National Capital Region Transportation Planning Board

Evaluating a Network of Variably Priced Lanes for the Washington Metropolitan Region

Draft for Discussion, December 5, 2007

FUNDED UNDER A GRANT FROM THE FEDERAL HIGHWAY ADMINISTRATION'S VALUE PRICING PILOT PROGRAM

Preface

In this study of the potential for value pricing in the Washington region, several different scenarios for adding new priced highway lanes, pricing existing highways, and enhancing bus services are analyzed and discussed. Prior to reviewing this work, it is appropriate to recognize that the idea of variably priced road facilities with enhanced bus services for the Washington region is not new: in 1959, Professor William Vickrey of Columbia University presented a statement to the Joint Committee on Washington Metropolitan Problems of the US Congress which advocated just such a set of policies. Professor Vickrey's presentation was subsequently published in 1994 in two articles (one in the Journal of Urban Economics, and one in Logistics and Transportation Review) in order to "rescue it from obscurity" and recognize it to be of "considerable historical interest in the context of urban economic transport theory and policy." In 1996, Professor Vickrey received the Nobel Price in Economics for this and other pioneering work on pricing.

Some selected quotations from Professor Vickrey's 1959 presentation to Congress provide an excellent starting point and context for the work reported in this study:

> *"Under urban conditions we cannot have both free flowing rush hour traffic and the absence of user charges or other constraints on highway use. One or the other of these desiderata must yield."*[1]
>
> *"Recent technological developments in electronics have placed within reach and within reasonable cost the possibility of assessing against the users of metropolitan streets and highways a set of charges that can be tailored about as closely to the costs occasioned by the actual usage as these costs themselves can be estimated. This can be done without interrupting or even slowing the flow of traffic, and at a cost that will be minute compared to the savings produced in inducing a more economical and less congested pattern of traffic flow and a more economical apportionment of traffic between the various available modes of transportation. It would, moreover, go far toward solving the financial problems associated with the provision of the expensive facilities required to provide adequate transportation in a modern metropolis".*[2]
>
> *"Pricing of highway use will thus make it possible to provide at reasonable cost uncongested and speedy transportation anytime, anywhere, and for anyone for whom the occasion is sufficiently urgent to warrant the payment of the corresponding charge. Without pricing, it is*

[1] Vickrey, William, "Reaching an Economic Balance Between Mass Transit and Provision for Individual Automobile Traffic (1959)", Logistics and Transportation Review, 1994

[2] Vickrey, William, "Statement to the Joint Committee on Washington, DC Metropolitan Problems (1959)", Journal of Urban Economics **36**, 42-65, 1994

very likely that during the rush hours this degree of freedom of movement would not be available to anyone at any price."[3]

"It is accordingly of the utmost importance, in evaluating plans for traffic facilities, to consider the various ways by which their use may be suitably controlled."[4]

Almost fifty years later, we now take up again the basic principles enunciated by Professor Vickrey and many other distinguished economists, planners and engineers, and present them for public consideration in a new context.

[3] Vickrey, William, "Statement to the Joint Committee on Washington, DC Metropolitan Problems (1959)", Journal of Urban Economics **36**, 42-65, 1994

[4] Ibid

1 Executive Summary

To be prepared upon completion of the remainder of this document.

2 Introduction & Background

Under a grant from the Federal Highway Administration's Value Pricing Pilot Program, the National Capital Region Transportation Planning Board (TPB) has undertaken a study to evaluate a regional network of variably priced lanes. Since 2003, the TPB has made substantial progress in examining such a network through a variety of efforts including: hosting a value pricing conference; the establishment of a TPB value pricing task force; the adoption of goals for a regional system of variably priced lanes; and the inclusion of three major variably priced projects in the constrained long-range regional transportation plan (CLRP).

The Virginia Department of Transportation (VDOT) has embraced the concept of High-Occupancy/Toll (HOT) lanes and, as described below, is actively working towards implementing two HOT lane projects. Virginia's HOT lanes will allow free use to transit vehicles and high-occupancy vehicles with three or more occupants (HOV-3). The Maryland and District Departments of Transportation (MDOT and DDOT) have adopted the concept of Express Toll Lanes (ETLs). Unlike HOT Lanes, ETLs require all those wishing to use the lane to pay the toll. This paper uses the term "variably priced lanes" (VPLs) to refer to both HOT Lanes and ETLs.

In 2003, the TPB's Task Force on Value Pricing for Transportation created a starting-point value pricing scenario: an extensive network of new value priced lanes throughout the region. The Value Pricing Pilot Program grant has allowed extensive analysis of this large network, as well as the creation of other scenarios that pare back portions of the large network and toll some existing roads and facilities.

This study has evaluated the potential benefits and performance of a regional network of variably priced lanes. Tasks performed include:

- Scenario Development: development and refinement of three variably priced lanes scenarios.
- Scenario Analysis: assessment of potential demand and revenue; potential costs; viability of transit; measures of effectiveness; land use impacts; and connectivity to the regional core and activity clusters.
- Assessment of Impacts of Pricing Scenarios on Different Populations: A study of how the pricing scenarios may impact traditionally transportation-disadvantaged groups, including low-income populations, minorities and persons with disabilities.

This is the final report of the study of a regional network of variably priced lanes. In the following chapters, the study methodology and study results are described, as well as other areas for future research.

2.1 About the Transportation Planning Board

The National Capital Region Transportation Planning Board (TPB) is the Metropolitan Planning Organization (MPO) for the Washington metropolitan region. As an MPO, the TPB is responsible for coordinating transportation planning at the regional level and developing the long-range (20 to 25 year) financially constrained transportation plan for the Washington region. A map of the TPB Planning Area is displayed in Figure 1.The TPB brings together key decision makers to coordinate planning and funding for the region's transportation system.

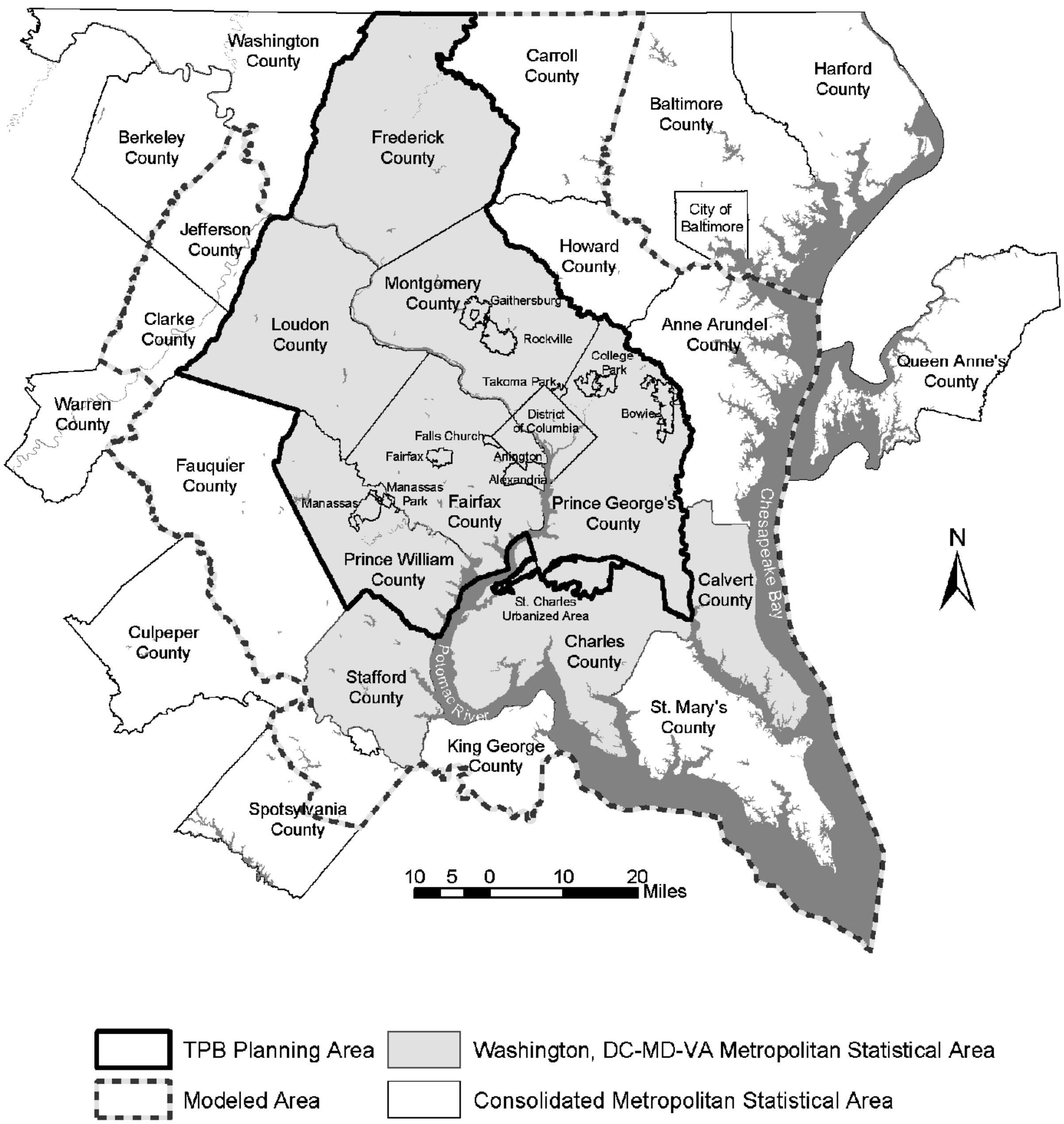

Figure 1: Transportation Planning Board Planning Area and Member Jurisdictions

Members of the TPB include representatives of local governments, the Maryland, Virginia, and District of Columbia departments of transportation, the Washington Metropolitan Area Transit Authority (WMATA), the Maryland and Virginia General

Assemblies, and non-voting members from the Metropolitan Washington Airports Authority and federal agencies.

2.2 Value Pricing Policy and Planning Activities

2.2.1 June 2003, Regional Value Pricing Conference

In June 2003, the TPB in conjunction with the Federal Highway Administration, and the Maryland, Virginia, and District of Columbia departments of transportation jointly sponsored a successful one-day conference on value pricing for transportation in the Washington region. 200 people attended the conference, including numerous local elected officials who spoke in support of value pricing. The conference was one of the region's first major public discussions regarding the need and opportunities for innovative transportation pricing strategies. News coverage of the event headlined on the front page of the Washington Post's Metro section: "Toll Lanes' Concept Catching On: Conference Looks at Pricing."

2.2.2 Fall 2003, Establishment of Value Pricing Task Force

After the value pricing conference, the TPB created a "Task Force on Value Pricing" to examine how value pricing could benefit the Washington region. The goals of the Task Force include the development of recommendations for the TPB regarding parameters, principles, guidelines and lessons learned with regard to the regional implications of value pricing.

The task force currently includes the following members:

Chair: Christopher Zimmerman – Arlington County
JoAnne Sorenson – Virginia Department of Transportation (VDOT)
Catherine Hudgins – Fairfax County Board of Supervisors
Sam Minnitte – Maryland Department of Transportation (MDOT)
Michael Knapp – Montgomery County Council
Phil Mendelson – District of Columbia Council

The task force adopted regional goals for variably-priced projects in the region in April of 2005. These goals, shown below in the Appendix, act as a guide for the development and evaluation of regional variably priced lane scenarios.

2.2.3 Value Pricing Studies

Fall 2005 to Fall 2006, Assisting VDOT in Analyzing Key Corridors

The TPB has provided technical assistance in the studies of the two VDOT variably priced projects described below. Through these analyses, performed under a technical assistance contract with VDOT, TPB staff estimated potential demand and toll revenue for the HOT Lane projects.

Fall 2006, Sensitivity Analysis of Enhanced Transit

Sensitivity tests were conducted using the network components created for the VDOT technical assistance studies. The goal of this analysis was to determine how enhanced transit service might impact the VPL network.

The test involved transit services that use the Virginia VPL corridors described above: the I-95/395 and the Capital Beltway HOT lane projects. The primary interest of the test was to determine the scale and direction of a collection of measures of effectiveness for increasing transit services on the VPL network. The 2006 CLRP contains many transit enhancements to be put in place by 2030 along the selected corridors. Those transit enhancements were moved forward in time to a 2010 network and integrated with existing and planned transit services. The headways on this bundle of transit routes were decreased to a maximum of 15 minutes.

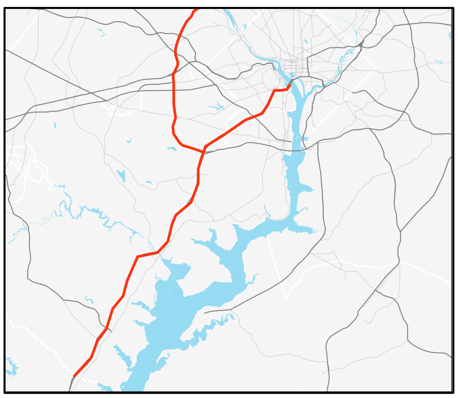

Figure 2: HOT Lane network used for transit sensitivity analysis, Fall 2006.

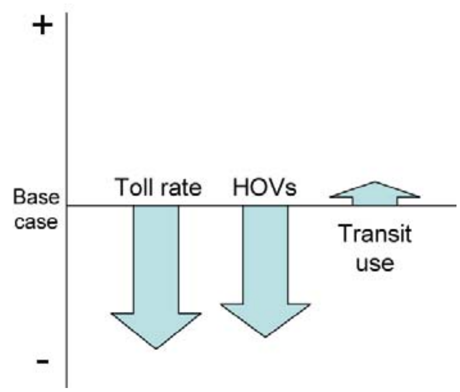

Figure 3: General impacts of increased transit service, from Fall 2006 sensitivity analysis.

This sensitivity test resulted in the following changes in the travel demand model output:

- Transit use increased along the corridors.
- HOV use decreased along the corridors.
    - Presumably, many of these HOV users switched to the transit service.
- The toll rates on the tested segments decreased.
- The overall revenue from the toll lanes stayed generally the same.

These results provide encouragement for the possibility of implementing increased transit service along additional corridors in the regional network of variably priced lanes.

The Regional Accessibility and Mobility Study

The TPB initiated the Regional Mobility and Accessibility Scenario Study ("the scenario study") in 2001 to evaluate additional highway and transit options beyond those that are currently funded and to examine the interaction of these transportation options with various land use alternatives. Federal law requires that the CLRP include only transportation projects that can be funded with revenues currently projected to be available over the next 25 years. The scenario study provides the TPB with the opportunity to examine additional facilities that could improve the future performance of the region's transportation system and that have a realistic possibility of being funded with the identification of additional transportation revenues.

Phase 1 of the study, summarized in a final report dated November 17, 2006, included the development and analysis of five alternative land use and transportation scenarios. A sixth scenario, a network of variably priced lanes, was created in 2003 under the scenario study but not analyzed during Phase 1. Instead, the sixth scenario was used as a starting point for a much more extensive evaluation of a variety of pricing scenarios, conducted under the Federal Value Pricing Pilot Program grant

This study of networks of variably priced lanes and associated transit and land use analyses will inform Phase 2 of the scenario study and may result in one or more second generation scenarios under the guidance of the new TPB Scenario Study Task Force.

2.2.4 The Future of Value Pricing in the Washington Region

2.3 2007 Value Pricing Projects

As of the release of this document, the region's financially Constrained Long-Range Transportation Plan (CLRP) will include three variably priced toll facilities: the Intercounty Connector, the Northern Virginia Capital Beltway HOT Lanes project, and the I-95/395 HOT Lanes project.

The Intercounty Connector is an 18-mile east-west highway in Montgomery and Prince George's counties in Maryland that will run between I-270 and I-95/US 1. The project will include six variably-priced lanes with express bus service connecting to Metrorail stations. This project was included in the CLRP in 2004, and construction is expected to begin in 2008.

The Northern Virginia Capital Beltway HOT lane project will add four new HOT lanes to a 15-mile segment of the Capital Beltway (I-495). Vehicles with three or more occupants, as well as transit buses and emergency response vehicles will be able to use the lanes for free; all other vehicles will pay a toll that varies according to the time of day. This project was added to the CLRP in 2005, completion is expected by 2012.

The I-95/395 HOT lane project in Virginia was included in the CLRP in 2007. This project will reconfigure the existing HOV facility between Eads Street in Arlington County and just south of the Town of Dumfries from 2 to 3 lanes, and convert those lanes to HOT lanes. The project also includes the construction of a nine-mile taper lane to ease congestion as the HOT lane traffic merges back into the general purpose lanes. Completion of this project is expected by 2010.

A map showing the variably priced facilities currently planned is presented in Figure 4.

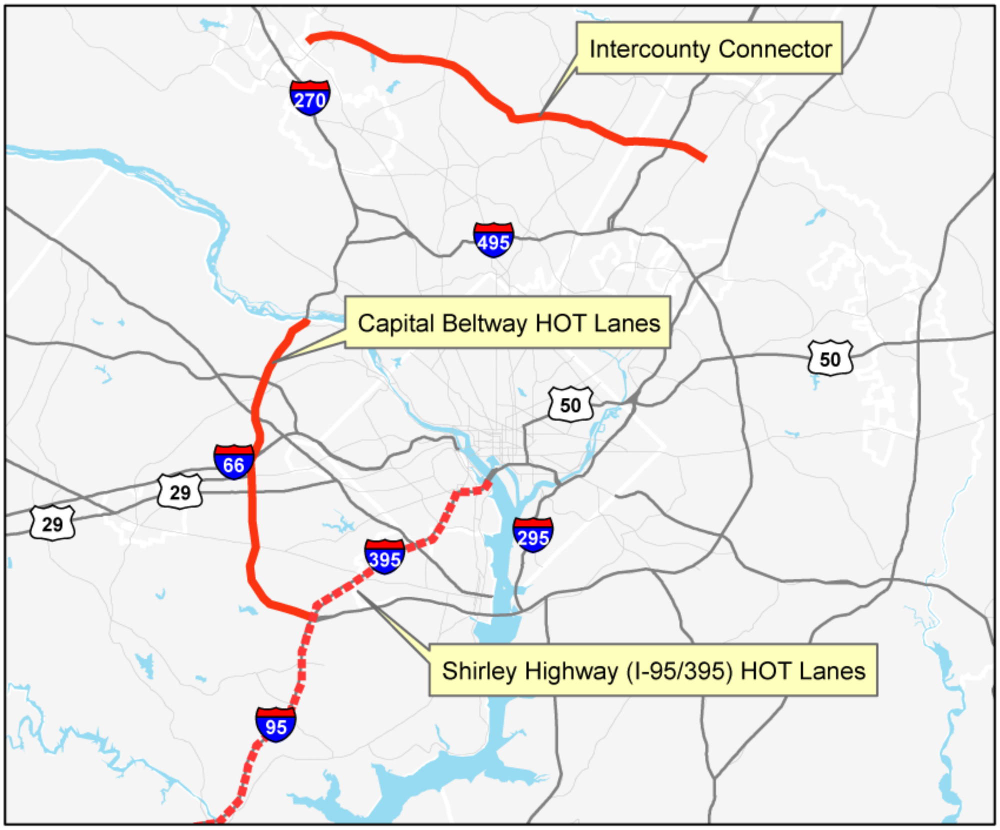

Figure 4: Value pricing projects in the 2006 CLRP as planned projects (solid lines) or studies (dashed line).

2.4 Current and Projected System Performance

2.4.1 Current highway congestion, 2005 Skycomp Report

The TPB regularly commissions monitoring of regional freeway congestion. Skycomp, an aerial freeway monitoring company, has been performing traffic congestion surveys of the TPB planning area's 300-mile highway network every 3 years since 1995.

> During this aerial survey program, overlapping photographic coverage was obtained for each designated highway, repeated once an hour over four morning and four evening commute periods. The morning times of coverage were 6:00-9:00 a.m. outside the Capital Beltway and 6:30-9:30 a.m. inside the Capital Beltway. The evening times were 4:00-7:00 p.m. inside the Capital Beltway and 4:30-7:30 p.m. outside the Capital Beltway. Survey flights were conducted on weekdays, excluding Monday mornings, Friday evenings and mornings after holidays. Data were extracted from the aerial photographs to measure average recurring daily traffic conditions by link and by time period.[5]

The most recent mobility monitoring report was completed in 2005.

Top Ten list of congested facilities

Based on the 2005 Skycomp report data, a list of the top ten most congested facilities in the TPB planning area was generated. A map of these facilities is displayed in Figure 5.

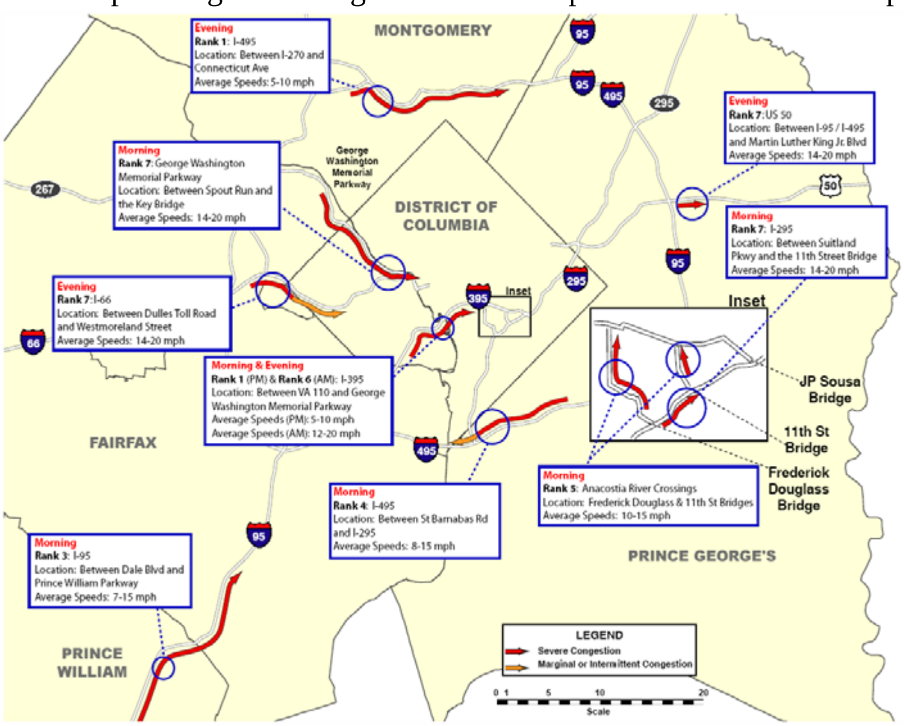

Figure 5: Top Ten Congested Segments on the Regional Freeway System, based on data from the 2005 SKYCOMP Report.

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[5] *Traffic Quality on the Metropolitan Washington Area Freeway System Spring 2005 Report*, February 15, 2005, National Capital Area Transportation Planning Board.

The map in Figure 6, generated from the 2005 Skycomp data, illustrates the average recurring evening peak period congestion throughout the region. According to this slice of the congestion data, the most congested corridors during the afternoon peak period are the following: the northwestern half of the Capital Beltway, I-270 from the Beltway to north of Gaithersburg, I-395 from the District's Southeast-Southwest Freeway to Dumfries, Virginia, and I-66 from the Beltway through the City of Fairfax, Virginia.

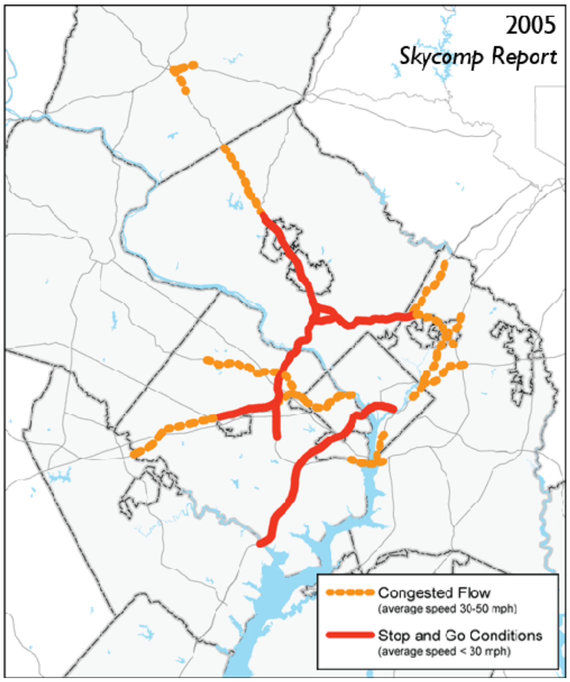

Figure 6: Map of average recurring afternoon peak congestion, based on data from the 2005 Skycomp Regional Traffic Report.

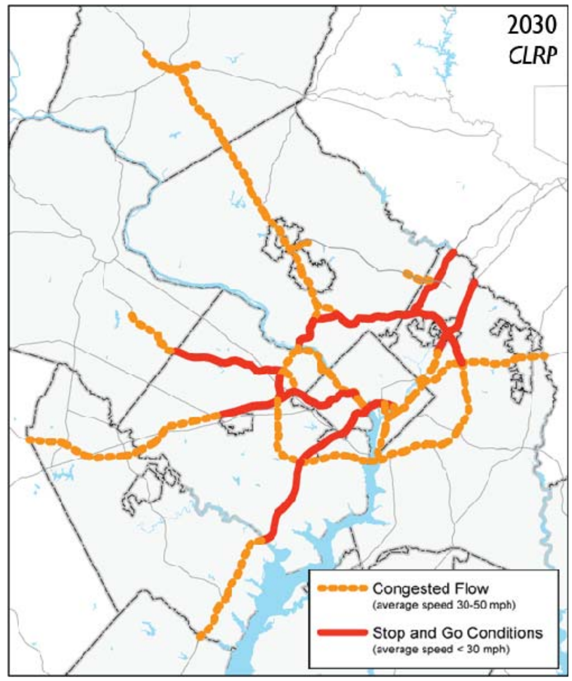

Figure 7: TPB Projection of traffic conditions in 2030 for the 2006 CLRP.

It should be noted that the top ten congested segments have been selected from both the morning and afternoon peak periods, whereas the map in Figure 6 displays afternoon peak period congestion only.   For example, Number 7 on the top-ten list (The George Washington Parkway, northern section, inbound) does not appear in the 2005 afternoon peak congestion map because this facility is only severely congested in the morning peak period.

2.4.2 Projected highway congestion of the 2006 CLRP

A similar map to that displayed in Figure 6 was created to illustrate forecasted conditions in 2030, incorporating currently existing facilities plus those listed in the 2006 CLRP. This map of forecasted congestion is displayed in Figure 7. It should be noted that the 2006 CLRP as pictured in this congestion map includes both the Intercounty Connector (ICC) and Beltway HOT Lane project as described above, but does not contain the Shirley Highway (I-95/395) HOT Lane project, as it was only listed as a study in the 2006 CLRP.

While the 2030 map does illustrate an increase of congestion from 2005, there are some areas where congestion has decreased. One such area is the Virginia portion of the Capital Beltway between the Shirley Highway (I-95/395) and the American Legion Bridge. The majority of this section shows an improvement over 2005 congestion levels, most likely attributed to the addition of the HOT lanes (two in each direction) along this segment. It should be noted, however, that despite the additional capacity included in the 2006 CLRP, the segment of the Capital Beltway between I-66 and the Dulles Toll Road is still listed as “stop and go conditions.”

Another facility that shows reduced congestion is I-270, where severe congestion along the corridor between the Capital Beltway and Gaithersburg is projected to reduce in severity. This decrease in congestion coincides with the addition of new capacity planned to be added to the I-270 corridor. The 2006 CLRP contains three projects along this corridor: the widening of I-270 through Gaithersburg and Rockville (planned for 2025); the addition of HOV lanes between Gaithersburg and Frederick (planned for 2020); and the Corridor Cities Transitway, which will extend transit service from the end of the Metrorail Red Line at Shady Grove along the I-270 Corridor (planned in two phases, 2012 and 2020).

However, the performance of many facilities is projected to worsen. These worsening facilities include the Dulles Toll Road from the Loudon County line to the Capital Beltway, I-66 from the Beltway to the Roosevelt Bridge, I-95 in Maryland and the Baltimore-Washington Parkway. It should also be noted that the projections for 2030 show the entire Capital Beltway experiencing some level of congestion during the evening rush hours.

2.5 Travel Demand Methodology

The Regional Value Pricing Study is based upon previous value pricing analysis work performed by TPB staff under the direction of the TPB Task Force on Value Pricing for Transportation. The key assumptions which were used for this study include the following:

2.5.1 Study Assumptions

- All scenarios are for the year 2030, and all toll values and revenue calculations are in 2010-dollars.
- Variable tolls will be used on the lanes to prevent congestion and maintain freely flowing traffic.
- Occupancy requirements for all HOV lanes will be increased to at least three people or more, based on planning assumptions in the region’s long-range plan.
- The variably priced facilities will be physically separated from the other lanes, where possible.

- Access and egress points will be primarily focused around the regional activity clusters[6].
- At least one variably priced lane will be provided in the peak direction.

2.5.2 Technical Methods

Travel Demand Model

This study utilizes the TPB regional travel demand model to forecast the demand and performance characteristics of a network of variably priced lanes for a series of scenarios. The model represents the region's jobs and households with over 2000 transportation analysis zones (TAZs), and includes tens of thousands of links in highway and transit networks. Each model run takes approximately 16 hours of computer processor time.

Analysis of a scenario involves two full model runs, with one run of an external toll search routine in between:

- First, the base tolls are set ($0.20 per mile) and a "pump prime" model run is performed to pre-load the network and determine traffic volume levels with the base toll.
- Next, an external toll update algorithm evaluates the demand on the toll lanes. For those toll lanes that show congestion with the base tolls, the tolls are raised and the demand on the toll lanes is again assessed. This process continues until the toll lanes are "free flowing."
    - Free flow is determined by using volume-to-capacity (V/C) ratios. Most types of facilities in the TPB model exhibit very low speeds when operating at maximum capacity. Therefore, it is important to find a compromise between high speeds and high flows. Different roads have different characteristics, design speeds, vehicles-per-hour capacities, etc. The V/C ratio, which compares a facility's operating volume to its design capacity, provides a good measure of how well any road is performing regardless of the type of facility. A V/C ratio range of from 0.6 to 0.8 was selected as the one which best finds the compromise between high speeds and high flows.
- Finally the toll rates in the model are updated to the toll rates determined by the toll update algorithm, and the four-step model is rerun, gathering impacts of the tolls on trip distribution, route selection and mode choice. This process is illustrated in Figure 8.

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[6] COG and TPB adopted regional activity centers and clusters to help guide regional transportation planning decision-making, The 58 Centers are based on local government growth forecasts and categorized according to similar employment, residential, and growth pattern characteristics. The 24 Clusters tend to be groupings of Centers and are a more conceptual, stylized depiction of development than the Centers. The activity clusters are shown in many of the maps below, beginning with the map of Scenario A in Figure 11.

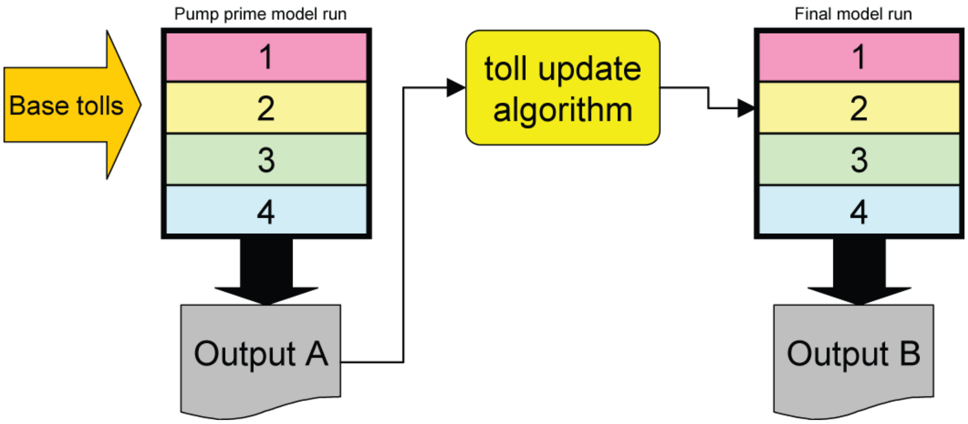

Figure 8: An external toll update algorithm is used to determine the tolls on the value priced network. This algorithm operates on the output of an initial travel demand model run, and the new tolls are fed back into a second model run.

Traditional analyses that estimate the potential demand for a new toll road use the diversion curve method for predicting the demand for the value priced lanes throughout the region. However, the TPB analysis has employed a technique which converts the toll penalties to equivalent time penalties based on a traveler's willingness to pay. These additional time penalties are then added to the individual links during the four-step travel demand modeling process. The TPB travel demand model used for this analysis (Version 2.1 D #50[7]) incorporates four different income categories, each with unique values of time for peak and off-peak periods. These income categories and values-of-time impact how the VPL tolls are to be translated to time-penalties for the different income groups.

Figure 9 displays the different values of time used for the four household income group quartiles. The income groups and the equivalent value of time for peak and off-peak travel are documented in the COG/TPB Travel Forecasting Model User's Guide of Version 2.1D#50 model, pages 2-3 to 2-9.

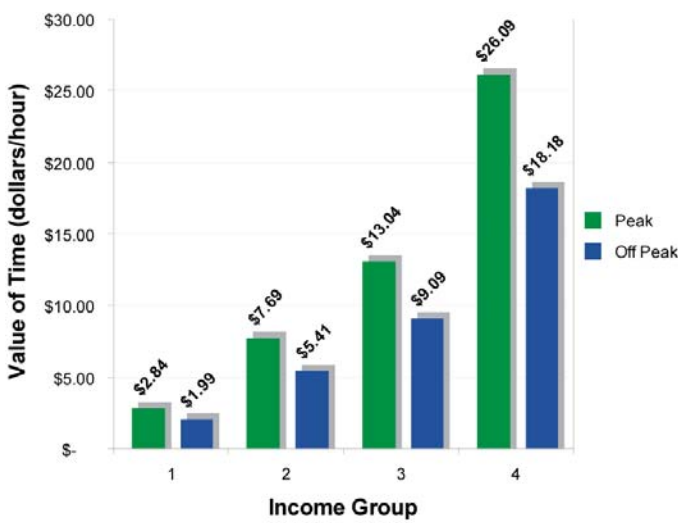

Figure 9: Income groups and corresponding values of time used in the TPB models and analyses.

It should be noted that the cooperative forecasting process used to specify the future numbers and locations of jobs and households does not produce future distributions of household income. Income data, as well as other demographic data, is from the 2000 Census.

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[7] Documentation for this model is available for purchase or download on the MWCOG/TPB website: http://www.mwcog.org/store/item.asp?PUBLICATION_ID=207

Incorporation of Tolls in the Travel Demand Model

Tolls are incorporated into the travel demand model in two of the four steps: trip distribution and trip assignment. Tolls are indirectly reflected in the third step, mode choice.

Trip Distribution: During trip distribution, the average travel time by mode is calculated between each pair of transportation analysis zones (TAZs). These travel times are used to determine the number of trips distributed to each pairing of zones.

Each of the 2200 TAZs has an average income associated with it. This average income falls into one of the four income categories described above, each of which has a different value of time for travel during peak and off-peak periods. A value of time is associated with each TAZ based on its average income. This value of time is used during the calculation of the time-penalty for using tolled facilities from each TAZ to every other TAZ. This time penalty is added to the travel time calculations during trip distribution, when the travel times between TAZs are calculated.

Example: The travel time from TAZ *a* to TAZ *b* is 55 minutes using the general purpose lanes and 35 minutes using the value priced lanes. Based on the average income of TAZ *a*, the tolls incurred on the value priced lanes translate to an additional 10 minutes of travel time, resulting in a 45 minute effective travel time from *a* to *b* using the value priced network. The lowest effective travel time from *a* to *b*, in this case 45 minutes, is then used as the auto travel time for the trip distribution process.

Mode Choice: As mentioned above, tolls do not directly impact the mode choice step. Effective travel times between zones change due to new tolled lanes (new capacity decreasing auto travel times) or new tolls on existing roads (new tolls increasing effective auto travel times). These changes in travel times then impact the mode choice, making transit more or less favorable. It should be noted that both scenarios described above should decrease travel time for bus transit, and therefore transit travel times would change as well. The new travel times per mode are then evaluated during the mode choice step of the four-step model.

Example: The effective travel times from TAZ *a* to TAZ *b* was 70 minutes before the VPLs were put in place. Bus travel time between the zones was 80 minutes. After the VPLs were opened, the travel times between TAZ *a* and TAZ *b* are 55 minutes and 45 minutes by general purpose lanes and value priced lanes, respectively. Additionally, because the bus can use the VPLs from TAZ *a* to TAZ *b*, the new transit travel time between these nodes is 50 minutes. In this example, the VPLs have made transit more favorable relative to driving in the general purpose lanes, and would increase transit's mode share.

Trip Assignment: During assignment, auto trips are assigned to routes based on travel times. This assignment process takes tolls into account, also using a time-toll penalty. Unlike during trip distribution, where the time-toll penalty is based on average TAZ income, the assignment stage assigns different values of time to different users/modes:

SOV, HOV2, HOV3, truck, airport, etc. This can result in different user types choosing different routes between any two TAZs.

Example: Route *m* from TAZ *z* to TAZ *w* has a base travel time of 35 minutes and uses priced lanes which have a toll of $1.50 for single-occupant vehicles and no toll for HOV3+. Because the different users/modes have different values of time, the effective travel time for route *m* could be 45 minutes for SOVs and 35 minutes for HOV3+. If another route *n* has a lower effective travel time, say 42 minutes, for SOVs from *z* to *w*, those trips will be assigned to route *n* instead of route *m*. Note that at this stage, the average income of TAZ *z* is not directly factored in, but is carried over from trip distribution by the number of trips that wish to go from *z* to *w*.

Sensitivity Testing

Sensitivity tests are conducted by comparing a modified model results with the original baseline model results. For example, the transit sensitivity tests are performed by adding enhanced transit service to the initial model before the “pump prime model run” and then the process continues as specified above. The model outputs are then compared between the baseline model run and the model run with enhanced transit service.

These sensitivity tests are conducted to better understand how a change in the modeled system (transit service, land use, etc.) might influence the system outputs. The specific numerical outputs of the sensitivity tests are less important than the general direction and magnitude of the change. For example, an increase in transit service might greatly increase transit use and person-miles traveled, slightly decrease toll levels and leave toll revenue unchanged.

Measures of Effectiveness (MOEs)

The travel demand model used for this analysis forecasts many outputs describing the utilization and performance characteristics of the system. Regional vehicle-miles traveled (VMT), High-Occupancy Vehicle (HOV) use and transit ridership provide good yard sticks for the performance of the regional system.

Inspection of the performance of individual highway links (such as speeds, volumes and rates of variable tolls) of the transportation network can also be easily accessed and can portray the performance of particular facilities, such as bridges.

Finally, total system revenue is an important measure for the study of a toll lane network. System revenue is estimated in order to determine the financial feasibility of the variably priced network and the possibility of funding remaining to help support transit services operating on the tolled facilities. Estimates of annual system revenue are calculated using the following technique:

- Multiply the average hourly per-link demand for the toll lanes by the average per-link toll rate for each of the three periods (AM peak, PM peak and off peak)
- Calculate the average daily revenue for a workday assuming a 3-hour AM peak, 3-hour PM peak and 18 off peak hours.
- Calculate average daily revenue for a non-workday (weekends and federal holidays), assume 24 off peak hours.

- Multiply the average daily workday revenue by the number of work days (250), and add to the average daily non-workday revenue multiplied by the number of non-work days per year (115).

3 Scenario Development

As described above, a pricing scenario was developed under the scenario study but not analyzed. This scenario, now referred to as Scenario A, was based on the 2006 CLRP for 2030 and included an extensive set of new variably priced lanes throughout the region. This scenario was used as the starting point for further development and analysis of additional pricing scenarios under the Federal Value Pricing Pilot Program grant.

The additional scenarios studied under the grant include variations of Scenario A, including pared-back networks, the pricing of existing facilities and adding enhanced transit.

3.1 Roadmap for the Scenarios

The work performed under the FHWA grant involved creating a series of variably priced network scenarios. A schematic illustrating this scenario development is displayed in Figure 10.

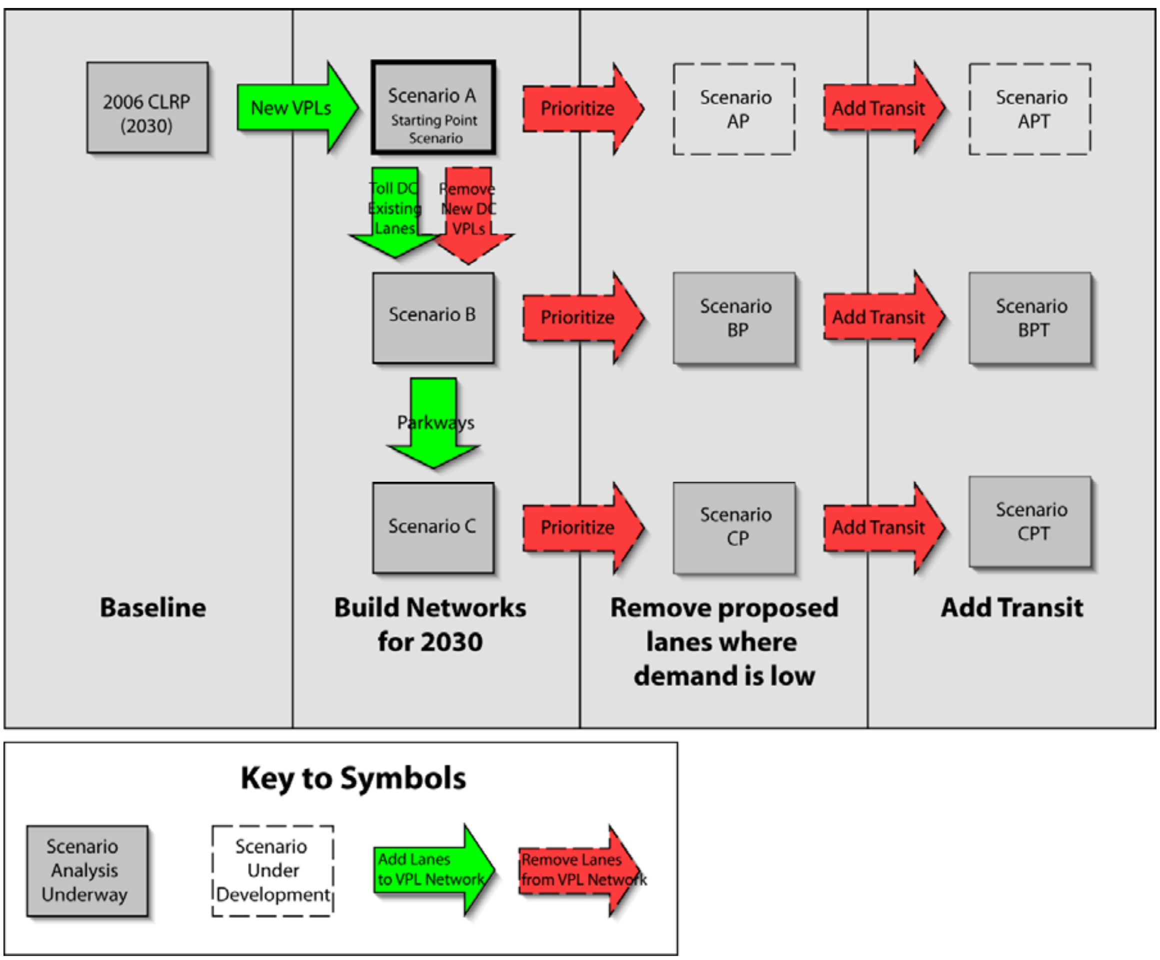

Figure 10: Scenario development flow chart.

In general, the following describes how the scenarios were developed:

1. Scenario A: Add two new toll lanes to each direction of every freeway in the region. Add one toll lane in each direction to major arterials outside the beltway. This scenario only tolls new capacity.
2. Scenario B: Starting from Scenario A, toll all DC river crossings, remove added VPLs from the District and instead toll all lanes of the freeways. Link tolled freeways with additional tolled facilities. Relieve bottlenecks in the variably priced network outside the beltway by adding additional tolled lanes.
3. Scenario C: In addition to Scenario B, toll the existing parkways in the region.
4. Scenarios AP, BP and CP are prioritized versions of Scenarios A, B and C, where priced lanes are removed based on lack of demand.
5. The enhanced transit scenarios APT, BPT and CPT include enhancements to the transit networks that use the variably priced lanes. APT and BPT include reduced run times and headways on existing (2030) bus routes that can operate on the value priced lanes. CPT includes enhanced and new bus routes that operate on the region's parkways.

These scenarios are described in greater detail in the following sections.

3.2 First Round Scenarios

3.2.1 Scenario A

Scenario A was created using the following rules:

1. All planned or studied variably priced facilities are added to the network.
2. All HOV lanes are converted to VPLs.
    a. This includes HOV lanes that are currently only HOV-restricted in the peak period and direction. These HOV lanes are converted to VPLs with 24/7 operation.
3. All freeways in the region have two VPLs added to them in each direction.
    a. In the case where the freeway had one HOV lane, another VPL is added.
    b. In the case where the facility was entirely HOV during the peak period, no additional lanes were added and the entire facility is variably

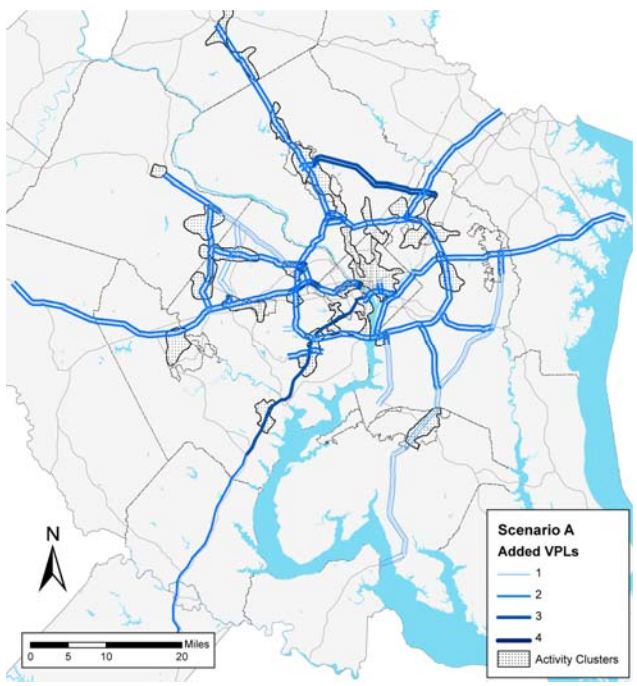

Figure 11: Scenario A, new capacity added to freeways and major arterials outside of the Capital Beltway.

priced.

4. All arterials outside of the beltway have one VPL added in each direction.
5. Tolled facilities that have tolls which can be set by time of day and direction are added to variably priced facilities.

These rules create an 1664-lane-mile regional network of value priced lanes that consists only of new capacity and converted HOV lanes: No existing capacity is tolled in this base scenario. A map of the resulting network is displayed in Figure 11.

3.2.2 Scenario B: Add Additional District of Columbia River Crossings

Relative to Scenario A, Scenario B tolls river crossings in the District of Columbia and removes all new priced capacity from the District and instead tolls existing freeway lanes and other facilities. The development of Scenario B is discussed below.

Scenario B includes the remainder of the District river crossings which were not included in the previous scenario because they are not part of the Interstate Highway system:

- Chain Bridge
- Key Bridge
- Memorial Bridge
- South Capitol Street (Frederick Douglas) Bridge
- Pennsylvania Avenue (John Phillip Sousa) Bridge
- East Capitol Street (Whitney Young Memorial) Bridge
- Benning Road Bridge

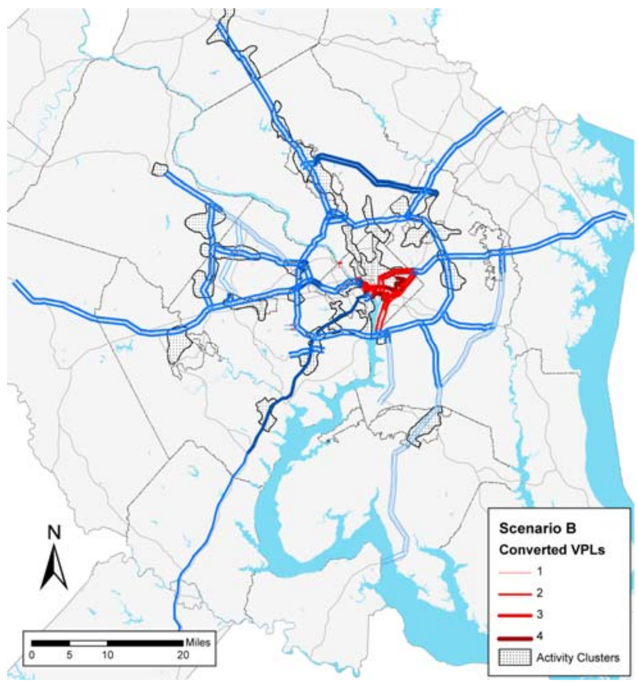

Figure 12: Scenario B includes tolling District of Columbia river crossings and other DC facilities added to Scenario A.

The addition of the bridges to the analysis came at the request of the District Department of Transportation (DDOT). As part of this study, these bridges are added to the regional network without the addition of any new capacity, but instead the existing lanes are tolled.

Additionally, at the request of DDOT, Scenario B removes all new VPL capacity added to the District's roadways in Scenario A and instead tolls the existing capacity on those facilities. This includes I-395 and I-66 through the District, the 14th Street Bridge and the Theodore Roosevelt Bridge. This request was based on the fact that there is very little right-of-way for adding new lanes within the heavily urbanized District.

Scenario B also tolls other existing facilities in the District in an effort to add connectivity between the disconnected ends of freeways that terminate in the District. I-395 in the District is connected to US-50 by tolling New York Avenue from the District line to its intersection with I-395 at 4th St NW. The Arlington Memorial Bridge is connected to the Southeast/Southwest freeway (I-395) by tolling portions of the Rock Creek and Potomac Parkway, Independence Ave. SW and Maine Ave. SW

Finally, Scenario B attempts to alleviate chokepoints where freeway VPLs intersect with arterial VPLs outside the District. At these interchanges, VPL traffic from each direction of the freeway attempts to exit to the arterial in the same direction, causing congestion and extremely high tolls in Scenario A. In Scenario B, these locations have additional VPLs added to the arterial to provide relief from this congestion. The chokepoints addressed using this technique are as follows:

- Fairfax County Parkway northbound and southbound at the Dulles Toll Road (VA-267)
- Braddock Road westbound at the Capital Beltway (I-495)
- Indian Head Parkway (MD-210) southbound at the Capital Beltway (I-495)

The changes to the value priced network in Scenario B increase the size of the network to 1758-lane-miles. The changes to the network are illustrated in red in Figure 12.

3.2.3 Scenario C: Add Parkways

Scenario C adds the parkways throughout the region to the network. The parkways are under the jurisdiction of the National Park Service. The parkways listed below were added to the value priced regional network without the addition of new capacity, with tolls added to the existing lanes:

- The Baltimore Washington Parkway (MD-295)
- The George Washington Parkway
- The Rock Creek and Potomac Parkway
- The Clara Barton Parkway
- The Suitland Parkway

The additional facilities added in Scenario C are illustrated in green in Figure 13. Figure 14 displays a close-up view of the Scenario C value priced facilities in the regional core. (Figures will be updated to show Suitland Parkway.) Scenario C results in a 1979-lane-mile regional value priced network.

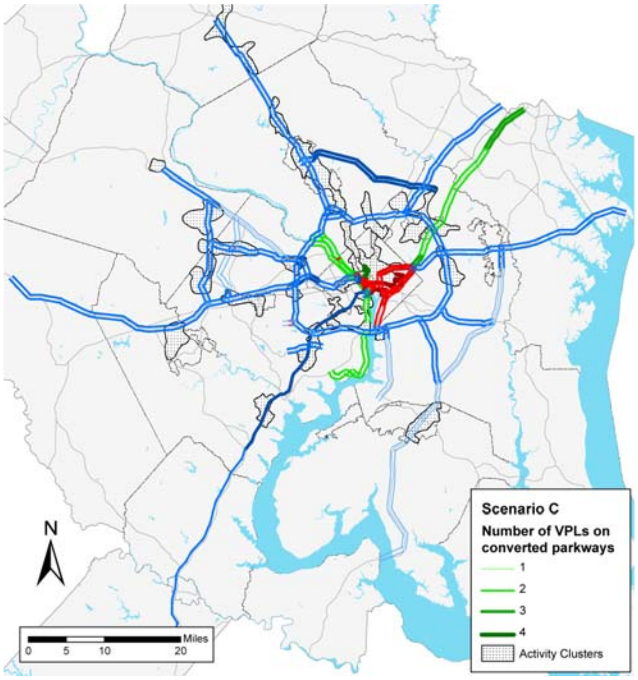

Figure 13: Scenario C: Regional parkways added to Scenario B.

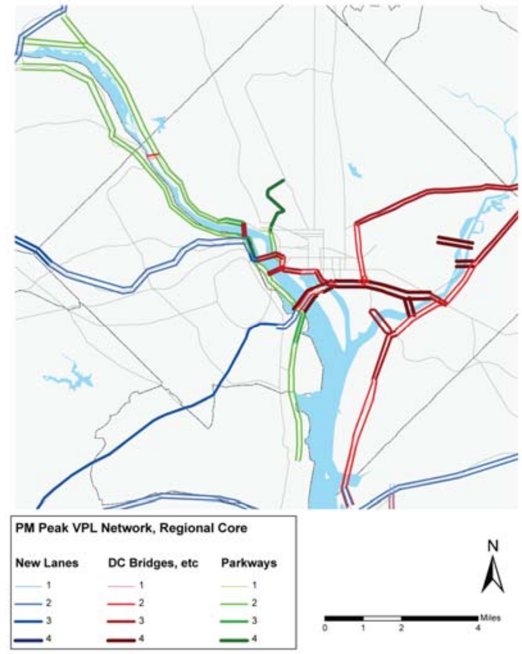

Figure 14: Zoom view of scenario C variably priced network.

3.3 *Prioritized Scenarios*

3.3.1 Scenario AP: Prioritizing from Scenario A

The AP scenario is currently under development.

3.3.2 Scenario BP: Prioritizing from Scenario B

Scenario BP was developed by paring back Scenario B. Segments with high toll rates in the peak direction but low or base tolls in the opposite direction were changed to directional toll lanes. (For example, US-50 from Annapolis to US-301) Segments with low toll rates in both directions were removed from the network. (US-301) This resulted in the variably priced network illustrated in Figure 15.

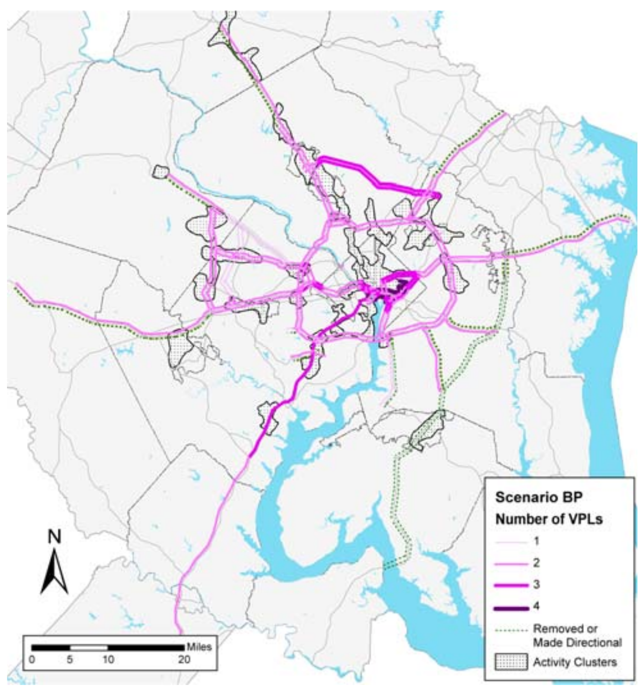

Figure 15: Scenario BP removes links with low demand (shown as dashed lines) from the value priced networks.

3.3.3 Scenario CP: Prioritizing

from Scenario C

Just as Scenario BP was derived from B, Scenario CP was developed by paring back Scenario C. Segments with high toll rates in the peak direction but low or base tolls in the opposite direction were changed to directional toll lanes. Segments with low toll rates in both directions were removed from the network. This resulted in the variably priced network illustrated in Figure 16. All of the lanes excluded from Scenario BP were also excluded from this scenario. Additionally, all of the parkways included in Scenario C had high enough demand to remain in the network.

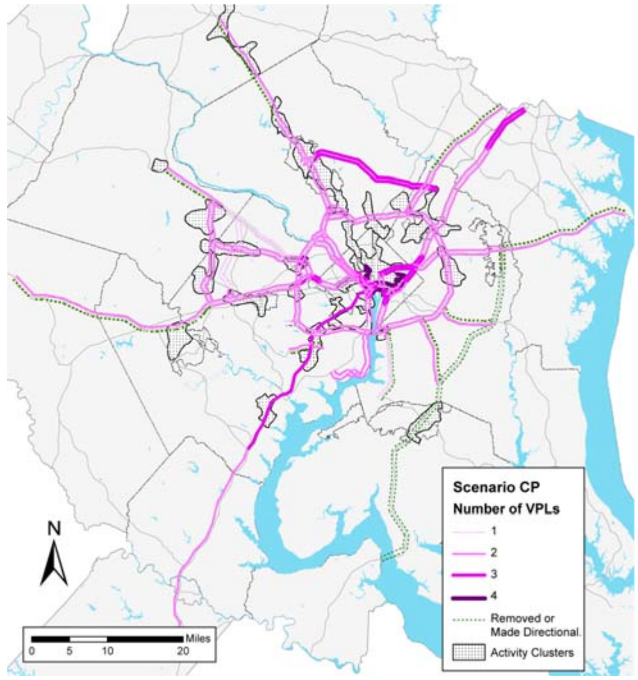

Figure 16: Scenario CP pares back scenario C based on low toll rates.

3.4 Scenarios with Enhanced Transit

This section describes the development of the enhanced transit scenarios. Analysis of the transit scenarios is covered in the next section.

3.4.1 APT

The APT scenario is currently under development.

3.4.2 BPT

The enhanced transit network for scenario BP was created out of the 2006 CLRP (for 2030) bus transit network. All 2030 bus transit routes which traverse the VPL network were recoded to use the VPLs instead of the general use lanes. Both MDOT and VDOT have employed TPB staff in technical aspects of studies of bus transit on the Capital Beltway. These studied Beltway transit routes were also added to the enhanced transit network. Finally, new bus transit routes were added to sections of the VPL network that have neither current nor planned bus transit routes: VA 28 and the Fairfax County Parkway. Bus transit routes were added to the VPLs on these roads between I-66 and VA-7, and include stops at major activity centers.

Next, the planned transit service was enhanced to reflect the benefits of running buses on value priced lanes: increased speeds and increased frequency. All bus routes running on the VPL network had their run times reduced by half to reflect potential increases in speeds when operating on the congestion-free VPL network. Also, the headways of all routes using the VPL network were reduced by 50%, reflecting the possibility of using toll revenues to increase the bus transit level of service.

This new transit network was added to the B-Prioritized (BP) Scenario described above, resulting in a new scenario: BPT.

3.4.3 CPT

Scenario CPT further adds to the transit operating on the VPL network by enhancing existing bus service operating on the parkways and adding new transit routes to the parkways. Existing commuter bus routes were modified to capture the potential benefits of operating on the VPL network. As with BPT, the headways of existing bus service on the parkways were reduced by 50%, and their running times were cut in half.

The following parkway bus routes were created or enhanced in scenario CPT. Bold route numbers are newly proposed bus routes for this transit scenario.

- Cabin John/Clara Barton Parkways
    - **Route 14** CBP – Lakeforest Mall/Montgomery Mall Transit Center to Farragut Square.
- Baltimore-Washington Parkway
    - Route B30 – Greenbelt Metro Station to BWI
    - Route 87 – Greenbelt Metro Station to Laurel
    - Route 88 – New Carrollton Metro Station to Laurel
    - **Route BWPI** – I-95/495 Park and Ride to Metro Center
- Suitland Parkway
    - Route MTA 02A – St. Leonard to State Department
    - Route MTA 02B – Calvert County Fairgrounds to State Department
    - Route MTA 03A – Charlotte Hall, St. Mary's County to North Capitol and H Sts.
    - Route MTA 04A – North Beach to State Department
    - **Route C11SPI** – Clinton Park and Ride to Farragut Square
    - **Route H11SPI** –Heather Hill Apartments to Farragut Square
    - **Route K12SPI** – Branch Avenue Metro Station to Farragut Square
    - **Route J15SPI** – Melwood Park and Ride (proposed) to Federal Triangle
- George Washington Parkway – Northern Section
    - Route 15K#20 – Rosslyn Metro Station to George Mason University
    - **Route 15KX** – Rosslyn Station to Tysons Central 123 Metro Station (proposed)
- George Washington Parkway – Southern Section
    - Route 11YXI – Mt. Vernon (VA) to Farragut Square Metro Station

4 Scenario Analysis

4.1 Potential Demand and Revenue

The scenarios developed, as described in Chapter 3, were analyzed for potential demand and revenue of the value priced lanes. All of the scenarios showed high demand for use of the variably priced lanes across the region. Segments with the highest demand for the tolled infrastructure include the District river crossings, the Baltimore-Washington Parkway, I-66 inside the beltway, and major intersections of the VPL network.

4.1.1 Demand and Revenue Analysis, First Round Scenarios

This initial network was analyzed as part of the scenario study, performed under the TPB work program before this study began. A map showing the predicted PM tolls on the network links is displayed in Figure 17.

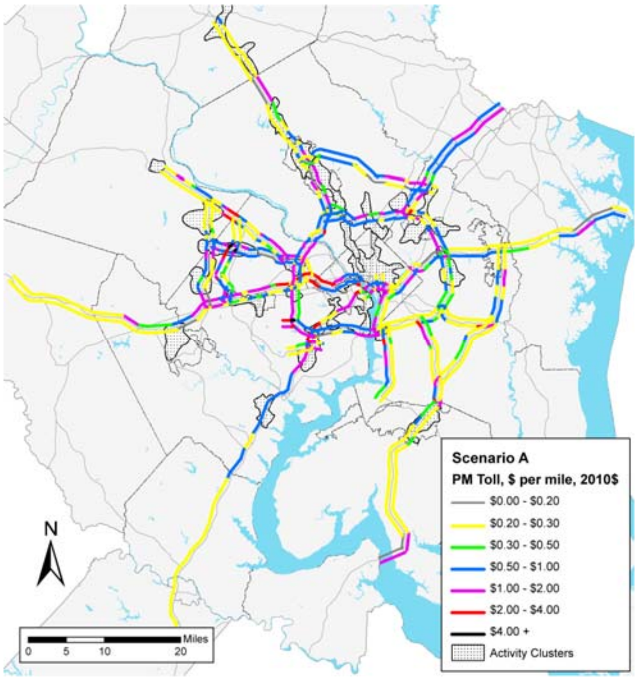

Figure 17: PM peak period tolls from Network A.

These results confirmed that tolls would have to vary by segment and direction in order to maintain a free flow on the toll lanes.

Scenario A includes three toll facilities that have been studied independently by the TPB as well as local jurisdictions and consultants: the Intercounty Connector, the Beltway HOT Lanes and the Shirley Highway I-95/395 corridor HOT Lanes. When studied as part of this larger network, the tolls on these facilities are projected to be much higher than when these facilities were studied in isolation. This is an indication of the *network effect*: each facility has higher connectivity – and provides greater accessibility – as part of a network than it would individually.

Scenario A increased regional HOV use by 12% and increased transit use by 3%. These gains were accompanied by a nearly 4% increase in regional VMT.

Analysis of this initial network also raised awareness of the need to further address access and egress to the priced lanes. The travel demand model assumes that traffic on variably priced lanes can freely enter and leave the toll network. This assumption cannot hold true for many parts of the modeled VPL network, as many of the modeled exit ramps connect into areas of heavy local congestion. In fact, many access and egress points of the current regional freeway network experience congestion that at times impacts traffic on the freeways. Microsimulation tools may be used in the future to examine access and egress issues and identify ways to remedy them.

Scenario B, which added the District river crossings, showed high toll rates on these bridges. The toll rate for the bridges was calculated to be generally between $3 and $10 per mile. Each of these bridges is shorter than a mile, so the resulting bridge tolls were estimated generally between $1 and $4.25 per one-way crossing.

The toll levels resulting from the analysis of Scenario B are displayed in the map in Figure 18.

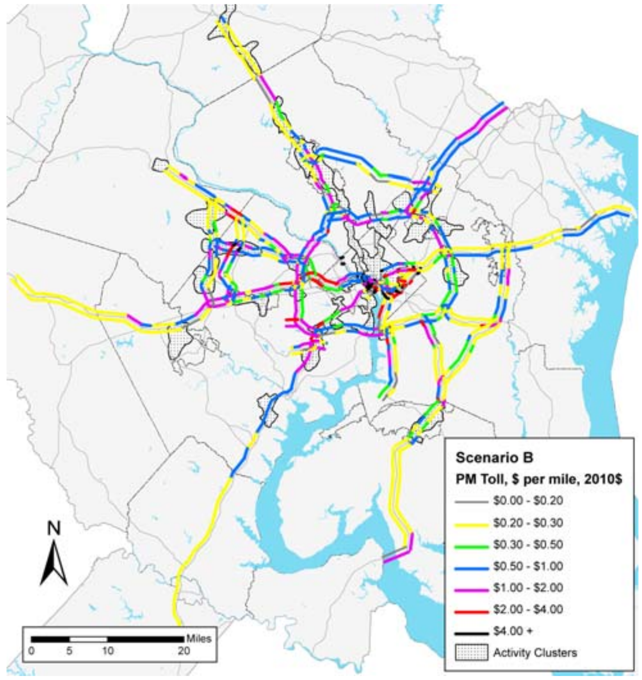

Figure 18: Projected toll rates from Scenario B.

The total revenue of the system increased by 33% compared to Scenario A. This result is expected, as new tolled facilities were added to the network and all of the DC facilities included in the network are toll-only. From Scenario A, the system-wide VMT was reduced by less than 1%, transit trips increased by over 2%, and HOV usage decreased by slightly over 3%.

The toll rates resulting from the analysis of Scenario C are displayed in the map in Figure 19. The most compelling result from Scenario C is the high tolls on the Baltimore/Washington Parkway, which has significant tolls on nearly every segment of its tolled length from its origin at US-50 to the Howard/Baltimore county line.

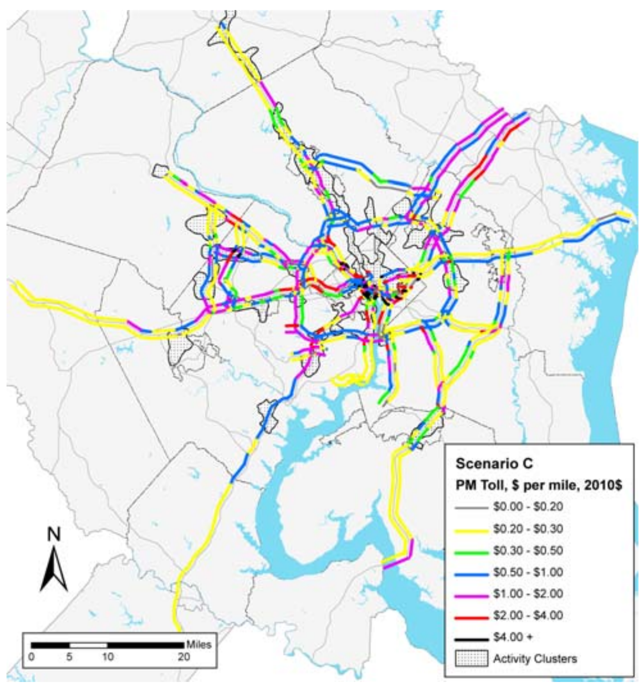

Figure 19: Projected toll rates from Scenario C

Compared to Scenario B, Scenario C resulted in higher bridge tolls: the average bridge toll increased by about $0.30, or $0.70 per mile. The system-wide revenue of Scenario C was 31% higher than that of Scenario B. Other changes between Scenarios B and C include:

- A small system-wide reduction in VMT (less than 1%)
- A slight increase in HOVs (less than 1%)
- A small increase in transit use (less than 1%)

4.1.2 Comparison Across First-Round Scenarios

It is also instructive to look at general trends in the measures of effectiveness (MOEs) across scenarios. In the above sections, the primary measures of effectiveness of the different scenarios were the following: regional vehicle miles traveled (VMT); high-occupancy vehicle (HOV) usage; transit use; total system-wide toll revenue; and bridge tolls. Table 1 displays these MOEs as percentage changes from the base case 2006 CLRP scenario.[8]

Table 1: Summary of changes in measures of effectiveness across scenarios, as a percentage change from the base 2006 CLRP. *Compared to Scenario A; **Compared to Scenario B.

	Scenario A	Scenario B	Scenario C
PM Priced Lane Miles	*1664*	*1758*	*1979*
Regional VMT	4%	3%	2%
HOV Use	12%	9%	9%
Transit Use	3%	5%	6%
Annual System Toll Revenue* (millions)	$1,700	$2,300 (33%)	$3,000 (74%)
Average Bridge Toll**	n/a	$2.70	$3.00 (15%)

Summary of Scenario Development

As described above and displayed in Figure 10, the primary scenarios (A, B and C) were based on the 2006 CLRP, each one increasing the size of the variably priced network. Scenario A added new capacity; Scenario B removed some of that added capacity and then tolled much existing capacity in the District; Scenario C then added more capacity to the network by tolling the existing parkways. In each of these scenarios, the size of the variably priced network increased.

It should be noted that, while increasing the size of the variably priced network, Scenarios B and C decrease the size of the regional non-tolled highway network because existing general purpose lanes are being converted to variably priced lanes.

	Scenario A	Scenario B	Scenario C
PM Priced Lane Miles	*1664*	*1758*	*1979*
PM GPL Lane Miles	?	?	?

[8] The percentages in the row "system toll revenue" shows toll revenues as compared to Scenario A, since the base case of the 2006 CLRP does not contain a variably priced network. The percentage in the row "average bridge toll" illustrates the percentage based on Scenario B, as the District river crossings were not included in the variably priced network in Scenario A.

VMT, HOV Use and Transit Ridership

As would be expected, the addition of new capacity in Scenario A increased regional VMT. However, because this new capacity is tolled, it is likely that this VMT increase is less than it would have been if the new capacity was added as un-tolled facilities. Throughout the rest of the scenarios, as un-tolled facilities are converted to tolled facilities and added to the variably priced network, regional VMT continues to decrease from the original 4% increase seen in Scenario A.

HOV use for all three additive scenarios (A, B and C) is greater than in the 2006 CLRP, with a 12% increase in Scenario A and 9% increases for Scenarios B & C. Keep in mind that only in Virginia are HOVs allowed free access to the variably priced lanes. It can be assumed that HOV use would be even greater if Maryland and the District permitted HOVs free access to their priced lanes.

The change in transit use across scenarios appears reasonable. With a large increase of capacity in Scenario A, transit vehicles (regardless of whether they use the new capacity or not) should experience reduced runtimes which would make bus transit a more viable alternative to driving alone. From Scenario A to Scenarios B and C, as the variably priced network grows and the general-use network shrinks, it is logical to expect that more commuters would choose transit, since the number of transit lines using the variably priced network increases.

Comparison of System Revenue

Table 1 displays the change in total system revenue across scenarios. Since the base case (2006 CLRP) did not contain a "value priced network" it is not possible to compare the toll revenue of Scenario A to the base case. Therefore, the scenarios subsequent to A are compared to Scenario A as the baseline.

Both scenarios B and C add capacity to the variably priced network and toll existing infrastructure, reducing the size of the general-use network. As would be expected, these scenarios both increase the total system revenue: by 33% for Scenario B and 74% for scenario C.

Comparison of Bridge Tolls

The District of Columbia river-crossings were added to the variably priced network with no new added capacity in Scenario B. Therefore, these bridge tolls cannot be compared to the base case or to Scenario A.

As displayed above in Table 1, the average bridge toll increased 15% from Scenario B to Scenario C. This is a reasonable reaction, as a larger variably priced network would make these river crossings more valuable to individual drivers. This is another example of the network effect, as previously mentioned in the description of Scenario A above.

4.1.3 Demand and Revenue Analysis, Prioritized Scenarios

The toll levels resulting from the analysis of Scenario BP are displayed in the map in Figure 20.

The bridge tolls in Scenario BP were slightly lower than those of Scenario B. Also, the system-wide revenue decreased by 9%. Paring back the network also had the following effects:

- System-wide VMT decreased slightly, less than one-percent.
- HOV use increased by 7.5%.
- Transit usage, however, remained unchanged.

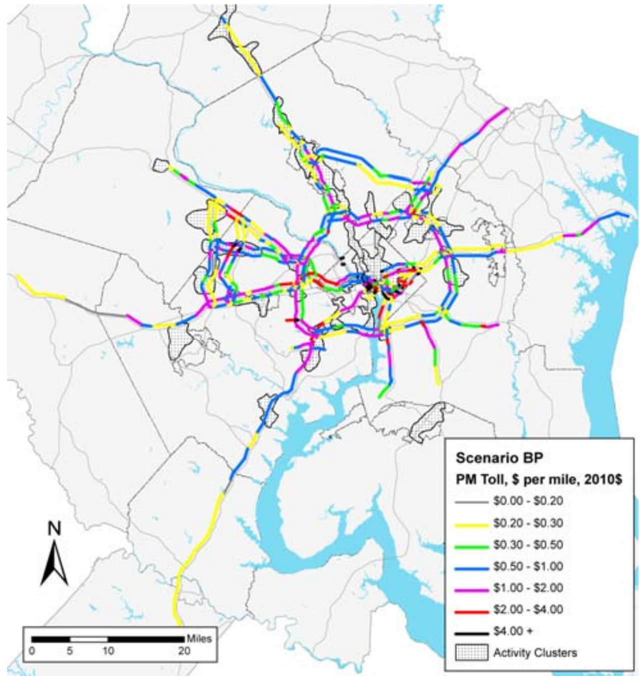

Figure 20: Projected toll rates from Scenario BP.

The toll rates resulting from the analysis of Scenario CP are displayed in the map in Figure 21. As with Scenario C, CP shows high tolls on the majority of the Baltimore-Washington Parkway, and on sections of the Clara Barton Parkway and the northern section of the George Washington Parkway.

Bridge tolls in Scenario CP are basically unchanged from that of Scenario C, and total revenue decreases by 5% between C and CP. Finally, compared with Scenario C, Scenario CP shows a nearly 4% reduction in HOV use, and very small decreases in transit use and regional VMT (0.09% and 0.07% decreases, respectively).

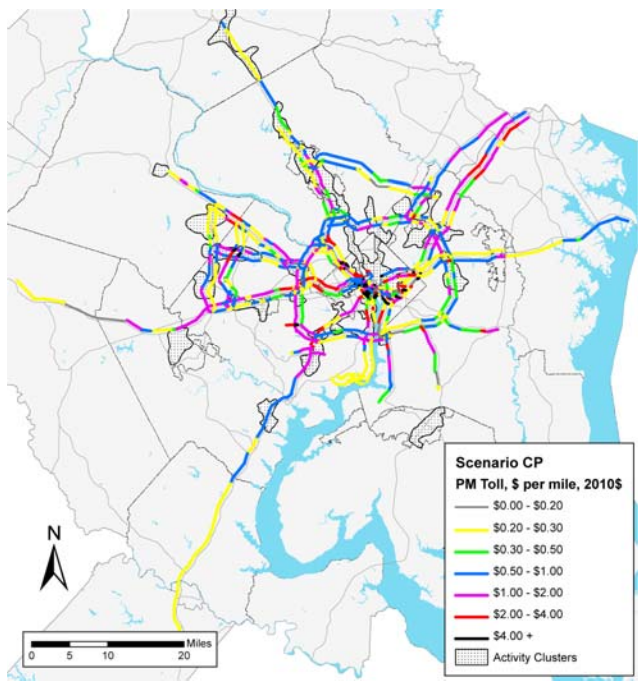

Figure 21: Projected toll rates for Scenario CP

4.1.4 Comparison Across Prioritized Scenarios

Unlike the additive first-round scenarios, the prioritized scenarios (AP, BP and CP) pruned back previous scenarios, removing links with low demand from the variably priced network. The removal of excess VPLs in Scenario BP resulted in a 17% increase in HOV usage from the base case. However, a similar removal of capacity in Scenario CP resulted in only a 5% increase from the base.

It is reasonable that the transit use percentage does not change between the additive scenarios (B and C) and the prioritized scenarios (BP and CP). Of the VPLs eliminated, most were lanes in the off-peak direction. Very few bus transit lines operate in the reverse-commute direction, so is natural to conclude that removing those lanes has little impact on transit use.

Both scenarios BP and CP pare back the value priced networks in their parent scenarios. Therefore, a reduction in total system revenue would be expected. Prioritizing B, resulting in Scenario BP, resulted in a 13 percentage point reduction in toll revenue, from 33% to 20%. Prioritizing C, resulting in Scenario CP, resulted in a smaller 7 percentage point reduction in toll revenue, from 74% to 67%.

Considering the network effect discussed above, it is also logical that the average bridge toll would decrease for the prioritized networks: a 4% reduction was noted for BP and a 1% reduction for CP. It is curious that the bridge tolls drop less between C and CP than for B and BP. This could be attributed to the fact that many of the parkways added to the network in Scenario C provide connectivity to the bridges, and that none of the parkways were removed in Scenario CP.

	Scenario A	**Scenario B**	**Scenario BP**	**Scenario C**	**Scenario CP**
PM Priced Lane Miles	*1664*	*1758*	*1424*	*1979*	*1640*
Regional VMT	4%	3%	2%	2%	2%
HOV Use	12%	9%	17%	9%	5%
Transit Use	3%	5%	5%	6%	6%
System Toll Revenue (millions)	$1,700	$2,300 (33%)	$2,100 (21%)	$3,000 (74%)	$2,900 (67%)
Change in Average Bridge Toll	n/a	$2.70	$2.61 (-4%)	$3.00 (15%)	$2.97 (-1%)

4.2 Scenario Cost Estimates

4.2.1 Methodology

The cost of a variably priced facility is, roughly, a function of the number of its lane miles and interchanges. Throughout the scenarios described above, many facilities have new lanes added while others have existing lanes converted. Additionally, new barrier-separated lanes require dedicated ramps at each access point, whereas the conversion of existing facilities generally does not. Therefore, the estimated cost of constructing the variably priced network is calculated as a function of the following four factors:

- New Variably priced Lane Miles ($ per lane mile)
- Converted Variably priced Lane Miles ($ per lane mile)

- New Interchanges ($ per interchange)
- Modified Interchanges ($ per interchange)

MDOT and VDOT were asked for unit cost estimates to attach to the above factors. MDOT responded with cost estimates from preliminary studies on the Capital Beltway (from their West Side and South Side Mobility Studies). VDOT responded with cost estimates based on the Capital Beltway HOT Lanes project described above. Because the costing factors presented by the different DOTs were not the same, these values were loosely averaged to determine the unit cost estimates. The responses from the DOTs and the unit cost values used in this analysis are displayed below in Table 2.

Table 2: Unit costs for factors of the value priced networks, in millions.

Summary	MDOT	VDOT	Reconciled Costs 2007$	Reconciled Costs 2010$
Cost Per New/Major Interchange	$230	$175	$200	$220
Cost Per Modified/Intermediate Interchange	$130	$100	$120	$132
Cost Per Non-access/Minor Interchange	$25	$25	$25	$28
Cost Per Non-Separated New VPL Lane Mile	$25		$25	$28
Cost Per New Separated VPL Lane Mile	$45	$11	$30	$33
Cost Per Converted Lane Mile	$4	$3	$4	$4

Each of the value priced network scenarios were assessed to calculate the values for the costing factors described above: the number of new and converted lane miles, and new and modified interchanges.

The lane miles calculations were performed using geographical information systems data of the value priced networks to determine the lengths of the individual coded network segments. These lengths were then linked to the lane-profiles of the segments. The lane profile specifies the number of VPLs per each segment, and which of these are converted from HOV lanes or newly constructed. The segment lengths were multiplied by the number of new or converted lane miles in each segment and then summed, resulting in the total number of new and converted lane miles per scenario.

The number of interchanges was determined by performing additional GIS analysis. First, interchanges were divided up into two categories: interchanges between lanes within the VPL network (VPL to VPL), and interchanges from the VPL network to the general purpose lanes (VPL to GPL). These two categories were further broken down into a typology of interchanges so that the number of interchange ramps could better be estimated. The interchanges in the network fall into the following categories:

- VPL to VPL
    - X: Full four-way interchange
    - T: Three-way or trumpet interchange
    - Y: Three-way merge/diverge interchange
- VPL to GPL
    - H: Diamond-style interchange
    - W: Other interchange, mostly consisting of a series of slip ramps

The interchanges were categorized and counted for each scenario. A map of the interchanges and types is presented in Figure 22. The quantity of lane miles (new and converted) and interchanges for each scenario are presented in Table 3.

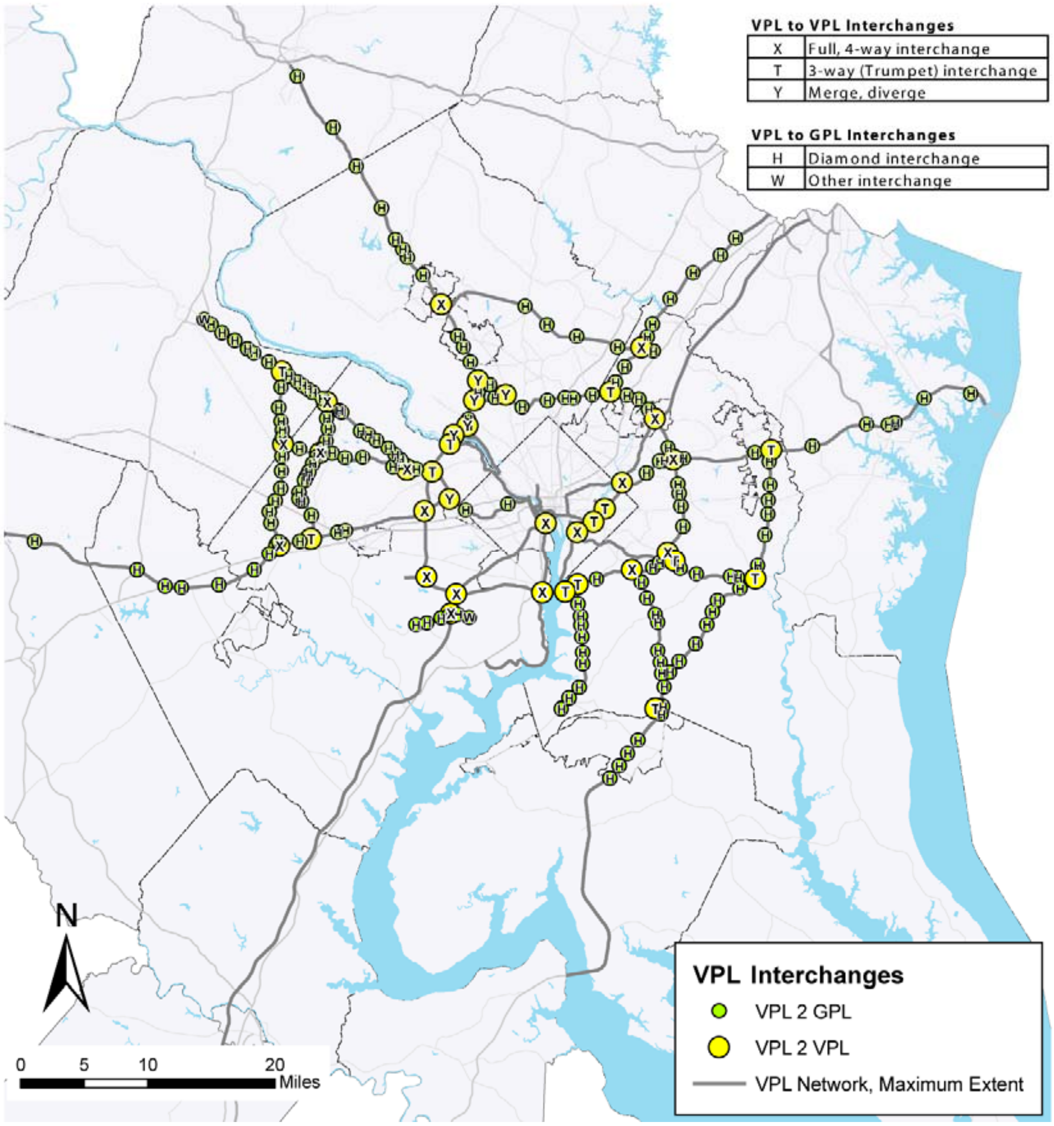

Figure 22: Map of interchanges within or connecting to the VPL networks. This map shows the maximum extent of the VPL network across scenarios, to show all possible interchanges involved.

Table 3: Cost-related attributes for the variably priced scenarios.

	A	B	BP	C	CP
New VPL to VPL Interchange	35	32	32	29	29
New VPL to GPL Interchange	172	172	172	152	152
Widened non-VPL Interchange	-	-	-	-	-
Non-Separated New VPL	-	-	-	-	-
New GPL Lane Mile	997	929	929	633	633
Converted Existing Lane Mile	337	481	819	481	819

The above summary of the attributes of the variably priced scenarios were multiplied by the cost factors. A breakdown of the costing factors multiplied by the unit costs is displayed in Table 4.

Table 4: Breakdown of costs for the variably priced scenarios, in millions.

	A	B	BP	C	CP
New VPL to VPL Interchange	$7,700	$7,000	$6,400	$7,000	$6,400
New VPL to GPL Interchange	$22,700	$22,700	$20,100	$22,700	$20,100
Widened non-VPL Interchange	$0	$0	$0	$0	$0
Non-Separated New VPL	$0	$0	$0	$0	$0
New VPL Lane Mile	$32,900	$30,700	$20,900	$30,700	$20,900
Converted Existing Lane Mile	$1,500	$2,100	$2,100	$3,600	$3,600
Total	**$64,800**	**$62,500**	**$49,500**	**$64,000**	**$50,900**

As would be expected, Scenario A has the highest costs. Scenario A adds new lanes throughout the region in all three jurisdictions. The cost of Scenario B is reduced due to the removal of the new infrastructure in the District. This carries through into Scenario C, which has some added costs due to tolling the existing lanes of the parkways. The costs of both Scenarios BP and CP are lower than those of their parent scenarios, as they involve the removal of additional new lanes from the network.

4.3 Scenario Financial Feasibility

In order to compare costs to revenues, the dollar figures must be in the same constant dollar year. The costs supplied by the DOTs were year 2007 dollars, while the revenue values from the analysis were year 2010 dollars. The cost figures calculated above were adjusted upwards by 10% to accommodate for inflation between 2007 and 2010. These total costs are displayed in Table 5, also broken down by jurisdiction.

Table 5: Cost estimates for the variably priced scenarios, broken down by jurisdiction, in millions, 2010$.

	A	B	BP	C	CP
Regional	**$64,800**	**$62,500**	**$49,500**	**$64,000**	**$50,900**
DC	$2,900	$600	$600	$700	$700
MD	$37,500	$37,500	$26,000	$38,400	$26,900
VA	$24,400	$24,400	$22,800	$24,900	$23,300

The revenues for the 5 scenarios under analysis are taken from the previous section. Additionally, these figures were broken down by jurisdiction. These values are displayed in Table 6.

Table 6: Annual revenues, in millions, 2010$, based on 2030 demand.

	A	B	BP	C	CP
Regional	**$1,700**	**$2,300**	**$2,100**	**$3,000**	**$2,900**
DC	$0	$500	$500	$600	$600
MD	$1,000	$1,100	$1,000	$1,700	$1,500
VA	$600	$600	$600	$800	$700

Based on a careful review of the VDOT Capital Beltway HOT Lanes Project, a basic rule of thumb was determined to assess the financial viability of the variably priced scenarios.

Revenues need to cover debt service (80%) and administrative costs (20%). It is assumed that 5% of a scenario's capital costs must be available each year to cover annual project costs: 4% goes to cover debt service, and 1% goes to cover operations and maintenance, administration, etc. Therefore, 20 years of revenue divided by capital cost is proposed as an indicator of financial viability.

The 20-year revenues for this analysis are displayed in Table 7 and the ratio of the 20-year revenue to scenario capital costs is displayed in Table 5.

Table 7: 20-year Revenues, in millions, 2010$, based on 2030 demand.

	A	B	BP	C	CP
Regional	**$34,300**	**$45,800**	**$41,500**	**$59,800**	**$57,100**
DC	$800	$10,200	$10,000	$11,700	$11,800
MD	$20,800	$22,800	$19,300	$33,000	$30,300
VA	$12,700	$12,800	$12,100	$15,100	$15,000

Table 8: Comparison of 20-Year Revenue divided by scenario capital costs.

	A	B	BP	C	CP
Regional	**53%**	**73%**	**84%**	**93%**	**112%**
DC	26%	1600%	1572%	1637%	1656%
MD	55%	61%	74%	86%	113%
VA	52%	53%	53%	61%	64%

According to this analysis, only the CP network will earn enough revenues to cover its capital costs. As discussed earlier, CP is the prioritized network which tolls the parkways and many existing lanes in the District. This tolling of existing lanes is what makes this scenario financially feasible: these low-cost money earners can subsidize other more expensive corridors with miles of newly constructed lanes.

It is particularly notable that Virginia is the least cost-performing jurisdiction. Even in Scenario CP, where both the District and Maryland achieve the cost viability criterion, Virginia still only covers 64% of its costs. This presumably results from the Commonwealth's HOV policy, under which vehicles with 3 or more occupants can use the toll lanes for free. It is likely that these toll lanes are being heavily utilized by toll-free HOVs, the presence of which raises the tolls and prices out other potentially paying customers.

4.4 Impact of Transit on Performance of the Scenarios

Managed lanes such as the variably priced lanes under study here can provide benefit to transit vehicles as well as private vehicles. Because the tolls will, in theory, keep the priced lanes free of congestion, the VPLs can act as dedicated running ways for transit vehicles, decreasing travel times and increasing reliability.

This study added enhanced transit services which run on the priced lanes to each of the three scenarios, and then analyzed the performance of the enhanced transit systems and the impacts of enhanced transit on the performance of the network of priced lanes.

4.4.1 Methodology

The viability of transit on the variably priced lanes was assessed by creating enhanced transit routes/services that operate on the priced lanes. Once these enhanced transit networks were coded, the travel demand model was rerun on the new transit-enhanced scenarios, and the model outputs were evaluated. Measures of effectiveness, similar to those used with the previous scenarios, were applied to the scenarios to determine the demand for transit and its impact on the value priced lanes.

4.4.2 Increased Transit Availability

Enhanced transit services were applied to the three prioritized scenarios, as described in section 3.4 above. The increases in transit service are displayed here as increases in transit availability, a new technique employed by TPB staff for visualizing changes in transit service. This technique is described in more detail here:

There are over 1000 bus routes coded in the TPB travel demand model for 2030. It is impossible to create an understandable regional bus transit visualization using standard bus transit mapping techniques.

TPB staff has been working to develop new methods of visualizing bus transit service on a regional level: a new technique to map regional transit service. This measure, currently referred to as *transit availability*, uses a 2-dimensional density function to calculate the amount of transit service (based on headways at bus stops) available within a radius of a given location.

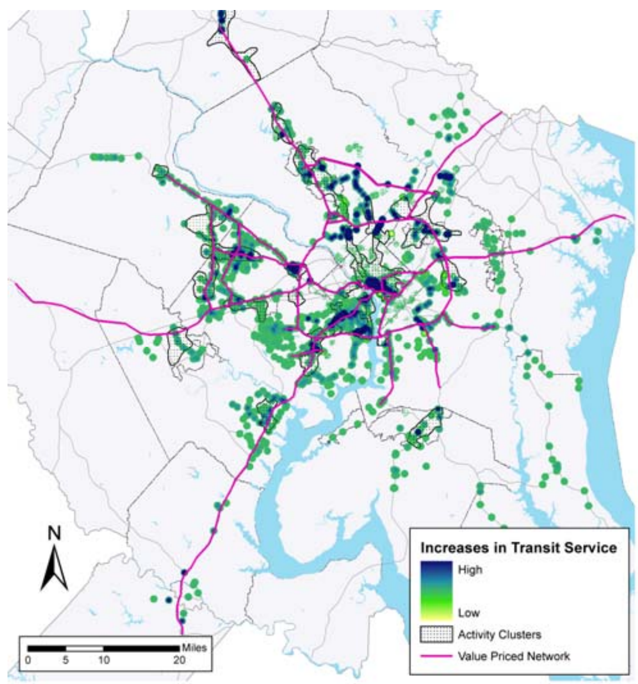

Figure 23: Increases in Bus Transit Availability due to the Enhanced Transit Services included in the Regional Value Pricing Scenario evaluation of Scenario BPT.

Figure 23 displays a map of the increases in transit availability between the BP and BPT scenarios. The darker blue areas on the map indicate where large of increases in transit service would be expected from the implementation of the enhanced transit network. The green areas show moderate increases in transit service, and the transit availability of the grey areas is unaffected by the enhanced transit network.

The figure illustrates that much of the increased transit service availability is located in areas near the proposed Value Priced Network. However, it is interesting to note that there are many areas of increased transit service that are significantly distant from the new variably priced lanes upon which the transit buses are expected to run. For example, transit service availability is expected to increase in areas of Charles and Calvert counties in Southern Maryland though the variably priced network does not extend into those jurisdictions. This is due to the fact that buses which serve areas far from the variably priced network can benefit from the variably priced lanes for a portion of their routes.

Transit availability analyses for scenarios APT and CPT are still under development.

4.4.3 Assessing the Impact of Enhanced Transit

To assess the impact of the enhanced bus transit network on the variably priced lanes, the proposed enhanced transit networks were coded into the scenarios APT, BPT and CPT, as described in section 3.4 above. The model was then run and the summary statistics and MOEs used to evaluate the earlier VLP network scenarios were evaluated and compared.

Compared to the BP Network, the BP+Transit Network resulted in a system revenue increase of 4%. The system-wide VMT increased slightly (less than 1%), transit trips increased by over 4%, and HOV usage decreased by 9%.

Compared to the CP network, …

Table 9: Change in measures of effectiveness between prioritized scenarios (APT, BPT, and CPT) and enhanced transit scenarios.

	Scenario BPT	Scenario CPT
Regional VMT	1%	?
HOV Use	-9%	?
Transit Use	4%	?
System Toll Revenue*	4%	?

These results reflect the fact that for commuter travel transit and HOV are close substitutes and improved transit service for the same travel corridor generally reduces HOV use in that corridor. The added transit service, in effect, soaks up HOVs and makes more space in the priced lanes. This has the effect of reducing the tolls, which allows more paying vehicles to enter the VPL network. This increase in paying vehicles accounts for the increase in total system revenue and slight increase in regional VMT. .

4.5 Evaluation of Potential Land Use Impacts

The link between transportation and land use has been well documented. Generally, transportation improvements impact land use by changing the land's accessibility: these improvements open up land for development either by creating access to previously inaccessible land, or by increasing the number of people who can access a given area within a reasonable amount of time. One measure of accessibility, for example, is the number of jobs which can be reached within a certain time from any given location.

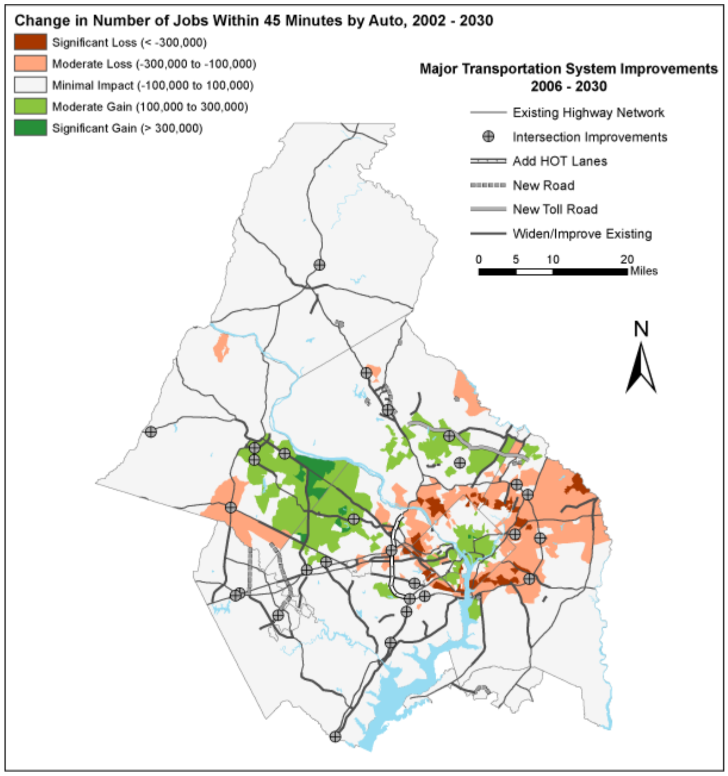

Figure 24: Sample map from the accessibility analysis of the 2006 CLRP. This map shows the change in accessibility to jobs by auto between 2006 and 2030.

Since this link between transportation and land use has been established, it is logical to use an accessibility analysis as a starting point for assessing the land-use impacts of the variably priced network under study. For example, locations that experience a change in accessibility to jobs are likely to also experience an increase in the number of households, as it is assumed that households are located where access to jobs is high. Conversely, locations that experience a change in accessibility to households are likely to experience an increase in the number of jobs, as employers relocate to where their employees can access them.

TPB staff has developed an accessibility analysis tool which uses our transportation demand model outputs to determine the number of jobs and households which are accessible within 45 minutes for each transportation analysis zone (TAZ). This accessibility analysis tool is used regularly to assess the impacts of the TPB's Constrained Long-Range Transportation Plan (CLRP): maps illustrate the change in accessibility between a base year and the plan year. An example map from the accessibility analysis of the 2006 CLRP is presented in Figure 24.

The accessibility analysis is also used to determine the impacts of the CLRP on traditionally transportation-disadvantaged populations. Changes in accessibility are divided up between the different populations to determine whether any particular group is disproportionately benefited or burdened by the changes in accessibility resulting from the CLRP.

Accessibility is surely not the only factor that influences job and housing location choices. In this study, however, accessibility is the only thing that is changing between scenarios. Therefore, it is reasonable to consider that the locations of jobs and houses may shift based on the relative accessibility of locations around the region.

The accessibility resulting from the accessibility analysis is influenced by the existence of tolls on the variably priced network. The average income of each TAZ is incorporated into the accessibility analysis through the travel demand modeling process. This is described in section 2.5.2.

4.5.1 Methodology

The accessibility analysis technique described above was use to evaluate the potential land use impacts of the value priced scenarios. Because such a large percentage of daily commute trips in the Washington region are by private vehicle, accessibility to jobs and households by highways was used. This assessment can provide some insight as to where this type of development could take place under the scenarios under study.

1. The TPB accessibility analysis tool is run on the transportation demand model outputs for the 2006 CLRP and the Regional Value Priced Network scenarios, APT, BPT and CPT, assessing accessibility to jobs and households by highways.
2. The accessibility outputs from each scenario are compared to the base 2006 CLRP outputs.
    a. Summary statistics of the average change in accessibility due to the regional value priced network were calculated.
3. Changes in accessibility are mapped using the symbology and break-points used in past CLRP analyses.
    a. Shades of green represent increased accessibility, shades of red represent decreased accessibility.
    b. Regional activity centers were superimposed on these maps for comparison.
    c. These maps indicate areas with increased accessibility to jobs and households by highway due to the introduction of the regional variably priced network.
    d. The areas where accessibility has changed will be the areas most likely to experience land-use changes.

4.5.2 Change in Accessibility to Jobs

The change in accessibility to jobs by highways for each of the three scenarios was moderate. The majority of the accessibility change is located around and within the beltway, at major intersections of the VPL network. These areas include Rockville, New Carrollton, Largo, Dunn Loring, Springfield, National Harbor, Eisenhower Avenue, and the Engineer Proving Ground. A map of the change in accessibility to jobs by highway for Scenario BPT is presented in Figure 25.

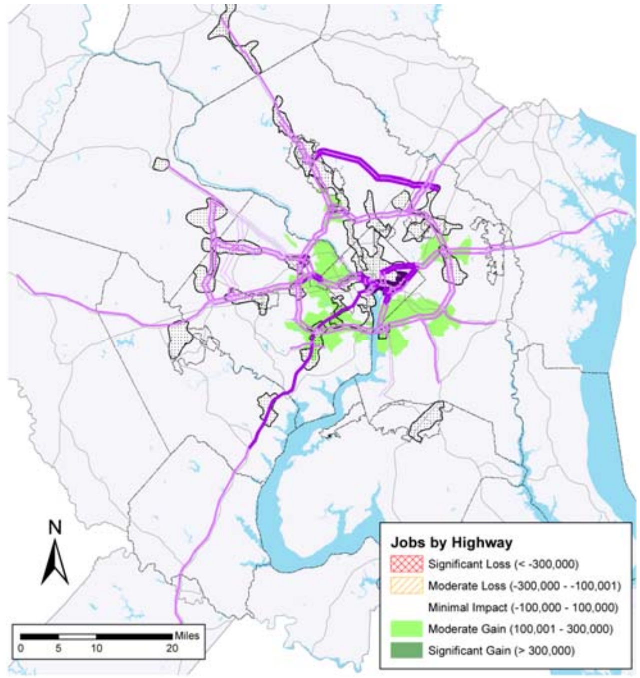

Figure 25: Change in accessibility to jobs by highway, 2006 CLRP versus RVPS Scenario BPT for 2030.

These results suggest that a value priced network will have a very moderate impact on the location of households in the region. Any impact it might have would be restricted to the inner suburban areas described above. It suggests that the value priced networks will not encourage rapid household growth in the exurbs.

4.5.3 Change in Accessibility to Households by Highways

The change in accessibility to households by highways was more significant than accessibility to jobs. The analysis resulted in areas of significant gain in and around the Tysons Corner area, along I-295/Anacostia Freeway corridor and near Andrews Air Force Base. Moderate gains in accessibility to households by highways resulted throughout the rest of the regional core and inner suburbs. As with accessibility to jobs, the impacts were limited to the inner jurisdictions: the outer suburban counties experienced minimal impact in accessibility to households by highways. The change in accessibility to households by highways for scenario BPT is presented in Figure 26.

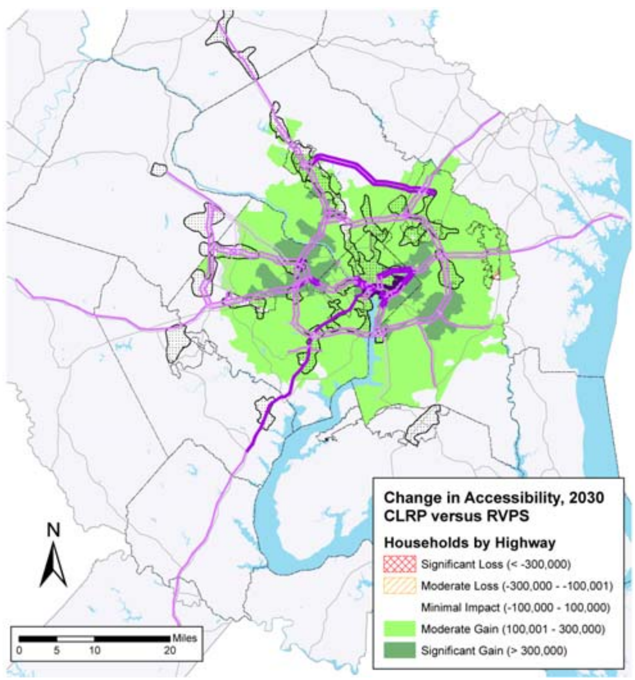

Figure 26: Change in accessibility to households by highway, 2006 CLRP versus RVPS Scenario BPT for 2030.

These results suggest employers may focus development in the activity centers near the locations which may experience the greatest change in accessibility to households. Jobs might further concentrate along the Dunn Loring/Tysons Corner corridor of the beltway, near Andrews Air Force Base and along the Anacostia Freeway in the District.

4.5.4 Next Steps to Development of a Land Use for the Value Pricing Scenarios

The Regional Mobility and Accessibility Study includes five scenarios which are comprised of packages of transportation and land-use changes. If the regional value pricing study is to be considered a sixth scenario of the scenario study, the land-use portion of the scenario should be further developed. This new land use forecast could be based on the results of the accessibility analysis above: the 2030 forecasts would be adjusted so that jobs are shifted to zones more accessible to households, and households are shifted to zones more accessible to jobs. This would be performed using a documented and justifiable rationale for shifting existing and projected jobs and households to areas of greater accessibility. This exercise may be performed with the assistance of the region's planning directors and the new TPB Scenario Study Task Force.

As described above, income and tolls interact to influence travel demand in the four-step model only in trip distribution and trip assignment. It may be desirable to include an additional factor that more directly incorporates income into the methodology used to shift jobs and housing from less-accessible to more-accessible nodes.

4.5.5 Summary of Accessibility Changes

In summary, the priced lanes scenarios evaluated in this study would appear to have limited impact on the location of households, and may have a significant impact on the location of jobs. The extent of this potential impact is generally located in and around the Capital Beltway, and is focused on intersections of major corridors of the value priced network.

A new set of land use forecasts based on these changes in accessibility could be developed. This scenario would incorporate the changes in accessibility reported above, and shift some households and jobs to areas with increased accessibility.

4.6 Connectivity to the Regional Core and Activity Centers

4.6.1 Methodology

The connectivity to the regional core and activity centers can be determined by assessing the changes in accessibility to regional core and suburban activity centers: greater accessibility translates to greater connectivity.

The accessibility analysis performed to evaluate potential land use impacts can also be used to determine change in connectivity to the regional core and activity centers. The changes in accessibility are assigned to individual traffic analysis zones (TAZs). These zones can be categorized as falling within one of three categories:

- Core Clusters: activity clusters within the regional core

- Non-Core Clusters: activity clusters outside of the regional core
- Non-Cluster: areas outside of activity clusters

The accessibility of the categorized TAZs can be grouped and summarized based on the above categories, resulting in a measurement of the impact of the variably priced lanes scenarios on connectivity to the regional core and activity centers.

4.6.2 Accessibility to Jobs

The change in accessibility to jobs categorized by activity cluster across the three scenarios is displayed in Table 10. The change in accessibility to jobs appears evenly spread between core clusters, non-core clusters and non-cluster zones, with the zones in non-core clusters having a slight percentage increase over the other areas.

Table 10: Change in accessibility to jobs by highway between the 2006 CLRP and the VPL scenarios categorized by activity cluster or non-cluster zones.

	Scenario APT	Scenario BPT	Scenario CPT
Core Clusters	?	30%	?
Non-Core Clusters	?	31%	?
Non-Cluster	?	30%	?
Regional Average	?	30%	?

The chart in Figure 27 shows the relative as well as absolute change in accessibility to the region's activity clusters for scenario BPT. It can be seen that, while the relative change in accessibility to jobs is evenly spread across the region, in absolute terms the core clusters remain the areas with the lowest accessibility to jobs, and the non-cluster areas remain the areas with the highest.

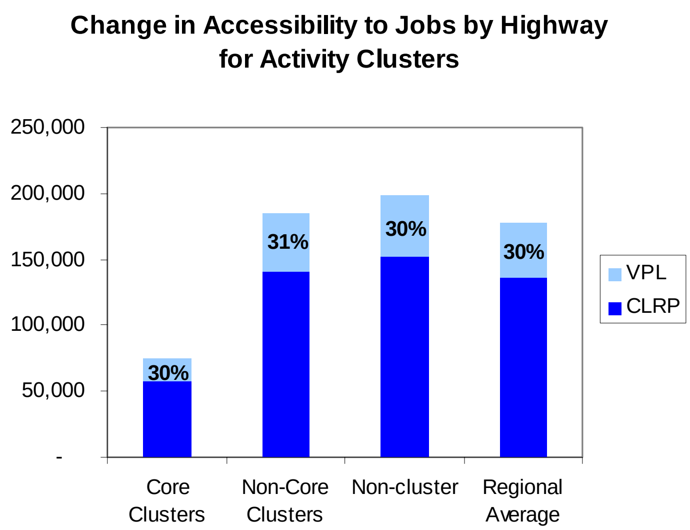

Figure 27: Scenario BPT changes in accessibility to jobs by highways for activity clusters.

4.6.3 Accessibility to Households

The change in accessibility to jobs categorized by activity cluster across the three scenarios is displayed in Table 11. Unlike the change in accessibility to jobs, the change in accessibility to jobs is not evenly disbursed. The core clusters receive a smaller percentage of growth in accessibility to households, and non-cluster zones experience the greatest increase.

Table 11: Change in accessibility to households by highway between the 2006 CLRP and the VPL scenarios categorized by activity cluster or non-cluster zones.

	Scenario APT	Scenario BPT	Scenario CPT
Core Clusters	?	21%	?
Non-Core Clusters	?	30%	?
Non-Cluster	?	33%	?
Regional Average	?	31%	?

It can be seen in the chart in Figure 28 that the core clusters experience the smallest percentage increase and remain areas of the least accessibility to households. The non-cluster zones receive the largest percentage change in accessibility to households, rivaling the accessibility to households by highways of the non-core activity clusters.

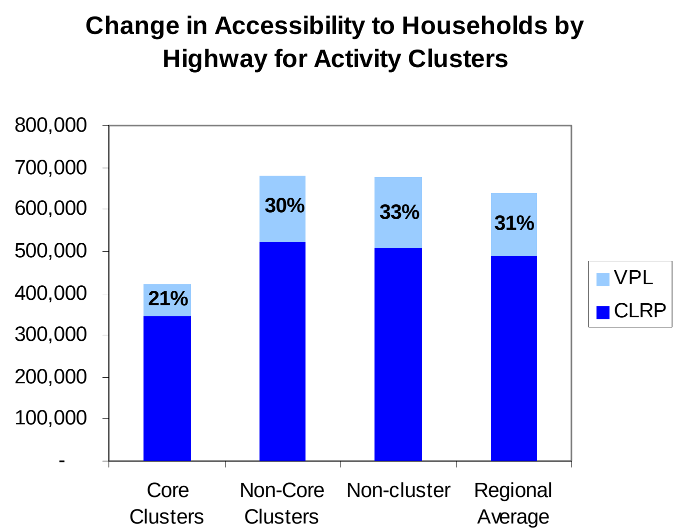

Figure 28: Scenario BPT changes in accessibility to households to jobs by highways for activity clusters.

4.6.4 Assessment

In general, the value priced lanes scenarios increase accessibility to jobs and households in both the activity clusters and non-cluster zones. The scenarios appear to have a more significant impact on the accessibility to households than the accessibility to jobs. Accessibility to both households and jobs remains the lowest in the core clusters. Non-cluster areas will maintain the highest accessibility to jobs, and non-core clusters will maintain the greatest accessibility to households.

5 Impacts of Pricing Scenarios on Different Populations

TPB staff includes in its regular analysis of the CLRP an assessment on the impacts of the plan on different population groups. This analysis also makes use of the accessibility analysis described above and used for the land use and activity cluster analyses of this study.

5.1 Methodology

As described above, the accessibility analysis technique evaluates how many jobs and/or households are accessible from any given traffic analysis zone (TAZ). The Census Transportation Planning Package (CTPP) also provides demographic data at the TAZ level. Combining these two data sets, the change in accessibility in each TAZ can be linked to the number of residents in each zone of the population groups of interest. From this, the average impact across the region on the different population groups can be estimated.

It should be noted that the latest version of the CTPP is based on the results of the 2000 Census. No attempt is made to forecast demographic shifts around the region for 2030.

In addition to the accessibility changes for the general population, analyses of the CLRP evaluate the impacts on the following census demographic categories:

- African American
- Asian
- Hispanic/Latino
- Low-income
- Disabled

The analysis results in the number and percentage of people from each population group who experience changes in accessibility, broken down into three categories: moderate to significant loss, minimal impact, and moderate to significant gain. An example of this analysis output is presented in Table 12.

Table 12: Example of results from the demographic assessment of the 2006 CLRP. Number and percent of minority, low-income and disabled individuals located in areas experiencing change in accessibility to jobs by auto, 2002 to 2030

Change in the number of jobs within 45 minutes by auto	Moderate to Significant Loss (<-100,000)	Minimal Impact (-100,000 to 100,000)	Moderate to Significant Gain (>100,000)
General Population	958,000 21%	2,819,000 62%	768,000 17%
African American	448,000 36%	598,000 48%	193,000 16%
Asian	48,000 15%	205,000 64%	68,000 21%
Hispanic/Latino	90,000 21%	252,000 60%	80,000 19%
Low-Income	134,000 28%	251,000 52%	100,000 21%
Disabled	154,000 24%	375,000 58%	113,000 18%

5.2 Analysis Summary

As of this writing, this analysis has not been performed for any of the scenarios in this study.

5.3 Assessing the Impact of Tolling Existing Lanes

The analysis above provides one way to examine the impact of the variably priced lanes scenarios on minority, low-income and disabled population groups. Comparing the impacts on low-income and minority populations of scenario APT against those of BPT and CPT provides an initial look at the impact of tolling existing lanes. However, a more thorough discussion of the potential impacts of tolling existing infrastructure is required to fully understand all the dimensions of the subject.

This study has been evaluating a network of variably or variably priced lanes. The cost of travel on these lanes adjusts according to demand: the tolls increase in order to prevent congestion on the lanes, providing free flow traffic conditions for those willing to pay the toll. The economic rationale for value pricing is that roads operate most efficiently when the volume of traffic on a road stays below its design capacity. In economics, the concept of value-pricing is referred as "efficiency tolls".

The economic rationale of efficiency tolls is not under dispute. The community-wide impacts of such tolls can be complex, however, as described in a classic paper, *The Basic Theory of Efficiency Tolls: The Tolled, The Tolled-Off and the Un-Tolled*, published in 1964, by Richard M. Zettel and Richard R. Carll.[9]

[9] Zettel, R., and R. Carll. 1964. The Basic Theory of Efficiency Tolls: The Tolled, the Tolled Off, and the Un-Tolled. In *Highway Research Record 47*, HRB, National Research Council, Washington, D.C.

Zettel and Carll frame the assessment of pricing strategies as follows:

> *"The economic question concerning the wisdom of this course can be phrased in the same way as for highway expansion: Would the benefits of traffic restriction be greater than the costs created? The benefits at issue are similar to those occurring from highway expansion: by reducing traffic flow, "savings" in travel time, accidents, operating costs, etc., are provided for those who continue to use the highway."*
>
> *"However, the costs to be compared with the benefits are altogether different. Instead of prices of land and other resources needed to provide highways, the cost arising from traffic restriction is the loss to users who must be prevented or induced not to use a congested road. The amount of the loss depends on what alternatives are available to those who are diverted."*

They note that the tolling of existing lanes creates three types of travelers:

- **The Tolled**, drivers using the newly tolled road who are willing to pay the toll:

  "What would be the attitude of the tolled? Does one know that these users, as individuals, are actually better off than they were before the toll? Would they rather have suffered the congestion (and time losses), and saved the toll? The fact that they are willing to pay the toll gives no answer."

- **The Tolled-Off**, Former users of the newly tolled road, who have switched routes, modes or times for their trip, or are no longer making their trip altogether:

  "It must be noted that the tolled-off user prefers the facility with congestion to any alternative he selects. The toll has motivated him to use a less desirable alternative and to incur a loss. Although it might be concluded that the loss cannot be larger than the amount of the toll payment (otherwise the user would pay and not be diverted), the main question is whether the loss is less than, or exceeds, the benefits of decongestion."

- **The Un-Tolled**, Drivers who do not use the road in question but are impacted by the drivers diverted by the tolls:

  "Consideration might be given to the impact on still another group—those who are already using the alternatives to which some of the former users of the toll facility shift"

"At this point, one suffers mental indigestion trying to picture the tolled, the tolled-off, and the untolled, the users and the nonusers, bouncing around among the alternatives, all the while a blinking giant of a computer is fixing and refixing tolls, shadowing users, and redistributing income to promote the general welfare through the optimal arrangement, not only of travel but also of nontravel".

Zettel and Carll argue that one must consider the possibility that imposing tolls on existing roadways may have a net social *cost*: the benefits to the tolled and society in general could be outweighed by potential social disbenefit caused by tolls prompting a broad restructuring of travel, work and living patterns:

On the basis of social cost theory, there is no conviction that the results of vehicle rationing through tolls would be beneficial on balance.

Benefit redistribution may be a possible way to reach a Pareto improvement, an improvement where some gain benefit and no one is worse off than before. However, the many groups of users who have the potential of being negatively impacted would be diverse, spread-out and potentially unidentifiable. It is likely impossible to ensure that each impacted individual is compensated for negative impacts of the efficiency tolling scheme.

To summarize, the tolling of existing lanes produces a very complicated chain reaction of effects. Understandably, such tolling schemes provide the opportunity for very challenging and complex problems to arise, problems that can impact the quality of life of many or even a majority of a region's individuals. This is not to suggest that efficiency tolling should be avoided. Instead, its benefits and burdens should be analyzed and understood. And innovative ways to redistribute benefits should be investigated before such tolling schemes are put in place.

Zettel and Carll summarize their extensive analysis of the benefits and costs of tolling existing roadway lanes as follows:

"It is not denied that worthy reasons may be found to support attempts at restriction or redirection of motor vehicle use in some urban areas. Pricing might be one of the better tools to accomplish this. But the rationale of a rationing policy should be drawn up in broad planning terms, involving community amenities and esthetics, rather than in the narrow context of social costs which users impose on each other. This requires a balancing of the total consequences of rationing, the adverse as well as the beneficial, not only as they affect users but also as they affect the community-at-large."

6 Topics for Further Consideration

6.1 What Scenarios Could be Assessed in Future Studies?

6.1.1 CAC Recommendation of evaluating a "scenario that focuses mainly on converting existing lanes to VPLs"

In February, 2007, the TPB Citizens Advisory Committee presented to the TPB a list of recommendations on the scenario study, including a recommendation to "analyze a scenario or scenarios that assume the conversion of existing general purpose lanes to variably priced lanes." Scenario A tolls existing HOV facilities and includes the single-lane HOV segments as well as the entirety of I-66 from the Capital Beltway to the Roosevelt Bridge. This study also includes Scenarios B and C that toll a significant number of existing lanes.

Scenario B includes removing VPLs in the District from Scenario A and tolls the following existing facilities:

- All District river crossings
- I-395
- I-295/Anacostia Freeway
- I-66
- New York Avenue from the District line to I-395 at 4th St NW
- Portions of the Rock Creek and Potomac Parkway, Independence Ave. SW and Maine Ave. SW

Scenario C takes Scenario B and adds tolls on all of the parkways in the region

- The Baltimore Washington Parkway (MD-295)
- The George Washington Parkway
- The Rock Creek and Potomac Parkway
- The Clara Barton Parkway
- The Suitland Parkway

As demonstrated in Section 4.5 on the feasibility assessment of the scenarios in this study, tolling existing general purpose lanes can generate significant revenues that could cover the costs to construct and operate a system of VPLs and, perhaps, provide new funding for transit service enhancements. Future work activities could build on this study's findings and assess the impacts of tolling more existing lanes. This potential new work activity could be presented to the new TPB Scenario Study Task Force and performed in the next phase of the TPB scenario study.

6.1.2 Evaluating Bus Rapid Transit (BRT) in the Scenarios

This study evaluates the impact of adding enhanced transit to the VPL networks in the Scenarios. Transit was enhanced by increasing levels of service of existing or planned bus lines that could make use of the VPLs. Existing and planned routes were enhanced by increasing the frequency of service and reducing the route running time. Additionally, a small number of new express bus routes were created to operate on segments of the VPL network without transit service.

This approach allowed for an assessment of improved transit without the extensive and coding required to model new transit routes. However, these enhanced services do not represent the much higher service levels that could be obtained with bus rapid transit (BRT) levels. And since the studied transit network is mostly comprised of existing or planned bus lines, no new radial (suburban to suburban) transit network links were included in the scenarios.

Designing and coding an expanded network of high-quality BRT service could be performed under the TPB Scenario Study.

6.1.3 Trucks Should Be Considered In Future Studies

Freight movement is very important for the region, and the impacts of trucks should be addressed in future studies that evaluate adding new capacity to the region's roadway network..

This study assumes that no trucks are permitted on any of the new VPLs. The ICC, as planned in the CLRP, will accommodate trucks and other freight vehicles. Under Scenarios B and C, the tolled existing capacity within the District will permit freight vehicles on any facilities where they are currently permitted. Because trucks would not be permitted on much of the VPL network and significant portions of the VPL networks involve tolling of existing lanes, these VPL networks will not provide a basis for the "two-tiered" system of roadways envisioned by some pricing advocates:

> What would eventually emerge over the next two to three decades is a two-tiered system of metropolitan and intercity roadways. Supplementing existing toll-free highways would be networks of premium service facilities offering congestion-free travel for a fee. As toll-free highways became saturated with traffic, individual motorists, shippers and truck-fleet operators would switch to the free-flowing priced facilities in sufficient numbers to ensure their political legitimacy and financial viability.[10]

6.2 What Considerations Affect the Inclusion of VPLs in a Regional Network?

6.2.1 Inclusion of the Parkways in the Regional Network

There are several issues related to inclusion of parkways in the regional network of priced facilities. First, the National Park Service is concerned about visual obstructions caused by gantries or other hardware required to implement and enforce tolling. Second, the geometries of the parkways and overpasses need to be examined in detail to identify

[10] Orski, Kenneth, Addressing the Transportation Challenges of the 21st Century, Innovation Briefs, November/December 2007

potential safety issues and determine potential problems for buses since the roadways and bridges were not designed to accommodate heavy vehicles. The current barrier walls are already a problem for larger vehicles such as SUVs and, may be inadequate if there is an accident to prevent buses from leaving the roadway.

6.2.2 Right-of-way Availability for the New VPLs

This study assumed that right-of-way to construct the new variably priced lanes in Scenarios B and C is available. However, it is known that right-of-way (ROW) is not available on some segments, including US-50 in Maryland between the Capital Beltway and the District border, and the Capital Beltway in Maryland between US-50 and the American Legion Bridge.

The availability of ROW and the cost for obtaining additional ROW will influence where new VPLs in a regional network can be considered. There are construction methods for entrenched or elevated roadways that could be considered to implement the VPLs for some of the segments in future scenarios. These engineering solutions, while technically feasible, will be more costly and could raise appearance and aesthetic issues.

Including an additional general purpose lane to the construction of a new VPL for some sections of the networks proposed in Scenario B or C in order to have two lanes in each direction could be examined in future studies.

6.2.3 How will Chokepoints Affect VPL Network Performance?

This analysis has identified two types of chokepoints in the variably priced network.. First, the convergence of many different toll lanes can result in a merge bottleneck. For example, in the studied network, traffic from 7 VPLs can converge at the Springfield intersection, all attempting to head south on the three I-95 VPLs, possibly resulting in backups on the toll lanes on the beltway and I-395. Second, high-demand access and egress points may result in bottlenecks getting in our out of the value priced network. For example, the street network in Tysons Corner may not be able to handle all of the vehicles wishing to exit the toll lanes, and congestion could back up onto the VPL network.

Three potential solutions can be investigated:

- Increase capacity through chokepoints
- Toll chokepoints, including previously toll-free ramps
- Transit-only lanes through chokepoints

6.2.4 How Could the VPL Facilities be Phased for a Regional Network?

One method to determine which facilities in the scenarios could be implemented first would be to exclude the segments with new lanes in the 2030 networks where new right-of-way would be needed. The resulting first phase, or perhaps 2020 network would thus have two-lane segments and some single-lane sections. Alternatively, one lane from the existing freeway could be included in the VPL in order to achieve two lanes everywhere in network.

6.3. Coordination with Current corridor studies in the region

There are currently several corridor studies underway or pending in the region, including the Southern Mobility Study, the Western Mobility Study, the 14th Street Bridge EIS, and the I-66 Corridor Study. The Regional Value Pricing Study includes assumptions and analysis that could be relevant to these and other corridor studies that may be considering the inclusion of managed lanes. The results of this study could be provided to these on-going studies.

6.4 Public Education about the Impacts and Rationale for Pricing to Manage Congestion Should be Considered

Public outreach and education about the potential benefits and impacts of charging users to manage congestion will be necessary because there is limited experience with such charges. While there is some US experience with providing drivers the choice of paying a toll for a congestion free trip, there is no experience with tolling existing general purpose lanes. The experiences in Stockholm and London and the impacts on those affected by the tolling of existing lanes should be useful in public education efforts.

7 References

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8 Appendix

- Excerpts from the Regional Value Pricing Study Work Plan, November 8, 2006
- Goals for a Regional System of Variably Priced Lanes
- FHWA Office of Operations: Fact Sheets: Tolling Programs

National Capital Region Transportation Planning Board

Regional Value Pricing Study Work Plan

November 8, 2006

Funded under a grant from the Federal Highway Administration's Value Pricing Pilot Program

MAJOR TASKS

The study includes five major tasks, listed below. Each task will be guided by the goals set by the TPB Value Pricing Task force, shown in Figure 2.

Task 1

- Examine corridors in the regional network to identify how specific segments of the regional system are performing, such as the Capital Beltway, existing Potomac River crossings, and major radial corridors.
- Examine traffic volumes, congestion levels, transit use, forecast revenues and air quality emissions to identify the highest potential corridors based on the regional goals for a system of variably priced lanes.
- Examine potential corridors not tested as part of the RMAS, such as the George Washington, Baltimore Washington and Rock Creek Parkways.

Task 2

- Apply the regional model and conduct sensitivity analysis to investigate the potential demand, revenue and costs, the viability of transit (including possible transit operating assumptions and direct access ramps) and changes in land use activity for *specific corridors* identified in Task 1.
- Examine connectivity to the regional core and activity centers. Suggest a phasing of corridors for variably priced facilities, possibly a network for 2010, 2020 and 2030, and policy options for vehicle eligibility.

Task 3

- Analyze the corridors examined in Task 2 as a regional network for 2030. This Phase 1 regional network will be analyzed for financial feasibility and with measures of effectiveness (MOEs).

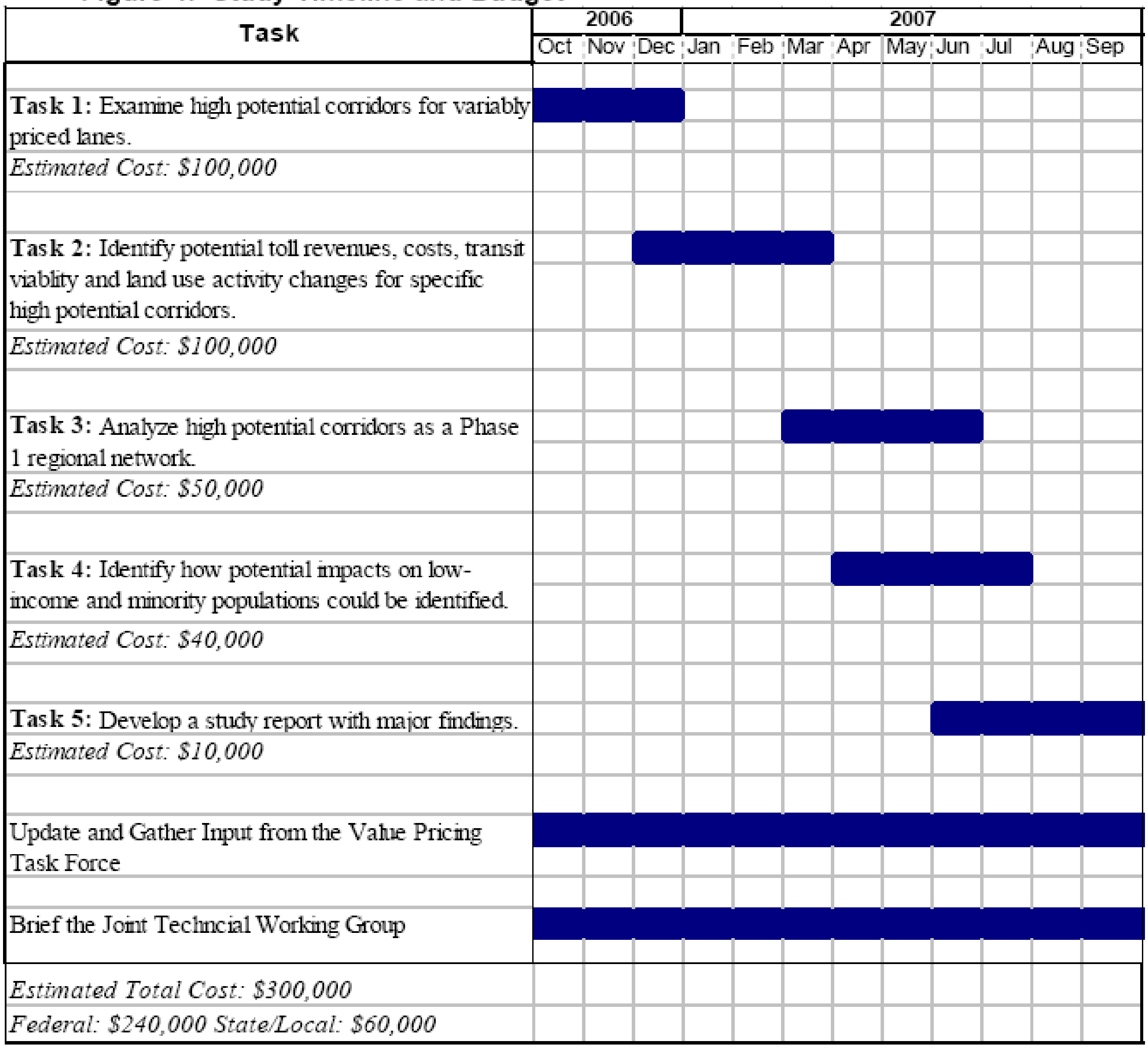
Task 4

- Examine ways of identifying regional impacts of pricing projects on low-income and minority populations. Forecast changes in travel times, accessibility, transit use and travel characteristics from the Census data could be used to look at potential regional impacts.

Task 5

- Document the results from each task in a final report.

Figure 4: Study Timeline and Budget



Goals for a Regional System of Variably Priced Lanes

Adopted by the TPB Task Force on Value Pricing for Transportation
January 19 2005

As the Washington region moves forward with plans to develop variably-priced lanes, it is anticipated that a system of variably-priced lanes will be implemented in phases, likely with one corridor or segment at a time. The following goals can help guide the regional development of variably-priced lanes that work together as a multi-modal system, while addressing the special policy and operational issues raised by the multi-jurisdictional nature of this area.

1. Operations, enforcement, reciprocity, technology, and toll-setting policies should be coordinated to ensure seamless connections between jurisdictional boundaries. The region should explore options for accommodating different eligibility requirements in different parts of the system of variably-priced lanes without inconvenience to the users.

2. The variably-priced lanes should be managed so that reasonably free-flowing conditions are maintained.

3. Electronic toll collection devices should be integrated and interoperable among the District of Columbia, Maryland and Virginia, and should work with other multi-state electronic toll collection systems, such as E-Z Pass^{SM}.

4. To ensure safety and to maintain speeds of variably-priced lanes on high-speed facilities, one lane with a wide shoulder consistent with applicable Federal Highway Administration (FHWA) guidelines should be provided at a minimum. Optimally, two lanes should be provided in each direction (or two lanes in the peak direction by means of reversible lanes) where possible.

5. Given the significant peak-hour congestion in the Washington area, transit bus service should be an integral part of a system of variably-priced lanes, beginning with project planning and design, in order to move the maximum number of people, not just the maximum number of vehicles.

6. Transit buses should have reasonably free-flowing and direct access to variably-priced lanes from major activity centers, key rail stations, and park-and-ride lots, so that transit buses do not have to cross several congested general purpose lanes.

7. Transit buses using the variably-priced lanes should have clearly designated and accessible stops at activity centers or park-and-ride lots, and signal priority or dedicated bus lanes to ensure efficient access to and from activity centers.

8. The region urges that the Congress and the Federal Transit Administration (FTA) recognize variably-priced lanes as fixed guideway miles so that federal transit funding does not decrease as a result of implementing variably-priced lanes.

9. The Washington region currently has approximately 200 miles of HOV lanes and a significant number of carpoolers, vanpoolers and other HOV-eligible vehicles. If the introduction of variably-priced lanes changes the eligibility policies for use of existing HOV facilities, transitional policies and sunset provisions should be set and clearly stated for all the users.

10. As individual phases of a system of variably-priced lanes are implemented, users of the lanes should be able to make connections throughout the region with minimal inconvenience or disruption.

11. Toll revenues from variably-priced lane projects may finance construction, service debt, and pay for operation and maintenance of the priced lanes. Should toll lanes operate at a revenue surplus, consideration should be given to enhancing transit services.

FHWA Office of Operations: Fact Sheets
TOLLING PROGRAMS

(From http://ops.fhwa.dot.gov/safetea/tollingfactsheet.htm)

	2005	2006	2007	2008	2009
Interstate System R&R Toll Pilot	$0	$0	$0	$0	$0
Interstate System Construction Toll Pilot	$0	$0	$0	$0	$0
Value Pricing Pilot	$11 M	$12 M	$12M	$12M	$12M
Express Lanes Demo	$0	$0	$0	$0	$0

Program Purpose
SAFETEA-LU offers States broader ability to use tolling on a pilot, or demonstration, basis, to finance Interstate construction and reconstruction, promote efficiency in the use of highways, and support congestion reduction. In addition to the expanded flexibility available under these four programs, the Value Pricing Pilot program provides grants for pre-implementation and implementation costs.

Note: SAFETEA-LU also enhances and clarifies provisions governing the use and operation of HOV lanes. *See separate fact sheet – High Occupancy Vehicle (HOV) Lanes* [1121]

Statutory References

SAFETEA-LU Section(s): 1604
Other: PL 102-240 (ISTEA) 1012; PL 105-578 (TEA-21) 1216

Interstate System Reconstruction & Rehabilitation Toll Pilot Program
SAFETEA-LU makes no revisions to the program as established under TEA-21. Thus, the program is continued, without change, to allow tolling on up to 3 existing Interstate facilities (highway, bridge, or tunnel) to fund needed reconstruction or rehabilitation on Interstate highway corridors that could not otherwise be adequately maintained or functionally improved. Each of the 3 facilities must be in a different State.

Interstate System Construction Toll Pilot Program
Similar to the Interstate System R&R Pilot (above), this new program authorizes up to 3 toll pilot facilities on the Interstate System for the purpose of constructing new Interstate highways.

Program features include the following:
- States or Interstate compacts of States are eligible to apply;
- there is no requirement that the facilities be in different States;
- tolling must be the most efficient and economical way to finance the project, but it doesn’t have to be the only way;
- a facility management plan must be submitted;
- automatic toll collection is required;

- non-compete agreements are prohibited -- a State may not enter into an agreement with a private entity that prevents the State from improving or expanding capacity of adjacent roads to address conditions resulting from diverted traffic;
- revenues may be used only for debt service, reasonable return on investment of private entity, and operation and maintenance costs; regular audits will be conducted;
- Interstate Maintenance funds may not be used on the facility while it is tolled;
- applications must be submitted within 10 years of enactment of SAFETEA-LU.

Value Pricing Pilot Program (VPPP)
This pilot program, initially authorized in ISTEA as the Congestion Pricing Pilot Program, is to encourage implementation and evaluation of value pricing pilot projects, offering flexibility to encompass a variety of innovative applications including area-wide pricing, pricing of multiple or single facilities or corridors, single lane pricing, and implementation of other market-based strategies.

The VPPP is funded by contract authority, to remain available for 4 years. Funds are subject to the overall Federal-aid highway obligation limitation. The Federal share is 80%. Pre-implementation costs, project design, and all development and start-up costs are eligible project expenses. There is no change to the current limit of 15 pilot value pricing programs, all of which are underway. For these programs, a new set-aside of $3 million per year (2006-2009) is to be used only for congestion pricing pilot projects that do not involve highway tolls.

Express Lanes Demonstration Program
This new demonstration programs permits tolling on selected demonstration projects to manage high levels of congestion, reduce emissions in a nonattainment or maintenance area, or finance added Interstate lanes for the purpose of reducing congestion.

The Secretary is authorized to carry out 15 demonstration projects during the period from 2005-2009 to allow States, public authorities, or public or private entities designated by States to collect a toll from motor vehicles at an eligible toll facility for any highway, bridge, or tunnel, including on the Interstate. An “eligible toll facility” includes:

- a facility in existence on the date of enactment that collects tolls;
- a facility in existence on the date of enactment that serves high occupancy vehicles;
- a facility modified or constructed after the date of enactment to create additional tolled capacity (includes construction by a private entity or using private funds); and
- in the case of an added lane on a previously non-tolled facility, only the new lane.

Program features include:

- variable pricing by time of day or level of traffic, as appropriate to manage congestion or improve air quality, is required if an HOV facility is tolled; for a non-HOV facility, variable pricing is optional;
- motor vehicles with fewer than 2 occupants may be permitted to use HOV lanes as part of a variable toll pricing program;
- automatic toll collection is required in express lanes to optimize free flow of traffic; and
- toll revenue may only be used for debt service, reasonable rate of return on private financing, operation and maintenance costs, or any eligible title 23 or 49 project if the facility is being adequately maintained.

Federal share of project cost of a facility tolled under this program, including installation of the toll collection facility, may not exceed 80%.

A final rule on interoperability of electronic collection systems is required within 180 days of enactment. Regular monitoring and reporting on the achievement of performance goals is required, as well as annual reports to Congress starting after 1 year on the use of funds, and reports on program successes beginning 3 years after enactment and then every 3 years thereafter.