I-66 Multimodal Study

Inside the Beltway

Supplemental Report

prepared for

Virginia Department of Transportation
Virginia Department of Rail and Public Transportation

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August 2013

CAMBRIDGE SYSTEMATICS

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1.0 Introduction

This Supplemental Report documents findings from continuing refinement analyses associated with the I-66 Multimodal Study after the June 2012 release of the Final Report. Building on the projects in the region's Financially Constrained Long-Range Plan (CLRP) and additional improvements recommended by the I-66 Transit/TDM Study, the I-66 Multimodal Study considered a wide range of complementary and mutually supportive multimodal improvement options that could be implemented to mitigate congestion and improve mobility along the I-66 corridor inside the Beltway. Among the options explored were expanded public transportation, additional highway lane capacity, enhanced transportation demand management (TDM), high-occupancy vehicle (HOV) policies, high-occupancy/toll (HOT) policies, congestion pricing, managed lanes, integrated corridor management (ICM), and bicycle and pedestrian corridor access.

The I-66 Multimodal Study Final Report provided core recommendations and package recommendations for the study area. The package recommendations encompassed elements of three of the four different multimodal packages that were evaluated during the study. Due to the short timeframe of the original effort, the recommended "hybrid" package was not able to be examined in detail prior to the publication of the Final Report.

The Supplemental Report effort developed and specified a refined recommended multimodal package and enabled performance of additional analyses. These analyses confirmed the recommendations of the Final Report and provided appropriate analytical support and documentation for future efforts in the corridor.

1.1 Highlights from the Final Report

The Final Report provided documentation of the year-long initial I-66 Multimodal Study process and included recommendations and actions that address the study goals.

Study Process

The path to developing a final set of recommendations was organized around a structured process for arriving at a set of multimodal solutions. A comprehensive set of transportation issues and needs were identified for the study area as follows:

1. Westbound roadway congestion;

2. Eastbound roadway congestion (including interchange capacity constraints at the Dulles Connector Road);

3. Capacity issues at I-66/arterial interchanges;

4. Non-HOV users during HOV operation hours;
5. Orange Line Metrorail congestion;
6. Adverse impact of roadway congestion on bus service;
7. Challenges to intermodal transfers (rail, bus, bicycle, car);
8. Bottlenecks on Washington and Old Dominion (W&OD) and Custis Trails; and
9. Limitations/gaps in bicycle and pedestrian accessibility and connectivity.

A subsequent evaluation process provided a means to move from a starting point of numerous ideas – referred to as mobility option elements – down a path to recommendations, considering first a set of eight to ten discrete mobility options and then narrowing to a set of four multi-modal packages before developing recommendations. The four multimodal packages carried into the Final Report are described in Table 1.1.

Recommendations

The Final Report offered recommendations, organized into two categories:

1. Core recommendations which were considered the first priority for implementation; and
2. Package recommendations that were derived specifically from the multimodal packages evaluated in this study.

Core Recommendations

The first tier of recommended improvements for the I-66 corridor inside the Beltway consists of the improvements in the corridor as included in the 2011 CLRP for 2040, including spot improvements along westbound I-66, increasing the HOV occupancy restriction on I-66 from HOV 2+ to HOV 3+, completing the Silver Line Metrorail extension to Loudoun County, and implementing the Active Traffic Management element of an ICM system.

The second tier of recommended improvements include the new transit services and TDM programs recommended by the 2009 DRPT I-66 Transit/TDM Study along with improvements deemed necessary to address Metrorail core capacity concerns in the I-66 corridor (e.g., eight-car trains). The I-66 Multimodal Study did not evaluate the effectiveness of these improvements independently, nor did it examine the timing and phasing strategy for them. It is assumed that the region will prepare a more rigorous implementation plan for these improvements as the travel conditions in the corridor warrant.

Table 1.1 Multimodal Package Summary Recommendations Framework

Summary Category	Multimodal Package 1	Multimodal Package 2	Multimodal Package 3	Multimodal Package 4
Description	Converts I-66 to a bus/ high-occupancy/toll (HOT) lane system.	Converts I-66 to a bus/ high-occupancy/toll (HOT) lane system and adds a lane in each direction.	Adds a bus/high-occupancy vehicle (HOV) lane in each direction.	Enhances bus service, including buses on shoulders along U.S. 50.
Core Package Purpose	Optimize the utilization of I-66 by allowing ***tolled*** SOV and HOV 2 trips. Includes enhanced bus service frequency.	Add single lane of capacity to I-66. Optimizes the utilization of the added capacity and roadway by allowing ***tolled*** SOV and HOV 2 trips. Includes enhanced bus service frequency.	Add single lane of capacity to I-66. Provides a bus/ HOV 2+ only lane in the reverse-peak direction. New and enhanced Priority Bus service on I-66, U.S. 29, and U.S. 50.	Greatly enhance bus transit options in the I-66 study area. Includes U.S. 50 bus-only shoulder lane and service into the D.C. core. New and enhanced Priority Bus service on I-66, U.S. 29, and U.S. 50.
Performance against Study Goal	**Reduce Congestion** • The proportion of congested VMT as percentage is reduced, but total VMT is increased. • Improves peak direction LOS on many segments of U.S. 29 and U.S. 50.	**Reduce Congestion** • Produces the lowest levels of congested VMT among the packages. • Improves peak direction LOS on many segments of U.S. 29 and U.S. 50.	**Reduce Congestion** • Slight increase in VMT with a slight increase in evening congested VMT. • Minimal change in the LOS on U.S. 29 and U.S. 50.	**Reduce Congestion** • Slight decrease in VMT and slight decrease in congested VMT. • Minimal change in the LOS on U.S. 29 and U.S. 50.
	Improve Mobility • Total PMT within the study area increases. • Person throughput increases at most cutlines in the study area. • PMT shifts from rail to freeways and arterials. • No substantial change in the commute mode share for HOV 2, HOV 3+, and transit.	**Improve Mobility** • Highest PMT on freeways among packages. • Slight decrease in the commute mode share for HOV 2, HOV 3+, and transit. • Highest person throughput for autos at cutlines among all multimodal packages.	**Improve Mobility** • Total PMT increases in the study area that is associated with travel in the off-peak period. • Highest person throughput at the cutlines. • Slight increase in transit mode share, resulting from improved bus service and speeds for reverse-peak routes.	**Improve Mobility** • Decrease in rail PMT, but increase in arterial PMT due to improved bus service on arterials. • Highest transit mode share among all packages. • Slight increase in person throughput at all cutlines in the study area.

Table 1.1 Multimodal Package Summary Recommendations Framework (continued)

Summary Category	Multimodal Package 1	Multimodal Package 2	Multimodal Package 3	Multimodal Package 4
Issues	• Policy issues with tolling existing capacity on an Interstate would need to be addressed. • Potential policy issues with tolling Dulles Airport users. • Public support for tolling existing capacity would need to be generated. • Addresses facility use by non-HOV users. • Impacts reverse-peak direction commuters differently than peak direction commuters.	• Potential public resistance to adding additional capacity on I-66. • Policy issues with tolling existing capacity on an Interstate would need to be addressed. • Potential policy issues with tolling Dulles Airport users. • Public support for tolling existing capacity would need to be generated. • Addresses facility use by non-HOV users. • Impacts reverse-peak direction commuters differently than peak direction commuters.	• Potential public resistance to adding additional capacity on I-66. • Facility design and enforcement system to accommodate the HOV lanes in both directions. • Does not directly address facility use by non-HOV users.	• High cost to affect already high transit share in the study area. • Bus operation on the shoulder of U.S. 50 could be challenging. • Potential enforcement issues associated with the bus only shoulder restriction on U.S. 50. • Increasing the bus level of service as tested in this package may be challenging. • Does not directly address facility use by non-HOV users.

Table 1.1 Multimodal Package Summary Recommendations Framework (continued)

Summary Category	Multimodal Package 1	Multimodal Package 2	Multimodal Package 3	Multimodal Package 4
Implications for Recommendations	• Lowest cost package. • The proportion of congested VMT is reduced, but total VMT is increased. • Open road tolling and systems for identifying eligible HOVs similar to the Beltway HOT lanes would need to be employed. • Policy issues and public acceptance of tolling will need to be addressed. • Potential for toll revenue to be used to fund improvements.	• Highest capital cost package as a result of adding a lane on I-66, plus adding open-road tolling equipment. • Increases VMT within the study area while decreasing congested VMT as a percentage. • Adds capacity on I-66 and moves a greater number of trips to the new freeway capacity. • Open road tolling and systems for identifying eligible HOVs similar to the Beltway HOT lanes would need to be employed. • Policy issues and public acceptance of tolling will need to be addressed (although there is added capacity). • Potential for toll revenue to be used to fund improvements. • Public acceptance of additional capacity on I-66.	• High capital cost package as a result of adding a lane on I-66. • New capacity on I-66 may be underutilized. • Design considerations to accommodate bus/HOV 2+ lane in the reverse-peak direction. • Public acceptance of additional capacity on I-66.	• Highest annual operating cost package. • Highest transit mode share of all packages tested. • Design and operational considerations of adding bus only shoulder lane on U.S. 50 may be significant.

Package Recommendations

A "hybrid" multimodal package was recommended for consideration as the third tier and end-state set of multimodal improvements to the I-66 corridor inside the Capital Beltway (joining the first and second tier articulated as core recommendations). This multimodal package was built up of elements from the four multimodal packages. It was recommended based on the evaluation of the individual packages from which its components were drawn. Outlined below are the various elements of the proposed hybrid package of improvements:

- Completion of the elements of the bicycle and pedestrian network to enhance service as a viable alternative to motorized trip-making in the corridor. Consideration should be given to the priority determination that follows as funding becomes available.

- Full operability of an ICM system inside the Beltway. These strategies maximize the use, operations, and safety of the multimodal network within the study corridor.

- Addition and enhancement to the suite of TDM programs in the corridor. As funding becomes available for TDM, consideration should be given to the priority grouping established in this study for implementation.

- Implementation of the best performing transit recommendations from Multimodal Package 4. This involves examination of all the transit service improvements in Multimodal Package 4 to determine those with the highest ridership in the corridor.

- Implementation of HOT lanes on I-66 to: provide new travel options in the corridor; utilize available capacity on I-66; provide congestion relief on the arterials; and provide new transit services as an alternative to tolled travel.

- Addition of a third through-lane on selected segment(s) of I-66, depending on the monitored traffic flow conditions and demand both on I-66 and the parallel arterials.

- Explore the full use of commonly used or proven design waivers/exceptions to enable remaining within the existing right-of-way for I-66.

1.2 Supplemental Report Objectives

The Supplemental Report builds on the Final Report in refining and testing of the recommended "hybrid" multimodal package, hereinafter referred to as the "refined multimodal package" and proceeds with analysis of potential shorter-term improvements, specifically examination of the HOV occupancy requirements. The Supplemental Report also explores prioritization of bicycle and pedestrian network elements for consideration as funding becomes available.

Refined Multimodal Package

The development, refinement, and testing of the recommended multimodal package is an opportunity to clarify the vision articulated in the Final Report and to estimate the multimodal impacts of the refined scenario. This effort includes refinement of the roadway and transit elements. Section 2.0 of the Supplemental Report, *Refined Multimodal Package,* describes the refinements and presents the evaluation measures.

Refined Bicycle and Pedestrian Recommendations

Section 3.0 of the Supplemental Report, *Refined Bicycle and Pedestrian Recommendations,* presents a refinement process undertaken for the recommended bicycle and pedestrian network enhancements presented in the I-66 Multimodal Study Final Report. The section describes the refinement process undertaken as well as the resulting short list of projects that support mobility and congestion relief through enhancements to the connectivity and functionality of the regional network.

Analysis of Potential Short-Term Improvements

Section 4.0 of the Supplemental Report, *HOV Occupancy Requirements,* focuses on the analysis of converting the HOV occupancy requirements from HOV 2+ to HOV 3+. The refined multimodal package assumes that the CLRP improvements in the I-66 corridor for 2040 will be completed. The CLRP currently assumes a change in HOV occupancy requirements (from HOV 2+ to HOV 3+) will happen on I-66 by 2020. Recommendations on when may be an appropriate timeframe for converting I-66 to HOV 3+ was examined using the regional model. The resulting model output is reviewed to assess conditions in the interim years of the I-66 Multimodal Study, and provides guidance as to when the region needs to consider the change to an HOV 3+ occupancy requirement.

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2.0 Refined Multimodal Package

The Final Report of the I-66 Multimodal Study discussed a "hybrid" package recommendation which was made up of promising elements of three of the multimodal packages. However, the study schedule did not permit discrete testing of the hybrid package. This section of the Supplemental Report discusses the development, refinement, and evaluation of the hybrid package, which is referred to herein as the "Refined Package."

2.1 Roadway Refinement

The roadway refinement associated with the Refined Package builds on the first and second tier improvements articulated as core recommendations in the Final Report. The roadway component of the Refined Package includes:

- Implementation of high-occupancy/toll (HOT) lanes on I-66, tested for two tolling options – peak-period-only tolls and all-day tolls; and
- Provision of an additional through-lane on eastbound I-66 and completion of a continuous third through lane on westbound I-66 between the Dulles Connector Road and Fairfax Drive.

2.1.1 Description and Depiction of Refined Roadway Network

The Refined Package tests a combined capacity and tolling scenario that was derived from those reviewed in the 2040 Baseline (CLRP+) and Packages 1 and 2. The description of the roadway components of the CLRP+ and Packages 1 and 2 are presented below as a point of reference.

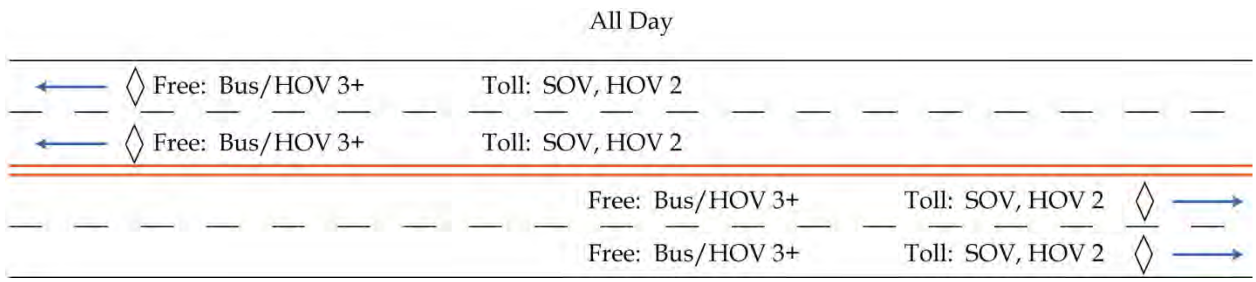
2040 Baseline – CLRP+

The 2040 Baseline for the I-66 Multimodal Study is called the CLRP+ and is comprised of the 2011 Financially Constrained Long Range Plan (CLRP) improvements plus the recommended bus services and TDM measures from the 2009 I-66 Transit/TDM Study. Among the CLRP+ projects included are three roadway expansion projects on I-66 inside the Beltway (refer to the Final Report for spot improvement project details).

Package 1 – Support of HOT, HOV, and Bus Lanes

Package 1 explores the performance of HOT, HOV, and bus lanes along the I-66 corridor. The key elements of this package include converting I-66 to an electronically tolled Bus/HOV/HOT roadway and applying tolls to all lanes in both directions at all times. This package maintains the present configuration of I-66 and applies a pricing strategy to permit SOV and HOV 2 use of the facility, while HOV 3+ and buses travel without a toll. The Package 1 treatment of I-66 is illustrated in Figure 2.1.

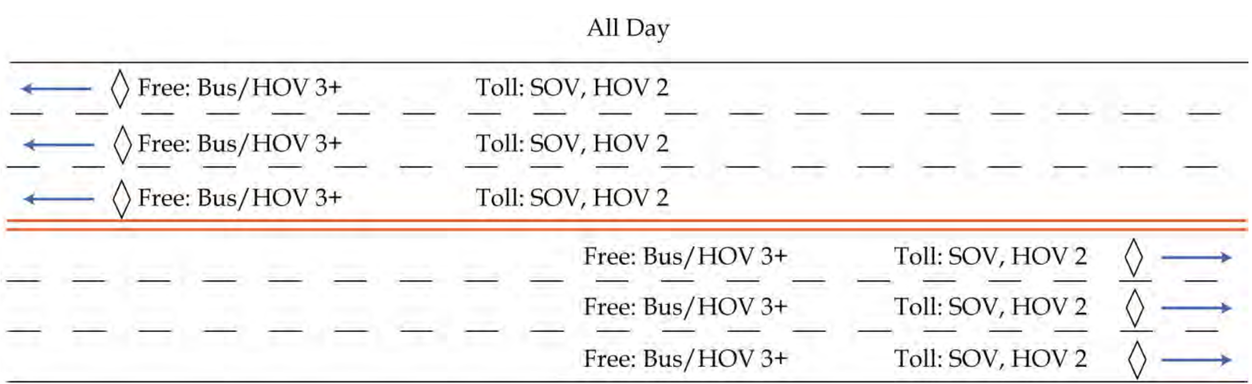
Figure 2.1 Package 1 I-66 HOT/HOV/Bus Lanes



Package 2 – Support of I-66 HOT/HOV/Bus Lanes using Widened I-66

Package 2 includes conversion of I-66 into an electronically tolled Bus/HOV/HOT roadway and a lane is added in each direction. Drivers using SOV and HOV 2 lanes would pay a toll while bus and HOV 3+ vehicles would not pay a toll. The tolls would be applied to all lanes in both directions all of the time. The Package 2 treatment of I-66 is illustrated in Figure 2.2.

Figure 2.2 Package 2 Widen I-66 HOT/HOV/Bus Lanes



Refined Package

The roadway refinement of I-66 associated with the Refined Package combines two primary concepts from Packages 1 and 2: 1) tolling I-66, and 2) widening I-66 along a critical portion.

- I-66 widening (westbound) – The I-66 westbound auxiliary lane spot improvement projects included in the 2040 CLRP+ do not include a third lane in the segment between the Sycamore Street off-ramp and the Washington Boulevard on-ramp. The Refined Package provides this connection and includes a third continuous through-lane from Fairfax Drive to the VA 267/Dulles Connector Road on-ramp.

- I-66 widening (eastbound) – The Refined Package includes an additional through lane on I-66 beginning at the merge with the VA 267/Dulles Connector Road off-ramp and extending eastward to the off-ramp to Fairfax Drive.
- I-66 HOT system – Two tolling options are considered: 1) a peak-period-only HOT system, and 2) an all-day HOT system.

The Refined Package provides a third through-lane only where forecast demand and service level merit the new capacity, as a means of reducing costs and potential impacts versus providing a third lane the entire length of the corridor. In addition, to further mitigate costs and potential impacts of widening I-66 in the segments identified, the full exploration of use of commonly used or proven design waivers/exceptions during the design phase of these projects is recommended in the Refined Package.

2.1.2 Cost Estimate

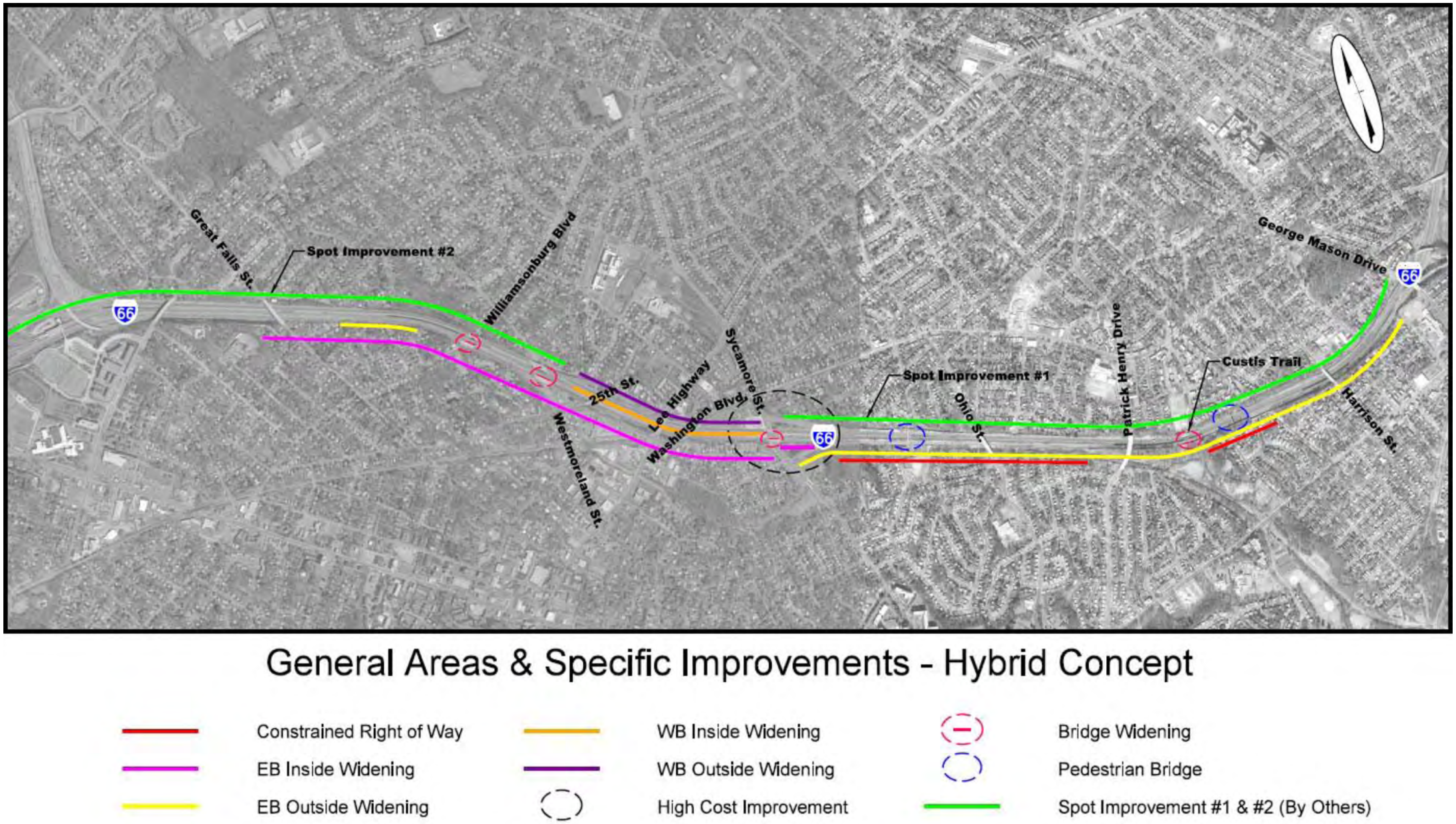
Planning-level cost estimates were prepared for the eastbound and westbound widening. Figure 2.3 presents a conceptual graphic of the roadway improvements in the Refined Package. For the westbound widening, two options were considered:

1. Adding one-lane primarily on the inside of I-66 westbound. This solution assumes that the inside widening adjacent to the Metrorail tracks can be coordinated with WMATA; or
2. Adding one lane primarily on the outside of I-66 westbound.

For the eastbound widening a single least-cost option was pursued with widening towards the inside or outside as might minimize costs, primarily on the inside of I-66 eastbound from Great Falls Street to Sycamore Street, and primarily on the outside from the on-ramp from Sycamore Street to I-66 eastbound to the off-ramp to Fairfax Drive. The latter eastbound segment was identified as having potential right-of-way constraints, which, it was assumed, will be explored and/or mitigated in any ensuing detailed engineering for the project via the full use of design features with design waivers and exceptions for lane widths, shoulder widths, horizontal and vertical clearances, pier protection, side slopes, and drainage.

The resulting estimate is that the roadway portion of the Refined Package would cost between $160 million and $180 million to construct, including tolling provisions. Assumptions regarding development of the cost estimates are noted in Appendix A.

Figure 2.3 I-66 Refined Package – Planning-Level I-66 Roadway Components



2.2 Transit Refinement

An important aspect of developing the Refined Package was to change the service frequency of proposed bus routes to be better aligned with forecasted ridership. The starting point for the proposed transit services included in the Refined Package was Package 4. The review and adjustment process refined the transit service recommendation for compatibility with the Refined Package roadway treatment and to improve the productivity of the proposed services.

In the refinement process, all service changes proposed in the CLRP+ were retained. Service realignments or changes from jurisdiction transit development plans (TDPs) were also retained, as these improvements have previously undergone significant planning attention.

Low-productivity routes were reviewed as indicated by the model assignment. The following productivity thresholds were set for evaluation:

- Peak-period 35 passengers per hour and off-peak cut-off of 20 passengers per hour for WMATA bus lines; and
- Peak-period 25 passengers per hour and off-peak cut-off of 15 passengers per hour for ART bus lines.

For routes with service frequency changes in Package 4 that did not meet these thresholds, the route service frequency was adjusted or the route was eliminated. These adjustments were made separately for the peak and off-peak period.

2.2.1 Transit Service Alternatives

As noted above, the transit refinement associated with the Refined Package tested a transit operating scenario that varies from that included in Package 4 based on a reassessment of bus route performance. The description of the transit components of Package 4 are presented below for reference.

Package 4 – Support of Enhanced Bus Service

- Increased transit service for all routes entering the study area, including increased frequency on local, commuter, and regional bus services.
- Headways on individual routes, that did not already have headways less than 15 minutes and were not part of trunk line services, were set at a minimum of 15 minutes in the peak and 30 minutes in the off-peak.
- Trunk line routes, which did not have a combined headway less than 15 minutes, were set for a combined headway of 15 minutes in the peak and 30 minutes in the off-peak. The 15-minute limit was set because there is a marginal benefit for headways under 15 minutes on those routes that do not already have that quality of service. In the CLRP+, the high-demand routes in the corridor are already coded with headways less than 15 minutes.

- This package also included enhanced U.S. 50 bus service with new routes from Tysons and Fair Oaks continuing on U.S. 50 into the D.C. Core and added a shoulder lane on U.S. 50 for bus operations only.
- This package also included new and enhanced Priority Bus services with 10-minute peak-period frequency on I-66, U.S. 29, and U.S. 50 with 10-minute service frequency, which represents an enhancement to I-66 Transit/TDM Study service levels.

2.2.2 Transit Network Modifications

The transit refinement takes into account performance of Package 4 routes through a comparison of level of service versus load factors. Based on analysis from ridership data and revenue service hours, recommended service reductions (primarily through scaling back route frequency) target segments with low productivity as presented in Table 2.1. The remaining routes in the study area maintain the same service characteristics as presented in Package 4.

The Refined Package is similar to Package 4 in that it calls for enhanced bus service along the I-66 Corridor including increased transit service for local, commuter, and regional bus routes entering the study area.

The Refined Package also includes:

- Enhanced U.S. 50 bus service with new routes from Tysons and Fair Oaks continuing on U.S. 50 into the D.C. Core; and
- New and enhanced Priority Bus services with 17-minute peak-period frequency on I-66, U.S. 29, and U.S. 50, which represents a scale back from the 10-minute service frequency levels in Package 4 that reflected I-66 Transit/TDM study service levels.

Table 2.1 Services Scaled Back Due to Low Performance

Services Operating During Peak Period[a]	Passengers per Hour[b]	Change from Package 4
WMATA 1X	30	Service eliminated
WMATA 2G, H	9	Service restored to CLRP+ level
WMATA 3B	28	Service restored to CLRP+ level
WMATA 3Y	5	Service restored to CLRP+ level
WMATA 4B	10	Service restored to CLRP+ level
WMATA 24T	11	Service restored to CLRP+ level
WMATA 28X	26	Service restored to CLRP+ level
WMATA 28T	28	Service restored to CLRP+ level
ART 53, 53A	16	Service restored to CLRP+ level
ART 62	5	Service restored to CLRP+ level

Table 2.1 Services Scaled Back Due to Low Performance (continued)

Services Operating During Off-Peak Period[a]	Passengers per Hour[b]	Change from Package 4
WMATA 1X	9	Service eliminated
WMATA 2G, H	3	Service restored to CLRP+ level
WMATA 3B	16	Service restored to CLRP+ level
WMATA 3A	15	Service restored to CLRP+ level
WMATA 3T	16	Service restored to CLRP+ level
WMATA 3E	18	Service eliminated
WMATA 4A	7	Service restored to CLRP+ level
WMATA 4B	10	Service restored to CLRP+ level
ART 75	1	Service eliminated
ART 53, 53A	10	Service restored to CLRP+ level
PRTC – Haymarket	6	Service eliminated
PRTC – Centreville	11	Service eliminated

Notes:

[a] Peak hours per weekday assumed to be 7 hours. For most new services, assumed 17 hours, 7 peak, and 10 off-peak.

[b] Transit assignment model output is considered approximate, but is useful for making relative comparisons.

2.2.3 Cost Estimates

The Refined Package has a 40 percent lower transit capital and operating cost compared to Package 4, as shown in Table 2.2. Transit operating expenses are incurred annually. Transit costs do not include additional costs associated with increased maintenance and storage needs. Assumptions regarding development of the cost estimates are noted below the table and are included in detail in Appendix A.

Table 2.2 Summary of Annual 2040 Transit Costs
2011 Dollars (Millions)

	Annual Costs				
	Operating Cost	Capital Costs[a]	Total Costs	Revenue[b]	Deficit
Package 4	$45.6	$8.8	$54.3	$13.1	$41.2
Refined Package	$27.7	$4.9	$32.6	$7.1	$25.5

Notes:

[a] Capital costs are annualized based on total vehicle capital cost estimates for ART, WMATA, and PRTC and a 12-year service life.

[b] Used the farebox recovery ratio (based on incremental cost recovery) appropriate for each operator and/or type of services – based on NTD data and differences in farebox recovery for local versus commuter services: Commuter Service (PRTC and Fairfax Connector) – assume 50 percent; Metrobus Express Services (WMATA) – 25 percent; Local Services – 20 percent.

2.3 Refined Package Model Results

The Refined Package was evaluated with two separate tolling options: 1) assuming the roadway operated as HOT lanes all day in both directions and 2) assuming the roadway would operate as HOT lanes during the peak periods only, in both directions. The discussion below focuses on the all-day tolling option, but the metrics for the peak-only toll option are also included. A subsequent report section discusses the merits of peak-only versus all-day tolling.

The performance of both of the tolling options for the Refined Package across all measures of effectiveness is presented in Table 2.3. These measures are systemwide measures and highlight the differences in performance of the Refined Package compared to the CLRP+. Overall, compared to the CLRP+, the Refined Package with all-day tolling:

- Increases study area peak-period vehicle miles traveled (VMT), while decreasing the proportion of VMT operating in over capacity conditions;
- Increases daily study area person miles traveled (PMT) for freeway and arterial trips, with a slight decrease in PMT for rail trips;
- Increases the transit mode share of all and home-based work trip productions and attractions;
- Increases the percentage of households and jobs with access to bus service; and
- Increases total daily person throughput across all cutlines, with increases in daily person trips for bus transit at or above 20 percent.

Figure 2.4 and Figure 2.5 present the increase in VMT by level of service and the increase in PMT as compared to the CLRP+. Figure 2.6 presents the improved travel time for selected origin and destination pairs.

For the Refined Package, the total daily peak-period VMT in the study area is higher than the CLRP+ (16 percent increase) due to the mix of added capacity on I-66 and the all-day toll approach which allows access for SOV and HOV 2 users (a comparison of the all-day toll approach to a peak-only toll approach is presented in the next section).

The proportion of congested peak-period VMT decreases by 2 percent compared to the CLRP+, a result of less congestion on parallel arterials. The proportion of VMT operating near capacity increases by 7 percent, primarily a result of added VMT on I-66. The total PMT in the study area increases by 6 percent over the CLRP+, representing the greatest increase in all packages tested in the study. There is a slight decrease in rail PMT compared to the CLRP+, but a significant increase in freeway PMT due to added capacity on I-66 and a lesser increase in arterial PMT due to the improvement in bus service on the arterials.

Study area travel times improve for transit and SOV/HOV 2 trips. This improvement stems from additional capacity and access to I-66 during all times of the day (particularly for SOV) and bus transit service improvements. The additional SOV and HOV 2 demand on I-66 results in a negative travel time (an increased travel time) impact for HOV 3+ trips. In the CLRP+, HOV 3+ trips are using I-66 in the peak periods at free flow speeds.

Figure 2.4 Peak-Period VMT by Level of Service

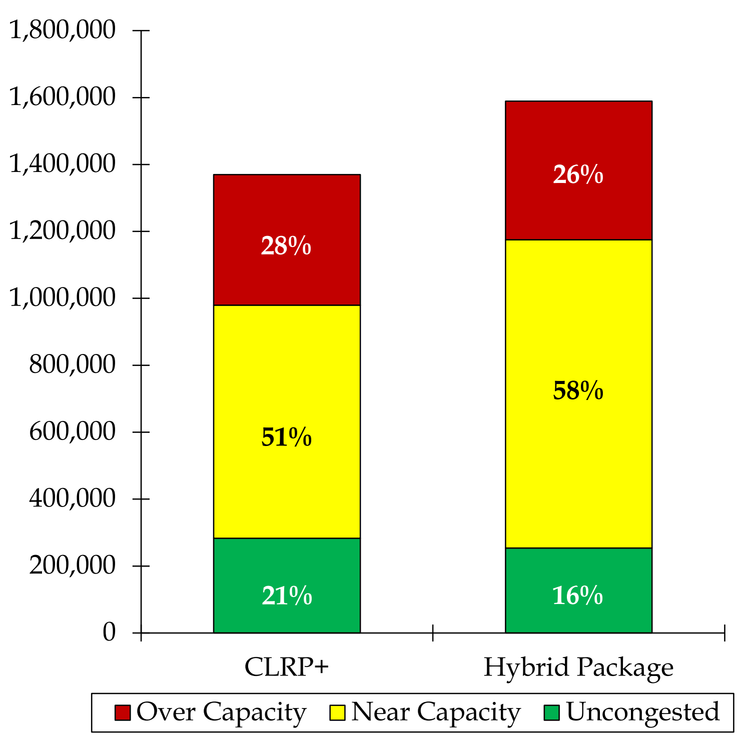


Figure 2.5 Refined Package Daily PMT

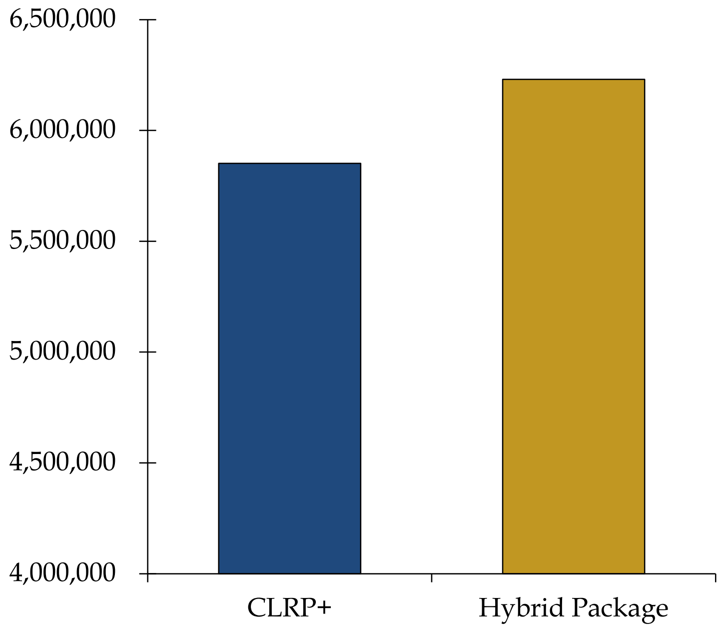
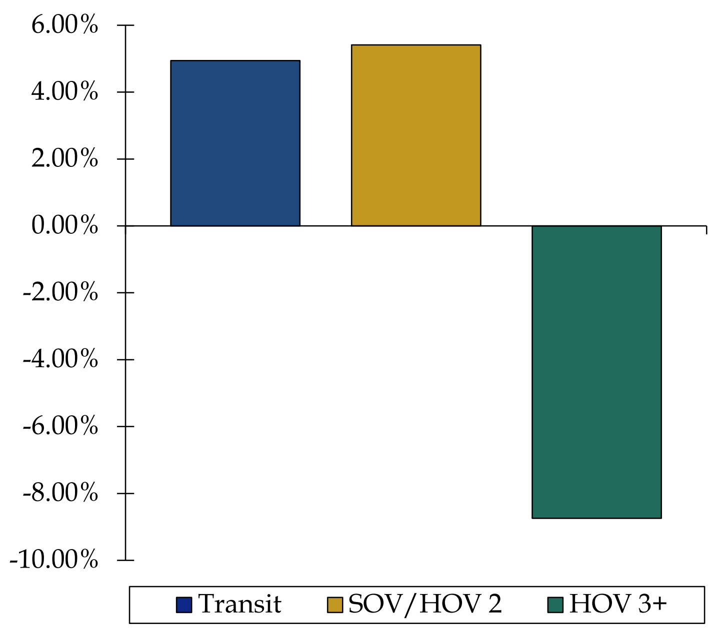


Figure 2.6 Refined Package Improved Travel Time By Mode Compared to CLRP+



The above graphic represents travel times between the following origins and destinations: Rosslyn, Ballston, the D.C. Core, Pentagon, Seven Corners, Tysons, Reston, Manassas, Merrifield, and City of Fairfax. Positive values reflect an improvement (reduction) in travel time.

Table 2.3 Measures of Effectiveness Summary

Measures of Effectiveness	2007	CLRP+	Refined Package (All-Day Toll)	Refined Package (Peak Period Toll)
Study Area VMT				
Morning (Total)	**558,700**	**555,300**	**640,100**	**640,700**
Uncongested	152,758 27.3%	135,666 24.4%	120,170 18.8%	120,674 18.8%
Near Capacity	303,671 54.4%	258,591 46.6%	341,299 53.3%	341,615 53.3%
Over Capacity	102,223 18.3%	161,126 29.0%	178,601 27.9%	178,416 27.8%
Evening (Total)	**872,100**	**814,400**	**949,300**	**951,600**
Uncongested	169,463 19.4%	147,441 18.1%	133,558 14.1%	133,710 14.1%
Near Capacity	517,964 59.4%	437,831 53.8%	580,086 61.1%	581,731 61.1%
Over Capacity	184,681 21.2%	229,117 28.1%	235,613 24.8%	236,188 24.8%
Study Area Daily PMT				
Rail	611,197	1,224,585	1,216,800	1,225,893
Freeway	2,063,637	2,122,972	2,463,452	2,673,569
Arterial	2,207,762	2,503,908	2,550,506	2,519,542
Total	*4,882,596*	*5,851,465*	*6,230,758*	*6,419,003*
Mode Share				
All Trip Productions				
SOV	45.5%	40.5%	40.1%	40.1%
HOV 2	22.8%	22.4%	22.2%	22.3%
HOV 3+	17.6%	20.1%	19.8%	19.7%
Transit	14.1%	17.0%	17.9%	17.9%
All Trip Attractions				
SOV	45.9%	38.4%	38.8%	38.8%
HOV 2	21.9%	20.0%	19.9%	20.0%
HOV 3+	17.6%	22.5%	21.5%	21.4%
Transit	14.6%	19.1%	19.8%	19.8%
Home-Based Work Productions				
SOV	49.1%	45.3%	44.8%	44.7%
HOV 2	6.5%	5.6%	5.8%	5.8%
HOV 3+	1.5%	2.1%	1.6%	1.6%
Transit	42.8%	46.9%	47.9%	47.9%
Home-Based Work Attractions				
SOV	54.3%	42.3%	44.1%	44.2%
HOV 2	8.2%	4.4%	5.0%	5.0%
HOV 3+	3.5%	13.8%	11.3%	11.3%
Transit	34.0%	39.4%	39.6%	39.5%

Table 2.3 Measures of Effectiveness Summary (continued)

Measures of Effectiveness	2007	CLRP+	Refined Package (All-Day Toll)	Refined Package (Peak Period Toll)
Study Area Transit Accessibility				
Households with Access to Bus Service	58.0%	76.8%	77.2%	77.2%
Jobs with Access to Bus Service	64.3%	87.7%	88.0%	88.0%
Nonmotorized Travel				
Daily Study Area Non-Motorized Trips	163,826	260,826	260,826	260,826
Walk Access Transit Productions	34,118	58,974	58,858	58,858
Walk Access Transit Attractions	35,890	51,860	53,562	53,624
Cutlines Daily Person Throughput				
Beltway Cutline				
Rail	36,482	37,295	33,401	33,698
Bus	1,850	7,603	11,456	11,639
Auto	278,021	276,625	300,527	311,093
Total	*316,353*	*321,522*	*345,384*	*356,429*
West of Glebe Road Cutline				
Rail	67,791	114,365	116,040	117,193
Bus	5,633	14,337	17,188	17,446
Auto	344,527	333,956	375,215	395,830
Total	*417,951*	*462,658*	*508,443*	*530,469*
Clarendon Cutline				
Rail	92,034	145,331	146,562	147,555
Bus	6,904	16,584	20,203	20,435
Auto	358,640	364,648	386,762	405,540
Total	*457,578*	*526,562*	*553,527*	*573,530*
Potomac River Cutline				
Rail	157,599	184,470	184,381	184,714
Bus	5,125	13,845	17,161	17,343
Auto	268,982	297,700	303,016	306,841
Total	*431,706*	*496,015*	*504,588*	*508,897*

Level of Service Performance

The following figures show the levels of service for highways and transit for the Refined Package. Traffic operations on I-66 during both the morning and evening peak hours were analyzed with the help of Highway Capacity Software (HCS), which uses the Highway Capacity Manual (HCM) methodology to assess I-66 travel lanes, ramp junctions, and weaving segments along the mainline to evaluate the operational performance of I-66 within the study area. Arterials were assessed using post-processed traffic volumes and capacities from loaded networks output from the TPB travel demand model.

The levels of service on I-66 and on the major arterials in the study area show some differences from the CLRP+. These differences are presented below and summarized in Table 2.4:

- Morning peak-hour level of service on I-66 (Figure 2.7) shows more segments in Arlington County operating at LOS D, otherwise the remainder of I-66 operates at LOS C or better. The increase in I-66 inbound and outbound miles operating in LOS D conditions reflects the impact of increased VMT on I-66 resulting from new tolled SOV and HOV 2 trips.
- Morning inbound peak-hour level of service on parallel arterials (Figure 2.8) shows fewer segments operating at LOS E and F. In particular, there are a number of areas of improvement along the length of U.S. 29, U.S. 50, and Wilson Boulevard inside the Beltway where LOS F conditions are eliminated. These improvements in level of service are tied primarily to SOV and HOV 2 trips diverting from the arterial system to a tolled I-66 (i.e., under the CLRP, these users cannot use I-66 in the peak period, peak direction, but under the Refined Package these users can pay a toll and use I-66).
- Morning outbound peak-hour level of service on parallel arterials (Figure 2.9) shows minimal differences in areas operating at LOS E and F.

Table 2.4 Refined Package Level of Service for the Morning Peak Hour

Facility and Direction	Alternative	Share of Study Area Miles by Level of Service (LOS)			
		A-C	D	E	F
Arterial – Inbound Direction	CLRP+	3%	5%	31%	60%
	Refined Package	7%	5%	49%	39%
Arterial – Outbound Direction	CLRP+	71%	17%	10%	2%
	Refined Package	71%	16%	10%	3%
I-66 – Inbound Direction	CLRP+	81%	19%	0%	0%
	Refined Package	72%	28%	0%	0%
I-66 – Outbound Direction	CLRP+	90%	10%	0%	0%
	Refined Package	48%	52%	0%	0%

The Refined Package optimizes bus service in the corridor to better meet demand. Compared to Package 4, at the Beltway and Glebe Road cutlines, the Refined Package reduces the number of buses per hour in the peak period by 8 to 14 percent (see Table 2.5). At all cutlines, the peak period bus service in the Refined Package is greater than what is planned in the CLRP+. Average passengers per bus remain the same or slightly decrease compared to Package 4. The decrease in passengers per bus is attributed to some mode shift occurring from transit to SOV/HOV 2 as a result of new capacity and tolled access to I-66 in the peak periods. Since there are no changes in Metrorail service in any of the Packages, passengers per Metrorail car in Table 2.5 are compared against the CLRP+. The load factors on Metrorail remain the same or slightly increase in the Refined Package.

Table 2.5 Refined Package Transit Load Factors for the Morning Peak Period

	Metrorail (Passengers per Car)		Bus (Passenger per Bus)		Peak-Period Bus Service (Buses per Hour)		
Cutline	**CLRP+**	**Refined Package**	**Package 4**	**Refined Package**	**CLRP+**	**Package 4**	**Refined Package**
Beltway	33	30	30	29	37	63	54
Glebe Road	58	59	26	23	68	102	94
Clarendon	70	73	29	22	71	106	107
Potomac River	73	74	32	32	44	67	65

The Refined Package includes improved transit service along U.S. 50. Along U.S. 50 at the western end of the study corridor there are 15 buses per hour in the Refined Package (see Figure 2.11) compared to 11 buses per hour in the CLRP+ (see Figure 2.10).[1] This is a significant drop from the service evaluated in Package 4, where 26 buses per hour served this segment of U.S. 50. Although there was a very good level of service supplied in Package 4, the ridership on U.S. 50 did not support the level of service provided.

Compared to the CLRP+, the Refined Package increases total daily transit ridership in the study area from 3,140 up to 4,048 trips per day (increases from 2.4 to 3.0 percent). Compared to Package 4, the combination of tolling on I-66 and the scaling back of low performing bus routes increases total daily transit ridership in the study area from 480 to 1,388 trips per day (increases from 0.4 to 1.0 percent).

[1] The CLRP+ transit service levels presented herein reflect corrections made since production of the Final Report.

Figure 2.7 Refined Package I-66 Level of Service Morning Peak Hour

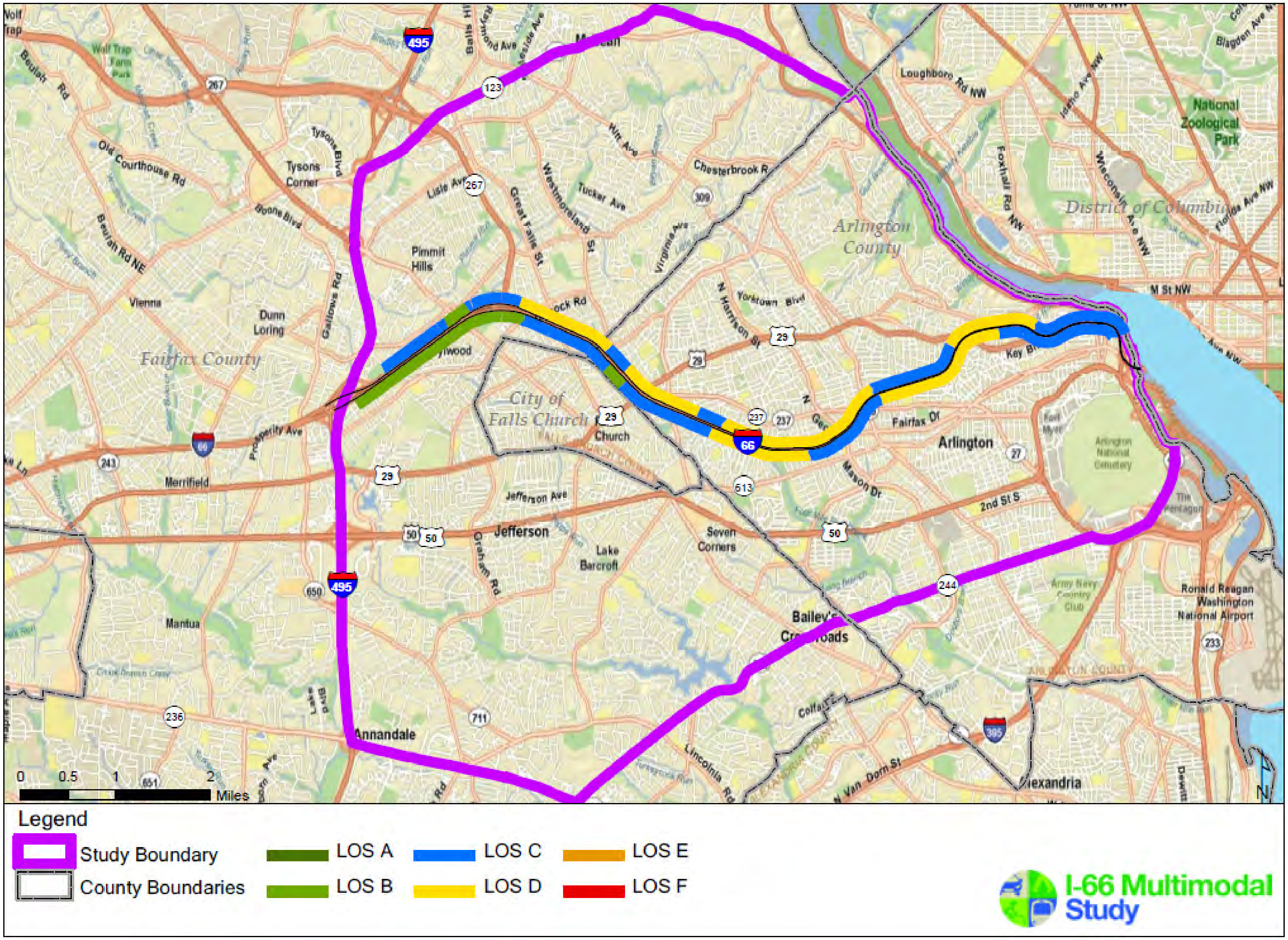


Figure 2.8 Refined Package Arterial Level of Service Morning Peak Hour Inbound

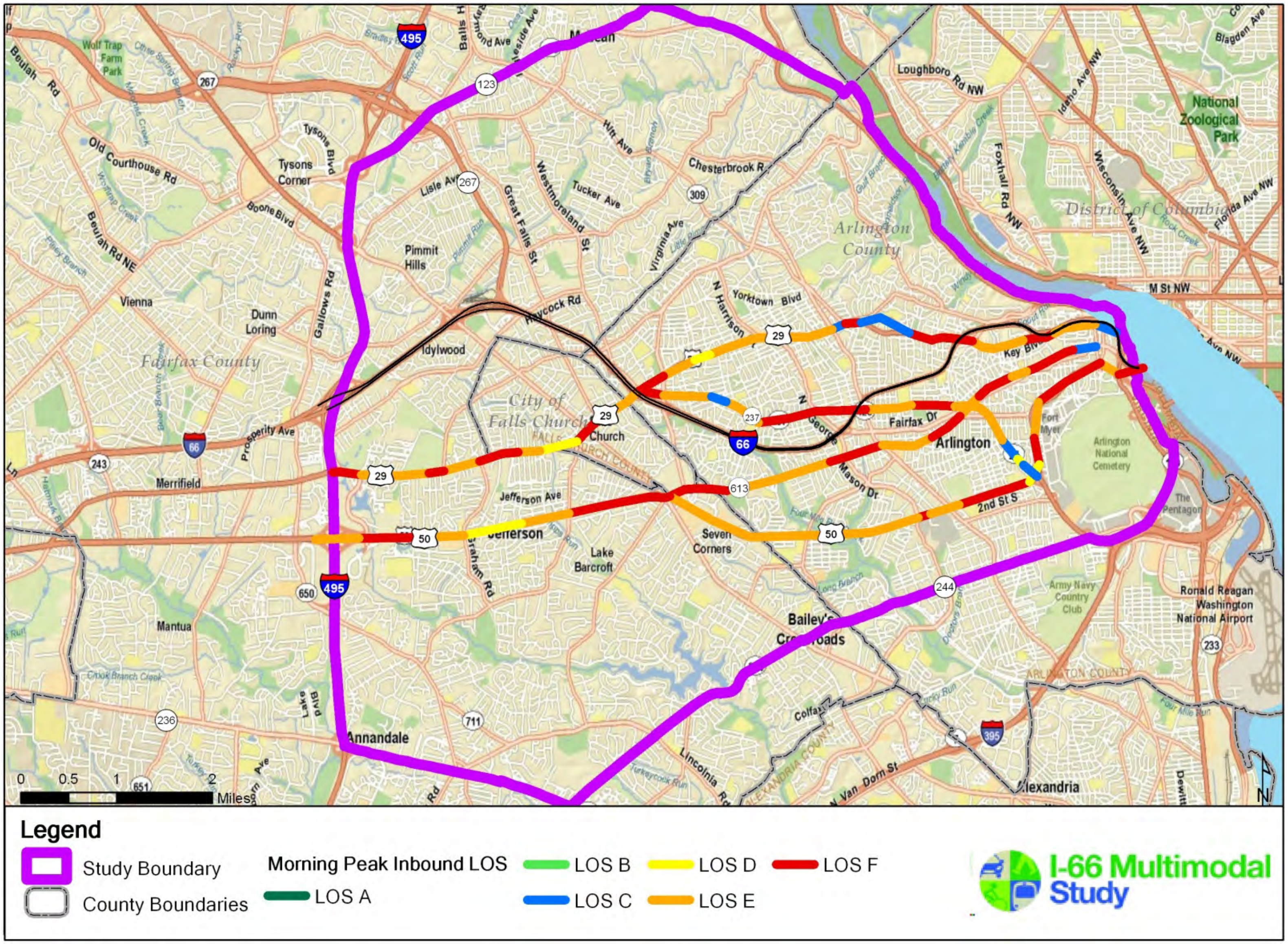


Figure 2.9 Refined Package Arterial Level of Service Morning Peak Hour Outbound

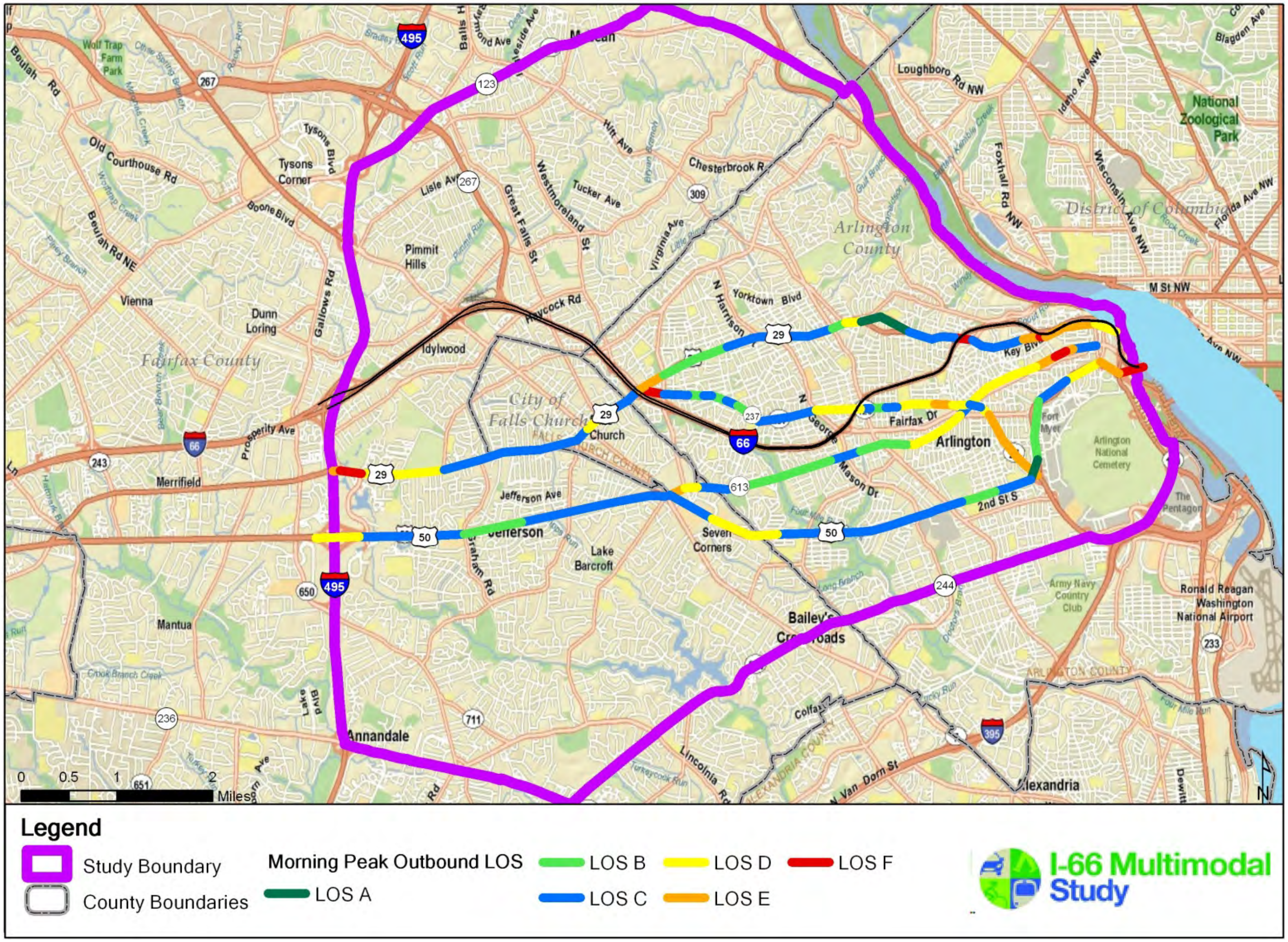


Figure 2.10 CLRP+ Inbound Buses per Hour in the Morning Peak Hour

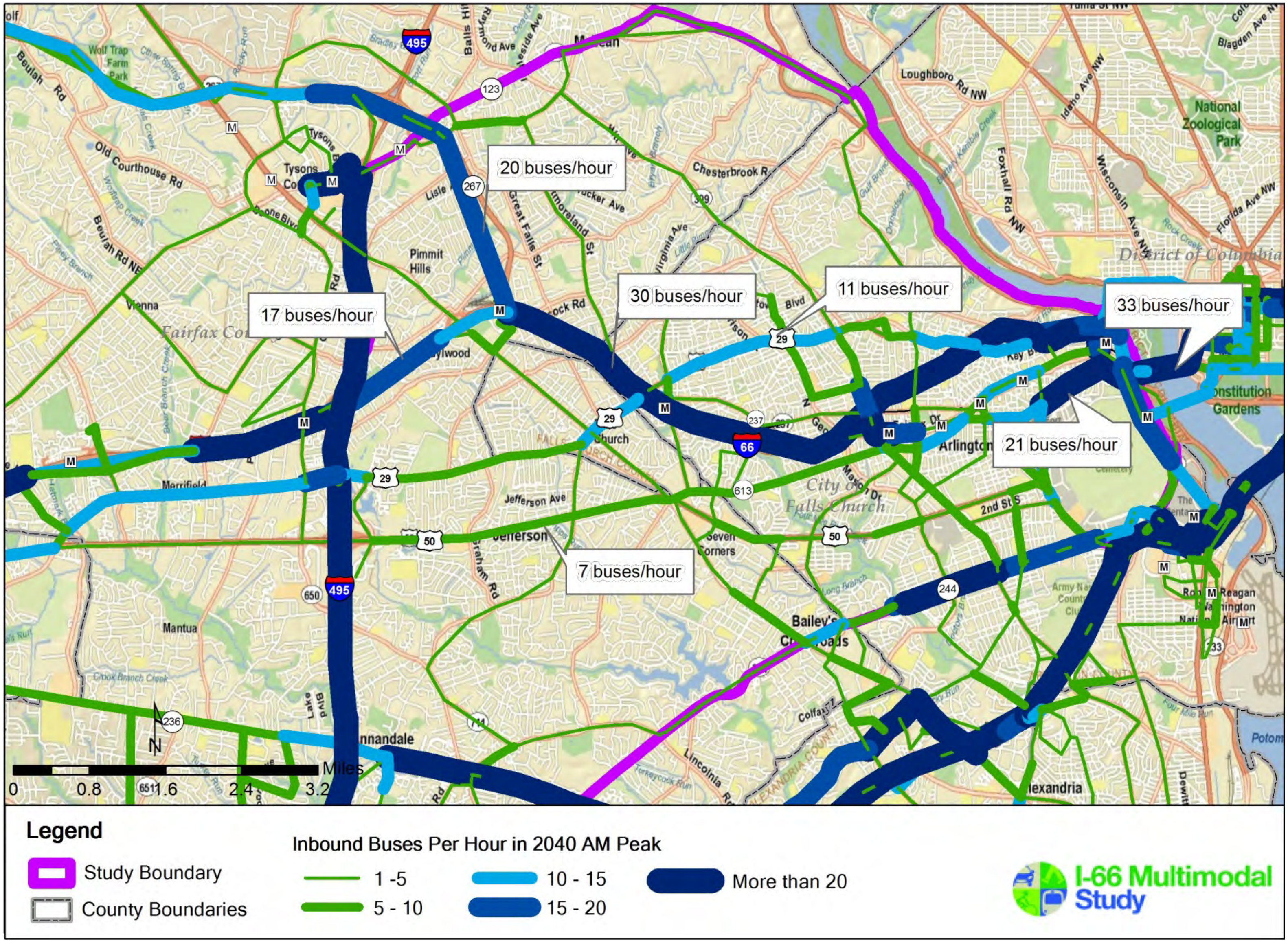
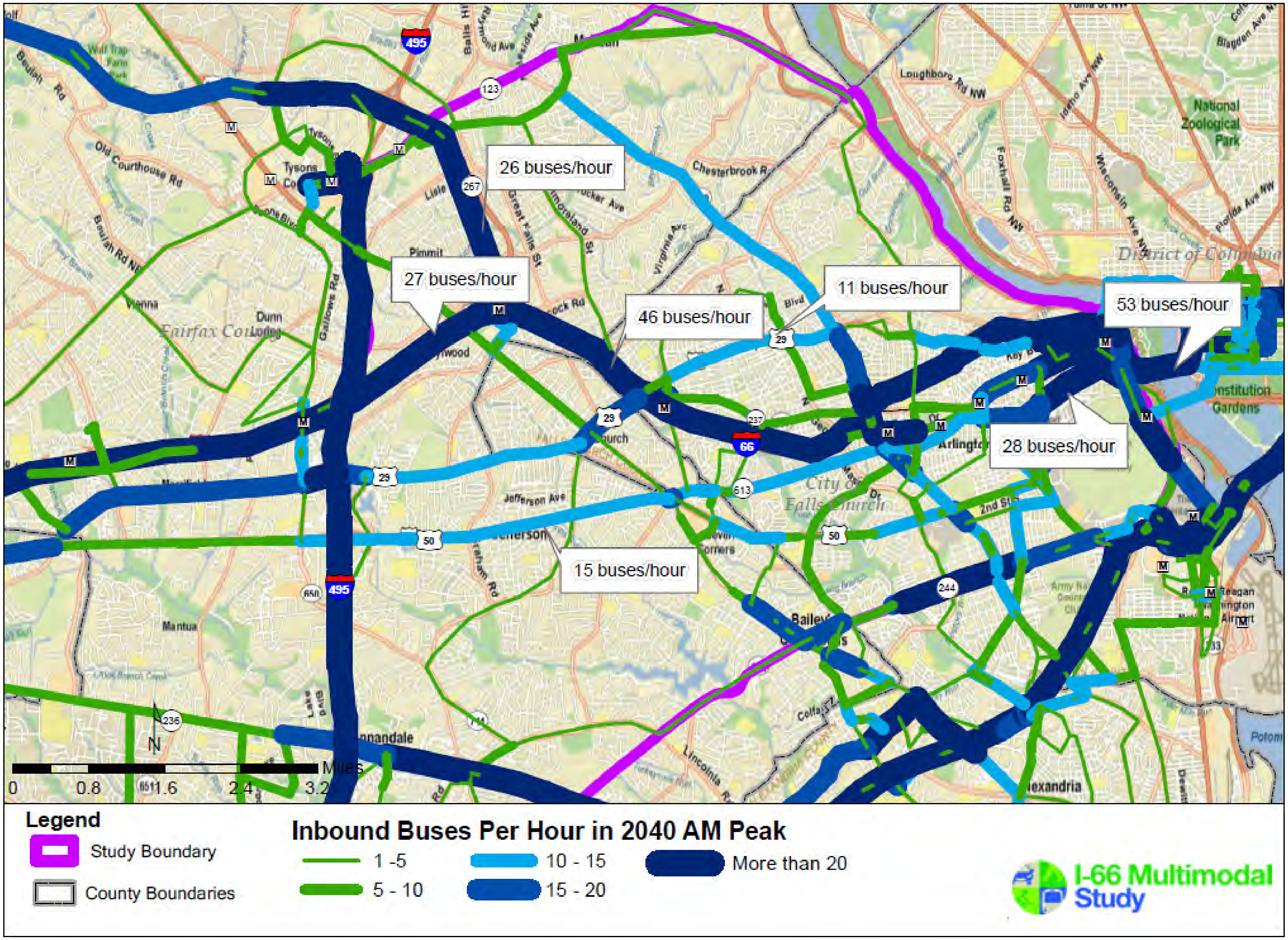


Figure 2.11 Refined Package Inbound Buses per Hour in the Morning Peak Hour



2.4 Peak-Only Tolls versus All-Day Tolls

The analysis of the Refined Package included an investigation of the study area transportation system performance across two I-66 tolling scenarios – peak-only tolls for SOV/HOV 2 users (free the remainder of the day), and all-day tolls for SOV/HOV 2 users.

Figure 2.12 presents the toll scenario for the peak and off-peak periods. The toll rate (cents per mile) varies by corridor segment, direction, and by time of day. The objective of these varying rates is to maintain average corridor speeds around 45 mph or better during all periods of the day. Rates are lower in the central segment of the corridor from VA 267 to Fairfax Drive where there are three lanes of capacity in both directions in the Refined Package, and higher in the sections to the east (Fairfax Drive to the Potomac River) and the west (VA 267 to the Beltway) where there is less capacity.

The results of the analysis of these two tolling scenarios are presented in Table 2.6. Both tolling scenarios show increases compared to the CLRP+ in daily PMT and person throughput in the study area. However, peak-only tolling shows a greater increase in daily PMT than all-day tolling. The reasons for this are as follows:

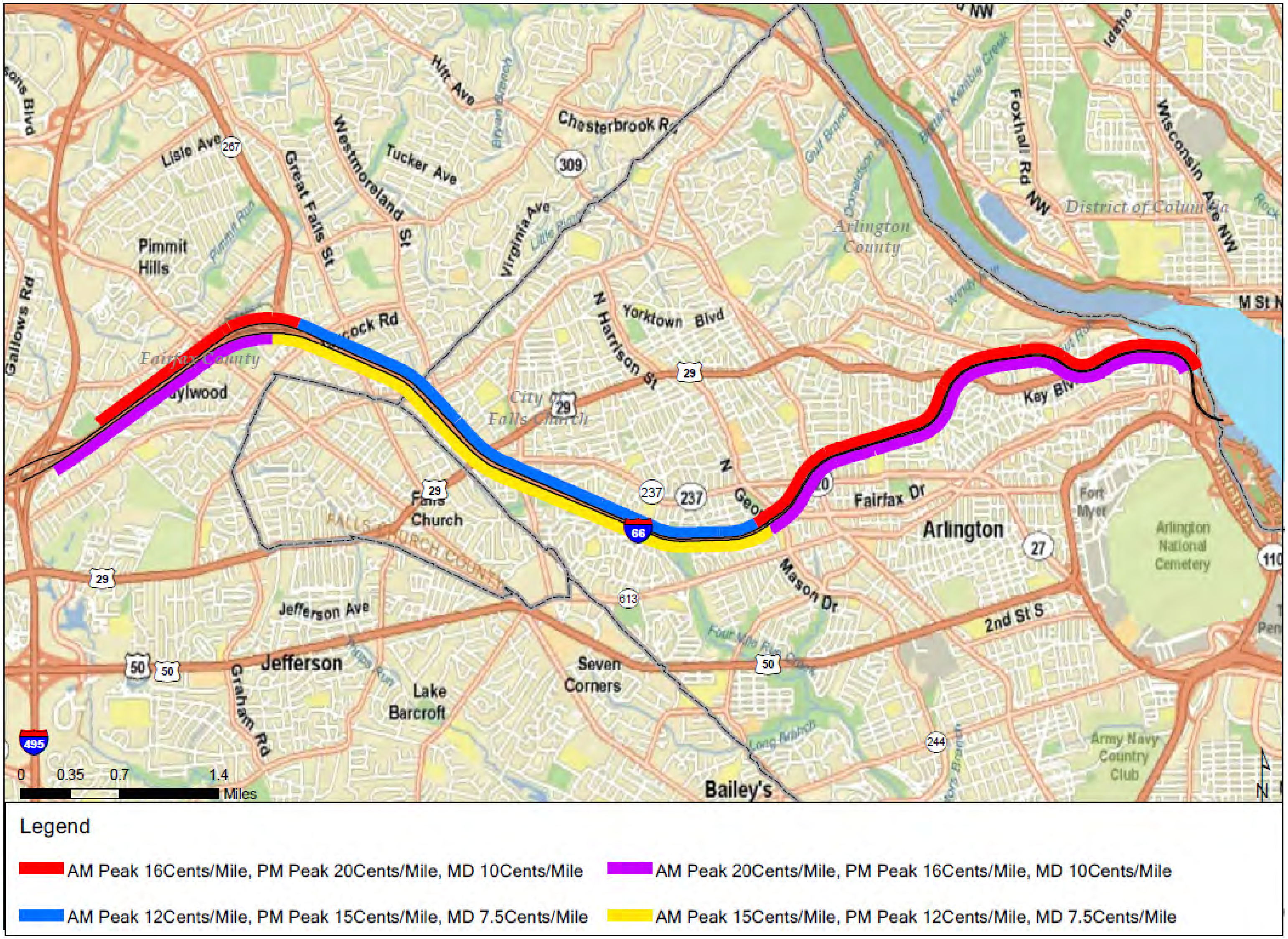
- I-66 is restricted to Bus/HOV 3+ in the peak direction in the CLRP+;
- When applying an all-day toll, SOV and HOV 2 users of the corridor in the off-peak are tolled instead of being free in the CLRP+ and peak-only toll approach; and
- The all-day tolling of the added capacity in the corridor draws fewer SOV/HOV 2 trips in the off-peak period, therefore generating a smaller increase in daily PMT and person throughput.

The peak-period congested VMT and transit ridership are essentially unchanged between the two tolling scenarios, as expected (there is no difference in peak-period tolls between the two scenarios, and no change in off-peak transit service or ridership).

Table 2.6 Refined Package PMT, Person Throughput, Congested VMT, and Transit Ridership

2040 Scenario Examined	Daily PMT	Person Throughput Measure	Peak-Period Congested VMT	Transit Ridership Measure
CLRP+	**5,851,465**	**451,689**	**390,243**	**133,458**
Refined Package – All-Day Toll	**6,230,759**	**477,978**	**414,214**	**136,598**
Change versus CLRP+	379,294	26,289	23,971	3,140
Percent Change versus CLRP+	+6.5%	+5.8%	+6.1%	+2.4%
Refined Package – Peak Toll	**6,419,003**	**492,331**	**414,604**	**137,506**
Change versus CLRP+	567,538	40,642	24,361	4,048
Percent Change versus CLRP+	+9.7%	+9.0%	+6.2%	+3.0%

Figure 2.12 Refined Package I-66 Toll Definitions



2.5 Refined Multimodal Package Conclusions

As detailed in the I-66 Multimodal Study Final Report and this Supplemental Report, the study examined four multimodal packages of improvements plus a Refined Package consisting of the most promising elements of the four packages. Each package included transit services, bicycle and pedestrian facilities, travel demand management strategies (TDM), technological applications, and roadway improvements that worked to complement each other with the objective of maximizing the potential for the package to achieve the twin goals of the study: improving mobility and reducing highway and transit congestion.

Table 2.7 presents a summary of selected measures for the CLRP+, the multimodal packages included in the Final Report, and the Refined Package. The results for the two Refined Package alternatives (all-day toll and peak-only toll) and how they address the study goals are summarized below:

- **Daily Person Miles Traveled (PMT)** – Daily PMT in the study area is higher than the CLRP+, 6.5 percent for the all-day toll and 9.7 percent for the peak-only toll, due to the mix of added capacity on I-66, the toll approach (which allows access for SOV and HOV 2 users on I-66 during peak periods), and new bus transit services.
- **Person Throughput** – Total person throughput in the study area is higher than the CLRP+, 5.8 percent for the all-day toll and 9.0 percent for the peak-only toll, due to the mix of added capacity on I-66, the toll approach (which allows access for SOV and HOV 2 users on I-66 during peak periods), and new bus transit services.
- **Peak Period Congested VMT** – Total peak period congested VMT in the study area is higher than the CLRP+, 6.1 percent for the all-day toll and 6.2 percent for the peak-only toll. In terms of share of total VMT, the percentage decreases from 28 to 26 percent as presented in Figure 2.4. Most of the reduction in the share of congested VMT occurs on parallel arterials as described earlier in reference to Figure 2.8.
- **Transit Ridership** – Daily transit ridership in the study area is higher than the CLRP+, 2.4 percent for the all-day toll and 3.0 percent for the peak-only toll, and also higher than Package 4. The Refined Package removes low performance bus service from Package 4 as detailed in Table 2.1. While this might have been expected to reduce total ridership slightly, the impact of all-day and peak-only tolls on I-66 leads to some additional mode shift to transit, and a net increase in ridership compared to Package 4.
- The proposed highway expansion and tolling components of the Refined Package can be implemented at a total cost of about 68 percent less than what is proposed in Package 2 while enhancing mobility with a 5 percent increase in daily person miles traveled and a 3 percent increase in person throughput. The proposed transit components of the Refined Package can be implemented and operated at a total cost of 40 percent less than what is proposed in Package 4 while slightly enhancing transit mobility, as evidenced by an approximately 1 percent increase in daily transit ridership over the transit-intensive package.

Table 2.7 Multimodal Package Summary Selection of Measures

2040 Scenario Examined	Daily PMT	Person Throughput Measure	Peak-Period Congested VMT	Transit Ridership Measure	Added Capital Cost ($2011)	Added Operating Cost ($2011)
CLRP+ Baseline	5,851,465	451,689	390,243	133,458	N/A	N/A
CHANGE IN STUDY AREA SUMMARY STATISTICS COMPARED TO CLRP+						
Multimodal Package 1 – Added to CLRP+ Scenario	40,490	5,632	10,726	1,423	HWY: $29 M	HWY: $0
	0.7%	1.2%	2.8%	1.1%	TRN: $5 M	TRN: $23 M
Multimodal Package 2 – Added to CLRP+ Scenario	267,509	24,098	-65,164	2,124	HWY: $377-702 M	HWY: $3 M
	4.6%	5.3%	-16.9%	1.6%	TRN: $5 M	TRN: $23 M
Multimodal Package 4 – Added to CLRP+ Scenario	2,306	494	-7,485	2,660	HWY: $211 M	HWY: $1 M
	0.0%	0.1%	-1.9%	2.0%	TRN: $9 M	TRN: $46 M
Refined Package (All-Day Tolls) – Added to CLRP+ Scenario	379,294	26,289	23,971	3,140	HWY: $160-180 M	HWY: $1 M
	6.5%	5.8%	6.1%	2.4%	TRN: $5 M	TRN: $28 M
Refined Package (Peak-Only Tolls) – Added to CLRP+ Scenario	567,538	40,642	24,361	4,048	HWY: $160-180 M	HWY: $1 M
	9.7%	9.0%	6.2%	3.0%	TRN: $5 M	TRN: $28 M

Notes: Person throughput and transit ridership measures are based on the average value across the four cutlines used in the study.

Capital cost estimates are not offset by potential toll revenues in any applicable package. Highway operating cost attributable to tolling is assumed offset by potential toll revenues.

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3.0 Refined Bicycle and Pedestrian Recommendations

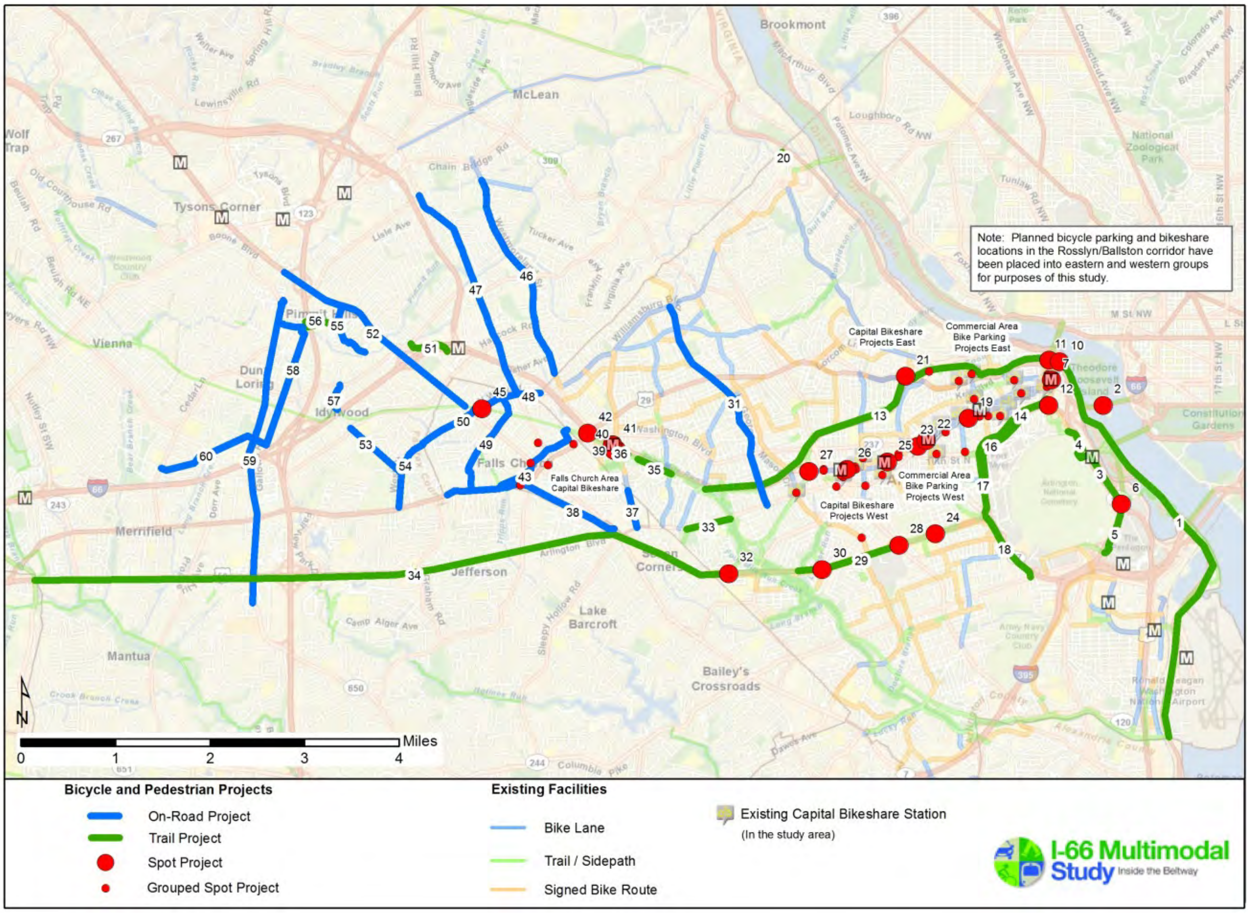
The Final Report for the I-66 Multimodal Study, issued in June of 2012, identified 60 potential projects that would enhance accommodations for bicyclists and pedestrians traveling along the I-66 corridor. Projects ranged significantly in scale from upgrading the Custis Trail along its entire length, to providing public bicycle parking in Rosslyn. This supplemental phase presents an opportunity to refine the initial package of projects into a consolidated list of regionally significant projects – those that can impact bicycling and walking for relatively large numbers of people. It is also an opportunity to differentiate those projects which will need additional interagency coordination in order to move forward from those that are in advanced stages of planning and implementation.

The resulting short list of projects supports mobility and congestion relief through enhancements to the connectivity and functionality of the regional network. These were among the highest ranked projects in Phase I of the I-66 Multimodal Study. These are projects that provide access to parts of the region that were previously unconnected, or projects that improve the functionality and performance of existing facilities.

The majority of the projects on the original list were sourced from ongoing planning activities in Fairfax County, the City of Falls Church, Arlington County, Washington Metropolitan Area Transit Authority (WMATA), and Virginia Department of Transportation (VDOT). Other projects were recommended either explicitly by stakeholders and the community, or were included based on general needs (e.g., need better transit access) articulated by stakeholders during Phase I at community meetings, during stakeholder interviews, or through the project survey. Figure 3.1 illustrates the 60 original Phase I projects.

The following sections describe the steps in the project refinement process. A set of profiles for each project, providing additional detail and location information, is included in the Appendix C.

Figure 3.1 Phase I Bicycle and Pedestrian Projects



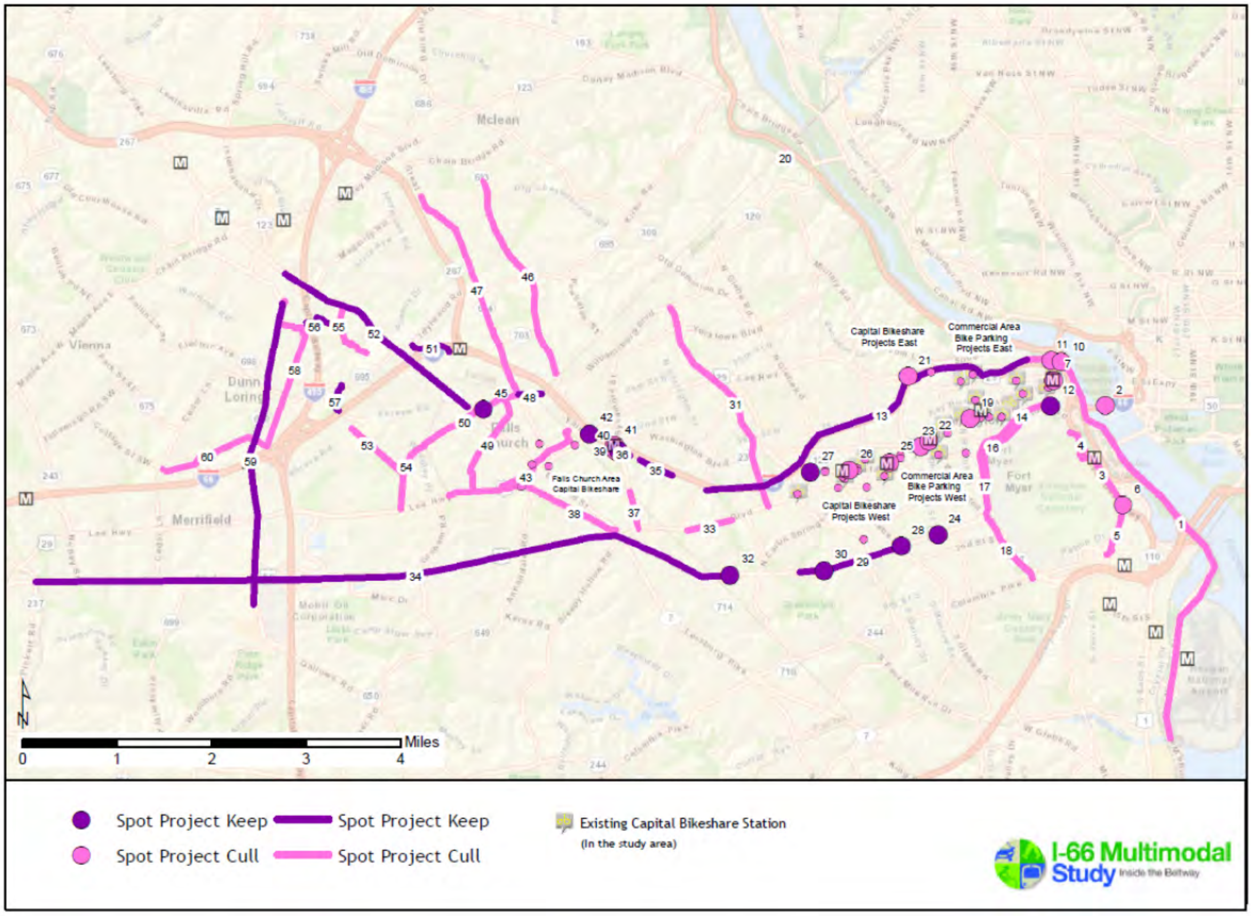
3.1 Bicycle and Pedestrian Project Refinement

The bicycle and pedestrian project list was refined through a multistep process that included consultation with local agency staff, assessment of a project's role in overall connectivity, and field investigation coupled with professional judgment.

The first step removed new bike share stations and bike parking from the project list. While it is recognized that bike share and bike parking are important elements in the multimodal transportation system, they were removed as standalone projects from this prioritization scheme as there is already significant momentum towards implementation.

In the next step, the project team consulted with local planning staff to assess the status of remaining projects on the list. A significant number were determined to be in advanced stages of planning, or would be moving towards implementation in the near future. Some were also determined to be primarily the responsibility of the local government, and would require little coordination with other regional agencies. While many of these projects will provide significant regional connections when completed, it was determined that they were moving substantively toward implementation and did not need to be included in the Phase II portion of the plan. Figure 3.2 illustrates the projects remaining at the end of these first two steps in the project refinement process. Projects illustrated by dark purple (spot and line) remain on the project list. Projects illustrated by the light magenta are removed from the project list.

Figure 3.2 Interim Bicycle and Pedestrian Projects



The project team assessed the remaining projects in the context of the larger bicycle and pedestrian network to gauge their overall function in improving regional connectivity, and subsequent impact on mobility and congestion mitigation. Key criteria in project evaluation were:

- Connecting major population or employment centers;
- Support for longer distance movements through the study area;
- Access to Metrorail stations; and
- Improving the functionality of existing facilities.

Projects that were determined to have the greatest potential for supporting the regional network were placed on a short list of approximately 20 projects for further evaluation.

Project planners and engineers conducted a planning-level feasibility assessment of the short list projects. This included in-office evaluation of the scale of potential right-of-way impacts using available digital imagery, on-line mapping, and geographic information system (GIS) property lines. Because this is a planning-level assessment, and projects have not progressed to even conceptual design, the intent was to merely highlight general areas where right-of-way availability appears to be an issue, rather than conduct an exhaustive survey of actual impacts. This information was added to the background information for each project, but no changes to the project list were made at this point.

Following the in-office assessment, project designers evaluated each of the remaining projects in the field. The purpose of this field investigation was to develop a general sense of existing conditions, evaluate opportunities and alternatives, and identify significant challenges to project implementation. During the field investigation, certain projects (such as the Gallows Road Bike Lanes) were determined to be substantially complete and could be removed from the project list. Projects along Arlington Boulevard were reorganized to reflect a more integrated arrangement. Several Arlington Boulevard intersection improvement projects were combined with the linear recommendations for a sidepath between Glebe Road and the I-495 interchange. The overall Arlington Boulevard sidepath project was divided into three segments reflecting the unique challenges and characteristics of the project (from east to west): Glebe Road to I-495 interchange, I-495 interchange, and I-495 interchange to City of Fairfax.

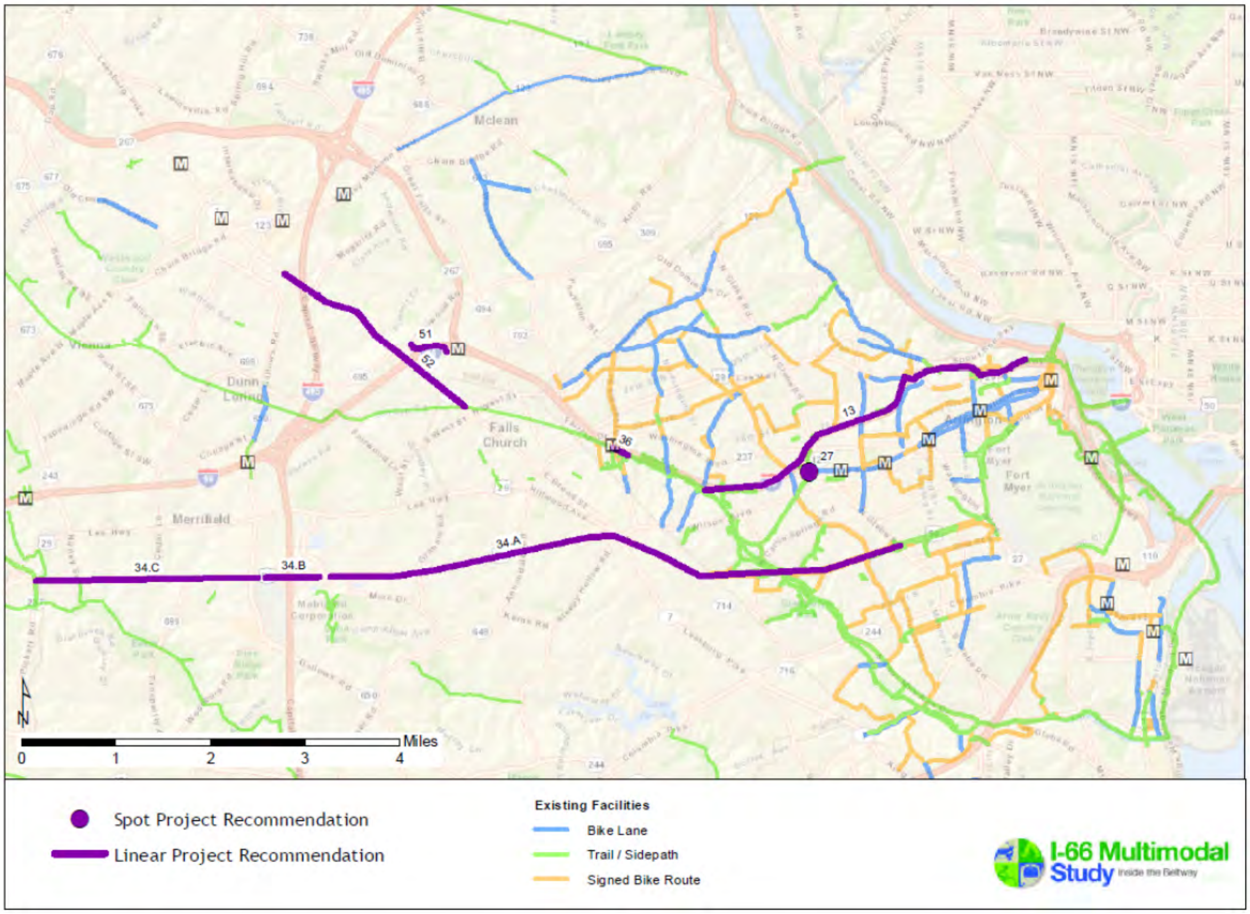
3.2 Regionally Significant Bicycle and Pedestrian Projects

Through this analysis, the project team identified seven projects that were deemed to be regionally significant. Each of these projects is shown on the project map in Figure 3.3, and is summarized below. The total cost of completing all seven projects is estimated at approximately $11 million; and projects are likely to be funded by a variety of sources, including local governments, state and Federal grants, developer contributions, and others.

The ID Number has been carried forward from the Phase I project list, and corresponds to the project map.

More detailed profiles for each project are included in Appendix C. Each profile includes a project description, pre-/post-improvement bicycle level of service (BLOS) or shared use path level of service (SUPLOS) as appropriate, planning-level cost estimate, project location map, statement of regional benefit, discussion of project considerations, and next steps for moving the project forward.

Figure 3.3 Regionally Significant Projects



Project 13 – Custis Trail

This project will widen the trail to 12 feet, where feasible (e.g., right of way is available and there are no utility conflicts); smooth cracked and heaved pavement; and upgrade trail lighting between Lynn Street in downtown Rosslyn and the intersection with the Washington and Old Dominion Trail (in Bluemont Park) near the western edge of Arlington County. This project supports bicycle commuter travel along the I-66 corridor parallel to the interstate providing access to many key destinations. These trail improvements will also help accommodate increased levels of reverse commuting (east to west) by bicycle that may occur in conjunction with increased development in Tysons and Merrifield.

Project 27 – Fairfax Drive Connector

This project will improve connectivity between the Custis Trail and the Bluemont Junction Trail, and the western edge of the Rosslyn-Ballston Corridor through wider sidewalks, improved signal timing, ramps and signage on N. Fairfax Drive west of N. Glebe Road. Improving access will enable more bicyclists and pedestrians to make commuting and recreational trips through the area. It will also increase safety for all users by clearly designating the location of a sidepath to motor vehicles, bicyclists, and pedestrians.

Project 34.A – Arlington Boulevard Trail (Glebe to Beltway)

This project will create a trail along Arlington Boulevard through a combination of constructing an off-road sidepath, on-street infrastructure, and signage. The project will continue the existing Arlington Boulevard sidepath west from Glebe Road to the I-495 interchange. The trail will enable bicyclists to travel from western Arlington County, and eastern/central portions of Fairfax County to locations in the Rosslyn-Ballston corridor, Crystal City, and east into the District of Columbia. The improvements will enhance bicyclist comfort through either a separated bicycle facility, or an on-road bicycle facility on a relatively low-speed, low-volume frontage road. Alternative alignments will need to be explored around challenging areas, such as Seven Corners.

Project 34.B – Arlington Boulevard Trail at I-495 Interchange

This project will construct bicycle and pedestrian accommodations across I-495 (Capital Beltway) in the vicinity of Arlington Boulevard. The ultimate facility will likely be a grade-separated crossing, and include overpass crossings of the interchange ramps, Fairview Park Drive (east of interchange), Gallows Road (west of interchange), as well as the 16 lanes of I-495. Constructing a crossing of the Beltway at this location will allow for bicycle and pedestrian traffic on the Arlington Boulevard trail to continue uninterrupted.

Project 34.C – Arlington Boulevard Trail (Beltway West to City of Fairfax)

This project will create a trail along Arlington Boulevard through a combination of constructing an off-road sidepath, on-street infrastructure, and signage from the I-495/Arlington Boulevard interchange to the City of Fairfax border at Fairfax Boulevard. The construction of this trail would make an important connection for cyclists between Fairfax/central Fairfax County and Arlington County.

Project 51 – West Falls Church Connector Trail

This project will construct a trail between the West Falls Church Metro station and the Pimmit Hills neighborhood to the northwest. The project will travel through VDOT and WMATA right of way. This connection has the potential to significantly improve access to the Metro station from the north.

Project 52 – VA 7 Tysons to Falls Church

This project will construct an off-road connection between the Washington and Old Dominion Trail in Falls Church and Tysons, running parallel to VA 7 (Leesburg Pike). Shorter-term improvements may use existing frontage roads to expedite initial implementation. The project will significantly improve connectivity between major regional destinations (Tysons, Falls Church) and existing facilities for nonmotorized traffic (Washington and Old Dominion Trail), and is part of the Fairfax County Bicycle Master Plan.

3.3 Additional Considerations for Bicycle and Pedestrian Improvements

As mentioned in the Phase I report, care must be exercised to ensure that any improvements to any aspect of the transportation system consider the impacts to bicycle and pedestrian accommodation. For example, adding a third lane to I-66 may mean that at least sections of the Custis Trail must be impacted as part of that project. It will be important to maintain the extensive connectivity between the trail and adjoining neighborhoods. Also, any construction activities should maintain connectivity with carefully planned detours that require minimal deviation from the main route, and minimize the duration of the disruption.

3.4 Next Steps

Moving these projects forward will require significant coordination between several stakeholders, including local governments, private landowners, and VDOT. Opportunities exist for integrating some of the projects into other road improvement projects, such as incorporating Arlington Boulevard Trail improvements into Arlington Boulevard roadway improvements. In the project profiles in Appendix C, projects that coincide with road projects in the National Capital Region Transportation Planning Board Financially Constrained Long-Range Plan have been identified.

In many cases, short-term improvements, such as striping on-road bike facilities, may be a suitable interim improvement where a separated sidepath is the ultimate goal. All projects should be evaluated for potential short-term improvements to address safety and connectivity. Longer-term improvements will provide enhanced levels of connectivity and comfort.

More detailed project feasibility studies may be needed for each of these projects to more accurately assess project design details, right of way, environmental and utility impacts, and costs.

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4.0 HOV Occupancy Requirements

The refined multimodal package assumes that the CLRP improvements in the I-66 corridor for 2040 will be completed. The CLRP currently assumes that a change in high-occupancy vehicle (HOV) occupancy requirements from HOV 2+ (two or more persons per vehicle) to HOV 3+ (three or more persons per vehicle) on I-66 will happen by 2020. This section focuses on the implications of implementing this change at various alternative intermediate years prior to 2040 in an attempt to provide guidance as to when the region should consider the change to an HOV 3+ occupancy requirement.

This analysis was conducted by applying the current TPB regional model. While this is the officially-accepted tool for performing regional travel demand forecasting, the ability of the model to predict HOV usage at an extremely fine grain such as on individual roadway links is limited. Moreover, the operation of this segment of I-66 (inside the Beltway) is significantly affected a variety of users, including single occupancy vehicles (SOV), HOV motorists, traffic oriented to Dulles Airport, and clean fuel vehicles that may carry any number of passengers. Thus, the findings of this study should be interpreted broadly, and final decisions on operating policies should be made by also considering speeds, travel times, delays and measures of congestion taken from actual empirical data in the field.

4.1 Existing and Competing Service

This section outlines the existing transportation facilities and services in the general I-66 corridor between I-495 and the Potomac River. This section provides background information and sets the stage for the analysis of the HOV occupancy requirements.

4.1.1 I-66 HOV Lanes

Between the Beltway and the Theodore Roosevelt Bridge, the entire eastbound (inbound) I-66 roadway, featuring two through lanes, is reserved from 6:30 a.m. to 9:00 a.m. for HOV 2+, Washington Dulles International Airport traffic, and clean fuel vehicles, and the entire westbound (outbound) roadway, featuring two through lanes, is reserved from 4:00 p.m. to 6:30 p.m. for HOV 2+, Dulles Airport traffic, and clean fuel vehicles. These restrictions are enforced by random police presence.

Consistent with Federal legislation and regulations governing the use of HOV lanes, both motorcycles[1] and qualified "clean special fuel" vehicles[2] are permitted to use HOV 2+ facilities on I-66 during times when HOV regulations are in effect without the required number of occupants. The "clean special fuel" designation is used primarily by hybrid vehicles, but is also available for vehicles using alternative fuels such as natural gas or electricity. To qualify for the HOV exemption, a vehicle owner must display a "clean special fuel" license plate. Currently the clean fuel vehicle exemption on I-66 is granted to clean fuel vehicles registered prior to July 1, 2011.

A December 2012 VDOT study of clean fuel vehicles using HOV lanes in Northern Virginia[3] collected data on eastbound I-66 between Fairfax Drive and Sycamore Street. In the morning peak hour, the facility averaged approximately 1,750 vehicles per hour per lane. Legal clean-fuel vehicles made up about 23 percent of this peak hour traffic. Most such vehicles were observed to have a single occupant. Prior year counts in 2010 and 2011 reported the proportion of legal clean-fuel vehicles at 16 percent and 19 percent, respectively, suggesting there has been growth in the proportion of traffic comprised by these vehicles.

A Spring 2011 TPB study on traffic quality of area freeways[4] discussed level of service and changes to the system performance over time. The report documented morning congestion issues present regularly during HOV hours on I-66 eastbound between the Dulles Connector Road merge and Sycamore Street, and less severe congestion (some days and not others) between Sycamore Street and Fairfax Drive. The study reported that after 7:30 a.m., moderate to severe congestion was consistently found on I-66 between VA 267 and George Mason Drive and noted that, historically, severe eastbound congestion did not develop at this location until after HOV restrictions were lifted (after 9:00 a.m.). That is, this problem appears to be an emerging issue. Shortly after HOV restrictions begin (4:00 p.m.), and soon after (6:30 p.m.), moderate westbound congestion was typically found on I-66 between U.S. 29 and Sycamore Street; but the study added that delays in general in this direction did not appear significant.[5]

It is important to keep in mind the existing conditions when considering the findings involving travel demand forecasting reported later in this section. This is particularly significant in view

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[1] Motorcycles are permitted by Federal law to use HOV lanes, even with only one passenger. The rationale behind allowing motorcycles to use HOV lanes is that it is safer to keep two-wheeled vehicles moving than to have them travel in start-and-stop traffic conditions. States can choose to override this provision of Federal law, if they determine that safety is at risk.

[2] Hybrid vehicles with clean fuel plates issued before July 1, 2011 are allowed to travel in the HOV lanes on I-66 during HOV hours with one occupant. During these times police will ticket any hybrid vehicle that does not have two people on board or a clean fuel plate issued before July 1, 2011.

[3] *Identifying the Number of Clean Fuel Vehicles Using HOV Lanes – Northern Virginia and Hampton Roads*, study performed for Virginia Department of Transportation by The Traffic Group, December 1, 2012.

[4] *Traffic Quality on the Metropolitan Area Freeway System, Spring 2011 Report*, study performed for National Capital Region Transportation Planning Board/Metropolitan Washington Council of Governments by Skycomp, Inc., October 4, 2011.

[5] The operation of westbound I-66 between Fairfax Drive and Sycamore Street has been significantly affected by completion of the "Spot 1" widening in the fall of 2012.

of the limitations of the forecasting model in addressing the unique operations of this segment of I-66, as discussed elsewhere in this report.

4.1.2 Arterials in the Study Corridor

Since I-66 inside the Beltway is HOV 2+ during peak hours, SOV commuters wanting to traverse the corridor must use alternative routes or travel in off-peak times. Two alternative routes that run parallel to I-66 inside the Beltway are U.S. 50 (Arlington Boulevard) and U.S. 29 (Lee Highway).

U.S. 50 from its interchange at I-495 to VA 7 (Seven Corners) is a four- to five-lane divided arterial with discontinuous one-way parallel access roads in both directions. From the grade-separated interchange at Seven Corners to the Theodore Roosevelt Bridge, U.S. 50 is primarily a six-lane divided arterial with managed access. Parallel access roads exist in both directions for much of this distance, primarily between Seven Corners and George Mason Drive/Glebe Road.

U.S. 29 crosses I-495 as a four-lane divided arterial just north of U.S. 50. Access is provided to and from the I-495 Express Lanes to the south, but there is no access to the north and no access to the I-495 mainline. The four-lane section runs through downtown Falls Church and continues almost the entire distance to Spout Run Parkway. U.S. 29 transitions to a six-lane arterial just west of Spout Run and parallels I-66 until turning north to cross the Francis Scott Key Bridge into Washington D.C.

Other arterial facilities such as Wilson Boulevard and Washington Boulevard also provide east-west mobility through the study area.

4.1.3 I-66 Corridor Buses

Express bus service in the I-66 corridor inside the Beltway is operated by four different transit agencies, including Fairfax Connector, Loudoun County Transit, OmniRide, and WMATA (Metrobus). There are also many local buses that run on the nearby arterials. Arlington Transit and WMATA are the primary local service operators in the study area (local Fairfax Connector service serves nearby locations outside the Beltway).

4.1.4 Metrorail Orange Line

The Metrorail Orange Line runs roughly parallel with I-66 through the study area. Study area stations include West Falls Church and East Falls Church in the I-66 median, and underground stations at Ballston, Virginia Square, Clarendon, Court House, and Rosslyn in Arlington. The Orange Line currently utilizes approximately 13 trains in the peak hour to offer peak capacity service. This is consistent with the designation of transit lines as included in the regional travel demand model. (For the forecast years, service levels are enhanced by the interlined Silver Line service between East Falls Church and Rosslyn.) The Rosslyn tunnel under the Potomac River is capacity constrained to 26 trains per hour and must accommodate Orange, Blue, and Silver Line services. This in-turn limits Orange and future Silver Line service in the I-66 corridor.

4.2 Travel Demand Model Analysis

4.2.1 I-66 HOV Lane Travel Modeling Approach

The peak-period, peak-direction HOV restrictions on I-66 are intended to result in an incentive for travelers to carpool or take transit by providing faster travel times than available driving alone. This travel time savings benefit is considered in the mode choice model within the regional travel demand model. The mode choice model considers the relative travel times, costs, and benefits of choices among SOV, HOV 2, HOV 3+, and different types of transit.

By maintaining the distinction of travelers in SOV, HOV 2, and HOV 3+ modes, the travel demand model can consider different usage rules of the highway links, such as links that exclude SOV motorists but allow HOV 2+ motorists (e.g., reflecting the existing operation of I-66 during the peak periods in the peak direction). Similarly, the usage rules can allow for the usage of links by only HOV 3+ motorists and prohibit the usage of links by SOV and HOV 2 motorists during the peak periods. The model can assess the impact on parallel roadway facilities of these eligibility changes, and somewhat assess the impact on transit ridership. In addition, the model has a special treatment of airport passenger trips, allowing them to use HOV facilities and airport access roadways, such as trips traveling to and from Dulles Airport. These trips were included in an assignment along with all other SOV, HOV 2, and HOV 3 users to identify the volume and performance of vehicles on I-66.

The TPB travel demand model, typical of most regional models, does not explicitly output separate motorcycle or clean fuel vehicle trip tables. Therefore, despite the designation of motorcycle and clean vehicle exemptions as defined above, the forecast measures of effectiveness (MOE) from the model for the HOV lanes cannot reflect the presence of these users. Since the model is based on the premise that the only vehicle types using a specific roadway are those allowed by law, violators are also excluded. This means that the results should be viewed through a lens that recognizes some traffic volume is likely missing from the forecasted figures.

4.2.2 I-66 HOV Lane Travel Modeling Runs

The analysis of HOV restrictions on I-66 was conducted by applying the regional travel demand model with weekday trip tables developed for the various modes, vehicle types, and auto occupancies that exist in the corridor. These include transit, several different auto occupancies (SOV, HOV 2, and HOV 3+), commercial vehicles, trucks, and auto trips to and from Dulles Airport. Except for the airport trips, the mode choice module of the regional travel demand model was used to determine these values.

Those trips that utilize the highway system are converted from person trips to vehicle trips based on the assumed occupancies of those vehicles. The regional model allocates these daily trip tables to four time periods: morning peak, midday, evening peak, and night, where morning peak and evening peak roughly correspond to the HOV usage restriction periods on I-66.

The model also applies the appropriate vehicle occupancy restrictions to each highway link. For example, under HOV 2+ restrictions on I-66, during peak periods in the peak direction HOV 2 and HOV 3+ motorists are able to use the links on I-66 in the peak direction. However under HOV 3+ restrictions, HOV 2 motorists are prohibited from using I-66 links in the peak direction.

The time of day trip tables are assigned to the highway network in accordance with the characteristics of each individual link. This process is repeated for several iterations to recognize the fact that traffic volumes tend to be somewhat evenly distributed over parallel facilities until an equilibrium level of congestion is reached.

Table 4.1 shows the modeling assumptions used for each scenario that was tested. Each run began with the socioeconomic data and network that was appropriate for that year. I-66 was modeled as HOV 2+ for 2013, 2016, 2020, and 2030. For the forecast years of 2020 and 2030, I-66 was also alternatively modeled as HOV 3+.

Table 4.1 HOV Restrictions Model Runs

Name of Run	Vehicles Allowed in Peak Periods and Direction on I-66 Links
2013-HOV-2	HOV 2, HOV 3+, and Dulles Airport
2016-HOV-2	HOV 2, HOV 3+, and Dulles Airport
2020-HOV-2	HOV 2, HOV 3+, and Dulles Airport
2020-HOV-3	HOV 3+ and Dulles Airport
2030-HOV-2	HOV 2, HOV 3+, and Dulles Airport
2030-HOV-3	HOV 3+ and Dulles Airport

4.3 HOV Measures of Effectiveness (MOEs)

Measures of effectiveness (MOEs) were selected to determine the effectiveness of the HOV restrictions on I-66 in each of the examined model years. MOEs are presented only for the morning peak period and peak direction. Selected MOEs developed from the model runs are summarized across four cutlines as presented in Figure 4.1. The MOEs examined include:

- LOS – Level of service (LOS) defined by the roadway volume to capacity ratio;
- Speed – Average estimated running speed;
- Volume – Vehicular volume for the morning peak time period;
- Auto Persons – The number of people in automobiles during the morning peak time period. This is derived from the number of vehicles times the average occupancy of those vehicles;
- Daily Persons – The number of person trips during the entire 24-hour day; and
- Travel time to the Theodore Roosevelt Bridge – The travel time between the indicated cut-line location and the Theodore Roosevelt (TR) Bridge.

For the parallel express bus transit service on I-66, daily transit volumes are reported for the 24-hour day across the same four cutlines. HOV 3+ policies will allow for increased bus speeds and thus promote additional bus ridership on I-66. However, as discussed later in this section, the model used in this supplemental analysis does not recognize this phenomenon, and further detailed analysis would be required to estimate this impact. For this reason, bus ridership is shown in the following tables for the HOV 2 condition only.

The MOEs from the modeled scenarios for the morning period, when the I-66 HOV lanes are operating inbound to D.C., are presented in Tables 4.2 though Table 4.5. MOEs from the model runs for the evening peak period, when the I-66 HOV lanes are operating outbound from the District, were also reviewed, but are not presented, as the morning peak period results are considered to be generally representative of conditions during both peaks.

Figure 4.1 Cutline Location

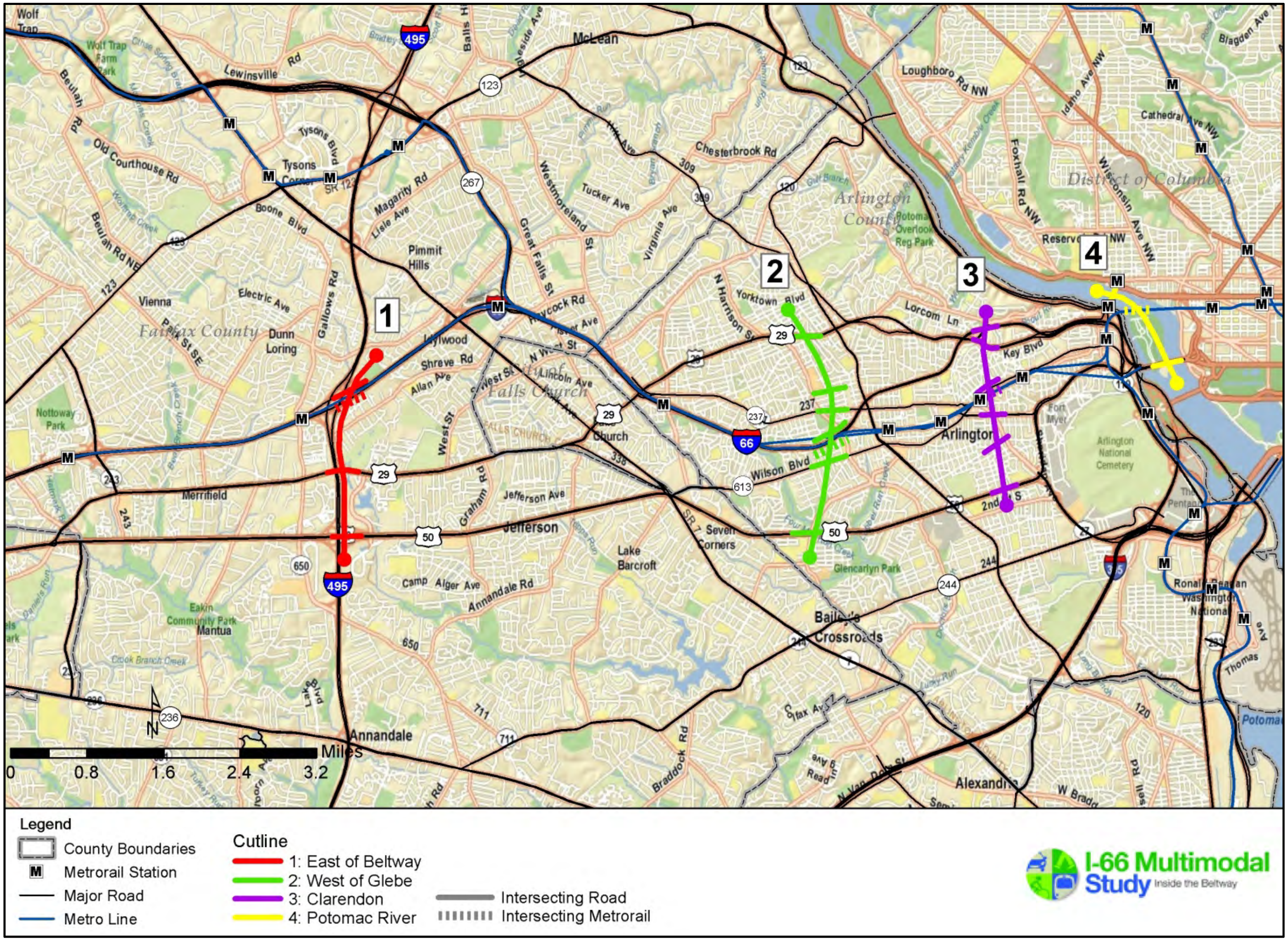

Table 4.2 Forecast of Performance of I-66 HOV Lanes at Cutlines

Scenario	East of Beltway											
	LOS	Speed	SOV	HOV 2	HOV 3+	Comm. Veh.	Truck	Airport (Auto)	Volume	Morning Persons (Auto)	Daily Persons	Travel Time to TR Bridge
2013-HOV-2	B	58	0	6,000	700	0	0	0	6,700	14,300	158,600	17
2016-HOV-2	C	58	0	7,100	600	0	0	200	7,800	16,500	162,200	17
2020-HOV-2	C	56	0	8,700	500	0	0	200	9,300	19,300	165,800	18
2020-HOV-3	A	59	0	0	2,800	0	0	500	3,300	10,700	154,200	11
2030-HOV-2	C	56	0	8,800	500	0	0	300	9,600	19,800	168,700	19
2030-HOV-3	A	59	0	0	3,000	0	0	800	3,800	11,800	163,400	11

Scenario	West of Glebe											
	LOS	Speed	SOV	HOV 2	HOV 3+	Comm. Veh.	Truck	Airport (Auto)	Volume	Morning Persons (Auto)	Daily Persons	Travel Time to TR Bridge
2013-HOV-2	E	17	0	8,100	900	0	0	700	9,600	20,300	212,800	7
2016-HOV-2	E	17	0	8,200	600	0	0	800	9,600	19,800	210,800	7
2020-HOV-2	E	17	0	8,000	900	0	0	800	9,600	20,200	210,800	7
2020-HOV-3	C	52	0	0	4,100	0	0	1,700	5,700	16,900	212,000	5
2030-HOV-2	E	16	0	7,600	1,100	0	0	1,100	9,700	20,600	215,100	8
2030-HOV-3	C	48	0	0	5,100	0	0	2,200	7,300	21,500	223,700	5

Scenario	Clarendon											
	LOS	Speed	SOV	HOV 2	HOV 3+	Comm. Veh.	Truck	Airport (Auto)	Volume	Morning Persons (Auto)	Daily Persons	Travel Time to TR Bridge
2013-HOV-2	D	35	0	7,200	800	0	0	600	8,600	18,000	170,200	5
2016-HOV-2	D	35	0	7,200	600	0	0	800	8,600	17,800	167,100	5
2020-HOV-2	D	34	0	7,100	800	0	0	800	8,700	18,300	172,000	5
2020-HOV-3	C	53	0	0	3,400	0	0	1,600	5,000	14,600	174,400	4
2030-HOV-2	D	30	0	7,000	900	0	0	1,000	8,900	18,800	177,700	6
2030-HOV-3	C	51	0	0	4,400	0	0	2,100	6,400	18,600	186,100	4

Scenario	Potomac River											
	LOS	Speed	SOV	HOV 2	HOV 3+	Comm. Veh.	Truck	Airport (Auto)	Volume	Morning Persons (Auto)	Daily Persons	Travel Time to TR Bridge
2013-HOV-2	D	14	8,600	3,700	500	1,800	0	300	14,900	19,900	193,200	0
2016-HOV-2	D	11	8,900	3,800	400	1,900	0	300	15,400	20,300	196,000	0
2020-HOV-2	D	11	8,500	3,700	500	2,100	0	400	15,300	20,600	198,200	0
2020-HOV-3	C	14	9,200	1,000	1,800	2,300	0	500	14,800	20,700	197,500	0
2030-HOV-2	D	10	8,600	3,800	600	2,300	0	500	15,800	21,300	207,100	0
2030-HOV-3	C	11	9,000	1,000	2,400	2,500	0	600	15,400	22,700	206,200	0

Table Notes:

LOS = level of service; SOV = single occupancy vehicles; HOV 2 = high occupancy vehicles, 2 persons; HOV 3+ = high occupancy vehicles, 3 or more persons; Comm. Veh. = commercial vehicles; Truck = trucks; Airport (Auto) = airport passenger auto driver trips; Travel Time to TR Bridge = estimated travel time in minutes to Theodore Roosevelt Memorial Bridge.

Daily Persons includes vehicle trips and transit passengers for a full day (both directions). Otherwise, volumes shown are estimated inbound (eastbound) volumes in the morning peak period (6-9 a.m.). Morning Persons (Auto) includes vehicle trips in the peak period inbound direction. Auto occupancy assumptions are: HOV 2 = 2 persons per vehicle, HOV 3+ = 3.5 persons per vehicle, Comm. Veh. = 1 person per vehicle, Truck = 1 person per vehicle, and Airport (Auto) = 1.6 persons per vehicle. Travel Time to TR Bridge was measured in terms of estimated congested morning peak travel time (in minutes) from the cutline on I-66.

Figure 4.2 LOS I-66 HOV Lanes Inbound 2020 HOV 2+ Scenario

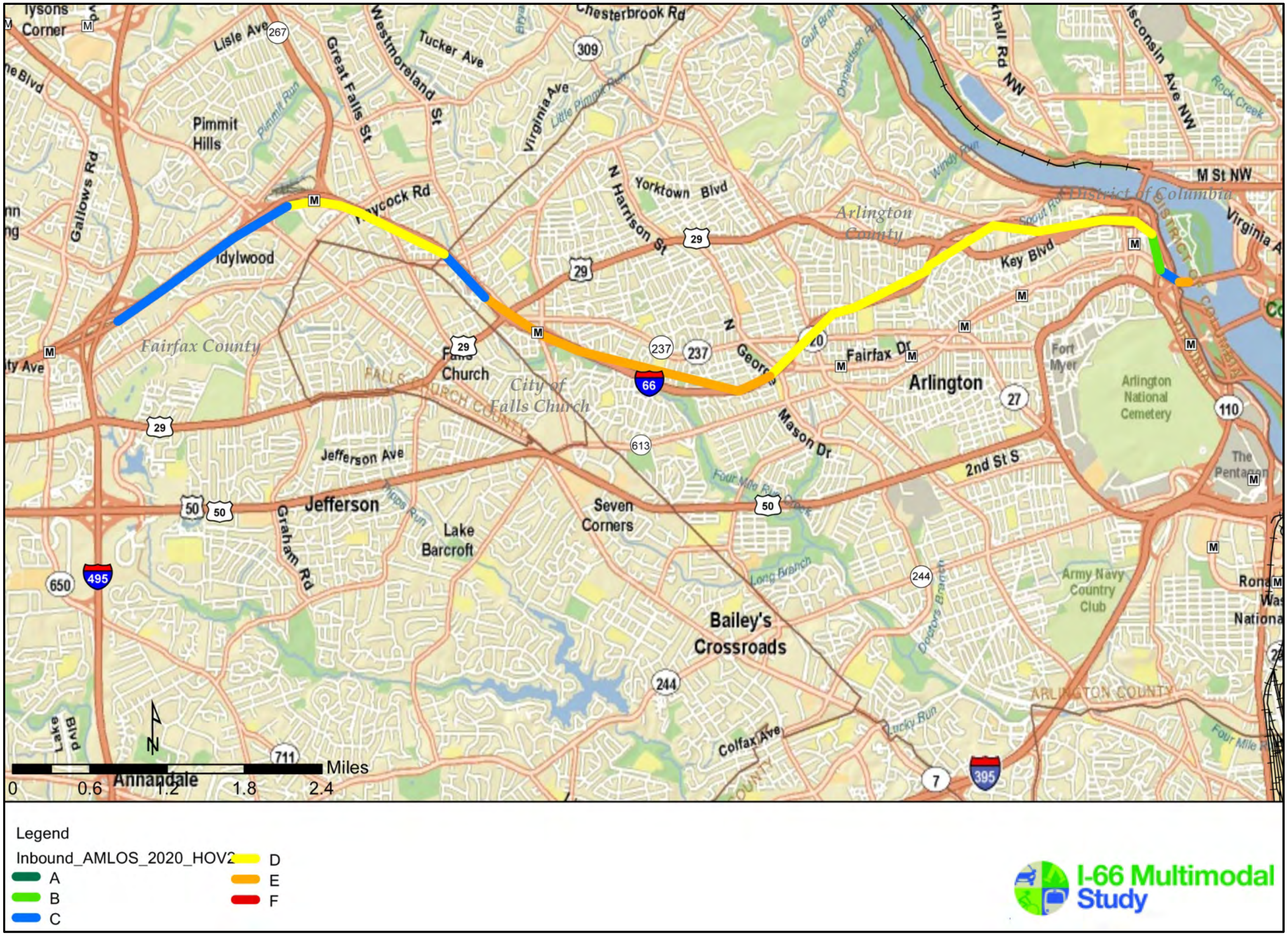

Figure 4.3 LOS I-66 HOV Lanes Inbound 2020 HOV 3+ Scenario

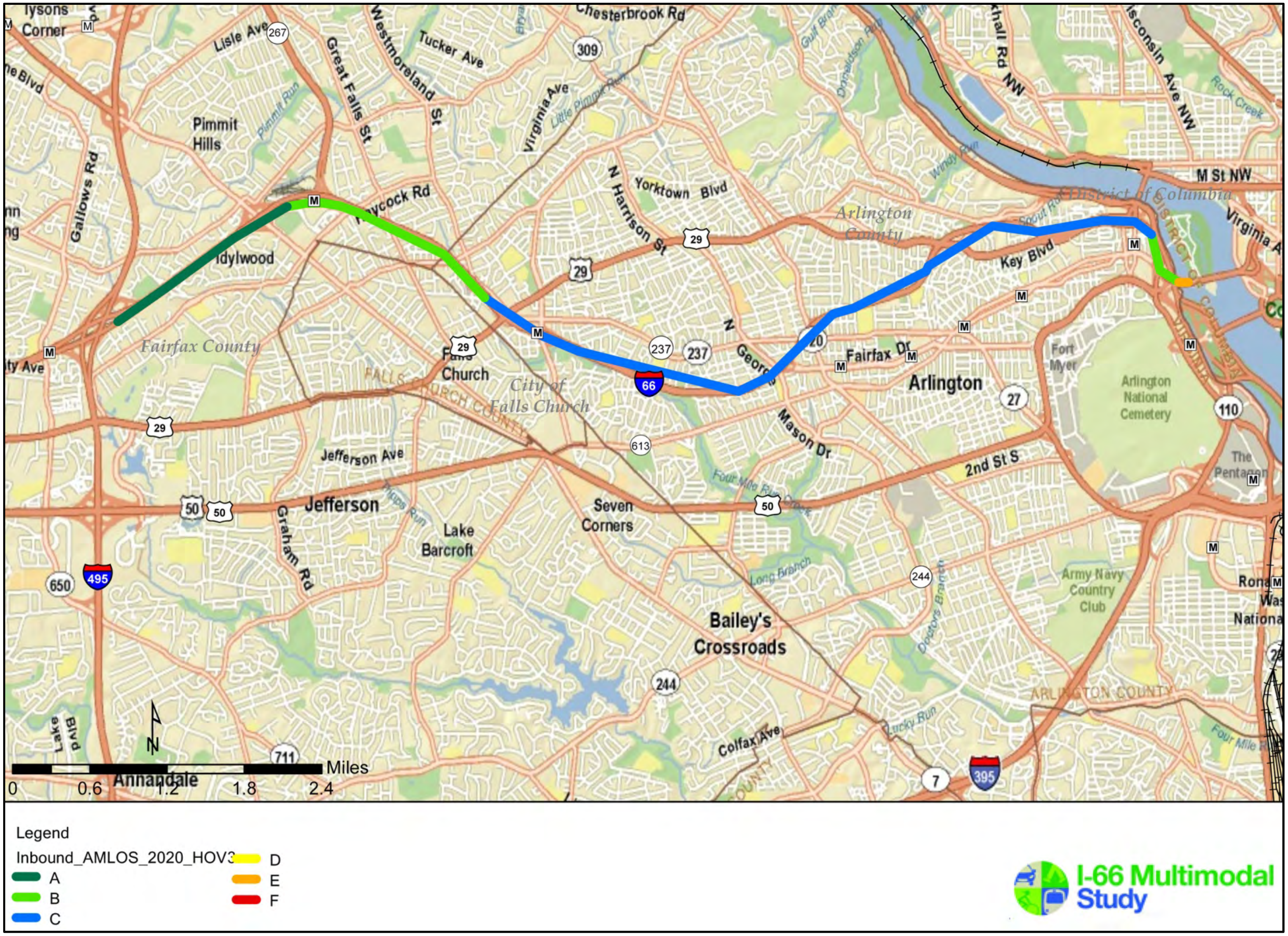

Figure 4.4 LOS I-66 HOV Lanes Inbound 2030 HOV 2+ Scenario

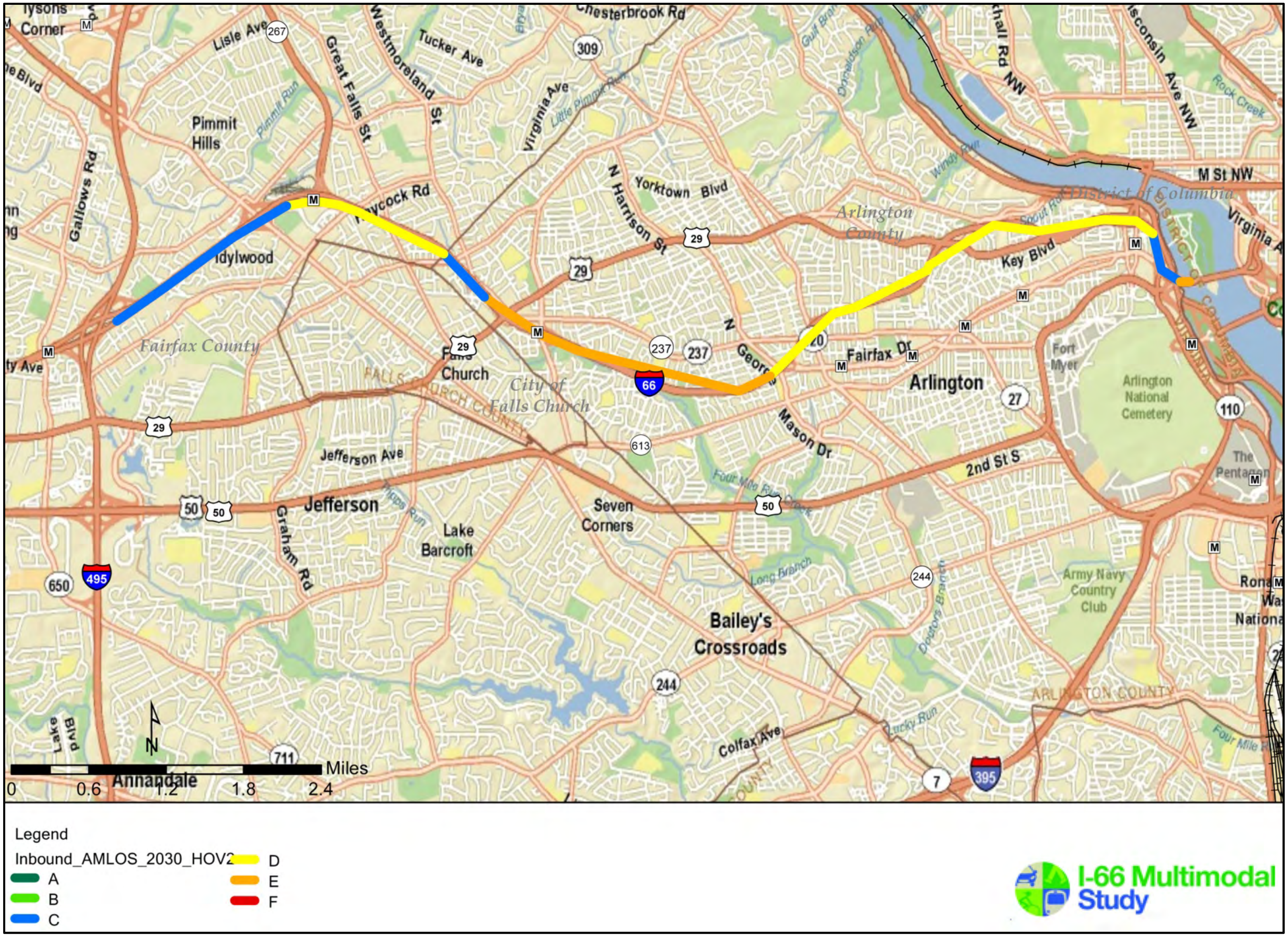

Figure 4.5 LOS I-66 HOV Lanes Inbound 2030 HOV 3+ Scenario

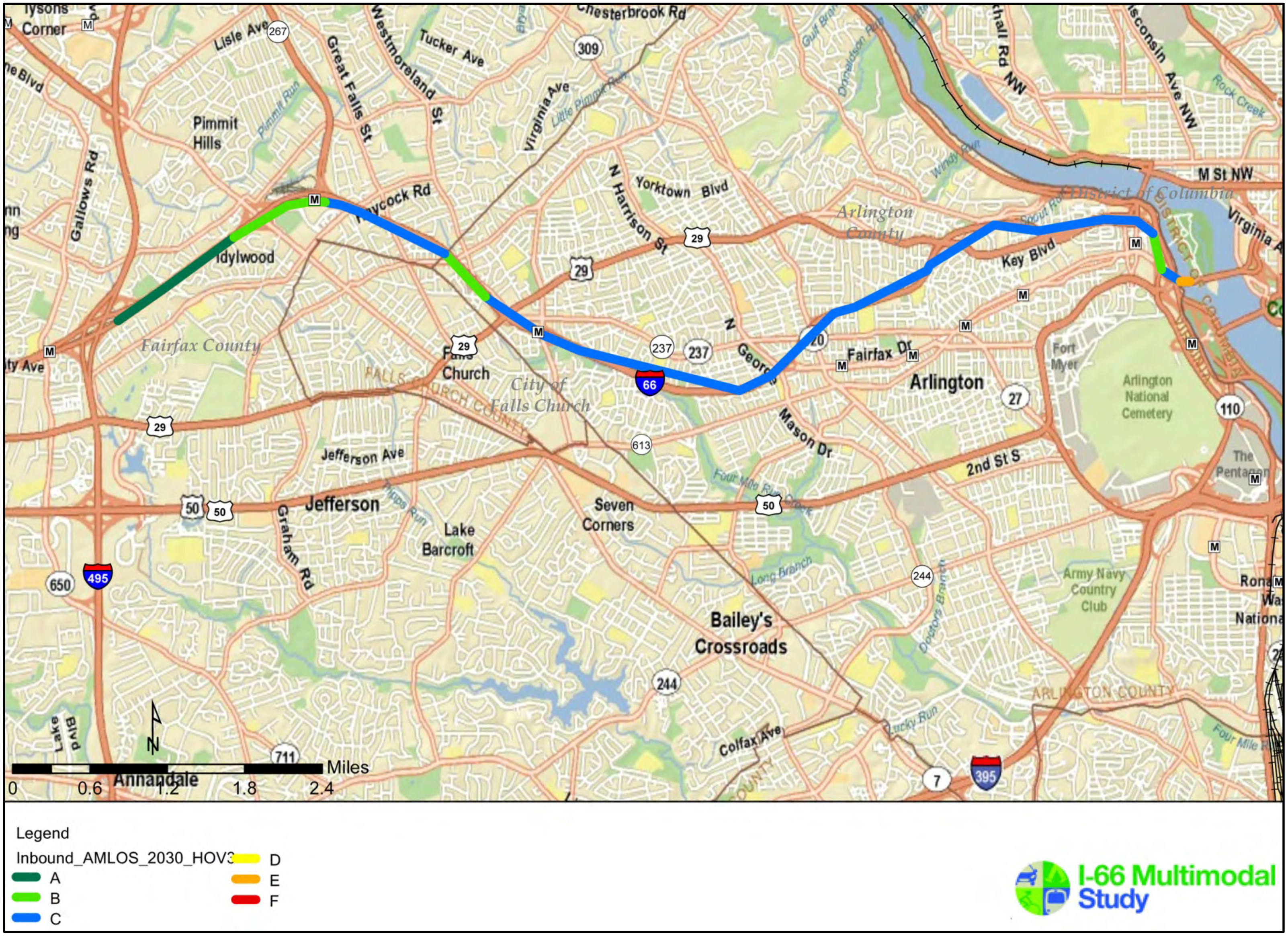

Table 4.3 Forecast of Performance of Arterials at Cutlines

	U.S. 29 – East of Beltway										
Scenario	Speed	SOV	HOV 2	HOV 3+	Comm. Veh.	Truck	Airport (Auto)	Volume	Morning Persons (Auto)	Daily Persons	Travel Time to TR Bridge
2013-HOV-2	8	4,320	180	120	460	200	0	5,270	5,740	59,500	35
2016-HOV-2	8	4,390	130	130	510	220	0	5,370	5,830	61,600	36
2020-HOV-2	7	4,340	100	140	570	250	0	5,390	5,850	64,100	37
2020-HOV-3	7	4,130	500	130	550	300	0	5,600	6,410	64,600	39
2030-HOV-2	6	4,450	120	160	660	280	0	5,680	6,190	68,100	37
2030-HOV-3	6	4,230	620	130	640	270	0	5,880	6,820	68,400	39

	U.S. 29 – West of Glebe										
Scenario	Speed	SOV	HOV 2	HOV 3+	Comm. Veh.	Truck	Airport (Auto)	Volume	Morning Persons (Auto)	Daily Persons	Travel Time to TR Bridge
2013-HOV-2	24	2,650	160	40	370	100	10	3,320	3,570	33,600	16
2016-HOV-2	24	2,660	160	40	420	110	10	3,400	3,670	35,000	16
2020-HOV-2	23	2,660	170	40	480	130	10	3,480	3,750	36,300	16
2020-HOV-3	21	2,580	320	10	500	150	0	3,560	3,910	36,800	17
2030-HOV-2	20	2,680	200	50	510	170	20	3,620	3,950	36,500	16
2030-HOV-3	20	2,570	360	20	510	170	0	3,630	4,030	36,900	17

	U.S. 29 – Clarendon										
Scenario	Speed	SOV	HOV 2	HOV 3+	Comm. Veh.	Truck	Airport (Auto)	Volume	Morning Persons (Auto)	Daily Persons	Travel Time to TR Bridge
2013-HOV-2	7	4,120	50	20	610	160	0	4,950	5,040	51,500	8
2016-HOV-2	7	4,040	60	20	610	190	0	4,900	4,990	51,600	8
2020-HOV-2	8	3,720	50	10	620	230	0	4,630	4,720	51,700	9
2020-HOV-3	8	3,480	400	10	610	220	0	4,720	5,140	52,200	10
2030-HOV-2	8	3,570	60	20	670	300	0	4,620	4,730	50,600	10
2030-HOV-3	8	3,270	480	10	640	300	0	4,690	5,190	51,200	10

	U.S. 29 – Potomac River										
Scenario	Speed	SOV	HOV 2	HOV 3+	Comm. Veh.	Truck	Airport (Auto)	Volume	Morning Persons (Auto)	Daily Persons	Travel Time to TR Bridge
2013-HOV-2	5	4,080	540	120	680	550	50	6,010	6,860	89,900	0
2016-HOV-2	4	4,230	570	90	760	680	60	6,400	7,240	92,900	0
2020-HOV-2	4	4,090	550	120	840	720	70	6,400	7,290	94,800	0
2020-HOV-3	5	3,720	520	210	800	730	120	6,090	7,200	94,400	0
2030-HOV-2	4	4,150	570	130	980	800	100	6,740	7,710	99,400	0
2030-HOV-3	4	3,820	560	220	930	800	210	6,520	7,740	98,700	0

Table 4.3 Forecast of Performance of Arterials at Cutlines (continued)

	U.S. 50 – East of Beltway										
Scenario	Speed	SOV	HOV 2	HOV 3+	Comm. Veh.	Truck	Airport (Auto)	Volume	Morning Persons (Auto)	Daily Persons	Travel Time to TR Bridge
2013-HOV-2	5	6,830	400	160	590	0	0	7,980	8,780	68,800	35
2016-HOV-2	5	7,160	420	130	620	0	10	8,340	9,090	71,100	37
2020-HOV-2	5	7,130	420	140	710	0	10	8,410	9,180	74,200	38
2020-HOV-3	4	6,940	910	130	730	0	0	8,710	9,950	74,700	41
2030-HOV-2	4	7,900	370	140	780	0	0	9,190	9,900	83,100	39
2030-HOV-3	3	7,610	940	130	810	0	0	9,500	10,780	83,900	41

	U.S. 50 – West of Glebe										
Scenario	Speed	SOV	HOV 2	HOV 3+	Comm. Veh.	Truck	Airport (Auto)	Volume	Morning Persons (Auto)	Daily Persons	Travel Time to TR Bridge
2013-HOV-2	24	4,170	160	20	720	0	0	5,070	5,270	45,500	14
2016-HOV-2	24	4,130	160	20	710	0	0	5,030	5,240	45,900	15
2020-HOV-2	24	4,060	210	20	790	0	0	5,080	5,350	48,100	15
2020-HOV-3	23	3,790	600	10	770	0	0	5,170	5,810	48,800	16
2030-HOV-2	18	4,670	140	20	880	0	0	5,710	5,900	54,700	18
2030-HOV-3	18	4,300	580	10	850	0	0	5,730	6,330	55,400	18

	U.S. 50 – Clarendon										
Scenario	Speed	SOV	HOV 2	HOV 3+	Comm. Veh.	Truck	Airport (Auto)	Volume	Morning Persons (Auto)	Daily Persons	Travel Time to TR Bridge
2013-HOV-2	20	4,510	260	20	700	0	0	5,490	5,800	45,900	8
2016-HOV-2	19	4,680	250	20	670	0	0	5,620	5,920	45,400	8
2020-HOV-2	18	4,600	300	20	730	0	0	5,640	5,990	47,800	9
2020-HOV-3	18	4,320	700	10	720	0	0	5,750	6,480	48,200	9
2030-HOV-2	17	4,780	240	20	770	0	0	5,800	6,080	51,600	10
2030-HOV-3	16	4,410	690	10	740	0	0	5,850	6,570	52,000	11

	U.S. 50 – Potomac River										
Scenario	Speed	SOV	HOV 2	HOV 3+	Comm. Veh.	Truck	Airport (Auto)	Volume	Morning Persons (Auto)	Daily Persons	Travel Time to TR Bridge
2013-HOV-2	14	8,600	3,700	500	1,800	0	300	14,900	20,030	193,200	0
2016-HOV-2	11	8,900	3,800	400	1,900	0	300	15,300	20,280	196,000	0
2020-HOV-2	11	8,500	3,700	500	2,100	0	400	15,200	20,390	198,200	0
2020-HOV-3	14	9,200	1,000	1,800	2,300	0	500	14,800	20,600	197,500	0
2030-HOV-2	10	8,600	3,800	600	2,300	0	500	15,800	21,400	207,100	0
2030-HOV-3	11	9,000	1,000	2,400	2,500	0	600	15,500	22,860	206,200	0

Table Notes:

LOS = level of service; SOV = single occupancy vehicles; HOV 2 = high occupancy vehicles, 2 persons; HOV 3+ = high occupancy vehicles, 3 or more persons; Comm. Veh. = commercial vehicles; Truck = trucks; Airport (Auto) = airport passenger auto driver trips; Travel Time to TR Bridge = estimated travel time in minutes to Theodore Roosevelt Memorial Bridge.

Daily Persons includes vehicle trips and transit passengers for a full day (both directions). Otherwise, volumes shown are estimated inbound (eastbound) volumes in the morning peak period (6-9 a.m.). Morning Persons (Auto) includes vehicle trips in the peak period inbound direction. Auto occupancy assumptions are: HOV 2 = 2 persons per vehicle, HOV 3+ = 3.5 persons per vehicle, Comm. Veh. = 1 person per vehicle, Truck = 1 person per vehicle, and Airport (Auto) = 1.6 persons per vehicle. Travel Time to TR Bridge was measured in terms of estimated congested morning peak travel time (in minutes) from the cutline on I-66.

Table 4.4 Forecast of Daily Ridership on I-66 Express Buses

	Daily Transit Persons			
Scenario	East of Beltway	West of Glebe	Clarendon	Potomac River
2013-HOV-2	700	2,400	2,400	2,600
2016-HOV-2	700	1,500	1,500	2,800
2020-HOV-2	700	1,600	1,600	2,800
2030-HOV-2	900	1,900	1,900	2,800

Note: Daily figures represent the total all-day volume for both directions.

Table 4.5 Forecast of Daily Ridership on Orange Line

	Daily Transit Persons			
Scenario	East of Beltway	West of Glebe	Clarendon	Potomac River
2013-HOV-2	37,800	88,800	117,000	182,100
2016-HOV-2	37,800	105,200	133,400	190,200
2020-HOV-2	40,200	110,200	140,500	179,100
2020-HOV-3	40,200	109,900	140,200	179,600
2030-HOV-2	43,200	120,300	151,000	189,400
2030-HOV-3	43,100	119,700	150,600	189,400

Note: Daily figures represent the total all-day volume for both directions.

4.4 Issues and Opportunities

According to Table 4.2 and Figures 4.2 to 4.5, I-66 is forecast to operate at LOS D or LOS E in 2013 and 2016 at most of the cutlines with continuation of the current HOV 2+ policy. Raising the requirements for HOV operation on I-66 during the peak period, from HOV 2+ to HOV 3+, will improve the forecast level of service, running speed, and travel times for those HOV 3+ motorists.

However, the forecasts also indicate that under the HOV 3+ requirements, fewer persons will traverse the major roads in the corridor in 2020 at all cutlines west of the Potomac River than under HOV 2+ policies. By 2030, the reduction in auto users will have been eliminated except at the Beltway, where there will continue to be fewer people in autos traveling the major roads in the I-66 corridor.

Changing the HOV requirement from HOV 2+ to HOV 3+ will divert some HOV 2 travelers to parallel arterial roadways and transit services. According to Table 4.3, a number of cutline locations on U.S. 29 and U.S. 50 are forecast to experience increased traffic levels during the morning peak period in 2020 and 2030 if the HOV requirements on I-66 are changed from HOV 2+ to HOV 3+, primarily due to shifts of HOV 2 motorists. However, the forecast number of vehicles shifted to the arterials under the HOV 3+ scenarios is fairly small, and is not forecast to alter their performance.

Increasing HOV occupancy requirements on I-66 has the potential to increase transit ridership in the corridor as travel times could be improved for buses using I-66 and as individuals currently using two person carpools to traverse the corridor may decide to shift to transit rather than to shift to three or more person carpools. The TPB model can capture the latter effect, but since it does not dynamically change transit vehicle travel times it can only capture the former effect if manual adjustments are made to the transit network coding. As a study simplification, the transit coding for express bus speeds was not changed manually, and therefore the calculated shifts are minimal. As shown in Table 4.5, shifts to Metrorail under the HOV 3+ scenarios are also minimal.

4.5 Next Steps

This analysis was conducted by applying the current TPB regional model. As indicated in the introduction, while this is the officially-accepted tool for performing regional travel demand forecasting, the ability of the model to predict HOV usage at an extremely fine grain, such as on individual roadway links, is limited. Moreover, the operation of this segment of I-66 is significantly affected by both SOV and HOV traffic oriented to Dulles Airport as well as by clean fuel vehicles that may carry any number of passengers. Thus, the findings of this study should be interpreted broadly, and final decisions on operating policies should also consider speeds, travel times, delays, and measures of congestion taken from actual empirical data in the field.

The modeling analysis conducted in this study indicated that continuation of HOV 2+ policies over time will result in a reduction in operating speeds on segments of I-66 during peak periods. These forecasts demonstrate that by 2020, the HOV 3+ assumption in the current CLRP is warranted.

However, this analysis did not assess the extent to which several types of non-HOV vehicles (i.e., those oriented to Dulles Airport, clean fuel vehicles, and violators) contribute to these conditions either today or in the future. It is possible that higher speeds on I-66 could be achieved by removal of some of these non-HOV vehicles, without modifying the actual HOV occupancy requirement.

Therefore, final decisions on HOV occupancy requirements should be made in recognition of all contributing factors, and evaluating the impact of removing them either individually or *in toto* from the HOV vehicle stream. In order to accomplish this objective, current monitoring and enforcement activities should be maintained and/or intensified, and more detailed analysis should be undertaken periodically with the more robust data obtained from these efforts.

Appendix A

Refined Package Component Costs

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Appendix A Refined Package Component Costs

Appendix A provides cost details for tolling, roadway, transit, and bicycle/pedestrian components of the Refined Package. The detailed cost estimates were utilized to develop the summary cost estimate for the Refined Package provided in Section 2.0 of the Supplemental Report.

A.1 Highway Component Costs

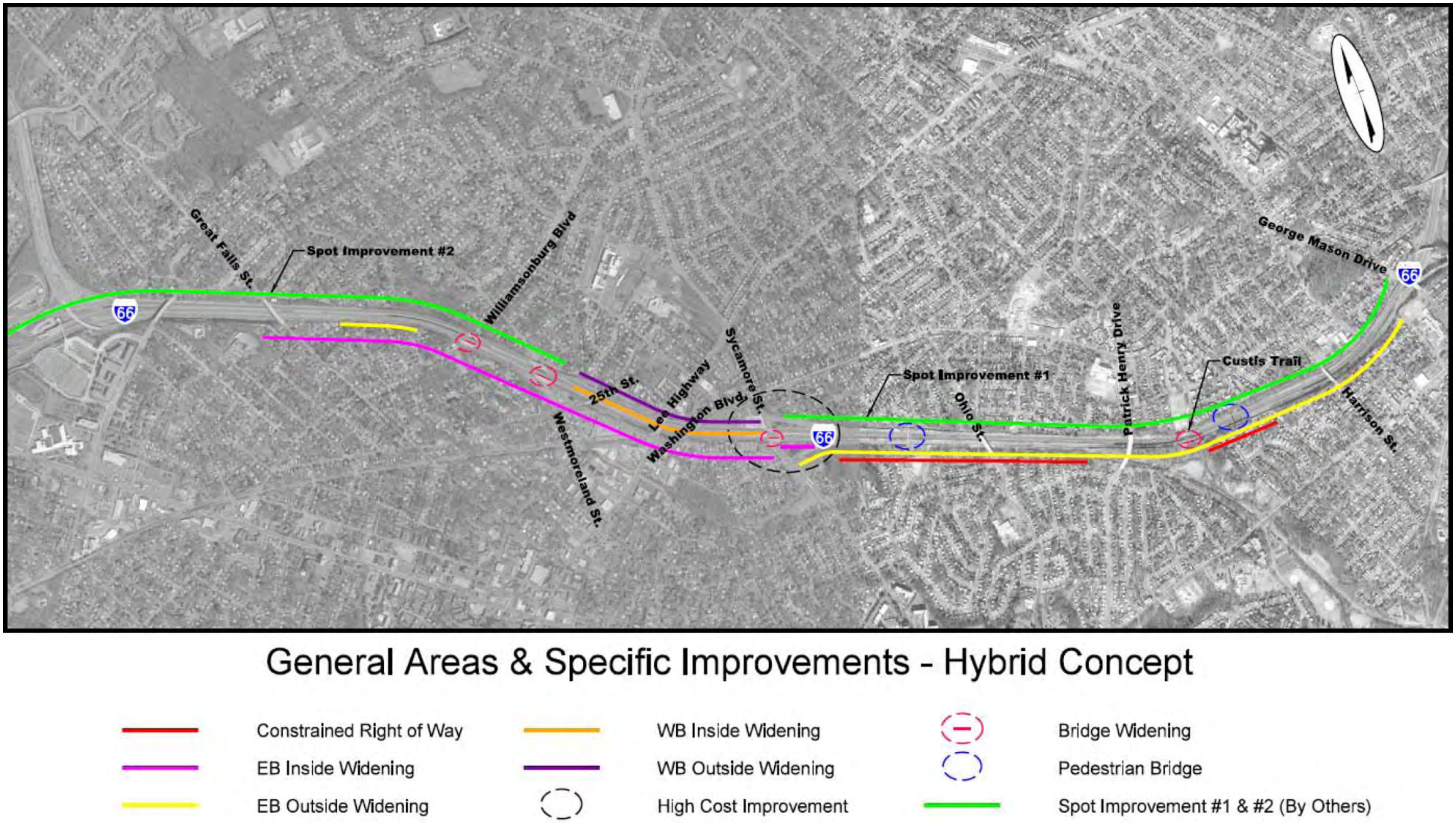
I-66 Additional Lane Costs

Figure A.1 presents the location of additional lanes in the refined package with the assumed widening location (inside/outside), structures, and special design features.

Costs for adding a lane in the eastbound and westbound direction on I-66 in the Refined Package were developed for completing the lane addition so as to minimize impact and cost with design exceptions and/or waivers. Costs and costing assumptions for the design exception approach are shown below. Possible design exceptions are required for: lane width; shoulder width; horizontal and vertical clearances; pier protection; side slope; and drainage. The following general assumptions were applied in developing the cost estimates for adding lanes along I-66:

1. The westbound widening between Sycamore Street and the Washington Boulevard on-ramp presents costs for inside and outside widening options;
2. The assumed typical pavement widening section in both directions is an additional 1-foot sawcut, 11-foot lane, 8-foot shoulder, and 3-foot shy line for total of 23 feet;
3. Widening towards the inside was considered where feasible and assumes that such design will be coordinated with WMATA;
4. Horizontal clearance for bridge piers is adequate in most cases and in such cases, the vertical clearance was assumed to be adequate as well;
5. Pier protection using TL-5 standard will be required at locations where a bridge pier is close to the proposed roadway;
6. These planning-level costs do not include right-of-way costs; it was assumed that design features, including design waivers/exceptions, will be used to fully utilize available right-of-way;

Figure A.1 I-66 Refined Package – Planning-Level I-66 Roadway Components



7. All costs are based on 2011 costs. VDOT average bid prices were used in the determination of the cost estimate;

8. The Custis Trail will need to be relocated from 800 feet east of Patrick Henry Drive to 400 feet east of the cul-de-sac on 9th Road North (approximately 0.2 miles). Some (not all) of the existing retaining walls may be impacted by the eastbound widening;

9. The W&OD Trail will need to be relocated from North Quintana Street to 400 feet east of North Madison Street (approximately 0.62 miles);

10. Sound barrier wall is provided wherever outside retaining walls are being provided; average height is assumed to be 10 feet;

11. Average retaining wall height is assumed to be 15 feet;

12. Spot improvements #1 and #2 are considered as existing conditions for the proposed improvements (see Figure A.1); and

13. I-66 Active Traffic Management (ATM) elements are considered as existing conditions in the proposed improvements.

Drainage requirements are based on 2012 Department of Conservation and Recreation (DCR) regulations.

Total cost estimate summaries are presented in Table A.1 (Eastbound), Table A.2 (Westbound Inside Option), and Table A.3 (Westbound Outside Option). Additional detail for each numbered item in the cost estimate summaries is then presented in Tables A.4 through A.16).

Table A.1 I-66 Additional Lane, Eastbound between Great Falls Street and Fairfax Drive Off-Ramp, with Design Exceptions

Planning Study Cost Estimate					
No. Item	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total**
1	Pavement	LS	1	$4,911,000	$4,911,000
2	Earthwork	LS	1	$2,367,000	$2,367,000
3	Retaining Wall	LS	1	$18,233,000	$18,233,000
4	Sound Barrier Wall	LS	1	$5,402,000	$5,402,000
5	Median Barrier and Sign Protection	LS	1	$1,934,000	$1,934,000
6	Existing Bridge Pier Protection	LS	1	$184,000	$184,000
7	Overhead Signs	LS	1	$5,000,000	$5,000,000
8	Relocation of ITS Elements	LS	1	$2,472,000	$2,472,000
9	Overpass Improvements				
	Williamsburg Boulevard	EA	1	$1,575,000	$1,575,000
	Westmoreland Street	EA	1	$2,085,000	$2,085,000
	Sycamore Street	EA	1	$1,500,000	$1,500,000
	Custis Trail	EA	1	$907,500	$907,500
10	Bridge Modifications		N/A		
11	Pedestrian Crossing Bridges (Reconstruction)				
	Between Sycamore Street and N. Ohio Street	EA	1	$3,000,000	$ 3,000,000
	Between Patrick Henry Drive and N. Harrison Street	EA	1	$3,000,000	$ 3,000,000
12	Bike Trail (Reconstruction)	LS	1	$986,000	$986,000
13	Maintenance of Traffic	LS	1	$4,200,000	$4,200,000
14	Drainage; Erosion and Sediment Control	LS	1	$11,870,000	$11,870,000
Construction Subtotal					**$69,626,500**
Survey (2%)					$1,392,530
Geotechnical (2%)					$1,392,530
Environmental (2%)					$1,392,530
Utility Cost (15%)					$10,443,975
Right-of-Way Cost					N/A
Engineering (10%)					$6,962,650
Construction Engineering and Inspection (12%)					$8,335,180
Contingency (25%)					$17,406,625
Total (Rounded)					**$116,953,000**

Table A.2 I-66 Additional Lane, Westbound (Inside Option) between Sycamore Street and Washington Boulevard On-Ramp, with Design Exceptions

Planning Study Cost Estimate					
No. Item	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total**
1	Pavement	LS	1	$680,000	$680,000
2	Earthwork	LS	1	$435,000	$435,000
3	Retaining Wall	LS	1	$4,042,000	$4,042,000
4	Sound Barrier Wall		N/A		
5	Median Barrier and Sign Protection	LS	1	$216,000	$216,000
6	Existing Bridge Pier Protection	LS	1	$83,000	$83,000
7	Overhead Signs		N/A		
8	Relocation of ITS Elements		N/A		
9	Overpass Improvements		N/A		
10	Bridge Modifications		N/A		
11	Pedestrian Crossing Bridges (Reconstruction)		N/A		
12	Bike Trail (Reconstruction)		N/A		
13	Maintenance of Traffic	LS	1	$382,000	$382,000
14	Drainage; Erosion and Sediment Control	LS	1	$818,000	$818,000
Construction Subtotal					**$6,656,000**
Survey (2%)					$133,120
Geotechnical (2%)					$133,120
Environmental (2%)					$133,120
Utility Cost (15%)					$998,400
Right-of-Way Cost					–
Engineering (10%)					$665,600
Construction Engineering and Inspection (12%)					$798,720
Contingency (25%)					$1,664,000
Total (Rounded)					**$11,182,000**

Table A.3 I-66 Additional Lane, Westbound (Outside Option) between Sycamore Street and Washington Boulevard On-Ramp, with Design Exceptions

Planning Study Cost Estimate					
No. Item	**Description**	**Unit**	**Quantity**	**Unit Price**	**Total**
1	Pavement	LS	1	$680,000	$680,000
2	Earthwork	LS	1	$662,000	$662,000
3	Retaining Wall	LS	1	$6,063,000	$6,063,000
4	Sound Barrier Wall	LS	1	$1,796,000	$1,796,000
5	Median Barrier and Sign Protection	LS	1	$216,000	$216,000
6	Existing Bridge Pier Protection	LS	1	$83,000	$83,000
7	Overhead Signs		N/A		
8	Relocation of ITS Elements		N/A		
9	Overpass Improvements		N/A		
10	Bridge Modifications				
	25th Street	EA	1	$1,789,800	$1,789,800
	Lee Highway	EA	1	$3,036,000	$3,036,000
	Fairfax Drive Flyover	EA	1	$1,035,000	$1,035,000
11	Pedestrian Crossing Bridges (Reconstruction)		N/A		
12	Bike Trail (Reconstruction)		N/A		
13	Maintenance of Traffic	LS	1	$1,700,000	$1,700,000
14	Drainage; Erosion and Sediment Control	LS	1	$1,430,000	$1,430,000
Construction Subtotal					**$18,490,800**
Survey (2%)					$369,816
Geotechnical (2%)					$369,816
Environmental (2%)					$369,816
Utility Cost (15%)					$2,773,620
Right-of-Way Cost					–
Engineering (10%)					$1,849,080
Construction Engineering and Inspection (12%)					$2,218,896
Contingency (25%)					$4,622,700
Total (Rounded)					**$31,065,000**

Table A.4 Item 1 Pavement

Station (From)	Station (To)	Road	Side	Width (Feet)	Length (Feet)	Area (Square Feet)	Full Depth SM-9.5D (in)	Full Depth IM-19.0A (in)	Full Depth BM-25.0A (in)	Full Depth No. 21B (in)	Quantities SM-9.5D (in)	Quantities IM-19.0A (in)	Quantities BM-25.0A (in)	Quantities No. 21B (in)
Eastbound and Westbound														
Great Falls Street	Fairfax Drive Ramp	I-66	EB	23	17,671	406,433	2	4	8	10	5,193	10,387	22,038	24,555
Ramp Widening		I-66	EB	23	2,190	50,370	2	4	8	10	644	1,287	2,731	3,043
Sycamore Street	Washington Boulevard Ramp	I-66	WB*	23	3,171	72,933	2	4	8	10	932	1,864	3,955	4,406
*Note: Same quantity and cost for WB outside and inside option.														
										Total	**6,769**	**13,538**	**28,724**	**32,004**

Summary		Qty.	Unit Cost	Extension	EB Qty.	EB Cost	WB Qty.	WB Cost
Asphalt Concrete Type SM-9.5D	Tons:	6,769	$74	$500,906	5,837	$431,933	932	$68,962
Asphalt Concrete Type IM-19.0A	Tons:	13,538	$71	$961,198	11,674	$828,844	1,864	$132,333
Asphalt Concrete Type BM-25.0A	Tons:	28,724	$36	$1,034,064	24,769	$891,679	3,955	$142,365
Aggregate Base Material Type I No. 21B	Tons:	32,004	$27	$864,108	27,599	$745,160	4,406	$118,972
Subtotal				$3,360,276		$2,897,616		$462,632
Miscellaneous Roadway Items (Marking, Signage, Markers, etc.)				$1,092,500		$1,000,000		$92,526
Saw Cut and Pavement Demo, Rumble Strip, etc. (20%)				$872,000		$779,523		$92,526
Mobilization (5%)				$266,200		$233,857		$32,384
Total (Rounded)				**$5,591,000**		$4,911,000		$680,000

Formulas and Assumptions

Formulas for pavement quantities:

- SM-9.5D = (Area/9) * (110 * Depth)/2000
- IM-19.0A = (Area/9) * (110 * Depth)/2000
- BM-25.0A = (Area/9) * (122 * Depth)/2000
- No. 21B = (Area * Depth/12) * 145/2000

Assume the thickness of full depth pavement is as follows:

- Surface: 2 inches
- Intermediate: 4 inches
- Base: 8 inches
- Subbase: 10 inches

Total Project Length:
Eastbound: 17,671 feet (mainline) + 2,190 feet (ramps)
Westbound: 3,171 feet

Table A.5 Item 2 Earthwork

Station (From)	Station (To)	Route	Side	Depth (Feet)	Length (Feet)	Width (Feet)	Volume (cf)	Volume (cy)	Cost ($/cy)	Total
Eastbound										
Great Falls Street	Fairfax Drive Ramp	I-66	EB	2	17,671	25	883,550	32,724.07	$25	$818,102
Widening Ramps		I-66	Ramp	2	2,190	25	109,500	4,055.56	$25	$101,389
Side Slope		I-66	EB	3	17,671	10	530,130	19,634.44	$25	$490,861
Side Slope		I-66	Ramp	10	2,190	14	306,600	11,355.56	$25	$283,889
Backfill of Bridges		I-66	EB	10	200	20	40,000	1,481.48	$25	$37,037
Retaining Wall		I-66	EB	7	9,004	3	189,084	7,003.11	$25	$175,078
Bike Trail		I-66	EB	3	4,010	22	264,660	9,802.22	$25	$245,056
Select Fill (10%)										$215,141
Total (Rounded)										**$2,367,000**
Westbound – Inside Option										
Sycamore Street	Washington Boulevard	I-66	WB	5	3,171	23	364,665	13,506.11	$25	$337,653
Retaining Wall		I-66	WB	7	2,994	3	62,874	2,328.67	$25	$58,217
Select Fill (10%)										$39,587
Total (Rounded)										**$435,000**
Westbound – Outside Option										
Sycamore Street	Washington Boulevard	I-66	WB	5	3,171	23	364,665	13,506.11	$25	$337,653
Side Slope		I-66	WB	3	2,994	10	89,820	3,326.67	$25	$83,167
Backfill of Bridges		I-66	WB	10	75	177	132,750	4,916.67	$25	$122,917
Retaining Wall		I-66	WB	7	2,994	3	62,874	2,328.67	$25	$58,217
Select Fill (10%)										$60,195
Total (Rounded)										**$662,000**

Table A.6 Item 3 Retaining Wall

Station (From)	Station (To)	Route	Side	Height (Feet)	Length (Feet)	Area (Square Feet)	Cost ($/Square Foot)	Total
Eastbound								
Great Falls Street	Sycamore Street	I-66	EB	15	1,370	20,550	$135	$2,774,250
Sycamore Street	Sycamore Ramp	I-66	EB	15	700	10,500	$135	$1,417,500
Sycamore Ramp	Harrison Street	I-66	EB	15	6,934	104,010	$135	$14,041,350
Total (Rounded)								**$18,233,000**
Westbound – Inside Option								
Sycamore Street	Washington Boulevard	I-66	WB	10	2,994	29,940	$135	$4,041,900
Total (Rounded)								**$4,042,000**
Westbound – Outside Option								
Sycamore Street	Washington Boulevard	I-66	WB	15	2,994	44,910	$135	$6,062,850
Total (Rounded)								**$6,063,000**

Table A.7 Item 4 Sound Barrier Wall

Station (From)	Station (To)	Route	Side	Height (Feet)	Length (Feet)	Area (Square Feet)	Cost ($/Square Foot)	Total
Eastbound								
Great Falls Street	Sycamore Street	I-66	EB	10	1,370	13,700	$60	$822,000
Sycamore Street	Sycamore Ramp	I-66	EB	10	700	7,000	$60	$420,000
Sycamore Ramp	Harrison Street	I-66	EB	10	6,934	69,340	$60	$4,160,400
Total (Rounded)								**$5,402,000**
Westbound – Inside Option								
None Required								$0
Westbound – Outside Option								
Sycamore Street	Washington Boulevard	I-66	WB	10	2,994	29,940	$60	$1,796,400
Total (Rounded)								**$1,796,000**

Table A.8 Item 5 Median Barrier and Sign Protection

Median Barrier – Type MB-7F

Station (From)	Station (To)	Route	Side	Length (Feet)	Unit Cost ($/Foot)	Total
Eastbound						
Great Falls Street	Fairfax Drive Ramp	I-66	EB	17,176	$80	$1,374,080
Westbound – Inside or Outside Option						
Sycamore Street	Washington Boulevard	I-66	WB	2,694	$80	$215,520

Overhead Sign Protection

Type	Unit Cost ($/Foot)	Quantity per Sign	EA	Total
Eastbound				
Median Barrier MB-7F	$80	50 feet	9	$39,300
Guardrail FOA-2	$2,300 each	–	9	$20,700
Guardrail GR-2	$16	25 feet	9	$3,600
Guardrail GR-9	$2,300	24 feet	9	$496,800
Subtotal				$560,400
Westbound – Inside or Outside Option				
None*				$0

Note: * Applicable westbound overhead sign protection is assumed to be handled within Spot Improvement projects (i.e., no additional cost in Refined Package).

Total

Summary Item	Total
Eastbound	
Median Barrier	$1,374,080
Overhead Sign Protection	$560,400
Total (Rounded)	**$1,934,000**
Westbound – Inside or Outside Option	
Median Barrier	$215,520
Total (Rounded)	**$216,000**

Table A.9 Item 6 Existing Bridge Pier Protection

Overpass	Route	Side	Length of Protection (Feet)	Bridge (Feet)	Length (Feet)	Cost ($/Feet)	Total
Eastbound							
Great Falls Street	I-66	EB	100	73	173	$175	$30,275
25th Street	I-66	EB	100	44	144	$175	$25,200
Lee Highway	I-66	EB	100	94	94	$175	$16,450
Fairfax Drive Flyover	I-66	EB	100	44	144	$175	$25,200
Ohio Street	I-66	EB	100	82	182	$175	$31,850
Patrick Henry Drive	I-66	EB	100	66	166	$175	$29,050
Harrison Street	I-66	EB	100	47	147	$175	$25,725
Total (Rounded)							**$184,000**
Westbound – Inside or Outside Option							
25th Street	I-66	WB	100	46	146	$175	$25,550
Lee Highway	I-66	WB	100	92	192	$175	$33,600
Fairfax Drive Flyover	I-66	WB	100	39	139	$175	$24,325
Total (Rounded)							**$83,000**

Note: Assumes use of median barrier MB-12B.

Existing bicycle/pedestrian bridges: 1) between Sycamore Street and Ohio Street and 2) between Patrick Henry Drive and Harrison Street are omitted from this cost schedule because they would be replaced as part of the widening project due in part to the existing bridge design, including pier spacing.

Table A.10 Item 7 Overhead Signs

Sign Types	Route	Side	Unit Price	Each	Each Total	Total
Eastbound						
Half Span	I-66	EB	$1,000,000	1	1	$1,000,000
Cantilever	I-66	EB	$500,000	2	2	$1,000,000
Detach Bridge Sign	I-66	WB	$500,000	1	1	$500,000
New Signs	I-66		$500,000	5	5	$2,500,000
Total						**$5,000,000**

Table A.11 Item 8 Relocation of ITS Elements

Type	Each	Unit Price	Total
Eastbound			
Closed-Circuit Television (CCTV)	6	$100,000	$600,000
Detector	14	$30,400	$425,600
Dynamic Message Sign (DMS)	1	$500,000	$500,000
Small DMS	1	$300,000	$300,000
Conduit	18,480	$35	$646,800
Total (Rounded)			**$2,472,000**

Table A.12 Item 9 Overpass Improvements

Overpass	Route	Side	Width (Feet)	Length (Feet)	Cost ($/SF)	Total
Eastbound						
Williamsburg Boulevard	I-66	EB	25	210	$300	$1,575,000
Westmoreland Street	I-66	EB	25	278	$300	$2,085,000
Sycamore Street	I-66	EB	25	200	$300	$1,500,000
Custis Trail	I-66	EB	25	121	$300	$907,500
Total						**$6,067,500**

Table A.13 Item 10 Bridge Modifications

Bridge	Route	Side	Width (Feet)	Length (Feet)	Cost ($/SF)	Total
Westbound – Outside Option						
25th Street	I-66	WB	38	157	$300	$1,789,800
Lee Highway	I-66	WB	92	110	$300	$3,036,000
Fairfax Drive Flyover	I-66	WB	30	115	$300	$1,035,000
Total						**$5,860,800**

Table A.14 Item 11 Pedestrian Crossing Bridges (Reconstruction)

Location	Route	Side	Unit Price
Between Sycamore Street and Ohio Street	I-66	EB	$3,000,000
Between Patrick Henry Drive and Harrison Street	I-66	EB	$3,000,000
Total			**$6,000,000**

Table A.15 Item 12 Bike Trail (Reconstruction)

Facility	Station (From)	Station (To)	Route	Side	Length (Feet)	Cost ($/Feet)	Total
W&OD Trail	Sycamore Street	Patrick Henry Drive	I-66	EB	3,100	$246	$762,600
Custis Trail	Custis Trail	Crossing Bridge	I-66	EB	910	$246	$223,860
Total							$986,460
Total (Rounded)							**$986,000**

Table A.16 Item 13 Maintenance of Traffic

Item	Cost
Eastbound	
7% of Highway Construction Cost	$3,324,230
15% of Overpass Improvement Cost	$910,125
Total (Rounded)	**$11,872,000**
Westbound – Inside Option	
7% of Highway Construction Cost	$381,920
Total (Rounded)	**$382,000**
Westbound – Outside Option	
7% of Highway Construction Cost	$665,000
15% of Overpass Improvement Cost	$1,075,256
Total (Rounded)	**$1,740,000**

Table A.17 Item 14 Drainage; Erosion, and Sediment Control

Item	Cost
Eastbound	
20% of Highway Construction Cost for Drainage	$9,497,800
5% of Highway Construction Cost for Erosion and Sediment Control	$2,374,450
Total (Rounded)	**$11,870,000**
Westbound – Inside Option	
10% of Highway Construction Cost for Drainage	$545,600
5% of Highway Construction Cost for Erosion and Sediment Control	$272,800
Total (Rounded)	**$818,000**
Westbound – Outside Option	
10% of Highway Construction Cost for Drainage	$950,000
5% of Highway Construction Cost for Erosion and Sediment Control	$475,000
Total (Rounded)	**$1,425,000**

A.2 Tolling Component Costs

I-66 corridor tolling costs for two or three lanes in each direction (depending on the section of the corridor where gantries are applied) are shown in Table A.18. The costs in Table A.18 represent a combination of unit cost information presented in the Final Report (Appendix D, Tables D.1 and D.2).

Table A.18 Tolling Cost for Refined Package in Each Direction

Tolling Component	Unit	Quantity	Unit Cost	Total
Full Span Gantry (EB and WB lanes of I-66, four-lane section)	EA	4	$1,200,000	$4,800,000
Full Span Gantry (EB or WB lanes of I-66, two-lane section)	EA	6	$900,000	$3,600,000
Full Span Gantry (EB or WB lanes of I-66, three-lane section)	EA	6	$1,260,000	$7,560,000
Software Cost	LS	1	$2,500,000	$2,500,000
Toll Processing Facility	LS	1	$1,000,000	$1,000,000
Subtotal				**$19,460,000**
Design Engineering (10% of subtotal)				$1,946,000
Construction Management (12% of subtotal)				$2,335,000
Contingency (30%)				$5,838,000
Total				**$29,579,000**

All Gantries Located on I-66

Gantries across EB and WB I-66:

- East of Rosslyn Tunnel
- East of 21st Street
- East of North Monroe Street
- West of N. Glebe Road

Gantries across EB I-66 only:

- East of N. Ohio Street
- East of N. Williamsburg Boulevard
- East of Dulles Connector Road
- East of West Falls Church Metro
- East of Barbour Road
- East of Beltway

Gantries across WB I-66 only:

- West of N. George Mason Drive
- West of N. Westmoreland Street
- West of N. Williamsburg Boulevard
- West of Dulles Connector Road
- East of Barbour Road
- East of Beltway

A.3 Transit Component Costs

This section documents the estimation of the costs associated with the provision of transit service called for in the Refined Package. First the overall assumptions are presented. This is followed by documentation of the operating and capital cost assumptions. A set of tables is presented to conclude this section showing:

- Summary bus transit cost differences between the Refined Package and Package 4 (see Table A.19);
- Bus transit operating cost calculations for the Refined Package (see Table A.20);
- Bus transit capital cost calculations for the Refined Package (see Table A.21); and
- Farebox recovery calculations for the Refined Package bus transit services (see Table A.22).

Overall Assumptions

1. Used current year 2011 dollars. Used 2010 National Transit Database (NTI) data with three percent increase (based on Consumer Price Index (CPI)).

2. Operating costs were for 2040 cost/benefit analysis. Assume that all new services would be in place by then.

3. Cost estimates based on increase in vehicle revenue hours above the CLRP+ in model. Only estimated cost of improvements beyond CLRP+.

4. Assumed 260 days for priority and express services. Depending on route, used either 260 or 312 days for local bus services (weekdays and one additional day spread across the weekend hours).

5. Speeds assume to be 12 mph for a local bus, 18 mph for skip stop or express services, and 30 mph for the long-distance commuter routes, consistent with TPB model coding conventions.

6. Peak hours per weekday assumed to be 7 hours. Span of service for existing routes based on current. For most new services, assumed 17 hours, 7 peak, and 10 off-peak.

Operating Costs

1. Used a straight cost per hour (rather than a multiple variable cost model). Felt that this level of accuracy was sufficient given that we are developing 2040 cost estimates.

2. Used incremental (operating and maintenance) rather than fully allocated costs.

3. Used cost per vehicle revenue hour from NTD. Used revenue hours rather than vehicle hours since most of the services proposed are bidirectional consistent with the recommendations of the I-66 Transit/TDM Study – deadhead hours will not vary significantly among the services. FY 2011 incremental cost per revenue hour figures (based on 2010 NTD inflated to 2011) include:

   – WMATA = $142.00;

   – Fairfax Connector = $104.00;

   – PRTC = $133.00;

   – ART = $72.00; and

   – No increase in rail operating costs assumed.

Capital Costs

1. Vehicles – Converted to cost per revenue hour based on assumed speed and the following capital costs (and 500,000 revenue miles useful life).

2. ART – Forty-foot Transit Bus with natural gas – 12-year @ $515,000.

3. WMATA – Hybrid Electric Bus – 12-year – 40-foot LF hybrid @ $620,000.

4. PRTC – Standard 45-foot OTRBs Standard Commuter Coach – 12-year @ $535,000.

5. Spare Vehicle – Twenty percent spare ratio.

6. Metrorail interline connection – Not needed but would have used planning-level costs from WMATA.

7. Metrorail – Assumed eight-car trains but did not cost.

Farebox Revenue

1. Used the farebox recovery ratio (based on incremental cost recovery) that seemed appropriate for each operator and/or type of services – based on NTD data and differences in farebox recovery for local versus commuter services.

2. Commuter Service (PRTC and Fairfax Connector) – assume 50 percent.

3. Metrobus Express Services (WMATA) – 25 percent.

4. Local Services – 20 percent.

Table A.19 Summary of Annual 2040 Transit Costs
In 2011 Dollars

	Annual Costs				
Scenario	**Operating Cost**	**Capital Costs**	**Total Costs**	**Revenue**	**Deficit**
Package 4	$45.6	$8.8	$54.3	$13.1	$41.2
Refined Package	$27.7	$4.9	$32.6	$7.1	$25.5

Table A.20 Refined Package Transit Service Changes

Route	Change	Added Revenue Hour per Service Hour	
		Peak	Off-Peak
PRTC			
I-66 Priority Bus – Haymarket	Add reverse-peak direction route from D.C. to Haymarket; increase peak frequency; add off-peak service	8.00	–
PRTC Total		**8.00**	–
WMATA			
I-66 Priority Bus – Centreville	Increase frequencies on Centreville routes, improve runtime (reverse-peak direction only), and add off-peak service	4.07	–
I-66 Priority Bus – Stringfellow Road	Add route from Stringfellow Road to D.C. core	5.08	–
U.S. 29 Priority Bus	Increase bidirectional frequencies	2.30	2.30
U.S. 50 Priority Bus – via Ballston	Increase bidirectional frequencies	2.10	2.90
U.S. 50 Priority Bus – via U.S. 50	Add route from Fair Lakes to D.C. core along U.S. 50	6.04	–
U.S. 50 Priority Bus – Tysons	Add route from Tysons Corner along U.S. 50 and Wilson Boulevard	5.08	–
Metrobus 1B	Increase peak-period frequency; improve inbound runtime	3.10	–
Metrobus 1C	Increase peak and off-peak frequencies	1.27	0.68
Metrobus 1E	Improve runtime	(0.07)	–
Metrobus 1X	New route Vienna and Ballston via U.S. 50 and Wilson Boulevard	–	–
Metrobus 2B, G, H	Restructured	–	–
Metrobus 2C	Increase peak and off-peak frequencies	3.17	1.47
Metrobus 3A	Extend routing to NVCC and East Falls Church and increase frequency	0.58	–
Metrobus 3B	Increase frequency (peak and off-peak)	–	–
Metrobus 3E	Add reverse-peak direction service and increase peak-direction service frequency; add off-peak service	2.25	–
Metrobus 3T	Increase off-peak-period frequency	–	–
Metrobus 3Y	Increase peak-period frequency	–	–
Metrobus 4A	Reroute to end at Seven Corners; increase frequency	0.57	–
Metrobus 4B	Increase peak and off-peak frequencies	–	–
Metrobus 4E	Increase peak-period frequency, improve runtime	0.57	–
Metrobus 4H	Improve runtime	(0.13)	–
Metrobus 10B	Increase peak-period frequency	4.00	–
Metrobus 15L	Increase peak-period frequency	1.23	–
Metrobus 22A	Increase peak-period frequency	1.02	–
Metrobus 23A	Increase peak-period frequency	5.87	–
Metrobus 23C	Increase peak-period frequency	8.75	–
Metrobus 24T	Increase peak-period frequency	–	–
Metrobus 25A	Increase peak and off-peak frequencies	3.37	1.63
Metrobus 25B	Increase northbound off-peak frequency and peak frequencies in both directions	3.90	1.02

Table A.20 Refined Package Transit Service Changes (continued)

Route	Change	Added Revenue Hour per Service Hour	
		Peak	**Off-Peak**
WMATA (Continued)			
Metrobus 28A	Increase peak-period frequency, improve runtime	4.77	–
Metrobus 28E	New route between Skyline Plaza and East Falls Church	3.20	1.53
Metrobus 28T	Increase peak-direction peak-period frequency	–	–
Metrobus 28X	Increase peak-period frequency	–	–
Metrobus 38B	Increase frequency	1.32	–
WMATA Total		**73.39**	**11.53**
ART			
ART 42	Increase the reverse-peak direction, peak-period frequency	0.42	–
ART 45	Increase peak-period frequency, improve run time	1.70	–
ART 52	Increase peak and off-peak frequencies	1.67	0.82
ART 53	Increase peak and off-peak frequencies	–	–
ART 62	Increase peak-period frequency	–	–
ART #75	Extend routing to Shirlington and Virginia Square; add off-peak service	3.20	–
ART #77	Extend to Rosslyn and increase frequency	2.20	0.27
New ART1	Add route between Arlington Hall and Crystal City	2.93	–
New ART2	Add route between Court House and Pentagon City	3.87	1.67
ART Total		**15.98**	**1.93**
Total Package		**97.37**	**13.47**

Table A.21 Refined Package Transit Operating Costs

Route	Peak Hours (7 Hours per Peak)	Span	Off-Peak Hours	Total Hours	Operating Cost
PRTC					
I-66 Priority Bus – Haymarket					
PRTC Total	**14,560**	**17**	**–**	**14,560**	**$1,936,480**
WMATA					
I-66 Priority Bus – Centreville	7,407	17	–	7,407	$1,051,851
I-66 Priority Bus – Stringfellow Road	9,246		–	9,246	$1,312,875
U.S. 29 Priority Bus	4,186	17	5,980	10,166	$1,443,572
U.S. 50 Priority Bus – via Ballston	3,822	17	7,540	11,362	$1,613,404
U.S. 50 Priority Bus – via U.S. 50	10,993	18	–	10,993	$1,560,978
U.S. 50 Priority Bus – Tysons	9,246	19	–	9,246	$1,312,875
Metrobus 1B	5,642		–	5,642	$801,164
Metrobus 1C	2,305	17	2,132	4,437	$630,101
Metrobus 1E	-121		–	-121	-$17,229
Metrobus 1X	–	19	–	-	–
Metrobus 2B, G, H	–	18	–	-	–
Metrobus 2C	5,763	17	4,576	10,339	$1,468,185
Metrobus 3A	1,056	16	–	1,056	$149,185
Metrobus 3B	–	16	–	–	–
Metrobus 3E	4,095	16	–	4,095	$581,490
Metrobus 3T	–	17	–	–	–
Metrobus 3Y	–		–	–	–
Metrobus 4A	1,037	13	–	1,037	$147,311
Metrobus 4B	–	16	–	–	–
Metrobus 4E	1,031		–	1,031	$146,449
Metrobus 4H	-243		–	-243	-$34,459
Metrobus 10B	7,280		–	7,280	$1,033,760
Metrobus 15L	2,245		–	2,245	$318,743
Metrobus 22A	1,850		–	1,850	$262,747
Metrobus 23A	10,677		–	10,677	$1,516,181
Metrobus 23C	15,925		–	15,925	$2,261,350
Metrobus 24T	–		–	–	–
Metrobus 25A	6,127	15	4,077	10,204	$1,448,987
Metrobus 25B	7,098	16	2,855	9,953	$1,413,298
Metrobus 28A	8,675	18	–	8,675	$1,231,897
Metrobus 28E	5,824	14	3,349	9,173	$1,302,538
Metrobus 28T	–		–	–	–
Metrobus 28X	–		–	–	–
Metrobus 38B	2,396		–	2,396	$340,279
WMATA Total	**133,564**		**30,508**	**164,072**	**$36,765,182**

Table A.21 Refined Package Transit Operating Costs (continued)

Route	Peak Hours (7 Hours per Peak)	Span	Off-Peak Hours	Total Hours	Operating Cost
ART					
ART 42	758		–	758	$54,600
ART 45	3,094		–	3,094	$222,768
ART 52	3,033	14	1,486	4,520	$325,416
ART 53	–	14	–	–	–
ART 62	–		–	–	–
ART #75	5,824	14	–	5,824	$419,328
ART #77	4,004	16	749	4,753	$342,202
New ART1	5,333	14	–	5,333	$383,947
New ART2	7,043	14	3,033	10,077	$725,525
ART Total	**29,090**		**5,268**	**34,358**	**$2,473,786**
Total Package	**210,847**		**135,537**	**346,384**	**$27,708,509**

Table A.22 Refined Package Transit Capital Costs

Route	Vehicle Unit Cost	Assumed Speed	Hourly Capital Cost	Capital Costs
PRTC				
I-66 Priority Bus – Haymarket	$642,000	30	$38.52	$560,851
PRTC Total	**$642,000**	**30**	**$38.52**	**$560,851**
WMATA				
I-66 Priority Bus – Centreville	$744,000	30	$44.64	$330,666
I-66 Priority Bus – Stringfellow Road	$744,000	30	$44.64	$412,724
U.S. 29 Priority Bus	$744,000	18	$26.78	$272,286
U.S. 50 Priority Bus – via Ballston	$744,000	18	$26.78	$304,320
U.S. 50 Priority Bus – via U.S. 50	$744,000	18	$26.78	$294,431
U.S. 50 Priority Bus – Tysons	$744,000	18	$26.78	$247,634
Metrobus 1B	$744,000	18	$26.78	$151,115
Metrobus 1C	$744,000	18	$26.78	$118,850
Metrobus 1E	$744,000	18	$26.78	-$3,250
Metrobus 1X	$744,000	18	$26.78	–
Metrobus 2B, G, H	$744,000	12	$17.86	–
Metrobus 2C	$744,000	12	$17.86	$184,619
Metrobus 3A	$744,000	12	$17.86	$18,849
Metrobus 3B	$744,000	12	$17.86	–
Metrobus 3E	$744,000	12	$17.86	$73,120
Metrobus 3T	$744,000	12	$17.86	–
Metrobus 3Y	$744,000	12	$17.86	–
Metrobus 4A	$744,000	12	$17.86	$18,524
Metrobus 4B	$744,000	12	$17.86	–
Metrobus 4E	$744,000	12	$17.86	$18,415
Metrobus 4H	$744,000	12	$17.86	-$4,333
Metrobus 10B	$744,000	12	$17.86	$129,992
Metrobus 15L	$744,000	12	$17.86	$40,081
Metrobus 22A	$744,000	12	$17.86	$33,040
Metrobus 23A	$744,000	12	$17.86	$190,654
Metrobus 23C	$744,000	12	$17.86	$284,357
Metrobus 24T	$744,000	12	$17.86	–
Metrobus 25A	$744,000	12	$17.86	$182,205
Metrobus 25B	$744,000	12	$17.86	$177,717
Metrobus 28A	$744,000	12	$17.86	$154,907
Metrobus 28E	$744,000	12	$17.86	$163,790
Metrobus 28T	$744,000	12	$17.86	–
Metrobus 28X	$744,000	12	$17.86	–
Metrobus 38B	$744,000	12	$17.86	$42,789
WMATA Total				**$3,837,501**

Table A.22 Refined Package Transit Capital Costs (continued)

Route	Vehicle Unit Cost	Assumed Speed	Hourly Capital Cost	Capital Costs
ART				
ART 42	$618,000	12	$14.83	$11,248
ART 45	$618,000	12	$14.83	$45,890
ART 52	$618,000	12	$14.83	$67,036
ART 53	$618,000	12	$14.83	–
ART 62	$618,000	12	$14.83	–
ART #75	$618,000	12	$14.83	$86,382
ART #77	$618,000	12	$14.83	$70,494
New ART1	$618,000	12	$14.83	$79,093
New ART2	$618,000	12	$14.83	$149,458
ART Total				**$509,600**
Total Package				**$4,907,952**

Table A.23 Refined Package Transit Costs and Revenue

Route	Total Annual Costs (2011 Dollars)	Assumed Farebox Recovery	Estimated Farebox Revenue	Deficit
PRTC				
I-66 Priority Bus – Haymarket	$2,497,331	0.5	$969,240	$1,529,091
PRTC Total	**$2,497,331**		**$969,240**	**$1,529,091**
WMATA				
I-66 Priority Bus – Centreville	$1,382,517	0.5	$525,925	$856,592
I-66 Priority Bus – Stringfellow Road	$1,725,598	0.5	$656,438	$1,069,161
U.S. 29 Priority Bus	$1,715,858	0.25	$360,893	$1,354,965
U.S. 50 Priority Bus – via Ballston	$1,917,724	0.25	$403,351	$1,514,373
U.S. 50 Priority Bus – via U.S. 50	$1,855,409	0.25	$390,244	$1,465,164
U.S. 50 Priority Bus – Tysons	$1,560,509	0.25	$328,219	$1,232,291
Metrobus 1B	$952,279	0.2	$160,233	$792,047
Metrobus 1C	$748,951	0.2	$126,020	$622,931
Metrobus 1E	-$20,479	0.2	-$3,446	-$17,033
Metrobus 1X	–	0.25	–	–
Metrobus 2B, G, H	–	0.2	–.	–
Metrobus 2C	$1,652,804	0.2	$293,637	$1,359,167
Metrobus 3A	$168,744	0.2	$29,979	$138,765
Metrobus 3B	–	0.2	–	–
Metrobus 3E	$654,610	0.2	$116,298	$538,312
Metrobus 3T	–	0.2	–	–
Metrobus 3Y	–	0.2	–	–
Metrobus 4A	$165,835	0.2	$29,462	$136,372
Metrobus 4B	–	0.2	–	–
Metrobus 4E	$164,865	0.2	$29,290	$135,5
Metrobus 4H	-$38,792	0.2	-$6,892	-$31,900
Metrobus 10B	$1,163,752	0.2	$206,752	$957,000
Metrobus 15L	$358,823	0.2	$63,749	$295,075
Metrobus 22A	$295,787	0.2	$52,549	$243,237
Metrobus 23A	$1,706,836	0.2	$303,236	$1,403,600
Metrobus 23C	$2,545,706	0.2	$452,270	$2,093,437
Metrobus 24T	–	0.2	–	–
Metrobus 25A	$1,631,192	0.2	$289,797	$1,341,395
Metrobus 25B	$1,591,015	0.2	$282,660	$1,308,355
Metrobus 28A	$1,386,804	0.2	$246,379	$1,140,425
Metrobus 28E	$1,466,327	0.2	$260,508	$1,205,820
Metrobus 28T	–	0.2	–	–
Metrobus 28X	–	0.2	–	–
Metrobus 38B	$383,068	0.2	$68,056	$315,012
WMATA Total	**$27,135,744**		**$5,665,608**	**$21,470,137**

Table A.23 Refined Package Transit Costs and Revenue (continued)

Route	Total Annual Costs (2011 Dollars)	Assumed Farebox Recovery	Estimated Farebox Revenue	Deficit
ART				
ART 42	$65,848	0.2	$10,920	$54,928
ART 45	$268,658	0.2	$44,554	$224,105
ART 52	$392,452	0.2	$65,083	$327,368
ART 53	–	0.2	–	–
ART 62	–	0.2	–	–
ART #75	$505,710	0.2	$83,866	$421,844
ART #77	$412,695	0.2	$68,440	$344,255
New ART1	$463,040	0.2	$76,789	$386,251
New ART2	$874,983	0.2	$145,104	$729,878
ART Total	**$2,983,385**		**$494,757**	**$2,488,628**
Total Package	**$32,616,461**		**$7,128,605**	**$25,487,856**

A.4 Bicycle and Pedestrian Component Costs

This section presents summary cost and cost detail information about the bicycle and pedestrian improvements considered in this study. Table A.24 presents a summary overview of the projects included. Tables A.25 through A.34 provide backup information, showing the facility estimates used to develop project-level cost estimates.

Table A.24 Estimated Bicycle and Pedestrian Improvement Costs

Map ID	Project Name	Revised Description	Project Type	Plan/ Source	LOS 2040 Without Improvements	LOS 2040 With Improvements	Estimated Cost
13	Custis (I-66) Trail Renovation	Renovate trail sections with asphalt cracking and washout, and, where feasible, widen the Custis Trail to 12 feet	Trail	Arlington MTP	D	B	$2,548,000
27	Fairfax Drive Trail Connectors	Reconstruct Fairfax Drive west of N. Glebe Road to improve access to the Bluemont Junction and Custis trails, through wider sidewalk/trails, and improved ramps and signage	Trail	Arlington MTP	B	B	$100,000
34a	Arlington Boulevard Trail – Glebe Road to Arlington Boulevard Interchange	Construct a 10-foot-wide sidepath from City of Fairfax to existing Arlington Boulevard trail in Arlington (may include some use of existing frontage roads)	Trail	NOVA Regional Bikeway and Trail Network Study	D	C	$3,062,000
34b	Arlington Boulevard Trail – Crossing I-495 Interchange	Construct a 10-footwide grade separated crossing of I-495 at Arlington Boulevard	Trail/Grade Separated Crossing	NOVA Regional Bikeway and Trail Network Study	D	C	$3,300,000
34c	Arlington Boulevard Trail – Crossing I-495 Interchange	Construct a 10-footwide sidepath from the I-495/Arlington Boulevard interchange to the City of Fairfax border at Fairfax Boulevard (may include some use of existing frontage roads)	Trail	NOVA Regional Bikeway and Trail Network Study	D	C	$865,000
51	West Falls Church Connector	Construct a trail to connect the Pimmit Run neighborhood to West Falls Church Metro Station	Trail	WMATA/Fairfax County	N/A	A	$1,500,000
52	VA 7 Falls Church to Tysons Connector	Install bike lanes from the W&OD Trail to Tysons Corner	On Road Facility	Tysons Corner Bicycle Master Plan	D	B	$1,043,300
						Total	**$12,418,300**

Table A.25 Two Bike Lanes

Item	Unit	Quantity	2011 Unit Cost	Total Cost	Comment
Earthwork, Excavation, Grading	CY	2,300	$25	$57,500	Assume 6 feet width and 2 feet depth
Aggregate Base Course for Pavement	CY	1,200	$30	$36,000	Assume 6 feet width and 1 feet depth
Asphalt Surface Course	TON	300	$75	$22,500	Assume 6 feet width and 0.125 feet depth, 13.3 CF in a ton
Asphalt Base Course	TON	1,200	$75	$90,000	Assume 6 feet width and 0.5 feet depth, 13.3 CF in a ton
Thermoplastic Pavement Marking (all widths up to 24”)	LF	20,000	$0.75	$15,000	Assume 4 lines entire length
Thermoplastic Pavement Marking Symbol	EA	40	$150	$6,000	Assume 1 symbol every 250 feet each side of road
24” Thermoplastic Pavement Marking	LF	200	$3	$600	Assume 1 high visibility crossing every 2,500 feet
New Sign	EA	10	$300	$3,000	Assume 1 sign every 500 feet
Eradication	LF	10,000	$2	$20,000	Assume 2 lines entire length
Maintenance of Traffic (5%)				$12,530	
Subtotal				**$263,130**	
Contingency (25%)				$65,783	
Estimated Construction Cost				**$329,000**	
ROW Acquisition (10%)				$32,900	
Design Contingency (20%)				$65,800	
Total Estimated Cost				**$427,700**	**Per Mile (2 Lanes)**
				$82	**Per Foot**

Table A.26 Shared Lane Markings

Item	Unit	Quantity	2011 Unit Cost	Total Cost	Comment
Thermoplastic Pavement Marking Symbol	EA	40	$150	$6,000	Assume 1 symbol every 250 feet per side of the road
New Sign	EA	10	$300	$3,000	Assume 1 sign every 500 feet
Maintenance of Traffic (5%)				$450	
Subtotal				**$9,450**	
Contingency (25%)				$2,363	
Estimated Construction Cost				**$11,900**	
ROW Acquisition (10%)				$1,190	
Design Contingency (20%)				$2,380	
Total Estimated Cost				**$15,500**	**Per Mile (2 Lanes)**
				$3	**Per Foot**

Table A.27 Bike Boulevards[a]

Item	Unit	Quantity	2011 Unit Cost	Total Cost	Comment
Curb Extensions	EA	32	$9,300	$297,600	
Speed Humps	EA	16	$5,690	$91,040	
Thermoplastic Pavement Marking (all widths up to 24")	LF	10,560	$0.75	$7,920	Assume 2 lines entire length
Thermoplastic Pavement Marking Symbol	EA	27	$150	$4,050	Assume 2 symbols every block
24" Thermoplastic Pavement Marking	LF	1,584	$3	$4,752	Assume 12 high visibility crossings
New Sign	EA	27	$300	$8,100	Assume 2 signs every block
Traffic Circle	EA	2	$5,690	$11,380	Assume at entrances to bike boulevard
Large Map or Interpretive Sign Panel	EA	2	$3,000	$6,000	Assume at entrances to bike boulevard
Landscaping (5%)				$21,542	
Drainage and Erosion & Sedimentation (10%)				$43,084	
Maintenance of Traffic (5%)				$21,542	
Utility Adjustments (10%)				$43,084	
Subtotal				**$560,094**	
Contingency (25%)				$140,024	
Estimated Construction Cost				**$700,118**	
ROW Acquisition (10%)				$70,012	
Design Contingency (20%)				$140,024	
Total Estimated Cost				**$910,200**	**Per Mile**
				$173	**Per Foot**

[a] Taken from Cincinnati Bike Boulevard – Hewitt Avenue.

Table A.28 Speed Hump

Item	Unit	Quantity	2011 Unit Cost	Total Cost	Comment
Milling	SY	22	$6	$132	Assume 10 long speed bump across 20 feet (travelway space)
Asphalt Surface Course	TON	2	$75	$150	Assume 10 long speed bump, across 20 feet, and 4" high
Thermoplastic Pavement Marking Symbol	EA	12	$150	$1,800	Assume 2 yield markings each speed hump
New Sign	EA	12	$300	$3,600	Assume 2 signs for each speed hump
Subtotal				**$5,682**	

Table A.29 Traffic Circle

Item	Unit	Quantity	2011 Unit Cost	Total Cost	Comment
Earthwork, Excavation, Grading	CY	23	$25	$575	Assume 10-foot radius traffic circle
Curb and Gutter	LF	70	$20	$1,400	
Concrete Unit Pavers	SY	35	$65	$2,275	
Aggregate Base for Sidewalk	CY	6	$40	$240	Assume 0.5-foot depth
New Sign	EA	4	$300	$1,200	Assume 4 signs per circle
Subtotal				**$5,690**	

Table A.30 Shared Used Path (10-Foot)

Item	Unit	Quantity	2011 Unit Cost	Total Cost	Comment
Earthwork, Excavation, Grading	CY	2,100	$25	$52,500	Assume 16-footwide grading
Aggregate Base Course for Pavement	CY	1,100	$30	$33,000	
Asphalt Surface Course	TON	200	$75	$15,000	
Asphalt Base Course	TON	700	$75	$52,500	
Thermoplastic Pavement Marking (all widths up to 24”)	LF	2,500	$0.75	$1,875	Assume 50% with centerline stripe
24” Thermoplastic Pavement Marking	LF	200	$3	$600	Assume 1 high visibility crossing every 2,500 feet
New Sign	EA	5	$300	$1,584	Assume 1 sign every 1,000 feet
New Signal Heads	EA	1	$5,000	$5,000	Assume new signal head every mile
Pedestrian Bridge	EA	0.5	$200,000	$100,000	Assume every 2 miles
Bollards	EA	2	$300	$634	Assume new bollard every 2,500 feet
Split Rail Fence	LF	100	$25	$2,500	Assume 100 LF of split rail fence every mile
Bench	EA	1	$1,200	$1,200	Assume at wayside, 1 every mile
Bike Rack	EA	1	$560	$560	Assume at wayside, 1 every mile
Trash Can	EA	1	$125	$125	Assume at wayside, 1 every mile
Large Map or Interpretive Sign Panel	EA	1	$3,000	$3,000	Assume at wayside, 1 every mile
Landscaping (5%)				$13,504	
Drainage and Erosion & Sedimentation (10%)				$27,008	
Maintenance of Traffic (5%)				$13,504	
Utility Adjustments (10%)				$27,008	
Subtotal				**$351,102**	
Contingency (25%)				$87,775	
Estimated Construction Cost				**$438,900**	
ROW Acquisition (10%)				$43,890	
Design Contingency (20%)				$87,780	
Total Estimated Cost				**$570,600**	**Per Mile**
				$109	**Per Foot**

Table A.31 Shared Used Path (12-Foot)

Item	Unit	Quantity	2011 Unit Cost	Total Cost	Comment
Earthwork, Excavation, Grading	CY	2,520	$25	$63,000	Assume 16-footwide grading
Aggregate Base Course for Pavement	CY	1,320	$30	$39,600	
Asphalt Surface Course	TON	240	$75	$18,000	
Asphalt Base Course	TON	840	$75	$63,000	
Thermoplastic Pavement Marking (all widths up to 24”)	LF	2,500	$0.75	$1,875	Assume 50% with centerline stripe
24” Thermoplastic Pavement Marking	LF	200	$3	$600	Assume 1 high visibility crossing every 2,500 feet
New Sign	EA	5	$300	$1,584	Assume 1 sign every 1,000 feet
New Signal Heads	EA	1	$5,000	$5,000	Assume new signal head every mile
Pedestrian Bridge	EA	0.5	$200,000	$100,000	Assume every 2 miles
Bollards	EA	2	$300	$634	Assume new bollard every 2,500 feet
Split Rail Fence	LF	100	$25	$2,500	Assume 100 LF of split rail fence every mile
Bench	EA	1	$1,200	$1,200	Assume at wayside, 1 every mile
Bike Rack	EA	1	$560	$560	Assume at wayside, 1 every mile
Trash Can	EA	1	$125	$125	Assume at wayside, 1 every mile
Large Map or Interpretive Sign Panel	EA	1	$3,000	$3,000	Assume at wayside, 1 every mile
Landscaping (5%)				$15,034	
Drainage and Erosion & Sedimentation (10%)				$30,068	
Maintenance of Traffic (5%)				$15,034	
Utility Adjustments (10%)				$30,068	
Subtotal				**$390,882**	
Contingency (25%)				$97,720	
Estimated Construction Cost				**$488,700**	
ROW Acquisition (10%)				$48,870	
Design Contingency (20%)				$97,740	
Total Estimated Cost				**$635,400**	**Per Mile**
				$121	**Per Foot**

Table A.32 Shared Used Path Bridge (14-Foot)

Item	Unit	Quantity	2011 Unit Cost	Total Cost	Comment
Path Bridge	SF	84,840	$450	$38,016,000	
Thermoplastic Pavement Marking (all widths up to 24”)	LF	2,500	$0.75	$1,875	Assume 50% with centerline stripe
New Sign	EA	5	$300	$1,584	Assume 1 sign every 1,000 feet
Maintenance of Traffic (5%)				$1,900,973	
Utility Adjustments (10%)				$3,801,946	
Subtotal				**$43,722,378**	
Contingency (25%)				$10,930,595	
Estimated Construction Cost				**$54,653,000**	
ROW Acquisition (10%)				$5,465,300	
Design Contingency (20%)				$10,930,600	
Total Estimated Cost				**$16,395,900**	**Per Mile**

Table A.33 Bridge Widening (per Square Foot)[a]

Item	Unit	Quantity	2011 Unit Cost	Total Cost	Comment
Bridge Widening	SF	1	$250	$250	
Maintenance of Traffic (5%)				$13	
Utility Adjustments (10%)				$25	
Subtotal				**$288**	
Contingency (25%)				$72	
Estimated Construction Cost				**$400**	**Per Square Foot**
ROW Acquisition (10%)				$40	
Design Contingency (20%)				$80	
Total Estimated Cost				**$600**	**Per Square Foot**

[a] $1,510.00 per foot.

Table A.34 Curb Extension

Item	Unit	Quantity	2011 Unit Cost	Total Cost	Comment		
Earthwork, Excavation, Grading	CY	50	$25	$1,262			
Concrete Curb and Gutter	LF	80	$20	$1,600	From Crossing Island estimate		
Concrete Sidewalk (4" Thickness)	SY	48	$30	$1,433	From D.C. Pedestrian Plan estimate		
Curb Ramp	EA	2	$2,500	$5,000	From Intersection Calculations, 1 for each side		
						Per 2-Sided	**Per 1-Sided**
Total				**$9,295**	**Total (Rounded)**	**$9,300**	**$4,650**

A.5 Travel Demand Management Component Costs

Table A.35 shows the costing assumptions for the Travel Demand Management (TDM) options for the Refined Multimodal Package. Details on these options can be found in the June 2012 Final Report.

Table A.35 TDM Costing Assumptions

TDM Strategy	Assumed Value	Description	Source
Enhanced Corridor Marketing	1,273,717	Total daily vehicle-trips originating and/or terminating in corridor	Travel demand model
	$ 843	Existing regional program – annual cost per daily VT reduced	MWCOG 2008 TERM analysis combined with Commuter Connections program budget data
	50%	Marginal benefit per dollar spent versus existing program	Professional judgment
	10%	Percent affected trips that result in no-trip	Professional judgment
	$ 2,200,000	Annual regional Commuter Connections marketing budget	MWCOG – 2008 budget
	23%	Regional budget % to reach study area commuter population (residents and workers)	Arlington-Alexandria-Fairfax County average share of regional employment and population
Rideshare Program Operational Support	209,596	Affected workers	MWCOG 2008 TERM analysis
	$ 22	Existing regional program – annual cost per daily VT reduced	MWCOG 2008 TERM analysis combined with Commuter Connections program budget data
	$ 200,000	Incremental program budget (versus I-66 baseline)	Program assumption
	50%	Marginal benefit per new dollar spent versus existing program	Professional judgment
Enhanced Telework!VA	1.3	Telecommute average days/week	Professional judgment
	$ 100	Average incentive or cost subsidy per new teleworker	Program assumption (Note: VA now provides up to a $1,200 one-time tax credit per new teleworker)
	2,500	New teleworkers	Calculation
Enhanced Employer Outreach	209,596	Affected workers	MWCOG 2008 TERM analysis
	$ 22	Existing regional program – annual cost per daily VT reduced	MWCOG 2008 TERM analysis combined with Commuter Connections program budget data
	$ 200,000	Incremental program budget (versus I-66 baseline)	Program assumption
	50%	Marginal benefit per new dollar spent versus existing program	Professional judgment

Table A.35 TDM Costing Assumptions (continued)

TDM Strategy	Assumed Value	Description	Source
Vanpool Driver Incentive	$ 250	Annual subsidy per driver	Program assumption from I-66 Transit/TDM Study
	50	Number of existing vanpools in study area	Estimate based on regional registered vanpools and ratio of study area to regional employment
	3	Number of new vanpools formed	Professional judgment (0 in I-66 Transit/ TDM study)
Enhanced Virginia Vanpool Driver Insurance Pool	$ 1,087	Savings per year per van	Calculated from program cost and total existing + new vanpools
	$ 110	Reduction in annual cost per participant	Calculated from savings per van and average vanpool occupancy
	$ 0.23	Reduction in participant cost per trip	Calculated from reduction in cost per participant and trips per participant per year
	12	Implied new vanpools	EPA COMMUTER Model calculation
Capital Assistance for Vanpools	$ 1,087	Capital subsidy per van per year	Calculated from program cost and total existing + new vanpools
	$ 110	Reduction in annual cost per participant	Calculated from savings per van and average vanpool occupancy
	$ 0.23	Reduction in participant cost per trip	Calculated from reduction in cost per participant and trips per participant per year
	12	Implied new vanpools	EPA COMMUTER Model calculation
Van Priority Access	2.0	Average minutes of travel time savings per van trip	Professional judgment
	$ 10,000	Annualized cost of education, signage and enforcement	Professional judgment
	6	Implied new vanpools	EPA COMMUTER Model calculation
Network	10	# of new vanpools formed	Professional judgment
	$ 10,000	Annualized cost to develop and operate program (incremental to vanpool operating cost)	Professional judgment

Table A.35 TDM Costing Assumptions (continued)

TDM Strategy	Assumed Value	Description	Source
I-66 Corridor-Specific Startup Carpool Incentives	$ 150	Incentive per participant	Atlanta Cash for Commuters started at $180 then capped at $100
	1,000	Annual participants awarded incentives	Program assumption
	2.0	Average carpool retention time (years)	Estimate based on retention data from Atlanta Cash for Commuters survey
	4.2	Average days/week carpooling	MWCOG 2010 SOC Report (Figure 52)
Northern Virginia Ongoing Financial Incentive	$ 50	Average annual incentive per participant	Program assumption
	2,000	Annual participants awarded incentives	Program assumption
	53%	incentive users switching from DA mode	MWCOG 2010 SOC Report – prior mode of travel
	1.0	Number of trips reduced per day per incentive user	Atlanta Cash for Commuters survey data, per I-66 Transit/TDM Study
Try Transit and/or Direct Transit Subsidy	$ 25.00	Average monthly transit subsidy per participant	Program assumption – per I-66 Transit/TDM Study
	$ 0.63	Cost savings per trip	Calculated from monthly subsidy and trips per month (20*2)
	100%	Prior private vehicle mode share of subsidy recipients	Assume not provided to existing transit users
	13,466	Unconstrained new transit users	Calculated using COMMUTER Model
	4,000	Annual program participant cap	Program assumption
	4.15	Average days/week using transit	MWCOG 2010 SOC Report (Figure 52)
Carsharing at Priority Bus Activity Nodes	10	Number of Priority Bus Activity Nodes	Professional judgment
	3	Number of cars deployed per node	Professional judgment
	20	Members per car	TCRP Report 108
	0.1	Change in daily vehicle-trips per member	MWCOG 2009 Carshare Survey per I-66 study
	$ 0	Public cost per car to support new carshare deployment	Assumed $0 in I-66 Transit/TDM study

Appendix B

Travel Demand Model Methodology

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Appendix B Travel Demand Model Methodology

Appendix B provides a summary of model revisions, the verification process, measures of effectiveness, and tolling approaches applied through use of the TPB Version 2.3.37 Travel Demand Model in the I-66 Multimodal Corridor Study – Refined Package evaluation.

B.1 Model Run Revisions and Verification

The Refined Multimodal Package was run using the TPB Version 2.3.37 Travel Demand Model with the following modifications:

- The HOV skims were calculated using the same regional highway network (including all existing and planned HOV lanes) as the non-HOV skims;
- The assignment of HOV trips was completed with all other trips for the specified time periods; and
- As typical for planning studies in the region, the transit constraint on trips going to the D.C. core was not included.[1]

Some coding corrections were made on the highway network including:

- I-66 westbound was previously incorrectly coded in the regional model as an intersection with Great Falls Street. It has been corrected in the new runs;
- The widening of the I-66 eastbound segment between the N. Westmoreland Street eastbound off ramp and the Washington Street (Boulevard) eastbound off ramp as proposed in the Refined Package is coded as four lanes instead of three lanes as incorrectly coded in original runs of Packages 1 through 4; and
- I-66 eastbound approaching VA 7 (from east of Virginia Lane) was previously incorrectly coded as three lanes, but has been corrected in the new runs to two lanes.

[1] When in use, the transit constraint reallocates "excess" Metrorail transit trips to the single-occupancy vehicle mode trip table to arrive at the worst case impact in terms of potential air quality conformity consequences.

The following coding correction was made on the transit network:

- The peak period frequency of bus line WM25B was changed to 15 minutes from 30 minutes as coded in Package 4.

After these coding corrections, the original package (Package 1) was re-run and the results were summarized and compared with the Final Report results. The MOE results for the re-run Package 1 and the re-run Package 1 sensitivity test (peak period tolling) were tabulated along with the Refined Package model runs and are presented in Table B.1. The re-run results confirm that the highway and transit network corrections detailed above do not materially change the results.

Table B.1 Measures of Effectiveness Summary

Measures of Effectiveness	2007	2040 CLRP +	Revised Package 1	Revised Package 1 (Sensitivity Test-Peak-Only Toll)	Refined Package (All-Day Toll)	Refined Package (Peak-Only Toll)
Study Area VMT						
Morning Peak (Total)	558,700	555,300	616,000	617,200	640,100	640,700
Uncongested	152,758 27.3%	135,666 24.4%	129,632 21.0%	130,329 21.1%	120,170 18.8%	120,674 18.8%
Near Capacity	303,671 54.4%	258,519 46.6%	313,295 50.9%	313,029 50.7%	341,299 53.3%	341,615 53.3%
Over Capacity	102,223 18.3%	161,126 29.0%	170,035 28.1%	173,872 28.2%	178,601 27.9%	178,416 27.8%
Evening Peak (Total)	872,100	814,400	918,600	922,300	949,300	951,600
Uncongested	169,463 19.4%	147,441 18.1%	136,887 14.9%	140,195 15.2%	133,558 14.1%	133,710 14.1%
Near Capacity	517,964 59.4%	437,831 53.8%	549,233 59.8%	562,205 61.0%	580,086 61.1%	581,731 61.1%
Over Capacity	184,681 21.2%	229,117 28.1%	232,488 25.3%	219,944 23.8%	235,613 24.8%	236,188 24.8%
Study Area Daily PMT						
Rail	611,197	1,224,585	1,206,382	1,214,813	1,216,800	1,225,893
Freeway	2,063,637	2,122,972	2,158,523	2,494,293	2,463,452	2,673,569
Arterial	2,207,762	2,503,908	2,514,490	2,450,450	2,550,506	2,519,542
Total	*4,882,596*	*5,851,465*	*5,879,394*	*6,159,555*	*6,230,759*	*6,419,003*
Mode Share						
All Trip Productions						
SOV	45.5%	40.5%	40.3%	40.2%	40.1%	40.1%
HOV 2	22.8%	22.4%	22.2%	22.3%	22.2%	22.3%
HOV 3+	17.6%	20.1%	19.9%	19.8%	19.8%	19.7%
Transit	14.1%	17.0%	17.6%	17.7%	17.9%	17.9%
All Trip Attractions						
SOV	45.9%	38.4%	38.9%	38.9%	38.8%	38.8%
HOV 2	21.9%	20.0%	19.9%	20.0%	19.9%	20.0%
HOV 3+	17.6%	22.5%	21.6%	21.5%	21.5%	21.4%
Transit	14.6%	19.2%	19.6%	19.6%	19.8%	19.8%

Table B.1 Measures of Effectiveness Summary (continued)

Measures of Effectiveness	2007	2040 CLRP +	Revised Package 1	Revised Package 1 (Sensitivity Test-Peak-Only Toll)	Refined Package (All-Day Toll)	Refined Package (Peak-OnlyToll)
Mode Share (continued)						
All Trip Attractions						
SOV	45.9%	38.4%	38.9%	38.9%	38.8%	38.8%
HOV 2	21.9%	20.0%	19.9%	20.0%	19.9%	20.0%
HOV 3+	17.6%	22.5%	21.6%	21.5%	21.5%	21.4%
Transit	14.6%	19.2%	19.6%	19.6%	19.8%	19.8%
Home-Based Work Productions						
SOV	49.1%	45.3%	45.4%	45.4%	44.8%	44.7%
HOV 2	6.5%	5.6%	5.9%	5.9%	5.8%	5.8%
HOV 3+	1.5%	2.1%	1.6%	1.6%	1.6%	1.6%
Transit	42.8%	46.9%	47.1%	47.1%	47.9%	47.9%
Home-Based Work Attractions						
SOV	54.3%	42.3%	44.3%	44.3%	44.1%	44.2%
HOV 2	8.2%	4.4%	5.0%	5.0%	5.0%	5.0%
HOV 3+	3.5%	13.8%	11.4%	11.4%	11.3%	11.3%
Transit	34.0%	39.4%	39.3%	39.2%	39.6%	39.5%
Study Area Transit Accessibility						
Households with Access to Bus Service	58.0%	76.8%	77.2%	77.2%	77.2%	77.2%
Jobs with Access to Bus Service	64.3%	87.7%	88.0%	88.0%	88.0%	88.0%
Nonmotorized Travel						
Daily Study Area Nonmotorized Trips[a]	163,826	260,826	260,826	260,826	260,826	260,826
Walk Access Transit Productions[b]	34,118	58,974	58,947	58,885	58,858	58,858
Walk Access Transit Attractions	35,890	51,860	51,896	51,907	53,562	53,624

[a] The model calculates this measure solely based on the socioeconomic data inputs; it does not include walk access to/from transit trips.

[b] This measure reflects output from the mode choice model reporting walk access/egress to/from transit trips.

Table B.1 Measures of Effectiveness Summary (continued)

Measures of Effectiveness	2007	2040 CLRP +	Revised Package 1	Revised Package 1 (Sensitivity Test-Peak-Only Toll)	Refined Package (All-Day Toll)	Refined Package (Peak-Only Toll)
Cutlines Daily Person Throughput						
Beltway Cutline						
Rail	36,482	37,295	34,568	34,873	33,242	33,380
Bus	1,850	7,603	11,084	11,308	11,369	11,433
Auto	278,021	276,625	288,436	305,492	296,283	300,406
Total	*316,353*	*321,522*	*334,088*	*351,672*	*340,894*	*345,219*
West of Glebe Road Cutline						
Rail	67,791	114,365	113,324	114,391	115,578	115,932
Bus	5,633	14,337	18,386	18,729	17,133	17,234
Auto	344,527	333,956	338,301	368,535	364,127	374,912
Total	*417,951*	*462,658*	*470,011*	*501,655*	*496,838*	*508,077*
Clarendon Cutline						
Rail	92,034	145,331	142,549	143,543	145,661	145,866
Bus	6,904	16,584	21,126	21,439	20,334	20,420
Auto	358,640	364,648	362,248	391,246	378,251	386,719
Total	*457,578*	*526,562*	*525,923*	*556,227*	*544,245*	*553,005*
Potomac River Cutline						
Rail	157,599	184,470	180,549	181,082	184,230	184,190
Bus	5,125	13,845	18,687	18,965	17,123	17,175
Auto	268,982	297,700	298,356	305,519	301,716	303,267
Total	*431,706*	*496,015*	*497,591*	*505,566*	*503,068*	*504,632*

B.2 Peak Toll and All Day Toll Modeling Approach

The TPB Version 2.3.37 Travel Demand Model considers toll effects on travel through the following processes:

- In trip distribution, tolls affect travel patterns as part of the composite time of travel. The toll is converted to a time equivalent using the value of time (VOT). Households in each of four income groups have different VOT by trip purposes.

- In mode choice, the tolls affect travelers' choice of modes as part of cost consideration. The model uses highway skims of tolls for different auto modes (SOV, HOV 2, HOV 3+) as an input into the travel cost component of mode choice.

- In traffic assignment, tolls affect travelers' choice of routes. Different vehicle classes have different VOT by time periods.

In the original study, I-66 was simulated as an HOV facility for peak periods using the TPB Version 2.3.37 Travel Demand Model. In the original Package 1, a toll was applied to the HOV facility on a daily basis, and a sensitivity test was run to evaluate the results of applying the toll to the peak periods only (see Table B.1). Both model results show that tolling helps address study objectives.

In the Refined Package, toll rates were varied by corridor segment and time periods to achieve the following objectives:

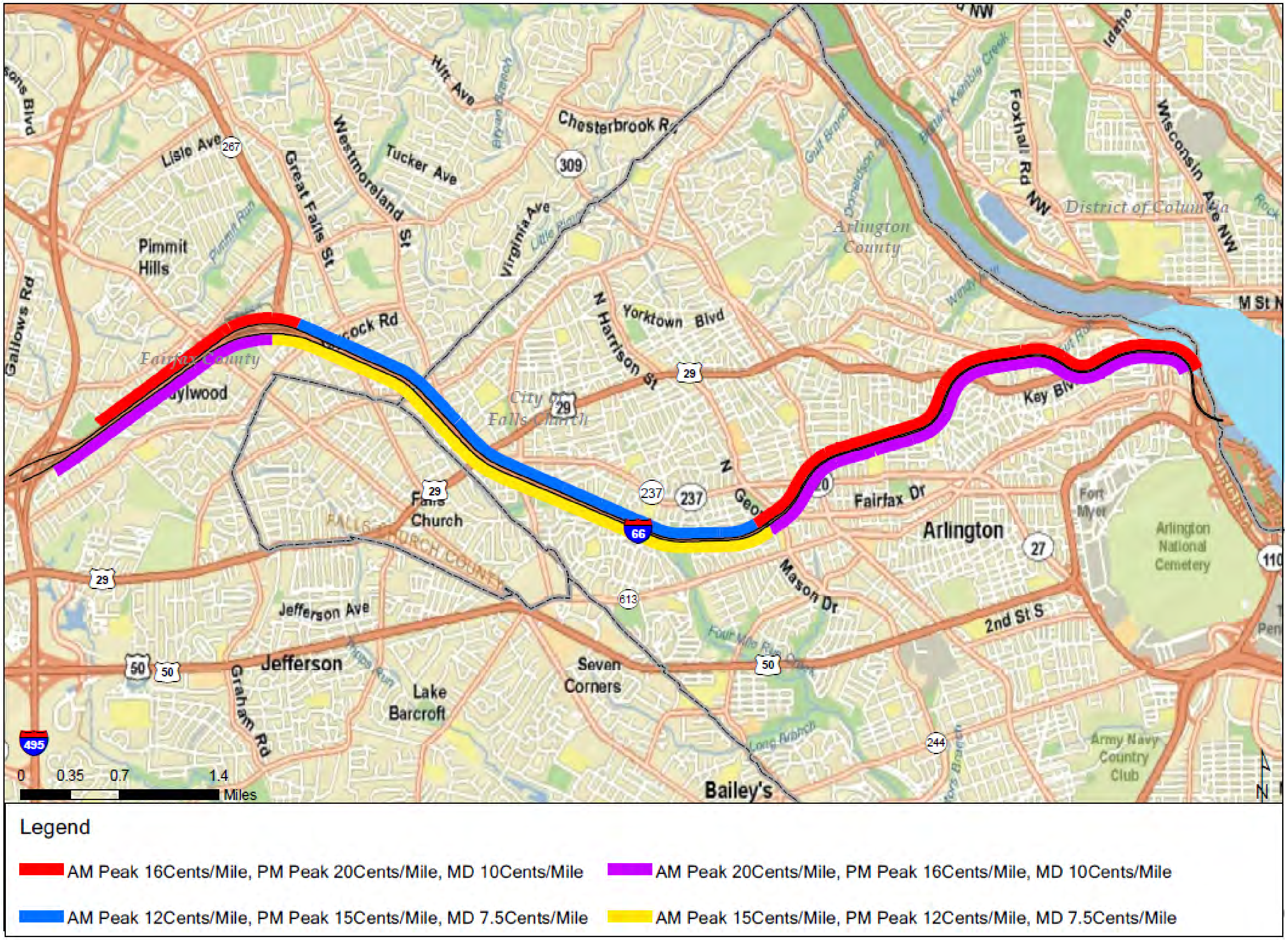
- To fully utilize the additional capacity from widening select segments of I-66; and

- To achieve the VDOT HOT operational policy that toll rates should be set such that the travel demand does not degrade the prevailing speed on the HOT facility.

To vary the toll rates by segment, the I-66 facility inside the beltway was segmented into three toll groups in each direction. This approach considered the high congestion level, the widening proposed in the "middle" section (between VA 267 and Fairfax Drive), and the varying travel demand for inbound and outbound directions. Toll rates were adjusted up or down from the original rates tested in Package 1, based on the congestion level on different segments of I-66.

The model results were summarized and the I-66 HOT performance was evaluated to assess if there is any extra capacity or unacceptable levels of service. The toll adjustments were repeated until the above mentioned objectives were achieved. Figure B.1 presents the resulting toll definitions used in the Refined Package and Table B-1 includes the MOEs for each of the two tolling options.

Figure B.1 Refined Package I-66 Toll Definitions



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Appendix C

Bicycle and Pedestrian Project Profiles

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Appendix C Bicycle and Pedestrian Project Profiles

C.1 Custis Trail Renovation

Project ID: 13

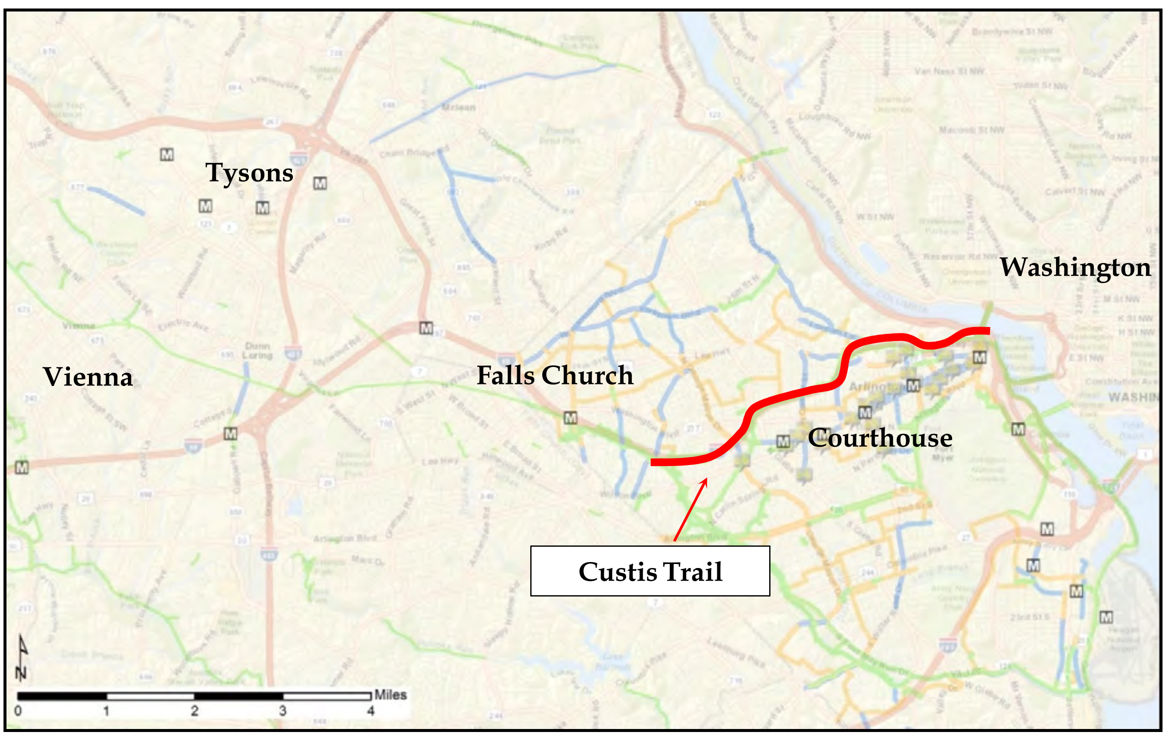
Project Description: This project will widen the trail to 12 feet where feasible, smooth cracked and heaved pavement, and upgrade trail lighting between Lynn Street in downtown Rosslyn and the intersection with the Washington & Old Dominion (W&OD) Trail (in Bluemont Park) near the western edge of Arlington County.

2040 Shared Use Path LOS without Improvement: D

2040 Shared Use Path LOS with Improvement: B

Project Cost Estimate: $2,548,000

Project Location



Statement of Regional Benefit

This project supports bicycle commuter travel along the I-66 corridor parallel to the Interstate, providing access to many key destinations. Trail improvements also will help accommodate increased levels of reverse commuting (east to west) by bicycle that may occur in conjunction with increased development in Tysons Corner and Merrifield. Ensuring that the trail can accommodate current volumes and projected increases in demand from growth in adjacent residential areas, as well as employment growth in Tysons Corner, may help lower the number of vehicles on adjacent I-66.

All of the proposed changes will improve both bicyclist and pedestrian safety. Widening the path will allow cyclists to pass each other and pedestrians, with less risk of collision and to maintain speed more consistently, which is an important consideration for commuters. Smoother pavement and better lighting also will help users avoid hazards, and facilitate year-round commuting by bicycle when days are shorter.

Project Photo

Pinch points, such as the underpass at I-66 along Lee Highway presents a particular right-of-way challenge to widening as it already is bound by the sidewalk and a retaining wall at the adjacent park. Photo credit: Toole Design Group.

Key Considerations

There are a number of pinch points along the trail that will make widening to 12 feet difficult because of right-of-way availability, adjacent infrastructure and topography. Many of the bridges are less than 12 feet in width, and would need to be widened to maintain a continuous width. In some sections of the trail where underpasses and bridge abutments will not allow for the 12-foot width, special design consideration should be given to these points to assess whether other factors could be changed to increase user friendliness.

Another key consideration is trail use during this construction project. The trail is heavily used, so provisions must be made for an alternative route when sections are unavailable for passage. This has been done before during smaller resurfacing projects, so similar protocols of timing, phasing, and detours, as well as advanced communication with trail users should be followed.

Next Steps in Moving Project Forward

A feasibility study will be needed to determine opportunities and constraints to trail widening. This should include study of obstructions (walls, utility poles, abutments, trees), topography, adjacent land ownership, and other considerations. This study will help identify the appropriate phasing scheme for construction.

This study should be accompanied by a survey to confirm boundaries and topography, and to identify areas where the trail already meets the 12-foot desired width.

C.2 Fairfax Drive Trail Connectors

Project ID: 27

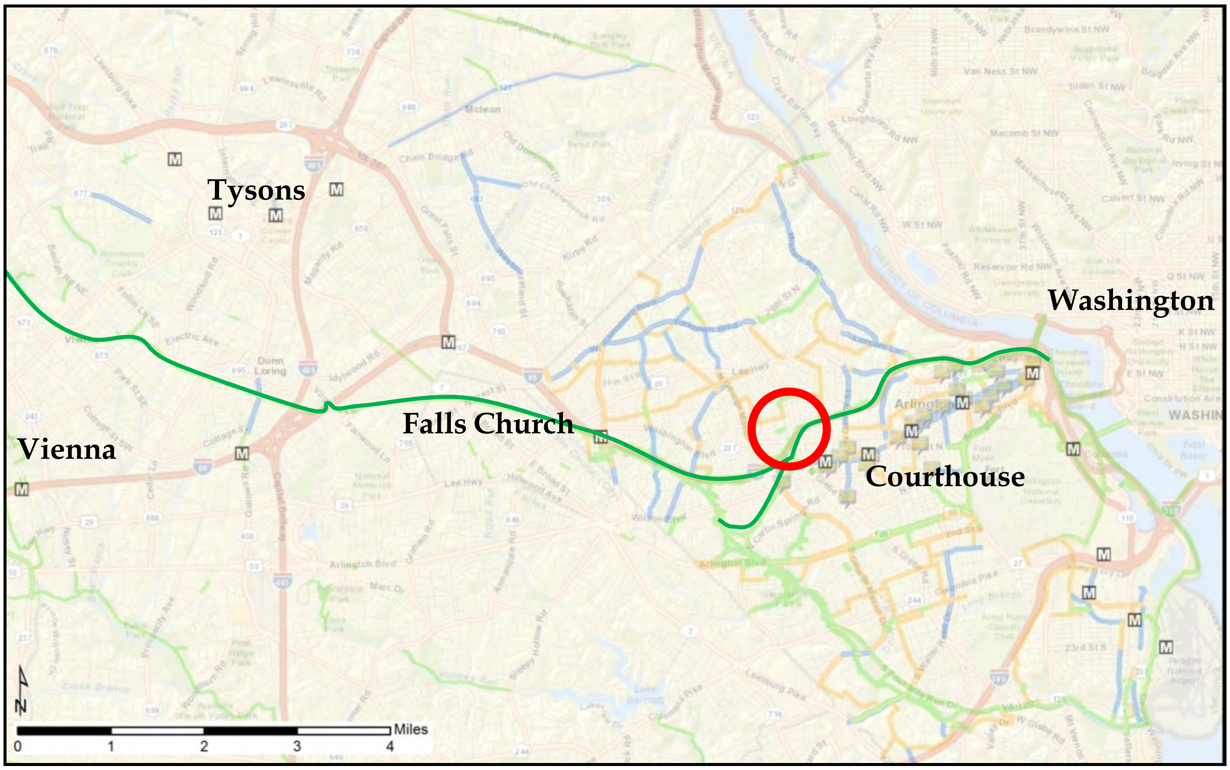
Project Description: This project will improve connectivity between the Custis Trail and the Bluemont Junction Trail, and the western edge of the Rosslyn-Ballston Corridor through wider sidewalks and improved signal timing, ramps, and signage on N. Fairfax Drive west of N. Glebe Road.

2040 Shared Use Path LOS without Improvement: N/A

2040 Shared Use Path LOS with Improvement: B

Project Cost Estimate: $100,000 for sidewalk improvements and signage

Project Location



Statement of Regional Benefit

This major nexus of two regional trails is a key bicycle connection in the I-66 corridor. The Bluemont Junction Trail provides bicycle access to neighborhoods south of the Interstate and to the W&OD Trail. The Custis Trail (also referenced in Project 13) is a vital east-west route that parallels I-66. These trails are used by many bicyclists and pedestrians for both commuting and recreational trips, and improved access will not only enable more cyclists to do so, but will increase safety for all users by providing clearly designated areas for bicyclists, pedestrians, and motor vehicles.

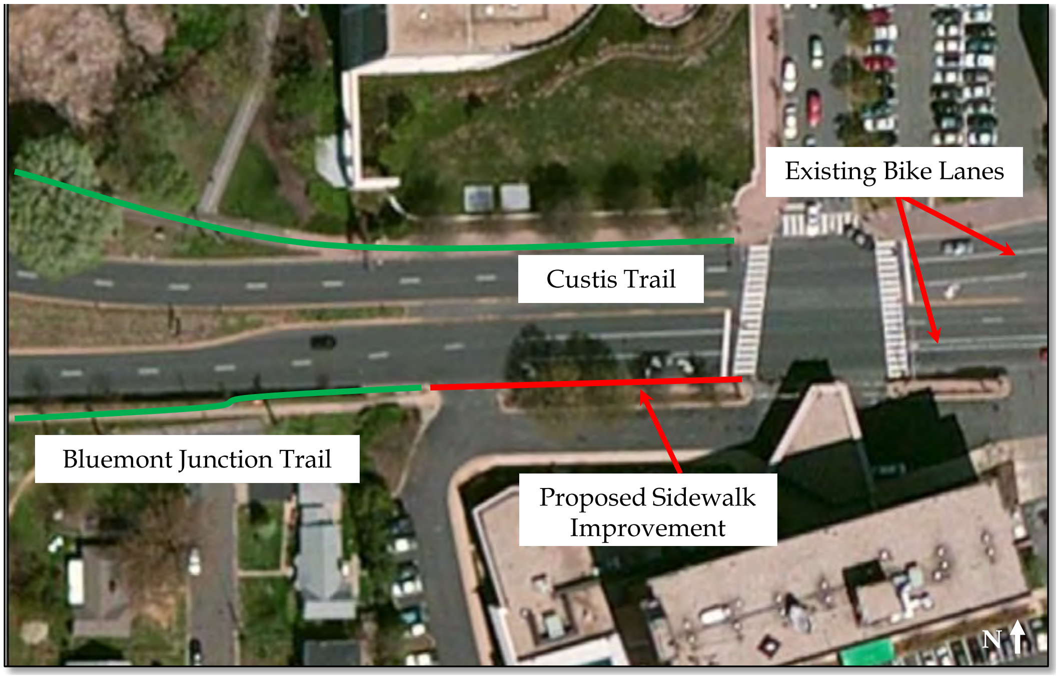
A key portion of this project is the crossing of Fairfax Drive that connects the two trails. There is a particularly high volume of traffic on Fairfax Drive here, as it is the main connection between the Ballston corridor and I-66 with on-/off-ramps beginning just to the west of the trail crossing. The crossing itself should indicate to motorists to expect crossing trail/bicycle traffic here. Special consideration should be given to southbound, right-turning traffic from N. Wakefield Street that would potentially interfere with the path of travel of cyclists and pedestrians using the crosswalk here.

Cyclists approach this intersection on the trails from the west and in bike lanes on N. Fairfax Drive from the east. Signage should be improved for all approaches so cyclists are aware of the appropriate path to access both trails as well as other destinations. Generally, better connections from on-street to off-street infrastructure are needed.

Both the Custis and Bluemont Junction Trails at this point travel along relatively narrow sidewalks on the north and south sides of Fairfax Drive to access the crossing, one that does not provide enough room for two cyclists or a cyclist and a pedestrian to pass each other safely and comfortably. Cyclists currently tend to use the Holiday Inn driveway to make the connection from the Bluemont Junction Trail to the crossing. The sidewalk in this stretch also has a severe cross slope posing safety problems for any wheeled users: bicyclists, wheelchairs, or strollers.

Project Photos

This narrow sidewalk on the south side of N. Fairfax Drive between the road and the Holiday Inn driveway comprises the end of the Bluemont Junction Trail. Its usable area is made even narrower by utility placements. Photo credit: Toole Design Group.



Underlying aerial photo © Google Maps and applicable third-party suppliers

Conflicts are created when trail users coming from the west must merge into the on-street bike lane on N. Fairfax Drive which is to the left of a right-turn-only lane. Photo credit: Toole Design Group.

Key Considerations

In this location, special attention will need to be paid to access to the driveways of the Holiday Inn at the intersection of Fairfax Drive and N. Wakefield Street. The Bluemont Junction Trail crosses two entrances to the hotel, and traffic from a third entrance may cross the eastbound bike lane on Fairfax Drive if drivers intend to travel east or make a left onto N. Glebe Road.

Additionally, any reconstruction of sidewalks in this area will need to take into consideration what right-of-way is available and the placement of existing surface and subsurface utilities. Some area that could be included in a widening project may be private property, so a concrete understanding of ownership is needed.

Next Steps in Moving Project Forward

Further information gathering on VDOT right-of-way extents, property ownership, existing lane widths, and utility location is needed. This will help determine the feasibility of widening sidewalks for trail connection. It may be possible to reallocate space within the existing right-of-way by narrowing motor-vehicle travel lanes (lane diet) and increasing sidewalk width.

In the near term, safety at the intersection should be addressed. Study of signal timing to ensure adequate crossing time is needed, and clear signage indicating a trail crossing to both trail users and drivers should be an early priority.

Longer term, studying the feasibility of a grade-separated crossing is recommended. This would enable through-flow of traffic on the trail network without creating conflicts between trail users and drivers at this crossing.

C.3 Arlington Boulevard Trail – Glebe Road to I-495 Interchange

Project ID: 34.A

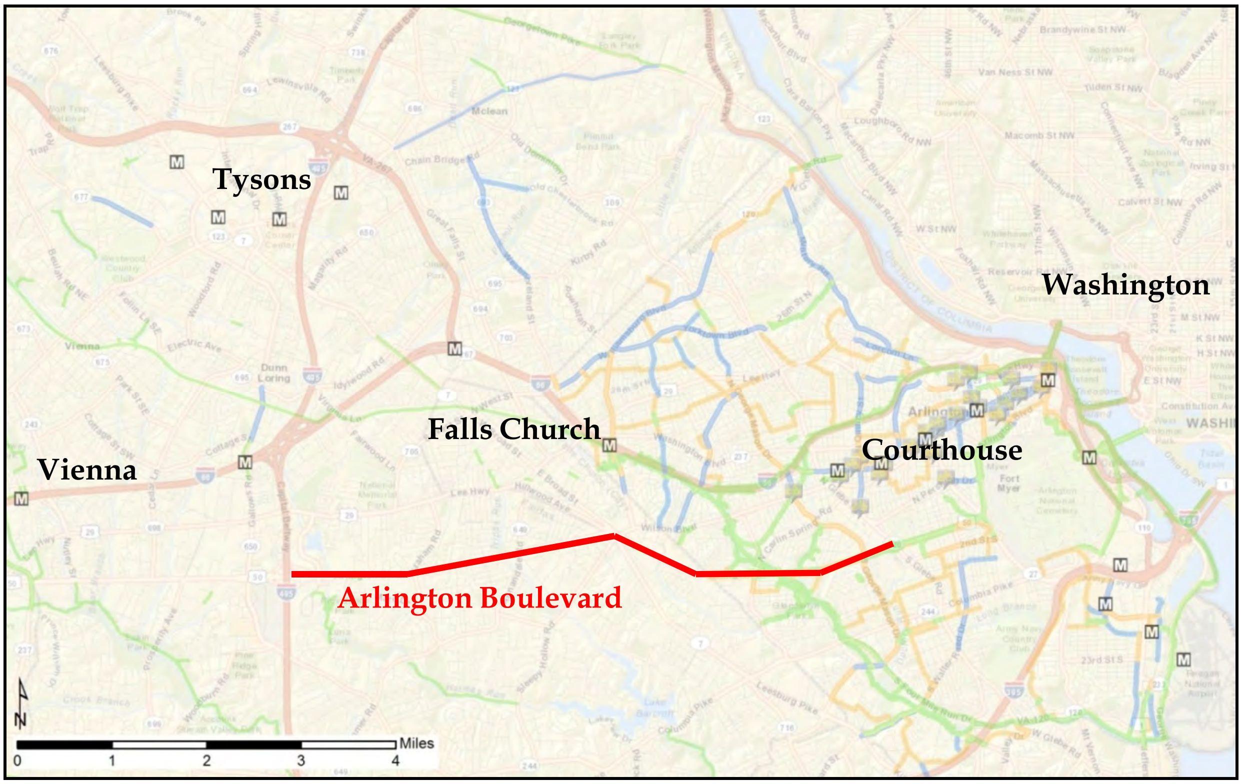
Project Description: This project will create a trail along Arlington Boulevard through a combination of constructing an off-road sidepath, on-street infrastructure, and signage. The project will continue the existing Arlington Boulevard sidepath west from Glebe Road to the I-495 interchange.

2040 Shared Use Path LOS without Improvement: N/A

2040 Shared Use Path LOS with Improvement: B

Project Cost Estimate: $3,062,000

Project Location



Statement of Regional Benefit

The trail will enable bicyclists to travel from western Arlington County, and eastern/central portions of Fairfax County to locations in the Rosslyn-Ballston corridor, Crystal City, and east into the District of Columbia. The improvements will enhance bicyclist comfort through either a separated bicycle facility, or an on-road bicycle facility on a relatively low-speed, low-volume frontage road. Improvements to transition this trail from a disjointed signed bike route to an effective bicycle facility are included in the Arlington Master Transportation Plan.

Project Photo

Arlington Boulevard and service road looking west at Park Road intersection. Photo credit: Toole Design Group.

Key Considerations

Some of the segments of service road along the corridor have many commercial driveway crossings from retail uses that line the road. These crossings may create conflicts between trail users and drivers, so particular attention should be given to trail design along these interrupted segments. Of particular difficulty will be traversing the Seven Corners area.

As the trail will move from on-road to off-road facilities and use many different types of streets, clear signage to direct trail users will be essential.

Additionally, widening of U.S. 50 from the eastern boundary of Arlington County to the City of Fairfax is included in the Metropolitan Washington Council of Governments/National Capital Region Transportation Planning Board (TPB) 2012 Financially Constrained Long-Range Transportation Plan (CLRP). This trail project will need to be coordinated with that widening (from four to six lanes).

Next Steps in Moving Project Forward

A detailed planning study is needed to look at opportunities and constraints for construction and signing of this path. The study should assess:

- Right-of-way ownership along alignment;
- Opportunities for creating dedicated off-road facilities;
- Connections between potential off- and on-road facilities;
- Potential for routing bicyclists through neighborhood streets to the south of the Seven Corners area, including assessment of parcel ownership for cut-through opportunities connecting cul-de-sacs for bicyclists and pedestrians;
- Potential for using grassy median between Arlington Boulevard and service road as location for off-road pathway; and
- Preference for trail placement to the north or south of Arlington Boulevard.

C.4 Arlington Boulevard Trail at I-495 Interchange

Project ID: 34.B

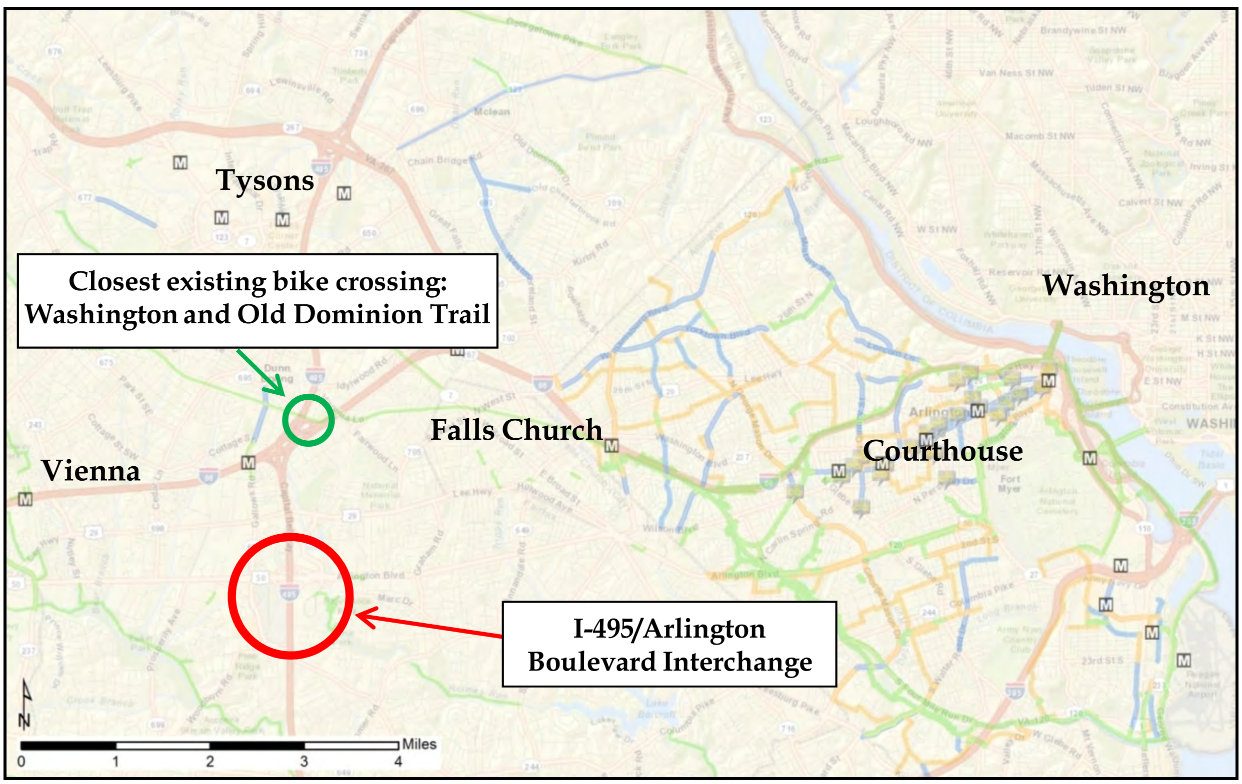
Project Description: This project will construct bicycle and pedestrian accommodations across the I-495 (Capital Beltway) in the vicinity of Arlington Boulevard. The ultimate facility will likely be a grade separated crossing, such as an overpass crossing the interchange ramps, Fairview Park Drive east of the interchange, and 16 lanes of I-495 (including the HOT lanes and merge lanes). The cost estimate anticipates a 16-foot wide bridge over the interstate, with grade separated crossings over Fairview Park Drive and interchange ramps.

2040 Shared Use Path LOS without Improvement: N/A

2040 Shared Use Path LOS with Improvement: A

Project Cost Estimate: $3,300,000

Project Location

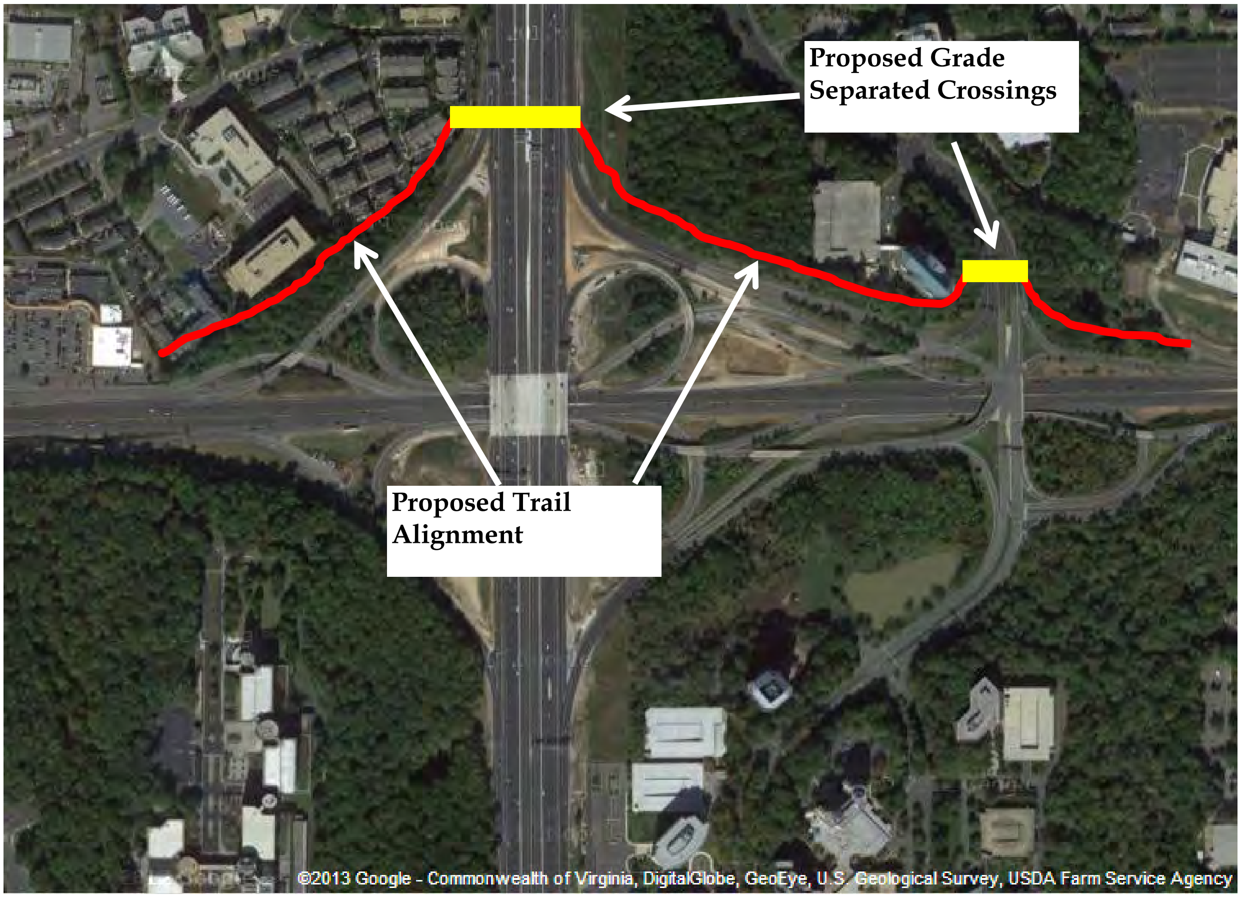


Statement of Regional Benefit

Currently, this interchange serves as a major barrier to east-west connectivity for cyclists between Fairfax County and Arlington County. On the east side of this interchange, the Arlington Boulevard Trail runs along the north side of the road, but it truncates before the interchange, heading north along Fairview Park Drive. Constructing a crossing in the vicinity of the Beltway will allow for traffic on the Arlington Boulevard trail to continue uninterrupted, and connect with a future sidepath or bikeway along Arlington Boulevard heading west from the interchange to the City of Fairfax.

Project Photos

Looking east at I-495 Interchange from Arlington Boulevard. Photo credit: Toole Design Group.



Aerial photo © Google Maps and applicable third-party suppliers.

Key Considerations

Though this project is complex, it provides a desirable option for enabling bicyclists to make the connection across I-495. Other east-west routes to the north and south in this area are less desirable for various reasons:

- *Gallows Road* – The right-of-way does not appear to be wide enough to accommodate necessary off-street bicycle facilities for the segment west of I-495, and this routing to the south of Arlington Boulevard would create a nearly two-mile detour, which is significant for bicyclists.

- *Lee Highway* – Similarly, detouring to Lee Highway adds two miles to this crossing and presents issues for accommodating bicyclists on Gallows Road to the west of the Beltway.

Additionally, there is no opportunity for the connection to be made underneath I-495 as the horizontal clearance may be too narrow between bridge abutments. This necessitates a bicycle/pedestrian bridge solution which adds to the complexity and cost of the project since the span of the highway itself here is over 300 feet. There is some precedent for such a project spanning the Beltway: the recently reconstructed W&OD Trail bridge over the highway has a support midspan in the median, as this Arlington Boulevard Trail crossing would need.

Next Steps in Moving Project Forward

The desired location for this connecting bridge would be north of Arlington Boulevard since the parcel to the southwest of the interchange is a large ExxonMobil campus (although they are likely moving their offices soon). This northern alignment also is more desirable as it would link to the growing Merrifield area and place users somewhat closer to accessing the Dunn Loring/Merrifield Metrorail station. However, there also is a high-voltage power line north of U.S. 50 which must be considered in design.

The next step in planning for the connection should be evaluating existing bicycle infrastructure and possible street network connections to the north of Arlington Boulevard, followed by a feasibility study, detailed cost estimates, and design.

C.5 Arlington Boulevard Trail – I-495 Interchange to City of Fairfax

Project ID: 34.C

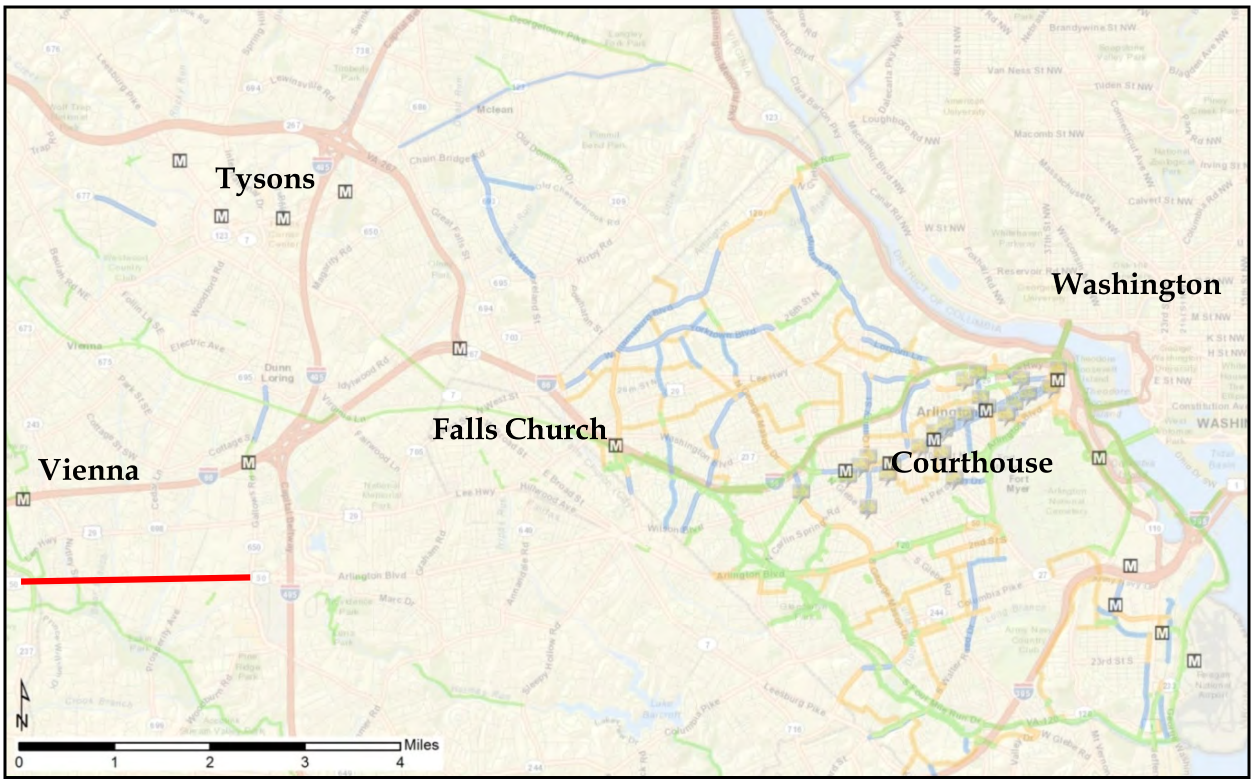
Project Description: This project will create a trail along Arlington Boulevard through a combination of constructing an off-road sidepath, on-street infrastructure, and signage from the I-495/Arlington Boulevard interchange to the City of Fairfax border at Fairfax Boulevard.

2040 Shared Use Path LOS without Improvement: N/A

2040 Shared Use Path LOS with Improvement: B

Project Cost Estimate: $864,000

Project Location



Statement of Regional Benefit

The construction of this trail would make an important connection for cyclists between Fairfax/central Fairfax County and Arlington County. This continuation of the Arlington Boulevard Trail also would connect to the new bike lanes on Gallows Road, and the Cross County Connector Trail at its western end, facilitating access to the Vienna Metrorail Station. Improvements to transition this trail from a disjointed signed bike route to an effective bicycle facility are included in the Arlington Master Transportation Plan.

Project Photo

Aerial photo © Google Maps and applicable third-party suppliers.

This is a typical cross-section along the corridor segment with service roads on one or both sides, separated from Arlington Boulevard by a wide, grassy median.

Key Considerations

Some of the segments of service road along the corridor have many commercial driveway crossings from retail and office uses that line the road. These crossings may create conflicts between trail users and drivers, so particular attention should be given to trail design along these interrupted segments. Locations where grade separated crossings intersect with Arlington Boulevard will require careful consideration to address pinch points (e.g., Gallows Road underpass), and crossings of on- and off-ramps.

As the trail will move from on-road to off-road facilities and use many different types of streets, clear signage to direct trail users, and well-designed transitions between on- and off-road facilities, will be essential.

Additionally, widening of U.S. 50 from the eastern boundary of Arlington County to the City of Fairfax is included in the 2012 CLRP. This trail project will need to be coordinated with that widening from four to six lanes.

Next Steps in Moving Project Forward

A detailed planning study is needed to look at opportunities and constraints for construction and signing of this path. The study should assess:

- Right-of-way ownership along alignment;
- Opportunities for creating dedicated off-road facilities;
- Connections between potential off- and on-road facilities;
- Potential for using grassy median between Arlington Boulevard and service road as location for off-road pathway; and
- Preference for trail placement to the north or south of Arlington Boulevard.

C.6 West Falls Church Connector Trail

Project ID: 51

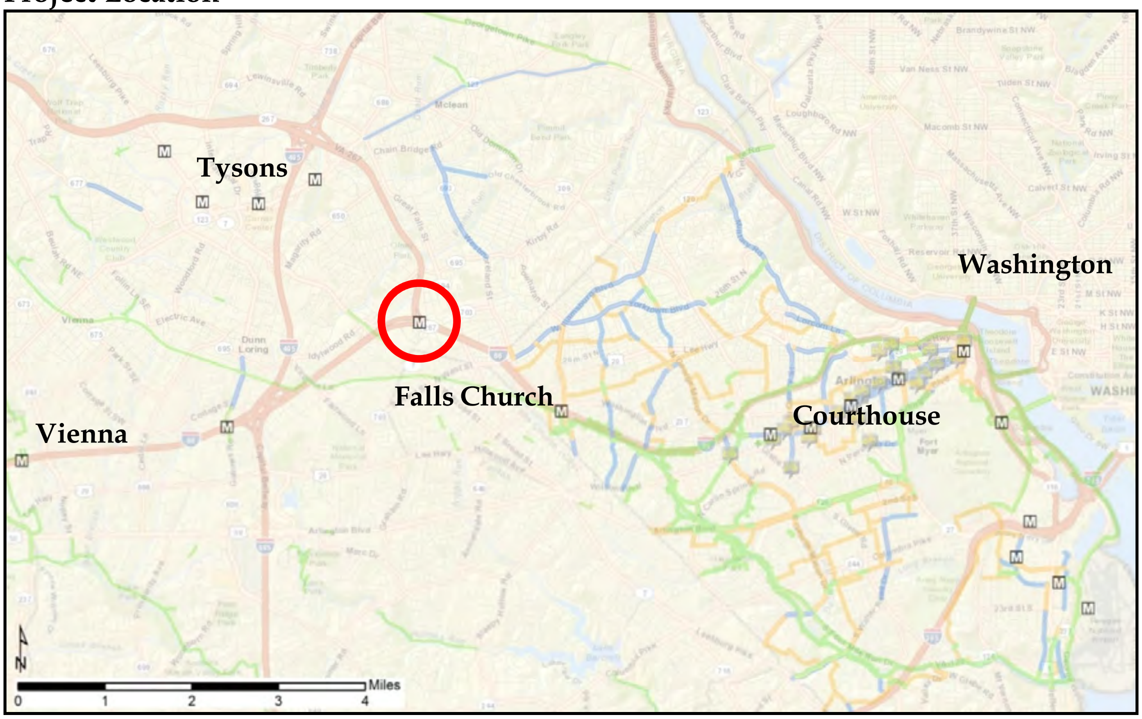
Project Description: This project will construct a trail between the West Falls Church Metro station and the Pimmit Hills neighborhood to the northwest. The project will travel through VDOT and WMATA right-of-way. This project also would entail new wayfinding and bicycle parking on the north side of Metrorail station.

2040 Shared Use Path LOS without Improvement: N/A

2040 Shared Use Path LOS with Improvement: A

Project Cost Estimate: $1,500,000

Project Location

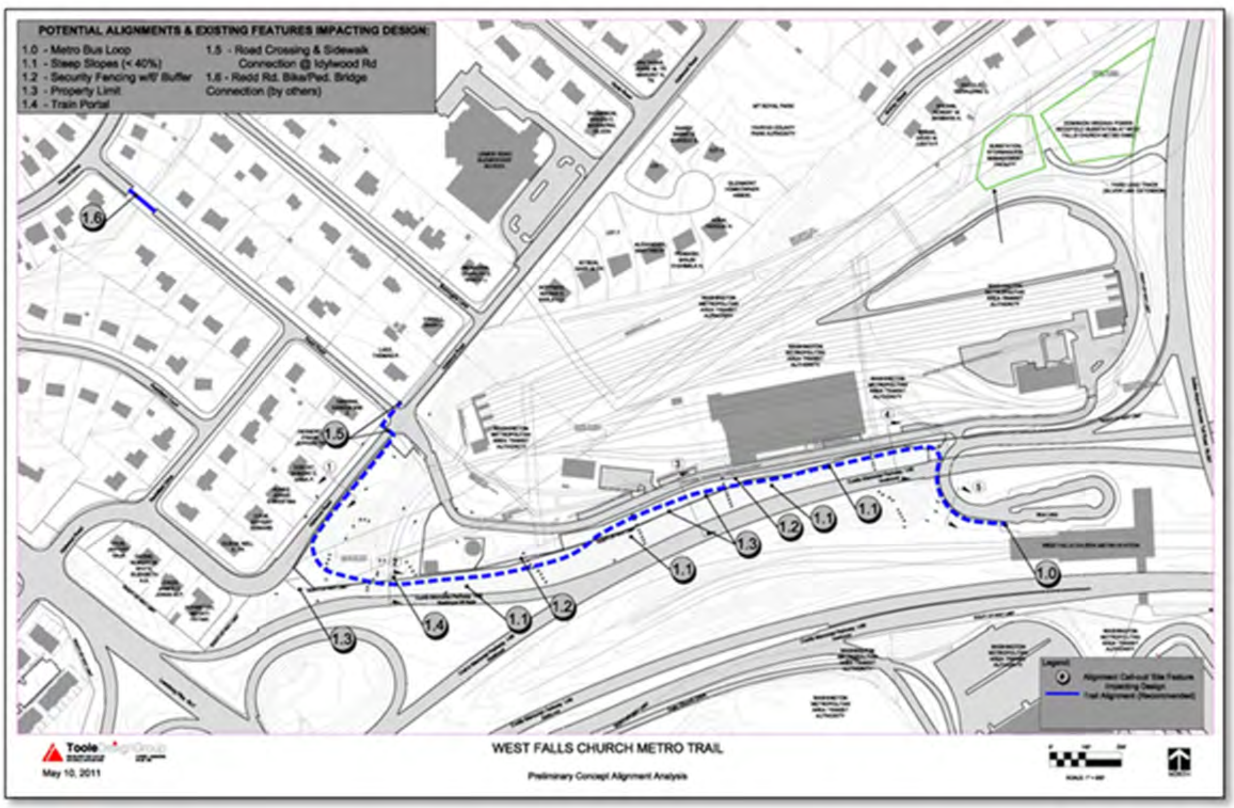


Statement of Regional Benefit

Currently, bicycle and pedestrian access from the West Falls Church Metro station to the adjacent Pimmit Hills neighborhood is inconvenient and uncomfortable for many cyclists and pedestrians. The only direct route is Leesburg Pike (VA 7), which has a substandard sidewalk with a minimal buffer and little separation from a four-lane, relatively high-speed road. The crossings of I-66 on- and off-ramps are particularly challenging for bicyclists and pedestrians.

This project would construct a trail from the north side of the West Falls Church Metro station bus loop underneath I-66, running to the west of the Metrorail yard and joining Idylwood Road. The project also would include new bicycle parking in the bus loop area.

This connection has the potential to improve access to the Metro station from the north and provide convenient access to new bicycle facilities along VA 7 discussed in Project 52 that enable bicyclists to easily reach Tysons Corner to the northwest or the W&OD Trail to the southeast.



Project Photo

VDOT right-of-way from WMATA service drive. Photo credit: Toole Design Group.

Key Considerations

There are significant topography and right-of-way issues to construction of the trail that will increase the cost of completion as a result of needed grading, retaining walls, and other infrastructure. WMATA has expressed some concern about the security of their rail yard with increased public access in the vicinity. Fencing of the trail similar to other trails located along I-66 may be warranted.

Some neighbors have expressed concern about the connection due to the potential for increased foot traffic, and commuters parking in the neighborhood.

Next Steps in Moving Project Forward

Conceptual design was completed for this project by Toole Design Group for WMATA in 2011. The next step needed to implement this project is to develop more refined design drawings, perform a survey, examine ownership of the proposed alignment, and gain permissions from VDOT and other property owners for construction of the facility. Further outreach to neighbors of both the connector trail also would be conducted, emphasizing the benefits of improved access to Metrorail.

C.7 VA 7 Falls Church to Tysons Connector

Project ID: 52

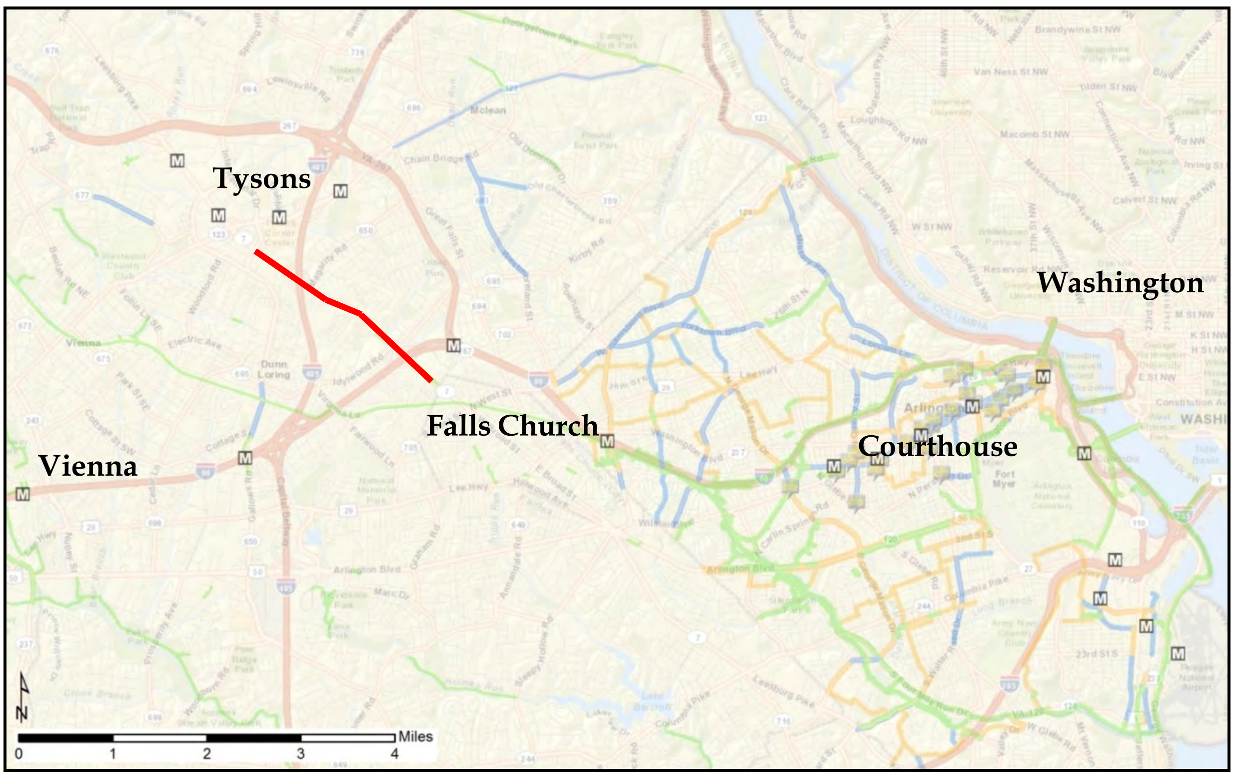
Project Description: This project will construct an off-road connection between the W&OD Trail in Falls Church and International Drive in Tysons Corner, running parallel to VA 7 (Leesburg Pike), and enabling a connection to planned bicycle facilities in Tysons. Shorter-term improvements may use existing frontage roads to expedite initial implementation.

2040 Shared Use Path LOS without Improvement: D

2040 Shared Use Path LOS with Improvement: B

Project Cost Estimate: $1,043,000

Project Location



Statement of Regional Benefit

The project will significantly improve connectivity between major regional destinations (Tysons Corner, Falls Church) and existing facilities for nonmotorized traffic (W&OD Trail) and is part of the Fairfax County Bicycle Master Plan. VA 7 has many destinations fronting this arterial corridor, but there are no parallel roads that offer similar access in this segment. The sidewalks, sidepaths, and service roads in existence today are discontinuous, narrow, and not configured effectively for bicycle access. Demand for such a facility will increase greatly in the coming years as Tysons Corner is redeveloped with thousands more residential units and square feet of commercial space.

The project will greatly enhance bicyclist and pedestrian safety and comfort traveling between these two destinations. The separated nature of the connector will reduce conflicts with motor vehicles. The Fairfax County Bicycle Master Plan recommends utilizing segments of existing frontage roads, coupled with signage and pavement markings, in the short term to expedite project implementation.

Project Photo

Photo illustrates typical conditions found along much of corridor. Note the relatively narrow sidewalk. The frontage roads paralleling VA 7 (Leesburg Pike) may be retrofitted for enhanced bicycle accommodation. Photo credit: Toole Design Group.

Key Considerations

As noted earlier, direct, convenient, and logical connections require using roads that have poor bicycling conditions today. Choosing this alignment presents significant topography and right-of-way issues to construction of the connector. The choice of the VA 7 corridor also necessitates an off-road, separated facility owing to traffic volumes and speeds that would make an on-road facility uncomfortable for bicyclists. Even with the off-street facility, the frequency and volume of usage of cross streets and driveways should be considered when choosing an alignment and facility type along segments of the corridor.

Perhaps the largest issues will be faced in designing appropriate and safe crossings of the two major Interstate interchanges at I-66 and I-495 (Capital Beltway). Careful consideration will have to be made for safe pedestrian and cyclist crossing of highway on- and off-ramps where motor vehicle traffic is often heavy and at or approaching highway speeds. The recently reconstructed overpass at the Beltway likely provides sufficient space for bicyclists and pedestrians on the sidewalk, but the underpass at I-66 should be evaluated for maintenance, sidewalk width, and the presence of signage and paint indicating pedestrian and bicyclist crossing at on- and off-ramps.

This project will need to be coordinated one project in the 2012 CLRP; VA 7 between the Dulles Toll Road and I-495 is planned to be widened to eight lanes with a project completion date of 2025. Additionally, there is a recently proposed addition to the CLRP that would widen VA 7 from four lanes to six between I-495 and I-66, with a project completion date of 2035.

Next Steps in Moving Project Forward

A feasibility study should examine opportunities on both the north and south sides of VA 7. This should include an assessment of available right-of-way, potential demand either side of the road, connections to existing and planned bicycle infrastructure, and interaction with planned developments in Tysons Corner.

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