved 220mph	Option 3 Richmond Direct 220mph	Option 4 Richmond Direct Improved 220mph
System Passenger Revenues	$5,034	$7,691	$2,039	$3,126
OBS	$403	$615	$163	$250
Users Consumer Surplus	$3,193	$6,456	$1,306	$2,647
Highway Congestion Savings	$2,400	$2,886	$936	$1,128
Airport Delay Saving	$420	$473	$165	$186
Safety Benefits	$870	$1,203	$355	$492
Highway Reduced Emissions	$185	$256	$74	$103
Total Benefits	**$12,503**	**$19,580**	**$5,037**	**$7,933**
Capital Cost	$5,306	$6,404	$3,621	$4,370
O&M Costs	$2,564	$3,432	$1,047	$1,409
Cyclic Mtn	$73	$90	$24	$30
Total Costs	**$7,943**	**$9,927**	**$4,692**	**$5,810**
NPV(Surplus)	**$4,560**	**$9,653**	**$345**	**$2,123**
Benefit/Cost Ratio	**1.57**	**1.97**	**1.07**	**1.37**

Exhibit 8-5: Comparison of Total Revenues and Costs for Option 3 Richmond Direct vs Option 4 Richmond Direct Improved at 3% Discount Rate

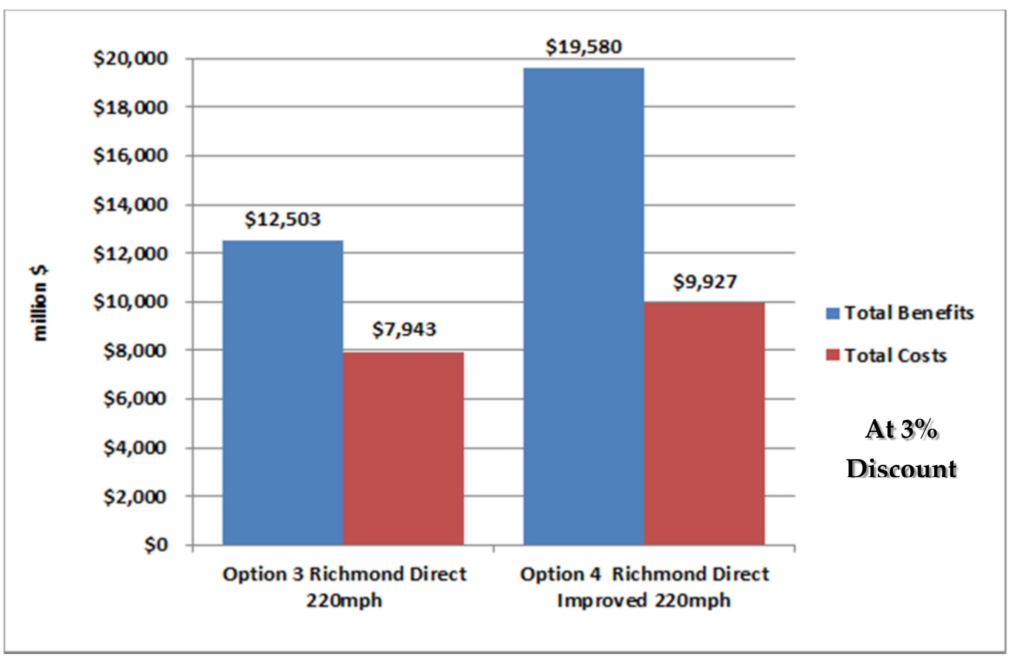
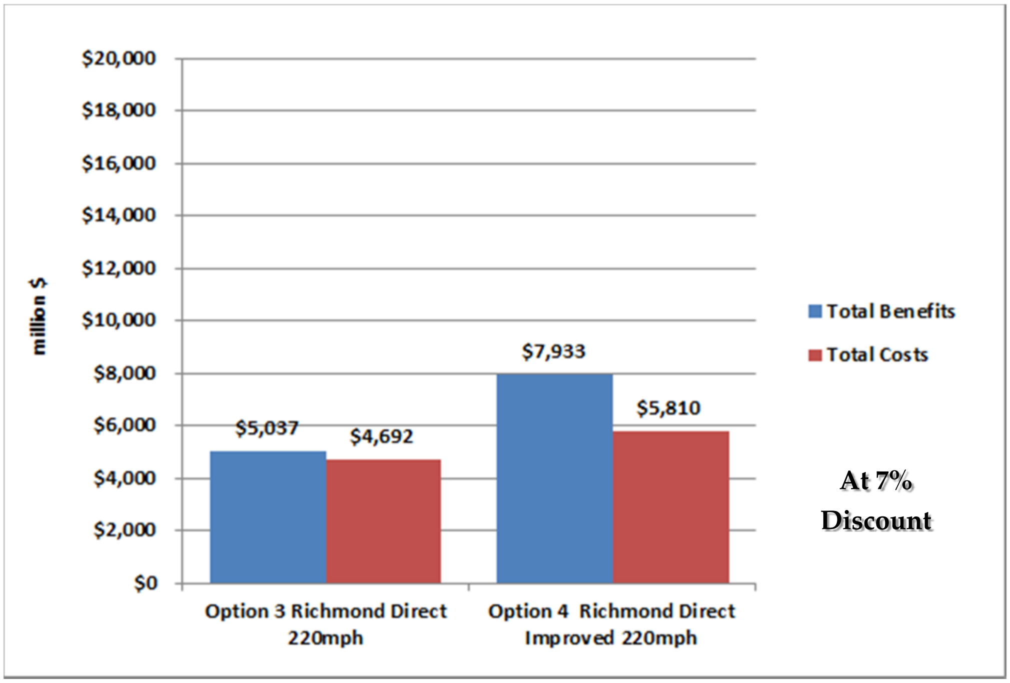


Exhibit 8-6: Comparison of Total Revenues and Costs for Option 3 Richmond Direct vs Option 4 Richmond Direct Improved at 7 % Discount Rate



8.5 Option 4, Richmond Direct Improved: Economic Cash Flows

Exhibit 8-7 shows the Economic Cash Flow Analysis for the proposed Option 4, Richmond Direct Improved for the period 2015 (the first year of construction) to 2050 (the assumed life of the project). In the exhibit, economic cash flows were discounted at 3 percent, which is in line with OMB requirements. It can be seen that the project makes a significant operating surplus in its first year of operation that steadily increases over the life of the project, i.e. 2050. This positive cash flow provides a basis for a public/private partnership with a contribution of $3-5 billion to total project costs of $6-7 billion.

Exhibit 8-7: Option 4, Richmond Direct Improved
Detailed Economic Benefits and Costs Flows by Year ($2012 Millions)

Benefit and Cost Items		Year	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Benefits to Users	**NPV at 3%**												
	System Passenger Revenues	$7,690.55	-	-	-	-	-	-	-	-	-	-	521.07
	OBS	$615.24	-	-	-	-	-	-	-	-	-	-	41.69
	Total Operating Revenues	**$8,305.79**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**562.75**
	Users Consumer Surplus	$6,456.08	-	-	-	-	-	-	-	-	-	-	457.59
	Total User Benefits	**$14,761.86**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1,020.35**
Benefits to Public at Large													
	HWY Congestion Savings	$2,886.14	-	-	-	-	-	-	-	-	-	-	152.06
	Airport Delay Saving	$473.42	-	-	-	-	-	-	-	-	-	-	26.39
	Safety Benefits	$1,202.95	-	-	-	-	-	-	-	-	-	-	84.08
	Highway Reduced Emissions	$255.61	-	-	-	-	-	-	-	-	-	-	16.13
	Total Public at Large Benefits	**$4,818.12**	-	-	-	-	-	-	-	-	-	-	278.66
Total Benefits		**$19,579.99**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**1,299.01**
Costs													
	Capital Cost	$6,404.24	7.80	7.80	7.80	15.60	288.66	816.05	1,432.38	2,318.64	2,249.99	1,486.99	-
	O&M Costs	$3,432.23	-	-	-	-	-	-	-	-	-	-	249.47
	Cyclic Mtn	$90.38	-	-	-	-	-	-	-	-	-	-	-
Total Costs		**$9,926.84**	7.80	7.80	7.80	15.60	288.66	816.05	1,432.38	2,318.64	2,249.99	1,486.99	249.47
Benefits - Costs		**$9,653.15**	(7.80)	(7.80)	(7.80)	(15.60)	(288.66)	(816.05)	(1,432.38)	(2,318.64)	(2,249.99)	(1,486.99)	1,049.54

Exhibit 8-7: Option 4, Richmond Direct Improved
Detailed Economic Benefits and Costs Flows by Year ($2012 Millions) (con't)

Benefit and Cost Items		Year	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038
Benefits to Users	**NPV at 3%**														
	System Passenger Revenues	$7,690.55	528.51	536.06	543.72	551.49	559.37	567.36	575.46	583.68	592.02	600.48	609.59	618.84	628.23
	OBS	$615.24	42.28	42.89	43.50	44.12	44.75	45.39	46.04	46.69	47.36	48.04	48.77	49.51	50.26
	Total Operating Revenues	**$8,305.79**	**570.79**	**578.95**	**587.22**	**595.61**	**604.12**	**612.75**	**621.50**	**630.38**	**639.39**	**648.52**	**658.36**	**668.35**	**678.49**
	Users Consumer Surplus	$6,456.08	462.51	467.47	472.49	477.56	482.68	487.86	493.10	498.39	503.74	509.15	514.48	519.87	525.32
	Total User Benefits	**$14,761.86**	**1,033.30**	**1,046.42**	**1,059.71**	**1,073.17**	**1,086.80**	**1,100.61**	**1,114.60**	**1,128.77**	**1,143.13**	**1,157.67**	**1,172.84**	**1,188.22**	**1,203.81**
Benefits to Public at Large															
	HWY Congestion Savings	$2,886.14	157.88	163.93	170.21	176.73	183.50	190.53	197.82	205.40	213.27	221.44	228.37	235.52	242.89
	Airport Delay Saving	$473.42	27.18	27.99	28.82	29.67	30.56	31.47	32.40	33.36	34.36	35.38	36.56	37.78	39.04
	Safety Benefits	$1,202.95	85.08	86.09	87.12	88.15	89.20	90.26	91.33	92.41	93.51	94.62	95.74	96.88	98.03
	Highway Reduced Emissions	$255.61	16.47	16.82	17.17	17.54	17.91	18.29	18.67	19.07	19.47	19.88	20.28	20.68	21.10
	Total Public at Large Benefits	**$4,818.12**	286.61	294.82	303.31	312.09	321.16	330.53	340.23	350.25	360.61	371.32	380.95	390.86	401.05
Total Benefits		**$19,579.99**	**1,319.91**	**1,341.24**	**1,363.02**	**1,385.26**	**1,407.96**	**1,431.15**	**1,454.83**	**1,479.02**	**1,503.74**	**1,528.99**	**1,553.79**	**1,579.08**	**1,604.86**
Costs															
	Capital Cost	$6,404.24	-	-	-	-	-	-	-	-	-	-	-	-	-
	O&M Costs	$3,432.23	251.03	252.59	254.16	255.75	257.34	258.94	260.56	262.18	263.81	265.45	268.79	272.17	275.60
	Cyclic Mtn	$90.38	-	-	-	3.14	3.14	3.14	5.49	5.49	5.49	7.84	7.84	7.84	7.84
Total Costs		**$9,926.84**	251.03	252.59	254.16	258.88	260.48	262.08	266.04	267.67	269.30	273.30	276.64	280.02	283.44
Benefits - Costs		**$9,653.15**	1,068.88	1,088.65	1,108.86	1,126.37	1,147.48	1,169.07	1,188.78	1,211.35	1,234.44	1,255.69	1,277.16	1,299.06	1,321.42

Exhibit 8-7: Option 4, Richmond Direct Improved
Detailed Economic Benefits and Costs Flows by Year ($2012 Millions) (con't)

Benefit and Cost Items		Year	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050
Benefits to Users		**NPV at 3%**												
	System Passenger Revenues	$7,690.55	637.76	647.44	657.26	667.24	677.36	687.64	698.07	708.66	719.42	730.33	741.41	752.66
	OBS	$615.24	51.02	51.80	52.58	53.38	54.19	55.01	55.85	56.69	57.55	58.43	59.31	60.21
	Total Operating Revenues	**$8,305.79**	**688.78**	**699.23**	**709.84**	**720.61**	**731.55**	**742.65**	**753.92**	**765.36**	**776.97**	**788.76**	**800.73**	**812.87**
	Users Consumer Surplus	$6,456.08	530.82	536.38	542.00	547.68	553.41	559.21	565.07	570.99	576.97	583.01	589.12	595.29
	Total User Benefits	**$14,761.86**	**1,219.60**	**1,235.61**	**1,251.84**	**1,268.29**	**1,284.96**	**1,301.86**	**1,318.98**	**1,336.34**	**1,353.94**	**1,371.77**	**1,389.84**	**1,408.16**
Benefits to Public at Large														
	HWY Congestion Savings	$2,886.14	250.49	258.33	266.42	274.76	283.36	292.23	301.37	310.81	320.54	330.57	340.92	351.59
	Airport Delay Saving	$473.42	40.34	41.68	43.07	44.51	45.99	47.53	49.11	50.75	52.44	54.19	56.00	57.86
	Safety Benefits	$1,202.95	99.19	100.37	101.56	102.76	103.98	105.21	106.46	107.72	109.00	110.29	111.60	112.93
	Highway Reduced Emissions	$255.61	21.52	21.95	22.39	22.83	23.29	23.76	24.23	24.71	25.21	25.71	26.22	26.75
	Total Public at Large Benefits	**$4,818.12**	411.54	422.33	433.44	444.86	456.62	468.72	481.18	494.00	507.19	520.76	534.74	549.13
Total Benefits		**$19,579.99**	**1,631.15**	**1,657.95**	**1,685.28**	**1,713.16**	**1,741.59**	**1,770.58**	**1,800.16**	**1,830.34**	**1,861.12**	**1,892.53**	**1,924.58**	**1,957.29**
Costs														
	Capital Cost	$6,404.24	-	-	-	-	-	-	-	-	-	-		
	O&M Costs	$3,432.23	279.06	282.57	286.13	289.72	293.37	297.06	300.79	304.58	308.41	312.28	316.21	320.19
	Cyclic Mtn	$90.38	7.84	11.76	11.76	11.76	11.76	11.76	15.68	15.68	15.68	15.68	15.68	15.68
Total Costs		**$9,926.84**	286.90	294.34	297.89	301.49	305.13	308.82	316.48	320.26	324.09	327.97	331.90	335.87
Benefits - Costs		**$9,653.15**	1,344.24	1,363.61	1,387.39	1,411.67	1,436.45	1,461.76	1,483.69	1,510.08	1,537.03	1,564.56	1,592.69	1,621.42

8.6 CONCLUSION

In addition to improving ridership and relieving traffic congestion within the Norfolk to Richmond corridor, the Option 4, Richmond Direct Improved 220-mph technology option would benefit ridership and revenues for the system and relieve traffic congestion outside the Norfolk to Richmond corridor (i.e. benefits to the Peninsula and Richmond to DC segments). Option 4 also provides a superior Financial and Economic return (Operating Ratio, Benefit-Cost Ratio) when compared with results for addressing only the Norfolk to Richmond corridor. However, the current assessment is limited by scope and should be subject to the same level of analysis as provided by the current study for the Norfolk-Richmond corridor. It is suggested that expanding the scope of the current project to consider the Peninsula corridor should be explored to ensure the capital costs and environmental conditions assumed along the route, are appropriate.

The evaluation of external factors suggests that both the Petersburg/Hopewell Options 1 and 2 and the Richmond Direct Option 3, are significantly improved when integrated with the other train services that use their corridor.

- The Northern and Southern Greenfield results for options 1 and 2 could be significantly improved by operating jointly with the SEHSR service between Petersburg and Washington. The Benefit-Cost Ratio increases from 1.5 to 1.8.
- The Richmond Direct Greenfield 220-mph Option 3 Benefit-Cost ratio would also be significantly improved if the Option 4 Peninsula service were added. Doing this would improve the Benefit-cost ratio at 3% discount rate from 1.57 to 1.97. Developing this option also does not preclude the ability to share the Richmond to Washington segment with SEHSR, and reduce the projects capital costs.

The integration with the Peninsula train services improves the financial and economic results by 20-25 percent. If both the Peninsula and SEHSR integration opportunities are considered, the overall results improve by 30-40 percent. It is the ability to integrate Norfolk-Richmond-Washington corridor with both SEHSR and Peninsula services that makes the results for the corridor so strong.

9. CONCLUSION AND NEXT STEPS

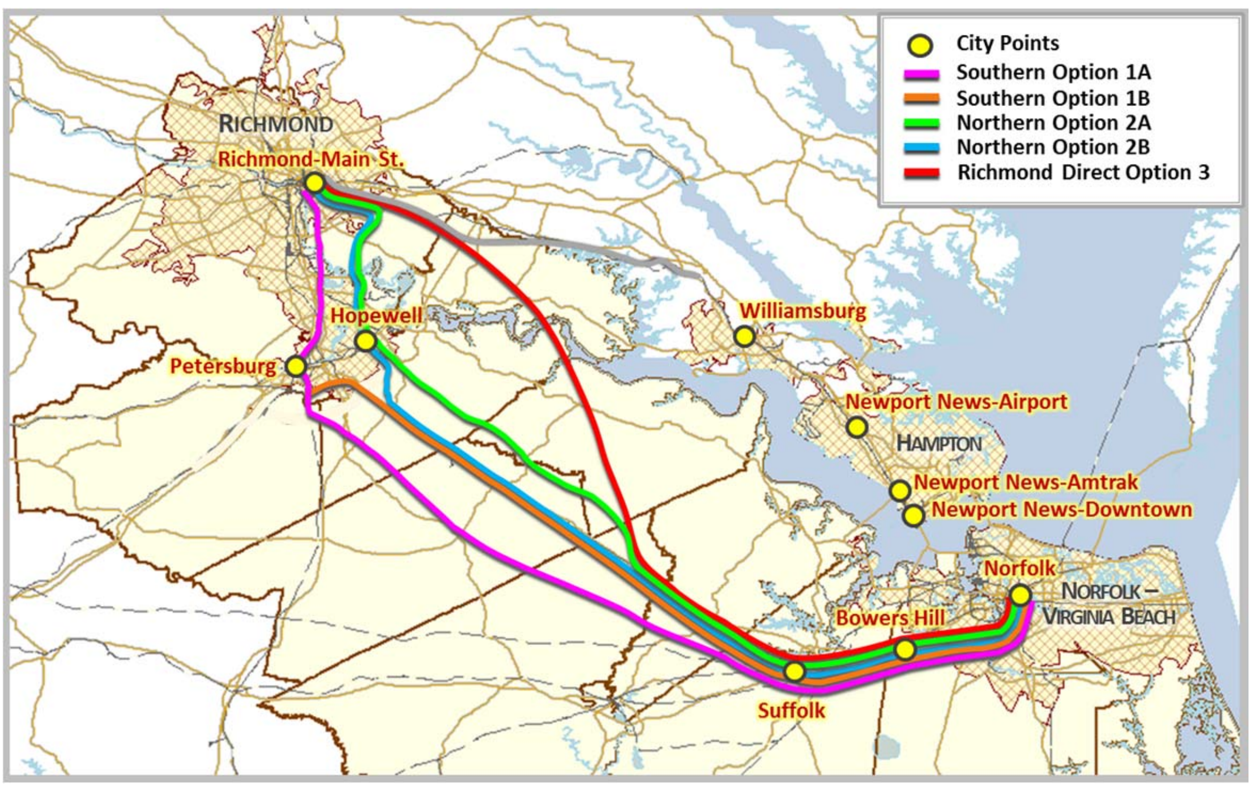
This chapter describes the key results of the study and the next steps needed to move the project towards the Tier 1 Environmental process.

9.1 RESULTS

The analysis shows that the potential for developing a true high speed system from Norfolk to Richmond is very real. It is clear that greenfield routes can be developed that, from the initial market operations, engineering and environmental analysis, would attain USDOT FRA financial and economic requirements and could avoid environmental "fatal flaws" that would prevent their construction.

In terms of the specific results, it was found that all of the options produced positive financial operating ratios (See Exhibit 7-2). Overall, 220-mph options showed higher returns than 130-mph options (Exhibit 7-2), and that the results for the Richmond Direct (Option 3) were marginally higher than the two Southern routes (Options 1A and 1B) via Petersburg or the two Northern routes (Options 2A and 2B) via Hopewell (Exhibit 7-2).

Exhibit 9-1: Vision Plan Alternatives Analysis: Rail Options



In Benefit-Cost terms, a similar set of results was found (Exhibits 7-4), with the Richmond Direct (Option 3) providing a marginal improvement over the Northern and Southern Route Options 1 and 2. And, again, the results for the 220-mph trains were higher than the results for 130-mph trains.

However, the results of the different options at this stage are so close that it is likely that external factors will determine which route is selected. Two key external factors are:

- The potential for Southern and Northern greenfield options sharing track and cost with the SEHSR trains from Petersburg to Richmond and Washington.
- The potential for the Richmond Direct option connecting with the Newport News-Richmond corridor, and both corridors being able to share track from Roxbury to Richmond and Washington.

The impact of the Southern and Northern options (1 and 2) sharing track with the SEHSR, would be on improving their Benefit-Cost results from 1.5 to 1.8. However, their operating ratios would remain unaffected as the impact would be on economic results only.

The impact of integrating the Norfolk-Richmond route with the Newport News-Richmond route is that considerable synergies are created in the operating costs of each route, and the improvement in demand for the Newport News-Richmond route is very significant. This increases demand dramatically so that more capacity is needed over the three trains per day option planned for Step 2 of the currently planned passenger rail for the corridor. Furthermore, with a short high speed connection to Toano, the demand increases to 8-10 trains per day, consistent with the original HRTPO Board resolution. This results in an improved Operating Ratio from 2.02 to 2.26 for the Richmond Direct Improved Option 4 (Exhibit 8-2). This also improves the Benefit-Cost Ratio which increases from 1.57 to 1.97 at a 3% discount rate (Exhibit 8-4).

These results show that a 220-mph greenfield option can be developed in the Norfolk to Richmond corridor. The specifics of the final selection depend on the likely degree of integration with the SEHSR or with the Newport News Peninsula route. However, at the current time, it would appear that the potential synergy with the Peninsula service could be very strong.

In the case of all the options, but in particular with the Richmond Direct Improved Option 4, the results show great potential for attracting a Public Private Partnership (P3). A P3 will be attracted by the strong financial result that suggests an operating surplus of $300 million per year by 2030 (See Exhibit 8-6).

9.2 NEXT STEPS

To move towards implementing the HRTPO Objectives, the HRTPO Next Steps should be:

- Work closely with the communities of the Peninsula to identify if the Richmond Direct Improved Option can be developed for the benefit of both the North and Southside Hampton Roads communities. This Option is a very cost effective way of developing higher speed options for the Peninsula, as well as achieving the high speed objectives of the Southside. It will give both communities the higher and high speed options they are seeking.
- Evaluate the potential for significant Capital Cost savings for linking with the Southeast High-Speed Rail in Petersburg using the Southern and Northern Greenfield Options 1A and 2A.
- Develop a Service Development Plan and a Service NEPA in order to make application to the USDOT FRA and/or the State of Virginia for funding for a Tier 1 High-Speed Rail EIS that determines the selection of the Final Preferred Alternative for the Hampton Roads-Richmond-Washington corridor.
- Develop partnership with freight railroads for engaging in right-of-way discussions.

- Engage SEHSR in a discussion of the potential synergies associated with the Northern and Southern Greenfield options, as well as the possible development of a high speed alignment north to Washington D.C.
- Develop the institutional framework to support a process for Public Private Partnership Development throughout the Environmental Process. This involves holding regular workshops with potential P3 partners through the environmental process.
- Identify the potential financial parameters for a public-private partnership considering: Design, Build, Operate, Maintain and Finance (DBOM-F) options similar to the approach in Florida that attracted $1.8 Billion in USDOT FRA money for a P3 project between Miami-Orlando-Tampa.

Key Documents for FRA Funding for high speed rail include:

- Service Development Plan/Service NEPA
- Environmental Documentation
- Railroad Agreements where existing rail rights-of-way will be used
- Agreements on Station Development with local communities
- Financial and Funding Plan
- Documentation of work with the USDOT FRA considered as part of the team to adopt 220-mph trains similar to those currently proposed for Northeast corridor and California.