October 2003

Capital Beltway HOT Lanes
Detailed Proposal
Virginia Public-Private Transportation Act

FLUOR DANIEL SM
A FLUOR Company

Capital Beltway HOT Lanes

Detailed Proposal

Public-Private Transportation Act of 1995

Submitted to

Virginia Department of Transportation

Submitted by

Fluor Daniel
2000 Chippenham Parkway
Richmond, Virginia 23234

Authorized Representative
Herbert W. Morgan
804-330-5215 (Telephone)
804-560-9381 (Facsimile)

October 1, 2003

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A FLUOR Company

2000 Chippenham Parkway
Richmond, Virginia 23234

Telephone: 804-330-5215
Facsimile: 804-560-9381

October 1, 2003

Mr. Malcolm Kerley, P.E.
Chief Engineer for Program Development
Virginia Department of Transportation
1401 East Broad Street, Room 310
Richmond, Virginia 23219

Subject: Capital Beltway HOT Lanes Detailed Proposal

Dear Mr. Kerley:

Fluor Daniel presents this Detailed Proposal for the development, financing, design, and construction of the Capital Beltway HOT Lanes project in response to your request for proposal. This proposal has been structured to facilitate easy review. The Executive Summary provides an overview of the Fluor Daniel Capital Beltway HOT Lanes advantages and why they are a smart choice for VDOT. Part 1 summarizes the Fluor Daniel project and team organization as described in our Conceptual Proposal submitted June 26, 2002. Part 2 provides our responses to the detailed questions raised in your letter dated August 13, 2003.

Enclosed are 30 copies of the written proposal, one CD containing an electronic copy of the proposal in Microsoft Word and in PDF format suitable for publication on VDOT's Web site, and a check in the amount of $40,000. A copy of this proposal is being delivered to Fairfax County Executive Anthony H. Griffin.

The Fluor Daniel team appreciates the opportunity to submit this proposal. Fluor Daniel is confident our solution to improve Virginia's busiest road will allow that critical facility to be delivered at a substantially lower cost, in a more environmentally friendly manner, much faster than originally planned and able to accommodate the HOV and express bus service to this underserved corridor.

Sincerely,

Herbert W. Morgan

Herbert W. Morgan
Project Director

cc: Anthony H. Griffin
Fairfax County Executive

Executive Summary

HOT LANES – THE SMART CHOICE

Fluor Daniel's concept provides real and tangible benefits to both the Commonwealth and Fairfax County offering the greatest possible level of multimodal transportation benefits at the lowest environmental and financial costs. Our proposal provides a financial plan based on a new source of revenue with no state obligation that can be leveraged by a modest public investment. At the same time, this approach provides the flexibility to make future system improvements that can be phased in, as additional transportation funding becomes available. By structuring the project as a business that pays for itself over time, we have made HOT lanes the smart choice for the Beltway. Specifically, the advantages include:

✓ Offers More Traveler Choices

- Allows choice to use faster paid lanes or regular lanes
- Express lane fees vary with time of day allowing travelers scheduling choices
- Car pools and express buses riders have more choices
- Provides a new source of revenue that allows improvements sooner

✓ Encourages Bus Transit and Car Pooling

- HOT lanes are HOV lanes (3+) and they allow car pools to ride free
- HOT lane operations encourage greater car pooling than HOV lanes
- Provides a bus transitway at no cost to area transit operators
- Connects the I-95/I-395, I-66, and the Dulles Toll Road HOV lanes
- Turns an interstate road into a multimodal corridor, encouraging smart growth

✓ Preserves Road Capacity

- Reduces congestion now – not in the future
- Guarantees mobility much farther than conventional lanes
- Improves travel on free lanes by diverting up to 15 percent of the traffic
- Reinforces existing Fairfax County land use patterns

✓ Substantially Pays for Itself

- Total construction cost of $693 million
- 87 percent of cost comes from toll revenue bonds and a TIFIA loan
- Public share of cost is 13 percent
- Bond holders, not the state, take all revenue projection risk
- Guaranteed construction cost and on-time performance with penalties for being late

✔ Environmentally Friendly

- Stays within existing right-of-way with only six or fewer residential structures displaced
- HOT lane characteristics have earned Environmental Defense Fund support
- Moves more people per mile versus cars than any other alternative considered

✔ The Public Likes It

- Concept developed in response to citizen concerns at 2002 VDOT public hearings
- State and county public officials are on record supporting HOT Lanes
- Major print and television media have commented favorably
- Business organizations support it
- Two-thirds of 600 citizens recently surveyed support Beltway HOT lanes
- Citizens particularly like the following HOT lane characteristics:
  - Consistently shorter travel times at a rate of – 15 to 1
  - Support fixed cost/date with penalties to contract for completion – 8 to 1
  - Banning trucks from HOT lanes – 7.5 to 1
  - Express buses can access Tysons, Dulles, Metrorail/VRE stations – 5.5 to 1
  - Variable pricing that changes with time of day – 2 to 1

FLUOR DANIEL'S COMMITMENT

As the nation's largest publicly traded design-build contractor, Fluor Daniel is well known to VDOT as a firm that can get the job done. We have proven our ability to develop and execute complex transportation projects, having successfully completed the Virginia Route 895 connector. Route 895 proved a major construction project can proceed at an accelerated pace without significant environmental impact while involving a high percentage of Virginia labor including disadvantaged businesses.

Fluor Daniel recognizes that public investment is a part of our plan of finance. We are committed to work with VDOT during the design development/negotiation phase to reduce or eliminate this public share of the project. Given time to perform additional value engineering and complete a more sophisticated traffic revenue analysis using variable pricing, and by investigating potential ancillary revenues, our goal will be to reduce the public share. Those savings can then be used on other projects or to fund one or more of the options offered in our proposal.

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Part 1: The Fluor Daniel Concept

INTRODUCTION

Fluor Daniel presented its Capital Beltway HOT Lane concept in a conceptual proposal submitted on June 26, 2002. A summary of the team organization and project description from that proposal is included in Part 1. The responses to the questions raised in VDOT's request for proposal dated August 13, 2003, are presented in Part 2.

PROJECT DESCRIPTION

Description of the Existing Facility

The 14-mile segment of the 22-mile long Capital Beltway in Virginia is part of the 64-mile multilane circumferential freeway serving the Washington, D.C., metropolitan area. It runs through northeastern Fairfax County, from the I-95/I-395/I-495 interchange in Springfield to the American Legion Bridge near Great Falls. This segment of the Beltway passes through some highly-sensitive environmental and economically vital areas and connects to major interstate highways (I-66, I-95, and I-395), limited-access roadways (George Washington Memorial Parkway and Dulles Access/Toll Road), and some high-capacity primary and secondary routes via 11 interchanges.

The Beltway is a critical element in the transportation network because of its unique dual role as a regional circumferential bypass and a major local road. Constructed as part of the interstate highway system, the Beltway was originally designed to serve through traffic bypassing Washington, D.C. Since its completion in 1964, however, growth in the Washington metropolitan area and changes in land use and travel patterns have made the Beltway an integral part of the regional and local transportation systems.

At present, the Beltway has four through lanes in each direction with auxiliary lanes or collector-distributor roadways provided at several interchanges. Along its path lie the highly-developed urban and environmentally sensitive areas of Springfield, Annandale, Merrifield, Tysons Corner, and McLean. Many dense commercial developments, high-rise office buildings, residential subdivisions, and parks and recreational areas are located in these areas.

Although still functioning as a bypass, the Beltway is now used primarily for travel to and from destinations within the region and is called Fairfax County's Main Street. Each day, hundreds of thousands of local residents use the Beltway to travel to work, shopping centers, and other destinations throughout the metropolitan area. It also serves as the primary route for the transfer and delivery of local goods and services. The Beltway comprises only three percent of the total highway lane-miles in Northern Virginia and carries almost 11 percent of all trips made in the region each day.

Travel demand on the Beltway routinely exceeds capacity during peak periods and commonly results in extended periods of congestion. For many people, the Beltway is the preferred (and sometimes only) route for trips to and between residential communities, activity centers, and major employment locations in Fairfax County and elsewhere in the Washington metropolitan area. More than 75 percent of the motorists who travel on the Beltway begin or end their trip within Fairfax County, and 30 to 40 percent of these trips are to or from locations within two miles of the Beltway. Future growth of traffic volumes and off-peak trips will further lengthen the periods of congestion. Without additional roadway capacity, the level and duration of congestion will get worse on the Beltway and on other parts of the regional transportation network.

The high traffic volumes and insufficient capacity lead to operational problems such as reduced travel speeds, longer backups, and extended periods of congestion. Minor traffic incidents on the Beltway can cause delays, and major accidents can cause delays lasting several hours. Crashes on the Beltway happen most often during peak periods near interchanges, and rear-end collisions account for 44 percent of all crashes.

Fluor Daniel's approach provides:

- Greater traveler choice
- Less congestion and assured mobility
- Improved Safety
- Connector between three existing HOV systems
- Express bus transitway

The design of the Beltway and interchanges does not meet current Federal requirements. Entrance and exit ramps to the left, substandard acceleration and deceleration lanes, and tight loop ramps create challenging driving conditions. Interchange spacing is inconsistent. With some interchanges located less than a mile apart, entry and exit to the Beltway requires accelerating and decelerating traffic to merge within a relatively short distance. Connections with intersecting roadways are insufficient for current traffic volumes. Improvements are needed to alleviate safety and operational concerns, provide road design features consistent with current standards, add capacity for congestion relief, enhance transportation system linkage, and fulfill the goals of local and regional plans.

Description of the Capital Beltway HOT Lane Concept

The proposed Capital Beltway HOT (high occupancy toll) lanes will extend from west of the Springfield interchange near the Hemming Avenue Bridge to just south of the Georgetown Pike (Route 193) (see Figure 1-1). This mainline roadway type consists of a continuous 12-lane system configured in the 4-2-2-4 typical section, shown in Figure 1-2. The four-lane (two in either direction) inner directional roadways are dedicated for use by qualifying HOT lane traffic and are separated from the adjacent general-purpose lanes by a four-foot striped buffer and yellow plastic pylons. Eight general-purpose roadways (four in

each direction) will be provided. The photos included with Figure 1-2 are of the operating HOT lanes on SR-91 in Orange County California, which are similar to the proposed Beltway concept. In addition to the beginning and ending points of the HOT lanes, five intermediate access/egress points to the HOT lanes will be provided. Two of these lanes will connect directly to interchanges at I-66 and the Dulles Airport Access and Toll Road, and three access points through entry/exit points in the buffer. The mainline general-purpose lanes will connect to all of the interchanges to and from the right. Collector-distributor (C-D) roadways will be relocated to accommodate the proposed widening.

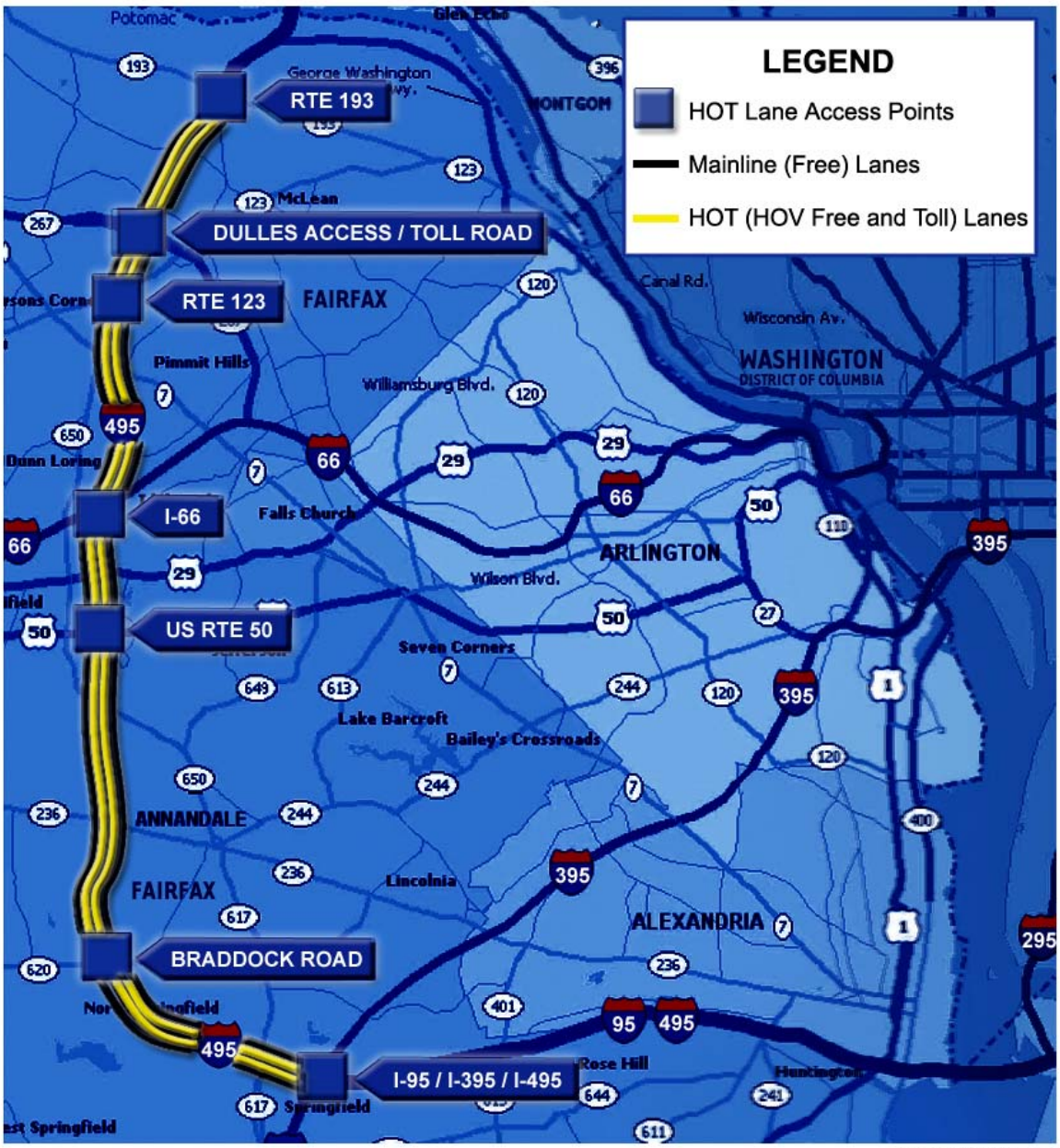


Figure 1-1. Capital Beltway HOT Lanes System Plan

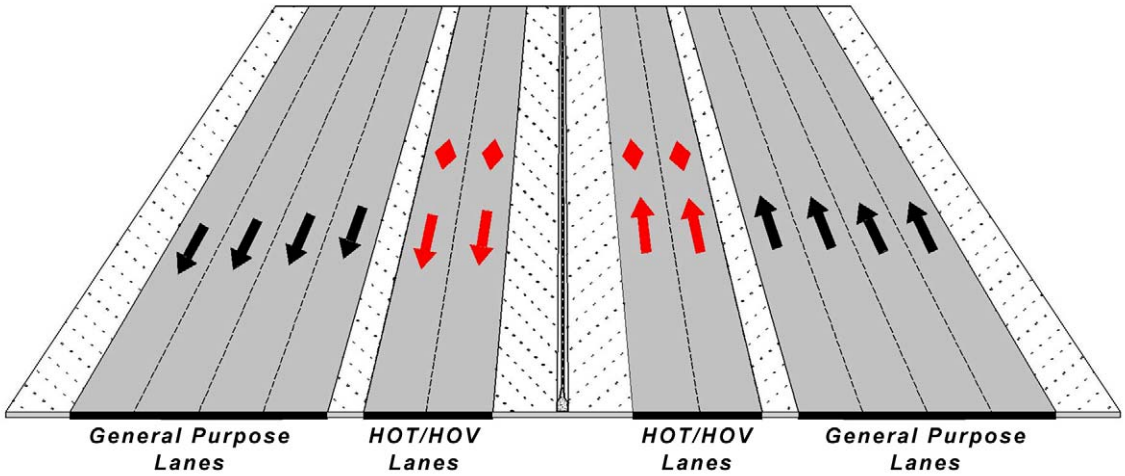


Figure 1-2. Proposed Capital Beltway HOT-Lane 4-2-2-4 Section and Photos of Similar SR-91 HOT Lanes in Operation

Roadway Operation

The addition of four HOT lanes on the Beltway will provide needed new capacity, encourage greater car pooling than would result from traditional HOV lanes, and facilitate greater bus ridership by allowing reliable express bus use of the HOT lanes/HOV network. Fluor Daniel projects the Capital Beltway HOT lanes could divert up to 15 percent of the 2015 traffic from the eight free lanes. The HOT lanes could operate at 65 mph while the general-purpose (outside eight) lanes continue to operate at the current 55 mph. A Smart Tag/E-Z Pass will be required to use the HOT lanes. At intermediate access points where direct HOT ramps are not provided, traffic will use existing Beltway interchanges and access HOT lanes from the general-purpose lanes. These intermediate exit and egress points will be strategically located to make maximum use of the HOT lanes and ensure safe Beltway operation.

Left exits and entrances from the mainline and the C-D roadways, for non-HOT traffic, will be eliminated. Such connections, however, could be provided from the HOT lanes, and only for HOT lane traffic at the above mentioned interchanges.

Collector-distributor roadways are barrier-separated from the mainline roadways at interchanges and also between closely-spaced interchanges to minimize movement conflicts and improve safety and traffic operations. Existing interchanges with C-D roadway configuration will not change. Generally, connection to interchanges is made via the collector-distributor roadways; however, at selected locations, direct access/egress will be provided from the general-purpose lanes.

At the northern end of the project, the 12-lane roadway configuration transitions to match the roadway cross-section south of the Georgetown Pike (Route-193) interchange. Towards that interchange, the required transition in the I-495 mainline cross section begins just north of the Dulles Airport Access and Toll Road. Similarly, at the southern end of the project, the I-495 mainline cross-section ties into the Springfield interchange project immediately east of the Hemming Avenue Bridge. At this location, the Beltway cross-section will consist of 12 lanes.

Optional Elements

HOT Lanes Operational Assistance

At the option of VDOT, Fluor Daniel is prepared to provide a toll system operation and maintenance contract for the Capital Beltway HOT lanes operation. A qualified contractor will be selected in cooperation with VDOT. An initial contract of 5 years with three additional 5-year options would be offered. To date, Fluor Daniel has used Cofiroute as a technical adviser because of the firm's experience an SR-91.

Asset Management Assistance

At the option of VDOT, Fluor Daniel is prepared to provide an asset management option for the long–term operation and maintenance of the Capital Beltway improvements. VMS, Inc., a recognized leader in the development and implementation of asset management programs, would be the responsible contractor that would plan, manage, and oversee all work. VMS would provide comprehensive programs to address long-term pavement maintenance, bridge operations, and traffic control features, excluding the toll-system operation and maintenance that will be covered under a separate maintenance contract option. An initial contract of 5 years with three additional 5-year options would be offered.

Additional Direct Ramp Access Points

The three intermediate access points, not served by direct ramp access, could be added concurrent to the Capital Beltway HOT Lanes concept at the outset, or in a later phase. Exercising this option at a later date will require reconfiguration of the relevant interchange.

System Expansion to the East

The Woodrow Wilson Bridge approach project, already under design and construction, is highly-compatible with the Fluor Daniel HOT Lane concept. As an option to this proposal, VDOT may wish to consider extending the HOT lanes to the east sometime in the future.

The Phase VIII section of the Springfield interchange, which is located just to the east of the Beltway HOT lane terminus, can accommodate both HOV and HOT lane traffic with its present design. No further environmental documentation will be required.

Additionally, if the project were to be extended further to the east, the present design at the Telegraph Road interchange would also be able to accommodate the HOT lanes, with some additional right-of-way and environmental documentation being required.

TEAM ORGANIZATION

Fluor Daniel, a division of Fluor Enterprises, Inc., will be the contracting party in the comprehensive agreement with the Virginia Department of Transportation, similar to that used on Route 895. Fluor Daniel will use the expertise of numerous Virginia-based professionals and will draw upon the resources of its parent company, Fluor Corporation, when necessary. Fluor Daniel will provide VDOT with a single point of responsibility for project execution.

Fluor Daniel's concept options offer:

- HOT lane operational assistance
- Asset management
- Additional direct ramp access
- System expansion easterly

Having developed the Pocahontas Parkway (Route 895 Connector), Fluor Daniel is well known to VDOT as a firm that can be relied upon to get the job done. Fluor is one of the largest design-build contractors in the United States. Fluor Daniel is a leader in the development and execution of public-private partnership projects and has proven it is a reliable PPTA performer.

VDOT, working with Fluor Daniel, has set the standard in the United States for delivery of innovative transportation facilities through the development and construction of the Pocahontas Parkway (Route 895) project. Like the 895 project, Fluor Daniel's approach includes an innovative financial arrangement and an aggressive timetable for delivery of a completed Capital Beltway project. Fluor Daniel's 895 project proved that a major construction project can proceed at an accelerated pace without significant environmental impacts while involving a high percentage of local labor and firms.

Fluor Daniel will make the same commitment to bring these benefits and lessons learned to the completion of the Capital Beltway project. Fluor Daniel intends to offer the Commonwealth an aggressive and forward-looking financial package coupled with a project approach that minimizes the time between financial closing and making the new Capital Beltway HOT lanes available to the public.

The Fluor Daniel Team

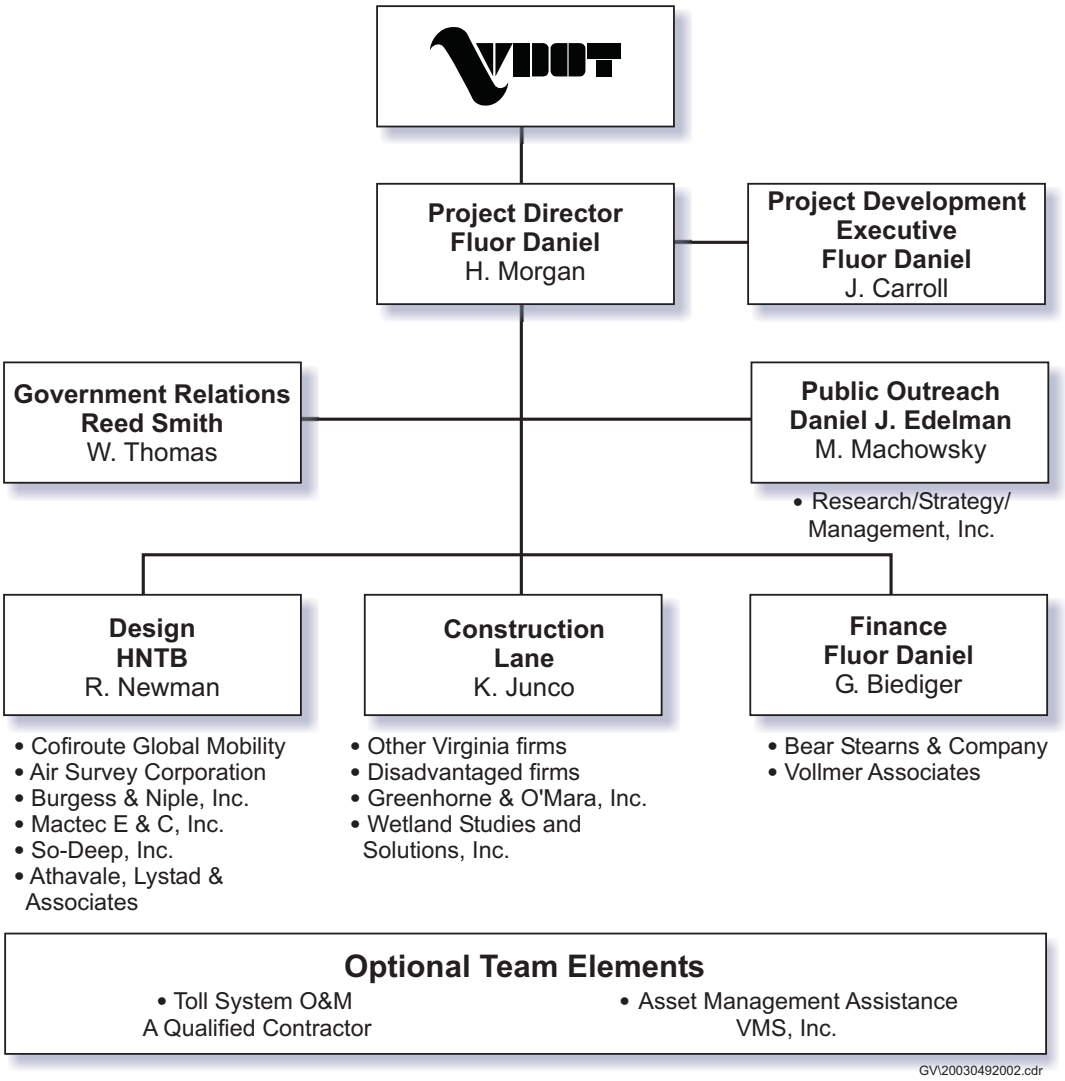


Figure 1-3. Project Team Development Phase Organization

The Fluor Daniel team is a fully-integrated organization that will develop, finance, and execute this complex project. The organization illustrated in Figure 1-3 will benefit from the core of experienced Fluor Daniel professionals who have "done it before with VDOT," eliminating the PPTA learning curve and allowing more time to focus on the timely development of the project. After signing the design-build agreement, the project team will shift its focus to successful fast-track design and construction.

Key Fluor Daniel team leaders include:

Jim Carroll, Project Development Executive – Having successfully led Fluor Daniel's team in the development of the Route 895 project, Jim will be in charge of the development effort. He will use his considerable development experience to fashion an innovative project financing and execution package to maintain a win-win approach for VDOT, the local area governments, and the traveling public.

Herb Morgan, Project Director – Having successfully completed the Route 895 project, Herb is available to direct the execution of this project.

William Thomas, Government Relations – William Thomas of Reed Smith LLP will be the team's government relations adviser.

Kirk Junco, Construction – Kirk is a vice president with Lane Construction who has managed the construction of numerous complex transportation and civil projects involving major bridge and road work such as the Springfield interchange. He will coordinate the fast-track design with the construction of the Capital Beltway.

Robert Newman, Design – Robert is director of engineering for the HNTB Alexandria office and is project manager for the I-95/I-395/I-495 interchange improvement. He will be the lead design manager for the project providing leadership and direction to all designers involved in the project.

Marty Machowsky, Public Outreach – Marty will develop and manage the community relations plan that will educate and inform local governmental officials, businesses, the driving public, and the public at large about the project to maintain and increase their support.

George Biediger, Finance – George was a key leader in developing the Route 895 financial plan as well as providing ongoing oversight. He will work with Fluor Daniel's underwriter **David Klinges** (Bear Stearns), bond counsel (Reed Smith), and VDOT to develop a workable financial plan.

A detailed listing of all subcontractors and their responsibilities can be found in Part 2 of this proposal.

The goal of the Fluor Daniel team is to have a minimum of 10 percent of project participation by DBE/MBE firms on the Capital Beltway project. Fluor Daniel is committed to a contracting approach that allows the maximum participation of Virginia- and Fairfax County-based DBE/MBE firms. Fluor Daniel has a listing of DBE/MBE firms certified by the Commonwealth of Virginia and their specific capabilities. Certified businesses will be accepted by Fluor Daniel as meeting the requirements to participate in the project's DBE/MBE program. The list is being used to develop a set of contracting packages that can be executed in a quality and profitable manner by these firms.

Fluor Daniel is prepared to start many of the project work activities well in advance of financial close providing for timely completion of the project. Backing these key project activities are firms that are recognized leaders in the engineering and construction industry: Fluor Daniel, Lane Construction, and HNTB. On *Fortune* magazine's 2003 Global Fortune 500 list, Fluor ranks number one in the "Engineering, Construction" category based on 2002 revenues. Lane Construction is ranked ninth in highway construction by *Engineering News-Record* (*ENR*). HNTB is third on *ENR*'s pure design firm list and is fourth in transportation design for 2003.

Part 2: Detailed Proposal Elements

The August 13, 2003, VDOT request for proposal contained a list of Capital Beltway HOT Lanes Proposal Elements that Fluor Daniel should address. For ease of review of and reference to our response in Part 2, Fluor Daniel has assigned a letter to each item as follows:

- 2-a Topographical Map/Typical Section
- 2-b Design Exceptions
- 2-c Sound Barrier Wall Estimate
- 2-d Impacted Public Utility Facilities
- 2-e Right-of-Way Requirements
- 2-f Right-of-Way Acquisition Plan
- 2-g Projected Level of Service
- 2-h PPTA Team Member Firms
- 2-i Project Schedule
- 2-j Construction Process
- 2-k Quality Control/Quality Assurance
- 2-l Performance-Based Specifications
- 2-m Estimating Methodology
- 2-n Financial Commitments/Obligations
- 2-o Preliminary Plan of Finance
- 2-p Assumptions
- 2-q Business Plan
- 2-r Guarantees and Warranties
- 2-s Government/Public Support
- 2-t Transit Enhancements
- 2-u Potential Staging Areas

2-a TOPOGRAPHICAL MAP/TYPICAL SECTION

A topographical map depicting the location of the proposed facilities in relation to the existing features, clearly identifying areas of widening, including both median and to the outside, the location and limits of any proposed toll facilities and the configuration of any proposed interchange improvements. Also include a drawing indicating the typical section(s) of any proposed improvements.

The plans (scale of 1"= 400') included in this section depict the proposed Capital Beltway HOT Lanes facility as follows:

- Two HOT lanes in each direction are shown in yellow, and operate as HOT/HOV lanes. Access to these lanes is provided at:
  - The beginning of the facility just south of Route 193 and just west of the Springfield interchange.
  - Dulles Airport Access/Toll Road and at the I-66 interchanges via direct ramp connections.
  - Intermediate access/egress points located near the Dulles Airport Access Road; Oak Street overpass; Route 236; and Braddock Road that will provide access from all other intermediate Beltway interchanges. See Figure 2-a.1 for typical access/egress layout.
- Electronic toll facilities will be located at all HOT lane access points.

The two HOT lanes are separated from the four general-purpose lanes by a 4-foot striped buffer containing yellow plastic pylons spaced at approximately 20 feet. Full 12-foot shoulders are provided along the median and the outside lanes. See Figure 2-a.1 for typical section.

2-b DESIGN EXCEPTIONS

The viability of a proposal without any design exceptions or how the proposing team plans to justify any design exceptions that will be required

The HOT lane section of the Capital Beltway has 8 interchanges with 59 ramps.

No design exceptions are required for the:

- Beltway mainline roadway
- Four interchanges
- 20 of 32 ramps at Route 123, Route 7, Route 236, and Route 620 interchanges
- Narrowing shoulders to no less than 4 feet at bridge piers

Design exceptions are required for 12 of 32 ramps at four interchanges including:

- Route 123 interchange 1 ramp
- Route 7 interchange 4 ramps
- Route 236 interchange 3 ramps
- Route 620 interchange 4 ramps

Total 12 ramps

- HOT lane concept meets current design standards for the mainline roadway and a majority of the interchange ramps.
- Only 12 interchange ramps will remain in as-built or better standard condition.
- Fluor Daniel expects FHWA approval of design exceptions for these 12 ramps because of the major additional displacement that would result.

Justification for Design Exceptions

If the 12 ramps identified above had to meet current design standards, which is not proposed by Fluor Daniel, major additional displacement and property takings would be required. A preliminary listing of the major structural and park displacements that would result from using current standards can be found in Table 2-b.1 that follows.

Table b-1.1. Inventory of Displacements That Could Result from Use of Current Design Standards

Interchange	No. of Ramps	Residential Structures	Multi-Unit Residential Structures	High-Rise Office Structures	Parkland	Access Roads
Route 123	1	0	0	1*	0	0
Route 7	4	0	0	4**	0	0
Route 236	3	4	3 Buildings (60 Apts.)	0	Yes – small	2
Route 620	4	6	0	0	Yes – 4 acres	0
Total	12	10	3	5	4+ acres	2

* Capitol One Building – 14-floor office building with attached seven-floor garage and several outbuildings

** 1–1951 Kidwell Drive Building – 8 floors with two lower-level parking floors
2–Tysons Doubletree Hotel, a 405-room hotel and conference center with attached two-floor garage structure
3–2000 Corporate Ridge Building – 10 floors with attached four-floor garage structure
4–2010 Corporate Ridge Building – 10 floors with attached four-floor garage structure

Fluor Daniel expects FHWA will approve the variances for these 12 ramps since they will be designed to as-built or better standards and because of the major displacement that would be required.

2-c SOUND BARRIER WALL ESTIMATE

An estimate of anticipated sound barrier wall needs for the proposed project. Include the methodology and reasoning used to develop the estimate

An estimated 250,000 square feet of existing sound barrier wall is required to be replaced and/or relocated as a result of the HOT lane concept as proposed. Fluor Daniel's proposal includes the replacement in kind and quantity of these walls. The replacement sound walls will be rebuilt to the same limits and top elevations including the required offsets from the highway. This proposal does not include provisions for any upgrade to the sound attenuation system currently in use, since Fluor Daniel had no basis on which to make such a decision.

A review of the Capital Beltway Noise Technical Report developed as part of the EIS effort indicates that a total of approximately 2,135,000 square feet of sound walls would be required for VDOT's Barrier-Separated HOV (4-2-2-4) Alternative, a similar but much more extensive concept than that proposed by Fluor Daniel. The need for additional noise attenuation efforts will be evaluated as part of the ongoing NEPA/FEIS effort. Once the need for additional noise walls, as well as other mitigating measures, is identified and quantified, Fluor Daniel will work with VDOT to incorporate them into the HOT lane project scope, if a build alternative is selected by VDOT. The NEPA Record of Decision will clearly define any such additional mitigation measures.

2-d IMPACTED PUBLIC UTILITY FACILITIES

An indexed listing of public utility facilities that will be impacted by the transportation facility with a statement including estimated cost for the proposer's plans to accommodate such utility facilities

The Fluor Daniel team has identified 13 utility owners that have facilities located along or crossing the Beltway corridor. These owners and their location are detailed on the chart in Figure 2-d.1. The proposed design and construction will affect some of these utility facilities and will require either protection or relocation. Because of the level of design available at this time, the proposed action for each specific utility is not currently known. Facilities located close to or within the proposed work are considered to be in conflict. The Fluor Daniel team estimates that it will cost approximately $10.5 million to protect or relocate the utilities. The impacts on utility facilities will be further examined during the preliminary design phase of the project.

Part of the preliminary design phase will be the identification of all utility facilities within the project corridor, including subsurface utility designation for underground utility facilities. Modification of the roadway design to eliminate or minimize the potential conflict will be the priority alternative. When a conflict is unavoidable, a cost-effective utility relocation design will be coordinated with the utility owner. Fluor Daniel will have consultant team members available to provide utility relocation design services for those utility owners needing assistance due to lack of available staffing or other resources.

Throughout the project development engineering process, Fluor Daniel will plan and coordinate the necessary utility relocations so that they are properly identified in the construction schedule. It is anticipated many of the utility relocations will not have a significant duration that may affect the overall completion of the construction of a particular segment.

The Fluor Daniel team will follow VDOT's Utility Relocation Policies and Procedures Manual in coordinating utility relocations and prorating cost responsibilities. Since the HOT lanes project is a public-private partnership, we have assumed the utilities will agree to work it as a normal VDOT project and waive any additional fees that may be charged for a private development project. Our estimate reflects the assumption that the utilities will not charge these additional fees and does not include such costs. We have estimated, however, that we will pay all normal costs associated with utility relocation.

Exit	Milepost	County	Description	Virginia Power (Transmission)	Virginia Power (Distribution)	Washington Gas	Fairfax County Water Authority	Falls Church Water	Fairfax County Sewer	Verizon	ACSI/E-Spire Communications	Arbrose Communications	Cox Communications	Level 3 Communications	Looking Glass Networks	MCI Telecommunications	Metro Media Fiber Network	PF Net / AT&T Long Dist	Teleport Comm Group
		Fairfax	Mainline																
44			Route 193 - Georgetown Pike																
			Mainline																
45			Dulles Airport Access Road																
			Mainline																
46			Route 123 - Chain Bridge Road																
			Mainline																
47			Route 7 - Leesburg Pike																
			Mainline																
49			I-66																
			Mainline																
50			Route 50 - Arlington Blvd.																
			Mainline																
51			Route 650 - Gallows Road																
			Mainline																
52			Route 236 - Little River Turnpike																
			Mainline																
54			Route 620 - Braddock Road																
			Mainline																

Assumptions:

1. This list is based on information gathered from VDOT, consultation with local utility companies and service authorities and supplemented with a limited amount of field verification.
2. Utility impacts are based on the proposed right of way acquisition and preliminary typical section developed for this study.

Legend:

Utility located in this project section

Utility adjustment required

Figure 2-d.1. Public Utility Involvement

2-e RIGHT-OF-WAY REQUIREMENTS

A statement of the right of way requirements for all area where the proposed design is anticipated to exceed the existing right of way limits, including all toll facilities and interchange improvements. Note right of way requirements if no design exceptions are granted, and if design exceptions are granted.

The Capital Beltway HOT Lane concept will stay within the existing right-of-way with the following exceptions:

- Four complete residential right-of-way displacements will be required along the ramp from EB Gallows Road to SB Beltway. Two other residential properties may be displaced as a result of final design requirements. They include one additional property along the ramp from EB Gallows Road to SB Beltway and one property along the ramp from SB Beltway to WB I-66. See plans in section 2-a for locations and the impacted property list in Figure 2-e.1.
- Four small parkland takings are required. See plans for locations.
- Fifty-eight small portions of property (no structures are displaced) will be required. See Figure 2-e.1 for a list of impacted property.

Fluor Daniel's HOT lane concept will:

- Generally stay within the right-of-way
- Displace only four residences and possibly two more – total
- Remaining property requirements will be small portions adjacent to the Beltway

Parcel Ref	E/W Ref	Tax Map	Current Owner	Parcel Address	Displacement	Fee Take Acres
ML						
						0.000
Rte 193						
						0.000
ML						
3	(983)E	021-3-15-0001	Poblete, Pio F. & Christina L.	01038 Delf Dr.		0.010
3A	(984)E	021-3-15-0002	Thomas, Gary & Donna L.	01036 Delf Dr.		0.019
3B	(985)E	021-3-15-0003	Yoon, Yong K. & Hae S.	01034 Delf Dr.		0.005
Dulles						
						0.000
7a		029-2-13-A	Snow Lear Homeowners Assn.	None assigned		0.226
10	(543)W	029-2-13-0016	Esherick, Mark & Aronson, Karen L.	07705 Lear Rd.		0.057
12	(946C)E	029-4-01-0003-A	Gates of McClean Development	07673 Old Springhouse Rd.		0.229
13	(508)W	029-2-15-A7	Gannett Co., Inc.	None assigned		0.065
Rte 123						
14	(464)W	029-4-01-0035-A	Lehndorff Tysons Property Joint Venture	07966 Tysons Corner Cnr.		0.089
15	(940)E	029-4-05-A2	Capital One Bank	None assigned		0.320
Rte 7						
16	(453)W	039-2-01-0012	Rappaport, Jerome L. Jr. Tr.	01951 Kidwell Dr.		0.092
17	(450)W	039-2-01-0013	Campus Point Realty Corporation II	07990 Boing Ct.		0.252
19	(439X)W	039-2-48-A	Tysons Executive Village	None assigned		0.866
20	(907)E	039-2-01-0062-B	New Boston Glenborough LLC	02000 Corporate Ri.		0.163
21	(906)E	039-2-01-0062-A	Teachers REA IV LLC	02010 Corporate Ri.		0.079
22	(893)E	039-2-01-0045-C	Tysons Corner Pt LP	07801 Leesburg Pl.		0.276
23	(887)E	039-2-01-0047-A	Lerner, Annette M. Et. Vir. & M. Lenkin Tr.	None assigned		0.145

Figure 2-e.1. Impacted Property List

Parcel Ref	E/W Ref	Tax Map	Current Owner	Parcel Address	Displacement	Fee Take Acres
ML						
24		039-2-01-0048	School Board of Fairfax County	07731 Leesburg Pl.		0.044
28	(863)E	039-4-06-0006-A	Delpriore, Donald A.	07805 Idylwood Rd.		0.056
29	(864)E	039-4-06-0007	Brothers, Thomas L.	07809 Idylwood Rd.		0.024
31	(438)W	039-4-54-A	Sandburg Park II Homeowners Assoc.	None assigned		0.106
33	(436)W	039-4-54-C	Sandburg Park II Homeowners Assoc.	None assigned		0.019
34	(412A)W	039-4-30-0004	Palfrey, Robert C.	02300 Morgan Ln.		0.064
35	(405)W	039-4-52-A	Morgan Chase Homeowners Association	None assigned		0.042
36	(404)W	039-4-01-0149	Spessard Family trust Home Investors Inc. Tr.	07836 Idylwood Rd.		0.056
37	(399)W	039-4-04-A-0001	Maher, Christopher	02401 Spring Street		0.053
I-66						
38	(271)W	039-4-04-B-0014	Randhawa, Inc.	07921 North Park St.		0.241
39		039-4-01-0139	Park Authority Northern Virginia Regional	None assigned (W&DO Regional Park)		0.130
40	(255)W	049-2-35-0007	Indellicate, John A. & Margaret W.	08000 Sandburg Ct.		0.040
41	(254)W	049-2-35-0008	Bui, Khai H. Et. Al.	08001 Sandburg Ct.	Maybe	0.039
42	(253)W	049-2-35-0009	Wilson, Emeline D.	08003 Sandburg Ct.		0.016
45	(235)W	049-2-03-0011	Cowett, Philip M. & Hedwine A.	02610 Sandburg St.		0.059
46	(372)W	049-2-01-0011	Shafer, Hugh A. M. Jr. Tr. & Johnson, Betty S.	02601 Stenhouse Pl.		0.037
52	(605)E	049-2-01-0054	McCaa, Gregg A.	07936 Shreve Rd.		0.116
ML						
56	(195B)W	049-4-06-22-0003	Ventura ADA, Villalobos, Erick	08002 Le Havre Place		0.838
Rte. 50						
57	(5631)E	049-4-01-0073	Fairview Property Investments LLC	None assigned		0.205
58	(189A)W	049-4-01-0057	Mobil Fairfax, Inc.	03225 Gallows Rd.		0.179

Figure 2-e.1. Impacted Property List

Parcel Ref	E/W Ref	Tax Map	Current Owner	Parcel Address	Displacement	Fee Take Acres
59	(563B)E	049-4-01-0072	3120 Fairview LLC	03112 Fairview Park Dr.		0.115
59A	(563E)E	059-2-26-0004	Prentiss Properties Acquisition Partners LP	03130 Fairview Park Dr.		0.075
Rte. 650						
60	(557)E	059-2-06-0009	Electric & Power Co. Virginia	03351 Gallows Rd.		0.142
61	(159)W	059-2-05-0021	Crowell, Glenn D.	03419 Luttrell Rd.	Maybe	0.021
62	(147)W	059-2-05-0002	Mills, Mark A. & Deborah A.	03427 Luttrell Rd.	Yes	0.633
63	(146)W	059-2-05-0003	Scalia, John L. & Margaret C.	03429 Luttrell Rd.	Yes	0.308
64	(145)W	059-2-05-0004	Vickery, Doug Tr.	03433 Luttrell Rd.	Yes	0.285
65	(137)W	059-2-05-0005	Colton, Ana G.	03437 Luttrell Rd.	Yes	0.311
Rte. 236						
66	(291A)E	059-4-18-P	Lafayette Village Community Association Care Armstrong Association, Inc.	None assigned		0.867
67	(275)E	070-2-01-0001-G	Karkenny, Moses H.	None assigned		0.309
68		059-4-01-0009	Milton Co.	None assigned		1.119
69	(49)W	070-4-01-0002	Park Authority Fairfax County	08100 Braddock Pl. (Americana Park)		0.120
Rte. 620						
71	(45A)W	070-4-01-0002	Park Authority Fairfax County	08100 Braddock Pl. (Wakefield Park)		1.375
72	(244A)E	070-4-01-0002-A	Park Authority Fairfax County	04966 Americana Dr. (Fitzhugh Park)		0.003
73	(208)W	070-4-06-0026	Pendleton, Lee W.	07905 Kalorama Rd.		0.016
75	(21)E	070-4-10-0002-B2	Port Royal Rd. General Partnership Care Summit Enterprise #302	05261 Port Royal Rd.		0.022
76	(17)E	070-4-10-0002-B1	Jones Investment Assoc. Two	05265 Port Royal Rd.		0.052
77	(16)W	070-4-10-0503	Elman Springfield Assoc. LP	05271 Port Royal Rd.		0.178
77A	(16)W	070-4-10-0503-A	Elman Springfield Assoc. LP	05285 Port Royal Rd.		0.064

Figure 2-e.1. Impacted Property List

Parcel Ref	E/W Ref	Tax Map	Current Owner	Parcel Address	Displacement	Fee Take Acres
81	(42)E	070-4-04-59-0029	Nguyen, An N. & Dang, Minh T. T.	05330 Ravensworth Rd.		0.021
82	(41)E	070-4-04-59-0030	Dolan, Mark C. & Mary A.	05328 Ravensworth Rd.		0.025
83	(39)E	070-4-04-59-0031	Gerndt, John G. & Angelina E.	05326 Ravensworth Rd.		0.025
ML						
						0.000

Figure 2-e.1. Impacted Property List

2-f RIGHT-OF-WAY ACQUISITION PLAN

A statement setting out a plan for securing and/or contributing all necessary property for the completion of the proposed project. The statement must include the names and addresses, if known, of the current owners of the property as well as a list of any property the proposer intends to request the Commissioner to condemn. Also including an estimate of the costs for acquisition of the property and the proposed source of funding for the acquisition

The Fluor Daniel team has determined that the acquisition of additional right-of-way will be necessary along the project corridor. The need for this property includes areas for roadway widening, retaining walls, sound walls, and utility easements.

We anticipate that our proposed design will require the acquisition of 58 fragments of land and the possible relocation of up to six homes. At this time, four residential structures and possibly two more have been identified for displacement. Most of the small portions to be acquired are narrow strips along the existing right-of-way.

As a part of the project development engineering, Fluor Daniel's engineering consultant team members will work closely to coordinate the roadway design with consideration to the impacts on right-of-way requirements. Alternatives will be considered to minimize any additional right-of-way needs and to avoid displacing any additional structures.

The Fluor Daniel team is prepared to acquire the necessary right-of-way for the Commonwealth and to provide relocation assistance services to the displaced individuals in accordance with the Uniform Relocation Assistance and Real Property Acquisition Laws. Adequate time will be established in the project schedule to allow the affected landowners and tenants to consider the acquisition and relocate.

As the project development schedule is established for each segment of the corridor, the parcels to be acquired will be prioritized based on the anticipated construction sequencing and the necessity for utility relocations. Parcel acquisition groupings will be identified in the segment schedule with start and finish dates conforming to the overall segment schedule. Throughout the project development timeframe, these acquisition grouping line items will be tracked to ensure the schedule is being met.

The Fluor Daniel team will monitor development activities along the corridor as the roadway plans are being prepared. The team will make every effort to see that the project right-of-way requirements are provided for in new development plans. Advance acquisitions will be made, where appropriate, to prevent costly development from occurring within the anticipated right-of-way limits.

In those instances where a right-of-way acquisition is clearly identified as a total parcel take, the Fluor Daniel team will proceed with those acquisitions in advance of the remaining partial acquisition requirements. This sequencing will ensure that any displaced family or business will have sufficient time to complete its relocation.

While the Fluor Daniel team will make every reasonable effort to negotiate the voluntary conveyances of the necessary additional right-of-ways or easements, it is anticipated that agreements will not be reached on all properties. There may be some properties where title defects or unknown landowners will require the use of eminent domain statutes. In all of these situations, Fluor Daniel will request that VDOT initiate an eminent domain proceeding by filing a Certificate of Take. Fluor Daniel will request VDOT and the Office of the Attorney General manage the cases through appointed counsel.

The Fluor Daniel team is also prepared to use and maintain data in VDOT's computerized Right-of-Way and Utilities Management System (RUMS). VDOT would have online access to the latest right-of-way acquisition and relocation assistance data. This accessibility by both parties would not only enhance the logistical coordination of the acquisitions, but would also allow VDOT to use RUMS reports to monitor the overall progress.

2-g PROJECTED LEVEL OF SERVICE

An explanation of how the proposer intends to satisfy the Level of Service (LOS) design criteria requirements for projects on the National Highway System, which mandates that any proposed design accommodate the projected traffic with a minimum of a 20 year horizon, including all mainline lanes and interchanges. This should include a detailed listing of all known traffic safety issues associated with the project including interchange capacity, weave/merge areas and conventional lane impacts associated with the construction of the HOT facility.

National Highway System roadways should generally operate at LOS C or better throughout the day. According to the Transportation Technical Report for the Capital Beltway Study (March 2002*),* today's Capital Beltway operates below those levels for most of the segments between Springfield and Georgetown Pike. Table 2-g.1 identifies the LOS for both the a.m. and p.m. peak hours.

Table 2-g.1. Existing Levels of Service on Capital Beltway Segments

Segment	AM Peak LOS		PM Peak LOS	
	Northbound	Southbound	Northbound	Southbound
Springfield to Braddock Rd.	F	E	E	F
Braddock Rd. to Little River Turnpike	F	C	D	F
Little River Tpke. To Gallows Road	F	C	C	F
Gallows Road to US Route 50	F	D	C	F
US Route 50 to I-66	F	D	E	F
I-66 to Leesburg Pike	F	D	C	F
Leesburg Pike to Chain Bridge Road	F	D	C	F
Chain Bridge Road to Georgetown Pike	F	F	F	F

The HOT lane concept will:

- Assure LOS C or better on the HOT lanes
- Improve LOS on GP lanes
- Improve overall safety

None of the previous studies that examined traffic operations on the Capital Beltway were able to identify any improvements that would permit the facility to operate at acceptable levels of service during the peak periods. While several alternatives provided relief during parts of the day, traffic would operate at level of service F throughout the peak period of the day for the design year.

Previous studies examined the peak hour of the morning and evening rush hours. None evaluated the full duration of the severely congested conditions. Currently, the Capital Beltway experiences severe congestion on many of the identified links for more than a single morning and evening peak hour. In the future, congestion will extend through much of the day.

The HOT lanes offer relief from congestion in two ways. First, the hours during which traffic operates at LOS F will decrease with the added capacity offered by the additional lanes. Second, the HOT lanes themselves will offer a congestion-free alternative to the general-purpose lanes. The qualitative analysis cited above noted the peak hour operating conditions on several segments of the HOT lanes of the Capital Beltway. These conditions are summarized in Table 2-g.2.

Table 2-g.2. Future LOS on Selected Segments of the HOT Lanes on the Capital Beltway

Segment	Peak LOS
Springfield to Braddock Rd.	A
I-66 to Leesburg Pike	A
Chain Bridge Road to Georgetown Pike	B

The result of the implementation of the HOT lanes, therefore, would be to reduce congestion over the course of the day on the general-purpose lanes and to offer an uncongested alternative to Beltway travel.

Fluor Daniel intends to conduct more detailed travel demand forecasting and operational modeling in subsequent phases of this project. That analysis will quantify the reduction in congestion and extent to which mainline, HOT lanes, and ramps can meet the criteria for roadways within the National Highway System.

HOT lane user characteristics were also evaluated. They were found to be very similar to existing Beltway origin-destination patterns as well as proposed EIS alternatives' characteristics. See Appendix A for detailed analysis and comparison.

Safety on the Capital Beltway

The Capital Beltway was designed to the standards in effect at the time of construction. Subsequent improvements to the facility have corrected and even improved deficiencies that have become apparent. The Fluor Daniel HOT Lanes proposal would make further improvements in some of the remaining safety deficiencies and, in no case, would other aspects of the road be degraded.

The Capital Beltway within the project limits includes two left-hand exits: one from northbound I-495 to westbound I-66, and a second from northbound I-495 to the westbound Dulles Access/Toll Road (VA 267). Left-hand entrance and exits ramps are no longer considered desirable given the disparity between travel speeds of the entering or exiting traffic with traffic on the mainline. The preferable condition of traffic entering or exiting from the slowest moving lane, the right lane, is now the standard and is used at all other ramps on this section of the Beltway.

The left-lane exits also increase and complicate weaving maneuvers. Vehicles entering the northbound Capital Beltway and intending to exit at I-66 or the Dulles Access/Toll Road must move across four existing lanes of traffic. Traffic entering at US Route 50 has little distance in which to weave across the four through lanes, creating an undesirable condition.

The proposed HOT lanes would eliminate the left-lane exits at both I-66 and the Dulles Access/Toll Road for traffic on the general-purpose lanes. Right-lane exits would be constructed between the Capital Beltway and these intersecting freeways. HOT lane traffic would continue to have a left-lane exit but traffic would be traversing two lanes, not nearly the challenge of the current four-lane mainline Beltway configuration. The HOT lanes would further reduce weaving by removing a portion of the through traffic into the HOT lanes and away from entering and exiting traffic. Consequently, entering and exiting traffic will interact with local traffic but not the HOT lane.

The most significant safety issue associated with the Capital Beltway today relates to the accidents caused by congestion. The Capital Beltway Safety Update determined that 77 percent of the accidents on the Beltway were caused by stopping/slowing, a type of accident most directly attributable to congestion. The Capital Beltway High Occupancy Toll (HOT) Lanes Safety Study (see Appendix B) evaluated the relationship between congestion and safety and the potential effect that HOT lanes might have on the accident rate. The study concluded that:

> The greatest potential improvement in safety on the Beltway…would be from the reduction in congestion, which is directly related to accident rate. An analysis of four years of VDOT accident and traffic volume data on the Capital Beltway shows that the accident rate is highest in stop-and-go conditions typical of extremely congested conditions technically known as oversaturated regime. When congestion is reduced from severe to moderate, accident rates drop considerably. The HOT lanes could be priced to remove sufficient traffic from the general purpose lanes to improve operations from severely congested to a more stable or near-capacity operation, thereby reducing accident potential and also increasing throughput of the road.

The proposed HOT lanes would eliminate the left-hand exits, reduce the volume of weaving traffic, and reduce congestion, which is the major contributor to accidents on the Beltway. The resulting facility would be measurably safer than today's Beltway.

2-h PPTA TEAM MEMBER FIRMS

A list of all PPTA team member firms and their respective responsibilities

Fluor Daniel has assembled a world-class team experienced in the financing, design, and construction of projects similar to the Capital Beltway HOT Lanes project. Following are the team members and their respective responsibilities:

Firm	Responsibility
Fluor Daniel	Overall Management – Project Development and Execution
HNTB Corporation	Design and CE&I
• Cofiroute Global Mobility*	Toll Operations Consultant
• Air Survey Corporation*	Mapping
• Burgess & Niple, Inc.*	Surveying
• Mactec E & C, Inc.*	Geotechnical
• So-Deep, Inc.*	Subsurface Utility Designation
• Athavale, Lystad & Assoc.*	DBE Designer
The Lane Construction Corporation	Lead Civil Contractor
• Other Virginia firms	To be identified
• Disadvantaged firms	To be identified
Vollmer Associates	Traffic and Revenue Forecasting
Greenhorne & O'Mara, Inc*	Utilities and Right-of-Way Acquisition
Wetland Studies and Solutions, Inc.	Wetland Permitting and Mitigation
Bear Stearns & Company	Bond Underwriter
Research/Strategy/Management, Inc.	Opinion Polling
Reed Smith LLP	Government Relations
VMS, Inc.	Asset Management
Daniel J. Edelman Company*	Public Outreach

* New firm, not included in the Conceptual Proposal

2-i PROJECT SCHEDULE

A schedule for the overall project and for each section or segment of the project showing the sequence and interdependence of activities required for completion of the work, the date on which work will commence and the contemplated dates for completing items of work. The initial baseline schedule should include either diagrams or bar charts and tabular schedule reports showing start and finish dates. Intermediate completion milestones shall be included. The diagram shall clearly depict the order, interdependence and duration of each activity. The diagram shall be neatly lettered and legibly drawn. A written narrative of the initial baseline schedule shall be submitted and describe each element shown. For your schedule, assume January 1, 2005 as the date of the Record of Decision for the project.

The baseline schedule shall include, but not be limited to:

1. **Any required legislative actions or regulatory approvals**
2. **Preliminary design**
3. **NEPA compliance activities**
4. **Finalization of Finance Plan**
5. **Environmental permitting**
6. **Design Completion**
7. **Right-of-way acquisition**
8. **Utility relocation work by public and private utility companies**
9. **Construction**
10. **Coordination with Dulles Rail project**
11. **Paving activities**
12. **Completion date**

The Fluor Daniel team has prepared a proposed project schedule. The schedule has been broken into five main categories, Project Level and Areas 1 through 4. Descriptions of these categories are as follows:

- **Project Level** – This category details the process to bring the project to financial close, as well as any activities that will be managed on a corridor-wide basis. The project level has been further broken down into the following five subsections:
  - ***Project Development*** – This section details the process required to sign a development agreement between VDOT and Fluor Daniel. It is estimated that this agreement will be signed by early February 2004. This agreement will commit Fluor Daniel to the scope of services needed to reach financial closing. Once the agreement is signed, Fluor Daniel will begin a detailed traffic and revenue study to verify the assumptions used to generate our preliminary finance plan.
  - ***NEPA Analysis and Permitting*** – If a build alternative is selected by VDOT, the record of decision (ROD) should be completed by January 1, 2005. This date assumes that the VDOT decision will be in the spring of 2004 as part of the independent NEPA process. Once the development agreement has been signed, the Fluor Daniel team will begin preliminary design at its risk to expedite the permitting process. Our goal is to have the permits completed by May 2005.

- ***Design-Build Contract Negotiations*** – The Fluor Daniel team will begin the preliminary design required to fix a lump-sum price if the Commonwealth Transportation Board (CTB) chooses a preferred alternative that is consistent with the HOT lane concept proposed by Fluor Daniel. It is anticipated that the CTB selection will occur in March 2004. Upon completion of the record of decision, Fluor Daniel will begin negotiations for a Design-Build Comprehensive Agreement with VDOT. Fluor Daniel anticipates that a signed agreement could be completed in April 2005.
- ***Finance*** – Upon receipt of the ROD, Fluor Daniel will begin to finalize the project plan of finance. At this time, Fluor will formally submit the TIFIA loan application. It is estimated that six months will be required for a TIFIA loan commitment. Once the commitment is made, environmental permits are complete, and the design-build contract is signed by VDOT, the bonds will be sold to finance the non-TIFIA or VDOT portion of the project. Financial close and a notice to proceed are anticipated in July 2005.

Fluor Daniel's schedule will:

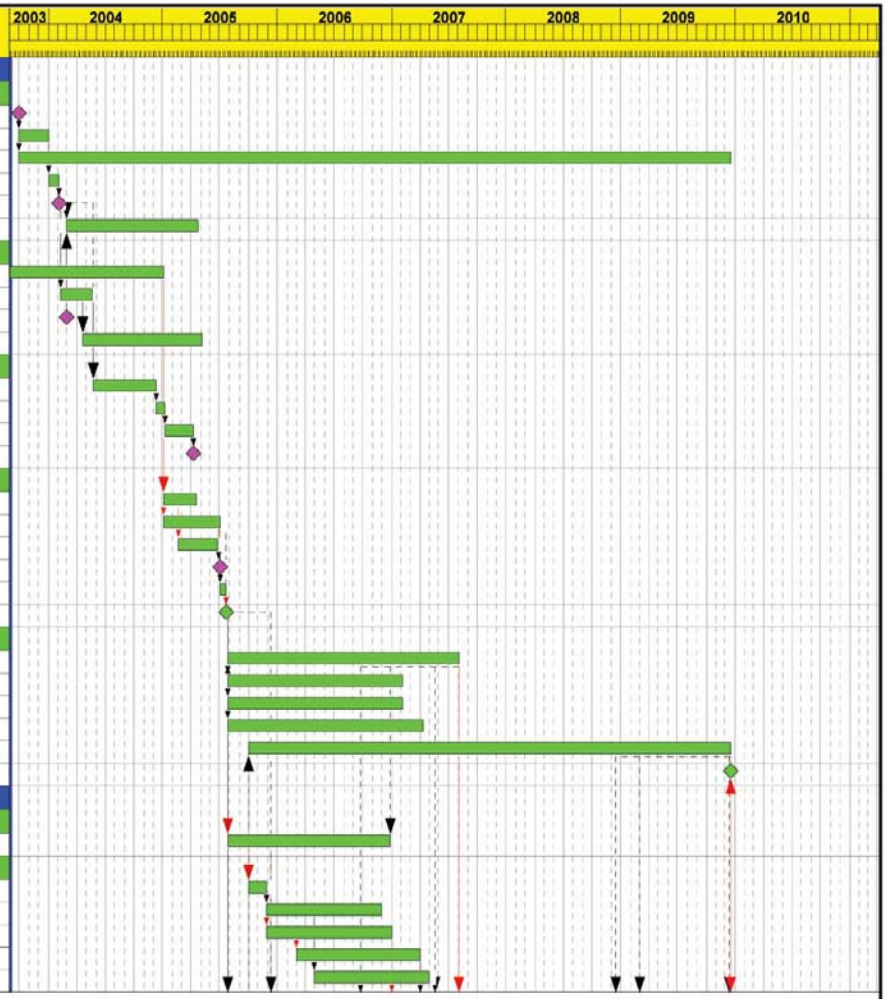
- Start design at risk before ROD
- Begin construction October 2005, if ROD approved
- Finish construction December 2009

- ***Project-Wide/Global Activities*** – Right-of-way acquisition, final design, utility relocations, and coordination with the Dulles Rail project will begin immediately after the design-build contract has been signed. Since ROW acquisition will be minimal, we anticipate having the ROW acquired in 18 months. Final design will take approximately two years to complete.

- **Area 1** – From the southern terminus of the project near Hemming Avenue to just past the Little River Turnpike interchange. Area 1 will begin final design in July 2005 and complete construction in March 2009.
- **Area 2** – From the end of Area 1 to just south of the I-66 interchange. Area 2 will begin final design in December 2005 and complete construction in December 2008.
- **Area 3** – From the end of area 2 to just north of the Leesburg Pike interchange. Final design for Area 3 will begin in July 2005 and construction will complete December 2009. This area is the most complex because of I-66 and the reconfiguration of the Leesburg Pike interchange.
- **Area 4** – From the end of area 3 to the northern terminus of the project at the Georgetown Pike interchange. This area will begin final design in December 2005 and complete construction in December 2009.

Based on this proposed schedule, the HOT lanes will be completed in December 2009.

Activity ID	Activity Description	Orig Dur	Early Start	Early Finish
Project Level				
Project Development				
P10000	Submit Detailed Proposal	0	01OCT03*	
P10100	Comment/Review Period to Detailed	68	01OCT03	02JAN04
P10500	Public Outreach and Information Program	1,621	01OCT03	16DEC09
P10700	Negotiate Development Agreement	25	05JAN04	06FEB04
P10800	Sign Development Agreement	0		06FEB04
P10400	Traffic and Revenue Study	300	01MAR04	22APR05
NEPA Analysis and Permitting				
P10200	FEIS Analysis & Record of Decision Process	489	01SEP03*	01JAN05
P11015	Design for Permits	75	09FEB04	21MAY04
P10210	CTB Selects Preferred Alternative	0	01MAR04*	
P11000	Obtain Permits	275	19APR04	06MAY05
Design/Build Contract Negotiations				
P10010	Preliminary Design	143	24MAY04	08DEC04
P10015	Estimate Lump Sum Price	30	09DEC04	07JAN05
P10300	Negotiate Design/Build Contract	65	10JAN05	08APR05
P10600	Sign Design/Build Contract	0		08APR05
Finance				
P10900	Finalize Project Financing Plan	75	03JAN05	15APR05
P10905	TIFIA Loan Processing	130	03JAN05	01JUL05
P10907	Bond Document Preparation	90	21FEB05	24JUN05
P10906	TIFIA Commitment	0		01JUL05
P10908	Bond Sale	15	04JUL05	22JUL05
P10910	Financial Close	0		22JUL05
Project Wide/Global Activities				
P11100	Final Design	739*	25JUL05	02AUG07
P12200	Right of Way Acquisition	400	25JUL05	02FEB07
P12300	Ulitity Relcations	400	25JUL05	02FEB07
P12400	Coordination with Dulles Rail	450	25JUL05	13APR07
P12100	Construction: Total	1,098*	03OCT05	16DEC09
P12110	Project Completion	0		16DEC09
Area 1: Heming Av-Little River Turnpike (North)				
Design				
A10000	Final Design Area 1	375	25JUL05	29DEC06
Construction				
A10001	Mobilization, Initial Survey, Clearing	60	01OCT05	29NOV05
A10002	Grade/Drain Widen Outer Loop Beltway to	365	30NOV05	29NOV06
A10004	Braddock Road Overpass - Stage 1	396	30NOV05	30DEC06
A10007	Little River Turnpike Overpass - Stage 1	397	01MAR06	01APR07
A10003	Grade/Drain Widen Inner Loop Beltway to	366	01MAY06	01MAY07



Start Date	01SEP03	I495	Sheet 1 of 3
Finish Date	16DEC09		
Data Date	01SEP03		
Run Date	23SEP03 09:47		

Capital Beltway HOT Lanes
Proposed Project Schedule

Date	Revision	Checked	Approved

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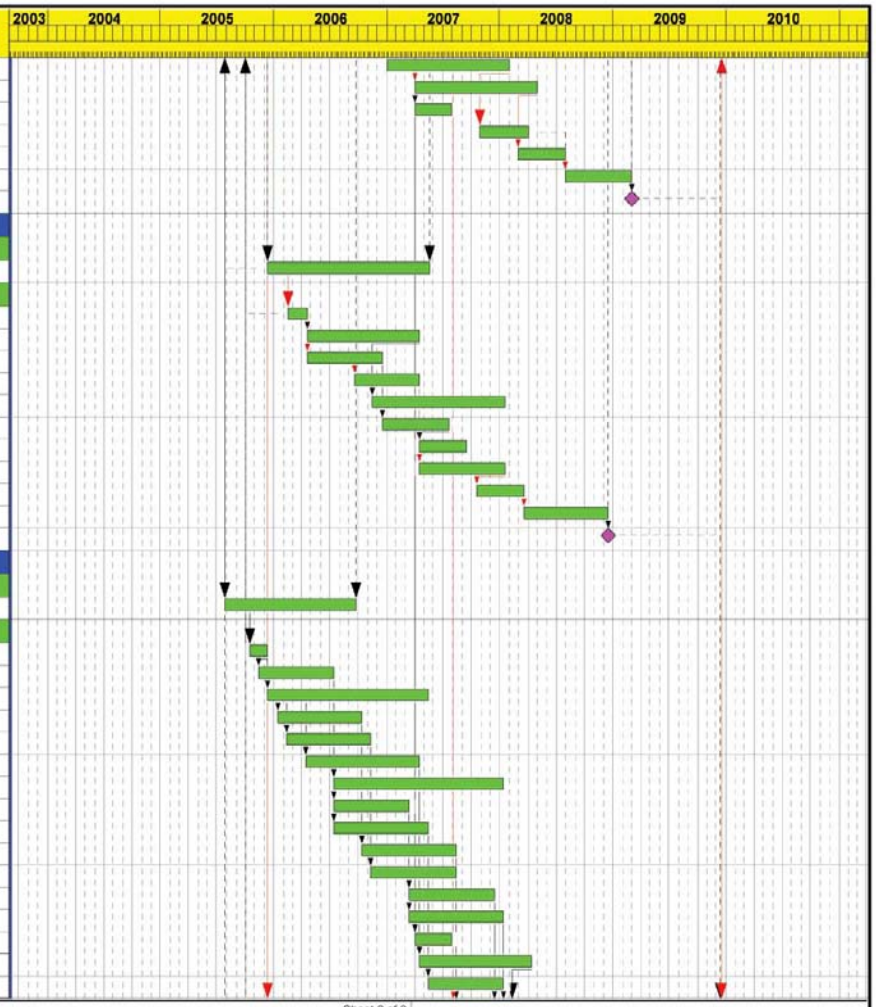
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish
A10005	Braddock Road Overpass - Stage 2	395	31DEC06	29JAN08
A10008	Little River Turnpike Overpass - Stage 2	395	02APR07	30APR08
A10009	Pedestrian Bridge over Beltway	121	02APR07	31JUL07
A10006	Revise Braddock Road Ramps	154	30OCT07	31MAR08
A10010	Revise Little River Turnpike Road Ramps	153	29FEB08	30JUL08
A10011	Mill, Overlay Pavement for HOT Lanes	215	31JUL08*	02MAR09
A10021	Complete Area 1	0		02MAR09
Area 2: Little River Turnpk (N)-I66 Interchg (S)				
Design				
B10000	Final Design Area 2	375	12DEC05	18MAY07
Construction				
B10001	Mobilization, Initial Survey, Clearing	60	18FEB06	18APR06
B10002	Grade/Drain Widen Outer Loop Beltway to	365	19APR06	18APR07
B10004	Gallows Road Overpass - Stage 1	243	19APR06	17DEC06
B10007	Widen Beltway Outer Loop Bridge over Rte 50	213	18SEP06	18APR07
B10003	Grade/Drain Widen Inner Loop Beltway to	427	16NOV06	16JAN08
B10005	Gallows Road Overpass - Stage 2	214	18DEC06	19JUL07
B10006	Revise Gallows Road Ramps	153	18APR07	17SEP07
B10008	Widen Beltway Inner Loop Bridge over Rte 50	273	19APR07	16JAN08
B10009	Revise Rte 50 Ramps	151	19OCT07	17MAR08
B10010	Mill, Overlay Pavement for HOT Lanes	273	18MAR08*	15DEC08
B10020	Complete Area 2	0		15DEC08
Area 3: I66 Interchg (South)-Rte 7 (North)				
Design				
C10000	Final Design Area 3	306	25JUL05	25SEP06
Construction				
C10001	Mobilization, Initial Survey, Clearing	60	15OCT05	13DEC05
C10004	I-66 EB Bridge over HOT - Stage 1	244	12NOV05	13JUL06
C10002	Grade/Drain Widen Outer Loop Beltway to	517	14DEC05	14MAY07
C10015	Idylwood Road Overpass - Stage 1	274	13JAN06	13OCT06
C10006	I-66 WB Bridge over Outer Loop Hot - Stage 1	274	12FEB06	12NOV06
C10019	Rte 7 Overpass - Stage 1	366	14APR06	14APR07
C10003	Grade/Drain Widen Inner Loop Beltway to	550	13JUL06	13JAN08
C10005	I-66 EB Bridge over HOT - Stage 2	245	14JUL06	15MAR07
C10010	I-66 WB Bridge over Inner Loop Hot - Stage 1	305	14JUL06	14MAY07
C10016	Idylwood Road Overpass - Stage 2	304	14OCT06	13AUG07
C10007	I-66 WB Bridge over Outer Loop Hot - Stage 2	274	13NOV06	13AUG07
C10008	Beltway Inner Loop Ramp left to I-66	273	16MAR07	13DEC07
C10012	I-66 EB Bridge over Inner Loop Hot - Stage 1	304	16MAR07	13JAN08
C10014	Pedestrian Bridge over Beltway	121	02APR07	31JUL07
C10020	Rte 7 Overpass - Stage 2	365	15APR07	13APR08
C10011	I-66 WB Bridge over Inner Loop Hot - Stage 2	244	15MAY07	13JAN08



Start Date 01SEP03 | I495
Finish Date 16DEC09
Data Date 01SEP03
Run Date 23SEP03 09:47

Sheet 2 of 3

Capital Beltway HOT Lanes
Proposed Project Schedule

Date	Revision	Checked	Approved

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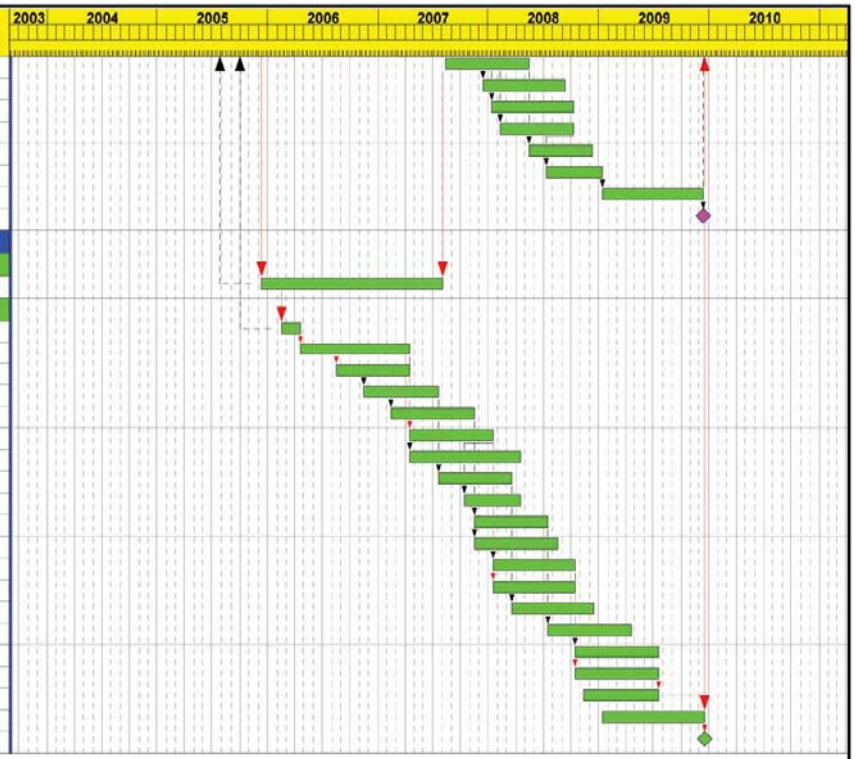
Activity ID	Activity Description	Orig Dur	Early Start	Early Finish
C10017	Oak Street Overpass - Stage 1	274	14AUG07	13MAY08
C10009	Beltway Inner Loop Ramp left to I-66	273	14DEC07	11SEP08
C10013	I-66 EB Bridge over Inner Loop Hot - Stage 2	273	14JAN08	12OCT08
C10022	Revise Rte 7 Ramps	244	12FEB08	12OCT08
C10018	Oak Street Overpass - Stage 2	213	14MAY08	12DEC08
C10021	Revise I-66 Ramps	185	12JUL08	12JAN09
C10023	Mill, Overlay Pavement for HOT Lanes	335	13JAN09	13DEC09
C10033	Complete Area 3	0		14DEC09
Area 4: Rte 7 (North)-Georgetown Pike Overpass				
Design				
D10000	Final Design Area 4	429	12DEC05	02AUG07
Construction				
D10001	Mobilization, Initial Survey, Clearing	60	18FEB06	18APR06
D10002	Grade/Drain Widen Outer Loop Beltway to	365	19APR06	18APR07
D10004	Widen Beltway Bridge over Rte 123 - Stage 1	244	17AUG06	17APR07
D10006	Widen Beltway Inner Loop Bridge over EB/NB	245	16NOV06	18JUL07
D10007	Widen Bltwy Inner Loop Bridge over	275	15FEB07	16NOV07
D10005	Widen Beltway Bridge over Rte 123 - Stage 2	273	18APR07	15JAN08
D10003	Grade/Drain Widen Inner Loop Beltway to	365	19APR07	17APR08
D10008	Widen Bltwy Inner Loop Bridge over WB Toll	243	19JUL07	17MAR08
D10017	Revise Rte 123 Ramps	185	16OCT07	17APR08
D10009	Widen Beltway Outer Loop Bridge over	244	17NOV07	17JUL08
D10016	Beltway Bridge (Slab Span) over Scotts Run	274	17NOV07	16AUG08
D10012	Lewinsville Road Overpass - Stage 1	274	16JAN08	15OCT08
D10014	Old Dominion Drive Overpass - Stage 1	274	16JAN08	15OCT08
D10010	Widen Bltwy Outer Loop Bridge over	273	18MAR08	15DEC08
D10011	Widen Beltway Outer Loop Bridge over WB	274	18JUL08	17APR09
D10013	Lewinsville Road Overpass - Stage 2	275	16OCT08	17JUL09
D10015	Old Dominion Drive Overpass - Stage 2	275	16OCT08	17JUL09
D10018	Revise Dulles Toll Road Ramps	245	15NOV08	17JUL09
D10019	Mill, Overlay Pavement for HOT Lanes	335	16JAN09	16DEC09
D10029	Complete Area 4	0		16DEC09



Start Date	01SEP03	I495
Finish Date	16DEC09	
Data Date	01SEP03	
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Sheet 3 of 3

Capital Beltway HOT Lanes
Proposed Project Schedule

Date	Revision	Checked	Approved

2-j CONSTRUCTION PROCESS

A detailed construction process to include the inspection and record keeping standards and requirements to be used

A key component of Fluor Daniel's construction process includes using work management teams (WMTs) to achieve total team integration. By including personnel from VDOT and Fluor Daniel design and construction groups in the WMTs, Fluor Daniel can achieve total integration of functional expertise from the beginning of the project through construction to project completion and final acceptance as shown in Figure 2-j.1.

The WMT structure promotes open communication within the team, sharing of ideas, and informed decision-making. These are necessary elements for the effective integration of the design, construction, and quality functions. Based on our past working relationships, Fluor Daniel team members have found that groups organized in this way are more knowledgeable of the overall design and construction status. Enabling the team to obtain the broadest range of knowledge about all areas of the project leads to effective integration of constructibility and maintainability into the design process where the greatest benefit to life cycle costing can be achieved. WMTs also facilitate open communications and more informed and timely decision making. WMTs enable the project team to address problems earlier and implement corrective actions more efficiently than traditional hierarchical organizational approaches.

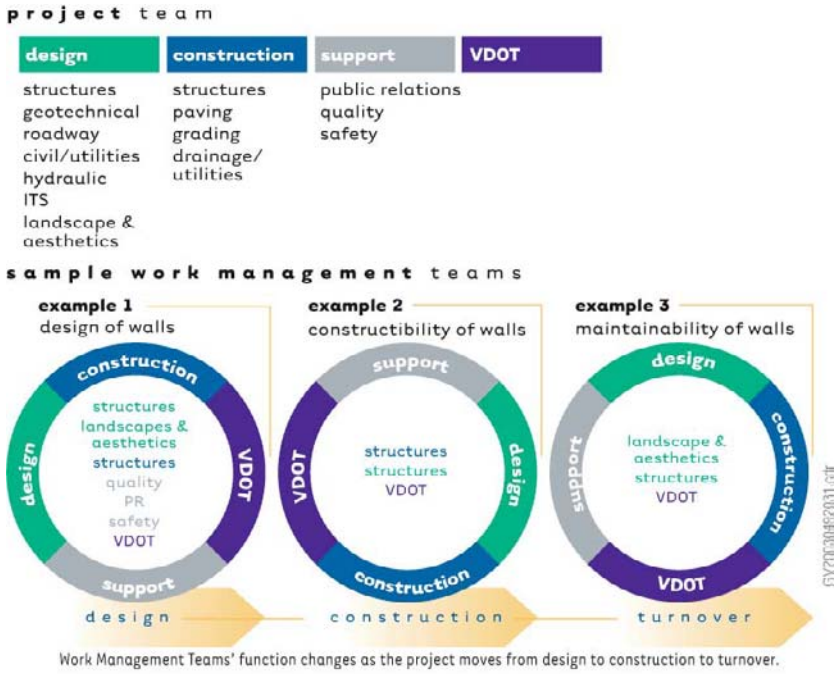


Figure 2-j.1. Examples of How Work Management Teams Integrate Resources to Resolve Issues

The function of the WMTs will change as the project moves from development to detail design to construction and to turnover. During the design phase, VDOT will be able to communicate directly with the designers in each discipline and listen to the input from the construction and quality functions. This interface will lead to greater design review efficiency for VDOT. As the project moves into the construction phase, the WMTs will provide opportunities for construction personnel, quality inspectors, and VDOT to communicate and resolve issues, for traffic management to provide and receive input into construction activities, and for public relations to provide feedback from the public and obtain project updates for public distribution. By participating in the WMTs, VDOT's awareness of the project status and issues will be enhanced because its staff will be fully integrated in the problem-solving process on a daily basis.

Key Functions of Construction Process

Project Management

Fluor Daniel has selected a highly competent and experienced management team to lead this important project. Fluor Daniel's Project Director, Herb Morgan, has led the team through the proposal development and developed an in-depth knowledge of the project. Herb carefully interviewed and subsequently approved the key members of his project management team. He knows their individual strengths, experience, and capabilities and is confident in their management and team-building attributes.

Herb has extensive experience with design-build projects, major highway construction, and the public-private initiative process used on the Route 895 project. He will be the single point of responsibility for the project and will report directly to VDOT. Herb's in-depth knowledge of the project, gained by his involvement with the proposal, places Fluor Daniel well up the learning curve. Herb will oversee all project operations and will be responsible for making final decisions regarding administrative, technical, and contractual matters.

Design

To lead the design, Fluor Daniel has selected HNTB. HNTB is currently ranked as one of the top design firms in the transportation design industry by *ENR*. Elements of our design management approach include:

- A matrix organization that facilitates communications between the design and construction functions and VDOT.
- An experienced highway design team under the leadership of a design manager with proven national design-build project experience. This design team also has significant highway design experience with VDOT.

- An organized approach to partnering for the duration of the project to achieve maximum coordination among the various project functions, VDOT, and stakeholders. This aspect of partnering is important to make certain that the viewpoints of VDOT, construction, utilities, other local stakeholders and the public, and our quality and safety organizations are incorporated into the design.

Construction

The structure of our organization has been developed to facilitate Fluor Daniel's approach to construction. Fluor Daniel has divided the project into four manageable areas:

- Area 1, South End to Little River
- Area 2, Little River to Route 50
- Area 3, Route 50 to Route 7 including I-66 interchange
- Area 4, Route 7 to North End

Each area will be assigned to an area manager who will be responsible for all activities in that segment. The area manager will report to the deputy project director. Each discipline superintendent (structures, asphalt paving, concrete paving, grading, drainage/utilities, and survey) will be responsible for the discipline's activities across all areas. Construction project engineers will interface with the area managers, superintendents, and design engineering to coordinate the activities and to maintain the overall construction schedule.

Partnering Approach and Commitment

Fluor Daniel is firm in our commitment to partnering with VDOT on this project and to continuing to build on the mutual trust that has emerged during the development of this proposal. We further commit to include the utility owners and all other stakeholders in the partnering effort. Fluor Daniel will strive to make the partnering process an integral part of the daily work activities.

For partnering to be effective, VDOT and Fluor Daniel project management teams must align early so that VDOT's project goals and expectations are jointly understood and communicated to both teams. The initial partnering session will include the top levels from both management teams. During our initial partnering meeting, VDOT and Fluor Daniel will have an opportunity to discuss, agree, and communicate specific roles and responsibilities and to establish procedures for effective interface between the parties.

The mechanics of the partnering process that we advocate are shown in Figure 2-j.2 and include:

- **Client Input –** VDOT will develop the project's goals and expectations with the Fluor Daniel project management team. Mutual goals and expectations will then be established for both project management teams. This session will also focus on getting to know each other better and on continuing the growth of the personal working relationships that were started during the proposal stage.
- **Partnering Session** – During this initial partnering session or project kickoff meeting, VDOT and Fluor Daniel will develop a purpose statement for the project and a list of key result areas, and will clarify roles and responsibilities. This session will address expectations and needs, define goals and measurements, and determine the team's path forward.
- **Implementation** – In this step, which occurs after the initial partnering session, VDOT and Fluor Daniel will identify improvement strategies; develop, communicate, and execute the value creation plan; and measure the results. The value creation process aligns management teams and builds value by encouraging all team members to develop innovative solutions to specific challenges and to identify and implement ways of improving the work environment and work processes.
- **Client Feedback** – In this step, VDOT will review key results and provide comments and recommendations to Fluor Daniel. Together, Fluor Daniel and VDOT will share lessons learned. Depending on the results, VDOT or Fluor Daniel project management will determine the best time for establishing follow-up alignment sessions and the need for alignments with stakeholders and other third parties.
- **Other Opportunities for Interfacing** – VDOT will play an important role in the design process, including involvement in design conferences, workshops, and over-the-shoulder reviews. VDOT will also be a participant in WMTs, interfacing with all project functions to identify and resolve issues.

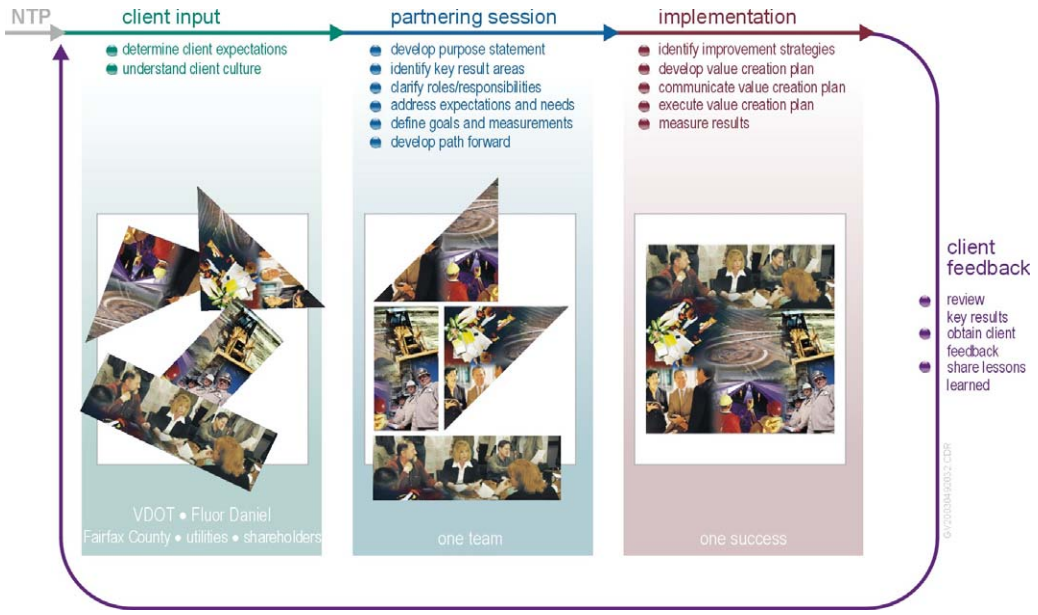


Figure 2-j.2. Partnering Process to be Used by Fluor Daniel to Interface with VDOT

Key subcontractors may be included in the initial partnering meeting to discuss goals and concerns of VDOT and Fluor Daniel. Additional alignment meetings will be conducted at all project levels within Fluor Daniel and VDOT to promote team building and to communicate the project goals regarding measuring and monitoring progress and performance. Refresher workshops will be conducted over the course of the project when deemed appropriate by VDOT or Fluor Daniel project management to review and re-emphasize the project goals and to orient new project participants. Partnering meetings among VDOT, Fluor Daniel, and other stakeholders will be held when appropriate as other parties become involved in the project.

All members of the Fluor Daniel team have used the partnering approach with other state DOTs on highway design-build projects, and they know that the success of the process requires a dynamic commitment to partnering by all parties. In particular, partnering increases the opportunities for success of the design-build projects, which require full integration of all project functions and a trusting relationship between owner and the design-build team. Partnering also increases the involvement of the owner and helps the design-build team focus on the owner's goals.

Communication

Our construction process will use a number of methods to foster communication internally among project functions and personnel and with VDOT, and externally with stakeholders.

As indicated, the WMTs will be a primary communication tool for facilitating design development and constructibility reviews, quality checks, and the resolution of issues. WMT meetings will enable participants to become involved in over-the-shoulder reviews early in the design process. In this forum, issues will surface and be resolved early on and at the lower levels of the organization through the daily involvement of all impacted groups (design, construction, VDOT, and, as may be required, local stakeholders and other contractors).

Regularly scheduled coordination meetings will support communication of project activities and provide coordination and control during design and construction. Effective project management requires adherence to a regimented meeting schedule. The participants in and the frequency of the meetings will vary depending on the objectives of any particular meeting.

Other means for communicating internally within the team will include electronic messaging through project e-mail and through the use of software applications such as Expedition.

A variety of tools are available for disseminating external communications. The Fluor Daniel team's approach to communicating and coordinating with communities, agencies, and other stakeholders is discussed in section 2-s, Government/Public Support.

Record Management (Document Control)

A document control system will be established to maintain operating and permanent files for the project. The electronic system will easily store and retrieve large volumes of documents; store scanned documents; and include Acrobat PDF, word, serial number, and other type of searches; and enable access of documents from the Internet. Fluor Daniel will maintain a complete set of all project documents. Types of documents that will be controlled include all technical, commercial, legal, and project correspondence. Incoming documents will be received in the project office and marked for distribution and action. A significant component of this control system is the retention of technical documents. The QC group will be responsible for checking, on a regular basis, that the document control procedures are being strictly followed.

Inspection Standards

Inspection standards are addressed in section 2-k, Quality Control/Quality Assurance.

2-k QUALITY CONTROL/QUALITY ASSURANCE

A detailed QC/QA process which specifies the roles of each party, including VDOT

Introduction

Guidelines for the quality assurance and quality control efforts will be detailed in Fluor Daniel's Capital Beltway HOT Lanes (I-495) Design-Build Quality Control Manual. The Quality Control Manual (QCM) describes Fluor Daniel's overall Quality Assurance/Quality Control Program, the personnel responsible for administering the program, and the various procedures and methods of achieving the program's goals that are common to the overall project. The QCM will outline project-specific design processes, construction methods, inspections, and test procedures. Fluor Daniel will develop the manual after VDOT grants a notice to proceed on the design-build contract.

The remainder of this section provides an overview of what the QCM will administer. Fluor Daniel's QC/QA will mirror the highly successful program used on the Pocahontas Parkway (Route 895 Connector) project in Richmond.

Implementation Policy

The objectives of the QCM are to make sure that:

- VDOT and FHWA requirements are met
- Applicable codes and standards are met
- Quality control authority and independence are established
- Compliance is achieved with:
  - Design
  - Procurement
  - Inspection and testing
  - Quality improvements
  - Documentation
  - Independent QA assessment
- Compliance with Fluor Daniel's policies is implemented

Quality Organization

The responsibility for the overall quality of the project will be broken down into two areas – design and construction. The Fluor Daniel design manager will be responsible for ensuring the design quality and the construction manager will be responsible for ensuring the quality for the construction of the Capital Beltway HOT lanes. Each subcontractor of Fluor Daniel will be responsible for providing an in-house quality manager who will report directly to the respective Fluor Daniel manager.

Authority

The QCM for the Capital Beltway HOT Lanes project will establish the independence of the quality staff. The staff's functions will be independent from cost and schedule considerations. The QCM will specify that the team will be provided with adequate resources and the organizational freedom to identify quality problems, initiate corrective actions, and stop work on specific products and processes until conditions adverse to quality are resolved.

Relationship Between VDOT and the Fluor Daniel Team

Design Oversight – The Fluor Daniel team will encourage VDOT personnel to co-locate in the central "hub" office dedicated to overall management of the project. Fluor Daniel encourages the involvement of VDOT in every step of the design review process. Design elements at all levels of detail will conform to this review process. Fluor Daniel will work on a daily basis with VDOT's designated representatives. This arrangement will ensure that EIS-, VDOT- and FHWA-referenced standards and project requirements for each design element are met.

The Fluor team will encourage VDOT to provide QA oversight of each area of the project. Fluor Daniel's design manager and respective lead engineers will ensure that all design QC procedures have been properly completed and documented for design under their supervision. The design area manager is responsible for ensuring completeness of documentation for design elements. This procedure is performed to meet the design manager's certification for construction readiness. Fluor Daniel's design manager will be the main contact for VDOT.

Once Fluor Daniel's design manager has approved a submittal for construction, VDOT will have a two-week final review period. During the review period, VDOT can determine that all comments made during the design process have been implemented to its satisfaction. After VDOT has completed this final review and signed off on the submittal, Fluor Daniel's project director will sign the submittal to be issued for construction.

VDOT and Construction QA – Fluor Daniel will hire a consulting firm to provide all onsite quality assurance inspection and materials testing. All offsite plant inspections and material certifications will remain the responsibility of VDOT. Fluor Daniel's QA subcontractor will be independent to Fluor Daniel's construction contractor. The QA staff will report directly to Fluor Daniel's construction manager. The construction manager will ensure that all work will conform to the plans and specifications.

VDOT will be invited to share office space with the construction operations staff. The QA and construction operations staff will be expected to maintain close schedule and activity coordination relationships. Timely and effective communication between the QA and VDOT personnel will be essential for keeping the project on schedule, while meeting the requirements for construction inspection and testing.

VDOT will also be afforded the opportunity to review the resumes of all the quality assurance staff before individuals are assigned to the project.

Design Quality Control and Quality Assurance – Process

Checking the quality of project documents is a major component of the work. For this project, all engineering team members will follow a project-specific QCM/Design Control Plan. Procedures will include checking documents to eliminate drafting, typographic, computation, and translation errors. The procedures verify that the final documents will contain no incongruities and conform to VDOT's requirements of sound engineering practices and professional standards. All project tasks will be progressed in accordance with a unified QCM to ensure that VDOT receives the best quality of services possible.

This QCM for design provides rigorous guidelines that will ensure the quality of the overall project design for each engineering firm and respective subconsultants on this project. Peer reviews, audits, and management systems will enable Fluor Daniel to maintain product quality, schedule, and budget adherence. This standardization, once staff and others are indoctrinated, eliminates the need to retrain personnel for each project segment and provides uniform processes throughout the project team, which enables multiple offices to support any project effort.

Project Operations Plan

In keeping with the QCM requirements, the design manager must develop a Project Operations Plan before project work begins. The objective of this plan is to provide the guidance to the engineering team members that will result in conformance to established requirements the first time. The Design Project Operations Plan will incorporate relevant information contained in the final proposal documents and the contract that defines the scope of work, responsibilities, and authority of each team member and the budgetary restraints, schedules, resources, design criteria, and procedures for carrying out assigned responsibilities.

Design Quality Control and Assurance

In summary, the five major elements of Fluor Daniel's QCM for design are:

1. **Planning.** The design manager and senior staff must prepare the formal QCM/Project Operations Plan. The final version is reviewed and approved by the project director. A description of how goals and objectives of the project will be achieved is contained in the QCM/Project Operations Plan, a compilation of the contract scope of services, negotiations, and the proposal. It addresses the project organization and the interfaces between VDOT, all engineering team members, and others involved in the project.

   The most important element of the QCM/Project Operations Plan is the work plan, which discusses how the design is to be accomplished and who will be responsible for performing each task. Other topics addressed include when the calculations and drawings will be checked, what reviews will be performed to assure there are no surprises on the job, and the detailed budget and schedule for achieving the work plan.

2. **Checking.** All design documents prepared by the design team are checked in detail before formal submittal to VDOT. While design personnel self-check their work as they produce it, the QCM requires a second, or independent, check of all engineering calculations, drawings, quantity computations, specifications, estimates, and reports.

   Checking is an integral part of the corrective process. Upon completing each sub-design element, the effort is checked. The checker and the designer then confer on any corrections to be made. This process enables both to resolve erroneous assumptions, flawed design methodology, or simple errors before they move forward in the design effort.

3. **Review.** Coordination between disciplines is a key facet of the review process. The respective lead designers and design manager will circulate review plans internally at predetermined intervals to maintain uniformity in the preparation of the plan and to ensure full coordination between the design leads.

4. **Project Management Review.** When design is complete and construction or procurement documents are ready for formal review, a complete set of documents will be assembled for review by the design manager, construction manager, and senior staff. This review ensures that the documents as assembled are biddable, constructible, and contractually complete and consistent with good engineering practices.

5. **Audit.** The Fluor Daniel design manager will lead all efforts for design quality assurance. Each area design manager will be responsible for the successful design of his project area and for complying with the QCM and the approved QCM/Project Operations Plan. Quality assurance compliance with these documents will be audited on a random basis by the design manager. Reports, including any necessary corrective action, will be issued to the project director.

Construction Quality Assurance and Control

The Capital Beltway HOT Lanes (I-495) project-specific QCM/Construction Quality Plan will include:

- Preparation of a written manual (QCM) that documents the Construction Quality Assurance (CQA) organization and procedures
- Implementation of a project-specific quality assurance inspection, testing, and surveillance program for onsite construction activities
- Establishment of a set of procedures for the inspection and testing of fabricated materials and services that come from the construction site

QA Personnel

Construction QA personnel will be certified by the respective construction discipline and procedures outlined in the VDOT Materials Division Manual of Instructions.

The construction QA organization is responsible for the inspection and testing of work and materials incorporated into the project. Formal test results will be available to the Fluor Daniel team construction supervisors and the VDOT Materials Division. Results of QA tests will be recorded on forms, and logged in alphanumeric, cumulative, and chronological format. All tests that do not meet specified requirements will be recorded in

a separate log of failed tests, where they will be monitored constantly by the construction QA organization to ensure proper handling of the related item. The minimum frequency for QA sampling and testing will be in accordance with those specified in the VDOT Materials Division Manual of Instructions.

Document and Data Control

The requirements for the collection, approval and distribution of project documents are outlined in this element of the quality plan. The specific controls for construction plans, specifications, records, and reference materials are specified in a project quality procedure. This procedure will outline the method of control for external and internal documents in either hardcopy or electronic version. In this procedure, the process for the review, approval, distribution, and collection documents and data is established. All quality system documentation is controlled to ensure the use of invalid or obsolete documents is prevented.

Inspection and Testing

The requirements for inspection and testing in the QCM will address the methodology, controls, processes, and responsibilities the quality control organization will implement on the project. Written project procedures will establish detailed responsibilities, authorities, and controls needed for each inspection and test process. The criteria for each inspection and test method will be referenced to the appropriate manual, test method, contract requirement, or product specification. Documentation produced from inspection and testing must be reported, approved, collected, and distributed in a consistent and controlled manner. Project procedures for inspection and testing will include receiving inspection and testing, in-process inspection and testing, and final inspection and testing.

Control of Inspection, Measuring, and Test Equipment

Inspection, measuring, and test equipment used by the Fluor Daniel team must demonstrate its conformance to specified project test requirements. This equipment must be used in a manner that ensures that the measurement is consistent with its capability. This control applies to items including moisture density gauges, survey equipment, concrete testing equipment, and laboratory equipment. Project procedures will outline the method of calibration and its frequency, approval, and record keeping.

Inspection and Test Status

Reporting, control, and communication of project inspections and tests will be required in accordance with the VDOT Materials Division Manual of Instructions. Nonconformance reports or a log of failed tests will reveal any product not meeting the project requirements. The process for capturing and communicating the inspection and test status will be defined in a project procedure.

Control of Nonconforming Product

Throughout the course of the project, it may be determined by VDOT and the QA manager that work is not in accordance with the project requirements, or that workmanship has not produced acceptable quality. This element addresses the controls needed to ensure that products, which do not conform to project requirements are identified and prevented for unintended use or delivery. These controls include the identification, documentation, and disposition of the nonconforming product.

If nonconformance is discovered, it is documented on a nonconformance report and is then verified by the design or construction QA manager. Nonconformance reports are documented and controlled in the project document control system as quality records. The nonconformance report includes a description of the nonconformance, accounts of deliberations, re-testing checking, and review and resolution of activities. The final determination may require the enactment of corrective actions.

Corrective and Preventive Action

Corrective action describes the action to be taken to eliminate the cause of nonconformities to prevent recurrence. Preventive action describes the action to be taken to eliminate the causes of potential nonconformities to prevent their occurrence.

Corrective or preventive action is initiated to prevent future nonconformance of the:

- **Product** – Action is required to correct nonconforming product. As part of the inspection and testing or checking and review process, the quality assurance manager initiates corrective action to correct the nonconformance.
- **Process** – Action may require an organizational or functional change within the Fluor Daniel team. If functional processes are in nonconformance the corrective action will correct the nonconformity.
- **Quality System** – Action is a result of the issue of a nonconformance or to the response of an audit observation or recommendation documented in the audit report.

Construction Quality Control Staff

Fluor Daniel's construction subcontractors will be responsible for their own quality control. They will have in-house staff independent to Fluor Daniel's quality assurance staff. The QC staff will coordinate its work on a daily basis with the QA staff. The QC staff will be required to sign off on an element stating that it meets the plans and specifications before the QA staff does final inspection. The QC and QA staffs will work closely together during the construction of an element to ensure that the final inspection punchlist of that element is minimal.

The Fluor Daniel team empowers its employees to improve their work processes through our quality improvement philosophy. The preventive action activity is an integral part of this improvement process. With preventive action, the Fluor Daniel team's employees initiate positive changes to keep the project on schedule and strive to maintain a high level of customer satisfaction.

2-I PERFORMANCE-BASED SPECIFICATIONS

A list of potential performance-based specifications that would introduce construction efficiencies for Fluor while adding value for VDOT

Fluor Daniel will have limited use of performance-based specifications for the Capital Beltway HOT Lanes (I-495) project, electing to stay with standard VDOT specifications. The one primary use of this type specification will be in the area of toll collection systems. Fluor Daniel would expect VDOT maintenance forces to be involved during the design stages. If VDOT elects to use the maintenance option provided in our proposal, then the maintenance contractor would input on the maintainability portion of the design.

Electronic Toll Collection (ETC) Subsystem

For the toll systems, the Fluor Daniel team proposal includes a performance specification for both the ETC lane subsystem and the Violation Enforcement capture subsystem. Patrons must establish and maintain a valid Smart Tag/E-ZPass account to use the system. HOT lanes are restricted to two-axle passenger and service vehicles, express busses, and emergency vehicles only. No trucks are permitted to use the HOT lanes. Data necessary to process the transaction will be captured electronically and stored by the system for processing. Tolls are assessed electronically, recorded in transaction records, and posted to customer prepaid toll accounts maintained in the Smart Tag/E-ZPass Customer Service Center (CSC).

The ETC lane hardware and software shall meet and/or exceed the following design and performance requirements:

ETC Detection – The system shall be able to :

- Read the Smart Tag or any IAG-compatible transponder (Type II, II+, or II++).
- Read transponders at any speed between 0 mph and 100 mph.
- Read transponders at any location in the pavement, including straddling the two lanes.
- Read transponders on motorcycles.
- Read license plate transponders (LPT).
- Complete the read-write-verify cycle with one transponder correctly in a multi-transponder environment (i.e., with two separate transponders in two separate lanes next to each other) .

- Avoid cross-lane reads with five misses in 10,000 successful reads (99.95 percent overall accuracy).

Shoulders – The system shall not be required to read transponders in the shoulders. Shoulders should be a "dead zone."

Classification – The system shall detect the vehicle transponder class for any vehicle passing through the payment zone, including lane straddlers. Because HOT lanes are restricted to passenger vehicles, busses, and emergency vehicles only, classification by the number of axles a vehicle has is irrelevant.

Violation Detection – The system shall:

- Determine the position of a violator and collect the appropriate data for a Violation Transaction.
- Detect the violator and capture the images at any speed between 0 mph and 100 mph.
- Capture images of vehicles with ten feet vehicle spacing.

Violations are declared for any vehicle that passes through the HOT lanes:

- Without completing a valid Smart Tag/E-ZPass transaction.
- At excess speed (user selectable).

The system shall capture digital images of any violator. For both passenger vehicles and multi-axle vehicles, the rear image shall be retained for Violation Processing.

Violation Enforcement System (VES)

VES Lane Design and Performance Parameters

The VES lane hardware and software shall meet and/or exceed the following design and performance requirements:

- The captured VES image shall be readable by the human reviewer at the VES workstation.
- The VES lane system shall be capable of storing (buffer) an average of 48 hours of violation data at each lane (images and transactional data) if the communication link to the Plaza or the CPS fails. This requirement may be modified if the VES Lane/Plaza configuration is such that the VES lane function is done by the VES plaza computer.

- The image capture system shall capture rear images and the license plate images of all vehicles traversing the lane:
  - At approximately the same vehicle location within the lane regardless of vehicle speed.
  - Under all lighting conditions.
  - Under all traffic conditions.
  - Regardless of vehicle configuration, including but not limited to, motorcycles passenger vehicles, van, trucks, tractor trailers, and vehicles pulling trailers.
- In the event of vehicles pulling trailers, the system shall capture the trailer's license plate.
- The camera systems shall use:
  - Full frame progressive scan digital camera technology or better technology.
  - Pixel isolation/control and/or "anti-blooming" technology.
  - All final evidentiary images shall be "digital images".
- Image data compression that does not alter the image in any way may be used before OCR processing.
- The image capture system shall be designed to eliminate or minimize the blurring effect of speed in the captured image.
- Minimum performance requirements shall include, but are not limited to:
  - Capturing images of license plates at vehicle speeds of 0-100 mph for all lane configurations.
  - Rate of image capture per camera shall be a minimum of two images per second.
- Minimum VES image quality requirements shall include:
  - Field of view at the focal plane shall cover, as minimum, an area 8 feet wide by 6 feet high.
  - Pixelation at the license plate/focal plane shall be a minimum of 9 pixels per inch in the horizontal and vertical directions.
  - Pixels contrast level shall be a minimum of 256 gray levels or 256 colors.
  - Equivalent shutter speed shall be faster (or less than) 1/2,000 second.
  - Image quality adequate for OCR.

VES Image Capture Performance and Image Quality

The image shall be of sufficient quality and detail to enable the VES processing system to "machine read" (OCR) correctly at least 80 percent (license plates have been misread 20 of 100 images) of the total license plates. The machine read function includes the identification of the state of issuance as well as the license plate alphanumeric and/or special character identifier (i.e., wheelchair character, environmental symbol, etc.). The process should allow all machine missed-read plates to be read by processing center personnel.

The VES capture image system performance and quality shall allow the correct license plate identification of at least 90 percent of all license plates physically unobstructed or impacted by weather. The plate identification and accuracy numbers shall take into account the following:

- Images in which the view of the license plate is obstructed by an object carried by the violating vehicle (such as trailer towing ball, license plate frame, bent or otherwise obstructed)
- Images captured during weather conditions that are non-conducive to image capture (such as rain, fog, or snow)
- Images in which the image of the license plate is incomplete or not present due to design and/or system performance issues. For example, the system failed to trigger the camera at the correct time to capture the license plate within the field of view, because:
  - Field of view is not large enough or incorrectly positioned within the lane.
  - System alignment and design fail to accommodate normal plate locations and vehicle/plate configurations, such as vehicle overhangs, etc.

2-m ESTIMATE METHODOLOGY

The project cost estimating methodology. Specify whether the cost estimate is stated in current or inflated dollars. If inflated, indicate the inflation factor(s) used. Provide a breakdown of the project cost estimate by phase. Address the need for items excluded from the cost estimate provided in the conceptual proposal.

The estimating process begins with the development of a scope of work. The Fluor Daniel team based its estimate for the project on the HOT Lanes Concept drawings included in section 2-a. Major quantities, including items such as pavement areas and bridge areas, were calculated from the work depicted on those sheets. Both drawings and quantities are conceptual in nature. As the design is developed, quantities and our estimate of cost will be adjusted.

Fluor Daniel's construction cost estimate is:

- $693 million
- With optional direct access ramps at:

  $31 million Braddock Road
  $26 million Route 50
  $26 million Route 123
- Real dollars inflated to year of construction

Once the major quantities were determined, the Fluor Daniel team applied historical data on the relationship of various minor quantities to the major quantities described. Items such as drainage, earthwork, removals, retaining walls, and traffic control were quantified in this manner. Unit prices were then applied to all quantities based on historical averages for similar work in the area. Hazardous materials, contaminated soils, and historical/archaeological impacts cannot be quantified in this manner, and are not included in our cost estimates. Fluor Daniel has assumed that existing drainage facilities are adequate to remain, and need only be extended or supplemented. Construction costs are based on VDOT 2002 Standard Specifications for Roads and Bridges. Once an estimate for the construction cost was developed, design, survey, CE&I, and program management costs were calculated based on normal industry percentages for work of this type.

Sound walls have been included in the project estimate as noted in section 2-c, Sound Barrier Wall Estimate. Included in our costs is replacement and/or relocation of 250,000 square feet of sound barrier wall. Additional walls could be incorporated into the project as noted in section 2-c.

Our breakdown of the project estimate, by phase, follows. The figures stated in this estimate breakdown are in inflated dollars. An inflation factor of four percent per annum has been applied. Costs have been inflated based on the project schedule provided in section 2-i, Project Schedule.

Estimated Cost

Fluor Daniel is proposing to develop, design, and construct the Capital Beltway HOT Lane project for a fixed price and deliver it on a date-certain schedule under a comprehensive agreement similar to that used on Route 895. Our Detailed Proposal estimated cost is $693.4 million. This estimate assumes a financial close in July 2005 and a project completion date in December 2009. Additional design and engineering will be performed to fix the price as part of the comprehensive agreement process.

Detailed Estimate Costs

Traffic Control/MOT	$44,000,000
Structures	$198,000,000
Retaining Walls	$53,000,000
Clearing and Grubbing	$11,000,000
Earthwork	$42,000,000
Drainage	$35,000,000
Erosion Control	$3,000,000
Pavement	$109,000,000
Guardrails/Barrier	$16,000,000
Striping/Lighting/Signage	$23,000,000
Sound Walls	$14,000,000
ITS	$3,500,000
Design/QA/Program Management	$104,000,000
Toll Systems	$15,000,000
Right-of-Way Acquisition	$12,400,000
Utility Relocations	$10,500,000
Total	$693,400,000

In addition to items included in our Conceptual Proposal, the Fluor Daniel team has studied requirements for right-of-way and utility relocations. An allowance for each of these items has been calculated as follows:

- Right-of-way impacts are based on existing topographic information and the preliminary typical sections and alignments developed for this proposal. In areas where the proposed construction exceeds the existing right-of-way, a proposed right-of-way line was assumed. Additional easements for utilities and construction of retaining walls and sound walls are also assumed where appropriate. Property values are based on limited research of assessment records
- Utility impacts are based on existing mapping and the preliminary typical sections and alignments developed for this proposal, supplemented with limited field verification and consultation with local utility companies.

The Fluor Daniel team will follow VDOT's Utility Relocation Policies and Procedures Manual in coordinating utility relocations and prorating cost responsibilities. We have assumed the utilities will agree to work this project as a normal VDOT project and have not included any additional costs that may be charged if this project were a private development.

The right-of-way and utility relocation costs are significant additions to the estimated cost included in the Fluor Daniel Conceptual Proposal. Other factors contributing to the increased cost estimate include inflation and added scope. In the schedule developed for this detailed proposal, start of construction has been shifted by approximately 18 months, resulting in escalated costs for the work. Also, additional work on a number of ramps is required due to necessary refinements in the geometry of those ramps. An additional ramp has also been added in the Dulles Toll Road interchange to increase traffic flow between the HOT lanes and the Toll Road. This added ramp is expected to contribute to enhanced revenue.

Optional Services

As indicated in our Conceptual Proposal, the intermediate access points that do not have direct access ramps under the current design could be added if state funding permits. If additional funding is identified during the negotiation phase, any or all of these ramps could be included by increasing the detailed cost estimate as follows.

Braddock Road Interchange	$30,800,000
Route 50 Interchange	$26,400,000
Route 123 Interchange	$26,400,000

2-n FINANCIAL COMMITMENTS/OBLIGATIONS

Any anticipated commitments/obligations from all parties: equity, debt or other financing mechanisms, appropriations, highway allocations or any other public sector resources. Include the schedule of project revenues and ongoing project operating and maintenance costs

Development, financing, and completion of the Capital Beltway HOT Lanes will require the successful integration by Fluor Daniel of commitments and obligations from a number of parties in the public and private sectors. The first steps have been successfully initiated by VDOT in funding and managing the federal NEPA /EIS process. The Fluor Daniel team has also made a major commitment of resources by funding and managing the development of the level of preliminary design, traffic and revenue analysis, project cost estimating and planning, and development of a conceptual plan of finance, first to prepare a Conceptual Proposal for the project in June 2002, and subsequently to refine that effort to offer VDOT this Detailed Proposal. Once we move into project implementation, commitments essential to the success of the project include:

- Commitment of the Fluor Daniel team to support the independent EIS process as required and to coordinate with VDOT before ROD
- Commitment of the Fluor Daniel team to project development resources at risk to fix the scope, schedule, cost, and plan of finance after the ROD is issued
- Commitment of investors to purchase non-recourse bonds necessary to finance the majority of the project
- Commitment of USDOT to fund the TIFIA financing proposed
- Commitment of VDOT and local governments to provide the funding or ongoing cash flow to finance the gap (if any) between what can be financed in the non-recourse debt market and the cost of the project
- Commitment of VDOT to appropriate on an annual basis the funds required to operate and maintain the project

A schedule of project revenues and ongoing project operating and maintenance costs is provided in the cash flow projections presented in the section 2-o, Preliminary Plan of Finance.

2-o PRELIMINARY PLAN OF FINANCE

A preliminary plan of finance for the project that includes all items required at the conceptual stage. Include in the finance plan all work necessary for the completion of the project, including assumptions where VDOT is responsible for the work and or the funding. Provide pro forma schedules detailing the preliminary plan of finance including debt amortization, project draw schedule, deposits to fund reserve accounts and anticipated cash flows

Overview

The Capital Beltway HOT Lanes project plan of finance is predicated on securing non-recourse loans from both the public municipal debt market as well as from USDOT as provided for in the Transportation Infrastructure Finance and Innovation Act (TIFIA). While detailed traffic and revenue analysis can only be finalized after the EIS process has established the scope of the project, preliminary analysis has demonstrated the significant revenue potential of the project.

Based on the preliminary traffic and revenue analysis prepared by Vollmer Associates LP, Bear Stearns has developed a preliminary plan of finance that relies on a public offering of investment grade toll revenue bonds, a $246 million loan from USDOT under the TIFIA program, and a contribution from the public sector.

Fluor Daniel's finance plan is based on:

- Toll revenue bonds and TIFIA loan financing 87 percent of project costs from user fees
- Public investment share of 13 percent

The revenue assumptions used for the preliminary plan of finance are inherently conservative at this stage of development due to the use of conservative assumptions appropriate to the limited time-of-day data available. Only after completion of a comprehensive time-of-day traffic and revenue analysis can the tolling strategy be optimized to support the actual value created by the facility during the worst hours of congestion. The Vollmer Associates revenue projections used for the preliminary plan of finance are based on a flat toll rate imposed at all hours of the day. In reality, the tolling strategy that is proposed (and is truly required to maintain free flow conditions on the HOT lanes) will set different tolls at different hours of the day based on the demand for the HOT lanes.

The flat rate assumed in the Vollmer model for the 2005 forecast year is $2.20 or approximately $.157 per mile. This value was inflated to the 2010 year of opening for purposes of developing our plan of finance. These values were adjusted to approximate the revenue benefit that would result from dynamic pricing (using different toll rates based upon different demand for each hour of the day), which was projected to increase base case toll revenues by 22 percent. This assumption appears conservative based on experience

with other HOT lanes facilities. By way of comparison, the SR-91 project in Orange County, California, has to set peak tolls at $3.60 in the westbound direction and $5.50 in the eastbound direction ($.36 and $.55 per mile respectively) to maintain free-flow conditions. Fluor Daniel anticipates that the more detailed modeling effort with the assumption of dynamic pricing will enhance the projected revenue for the project and will result in reducing the requirement for public investment.

Project Development

Upon execution of a development agreement between VDOT and the Fluor Daniel team and after resolution of the scope permitted and required by the ROD, we will mobilize the resources needed to develop a fixed construction price quote and guaranteed completion schedule. In addition, we will undertake the more detailed traffic and revenue analysis that is required to access the capital markets. This development effort should take approximately 18 months (see section 2-i, Project Schedule) to complete and requires estimated development funding of $10 million. Fluor Daniel assumes that VDOT will continue with the existing federal EIS effort, reaching a Record of Decision by January 1, 2005. To the extent that the ROD is accomplished earlier, the development schedule will be improved.

Project Financing

For purposes of our conceptual plan of finance, we have assumed that tax-exempt toll revenue bonds will be issued in mid-2005 to finance most of the cost of the project. In addition to paying for the capital costs of the project, bond proceeds will also be used to capitalize interest during construction, to fund necessary reserves, and to pay associated legal and financing expenses. Concurrent with closing on the toll revenue bonds, the plan of finance assumes a closing on the TIFIA loan. Our preliminary plan of finance assumes approximately $40 million in negative arbitrage on project funding balances, due to the unusually low short-term investment rates currently available. The plan of finance would be enhanced to the extent that rates adjust before project funding to reduce or eliminate negative arbitrage. An additional possibility is increasing the size of the TIFIA commitment, locking in the rate but deferring TIFIA funding as was done in the Central Texas Turnpike financing that supported Fluor Daniel's construction of SH 130. A portion of the TIFIA loan would remain as a funding commitment, and the project would then issue variable rate bonds during the construction period. The cost of the variable rate debt should closely track the reinvestment rate for the construction fund. The variable rate debt could then be refinanced with the TIFIA loan upon completion. In addition, this negative arbitrage could be used to offset positive arbitrage on reserve fund balances during the life of the tax-exempt bond financing.

Toll Revenue Bonds

The Capital Beltway HOT Lanes project will secure a majority of project funding through the public issuance of non-recourse, investment-grade rated toll revenue bonds. Fluor Daniel's Financial Adviser, Bear Stearns, worked on the first public offering of debt securities backed by the revenues of a standalone express lane project and believes that the municipal bond market will readily accept the revenue potential of a free-flow facility serving the Capital Beltway.

The ability to secure investment grade ratings and market the senior project debt will be facilitated by the subordinate nature of the TIFIA loan. As such, the role of the TIFIA loan in the project capital structure is critical.

The Fluor Daniel team will explore several legal structures for the issuance of the toll revenue debt for the project funding. Working in cooperation with VDOT, our successful implementation of the financing for the Pocahontas Parkway demonstrates the viability of using a private, not-for-profit corporation consistent with IRS Revenue Ruling 63-20 for the issuance of toll revenue bonds. As we integrate VDOT finance management into the team, Fluor Daniel proposes to further explore the viability of issuing the debt through another governmental or development entity. The preliminary plan of finance assumes that there will be no ancillary credit support provided to the project debt from any governmental entity, and that the bonds will be repaid solely from revenues generated by the implementation of the project and the toll system installed.

To maximize the debt proceeds that can be generated from the toll revenue stream and consequently reduce or eliminate the need for public-sector funding of capital cost, we have proposed that VDOT take responsibility for the costs of operating and maintaining the project subject to reimbursement subordinate to the project debt. For purposes of this proposal, Fluor Daniel assumes a legal structure that mirrors that agreed to for the implementation of the Pocahontas Parkway project, where the VDOT retains the right to provide for operations itself or contract out operations. Should VDOT wish to be insulated from the obligation to operate, the need for public-sector contribution to capital costs would increase.

TIFIA Loan

The Transportation Infrastructure Finance and Innovation Act provides for loans of up to 33 percent of the capital and capitalized development costs of a qualifying project. Fluor Daniel proposes to apply for a TIFIA loan, and has recently submitted a Letter of Interest to FHWA as a formal initiation of the application process. A copy of that letter is included later in Appendix C.

Under our preliminary plan of finance, the size of this loan is limited by the statutory requirement that the project revenues pledged to the TIFIA loan provide a debt service coverage of at least 110 percent. This constraint will be reviewed after the completion of the detailed traffic and revenue analysis. Fluor Daniel has not factored into project revenues at this point any additional revenue that may be received from sources other than traditional toll charges. If the final traffic and revenue forecast provides a sufficiently robust revenue forecast, Fluor Daniel anticipates that the full 33 percent of project costs will be sought under the TIFIA program. The TIFIA program permits development, construction, required capitalized interest, and debt service reserves to count in determining the 33 percent of total cost threshold. As such, under the preliminary plan of finance the TIFIA loan could be for as much as $274.4 million. The assumed amount of the TIFIA loan has been increased from the Conceptual Proposal plan of finance due to the elimination of the grace period we had assumed then versus our current assumption of beginning amortization in 2011. The Conceptual Proposal assumed no loan amortization until the fifth year following completion of the project. To increase the proceeds available from the revenue projected, we are now assuming that this amortization begins immediately, and does not take advantage of the ability to defer TIFIA loan amortization by up to five years. A further TIFIA requirement is that the debt senior to TIFIA be ratable as investment grade by credible bond credit rating agencies. We have had preliminary discussions with credit analysts who indicate that the structure we propose can achieve investment grade rating for the senior debt.

Fluor Daniel believes that the Capital Beltway HOT Lanes project clearly meets the requirements of the TIFIA program and should score quite highly under the selection criteria established by FHWA for the program.

VDOT Funding

The preliminary plan of finance assumes that VDOT will continue to fund the cost of the environmental approval process through the release of the Record of Decision. Furthermore, the plan assumes the Department will annually appropriate funds sufficient to provide for operating and maintenance costs. The plan also assumes approximately $91 million of public-sector contribution. While VDOT is not assumed to be the source of all of this funding, the current plan of finance would almost certainly imply looking at the option of some direct VDOT funding as part of the public-sector investment. Options to reduce or eliminate the need for VDOT support include value engineering, scope reduction of the project, optimizing revenue projections after detailed revenue analysis, and the identification of other capital and revenue sources. As we did during negotiation of the Pocahontas Parkway comprehensive agreement, we are prepared to work with VDOT to identify the most feasible structure for any VDOT participation.

Sources and Uses of Funds

Sources of Funds

Senior Current Interest Bonds	$351,315,000
Senior Capital Appreciation Bonds	99,609,989
Subordinated TIFIA Loan	246,437,053
Public-Sector Investment	91,055,000
Investment Earnings	58,299,469
Total Sources	$846,716,511

Uses of Funds

Project Costs	693,400,000
Pre-Development Costs	10,000,000
Issuance Costs	11,273,125
Capitalized Interest	86,950,463
Debt Service Reserve Fund	45,092,499
Contingency / (Shortfall)	425
Total Uses	$846,716,511

A detailed bond sizing model summarizing construction period and operating cash flows is presented in Figure 2-o.1.

Operations

Since this project will be integrated into an existing VDOT facility and become an integral component of the Capital Beltway, we assume that VDOT will retain financial responsibility for operations and maintenance of the roadway and toll system. Fluor Daniel proposes an arrangement similar to that used on the Pocahontas Parkway project, where VDOT will operate and maintain the facility after completion. This structure permits the gross pledge of toll revenues that has been assumed for the plan of finance, providing significantly greater capital markets debt capacity. Under this arrangement, VDOT retains the flexibility to operate the facility itself or arrange for a private operator under terms consistent with qualified management contract limitations placed by the Treasury on facilities financed with the proceeds of tax-exempt bonds. Alternately, as VDOT elected not to do on Pocahontas Parkway, VDOT may prefer to fund a higher level of the capital costs and have toll systems O&M paid before debt service.

If VDOT prefers that we take responsibility for toll systems operations, the Fluor Daniel team is prepared to identify a qualified toll system operator to become part of the proposal team and provide operating services for the project. We have had discussions with leading toll system operators who have indicated a willingness to join the Fluor Daniel team if we are asked to provide these services. We are prepared to make this structure an essential part of the comprehensive agreement.

Fluor Daniel will place considerable importance on designing the improvements in a manner that facilitates efficient operation and maintenance. We will provide warranties and/or insurance to cover certain aspects of the design and construction work after completion.

Sources and Uses of Funds

	Assumed Delivery Date	07/01/2005
	Sources of Funds	
41%	Senior Current Interest Bonds	$351,315,000
12%	Senior CABs	99,609,989
11%	Private-Sector Investment	91,055,000
29%	Subordinated TIFIA Loan	246,437,053
7%	Investment Earnings [1]	58,299,469
	Total Sources	$846,716,511
	Uses of Funds	
	Project Costs	$693,400,000
	Development Cost reimbursement [2]	10,000,000
	Capitalized Interest	86,950,463
	Debt Service Reserve Fund [3]	45,092,499
	Issuance Costs [4]	11,273,125
	Contingency / (Shortfall)	425
	Total Uses	$846,716,511

Construction Fund

	Period Ending	Beginning Balance	**Construction Draws and Expenditures**	Investment Earnings @ 3.00%	Ending Balance
-	07/01/2005	$648,818,609	**23,113,333**	-	625,705,276
6	01/01/2006	625,705,276	**46,226,667**	9,385,579	588,864,188
12	07/01/2006	588,864,188	**69,340,000**	8,832,963	528,357,151
18	01/01/2007	528,357,151	**92,453,333**	7,925,357	443,829,175
24	07/01/2007	443,829,175	**115,566,667**	6,657,438	334,919,946
30	01/01/2008	334,919,946	**115,566,667**	5,023,799	224,377,079
36	07/01/2008	224,377,079	**92,453,333**	3,365,656	135,289,401
42	01/01/2009	135,289,401	**69,340,000**	2,029,341	67,978,743
48	07/01/2009	67,978,743	**46,226,667**	1,019,681	22,771,757
54	01/01/2010	22,771,757	**23,113,333**	341,576	-
60	07/01/2010	-	**-**	-	-
66	01/01/2011	-	**-**	-	-
72	07/01/2011	-	**-**	-	-
			$693,400,000	$44,581,391	

Capitalized Interest Fund

Period Ending	Beginning Balance	Interest Payments	Investment Earnings 3.00%	Reserve Earnings 4.00%	Ending Balance
07/01/2005	$73,232,384	-	-	-	73,232,384
01/01/2006	73,232,384	9,661,163	1,098,486	901,850	65,571,557
07/01/2006	65,571,557	9,661,163	983,573	901,850	57,795,818
01/01/2007	57,795,818	9,661,163	866,937	901,850	49,903,443
07/01/2007	49,903,443	9,661,163	748,552	901,850	41,892,682
01/01/2008	41,892,682	9,661,163	628,390	901,850	33,761,760
07/01/2008	33,761,760	9,661,163	506,426	901,850	25,508,874
01/01/2009	25,508,874	9,661,163	382,633	901,850	17,132,194
07/01/2009	17,132,194	9,661,163	256,983	901,850	8,629,865
01/01/2010	8,629,865	9,661,163	129,448	901,850	-
07/01/2010	-	-	-	-	-
		$86,950,463	$5,601,429	$8,116,650	

[1] Anticipated investment earnings on construction fund, reserve fund, and capitalized interest account through January 1, 2010.
[2] Subject to negotiation with VDOT
[3] Limited to 10% of par amount of debt pursuant to relevant tax law
[4] Placeholder. Fees and expenses for participants in financing subject to negotiation with VDOT

Figure 2-o.1. Detailed Bond Sizing Model

Revenue Available for Debt Service

	Annual Toll Transactions	*% growth*	Average Toll Rate	Peak Toll Rate	**GROSS TOLL REVENUE**	*% growth*	Investment Earnings	**PROJECTED NET REVENUE**
2005			$2.20	$4.18	**-**			
2006	-		$2.28	$4.32	**-**		-	**-**
2007	-		$2.35	$4.47	**-**		-	**-**
2008	-		$2.43	$4.61	**-**		-	**-**
2009	-		$2.50	$4.76	**-**		-	**-**
2010	14,265,168		$2.58	$4.90	**36,804,134**		1,803,700	**38,607,834**
2011	14,444,248	*1.3%*	$2.66	$5.05	**38,363,923**	*4.2%*	1,803,700	**40,167,623**
2012	14,613,365	*1.2%*	$2.73	$5.19	**39,923,712**	*4.1%*	1,803,700	**41,727,412**
2013	14,773,327	*1.1%*	$2.81	$5.34	**41,483,501**	*3.9%*	1,803,700	**43,287,201**
2014	14,924,858	*1.0%*	$2.88	$5.48	**43,043,290**	*3.8%*	1,803,700	**44,846,990**
2015	15,068,608	*1.0%*	$2.96	$5.62	**44,603,079**	*3.6%*	1,803,700	**46,406,779**
2016	15,205,161	*0.9%*	$3.04	$5.77	**46,162,868**	*3.5%*	1,803,700	**47,966,568**
2017	15,335,044	*0.9%*	$3.11	$5.91	**47,722,657**	*3.4%*	1,803,700	**49,526,357**
2018	15,458,735	*0.8%*	$3.19	$6.06	**49,282,446**	*3.3%*	1,803,700	**51,086,146**
2019	15,576,665	*0.8%*	$3.26	$6.20	**50,842,235**	*3.2%*	1,803,700	**52,645,935**
2020	15,689,229	*0.7%*	$3.34	$6.35	**52,402,024**	*3.1%*	1,803,700	**54,205,724**
2021	15,796,784	*0.7%*	$3.42	$6.49	**53,961,813**	*3.0%*	1,803,700	**55,765,513**
2022	15,899,657	*0.7%*	$3.49	$6.63	**55,521,602**	*2.9%*	1,803,700	**57,325,302**
2023	15,998,148	*0.6%*	$3.57	$6.78	**57,081,391**	*2.8%*	1,803,700	**58,885,091**
2024	16,092,530	*0.6%*	$3.64	$6.92	**58,641,180**	*2.7%*	1,803,700	**60,444,880**
2025	16,183,056	*0.6%*	$3.72	$7.07	**60,200,969**	*2.7%*	1,803,700	**62,004,668**
2026	16,263,971	*0.5%*	$3.79		**61,712,013**	*2.5%*	1,803,700	**63,515,713**
2027	16,345,291	*0.5%*	$3.87		**63,260,984**	*2.5%*	1,803,700	**65,064,684**
2028	16,427,018	*0.5%*	$3.95		**64,848,835**	*2.5%*	1,803,700	**66,652,535**
2029	16,509,153	*0.5%*	$4.03		**66,476,541**	*2.5%*	1,803,700	**68,280,241**
2030	16,591,699	*0.5%*	$4.11		**68,145,102**	*2.5%*	1,803,700	**69,948,802**
2031	16,674,657	*0.5%*	$4.19		**69,855,544**	*2.5%*	1,803,700	**71,659,244**
2032	16,758,030	*0.5%*	$4.27		**71,608,918**	*2.5%*	1,803,700	**73,412,618**
2033	16,841,820	*0.5%*	$4.36		**73,406,302**	*2.5%*	1,803,700	**75,210,002**
2034	16,926,030	*0.5%*	$4.45		**75,248,800**	*2.5%*	1,803,700	**77,052,500**
2035	17,010,660	*0.5%*	$4.53		**77,137,545**	*2.5%*	1,803,700	**78,941,245**
2036	17,095,713	*0.5%*	$4.63		**79,073,698**	*2.5%*	1,803,700	**80,877,397**
2037	17,181,192	*0.5%*	$4.72		**81,058,447**	*2.5%*	1,803,700	**82,862,147**
2038	17,267,098	*0.5%*	$4.81		**83,093,014**	*2.5%*	1,803,700	**84,896,714**
2039	17,353,433	*0.5%*	$4.91		**85,178,649**	*2.5%*	1,803,700	**86,982,349**
2040	17,440,200	*0.5%*	$5.01		**87,316,633**	*2.5%*	1,803,700	**89,120,333**
2041	17,527,401	*0.5%*	$5.11		**89,508,281**	*2.5%*	1,803,700	**91,311,981**
2042	17,615,038	*0.5%*	$5.21		**91,754,938**	*2.5%*	1,803,700	**93,558,638**
2043	17,703,113	*0.5%*	$5.31		**94,057,987**	*2.5%*	1,803,700	**95,861,687**
2044	17,791,629	*0.5%*	$5.42		**96,418,843**	*2.5%*	46,896,199	**143,315,042**
					$2,255,201,900		$108,221,997	**$2,363,423,897**

Figure 2-o.1. Detailed Bond Sizing Model

Senior Debt

	PROJECTED NET REVENUE	Senior Current Interest Bonds				Senior Capital Appreciation Bonds			Total Senior Debt Service	*Debt Service Coverage Ratio*	Net Available Revenue
		Principal	Coupon	Interest	CIA	Principal	Coupon	Interest			
2005				9,661,163	9,661,163				-		-
2006	-			19,322,325	19,322,325	-		-	-		-
2007	-			19,322,325	19,322,325	-		-	-		-
2008	-			19,322,325	19,322,325	-		-	-		-
2009	-			19,322,325	19,322,325	-		-	-		-
2010	38,607,834			19,322,325		-		-	**19,322,325**	*2.00 x*	19,285,509
2011	40,167,623			19,322,325		**2,039,449**	6.000%	955,551	**22,317,325**	*1.80 x*	17,850,298
2012	41,727,412			19,322,325		**2,477,587**	6.000%	1,382,413	**23,182,325**	*1.80 x*	18,545,087
2013	43,287,201			19,322,325		**2,858,703**	6.000%	1,866,297	**24,047,325**	*1.80 x*	19,239,876
2014	44,846,990			19,322,325		**3,190,750**	6.000%	2,404,250	**24,917,325**	*1.80 x*	19,929,665
2015	46,406,779			19,322,325		**3,472,568**	6.000%	2,987,432	**25,782,325**	*1.80 x*	20,624,454
2016	47,966,568			19,322,325		**3,711,517**	6.000%	3,613,483	**26,647,325**	*1.80 x*	21,319,243
2017	49,526,357			19,322,325		**3,911,590**	6.000%	4,278,410	**27,512,325**	*1.80 x*	22,014,032
2018	51,086,146			19,322,325		**4,078,713**	6.000%	4,981,287	**28,382,325**	*1.80 x*	22,703,821
2019	52,645,935			19,322,325		**4,211,638**	6.000%	5,713,362	**29,247,325**	*1.80 x*	23,398,610
2020	54,205,724			19,322,325		**4,315,861**	6.000%	6,474,139	**30,112,325**	*1.80 x*	24,093,399
2021	55,765,513			19,322,325		**4,396,126**	6.000%	7,263,874	**30,982,325**	*1.80 x*	24,783,188
2022	57,325,302			19,322,325		**4,451,177**	6.000%	8,073,823	**31,847,325**	*1.80 x*	25,477,977
2023	58,885,091			19,322,325		**4,485,422**	6.000%	8,904,578	**32,712,325**	*1.80 x*	26,172,766
2024	60,444,880			19,322,325		**4,502,646**	6.000%	9,757,354	**33,582,325**	*1.80 x*	26,862,555
2025	62,004,668			19,322,325		**4,501,624**	6.000%	10,623,376	**34,447,325**	*1.80 x*	27,557,343
2026	63,515,713			19,322,325		**4,478,868**	6.000%	11,486,132	**35,287,325**	*1.80 x*	28,228,388
2027	65,064,684			19,322,325		**4,449,180**	6.000%	12,375,820	**36,147,325**	*1.80 x*	28,917,359
2028	66,652,535			19,322,325		**4,413,126**	6.000%	13,291,874	**37,027,325**	*1.80 x*	29,625,210
2029	68,280,241			19,322,325		**4,372,425**	6.000%	14,237,575	**37,932,325**	*1.80 x*	30,347,916
2030	69,948,802	**15,680,000**	5.500%	19,322,325		**854,848**	6.000%	3,005,152	**38,862,325**	*1.80 x*	31,086,477
2031	71,659,244	**16,540,000**	5.500%	18,459,925		**1,004,089**	6.000%	3,805,911	**39,809,925**	*1.80 x*	31,849,319
2032	73,412,618	**17,450,000**	5.500%	17,550,225		**1,138,298**	6.000%	4,646,702	**40,785,225**	*1.80 x*	32,627,393
2033	75,210,002	**18,410,000**	5.500%	16,590,475		**1,258,427**	6.000%	5,526,573	**41,785,475**	*1.80 x*	33,424,527
2034	77,052,500	**19,420,000**	5.500%	15,577,925		**1,365,384**	6.000%	6,444,616	**42,807,925**	*1.80 x*	34,244,575
2035	78,941,245	**20,490,000**	5.500%	14,509,825		**1,459,210**	6.000%	7,395,790	**43,854,825**	*1.80 x*	35,086,420
2036	80,877,397	**21,615,000**	5.500%	13,382,875		**1,543,202**	6.000%	8,391,798	**44,932,875**	*1.80 x*	35,944,522
2037	82,862,147	**22,805,000**	5.500%	12,194,050		**1,615,670**	6.000%	9,419,330	**46,034,050**	*1.80 x*	36,828,097
2038	84,896,714	**24,060,000**	5.500%	10,939,775		**1,678,874**	6.000%	10,486,126	**47,164,775**	*1.80 x*	37,731,939
2039	86,982,349	**25,385,000**	5.500%	9,616,475		**1,732,749**	6.000%	11,587,251	**48,321,475**	*1.80 x*	38,660,874
2040	89,120,333	**26,780,000**	5.500%	8,220,300		**1,779,199**	6.000%	12,730,801	**49,510,300**	*1.80 x*	39,610,033
2041	91,311,981	**28,255,000**	5.500%	6,747,400		**1,817,495**	6.000%	13,907,505	**50,727,400**	*1.80 x*	40,584,581
2042	93,558,638	**29,805,000**	5.500%	5,193,375		**1,849,890**	6.000%	15,130,110	**51,978,375**	*1.80 x*	41,580,263
2043	95,861,687	**31,445,000**	5.500%	3,554,100		**1,874,630**	6.000%	16,380,370	**53,254,100**	*1.80 x*	42,607,587
2044	143,315,042	**33,175,000**	5.500%	1,824,625		**4,319,056**	6.000%	40,300,944	**79,619,625**	*1.80 x*	63,695,417
	$2,363,423,897	**$351,315,000**		$647,080,638	$86,950,463	**$99,609,989**		$299,830,011	**$1,310,885,175**		$1,052,538,722

Figure 2-o.1. Detailed Bond Sizing Model

Subordinate Debt

	Net Revenue after Senior Debt	Subordinated TIFIA Loan				*Coverage All Debt*	Net Available Revenue
		Principal	Coupon	Interest	Net D/S		
2005	-						-
2006	-						-
2007	-						-
2008	-						-
2009	-						-
2010	19,285,509					*2.00 x*	19,285,509
2011	17,850,298	**10,139,047**	5.250%	4,060,953	14,200,000	*1.10 x*	3,650,298
2012	18,545,087	**9,999,873**	5.250%	4,750,127	14,750,000	*1.10 x*	3,795,087
2013	19,239,876	**9,852,114**	5.250%	5,452,886	15,305,000	*1.10 x*	3,934,876
2014	19,929,665	**9,690,719**	5.250%	6,164,281	15,855,000	*1.10 x*	4,074,665
2015	20,624,454	**9,520,498**	5.250%	6,884,502	16,405,000	*1.10 x*	4,219,454
2016	21,319,243	**9,345,508**	5.250%	7,614,492	16,960,000	*1.10 x*	4,359,243
2017	22,014,032	**9,161,296**	5.250%	8,348,704	17,510,000	*1.10 x*	4,504,032
2018	22,703,821	**8,971,853**	5.250%	9,088,147	18,060,000	*1.10 x*	4,643,821
2019	23,398,610	**8,780,538**	5.250%	9,834,462	18,615,000	*1.10 x*	4,783,610
2020	24,093,399	**8,583,424**	5.250%	10,581,576	19,165,000	*1.10 x*	4,928,399
2021	24,783,188	**8,383,824**	5.250%	11,331,176	19,715,000	*1.10 x*	5,068,188
2022	25,477,977	**8,182,493**	5.250%	12,082,507	20,265,000	*1.10 x*	5,212,977
2023	26,172,766	**7,982,031**	5.250%	12,837,969	20,820,000	*1.10 x*	5,352,766
2024	26,862,555	**7,779,127**	5.250%	13,590,873	21,370,000	*1.10 x*	5,492,555
2025	27,557,343	**7,576,360**	5.250%	14,343,640	21,920,000	*1.10 x*	5,637,343
2026	28,228,388	**7,369,309**	5.250%	15,085,691	22,455,000	*1.10 x*	5,773,388
2027	28,917,359	**7,166,963**	5.250%	15,833,037	23,000,000	*1.10 x*	5,917,359
2028	29,625,210	**6,972,178**	5.250%	16,592,822	23,565,000	*1.10 x*	6,060,210
2029	30,347,916	**6,781,596**	5.250%	17,358,404	24,140,000	*1.10 x*	6,207,916
2030	31,086,477	**6,595,149**	5.250%	18,129,851	24,725,000	*1.10 x*	6,361,477
2031	31,849,319	**6,416,569**	5.250%	18,918,431	25,335,000	*1.10 x*	6,514,319
2032	32,627,393	**6,241,611**	5.250%	19,713,389	25,955,000	*1.10 x*	6,672,393
2033	33,424,527	**6,070,241**	5.250%	20,514,759	26,585,000	*1.10 x*	6,839,527
2034	34,244,575	**5,905,682**	5.250%	21,334,318	27,240,000	*1.10 x*	7,004,575
2035	35,086,420	**5,745,350**	5.250%	22,164,650	27,910,000	*1.10 x*	7,176,420
2036	35,944,522	**5,588,103**	5.250%	23,001,897	28,590,000	*1.10 x*	7,354,522
2037	36,828,097	**5,436,726**	5.250%	23,858,274	29,295,000	*1.10 x*	7,533,097
2038	37,731,939	**5,289,029**	5.250%	24,725,971	30,015,000	*1.10 x*	7,716,939
2039	38,660,874	**5,145,730**	5.250%	25,609,270	30,755,000	*1.10 x*	7,905,874
2040	39,610,033	**5,005,798**	5.250%	26,504,202	31,510,000	*1.10 x*	8,100,033
2041	40,584,581	**4,869,892**	5.250%	27,415,108	32,285,000	*1.10 x*	8,299,581
2042	41,580,263	**4,737,095**	5.250%	28,337,905	33,075,000	*1.10 x*	8,505,263
2043	42,607,587	**4,609,370**	5.250%	29,285,630	33,895,000	*1.10 x*	8,712,587
2044	63,695,417	**6,541,956**	5.250%	44,123,044	50,665,000	*1.10 x*	13,030,417
	$1,052,538,722	**$246,437,053**		$575,472,947	$821,910,000		$230,628,722

Figure 2-o.1. Detailed Bond Sizing Model

2-p ASSUMPTIONS

A detailed discussion of assumptions about user fees or other revenue sources, and usage of the facility such as traffic and revenue forecasts and assumptions

Key assumptions used at this stage of project development include:

Moderate Increases in Traffic and Toll Rates

Vollmer Associates LP expects average weekday traffic on the Capital Beltway HOT Lanes will be 283,990 in 2005, of which 204,110 will be toll-paying. Assumed annual growth in toll traffic following the ramp-up period of two years averages approximately 1 percent, an extremely conservative rate of growth that reflects the intention to maintain a free-flow of traffic on the express lanes by raising toll rates. Toll rates in the opening year range from approximately $1.00 (off-peak) to $4.80 (peak hours). The effective annual increase in toll rates thereafter, primarily due to inflationary adjustments, averages less than 3.3 percent annually. A letter from Vollmer Associates summarizing its analysis is presented Appendix C.

No Contributions from Ancillary Revenues

Most toll facilities currently generate significant amounts of revenue from ancillary sources, such as transponder fees, statement charges, administrative fees for tolls not collected at time of use, and the like. While it is anticipated that many of these additional revenue sources will be available to the operator of the Capital Beltway HOT lanes, no additional revenue is assumed for the preliminary plan of finance. The SR-91 Express Lanes have received at least $1 million in ancillary revenues in each of the last three years, much of it from a $2 monthly charge against inactive accounts.

2-q BUSINESS PLAN

A business plan which details the risks and contributions proposed to be made by all parties participating in the Project, including bondholders, members of the proposer's team, and the Virginia Department of Transportation. Discuss your proposed approach to the assignment/assumption of various project risks.

The project financing will be structured so that the principal risks associated with the transaction are allocated among the Fluor Daniel team, investors, and/or third parties that are compensated for taking risk, such as an insurance company. Fluor Daniel's business plan is to act as an at-risk developer to provide the citizens of Virginia a privately-developed, publicly-owned project at the lowest cost to the Commonwealth and the users. To be successful, we have to identify a public project with a high enough value to the public that it will pay user charges high enough to pay debt service on the capital cost. As developers, we then build a self-supporting business around the project that provides investors a reasonable expectation of risk and return. Once the business proposition can be confirmed with cost estimates, a revenue study, and a plan of finance, we package the business in a proposal to a public sponsor to confirm the public utility and political desire for the project. The culmination of our business plan is the execution of a comprehensive agreement with VDOT that allows for the financing, construction, and operation of the project as a self-supporting business. Upon successful operation and repayment of debt, the business terminates and the remaining value of the asset reverts to VDOT.

Fluor Daniel business plan assumes:

- Fixed price and on-time guarantee
- Bondholders bear all revenue projection risk
- VDOT funds O&M
- No additional Beltway lanes in future

In addition to the response on commitments and allocations provided in section 2-n, Financial Commitments/Obligations, the business plan allocates risks as follows.

Construction of Facility on Time and Under Budget

The Fluor Daniel team will provide VDOT a single point of responsibility for delivering the project backed by a corporate guarantee from Fluor Corporation. As was the case on the Pocahontas Parkway, risks associated with utility relocations, right-of-way, and undeterminable conditions will be the subject of negotiation of risk allocations made in the proper contingency accounts. The risk component of these elements has been excluded for the purpose of completing our cost estimates and will be resolved at a future date at the direction of VDOT.

Traffic and Revenue Risk

Purchasers of the project debt and potential credit enhancers bear the risk that project revenues may not be sufficient to pay scheduled debt service. VDOT will have absolutely no debt payment obligation to those investors. Under our current proposal though, VDOT would be required to provide funds to operate and maintain the facility if net project revenue is not sufficient. In addition, the subordinated position of the proposed TIFIA loan provides senior bondholders the security that projected toll revenue is anticipated to equal 180 percent of annual debt service on the publicly-offered debt. Furthermore, Fluor Daniel will consider taking a risk position in the financial architecture of the transaction to mitigate revenue realization risk, similar to what we did for the Pocahontas Parkway transaction, if required to achieve investment grade credit rating.

VDOT Funding of Operations

The conceptual plan of finance assumes that investors are given a first lien on all toll revenue to maximize potential debt capacity. Though projected revenue available after payment of debt service is anticipated to be sufficient to cover assumed operating expenses, VDOT would need to commit to appropriate the funds needed to continue operations if for some reason toll revenues are not sufficient to reimburse VDOT on a timely basis. VDOT provided a similar arrangement on operations to facilitate the financing for the Route 895 project.

1.80x Minimum Debt Service Coverage

The debt service coverage required by rating agencies and credit enhancers for start-up toll facilities varies based on the level of local economic growth needed to achieve the traffic projections, the anticipated toll elasticity of the users (sensitivity to toll rate increases), and liquidity considerations (funded reserves and provisions for capturing excess cash flow). For purposes of the conceptual plan of finance, we have assumed 1.80 minimum debt service coverage. Increasing the requirement by 0.20 (i.e., 2.00x) would decrease bond proceeds by approximately $33 million, with a $67 million increase in senior bond proceeds if the assumed minimum coverage ratio is lowered to 1.50x. These fluctuations in required coverages could be largely offset by adjusting the amount of the TIFIA loan that could be serviced with the extra coverage.

USDOT Participation

Our preliminary plan of finance is dependent on our ability to fully leverage projected project revenues by taking advantage of the flexible terms offered by the USDOT TIFIA Program. While Fluor Daniel anticipates that the Capital Beltway HOT Lanes project will

be favorably received by the TIFIA JPO Office, it is unlikely that similar leverage could be achieved with the traditional lending community.

Debt Sold without Credit Enhancement

The conceptual plan of finance assumes an average tax-exempt borrowing cost of approximately 5.80 percent. This assumption represents a slightly higher cost of borrowing that would be found currently, as the assumed timing for the capital markets issue raises the possibility that market rates may not be as favorable. It may be possible to obtain third-party credit enhancement, such as municipal bond insurance, that would significantly reduce the effective borrowing cost and thereby increase the potential amount of bond proceeds. The potential increase in debt capacity could range between $40 million and $60 million depending on the cost of the credit enhancement and the resulting decrease in interest rates.

No Competing Facility

To achieve investment grade credit ratings on the senior project debt, VDOT will have to agree not to add additional free lanes or other directly competing enhancements until the project debt is repaid or restructured to accommodate new capacity unless other appropriate accommodations are made to bondholders. We understand the sensitivity of VDOT to the difficulties that a non-compete clause can present based on the SR-91 experience, but point out that this project will be a VDOT project with all residual cash owned by VDOT. We will work closely with VDOT to address this requirement in a manner that will not hamper VDOT's flexibility to do what is right for the citizens of the Commonwealth. The substance of this limitation will be the requirement that VDOT must accommodate the need to repay bond purchasers as it plans future capacity for the corridor. It is not reasonable that VDOT would want to invest in new capacity in this expensive corridor if the HOT lanes were not being used well in excess of projected levels.

2-r GUARANTEES AND WARRANTIES

A detailed listing of all firms who will provide specific design, construction and completion guarantees and warranties. Include a brief description of the guarantees and warranties. Any guarantees, warranties or representations regarding quality of materials and assets must be clearly identified.

Fluor Daniel will be responsible for the entire project. In turn, HNTB will be responsible for design services and Lane will be responsible for construction. Warranties and guarantees that require the repair, replacement, or reperformance of defective workmanship, materials, or services for a period of three years will be in place. Equipment warranties and/or guarantees will be provided directly to the Commonwealth from the suppliers of toll collection/surveillance equipment, typically with durations of one year from the date on which such equipment is placed in service. Otherwise, all subcontractors, suppliers, and vendors will provide standard warranties and/or guarantees in favor of both Fluor Daniel and the Commonwealth.

2-s GOVERNMENT/PUBLIC SUPPORT

Any known government support or opposition, or general public support or opposition for the project. Government/public support should be demonstrated through resolutions of official bodies, minutes of meetings, letters, etc.

Fluor Daniel's Concept Grew from Citizen Concerns at the Beltway Public Hearings

Fluor Daniel representatives attended all three VDOT public hearings on the three widening alternatives for the Capital Beltway May 28 to May 30, 2002. More than 900 citizens attended the hearing and made over 1,800 comments in support or opposition to the alternatives. Fluor Daniel staff summarized the citizen concerns voiced during those meetings and discussed them in the Conceptual Proposal.

Citizen comments gave Fluor Daniel the concept ideas that ultimately became the Capital Beltway HOT Lanes proposal. Following the public hearings, VDOT published a report analyzing the citizen comments received during those public hearings. (This report is available on the EIS project Web site, http://project1.parsons.com/capitalbeltway.) The results of this analysis were consistent with Fluor Daniel's earlier observations and illustrate how the HOT lane concept responds to the majority of citizen concerns. Following are summaries of the VDOT report conclusions grouped under the four areas mentioned in Fluor Daniel's Conceptual Proposal:

Citizen Concern	VDOT Report
Many citizens were concerned that all reasonable alternatives were not considered.	According to the VDOT report, many citizens suggested that alternatives need to accommodate other modes of transportation, which they felt the VDOT alternatives lacked. Non-DEIS alternatives were suggested relating to transit and other modes, such as developing a package of multimodal transportation improvements as part of the Beltway project. There was support for combining or converting HOV with HOT lanes.
	Fluor Daniel Concept Response
	• Reduce the VDOT Barrier-Separated HOV (4-2-2-4) Alternative's width and the number and extent of interchange improvements allowing it to fit within existing right-of-way as the HOT Lane Alternative. • Convert the alternative to a multimodal transportation facility that encourages car pooling and express bus use.

Citizen Concern	VDOT Report
Citizens questioned the high costs and wondered where the money would come from.	The VDOT report stated that many citizens thought the costs of the project ($ billions) were too high and that those funds would be better used for other area projects or uses. A number of citizens supported funding for toll lanes or HOT lanes.
	Fluor Daniel Concept Response
	• Reduce the project cost to $693 million as a result of the scaling back of the Barrier-Separated Alternative scope. • Projected HOT lane toll revenues will help finance approximately 87 percent of the improvements, while allowing car pools and express buses to ride for free. • State and federal project cost contributions to this public-private partnership are approximately 13 percent, or $87 million.
Citizen Concern	**VDOT Report**
To most citizens, the quality of life issues, displacement, air quality, and better mass transit were very important.	Numerous citizen comments were made, according to the VDOT report, regarding environmental impacts with displacement and right-of-way concerns being the most frequent comment due to the 200 to 300 homes and businesses potentially displaced by the DEIS alternatives. Citizens suggested the avoidance of homes, especially in the I-66 interchange/Barbour Road area. VDOT has estimated displacement of up to 15 businesses, more than 90 homes, and an apartment building with 33 units in the I-66 interchange area. Citizens commented on air quality and were concerned that the VDOT alternatives would not meet air quality requirements and not improve the air quality. Citizens said they wanted to include improved transit in solving the Beltway problem and many specifically supported bus and regional transit improvements.

	Fluor Daniel Concept Response
	• Current Fluor Daniel estimates indicate that only four residential structures and possibly two more will be displaced. • Included in this count is one structure in the area around the I-66 interchange. • A qualitative analysis of the potential regional air quality impacts of HOT lanes on the Capital Beltway through the Metropolitan Washington Council of Governments indicates HOT lanes perform much better than the conventional widening solutions (see Appendix D). • HOT/HOV lanes will interconnect with existing I-95, I-66, and Dulles Toll Road HOV lanes, providing a major missing link in the regional HOV system and through this linkage allow greater regional express bus opportunities.
Citizen Concern	**VDOT Report**
Concern that EIS alternatives will not offer a long-term solution requiring more widening in 15 years.	Some citizens opposed the alternatives because they would not solve the long-term traffic problem as indicated by the DEIS level of service analysis and would be a disincentive for HOV or mass transit use.
	Fluor Daniel Concept Response
	• Using variable tolls and market forces (supply and demand) to permit HOT lane users to operate at posted speed limits 24/7 assures continued mobility for Fairfax County's main street, one of its major economic development assets. • Introducing the HOT lane concept that has been proven to encourage car pooling beyond what could result from HOV lanes, and by allowing express bus use in a corridor that currently has very poor mass transit service. • Moves more people versus cars than any alternatives to date.

Government (Public Official's) Support

At the time of the May 2002 VDOT public hearings, there was encouragement from a public official for the development of a HOT Lanes Alternative. Fairfax County Supervisor Gerry Connolly (Providence District), whose district includes much of Tysons Corner and the Beltway, wrote a letter June 3, 2002, encouraging the consideration of a HOT Lanes Alternative to the three VDOT alternatives considered in the DEIS (see Figure 2-s.1). Later the

entire Fairfax County Board of Supervisors called for consideration of a HOT Lanes Alternative when by letter to VDOT, dated July 31, 2002, it made its official comments on the DEIS alternatives (see Figure 2-s.2).

Fluor Daniel's plan has support of:

- Fairfax County elected officials
- The Northern Virginia General Assembly Delegation

During the 2003 General Assembly, HB 2750, patroned by Delegate Jack Rollison, proposed some alternative funding for transportation improvements that provided for partial funding of the Beltway HOT lane proposal. While this bill failed in the Senate, for reasons unrelated to HOT lanes, it passed the House of Delegates by a substantial margin (see Figure 2-s.3).

In an August 20, 2003, interview on radio station WTOP, Fairfax County Chairman Kathleen Hanley argued in support of the HOT lane proposal (transcript of Chairman Hanley's remarks provided in Figure 2-s.4). Several quotes of interest in this interview include "…the Fairfax Board said you (VDOT) really ought to examine HOT lanes, that would be a way to pay for it and, oh by the way, our understanding is that it could probably be done mostly within the existing right-of-way… [T]here seems to be an awful lot of people now who are willing to pony up a little bit more to have access to lanes with lighter traffic. "

Virtually the entire Northern Virginia General Assembly delegation, with any portion of their district touching the Beltway, have endorsed the Fluor Daniel proposal and called for its speedy implementation. Figure 2-s.5 is a copy of that letter published in the *Fairfax Journal* on August 27, 2003, which is signed by 21 Senators and Delegates of which 9 are Republicans and 12 are Democrats.

Survey Shows Broad General Public Support

An independent public opinion survey conducted in September 2003 indicates that a proposal to increase the number of lanes on the Capital Beltway by adding HOT Lanes would win public acceptance. The survey, conducted by Research/Strategy/Management, asked 600 northern Virginia residents their views on highway transportation issues in their area, and focused specifically on the specific attributes of the Fluor Daniel Capital Beltway HOT Lanes proposal. See Figure 2-s.6 for the Northern Virginia area the survey covered.

The underlying basis of support for the proposal begins with the view that traffic conditions in the region are not good. Asked to describe "traffic conditions where you live and work," 73 percent said they were either "very bad" (32 percent), or "more bad than good" (41 percent). Sixty-one percent of the respondents expressed this concern by agreeing that "there is a need to build new or widen highways" in the area, including 49 percent who felt strongly about the need.

The Beltway is seen as being an even bigger problem than overall traffic conditions, with 82 percent describing conditions there as either "very bad" (44 percent) or "more bad than good" (38 percent). Sixty-one percent felt the solution for the problems of the Beltway was to "build new lanes or widen" it. Forty-four percent felt strongly about this solution.

Figure 2-s.6. Northern Virginia Counties and Independent Cities Surveyed

The use of tolls to finance highway construction, which gets slightly less than 50 percent support in the abstract, achieves a solid majority of support if the following conditions are expressed:

• There are insufficient general highway funds, and tolls keep taxes from being raised	63 percent
• Tolls are dedicated to that particular project	59 percent
• Drivers have a choice of free or toll lanes and the tolls are used to pay for the toll lanes	64 percent

Northern Virginians also want mass transit included in any Beltway widening plan, agreeing by a 68 percent to 21 percent margin that "any action to improve the Beltway should include provisions for mass transit such as light rail and express buses and car pools."

Only 12 percent of respondents had heard about a proposal by a private company to widen the Beltway; but when the proposal was outlined, 62 percent of respondents said they would favor it as a plan for widening the Beltway. Following is the description provided to the citizens during the survey:

> One company has submitted a plan to widen the Beltway by adding HOT Lanes, a new type of roadway found in several locations throughout the U.S. HOT stands for High Occupancy Toll. HOT lanes are new lanes added to the middle of existing freeways, which charge a variable toll to use. Car pools and express buses use the HOT lanes for free while other vehicles must pay a toll, which helps finance the new lanes. The regular existing lanes of the highway are still available for free use by anyone who chooses to use them.

Respondents were asked a series of questions to determine what aspects of the HOT lane idea had the greatest public appeal. In one group of questions, they were asked to indicate whether they would be more or less likely to support the HOT lane plan based on their knowledge of certain criteria. Following are the margins of support for the various aspects:

• Shorten travel time on a consistent basis	15-1
• Fixed cost/fixed date with financial penalties to contractor	8-1
• Trucks banned from HOT lanes	7.5-1
• No new taxes	6-1
• No more than 10 homes and no business displaced	5.5-1
• Allows express buses to access Springfield, Tysons, Dulles, Metrorail/VRE stations	5.5-1
• Variable pricing	2-1

When asked to choose which one of several attributes of the HOT Lanes plan was the most appealing, respondents found all aspects desirable. Each of the attributes received at least eight and no more than 14 percent of the total:

- Can be built without new taxes
- Offer more choices when making driving decisions
- Save time by making travel consistently more reliable
- Reduce congestion on the conventional lanes
- Improve Beltway safety
- Can be built with minimal disruption to community and environment
- Permit rapid transit around the Beltway

Majority of 600 Northern Virginia citizens interviewed said:

- Traffic conditions are bad but worse on Beltway
- Toils are good if they retain a choice
- Beltway plans should include HOV and mass transit
- They support Beltway HOT lanes That support increases if:
  - Improved travel time is reliable
  - Trucks are restricted
  - Express bus option is included
  - Variable toll is used but user maintains a choice

The survey demonstrated that Northern Virginia residents feel that local traffic conditions are bad and that those on the Beltway are particularly so. General support for the use of tolls to finance highways is strong if the public understands that the tolls keep taxes from being raised and are used to finance a specific project. If a free option is also maintained (as HOT lanes do), almost two-thirds of the public supports the use of tolls.

At the present time, the public is not well informed about the HOT Lanes proposal; but the survey suggests that as people become more informed about the specifics of the HOT Lanes proposal, they will be more likely to favor it.

The general public support for HOT lanes is broadly based and not confined to a single-issue factor. This circumstance tends to improve the durability of support in the face of any opposition that may develop.

Media Support

It is highly unusual to find the *Washington Post* and the *Washington Times* in agreement editorially on any subject, but HOT lanes on the Beltway is one area where they agree. On Tuesday July 16, 2002, the *Washington Post* published an editorial supporting the Fluor Daniel proposal entitled "A New Way to go Beltway" (Figure 2-s.7). The editorial said "…a roadbuilding company's proposal to add four lanes to the Capital Beltway in Northern Virginia – for car poolers to use for free and willing solo drivers for tolls – is worth a serious look…

Virginia – strapped for highway funds, but choking on traffic – is right to consider different ways to finance transportation…."

On Wednesday July 17, 2002, the *Washington Times* published its editorial entitled "Tolls, Gridlock and the Beltway" (Figure 2-s.8) that said "The plan put forward by Fluor Daniel to deal with the impending morass envisions adding four lanes to the existing Beltway… Like it or lump it, though, the only way we'll see any relief from gridlock is by going with something along the lines proposed by Fluor Daniel. Paying to get moving may be a better deal than not moving at all."

Business Support

In light of the broad political and media support for the HOT Lanes proposal, it is not surprising that the business community is also joining in that support. The principal business group in the area, The Fairfax County Chamber of Commerce, did so by letter on July 15, 2003 (see Figure 2-s.9). Given the past opposition to tolls, it is significant that The American Automobile Association of the Mid-Atlantic has specifically indorsed the Fluor Daniel HOT Lanes Proposal (see Figure 2s-10).

NEPA/FEIS Independent Community Input

The HOT lane concept is being evaluated as part of the ongoing Capital Beltway environmental impact statement (EIS) process. This EIS process is independent from the PPTA process since it is required to maintain objectivity in evaluating all alternatives including the No-Build alternative. Any Fluor concept must comply with the National Environmental Policy Act (NEPA) and the Capital Beltway EIS process.

Public Outreach and Information Program

The HOT lanes have a high potential for broad public support for the Capital Beltway HOT Lane project as demonstrated by the August 2003 survey results summarized earlier. Moreover, the nature of the project is such that it can mitigate most citizen concerns raised during the May 2002 Beltway public hearings. Fluor Daniel will establish a proactive public participation program. Public outreach and education are critical to the success of HOT lanes. Informing the public is simply good business since many of the same citizens may become HOT lane users. The public information program will attempt to anticipate the information needs of the citizens, businesses, and public officials. The program will be designed to help the public improve its understanding of this concept and project.

This public information program will begin in the near future and consist of:

- Analysis of the recent public opinion survey to define citizen opinions and reactions to the Fluor proposal with the goal of modifying the concept to mitigate any negative impacts or concerns
- A comprehensive communications plan covering all aspects of the program
- An ongoing public appearance program
- A community relations program to provide information to and build positive relationships
- Public appearances at civic organizations by the project director and key staff
- A well-publicized, interactive Web site
- Carefully planned news releases at important moments in the process
- Direct communications with community leader such as local elected officials, business and labor leaders, the news media, and others
- Selective use of advertising, timed around key events in the process; brochures and other publications; direct mail; and print, radio, and television advertising

Figure 2-s.1. Fairfax Supervisor Connolly's Letter to VDOT

GERALD E. CONNOLLY
SUPERVISOR
PROVIDENCE DISTRICT
8739 LEE HIGHWAY
FAIRFAX, VIRGINIA 22031

TELEPHONE 703/560-6946
FAX 703/207-3541

COMMONWEALTH OF VIRGINIA
COUNTY OF FAIRFAX
BOARD OF SUPERVISORS
FAIRFAX, VIRGINIA 22035

June 3, 2002

Whittington W. Clement
Secretary of Transportation
Office of the Governor
State Capitol, 9th Street Office Building
Richmond, VA 23219

Dear Secretary Clement:

I have reviewed the three Build Alternatives presented in the Capital Beltway Draft Environmental Impact Statement (EIS) dated March 2002. I have a number of serious concerns with all of the alternatives.

My concerns are summarized as follows:

- The Build Alternatives do not adequately minimize displacement of homeowners and businesses and, additionally, adversely affect park and cultural resources. We need a solution that optimizes the use of existing right-of-way for both thru lanes and interchanges.

- The Build Alternatives are not sufficiently environmentally sensitive. Not enough has been done to encourage car pooling, express bus ridership and assure long term future mobility of what has become our Main Street.

- The Build Alternatives do not adequately address the need for the Capital Beltway to provide for assured access for emergency vehicles nor for facilitating evacuation in the event of an emergency or disaster affecting the core of the Washington region.

- The Build Alternatives do not address the possible extension of a rail system around the Beltway.

Figure 2-s.1. Fairfax Supervisor Connolly's Letter to VDOT

- The Build Alternatives do not address the possibility for some portion of the new lanes to be tolled as so-called "hot lanes" in order to make the project more fiscally achievable and thus, within a short period of time, a reality rather than a dream, while providing a source of revenue that could be used in the future for other critical transit and transportation projects.

I am aware that in other areas of the country, there are highly popular, innovative concepts and technology that have been used on interstate highway projects which might have applicability here. The citizens of Fairfax are intelligent, sophisticated and open to new transportation concepts, especially if they address the concerns I have summarized. Therefore, I request there be an evaluation of the concept and technology available to provide for the combined use of the HOV lanes with non-HOV toll use of the express lanes. It is my hope that a fair evaluation of these concepts and technology might produce an approach which could address more adequately the concerns expressed above.

I believe that whatever we do to address capacity should be done within the existing right-of-way thus minimizing impacts on neighborhoods, homeowners and the environment.

Thank you for your thoughtful consideration of these suggestions.

Sincerely,

Gerry Connolly
Providence District Supervisor

GEC/lwf

Cc: Capital Beltway Study c/o Parsons Group

* Highlights added by Fluor Daniel

Figure 2-s.2. Fairfax County Board Letter to VDOT – 7/31/02

COMMONWEALTH OF VIRGINIA
COUNTY OF FAIRFAX
BOARD OF SUPERVISORS
OFFICE OF THE CHAIRMAN

KATHERINE K. HANLEY
CHAIRMAN

Suite 530
12000 GOVERNMENT CENTER PARKWAY
FAIRFAX, VIRGINIA 22035-0071

TELEPHONE 703/324-2321
FAX 703/324-3955
chairman@fairfaxcounty.gov

July 31, 2002

The Honorable Whittington Clement
Secretary of Transportation
Commonwealth of Virginia
1401 East Broad Street
Richmond, Virginia 23219

Dear Secretary Clement:

I am writing on behalf of the Fairfax County Board of Supervisors to provide comments to you and the members of the Commonwealth Transportation Board (CTB) regarding the Location Study and Environmental Impact Statement for the widening of the Capital Beltway (I-495) from the American Legion Bridge to the Springfield Interchange. The Board reviewed this matter at its July 22, 2002, meeting and expressed extremely serious concerns regarding the project.

In particular, the Board found that all three Build Alternatives are unacceptable because they have substantial impacts on the surrounding communities, including numerous homes, businesses, parks, and cultural resources. Rather than adopting one of the options studied to date, the Board recommended that VDOT reevaluate the alternatives to significantly reduce the impacts on the adjacent properties while mitigating traffic congestion in the critical areas. The Board suggested that the typical mainline section stay within existing right-of-way wherever possible. Any improvements to the Beltway interchanges should be more constrained than what has been proposed.

The Board had the following additional comments for your consideration:

- VDOT should develop their design in recognition of the right-of-way dedications already provided by adjacent landowners, for example in the Tysons Corner area, where those dedications were based on information provided by VDOT. Every effort should be made to eliminate any additional impacts to these sites.

* Highlights added by Fluor Daniel

Figure 2-s.2. Fairfax County Board Letter to VDOT – 7/31/02

The Honorable Whittington Clement
July 31, 2002
Page 2

- There are significant additional impacts to residential areas along the length of the project that had not been previously identified to the public and that need to be reduced. One example is the reconstruction of the Barbour Road bridge over I-66 that had not been shown at previous meetings but is now shown as impacting approximately a dozen homes.

- Alternative funding sources that would allow improvements to move forward, such as the use of high-occupancy toll (HOT) lanes, should be identified and considered.

- In addition to the reevaluation of the Build Alternatives, VDOT should study ways to improve capacity and safety on the Capital Beltway through the development of short and mid-term projects that could realistically be funded. These projects should address critical areas of the Capital Beltway including the segment between Route 50 (Arlington Boulevard) and the Dulles Toll Road. VDOT should identify ways to improve capacity and safety at the interchange of the Capital Beltway and I-66 while significantly minimizing impacts on the surrounding communities. Funding for interim improvements at I-66 had previously been included in the Virginia Transportation Act of 2000 and fully funded in prior six-year programs.

- The State, in cooperation with transit agencies and local governments, should study ways to improve transit in the Beltway corridor. This should look at alternatives previously studied, as well as any new potential solutions for improving the north/south transit corridor connecting Springfield with Tysons Corner and areas beyond and in between. Any options should be compatible with those alternatives being studied by Maryland.

- VDOT must study ways to improve pedestrian and bicycle access across and along the Capital Beltway to minimize the effect that the Beltway has as a barrier to these non-motorized transportation options.

* Highlights added by Fluor Daniel

Figure 2-s.2. Fairfax County Board Letter to VDOT – 7/31/02

The Honorable Whittington Clement
July 31, 2002
Page 3

- The CTB needs to establish a process and take actions that will remove the cloud of uncertainty that exists on those properties impacted by VDOT's proposed alternatives.

The operation and safety of the Capital Beltway is a critical quality of life issue for the Washington Metropolitan area, most particularly for those who live in close proximity to the roadway and those who use the Beltway daily. We request that VDOT explore additional options for the Beltway that would give as much consideration to minimizing impacts to the adjacent communities as has been given to providing additional traffic capacity. We appreciate your assistance and support in this and other critical transportation issues in Fairfax County.

Sincerely,

Kate Hanley

Katherine K. Hanley

KKH:lw

cc: Members, Commonwealth Transportation Board
Members, Fairfax County Board of Supervisors
Philip A. Shucet, Commissioner, Virginia Department of Transportation
Karen J. Rae, Director, Virginia Department of Rail and Public Transportation
Thomas F. Farley, District Administrator, Virginia Department of Transportation
Young Ho Chang, Director, Fairfax County Department of Transportation

* Highlights added by Fluor Daniel

Figure 2-s.3. Rollison Bill in General Assembly Included Funding for HOT Lanes

031

bil

Another bill?

HB 2750 Commonwealth Private Investment Inducement Act of 2003. Patron - John A. Rollison;Resigned 9/14 (all patrons) ..... notes

Summary as passed House: (all summaries)

Commonwealth Private Investment Inducement Act of 2003. Dedicates one-third of the annual insurance license tax revenue to transportation projects in highway construction districts based on the percentage of the population of the Commonwealth residing in each such district. The portion of such revenues that otherwise would be distributed to: (i) the Northern Virginia Construction District is instead deposited into the Northern Virginia Investment Fund, created under the bill, and used to finance bonds in an amount not to exceed $350 million for specific transportation projects; (ii) the Hampton Roads Construction District is instead deposited into the Hampton Roads Investment Fund, created under the bill, and used to finance bonds in an amount not to exceed $350 million for specific transportation projects in that area; (iii) the Bristol, Salem, and Staunton Construction District is instead deposited into the Western Virginia Investment Fund, created under the bill, and used to finance bonds in an amount not to exceed $350 million for specific transportation projects in that area. The amount of such bond proceeds utilized must be matched by equal or greater funds from private entities, localities, or both, unless certain conditions exist.

Full text:
01/17/03 House: Presented & ordered printed 032020916
01/30/03 House: Committee substitute printed 032035916-H1
02/01/03 House: Printed as engrossed 032035916-EH1 **(impact statement)**

Amendments:
House amendments

Status:
01/17/03 House: Presented & ordered printed 032020916
01/17/03 House: Referred to Committee on Transportation
01/21/03 House: Referred from Transportation (22-Y 0-N)
01/21/03 House: Referred to Committee on Appropriations
01/29/03 House: Reported from Appropriations with sub (25-Y 0-N)
01/30/03 House: Committee substitute printed 032035916-H1
01/31/03 House: Read first time
02/01/03 House: Read second time
02/01/03 House: Committee substitute agreed to 032035916-H1
02/01/03 House: Engrossed by House - committee substitute 032035916-H1
02/01/03 House: Engrossment reconsidered by House (51-Y 43-N)
02/01/03 House: VOTE: RECONSIDER (51-Y 43-N)
02/01/03 House: Amendments by Del. Joannou agreed to
02/01/03 House: Motion to pass by fl. amd. by Del. Armstrong agreed to
02/01/03 House: Motion to pass by fl. amd. by Del. Hamilton agreed to
02/01/03 House: Pending question ordered
02/01/03 House: Engrossed by House - com. sub. w/amds 032035916-EH1
02/01/03 House: Printed as engrossed 032035916-EH1
02/03/03 House: Read third time and passed House (88-Y 11-N 1-A)
02/03/03 House: VOTE: PASSAGE (88-Y 11-N 1-A)
02/03/03 House: Communicated to Senate
02/04/03 Senate: Constitutional reading dispensed
02/04/03 Senate: Referred to Committee on Finance
02/12/03 Senate: Failed to report (defeated) in Finance (6-Y 9-N)

* Highlights added by Fluor Daniel

Figure 2-s.4. Fairfax Chairman Hanley's WTOP Comments - 8/20/03

Transcript of Chairman Hanley's WTOP Interview

August 20, 2003 (Text is Limited to HOT Lane Questions)

Question re transportation in Washington. "Our roads are saturated, construction continues which increases traffic and the mess gets bigger, public transportation will alleviate part of the problem, but will not eradicate it."

Moderator - and this takes us to the idea of HOT lanes which have been catching on recently.

KH [Katherine Hanley] – Well, the Fairfax Board of Supervisors went on record a year ago as suggesting to VDOT that an opportunity to put HOT lanes on the Beltway in Northern Virginia was one that they should look seriously at.

Moderator – These are toll lanes.

KH – Particularly because there was a widening project for the beltway and it was going to have HOV lanes and it was huge. It would have been great in Kansas where there was a lot of land but it was going to take all kinds of houses so the Fairfax Board said you really ought to examine HOT lanes, that would be a way to pay for it and, oh by the way, our understanding is that it could probably be done mostly within the existing right-of-way. HOT lanes, where you are adding capacity are really HOV lanes where some HOV 2/HOV 3 still get to go free on the HOT lanes (High Occupancy Toll), but those who are in a single occupancy vehicle pay and often times it is a process where you pay differently depending on how congested it is. It's like rush hour fares on Metro because you have to be sure that you don't jam up those lanes to make it unproductive. Time is money here for those people in HOV which is what you are really trying to do here. You're trying to get people to cut down on the number of cars. In that case, let's say, it is not restricting the existing capacity that's free right now. Nothing changes about that, it's just the addition. Way back in 1992, then-Transportation Secretary John Milliken put a network connecting the 95 HOV lanes to the Dulles Toll Road HOV lanes. He put an HOV lane on and it got on the region's long-range plan so that's been a discussion for a long time. I think it has possibilities in areas where it doesn't restrict access so that you have the road that people have but you have an opportunity to encourage HOV and you have an opportunity to pay for the facility.

Moderator – so when there's an area where the road is going to be expanded and a lane added to it or where there is a dedicated HOV lane, that's HOV 24 hours a day you are saying, that would be eligible.

Figure 2-s.4. Fairfax Chairman Hanley's WTOP Comments - 8/20/03

KH – Yes, I think people don't understand that it is not a restriction. Now, there may be some cases where you would want to build HOT lanes, I'm not addressing that but this is not restricting access only to those who can pay because the existing transportation capacity is there.

Moderator – So you take all flexible HOV lanes out of the mix then?

KH – Well, flexible HOV lanes are harder in a number of ways. You've notice that the state highway patrol and VDOT are cracking down on HOV lane violators.

Moderator – Plenty of cheaters out there.

KH – Yeah, there are. and there harder to get compliance on, particularly, in places like 66 where there are no shoulders. It is really hard for the state police. They almost have to do that at the exits. But they really do need to monitor that and get compliance because HOV lanes are a form of , we're talking about moving people, not cars, and they move a lot more people and it is also good for the air.

Moderator – Now, the opponents of the HOT lanes were quick to say, hey, they are Lexis lanes and hey, it's just a tax to use the same roads we are using now but there seems to be an awful lot of people now who are willing to pony up a little bit more to have access to lanes with lighter traffic.

KH – Well, the situation I described is really not . . you still have the same opportunity to go on the road that you have now. You have the same opportunity to sit in the same traffic jam, yes, but you have the same opportunity and this is a user fee and there is a lot of discussion about paying for things with user fees. Having said that, there does have to be a balance. Public transportation, the network, not just buses and rail but cars, the roads, the public needs to be able to get around and so you have to have a balance of that. You couldn't put tolls on everything, that wouldn't be fair.

Moderator – so if we do go to HOT lanes, you would expect to see some sort of addition to public transportation to balance that out?

KH – No, I was just describing the whole network. Certainly, one of things that HOV lanes, whether they are HOT lanes or not, HOV lanes allows you to do is run bus because you have a multiple occupancy vehicle there.

Figure 2-s.4. Fairfax Chairman Hanley's WTOP Comments - 8/20/03

Moderator – Now, those took a lot of heat when they came around the first time, too. I remember when they first started with HOV lanes. People said oh, this is terrible.

KH – and people still do. I mean it is not a universally accepted facility.

Moderator – Well, I think it has become accepted. It may not be loved . .

KH – well, alright. That's better. It is not a universally loved facility.

Moderator – but, isn't acceptance all you are really going for? If it is a good policy, you are never going to . .

KH – well, I would go back to my earlier point that the idea is to have a balanced transportation network in the region where people have choices, choices about route and choices about how they get there and choices about mode and you know during the snowstorm, you remember the day that I couldn't get here. It seems like everybody listened to your radio station that day is because everybody was on the main roads and while we don't like to have cut-through traffic in our neighborhoods, it is a fact of life and so when everybody got on the main roads, you know they didn't have a choice and it just completely overwhelmed the capacity of the major highways.

Moderator – I should add that you ultimately did get here.

KH – Yes, I did!

The remainder of the program was devoted to commuter tax, budget surplus, baseball stadium, and West Nile virus.

* Highlights added by Fluor Daniel

Figure 2-s.5. Congressional Delegation Letter

Dear Editor,

While transportation problems abound throughout Northern Virginia, everyone agrees that the current situation on the Beltway from the Springfield interchange to the American Legion Bridge is one of our most critical.

For many years, the Virginia Department of Transportation (VDOT) has been studying the Beltway as a part of an Environmental Impact Statement (EIS) process. Last year VDOT held hearings on its draft EIS and virtually everyone rejected the three proposed build alternatives because of substantial impacts, especially the hundreds of homes and businesses that would have been displaced, outside the existing I-495/Beltway right-of-way.

Now a private firm, Fluor, has come up with a plan which seems to make a great deal of sense. Fluor proposes to add four new lanes, two each way, which will be restricted to HOV, transit and emergency vehicles traveling for free while all others would pay a variable toll. This system is called HOT lanes.

The Commonwealth Transportation Board (CTB) just recently authorized VDOT to proceed further with the Fluor HOT lanes proposal. We applaud the CTB for this action; however, our concern is that the process proceed promptly.

The Fluor plan will allow improvement of the Beltway capacity in the correct way. It is environmentally sensitive and, critically, is mass-transit friendly. The HOT lanes would provide a congestion-free express-bus transit link between Springfield and Tysons Corner, joining a number of existing Metro stations in a way not otherwise economically feasible. It also is the only plan which stays almost entirely within existing right-of-way and provides the funds to make the improvements so that relief can occur sooner rather than later.

We have two messages for VDOT as the process proceeds:

- Keep the improvements to the Beltway within the existing right-of-way.
- Move this along on the fastest schedule possible. We cannot afford to have this project languish because of bureaucratic delays.

We stand ready to assist VDOT and CTB as this important project proceeds. For the sake of all stuck in traffic on the Beltway in Northern Virginia, let's get it done now!

Delegate Vincent Callahan
(Co-Chairman of the Northern Virginia Delegation)

Delegate David Albo
Delegate Kristen Amundson
Delegate Thomas Bolvin
Delegate Jeannemarie Devolites
Delegate James Dillard
Delegate Timothy Hugo
Delegate Robert Hull
Delegate Brian Moran
Delegate Chapman Petersen
Delegate Kenneth Plum
Delegate Thomas Rust
Delegate James Scott
Delegate Vivian Watts

Senator Richard Saslaw
(Co-Chairman of the Northern Virginia Delegation)
Senator Ken Cuccinelli
Senator Janet Howell
Senator Jay O'Brien
Senator Linda Puller
Senator Patricia Ticer
Senator Mary Margaret Whipple

* Highlights added by Fluor Daniel

Figure 2-s.7. *Washington Post* Editorial - 7/16/02

The Washington Post
An Independent Newspaper

"A NEW WAY TO GO BELTWAY?

It's still far from any official drawing board, but a road-building company's proposal to add four lanes to the Capital Beltway in Northern Virginia–for carpoolers to use for free and willing solo drivers for tolls–is worth a serious look. The idea itself isn't new, though it would be a first in Virginia. The Proposal, by Fluor Daniel, one of the world's largest engineering and construction companies, is to widen the beltway to 12 lanes between the Springfield interchange and the American Legion Bridge. Toll money would be used instead of state money.

Lone drivers could stay in the regular lanes or pay a fee to use the High Occupancy Toll, or HOT lanes. A company spokesman says the base toll could be $1, with higher prices charged during rush hours. So far, local and state officials are reacting cautiously, which is the right response given the number of questions the proposal raises.

One criticism was raised last year in Maryland by Gov. Glendening, who suddenly pulled the rug out from under his own state transportation secretary and summarily scrapped a plan for a test of a similar HOT lane on Route 50. He cast the idea as a class issue, echoing critics elsewhere in the country who say it favors the more monied motorists. But if it reduced congestion in the free lanes and resulted in more car pools in the faster lanes, wouldn't everybody be better off? Might the air suffer a little less, benefiting all taxpayers? Many transportation officials point to California, where people of all income levels reportedly elect to use the HOT lanes when they need to get somewhere fast.

The biggest questions have to do with private financing, which Maryland wasn't considering. How much money are we talking about here, and given the history of all too many big road projects in Virginia, who would pick up the tab for a hefty cost overrun? Who would set and control the tolls? Who would absorb any losses if the plan bombs? And how many homes would it take out?

Virginia–strapped for highway funds, but choking on traffic–is right to consider different ways to finance transportation, from private projects to tolls, and in this case, both. Whether HOT, HOV or regular, more lanes belong to the mix."

* Highlights added by Fluor Daniel

Figure 2-s.8. *Washington Times* Editorial - 7/17/02

The Washington Times
America's Newspaper

"TOLLS, GRIDLOCK AND THE BELTWAY

Anything that's free – or at least perceived to be–will be overused. This is one reason why our roads are increasingly clogged and why building our way out of gridlock is not likely to relieve gridlock. What might help, though, is introducing a little free-market medicine – specifically, tolls.

Such a solution has been offered by a private contractor, Fluor Daniel, as part of a plan to increase the capacity of the Capital Beltway. The region's major thoroughfare is already significantly over capacity and projected to become virtually impassable within the next 20 years. Rush "hour" will become 14-plus hours per day of near-standstill traffic, effectively paralyzing the region and making local travel an unimaginable ordeal. The effect on the regional economy – to say nothing of the quality of life for area residents – would be disastrous. Something clearly must be done.

The plan put forward by Fluor Daniel to deal with the impending morass envisions adding four lanes to the existing Beltway, two in each direction (for 12 total) at major traffic choke points, including the I-95/I-495 Springfield interchange. But the real innovation is the suggestion that toll revenue be used to finance the upgrade. Fluor Daniel claims that the creation of toll lanes, with fees ranging from as low as $1 to perhaps as high as $4, would make the project financially viable, as well as help keep traffic flow manageable by limiting unnecessary trips. Critics, including Maryland Gov. Parris Glendening, have derided the toll lanes as "Lexus lanes" that would allow affluent motorists to escape gridlock while condemning low-income motorists to sit and stew.

However, there is much to commend the basic concept of self-financing roads with a built-in mechanism for managing traffic volume. On the one hand, while it is true that those with a little extra money would be more able to avail themselves of the less crowded toll lanes, it is also true that the regular lanes would likely see a decrease in volume as a side effect. California has had good results with toll lanes (known as HOT lanes), and it seems Washington could emulate the example without making matters worse than they already are – or will be, as the depth and breadth of gridlock increases with each passing year.

Figure 2-s.8. *Washington Times* Editorial - 7/17/02

Moreover, the proposal to use tolls as a means of financing improvements to the Beltway may be the only way that the roadwork ever gets under way. The Virginia Department of Transportation has estimated that widening the Beltway to 12 lanes would cost between $2.3 billion and $3.5 billion. To put that figure in perspective, the regional taxing authority being pushed by Virginia Gov. Mark R. Warner to fund road improvements would generate all of $200 million. Where, precisely, will the remaining $2 billion to $3 billion come from? No one has a clue. Virginia, which is home to about half the I-495 Beltway, is in financial straits, with massive budget shortfalls predicted. It's not much better in Maryland. New taxes aren't going to solve the shortfall problem, leaving aside the damage they would do to family budgets. "The time is probably here when the piper has to be paid," said AAA's Lon Anderson, who remains less-than-enthusiastic about the potential for $4 one-way toll charges.

Like it or lump it, though, the only way we'll see any relief from gridlock is by going with something along the lines proposed by Fluor Daniel. Paying to get moving may be a better deal than not moving at all."

* Highlights added by Fluor Daniel

Figure 2-s.9. Fairfax County Chamber of Commerce Letter - 7/16/03

FAIRFAX COUNTY
CHAMBER OF COMMERCE
The Voice of Business in Northern Virginia™

July 15, 2003

The Honorable Mark R. Warner
Governor, Commonwealth of Virginia
State Capitol, Third Floor
Richmond, Virginia 23219

Dear Governor Warner:

It was with great interest that I read the Washington Post story on Saturday, July 12th, outlining Commissioner Shucet's support for moving forward with adding variable toll lanes to the Beltway. On behalf of the Fairfax County Chamber of Commerce, I urge you to put the weight of your office behind moving this project forward.

In the face of dwindling resources, we are left with fewer and fewer choices about how to address our transportation crisis. This is a solution that allows everyone to win. Carpoolers and those using mass transit will find added capacity on a major roadway that has never been available to them before. Single drivers will have the option of paying a variable toll to speed their commute. Those who want to maintain access to the freeways will find their experience a less congested one. And this all can be accomplished using the tolls to fund most of the construction of the new lanes.

There are precious few solutions left to us for addressing perhaps the single biggest threat to our quality of life in Northern Virginia. It is imperative that we embrace alternatives that provide greater choice in how we access out transportation network and that provide some congestion relief.

The Fairfax County Chamber fully understands that this is only a partial solution. But it gives us a solid starting place that we can build on in the future.

Sincerely,

William D. Lecos
President & CEO
Fairfax County Chamber of Commerce

Cc: Fairfax County Board of Supervisors
The Honorable Whittington Clement, Secretary of Transportation
Commissioner Philip A. Shucet
Board of Directors, Fairfax County Chamber of Commerce

8230 Old Courthouse Road, Suite 350
Vienna, VA 22182-3853
(703) 749-0400 • (703) 749-9075 - fax
www.fccc.org

Figure 2-s.10. American Automobile Association of the Mid-Atlantic - 8/06/02

AAA Mid-Atlantic

Statement by Lon Anderson,
Director of Public and Government Relations,

With the third worst congestion in the United States, the Washington Metropolitan Area has a transportation crisis, and very little money with which to fix it. The Capital Beltway is exhibit A in the region's gridlock.

While AAA Mid-Atlantic typically opposes tolls as a tax on roads for which drivers have already paid through gas taxes and fees, we recognize that with little money in the coffers for new projects, creative Public-Private Partnerships become a very attractive and viable alternative solution. Further, if that involves using tolls to pay for new capacity, and that is the only way realistically of achieving the added capacity in the foreseeable future, then we will support that effort.

2-t TRANSIT ENHANCEMENTS

A detailed listing of actual or potential transit enhancements in the I-495 corridor as a result of this project, including impacts to "slugs"

The proposed HOT lanes represent a significant multimodal facility for the Washington Region. In addition to use by toll-paying vehicles, the HOT lanes would function as both a high-occupancy vehicle (HOV) lane used by carpools (HOV3+) and vanpools and a transitway for use by regional express bus transit services.

HOV Benefits

The current Northern Virginia HOV system is limited to:

- I-95/395 from south of VA-234 at Dumfries in Prince William County to South Eads Street near the Pentagon in Arlington County.
- I-66, composed of 18 miles of an HOV-2 inner diamond lane each way from west of VA-234 at Manassas to I-495 Capital Beltway, and 9.6 miles of 2-lane exclusive HOV-2 in peak hours in peak direction, from I-495 to Rosslyn. Dulles Airport SOV traffic can use the highway at all times from Rosslyn to the Dulles Airport Access Road (DAAR). The eastern 3 miles of the DAAR is part of this HOV facility.
- Dulles Toll Road composed of 12.2 miles of HOV-2 each way from I-495 Capital Beltway to Route 28 in Fairfax County.
- US Route 1 within Old Town Alexandria reserves the right lane for HOV-2 during peak hours.

Fluor Daniel's HOT lane concept represents a major new multimodal facility for the Washington Region area. It offers:

- Significant HOV system benefits
- Express bus transit benefits
- Slug benefits
- Potential Metrorail station access benefits

Introducing HOT lanes on the Capital Beltway will create 11 miles of new HOV facilities and provide the missing link to connect the existing HOV facilities on I-95/395, I-66, and the Dulles Toll Road. Research has shown that ridesharing greatly increases as the network of HOV facilities is expanded, linked, and integrated. In addition, existing HOT operations have proven to increase carpooling even more than conventional HOV lanes. HOT lanes would permit HOV traffic from south of the Capital Beltway to travel to the Tysons Corner area, an area that does not currently support ridesharing with dedicated facilities. Carpools and vanpools would also be able to access the Merrifield area, a growing activity center.

Express Bus Transit Benefits

Express bus transit service could greatly benefit from HOT lanes on the Capital Beltway. Six existing Metrobus and three Fairfax Connector routes could be rerouted to use at least part of the length of the proposed HOT lanes to improve travel time on their current trips. The 17G, a discontinued route, followed a path that also could have used the HOT lanes on its trip between Burke and the Dunn Loring Metrorail station. Allowing these vehicles to operate on the higher speed HOT lanes rather than in the congested general-purpose lanes available today would increase dependability and reliability of bus service. Four of the Metrobus routes and one Fairfax Connector route enter the Capital Beltway at Braddock Road via the concurrent access points (or the optional direct ramp connection depicted in Figure 2-t.1) and continue to the Pentagon via the I-395 HOV lanes. Shifting these routes to the HOT lanes (Figure 2-t.1) would permit them to complete their local circulation through the neighborhoods and then enter the HOT lanes for a high-speed trip to the Pentagon. Appreciable travel time saving and increased reliability of service would be anticipated.

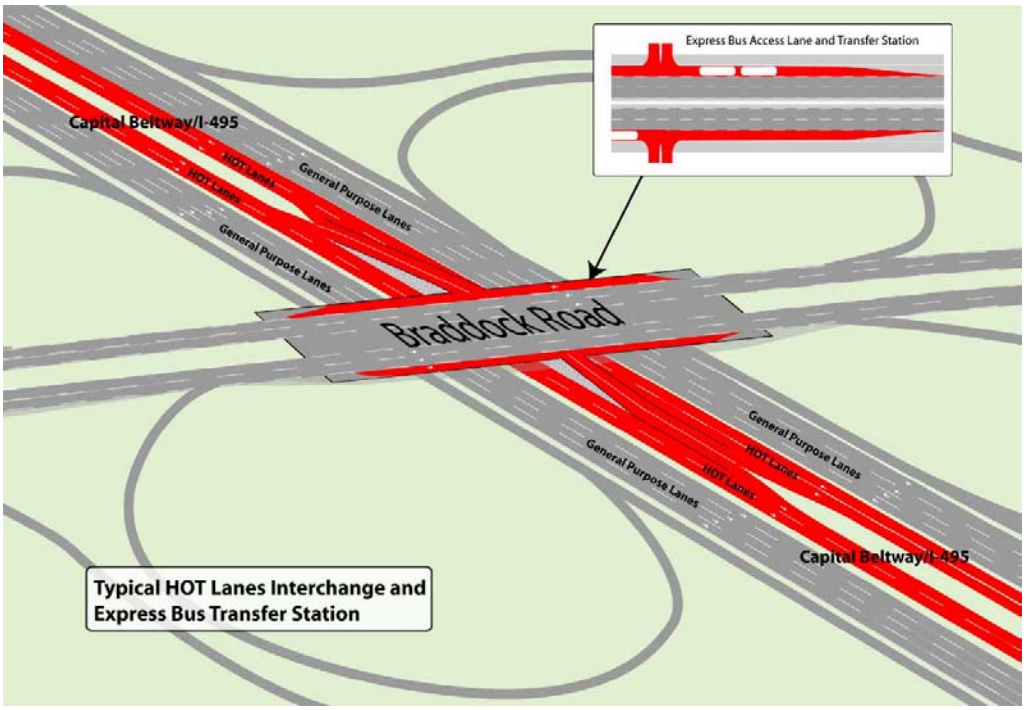


Figure 2-t.1. Optional Braddock Road Direct Ramp Access Concept

The HOT lanes could facilitate the expansion of the express bus system in Northern Virginia, forming the trunk for routes from locations as diverse as Dulles Airport, Tysons/McLean, Fair Oaks, Franconia-Springfield, East Falls Church, Seven Corners, Ballston, and the Van Dorn Metro.

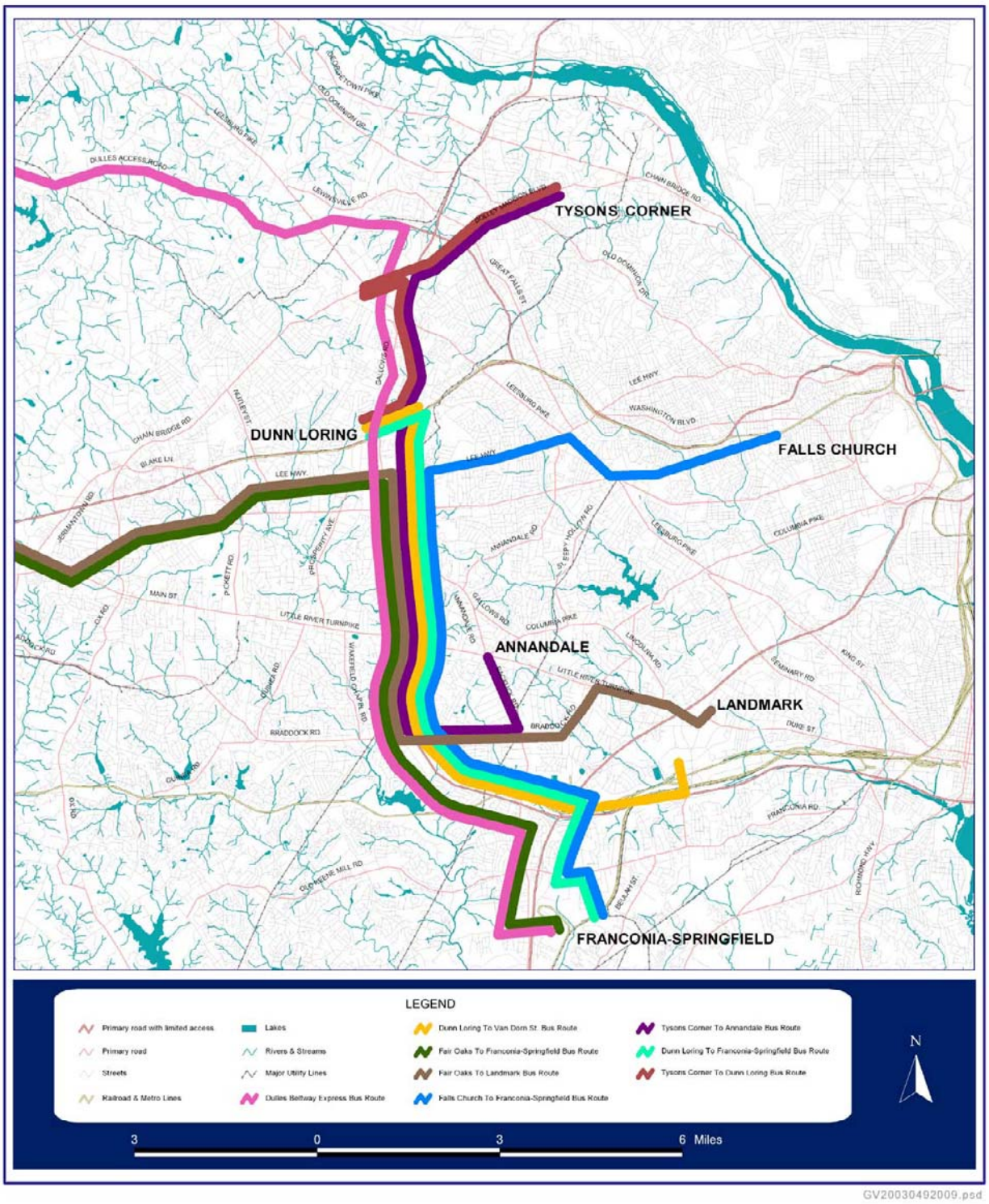


Figure 2-t.2. Proposed Bus Route Network Using HOT Lanes

Figure 2-t.2 shows a potential network of new bus transit service that could serve Northern Virginia via the proposed HOT lanes. The routes shown on this network could supplement existing service with express, point-to-point service between more distant locations. With the use of existing or future park-and-ride lots, this additional service could create "rail-like" transit service without the substantial cost in infrastructure typically required for rail operations.

Slug Benefits

The Washington Region is home to a network of informal carpooling, in which travelers and motorists team up to take advantage of HOV facilities. The travelers, referred to as "slugs," wait at known pickup points. Motorists, with insufficient passengers to meet HOV requirements, drive to these pickup points and collect passengers to a convenient destination. Although the pairing of drivers with passengers varies from day to day, countless commuters make routine use of this system. Currently, slug lines form along the I-95 and I-66 corridors and along Old Keene Mill Road. Numerous lines form in the Springfield, Woodbridge/Dale City, Stafford, Manassas, Herndon/Reston, and Centreville areas. In fact, several slug line Web sites, such as www.slug-lines.com, help coordinate these activities. The slug lines allow carpools to form and then make use of the I-95/395 and I-66 carpool lanes.

These same slug lines could take advantage of HOV operations on the proposed HOT lanes. Commuters destined for Tysons Corner and other locations along the western leg of the Capital Beltway would be able to meet and travel together. The proposed HOT lanes, therefore, would support the informal carpooling of the current slug system and could expand ridesharing opportunities. Additional slug lines could be created in the Dulles corridor, linking western Fairfax County with the I-395 corridor via the Capital Beltway.

Potential Metrorail Station Access Benefits

The HOT lanes have the potential to improve connectivity between future express bus service that would use the HOT lanes and existing and future Metrorail stations. Both *the Capital Beltway Environmental Impact Study* and *Capital Beltway Rail Transit Feasibility Study* envisioned a connection between the Dunn Loring Metrorail Station and bus transit service on the Capital Beltway. While the cost of this connection has not been included in the current proposal, such a connection would link many neighborhoods to the regional Metrorail system in a manner vastly superior to today's connections. Bus service in the Dulles Corridor could link with Metrorail, as could that of routes approaching the Beltway during the morning peak hour along the Braddock Road and Little River Turnpike corridors.

2-u POTENTIAL STAGING AREAS

A detailed listing of potential staging areas

The Fluor Daniel team will open a main project office in a business park close to the Capital Beltway HOT lanes project corridor. This office will house Fluor Daniel's senior management, design, and accounting personnel. Smaller site offices will be located at strategic points in close proximity to the work zone to manage construction.

Equipment storage and staging areas will be located at each interchange while construction is taking place. Infield, medians, and loop areas at the interchanges will be used for staging materials and equipment. Selection of which loops or infield areas will be used will be coordinated with VDOT. Any equipment not returned to the staging areas overnight will be stored outside the clear zone or behind positive protection devices, such as concrete barriers.

Appendix A

Beltway HOT Lane User Characteristics

VOLLMER ASSOCIATES LLP
Engineers
Architects
Landscape Architects
Surveyors
Planners

50 West 23rd Street
New York, NY 10010-5205

Tel: 212.366.5600
Fax: 212.366.5629

TECHNICAL MEMORANDUM

TO: Gary Groat, Fluor Daniel

FROM: Suzanne Seegmuller

DATE: 4/21/03

RE: Beltway HOT Lane User Characteristics

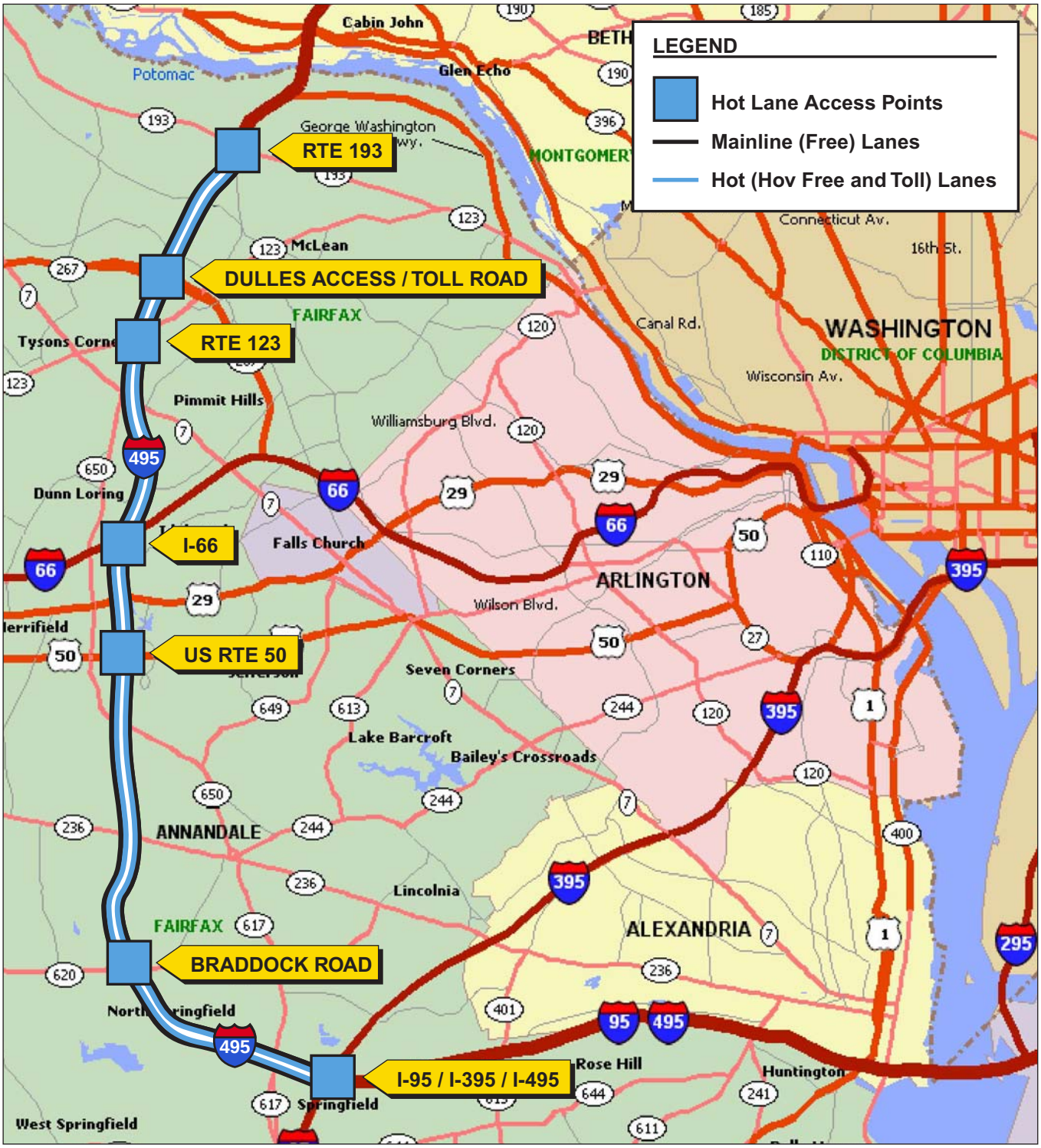
Introduction and Purpose

Last year we completed a preliminary estimate of likely traffic and revenue for the high occupancy/toll ("HOT") lanes on the Capital Beltway. For this current study, we were asked to provide information on the characteristics of the HOT lane users.

For this study, we used MWCOG's 1997 MINUTP traffic models, which we have refined over the years for a number of traffic and revenue studies, including Dulles Greenway Refinancing, the Dulles Toll Road Financial Feasibility, and the Beltway & I-66 HOT Lanes Preliminary Traffic and Revenue Study. The select link feature of the modeling software was used to determine characteristics of users of particular pieces of roadway, or "links". The two main outputs of a select link analysis are: a) the volume that passes through a given set of links, and b) a list of origin zones, destination zones, and volumes corresponding to multiple sets of links. We chose to perform the analyses using the model year 2005. Of the two model years modified for the previous Beltway study (2005 and 2015), this was closest to the opening year of the HOT lanes.

HOT Lane Configurations

We used the HOT lane configuration as described in the Capital Beltway HOT Lanes Conceptual Proposal (Fluor Daniel, June 2002). The roadway will have a 4-2-2-4 configuration – four general-purpose and two concurrent HOT lanes per direction. As shown in Figure 1, the HOT lanes will extend from Route 193 (the Georgetown Pike) at the northern end to I-95/395 at the southern end. Five intermediate access points are planned; from north to south they are: the Dulles Toll Road, Route 123, I-66, Route 50, and Braddock Road.



Capital Beltway Hot Lane System Plan

Figure 1

The HOT lanes as described in Fluor Daniel's HOT lanes proposal will be constructed with direct connections to the Dulles Toll Road and I-66. At the other access points, access will be provided via slip ramps from the general-purpose lanes. The optional Phase II upgrade was also modeled in this user study; it will have no intermediate slip ramps; only direct connectors at the five intermediate access points. Both of these configurations - "Direct Connectors at I-66 & DTR only" and "Direct Connectors Only" - were modeled for the year 2005.

Each of the two configurations has its advantages and disadvantages. The proposed configuration allows vehicles from almost all Beltway entrances to use some portion of the HOT lanes. However, one must cross three general-purpose lanes to enter the HOT lanes. This problem does not exist when the access is by direct connectors only. But when there are no intermediate slip ramps, traffic in the general-purpose lanes cannot enter the HOT lanes except at their northern and southern ends.

Entry and Exit Analysis

The first select link analysis traced the volumes entering and exiting the HOT lanes. Tables 1 and 2 show these point-to-point volumes for the two configurations. The most popular trip on the HOT lanes the 1.9-mile trip between the north end and the Dulles Toll Road. It makes up one-third of all HOT lane trips with the proposed configuration, and one-fourth of all HOT trips with the direct connectors only configuration. The second most popular trip is between the south end and Braddock Road; 9% of HOT lane users with the proposed configuration and 15% of users with the direct connectors only configuration make this trip. For both alignments, around 50% of traffic is only using one segment of the HOT lanes. The average trip length on the HOT lanes is around five miles, about 38% of its 13.3-mile length.

Origin/Destination Analysis

<u>All HOT Lane Users</u>

The next select link analysis looked at the origins and destinations of all HOT lane users. Tables 3 and 4 present the results for each configuration. About one-third of all HOT lane trips both begin and end in Fairfax County, while 43% of HOT trips have only one trip end in Fairfax. The proposed configuration has a slightly higher percentage of through (i.e., end-to-end) trips than the "Direct Connectors Only" configuration, indicating that it may be more difficult to access the HOT lanes at intermediate points with the proposed configuration.

TABLE 1

CAPITAL BELTWAY SELECT LINK ANALYSIS: SEGMENTS & DISTANCES TRAVELED ON BELTWAY
2005 With Direct Connectors at I-66 & DTR Only

From	To	Volume	% of Directional Trips	Trip length	vehicle-miles	# of segments	vehicle-segments
SOUTHBOUND TRIPS							
1-North End	2-DTR	23,406	32%	1.9	44,471	1	23,406
1-North End	3-Rte 123	3,334	5%	2.65	8,835	2	6,668
1-North End	4-I66	3,804	5%	5.1	19,400	3	11,412
1-North End	5-Rte 50	1,464	2%	6.6	9,662	4	5,856
1-North End	6-Braddock	1030	1%	10.4	10,712	5	5,150
1-North End	7-South End	5,549	8%	13.3	73,802	6	33,294
2-DTR	3-Rte 123	0	0%	0.75	-	1	-
2-DTR	4-I66	1,264	2%	3.2	4,045	2	2,528
2-DTR	5-Rte 50	3,435	5%	4.7	16,145	3	10,305
2-DTR	6-Braddock	1070	1%	8.5	9,095	4	4,280
2-DTR	7-South End	3,228	4%	11.4	36,799	5	16,140
3-Rte 123	4-I66	1,904	3%	2.45	4,665	1	1,904
3-Rte 123	5-Rte 50	2,120	3%	3.95	8,374	2	4,240
3-Rte 123	6-Braddock	700	1%	7.75	5,425	3	2,100
3-Rte 123	7-South End	1,602	2%	10.65	17,061	4	6,408
4-I66	5-Rte 50	2,704	4%	1.5	4,056	1	2,704
4-I66	6-Braddock	850	1%	5.3	4,505	2	1,700
4-I66	7-South End	3,426	5%	8.2	28,093	3	10,278
5-Rte 50	6-Braddock	1,778	2%	3.8	6,756	1	1,778
5-Rte 50	7-South End	3,671	5%	6.7	24,596	2	7,342
6-Braddock	7-South End	6,293	9%	2.9	18,250	1	6,293
NORTHBOUND TRIPS							
7-South End	6-Braddock	6,147	9%	2.9	17,826	1	6,147
7-South End	5-Rte 50	3,859	5%	6.7	25,855	2	7,718
7-South End	4-I66	3,160	4%	8.2	25,912	3	9,480
7-South End	3-Rte 123	1,561	2%	10.65	16,625	4	6,244
7-South End	2-DTR	3,813	5%	11.4	43,468	5	19,065
7-South End	1-North End	5,779	8%	13.3	76,861	6	34,674
6-Braddock	5-Rte 50	1,895	3%	3.8	7,201	1	1,895
6-Braddock	4-I66	741	1%	5.3	3,927	2	1,482
6-Braddock	3-Rte 123	705	1%	7.75	5,464	3	2,115
6-Braddock	2-DTR	1,100	2%	8.5	9,350	4	4,400
6-Braddock	1-North End	1,034	1%	10.4	10,754	5	5,170
5-Rte 50	4-I66	2,468	4%	1.5	3,702	1	2,468
5-Rte 50	3-Rte 123	2,121	3%	3.95	8,378	2	4,242
5-Rte 50	2-DTR	3,943	6%	4.7	18,532	3	11,829
5-Rte 50	1-North End	1,491	2%	6.6	9,841	4	5,964
4-I66	3-Rte 123	1,962	3%	2.45	4,807	1	1,962
4-I66	2-DTR	1,327	2%	3.2	4,246	2	2,654
4-I66	1-North End	4,914	7%	5.1	25,061	3	14,742
3-Rte 123	2-DTR	0	0%	0.75	-	1	-
3-Rte 123	1-North End	183	0%	2.65	485	2	366
2-DTR	1-North End	22,049	31%	1.9	41,893	1	22,049
	Total Trips	142,884			714,936		328,452
				Avg:	5.0 miles, 38% of length		2.3 segments

	Volume ON	Volume OFF
1-North End	38,587	35,450
2-DTR	31,046	33,589
3-Rte 123	6,509	9,683
4-I66	15,183	13,341
5-Rte 50	15,472	15,477
6-Braddock	11,768	11,575
7-South End	24,319	23,769
Total	142,884	142,884

Segments Traveled	Vol	% of total
1	70,606	49%
2	19,470	14%
3	24,087	17%
4	8,288	6%
5	9,105	6%
6	11,328	8%
Total	142,884	

TABLE 2

CAPITAL BELTWAY SELECT LINK ANALYSIS: SEGMENTS & DISTANCES TRAVELED ON BELTWAY
2005 With Direct Connectors Only

From	To	Volume	% of Directional Trips	Trip length	vehicle-miles	# of segments	vehicle-segments
SOUTHBOUND TRIPS							
1-North End	2-DTR	16,169	23%	1.9	30,721	1	16,169
1-North End	3-Rte 123	3,563	5%	2.65	9,442	2	7,126
1-North End	4-I66	6,617	9%	5.1	33,747	3	19,851
1-North End	5-Rte 50	1,102	2%	6.6	7,273	4	4,408
1-North End	6-Braddock	943	1%	10.4	9,807	5	4,715
1-North End	7-South End	4,387	6%	13.3	58,347	6	26,322
2-DTR	3-Rte 123	2,355	3%	0.75	1,766	1	2,355
2-DTR	4-I66	1,207	2%	3.2	3,862	2	2,414
2-DTR	5-Rte 50	1,781	3%	4.7	8,371	3	5,343
2-DTR	6-Braddock	1060	2%	8.5	9,010	4	4,240
2-DTR	7-South End	2,670	4%	11.4	30,438	5	13,350
3-Rte 123	4-I66	2,578	4%	2.45	6,316	1	2,578
3-Rte 123	5-Rte 50	1,493	2%	3.95	5,897	2	2,986
3-Rte 123	6-Braddock	1,411	2%	7.75	10,935	3	4,233
3-Rte 123	7-South End	2,531	4%	10.65	26,955	4	10,124
4-I66	5-Rte 50	2,401	3%	1.5	3,602	1	2,401
4-I66	6-Braddock	839	1%	5.3	4,447	2	1,678
4-I66	7-South End	2,179	3%	8.2	17,868	3	6,537
5-Rte 50	6-Braddock	2,158	3%	3.8	8,200	1	2,158
5-Rte 50	7-South End	3,042	4%	6.7	20,381	2	6,084
6-Braddock	7-South End	9,541	14%	2.9	27,669	1	9,541
NORTHBOUND TRIPS							
7-South End	6-Braddock	9,288	16%	2.9	26,935	1	9,288
7-South End	5-Rte 50	2,982	5%	6.7	19,979	2	5,964
7-South End	4-I66	1,960	3%	8.2	16,072	3	5,880
7-South End	3-Rte 123	2,368	4%	10.65	25,219	4	9,472
7-South End	2-DTR	3,111	5%	11.4	35,465	5	15,555
7-South End	1-North End	4,077	7%	13.3	54,224	6	24,462
6-Braddock	5-Rte 50	2,269	4%	3.8	8,622	1	2,269
6-Braddock	4-I66	780	1%	5.3	4,134	2	1,560
6-Braddock	3-Rte 123	1,363	2%	7.75	10,563	3	4,089
6-Braddock	2-DTR	1,090	2%	8.5	9,265	4	4,360
6-Braddock	1-North End	748	1%	10.4	7,779	5	3,740
5-Rte 50	4-I66	2,059	4%	1.5	3,089	1	2,059
5-Rte 50	3-Rte 123	1,511	3%	3.95	5,968	2	3,022
5-Rte 50	2-DTR	1,890	3%	4.7	8,883	3	5,670
5-Rte 50	1-North End	545	1%	6.6	3,597	4	2,180
4-I66	3-Rte 123	2,663	5%	2.45	6,524	1	2,663
4-I66	2-DTR	1,231	2%	3.2	3,939	2	2,462
4-I66	1-North End	3,239	6%	5.1	16,519	3	9,717
3-Rte 123	2-DTR	0	0%	0.75	-	1	-
3-Rte 123	1-North End	180	0%	2.65	477	2	360
2-DTR	1-North End	14,605	25%	1.9	27,750	1	14,605
	Total Trips	127,986			630,060		283,990
				Avg:	4.9 miles, 37% of length		2.2 segments

	Volume ON	Volume OFF
1-North End	32,781	23,394
2-DTR	23,678	23,491
3-Rte 123	8,193	13,823
4-I66	12,552	15,201
5-Rte 50	11,205	12,028
6-Braddock	15,791	15,699
7-South End	23,786	24,350
Total	127,986	127,986

Segments Traveled	Vol	% of total
1	66,086	52%
2	16,828	13%
3	20,440	16%
4	8,696	7%
5	7,472	6%
6	8,464	7%
Total	127,986	

TABLE 3

Beltway HOT Lanes - Origin/Destination Districts: 2005 with Direct Connectors at I-66 & DTR Only

		ORIGIN												
	DISTRICT	DC	Montgomery Co., MD	Pr. George Co., MD	Outer MD	Arlington, VA	Alexandria, VA	Fairfax Co., VA	Pr. William Co., VA	Loudoun Co., VA & pts west	Dulles Airport, VA	Outer VA	**TOTAL**	*Percent of Total*
DESTINATION	DC	-	-	-	-	-	-	2,988	26	1,734	6	86	**4,840**	*3%*
	Montgomery Co., MD	-	-	8	-	-	90	8,259	584	3,022	-	1,465	**13,428**	*9%*
	Pr. George Co., MD	-	10	-	2	-	-	3,547	178	1,276	209	406	**5,628**	*4%*
	Outer MD	-	-	2	-	-	129	5,006	563	1,312	140	3,971	**11,123**	*8%*
	Arlington, VA	-	-	-	-	-	6	2,575	110	620	5	146	**3,462**	*2%*
	Alexandria, VA	-	68	-	109	7	-	4,146	147	216	180	158	**5,031**	*4%*
	Fairfax Co., VA	3,048	9,343	3,257	5,140	2,574	4,087	44,521	773	1,468	640	620	**75,471**	*53%*
	Pr. William Co., VA	22	517	141	463	81	134	819	-	-	-	-	**2,177**	*2%*
	Loudoun Co., VA & pts west	1,895	3,179	1,474	1,382	612	307	1,705	-	-	-	-	**10,554**	*7%*
	Dulles Airport, VA	122	951	524	904	15	294	857	-	-	-	-	**3,667**	*3%*
	Outer VA	21	1,299	287	3,641	87	148	624	-	-	-	-	**6,107**	*4%*
	TOTAL	**5,108**	**15,367**	**5,693**	**11,641**	**3,376**	**5,195**	**75,047**	**2,381**	**9,648**	**1,180**	**6,852**	**141,488**	*100%*
	Percent of Total	*4%*	*11%*	*4%*	*8%*	*2%*	*4%*	*53%*	*2%*	*7%*	*1%*	*5%*	*100%*	

Trips that neither begin nor end in Fairfax Co.:	35,491	25%
Trips that begin and/or end in Fairfax Co.:	105,997	75%
Trips that begin and end in Fairfax Co.:	44,521	31%
Trips with only one trip end in Fairfax Co.:	61,476	43%

TABLE 4

Beltway HOT Lanes - Origin/Destination Districts: 2005 with Direct Connectors Only

		ORIGIN												
	DISTRICT	DC	Montgomery Co., MD	Pr. George Co., MD	Outer MD	Arlington, VA	Alexandria, VA	Fairfax Co., VA	Pr. William Co., VA	Loudoun Co., VA & pts west	Dulles Airport, VA	Outer VA	**TOTAL**	*Percent of Total*
DESTINATION	DC	-	-	-	-	-	-	1,125	14	316	1	16	**1,472**	*1%*
	Montgomery Co., MD	-	-	-	-	-	30	7,183	729	2,949	-	1,280	**12,171**	*10%*
	Pr. George Co., MD	-	5	-	3	-	-	2,520	118	970	149	270	**4,035**	*3%*
	Outer MD	-	2	-	-	-	90	4,337	429	1,281	118	2,443	**8,700**	*7%*
	Arlington, VA	-	-	-	-	-	4	2,359	99	35	4	137	**2,638**	*2%*
	Alexandria, VA	-	49	-	96	5	-	4,211	49	158	130	92	**4,790**	*4%*
	Fairfax Co., VA	1,046	11,016	2,574	5,350	2,376	3,899	43,992	1,035	1,442	460	776	**73,966**	*58%*
	Pr. William Co., VA	-	1,667	231	761	42	41	1,058	-	-	-	-	**3,800**	*3%*
	Loudoun Co., VA & pts west	375	2,847	1,126	1,232	52	212	939	-	-	-	-	**6,783**	*5%*
	Dulles Airport, VA	45	999	385	846	6	213	571	-	-	-	-	**3,065**	*2%*
	Outer VA	6	1,476	273	3,163	65	83	743	-	-	-	-	**5,809**	*5%*
	TOTAL	**1,472**	**18,061**	**4,589**	**11,451**	**2,546**	**4,572**	**69,038**	**2,473**	**7,151**	**862**	**5,014**	**127,229**	*100%*
	Percent of Total	*1%*	*14%*	*4%*	*9%*	*2%*	*4%*	*54%*	*2%*	*6%*	*1%*	*4%*	*100%*	

Trips that neither begin nor end in Fairfax Co.:	28,217	22%
Trips that begin and/or end in Fairfax Co.:	99,012	78%
Trips that begin and end in Fairfax Co.:	43,992	35%
Trips with only one trip end in Fairfax Co.:	55,020	43%

Comparison with VDOT's Capital Beltway EIS Analysis

Another analysis was performed where we traced the origins and destinations of HOT lane users north of I-66 and south of I-66 separately. This was done specifically because VDOT's Capital Beltway EIS had estimated the origin/destination patterns of current Beltway users on these two sections of roadway. Our results were compared to the existing conditions described in the Capital Beltway Draft Transportation Technical Report (November 2001), a supporting document to the EIS.

First we performed our analysis for the HOT lanes north of I-66. Tables 5 and 6 show the volumes for each origin and destination pair for the two configurations. Below each table is a summary comparing the results of our model runs to the current patterns presented in the Capital Beltway Study. For both HOT configurations, about one-fourth of the HOT lane users north of I-66 begin and end their trips in Fairfax County. This matches the 25% of existing users in the Beltway Study. About 45% of the trips have only one trip in Fairfax County. This is slightly less than the 50% on the existing Beltway, estimated by VDOT. However, since the HOT lanes are not as easily accessed as the current Beltway, it is expected that the HOT lanes would have a greater percentage of through trips.

Next we analyzed HOT trips south of I-66, as shown on Tables 7 and 8. Once again, results were similar to the Capital Beltway Study estimates: 46%-49% of HOT lane trips both begin and end in Fairfax County, as opposed to 50% of existing users in the Beltway Study; and 37% of HOT lane trips have only one trip end in Fairfax, as opposed to the 40% estimated by VDOT. HOT lane trips neither beginning nor ending in Fairfax make up 14 to 17% of all HOT trips south of I-66, higher than VDOT's estimated 10%. Again, due to the limited accessibility of the HOT lanes, more through trips are expected on the HOT lanes than on the general Beltway.

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TABLE 5

Beltway HOT Lanes - Origin/Destination Districts: 2005 with Direct Connectors at I-66 & DTR Only

O-D for HOT Lanes North of I-66 Only

		ORIGIN												
	DISTRICT	DC	Montgomery Co., MD	Pr. George Co., MD	Outer MD	Arlington, VA	Alexandria, VA	Fairfax Co., VA	Pr. William Co., VA	Loudoun Co., VA & pts west	Dulles Airport, VA	Outer VA	**TOTAL**	*Percent of Total*
DESTINATION	DC	-	-	-	-	-	-	2,694	14	1,728	6	72	**4,514**	*4%*
	Montgomery Co., MD	-	-	8	-	-	90	8,259	584	3,022	-	1,465	**13,428**	*13%*
	Pr. George Co., MD	-	10	-	2	-	-	2,274	51	1,234	209	209	**3,989**	*4%*
	Outer MD	-	-	2	-	-	129	4,382	482	1,306	140	3,943	**10,384**	*10%*
	Arlington, VA	-	-	-	-	-	-	1,186	3	594	5	-	**1,788**	*2%*
	Alexandria, VA	-	68	-	109	-	-	1,061	-	175	180	-	**1,593**	*2%*
	Fairfax Co., VA	2,809	9,343	2,130	4,498	1,194	1,023	24,759	518	1,380	640	330	**48,624**	*46%*
	Pr. William Co., VA	15	517	45	388	1	-	564	-	-	-	-	**1,530**	*1%*
	Loudoun Co., VA & pts west	1,887	3,179	1,415	1,373	593	264	1,659	-	-	-	-	**10,370**	*10%*
	Dulles Airport, VA	122	951	524	904	15	294	857	-	-	-	-	**3,667**	*3%*
	Outer VA	8	1,299	123	3,612	-	-	344	-	-	-	-	**5,386**	*5%*
	TOTAL	**4,841**	**15,367**	**4,247**	**10,886**	**1,803**	**1,800**	**48,039**	**1,652**	**9,439**	**1,180**	**6,019**	**105,273**	*100%*
	Percent of Total	*5%*	*15%*	*4%*	*10%*	*2%*	*2%*	*46%*	*2%*	*9%*	*1%*	*6%*	*100%*	

	This Study		From Capital Beltway Study - Transportation Techical Draft Report*
Trips that neither begin nor end in Fairfax Co.:	33,369	32%	25%
Trips that begin and/or end in Fairfax Co.:	71,904	68%	75%
Trips that begin and end in Fairfax Co.:	24,759	24%	25%
Trips with only one trip end in Fairfax Co.:	47,145	45%	50%

*Estimates for existing Beltway users

TABLE 6

Beltway HOT Lanes - Origin/Destination Districts: 2005 with Direct Connectors Only

O-D for HOT Lanes North of I-66 Only

		ORIGIN												
	DISTRICT	DC	Montgomery Co., MD	Pr. George Co., MD	Outer MD	Arlington, VA	Alexandria, VA	Fairfax Co., VA	Pr. William Co., VA	Loudoun Co., VA & pts west	Dulles Airport, VA	Outer VA	**TOTAL**	*Percent of Total*
DESTINATION	DC	-	-	-	-	-	-	720	-	314	1	-	**1,035**	*1%*
	Montgomery Co., MD	-	-	-	-	-	30	7,183	729	2,949	-	1,280	**12,171**	*14%*
	Pr. George Co., MD	-	5	-	3	-	-	1,637	35	929	149	109	**2,867**	*3%*
	Outer MD	-	2	-	-	-	90	4,010	353	1,277	118	2,417	**8,267**	*9%*
	Arlington, VA	-	-	-	-	-	-	103	-	11	4	-	**118**	*0%*
	Alexandria, VA	-	49	-	96	-	-	967	-	128	130	-	**1,370**	*2%*
	Fairfax Co., VA	681	11,016	1,764	5,024	154	868	21,685	613	1,381	460	385	**44,031**	*50%*
	Pr. William Co., VA	-	1,667	179	681	-	-	646	-	-	-	-	**3,173**	*4%*
	Loudoun Co., VA & pts west	367	2,847	1,082	1,224	30	173	903	-	-	-	-	**6,626**	*8%*
	Dulles Airport, VA	45	999	385	846	6	213	571	-	-	-	-	**3,065**	*3%*
	Outer VA	-	1,476	170	3,141	-	-	392	-	-	-	-	**5,179**	*6%*
	TOTAL	**1,093**	**18,061**	**3,580**	**11,015**	**190**	**1,374**	**38,817**	**1,730**	**6,989**	**862**	**4,191**	**87,902**	*100%*
	Percent of Total	*1%*	*21%*	*4%*	*13%*	*0%*	*2%*	*44%*	*2%*	*8%*	*1%*	*5%*	*100%*	

	This Study		From Capital Beltway Study - Transportation Techical Draft Report*
Trips that neither begin nor end in Fairfax Co.:	26,739	30%	25%
Trips that begin and/or end in Fairfax Co.:	61,163	70%	75%
Trips that begin and end in Fairfax Co.:	21,685	25%	25%
Trips with only one trip end in Fairfax Co.:	39,478	45%	50%

*Estimates for existing Beltway users

TABLE 7

Beltway HOT Lanes - Origin/Destination Districts: 2005 with Direct Connectors at I-66 & DTR Only

O-D for HOT Lanes South of I-66 Only

		ORIGIN												
	DISTRICT	DC	Montgomery Co., MD	Pr. George Co., MD	Outer MD	Arlington, VA	Alexandria, VA	Fairfax Co., VA	Pr. William Co., VA	Loudoun Co., VA & pts west	Dulles Airport, VA	Outer VA	**TOTAL**	*Percent of Total*
DESTINATION	DC	-	-	-	-	-	-	337	12	12	6	14	**381**	*0%*
	Montgomery Co., MD	-	-	8	-	-	90	2,069	395	-	-	952	**3,514**	*5%*
	Pr. George Co., MD	-	10	-	2	-	-	1,678	138	149	208	221	**2,406**	*3%*
	Outer MD	-	-	2	-	-	129	2,216	253	55	140	2,510	**5,305**	*7%*
	Arlington, VA	-	-	-	-	-	6	1,496	107	41	5	146	**1,801**	*2%*
	Alexandria, VA	-	68	-	109	7	-	4,114	147	201	176	158	**4,980**	*6%*
	Fairfax Co., VA	282	1,961	1,508	2,143	1,528	4,054	35,830	438	1,099	619	452	**49,914**	*64%*
	Pr. William Co., VA	7	378	101	211	80	134	430	-	-	-	-	**1,341**	*2%*
	Loudoun Co., VA & pts west	58	-	283	82	53	296	1,335	-	-	-	-	**2,107**	*3%*
	Dulles Airport, VA	6	-	280	177	12	291	799	-	-	-	-	**1,565**	*2%*
	Outer VA	13	954	189	2,518	87	148	443	-	-	-	-	**4,352**	*6%*
	TOTAL	**366**	**3,371**	**2,371**	**5,242**	**1,767**	**5,148**	**50,747**	**1,490**	**1,557**	**1,154**	**4,453**	**77,666**	*100%*
	Percent of Total	*0%*	*4%*	*3%*	*7%*	*2%*	*7%*	*65%*	*2%*	*2%*	*1%*	*6%*	*100%*	

	This Study		From Capital Beltway Study - Transportation Techical Draft Report*
Trips that neither begin nor end in Fairfax Co.:	12,835	17%	10%
Trips that begin and/or end in Fairfax Co.:	64,831	83%	90%
Trips that begin and end in Fairfax Co.:	35,830	46%	50%
Trips with only one trip end in Fairfax Co.:	29,001	37%	40%

*Estimates for existing Beltway users

TABLE 8

Beltway HOT Lanes - Origin/Destination Districts: 2005 with Direct Connectors Only

O-D for HOT Lanes South of I-66 Only

		ORIGIN												
	DISTRICT	DC	Montgomery Co., MD	Pr. George Co., MD	Outer MD	Arlington, VA	Alexandria, VA	Fairfax Co., VA	Pr. William Co., VA	Loudoun Co., VA & pts west	Dulles Airport, VA	Outer VA	**TOTAL**	*Percent of Total*
DESTINATION	DC	-	-	-	-	-	-	447	14	20	1	16	**498**	*1%*
	Montgomery Co., MD	-	-	-	-	-	30	1,069	554	-	-	919	**2,572**	*4%*
	Pr. George Co., MD	-	5	-	3	-	-	1,180	95	126	149	182	**1,740**	*2%*
	Outer MD	-	2	-	-	-	90	1,686	190	48	118	1,531	**3,665**	*5%*
	Arlington, VA	-	-	-	-	-	4	2,359	99	35	4	137	**2,638**	*4%*
	Alexandria, VA	-	49	-	96	5	-	4,211	49	158	130	92	**4,790**	*7%*
	Fairfax Co., VA	417	1,368	1,153	1,680	2,376	3,899	35,889	664	807	446	596	**49,295**	*67%*
	Pr. William Co., VA	-	788	69	218	42	41	660	-	-	-	-	**1,818**	*2%*
	Loudoun Co., VA & pts west	55	-	264	67	52	212	901	-	-	-	-	**1,551**	*2%*
	Dulles Airport, VA	-	-	155	107	6	213	554	-	-	-	-	**1,035**	*1%*
	Outer VA	6	881	130	1,955	65	83	558	-	-	-	-	**3,678**	*5%*
	TOTAL	**478**	**3,093**	**1,771**	**4,126**	**2,546**	**4,572**	**49,514**	**1,665**	**1,194**	**848**	**3,473**	**73,280**	*100%*
	Percent of Total	*1%*	*4%*	*2%*	*6%*	*3%*	*6%*	*68%*	*2%*	*2%*	*1%*	*5%*	*100%*	

	This Study		From Capital Beltway Study - Transportation Techical Draft Report*
Trips that neither begin nor end in Fairfax Co.:	10,360	14%	10%
Trips that begin and/or end in Fairfax Co.:	62,920	86%	90%
Trips that begin and end in Fairfax Co.:	35,889	49%	50%
Trips with only one trip end in Fairfax Co.:	27,031	37%	40%

*Estimates for existing Beltway users

Appendix B

Capital Beltway High Occupancy Toll (HOT) Lanes Safety Study

Capital Beltway High Occupancy Toll (HOT) Lanes Safety Study

Prepared by

HNTB Corporation
Alexandria, Virginia

Prepared for

Fluor Daniel

May 6, 2003

EXECUTIVE SUMMARY

Traffic volumes continue to increase on the Capital Beltway (I-495) and congestion occurs during many hours of the day. The Virginia Department of Transportation (VDOT) conducted an environmental impact study to evaluate the benefits and impacts of several alternatives for improving the facility to better handle growing traffic volumes. Subsequently, Fluor Daniel proposed constructing a variation of the Barrier-Separated 4-2-2-4 Alternative and converting the express lanes to high-occupancy toll (HOT) lanes. The four new travel lanes could be used either by high occupancy vehicles (HOV 3+) at no charge or by other vehicles that would pay a toll.

The HOT lanes would be constructed to the inside of the general purpose lanes and would be separated from those lanes by a two to four-foot yellow—striped buffer. A series of plastic pylons could be placed along the center of the buffer strip to discourage traffic from entering the HOT lanes at other than the prescribed locations.

BELTWAY SAFETY BENEFITS

The HOT lane proposal has raised three issues: one regarding safety improvements on I-495, a second the safety records on similar HOT lanes, and the third regarding snow removal. The fundamental question regarding safety is "How do the HOT lanes compare with traditional lanes with respect to the potential for accidents?" The HOT lanes proposal would eliminate all left-hand entrances and exits. Left-hand entrance and exit ramps are not recommended by FHWA as they require accelerating and decelerating vehicles to traverse the higher speed, left-hand travel lane. While at one time considered a less intrusive way of connecting intersecting interstate highways, experience has shown that the safety concerns outweigh the cost and environmental benefits and the Federal Highway Administration (FHWA) guidelines no longer recommend this practice. Consequently, the HOT lanes will help remedy this condition on the Beltway.

The HOT lanes would also isolate some through traffic from the weaving traffic on the general purpose lanes. The reduction in the volume of traffic involved in the weaving movements of entering and exiting traffic should improve the safety of the both the general purpose and HOT lanes.

The greatest potential improvement in safety on the Beltway, however, would be from the reduction in congestion, which is directly related to accident rate. An analysis of four years of VDOT accident and traffic volume data on the Capital Beltway shows that the accident rate is highest in stop-and-go conditions typical of extremely congested conditions technically known as oversaturated regime.[1] When congestion is reduced from severe to moderate[2], accident rates drop considerably. The HOT lanes

[1] Oversaturated regime is defined on the Highway Capacity Manual 2000 as "*a traffic condition in which the arrival flow rate exceeds capacity*". See Section 3.22 for a more detailed discussion on oversaturated conditions.

[2] For the purpose of this analysis, three operational conditions have been defined: a) uncongested: free-flow operation in which density is lower than 35 vehicles per mile per lane (veh/mi/ln); b) moderate congestion:

could be priced to remove sufficient traffic from the general purpose lanes to improve operations from severely congested to a more stable or near-capacity operation thereby reducing accident potential and also increasing throughput of the road.

EXISTING HOT LANE SAFETY RECORD

An analysis of the existing HOT lanes on SR 91 in California concluded that there occurred a temporary reduction in congestion-related collisions in the Orange County section of SR 91 containing the HOT lanes. At the same time, congestion-related collisions increased in the section of SR 91 without HOT lanes in Riverside County. There is no evidence that the operating characteristics of the SR 91 HOT lanes result in any systematic differences in collision characteristics.

While the actual improvement in safety attributable to the HOT lanes is small, the perception of greater safety is strongly evident. However, a Texas Transportation Institute (TTI) study of an eight-mile section of I-10 East Freeway, in which trucks were banned from the left-hand lane, showed actual safety benefits.[3] TTI researchers compiled crash data during the 36-week lane restriction demonstration project and compared it to data taken on the same stretch of road prior to the restriction. The study results indicated a dramatic 68 percent reduction in crashes. Both SR 91 and the Fluor HOT lanes will restrict truck use.

Fluor proposes slip ramps for intermediate access to the HOT lanes. Slip ramps currently provide access to many existing HOV managed lane facilities from general purpose lanes throughout the United States. To date no comprehensive studies have been performed to assess the safety of these slip ramps. FHWA and AASHTO remain the best source of guidelines for safe design.

HOT LANE SNOW REMOVAL ISSUES

The third issue raised regarding the HOT lanes proposal was the effect that the proposed roadway configuration would have on snow removal. Questions of how snow removal would be impaired by the four-foot buffer strip and the complications of plowing around plastic pylons on the buffer strip were raised.

Transportation officials responsible for snow removal in five northeastern states were questioned regarding this issue. Generally, no one saw the presence of the buffer strip as a unique problem with respect to snow removal. Officials pointed to gore areas and other conditions that present the same issues. While snow removal is easier in a traditional, un-separated configuration, this configuration is not unique and can be accommodated by a combination of careful plowing and snow-blowing. Similarly, the pylons may be removed during plowing, as is the case for raised pavement markers and other devices affixed to the roads. Many departments of transportation

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near-to-capacity operation in which density varies from 35 to 60 veh/mi/ln; and c) severe congestion: stop-and-go, oversaturated conditions in which density exceeds 60 veh/mi/ln.

[3] *Truckin' – A Look At TTI's Commercial Vehicle Transportation Research*, Texas Transportation Researcher, Volume 38, Number 1, 2002.

report dislodging these devices annually and include periodic replacement as part of their operating budgets.

In Virginia, the issue of snow removal is less significant. First, treatment of the roadways is the first line of defense against snow conditions. VDOT attempts to treat the roadways to prevent the buildup of snow that would need to be plowed. Second, significant snow events sufficient to require plowing are relatively infrequent, and the volume of snow generally lower, so the risk to the pylons is relatively minor.

Experience on similar HOT lane facilities in warm climates (e.g., SR 91 in California) indicates that the plastic pylons have at best a life of 12 to 18 months before replacement is required.

CONCLUSIONS

Neither Beltway safety, the HOT lane design, nor snow removal should be considered significant obstacles to the construction of HOT lanes along the Capital Beltway. Beltway safety would potentially improve under the HOT lane proposal. Snow removal would be somewhat complicated but no more than countless other situations in the region.

SECTION 1
INTRODUCTION AND OVERVIEW

Traffic on the Capital Beltway experiences congestion with increasing frequency. Over the past several years, the Virginia Department of Transportation (VDOT) has studied alternative means of relieving congestion through widening the road, the introduction of high occupancy vehicle (HOV) lanes, and increasing transit service. In addition to the substantial cost of any of these proposals, as described in the Environmental Impact Statement, each would entail significant right-of-way requirements and other environmental impacts.

Fluor Daniel (Fluor) has proposed constructing high-occupancy toll (HOT) lanes under the state's Public-Private Transportation Act. Fluor would design and construct two HOT lanes in each direction. Right-of-way requirements would be less than those anticipated under the alternatives examined by VDOT as construction would be limited primarily to the mainline with little change in the configuration of the interchanges. Consequently, no more than ten private homes would be directly affected. Overall, environmental impacts would be less severe than under the original VDOT 4-2-2-4 Build Alternative.

The Fluor concept is a variation of VDOT's Barrier-Separated HOV 4-2-2-4 Alternative with four new express HOV lanes and the eight existing local or general purpose lanes. Fluor proposes to narrow that alternative cross-section and convert the express/HOV lanes to HOT lanes. The HOT lanes would allow HOV 3+, emergency vehicles, and express buses to use the lanes for free while all other vehicles would pay a toll. Trucks would not be allowed to use the HOT lanes.

The HOT lanes would be constructed in the center of the Beltway right-of-way. Two lanes in each direction, as shown in Figure 1-1, would carry high-occupancy or toll traffic. The four existing general purpose lanes in each direction would flank the HOT lanes resulting in a total of 12 lanes of traffic. The HOT lanes would be separated from the general purpose lanes by an approximately four-foot buffer that would contain plastic pylons, approximately four to five feet on center, to segregate traffic.

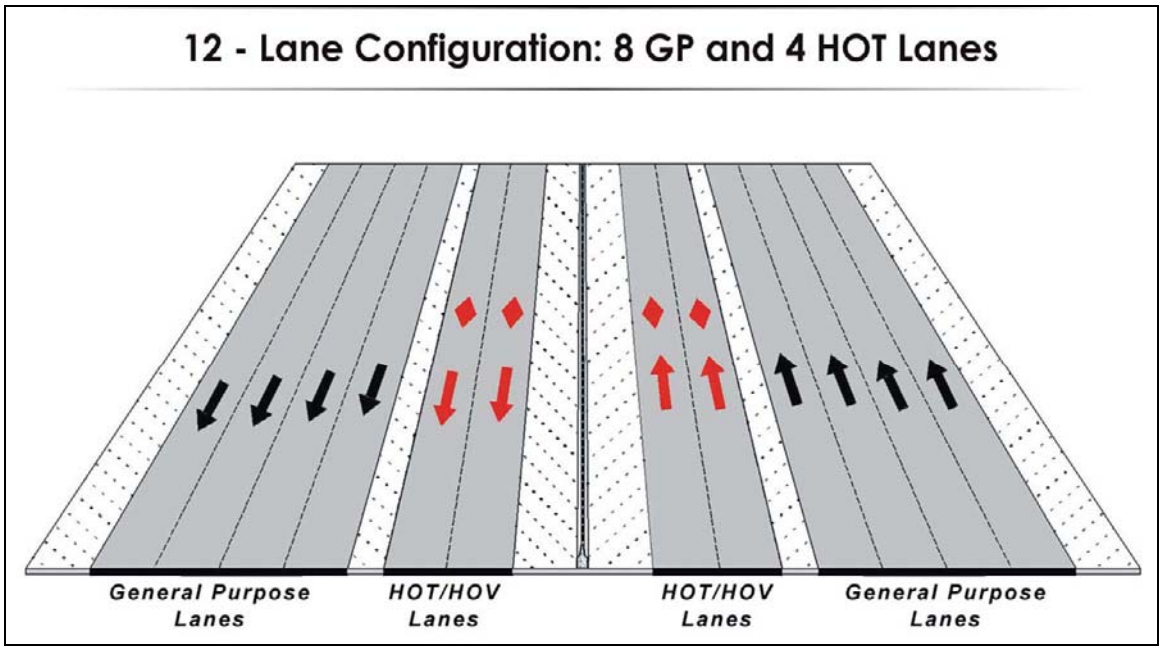

Figure 1-1
Proposed HOT Lane Configuration

1.1 ISSUES AND CONCERNS

HOT lanes are operating in several locations and are being considered in many other locations across the United States. The newness of the HOT lane concept has raised some concerns and questions, although actual operations at two locations in California have proven highly successful to date. A more detailed discussion of the safety aspects can be found in Section 4.

HOT lanes can be expected reduce congestion and increase travel speeds. At the same time, they prompt several questions:

- How safe is the basic HOT lane configuration?
- Beyond the inherent safety of the HOT lane concept, what effect will HOT lanes have on current and future safety along the Capital Beltway?
- How would snow be removed, a condition not found in the California HOT lane operations?

On the one hand, reductions in congestion might be expected to reduce accident potential. Decreasing conflicts between vehicles by reducing traffic congestion could result in fewer accidents and lower accident rates. The plans for the HOT lanes will eliminate all left-hand entrances and exits to the Beltway, which because they are atypical, are believed by the Federal Highway Administration and others, to be more hazardous than the more traditional highway access configurations. Separating some of the traffic into HOT lanes could also reduce the volume of traffic that weaves on to and off of the general purpose lanes. Again, this would result in improvements in safety.

Conversely, the potential for increased speed on the HOT lanes and even on the general purpose lanes could result in greater accident potential. Higher speeds and greater differentials between the fastest and slowest vehicles on the highway are perceived to result in an increase in accidents and accident rates.

A separate issue arises in the configuration of the HOT lanes. The HOT lanes would be separated from the general purpose lanes by a two to four-foot buffer in which plastic pylons would be placed at 4 to 5-foot intervals. For most of the year, these pylons create no particular concerns. During snowfall, however, VDOT would need to plow snow, possibly across the pylons. Concerns have been raised about potential damage to the pylons and the ability of plows to remove the snow with the pylons in position.

1.2 STUDY OBJECTIVES

This study examined the issues of Beltway safety, existing HOT lane safety, and snow removal with respect to the Fluor HOT lane configuration. Accident rates were calculated for the Beltway, between Springfield and the American Legion Bridge for the years 1997 through 2000. Correlations between congestion and accident rates were calculated to assist in ascertaining the safety implications of constructing HOT lanes in the Capital Beltway Corridor. Findings from other research and from the SR 91 HOT lanes in California were also assembled to assess the safety record of existing HOT lane operations.

In addition, interviews were conducted with transportation officials in five northeastern states with snow removal responsibilities, to determine the likely affect of the proposed HOT lane configuration. While these agencies generally look to address snow before it accumulates, each offered insights on the impediment that the four-foot buffer and plastic pylons might pose on snow removal efforts.

1.3 ORGANIZATION OF THIS REPORT

This report is organized into five sections. Following this introduction is a discussion of the data employed and methodology used to assess the relationship between congestion and safety. Section 3 discusses the evaluation of congestion on safety as determined from the methods discussed in Section 2. Section 4 discusses the SR 91 case study and relates those findings to the Capital Beltway. In Section 5, the interviews with state agencies with snow removal responsibility are discussed. The conclusions and recommendations are summarized in Section 6, the final section of this report.

SECTION 2
METHODOLOGY AND DATA COLLECTION

This study sought to identify the relationship between highway accidents and highway congestion. Generally, previous studies have suggested that accident rates, the number of accidents per 100 million vehicle miles, would increase as traffic congestion increased. Other studies have indicated that differentials in highway speeds were the more significant factor in predicting accident rates; therefore, lower congestion levels and corresponding higher traffic speeds would result in increased accident levels. The data and methodology employed for this study simply compared accident rates with congestion levels, without hypothesizing on one outcome or the other.

Two main sources of data were used for this study:

- police reports from accidents occurred on the Beltway segments under study between 1997 and 2000
- traffic counts for the same freeway segments and the same years. These data were obtained from the Virginia Department of Transportation (VDOT) in two separate databases.

Following is a discussion about data characteristics and limitations.

2.1 ACCIDENT DATA

The accident database used for this study contained approximately 8,500 records of accidents that occurred at different locations along I-495 and I-395 between 1997 and 2000. Each record reflects the details of an accident for which a police officer has filed a report. The accident report includes a variety of fields that characterize the accident, the drivers involved, the location, and all of the external factors. Table 2-1 summarizes some of the fields that were more relevant to this study.

Table 2-1: Data Fields Contained Within Accident Report Records.

Field	Descriptions relevant to the analysis
Collision Type	• Rear end • Angle • Sideswipe • Fixed object • Overturned, jackknifed, or ran off road
Date and Time	Self-explanatory
Location	Accident is related to a node of the roadway network
Vehicle Speed	For all included vehicles
Vehicle Type	• Car • Trucks/oversize • Others
Major Factor	• Driver had handicap (Asleep, ill, fatigued, or loss of limb, etc.) • Driver under the influence of alcohol, drugs, or other agents • Driver speeding • Driver inattention or error • Vehicle defective • Weather or visibility condition • Road defective • Road slick
Severity	• Fatality • Major injury • Minor injury • No visible injury
Vehicle Damage	• No Damage • Overturned • Motor • Undercarriage • Totaled • Fire
Vehicle Impact	• Front • Side • Rear
Vehicle Maneuver	• Going straight ahead • Slowing or Stopping • Ran off Road • Passing, changing lanes
Weather	• Clear • Fog, raining, snowing, sleeting

2.2 TRAFFIC VOLUME DATA

Traffic volume data was taken from a traffic database that included more than 500,000 records of the 15-minute interval traffic volumes from 24-hr traffic counts conducted on all of the freeway segments under analysis. The counts covered one or more months of traffic volumes for the same years of 1997 to 2000. The database

included network link identification, date and time, duration of the count, and traffic volumes by vehicle classes.

2.3 LIMITATIONS OF THE DATA

Although the amount of data was considerable and appropriate for the analysis, it is important to note some of the limitations and issues associated with both the type of data and the way these data are collected.

The accident database contains fields describing the characteristics of the accident. These data need to be used with caution however, as the information was obtained from police and drivers' reports—sources of unknown reliability and that could be subject to error or deliberate misrepresentation. One needs to be particularly skeptical of information related to the speed reported by the driver, police, or a third party. This reported speed does not necessarily correlate with the average flow speed on the road segment under consideration. Additionally, drivers could be biased toward reporting lower speeds than actually traveled when the accident occurred at high speed or when the preceding vehicle was actually stopped in the travel lane.

Another limitation of the data is that traffic volume data was not always available on the exact date and time for every single accident record. For those cases in which "actual" traffic data were not available, an estimated traffic volume, based on the available records for the same freeway segment and the same hour on a different day, was used. The order of precedence in which volume data was used in the analysis follows:

- Volume for the same hour, same day, same month, same year ("actual volume").
- Average volume for the same hour, other days (either weekdays or weekend days), same month and same year.
- Average volume for the same hour, other days (either weekdays or weekend days), all available months for the same year.
- Average volume for the same hour, other days (either weekdays or weekend days), all available months and all available years.

Additionally, the "actual measured volumes" may have been affected by the accident itself. Depending on the type and severity of the accident, the occurrence might affect upstream and downstream traffic operations. If traffic was counted downstream of the accident, it may have reflected less severe traffic conditions than before the accident. Conversely, traffic volumes counted upstream of the accident may reflect congestion caused by the accident instead of recurring congestion.

2.4 DEFINITION OF THE FINAL DATA SET FOR ANALYSIS

Table 2-2 summarizes the size of the data samples obtained when accidents and traffic data were correlated.

Table 2-2: Number of Accidents for which Specific Traffic Data Were Available.

Sample	Number of records	Percent
Total Data Set: Accidents between 1997 to 2000 occurred on I-495N and I-495S	3,403	100.0%
Subset 1: Accidents from previous set with any traffic data as defined in Section 2.3	1,830	53.8%
Subset 2: Accidents from previous set with actual traffic volume data on the same time and date	333	9.8%

Accident data used was geographically limited to I-495 between Springfield and the American Legion Bridge, as shown in Figure 2-1. Accident data was further limited to those roadway segments where traffic data existed. This particularly eliminated off-ramps from consideration. Accidents occurred on on-ramps with enough proximity to the mainline were linked to volumes on the mainline segment. Finally, accident data was temporally limited to times and dates on which traffic volumes were measured.

Both data subsets shown on Table 2-2 (subset1 and subset2) were analyzed using the same methodology described on Section 3 of this report. No significant differences were found when comparing the results obtained from both data subsets. Results and finding shown in Section 3 correspond to subset1, which represents more than 50 percent of the total accidents occurred between 1997 and 2000 on the freeway segments under study.

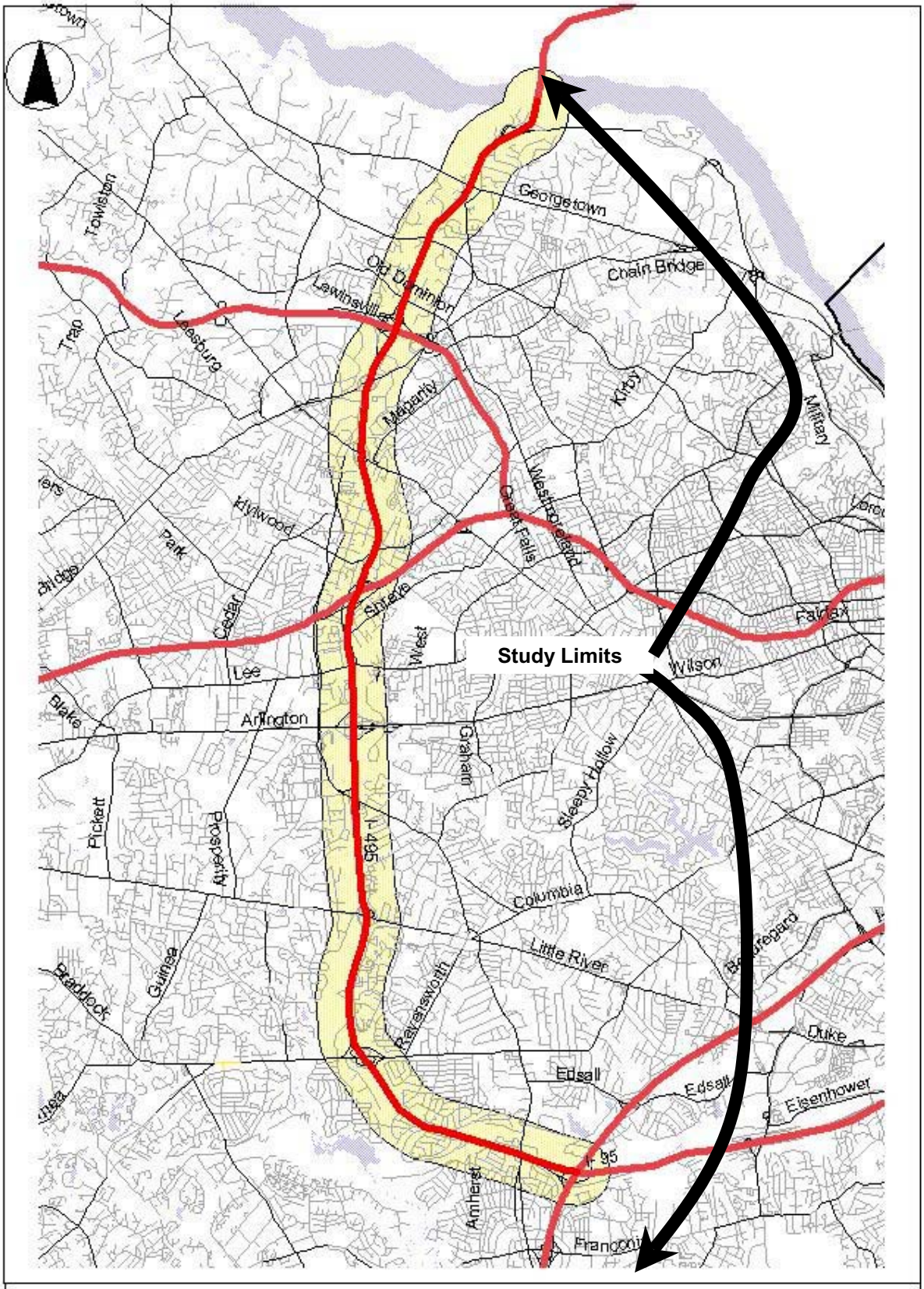

Figure 2-1: Map showing I-495 between Springfield and the American Legion Bridge

SECTION 3
EVALUATION OF CONGESTION AND SAFETY

This analysis was conducted to determine what correlation, if any, exists between freeway congestion and accident occurrence and to infer the potential safety impacts of implementing the HOT lanes on a portion of I-495. The initial premise was that when traffic operations deteriorate, creating congestion in a particular freeway segment, the likelihood of an accident occurring increases as more vehicular conflicts take place in the road.[4] Furthermore, if this hypothesis is true, then as measures to improve traffic operation on a specific freeway segment are implemented — as would be the case of the HOT lane implementation — reduction in accident rates would occur. As shown in the following sections, the results from the analysis tend to support this hypothesis.

3.1 SPEED AS A CONGESTION SURROGATE

The first step in the analysis was to select an indicator that would identify congestion conditions on the freeway segments under study. It is well known that during peak hours, most of the I-495 segments operate at oversaturated conditions. During oversaturated conditions the throughput volume is typically less than the maximum flow rate that could be processed under unsaturated conditions. Consequently, the traffic volume (or the volume to capacity ratio—v/c) by itself would not provide a reliable indication of congestion since most of the segments would reflect a v/c ratio less than one.

Average flow speed would be a better indicator of congestion under over-saturated conditions since it directly relates to the segment density and clearly represents the overall traffic condition. Average speed data were not available on each segment, time, and date of accident occurrence. However, bearing in mind the limitations described on Section 2-3, the speed reported during the accident (which was available for each accident event) offered an approximation of the average flow speed. Additionally, if a specific freeway segment could be identified as operating under oversaturated conditions, then speeds or densities (under congested operation) could be derived from flow rates by following the methodology proposed on the Highway Capacity Manual[5] (See Figure 3-1). These two proxy indicators of average flow speed were used in this analysis to investigate the correlation with traffic conditions and accident occurrence.

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[4] Congestion for this study refers to recurring congestion, and it is defined as the traffic operation in which the density (number of vehicles per mile per lane) of the freeway segment is equal or greater than 45 veh/mi/ln. This is consistent with the definition included in the *Highway Capacity Manual version 2000*. See also Note 2 for a description of congestion levels used in this analysis that are based on density.

[5] *Highway Capacity Manual 2000*. Transportation Research Board, ed. 2000, Washington DC. Chapter 22 – Freeway Facilities – Appendix A – Page 22-51, Exhibit A22-5 -Segment Flow Density Function.

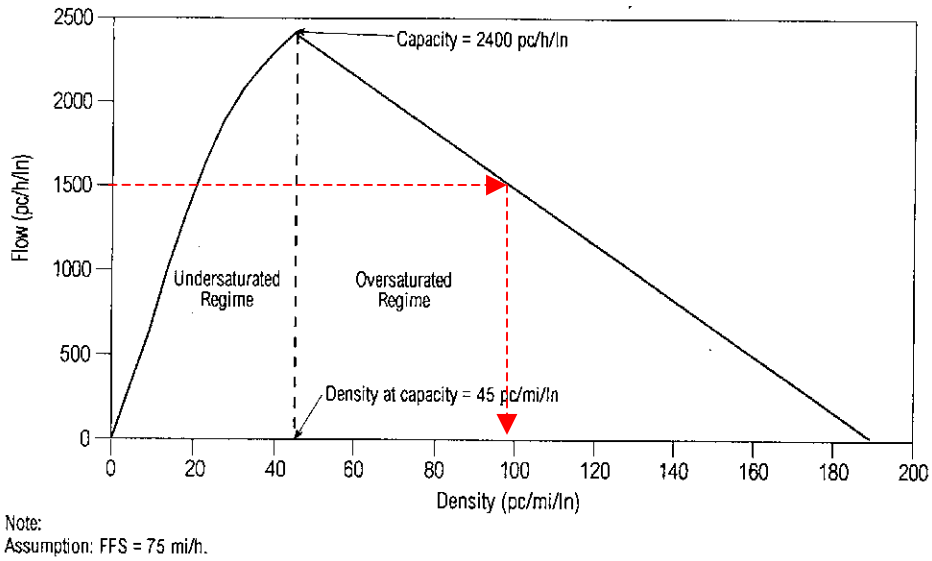

Figure 3-1: Flow rate vs. Density for Under-Saturated and Over-Saturated Conditions. *(Source: See footnote 2)*

3.2 DATA ANALYSIS

3.2.1 Analysis using Reported Speed

In order to test the validity of using "reported speed" as a surrogate for congestion the daily variations in reported speed were examined. As shown in Figure 3-2, the diurnal distribution of average reported speeds (for the entire accident database) is consistent with the expected peak and off-peak period traffic conditions. At the same time, Figure 3-3 shows that the total number of accidents significantly increases during peak periods. Figure 3-4 shows the same diurnal distribution for accident rates (number of accidents per 100 million vehicle miles traveled). In this case, the accident rate is significantly lower during peak periods. This correlation is most notable when compared during the evening off-peak period.

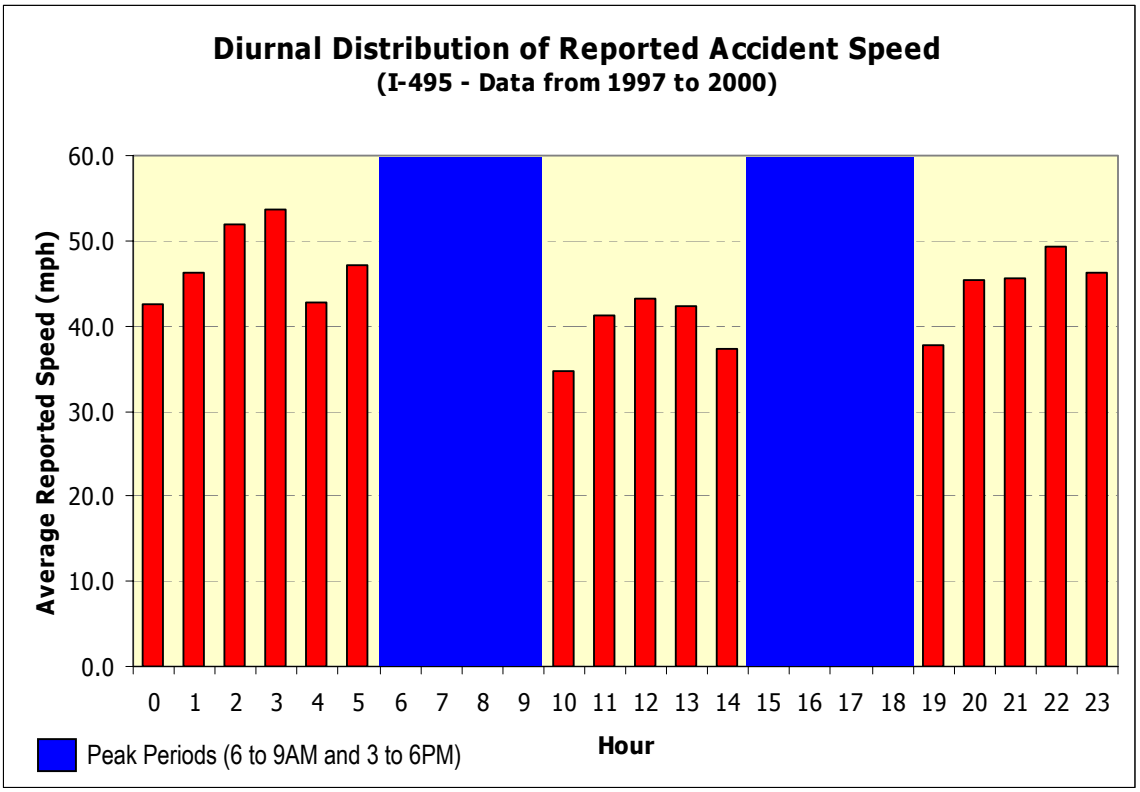

Figure 3-2: Distribution of Accident Speed.

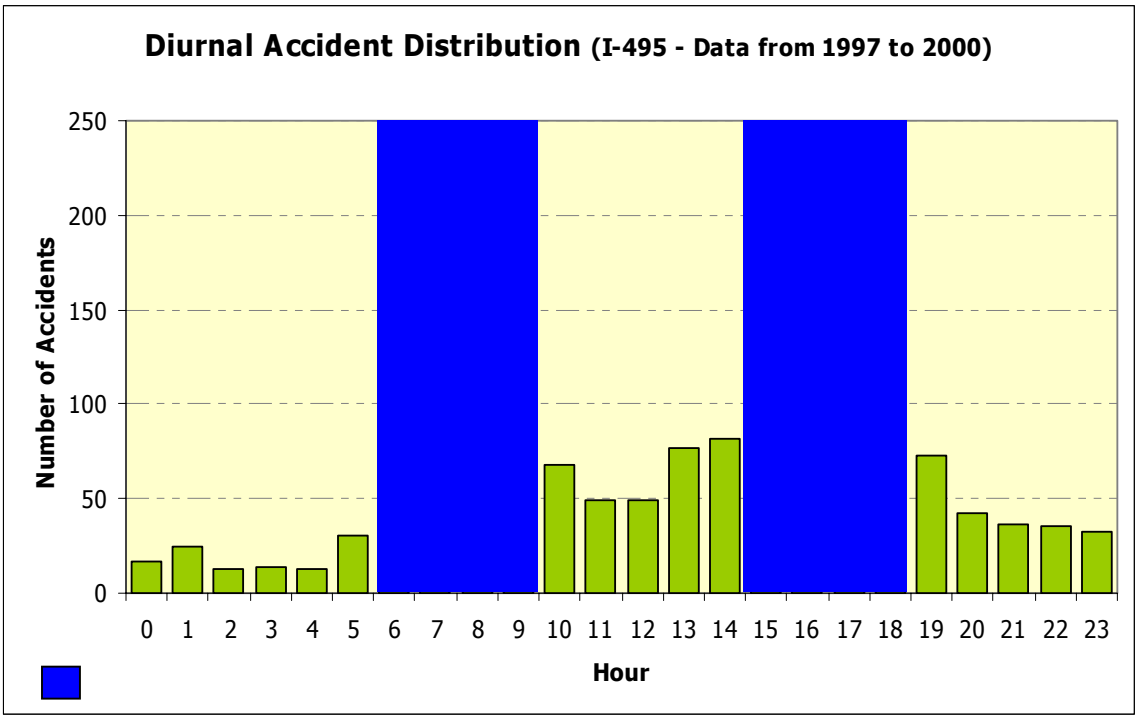

Figure 3-3: Distribution of Number of Accidents.

It is important to note that the diurnal distribution of accidents does not necessarily discriminate between congested and uncongested conditions, since even on peak periods, when one travel direction of I-495 could be congested, the opposite travel direction could be operating below capacity. Additionally, the high increase in accident rate during the nighttime off-peak period could be attributable to other factors not related with traffic operational conditions such us visibility, driving under alcohol influence, animals on the road, etc. Nevertheless, the reported speeds appear to correlate with the speed that traffic moves along the Beltway throughout the day.

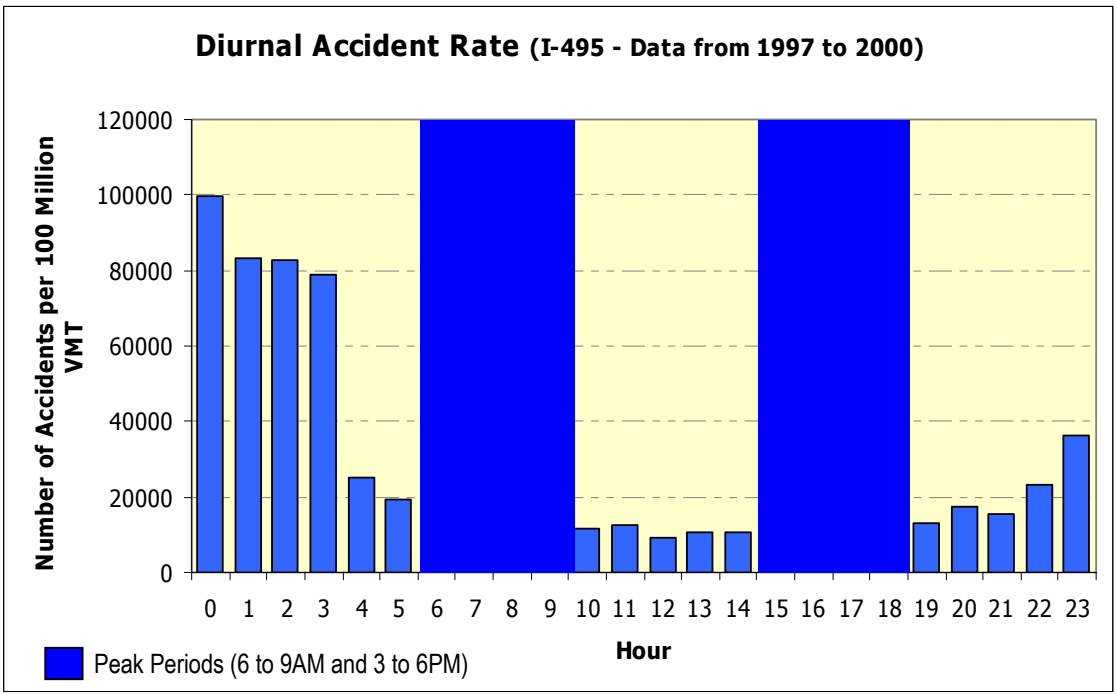

Figure 3-4: Distribution of Accident Rate.

3.2.2 Analysis of Reported Speed, Congestion, and Accidents

Using the reported speeds as an indication of traffic conditions, accident rates and number of accidents were plotted for the following three reported speed categories:

- 0 to 35 mph (severely congested operation)
- 35 to 55 mph (moderate congestion to near capacity operation)
- greater than 55 mph (free flow operation)

Figures 3-5 and 3-6 show the results obtained for the entire data set (roughly 1,800 accident records with traffic information). A cursory review of these results shows that accident rates increase drastically for free-flow conditions as compared with near-capacity or oversaturated conditions. At the same time, accident rates are higher under over-saturated conditions than under moderate or near-capacity conditions. Considering the same reported speed categories, Figure 3-6 shows that total number of accidents significantly increases for severely congested operation (stop-and-go conditions).

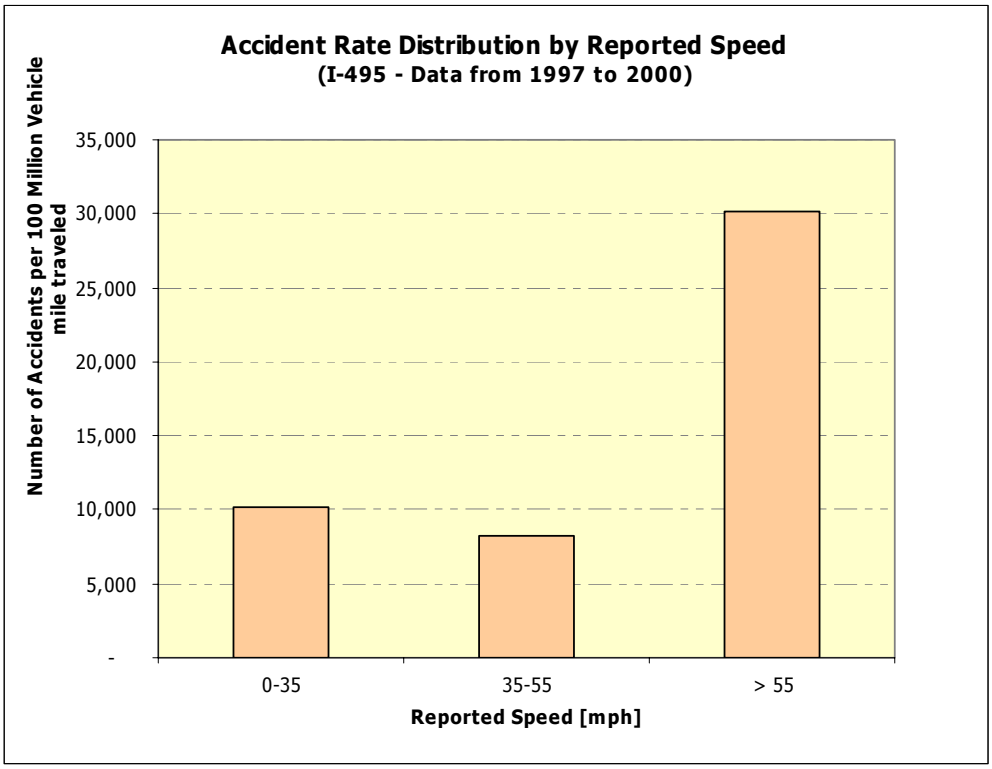

Figure 3-5: Accident Rate Distributed by Reported Speed.

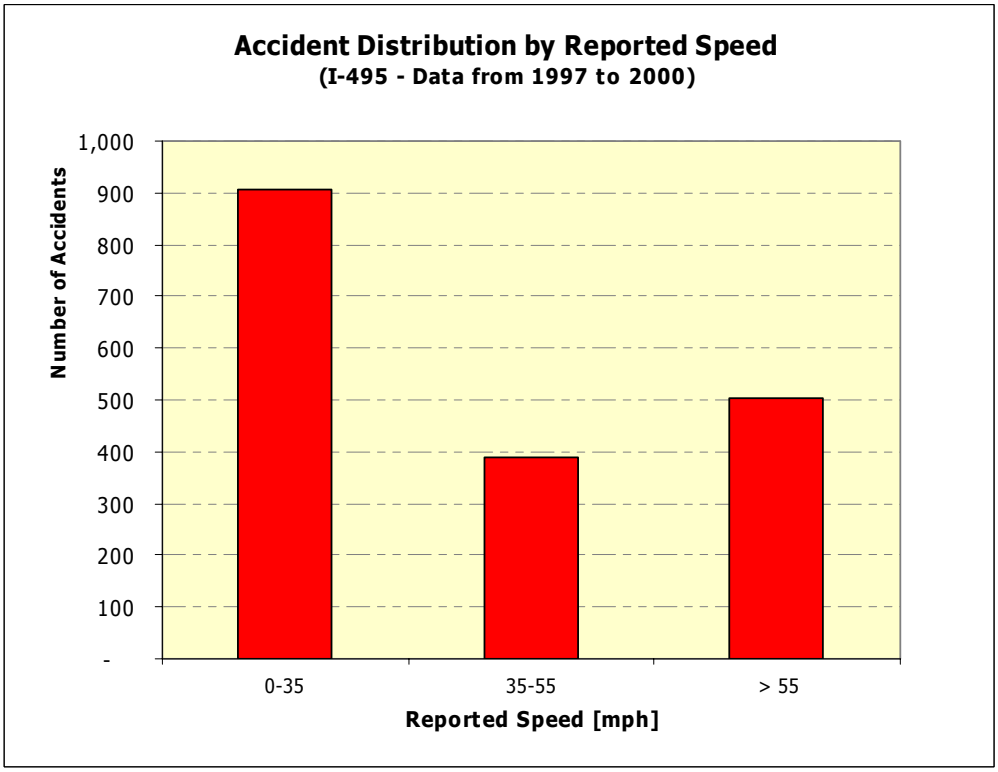

Figure 3-6: Number of Accidents Distributed by Report Speed.

3.2.3 Analysis using Speed and Density Derived from Flow Rates

As explained in Section 3.1, speed and density could be derived from flow rates by knowing the flow regime (over or under saturation) in which the volume was measured. For this analysis, flow rates greater than 1,500 vehicles per hour per lane occurring during peak periods (7AM to 9AM and 4PM to 7PM) were considered very likely to be operating under oversaturated conditions. Using the chart shown in Figure 3-1, density and average flow speed were estimated for each accident record. Figures 3-7 and 3-8 depict the results using a similar categorization of operating speeds as described (or related density) in Section 3.2.1.

- Severe congestion:
  - average flow speed: 0 to 35 mph
  - average density: > 60 veh/mi/ln
- Moderate congestion or near-capacity operation
  - average flow speed: 35 to 55 mph
  - average density: 35 to 60 veh/mi/ln
- No congestion or free flow operation
  - average speed: > 55 mph
  - average density: < 35 veh/mi/ln

Results shown on Figures 3-7 and 3-8 are consistent with the results found using reported speed. As shown by these figures, accidents rates seem to reach a minimum when traffic conditions are near capacity or at moderate congestion and increase for both free flow conditions and highly oversaturated conditions.

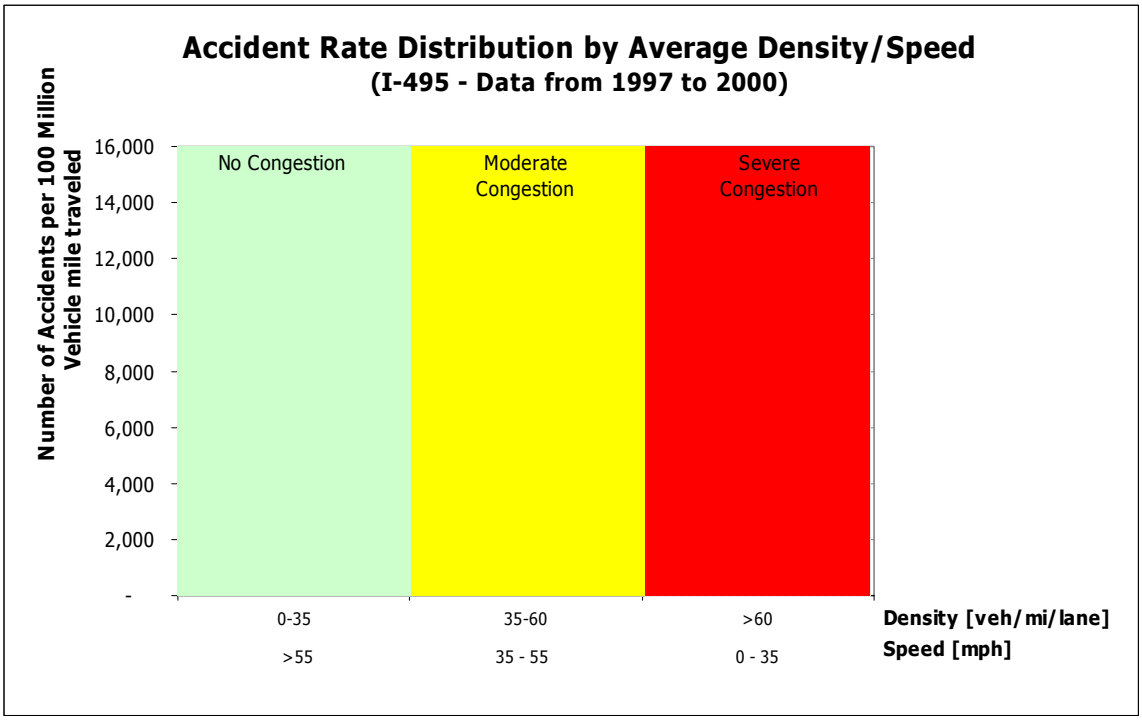

Figure 3-7: Accident Rate Distributed by Average Density/Speed.

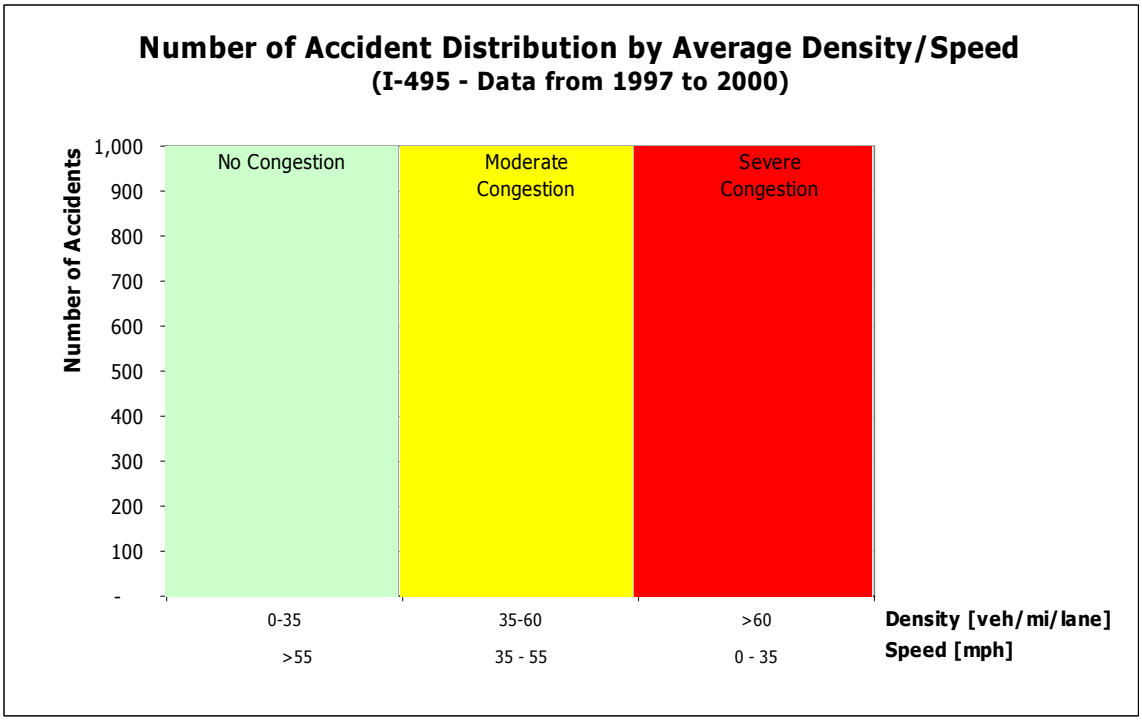

Figure 3-8: Number of Accidents Distributed by Average Density/Speed.

3.2.4 Analysis of Other Indicators

Other accident indicators, as listed on Table 2-1, were analyzed to observe differences between congested and uncongested conditions. Table 3-1 summarizes the number of accidents for both conditions when congestion is defined as traffic operating above the threshold density (45 vehicles per mile per lane).

Table 3-1: Number of Accidents on Congested vs. Uncongested Conditions.

Traffic Operation	Number of Accidents	Percent
Congested (Level of Service F - Density >45 veh/mi/ln)	1016	55.5%
Uncongested	814	44.5%
Total	**1830**	**100%**

Table 3-2 show the number and percentage of accidents by congestion categories as defined in Section 3.2.3.

Table 3-2: Number of Accidents on Oversaturated, Near Capacity, and Free Flow Conditions.

Traffic Operation	Number of Accidents	Percent
Uncongested – Free flow	732	**40.0%**
Moderate Congestion	67	**3.7%**
Severe Congestion (oversaturated – stop and go)	1032	**56.4%**
Total	**1831**	**100.0%**

Table 3-3 details the differences observed on the "accident major factor" indicator when accidents are segregated between congested and uncongested. As shown, the vast majority (93.8%) of accidents during congested conditions are due to driver inattention or error. On the other hand, while this is still a major factor on accidents during uncongested conditions, there is a significant increase of other factors such us speeding and alcohol influence.

Table 3-3: Factors Causing Accidents in Congested and Uncongested Conditions.

Accident Major Factor	Code	Congested	%	Uncongested	%
Driver had handicap (Asleep, ill, fatigued, or loss of limb, etc.)	1	6	0.6%	14	2.0%
Driver under the influence of alcohol, drugs, or other agents	2	3	0.3%	29	4.2%
Driver speeding	3	30	3.1%	80	11.6 %
Driver inattention or error	4	900	93.8 %	539	78.3 %
Vehicle defective	5	2	0.2%	9	1.3%
Weather or visibility condition	6	1	0.1%	1	0.1%
Road defective	7	0	0.0%	0	0.0%
Road slick	9	17	1.8%	16	2.3%
Totals		**959**	**100**	**688**	**100**

Note: Shaded rows indicate the most prevalent major factors.

Table 3-4 shows the same analysis for type of accident. Three types of accidents are predominant for the entire data set; rear end, sideswipe, and fixed object off road. As it was expected, there is a higher share of rear-end accidents under congested conditions (76.2%) compared with uncongested (43.1%). Conversely, sideswipe and fixed object road off account for roughly fifty percent of the accidents under uncongested conditions. Figure 3-9 summarizes these findings.

Table 3-4: Type of Accidents under Congested and Uncongested Conditions.

Type of Accident	Code	Congested	%	Uncongested	%
Rear End	1	770	76.2%	351	43.1%
Angle	2	8	0.8%	11	1.4%
Head on	3	1	0.1%	0	0.0%
Sideswipe - Same direction of travel	4	145	14.3%	181	22.2%
Sideswipe - Opposite direction of travel	5	0	0.0%	2	0.2%
Fixed object in road (from ditch to ditch)	6	4	0.4%	14	1.7%
Non-Collision, overturned, jackknifed or ran off road (no object)	8	10	1.0%	10	1.2%
Fixed object off road (from outside of ditch)	9	56	5.5%	201	24.7%
Animal	10	3	0.3%	13	1.6%
Pedestrian	12	0	0.0%	3	0.4%
Bicyclist	13	0	0.0%	0	0.0%
Motorcyclist	14	0	0.0%	0	0.0%
Backed Into	15	1	0.1%	0	0.0%
Miscellaneous or other	16	13	1.3%	28	3.4%
Total Accidents		**1011**	**100%**	**814**	**100%**

Note: Shaded rows indicate the most prevalent accident types. These are graphed in Figure 3-9.

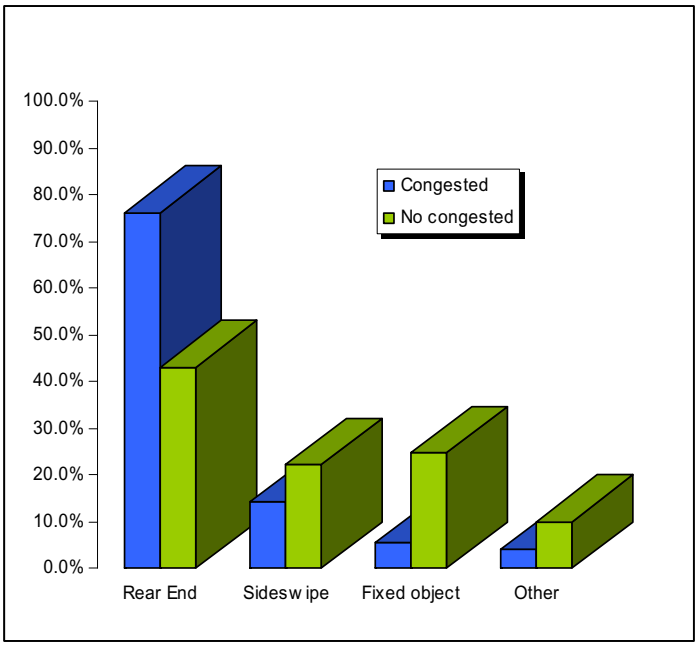

Figure 3-9: Major Type of Accidents on Congested vs. Uncongested Conditions.

Finally, Table 3-5 summarizes the results when accident data is categorized by severity for each traffic condition group. No significant difference in the severity of accidents between congested and uncongested conditions is evident. This result is surprising since it would be expected that at lower speeds, accidents should be also less severe.

Table 3-5: Accident Severity under Congested and Uncongested Conditions.

Accident Severity	**Code**	**Congested**	**%**	**Uncongested**	**%**
Dead before report made	1	1	0.1%	3	0.4%
Visible signs of injury, as bleeding wound or distorted member, or had to be carried from scene	2	0	0.0%	1	0.1%
Other visible injury, as bruises, abrasions, swelling, lumping, etc.	3	343	33.9 %	300	36.9 %
No visible injury but complaint of pain or momentary unconsciousness	4	667	66.0 %	508	62.6 %
Died Later	5	0	0.0%	0	0.0%
Not Stated	6	0	0.0%	0	0.0%
Total Accidents		**1011**	**100 %**	**812**	**100 %**

Note: Shaded rows indicate the most prevalent accident severities.

3.3 SUMMARY OF FINDINGS

The data analysis described in this section sought a correlation between accident occurrence and level of congestion on a series of freeway segments on I-495 between Springfield and the American Legion Bridge. The chief challenge of this exercise was to define the right indicator that would allow an identification of whether an accident occurred during congested or uncongested traffic operations. Vehicle speed from the accident reports and average flow density (also related with average flow speed) derived from measured traffic volumes were used as surrogates of congestion. The analysis using both indicators showed qualitatively consistent results, which would indicate that both indicators could be used to reasonably represent the traffic regime.

The results showed that accident rates on the analyzed segments of I-495 were significantly higher when traffic operates at lower densities equivalent to free flow speeds (uncongested conditions) than at higher densities or lower oversaturated speeds. A cursory review would conclude that congested conditions are "safer" than uncongested. However, a more careful analysis of congested conditions showed that operation near capacity or at moderate congestion resulted in lower accident rate than at highly oversaturated operation (stop-and-go regime caused by bottleneck conditions).

Other research has shown the relationship between accident rates and speed variations, concluding that accident rates are lower for travel speeds near the average flow speed of traffic and increase with greater deviations above or below the average.[6] This statement would also explain the reason for the minimum accident occurrence when conditions are near capacity (or moderate congestion) since it is at that condition when traffic tends to move more uniformly and therefore there are fewer opportunities for vehicles to deviate from the average flow speed. As vehicles approach operation under oversaturated conditions, stop-and-go regime takes place, creating higher deviation of speed distributions as vehicles encounter stopped traffic.

The analysis of other indicators such as major factor, type of accident, and severity showed a greater incidence of distractions and errors of the driver during congested conditions and a biggest share of rear-end type of crashes. The results did not show significant differences regarding the severity of the accidents between congested and uncongested conditions.

3.4 IMPLICATIONS OF RESULTS FOR THE HOT LANES

The main objective behind the implementation of the HOT lanes is the reduction of congestion during peak hours. However, given the extremely high traffic volumes experienced on I-495 during these periods, it is not likely that the implementation of the HOT lanes will improve operation in such a way that will change traffic conditions from oversaturated today to free flow (or completely uncongested) in the future, at least in the general purpose lanes. A reduction of congestion on the mainline combined with a near capacity operation on the HOT lanes is an

[6] *Synthesis of Safety Research Related to Speed and Speed Limits*, Transportation Research Board, Publication No. FHWA-RD-98-154, 1998.

improvement more likely to take place during peak hours. Under this scenario, and based on the above analysis, the implementation of the HOT lanes should not represent an increase in accident rates. HOT lanes may even offer a potential reduction in accident rate. During off-peak, non-congested periods, it is expected that both the HOT lanes and the all-purpose lanes will operate at a similar free flow conditions, thus accident rates would not be different from existing off-peak conditions.

A limitation of this analysis that cannot be overemphasized is the use of two proxy measures for average speed, which in turn was a surrogate for congestion. Average speed was never measured directly. It was estimated from reported speeds from accident records, and also estimated from measured traffic volumes. Because both estimation methods produced consistent results, conclusions drawn about the correlation between congestion and accident rates are meaningful but not fully proven.

SECTION 4
EXISTING HOT LANE SAFETY RECORD
SAFETY EVALUATION OF SR 91

Value-priced HOT lanes were constructed in the median of the Riverside Freeway (State Route 91) in Orange County, California, in response to considerable congestion in the corridor. The project was accomplished through a public-private partnership. The Fluor Beltway concept was modeled after SR 91. The roadway was funded privately, with the investment to be recouped through toll revenues.

Opened on December 27, 1995, the project added two HOT lanes in each direction between the SR 91/SR 55 interchange in Anaheim east to the Riverside County line. The length of the HOT lanes is 10 miles; no intermediate entrances or exits to the HOT lanes exist within the project limits.

This segment of SR 91 has an identical typical section to that proposed by Fluor for the Capital Beltway. Four general purpose lanes in each direction flank two HOT lanes in each direction. A concrete barrier separates opposing traffic at the facility centerline. General purpose lanes are separated from HOT lanes by a two to four-foot striped buffer and plastic pylons.

Tolls are collected electronically. Sensors mounted on overhead sign bridges detect a transponder in each vehicle in the express lanes, automatically deducting the toll from the vehicle owner's account. Pricing varies with time of day and day of week: tolls are higher during anticipated congestion periods. Vehicles with three or more occupants (HOV 3+) have reduced tolls. Trucks are not permitted on the express lanes.

A study of SR 91 was performed by researchers at Cal Poly State University for the California Department of Transportation (Caltrans). Among other topics, the study looked at safety and user perceptions. Results of the study in these areas are summarized in this section.

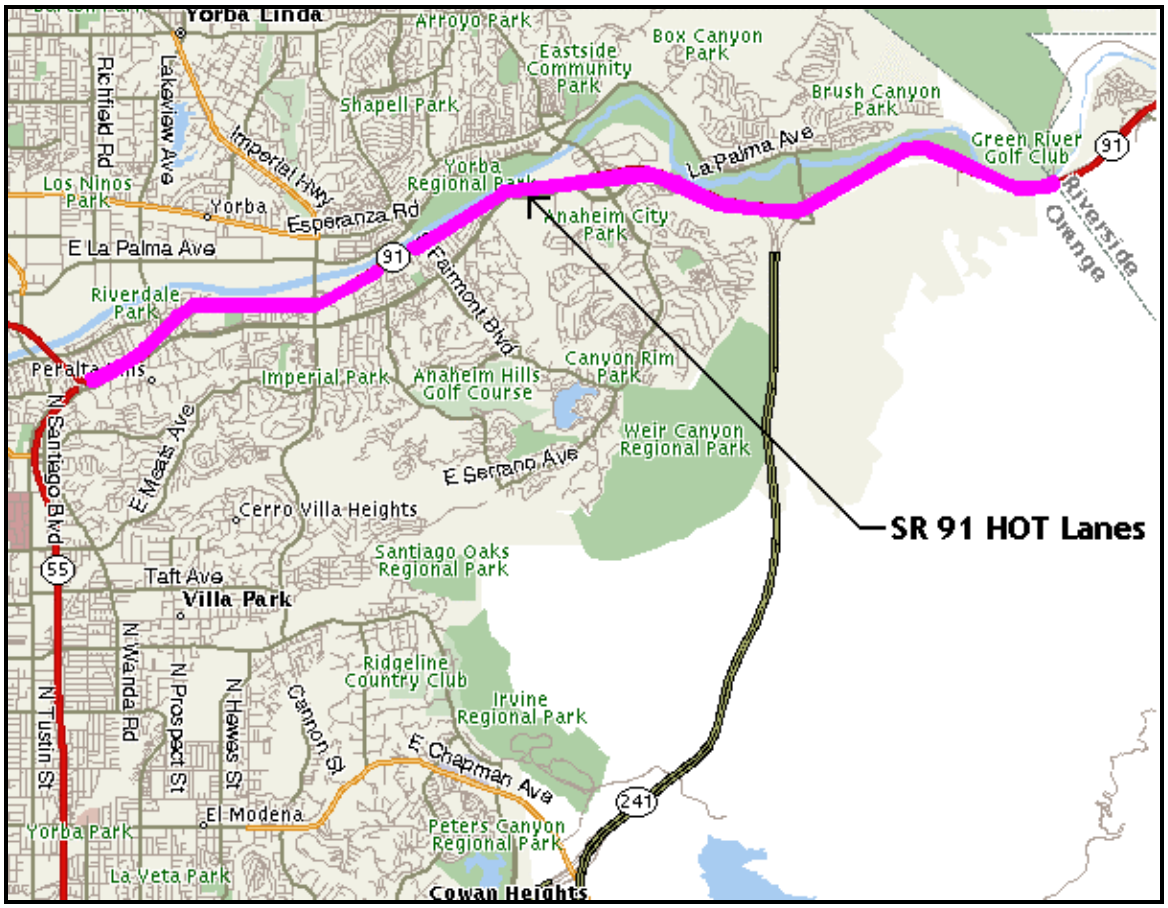

Figure 4-1: Location of SR 91, Orange County, California.

4.1 RESULTS OF ACCIDENT RATE STUDY

The study reported that the accident rate on the segment of SR 91 in Orange County with HOT lanes decreased after the opening of those lanes. The accident rate was computed by dividing the number of accidents by the estimated average daily traffic (ADT). The ADT was computed from counts at one location in the corridor and then applied throughout the corridor. While this extrapolation is not particularly precise, it did give an indication of relative traffic levels throughout the day.

A drop in weekday accident rate (both total accidents and fatality and injury accidents) occurred between just before opening and just after opening of the HOT lanes. The facility was under construction during the period just before opening. According to the study's authors, the reduction in weekday accident rate may be attributable to the reduction in congestion as well as to the cessation of construction activity.

A less marked reduction in accident rate was noted during the peak period and in the peak direction. The total accident rate decreased but the fatality and injury accident rate did not. One year after the opening of the HOT lanes, the weekday fatality and injury accident rate returned to the pre-opening rate and, as observed by the study, remained there for the following two years of study.

No significant change in the types of accidents was found for peak period/peak direction before and after the opening of the HOT lanes. Accident records for the peak period were compared to the off-peak. The percentage of rear-end accidents is much lower during the off-peak than during peak period, while the percentage of sideswipe accidents is about the same as during the peak period. This tends to support the assertion that rear-end collisions are more typical of the type of accident that occurs under congested conditions.

As a comparison, a second analysis was conducted of a two-mile segment of SR 91 without HOT lanes, with similar results. This segment is immediately east of the eastern terminus of the HOT lanes; therefore, it contains the transition from HOT lanes and general purpose lane to only general purpose lanes. The weekday accident rates for total accidents increased between just before opening and just after opening of the HOT lanes. No similar increase in fatality and injury accidents was evident. Furthermore, no statistically significant increase in accident rates occurred in subsequent years. The increase was attributed by the authors to an increase in congestion.

In the Riverside County segment a statistically significant redistribution of accident types away from "sideswipe" to "rear end" occurred. The increase in rear-end over sideswipe and other accidents appears consistent with increase in congestion rather than the increase in weave activity. Though not explicitly analyzed, it would appear that the weaving movements that occur at the eastern terminus of the HOT lanes, where the HOT lanes transition to general use lanes may be an important factor in accident rate. The data on rear end and sideswipe accidents did not support this hypothesis; nevertheless, the analysis suggests concerns about the transitions at the ends of the HOT lanes.

As a control, a segment of SR 57 in Orange County, also without HOT lanes, was also examined. Results were similar to those of the Riverside County section of SR 91. The study's authors attribute the increase in accident rate to a regional increase in congestion.

4.2 REVIEW OF SELECTED ACCIDENTS

Researchers examined reports of nine accidents in detail. The following contributing factors were proposed.

- "Soft" barriers between free and HOT lanes are easily crossed by out-of-control vehicles, sometimes resulting in collisions. A hard barrier would not necessarily prevent accidents, but could contain them to just one set of lanes.

  It should be noted that while installing hard barriers between free and HOT lanes may have the advantage of containing incidents, it may require additional right-of-way to provide an offset from the barrier. Constructing the barriers might necessitate a reduction in shoulder width which would

have a friction effect on traffic flow. Additionally, concrete barriers come with increased cost.

- Higher speeds and observed driving behavior suggest that some HOT lane users feel insulated from mainline congestion and therefore fail to react to hazards.

4.3 RESULTS OF USER SURVEY

As part of a continuing evaluation of the SR 91 project, surveys were conducted of users of the HOT lanes by the Cal Poly State University researchers. Questions regarding motorists' choice of the HOT lanes and reaction to the facility were asked. In response to the general question of why motorists chose to use the HOT lanes, beyond the obvious benefit of saving time by avoiding congestion, drivers cited driving comfort and the perception of greater safety as the principal supplemental benefits.

On a separate study, Texas Transportation Institute (TTI) researchers studied the benefits of separating truck traffic from general automobile traffic. As a test bed, they chose an eight-mile section of I-10 East Freeway for a demonstration project in which trucks were banned from the left lane of the freeway. TTI compiled crash data during the 36-week lane restriction demonstration project and compared it to data taken on the same stretch of road prior to the restriction. The study results indicated a dramatic 68 percent reduction in crashes. Both SR 91 and the Fluor HOT lanes restrict trucks.

To investigate further the perception of greater safety, researchers asked a sample of 408 HOT lane users to compare safety of the SR 91 HOT lanes versus regular freeway lanes. Among the respondents 58 percent said HOT lanes were somewhat safer or much safer, 14 percent said HOT lanes were somewhat less safe or much less safe, and the remaining 28 percent said HOT lanes and regular lanes were about the same.

- Those who thought the SR 91 HOT lanes are safer cited less traffic (40%), less congestion (28%), and less aggressive driving (18%) as the primary reasons.
- Those who thought the SR 91 HOT lanes are less safe cited high speeds (44%), more aggressive driving (24%), less enforcement (11%), and no shoulders (10%) as primary reasons.
- Reasons for greater perceived safety given infrequently by survey respondents were no large vehicles (7%), better emergency response (2%), and better enforcement (3%).

HNTB conducted a brief interview with an SR 91 facility operator. The interview reinforced the conclusion that motorists in the HOT lanes have a greater sense of safety than on other roads. Three anecdotal reasons were cited:

1. Trucks are not permitted in the HOT lanes. Consequently, Motorists feel safer not having to contend with 5- to 7-axle vehicles.

2. SR 91 operates a contract service that patrols the HOT facility 16 hours/day with tow trucks and utility vehicles. Motorists are believed to feel safer with roadside assistance readily available.

3. The HOT lanes are under CCTV observation at all times, and users are generally aware of this surveillance. They feel safer believing incidents will be responded to more quickly.

While it is interesting to note that these anecdotal reasons are not confirmed by the survey results, it is clear SR 91 HOT lane users feel safer versus less safe by a four-to-one margin. On the other hand, the Fluor HOT lanes proposal would separate trucks from general automobile traffic. Based upon the TTI findings for I-10 in Houston, removing trucks from the traffic stream would be expected to reduce accidents and would indeed improve safety on the HOT lanes.

4.4 INTERMEDIATE ACCESS POINTS

The concept proposed by Fluor includes three intermediate access points at Braddock Road, U.S. 50, and Route 123. In the initial implementation, slip ramps and buffer openings will allow access at these locations. In the recommended Phase 2 of the HOT lane development all three locations will be upgraded to direct ramp access.

The intermediate access points can be designed to current FHWA guidelines for HOT lanes and AASHTO guidelines for HOV facilities. FHWA provides for a range of slip ramp configurations. Acceleration and deceleration space can lead to openings in the proposed buffer, allowing for a merge area. A buffer opening of 1,500 feet with a weaving distance of 1,000 feet per lane to the nearest upstream and downstream ramps is recommended. In final design the precise location of the slip ramps should be determined by local topography, lines of sight, and operating characteristics of the adjacent lanes.

Slip ramps currently provide access to many existing HOV managed lane facilities from general purpose lanes throughout the United States. To date no comprehensive studies have been performed to assess the safety of these slip ramps. FHWA and AASHTO remain the best source of guidelines for safe design.

4.5 SUMMARY

The SR 91 study's authors concluded that there occurred a temporary reduction in congestion-related collisions in the Orange County section of SR 91 containing the HOT lanes. At the same time, congestion-related collisions increased in the section of SR 91 without HOT lanes in Riverside County. There is no evidence that the operating characteristics of the SR 91 HOT lanes result in any systematic differences in collision characteristics.

While the actual improvement in safety attributable to the HOT lanes is small, the perception of greater safety is strongly evident. The results of the TTI study on I-10 in Houston, however, suggest that by separating trucks from general automobile traffic, very tangible safety improvements can result.

SECTION 5
EVALUATION OF SNOW REMOVAL ISSUES

HNTB interviewed representatives from several transportation and highway departments in the northeastern United States. Among these departments were the New York State Department of Transportation, the New York State Thruway Authority, the Connecticut Department of Transportation, the Massachusetts Highway Department, and the New Jersey Turnpike Authority. Each interviewee was questioned about their snow removal operations, including:

- the threshold for deploying snow removal trucks
- the actual process of clearing the roads; and
- how this process is affected by a concrete barrier or buffer with plastic pylons.

5.1 THRESHOLD FOR SNOW REMOVAL

For the most part, state DOTs do not have a standard threshold for determining when plowing is required. Instead, they treat the road prior to or during the first snowfall. Most agencies rely on weather reports to determine the need for any treatment at all, depending on the predicted snowfall intensity. The Virginia Department of Transportation (VDOT), for example, uses a liquid magnesium solution to keep the road clear if a winter storm threatens. If the snow accumulates slowly, the liquid magnesium on the road surface will keep the road clean without plowing. When a large amount of snow falls within a short amount of time, this solution is not sufficient and the snow accumulates, requiring plowing.

Mobilization time is important. Depending on the weather forecast, if rapid accumulation is imminent, sand/salt trucks are mobilized and placed in strategic positions before the weather hits. The Connecticut Department of Transportation states that trucks can be active with a two-hour notice. The New Jersey Turnpike Authority can deploy trucks with three hours' notice.

5.2 SNOW REMOVAL METHODS

Along multilane highways, the usual procedure is to push all the snow beyond the outside lane — to the right. For a four- to five-lane highway, eight to twelve trucks are required to complete the task. The leftmost lane is plowed first, pushing snow to the right. In the next lane, and following the first plow, a second plow pushes the snow from its lane, which now includes the snow pushed over from the leftmost lane. The next lane has another plow that pushes the even larger amount of snow to the right, and so on. Because the amount of snow to be pushed aside increases as the moves to the outside, the amount of snow can get to be quite large.

The Massachusetts Highway Department uses a different procedure, employing snow blowers and loader trucks to handle the excess snow in normal plowing situations. For heavier snows the department uses what it known as a "wing plow." A wing plow

has an extra long wing that pushes down the snow. Another plow comes from behind and pushes the flattened snow aside.

In areas where there is no shoulder, there is no adjacent area to place the snow. Gore areas and collector-distributor lanes are two such examples. The majority of those surveyed used one of two strategies: using a snowblower to blow the snow to an intermediate location, or using a snowblower to load snow into a truck so it can be hauled to another location.

Figure 5-1: Snowplows clearing the NY Thruway (courtesy NY State Thruway Authority).

5.3 SNOW REMOVAL WITH BARRIERS

Fluor is considering the use of a buffer with plastic pylons to separate the HOT lanes from the general purpose lanes. However, in preliminary discussions VDOT has expressed some reservations about the use of buffers, mainly because of the fear of damage to the pylons. In the case of buffers, there is an additional fear of damage to the blade of the snowplow. In the case of plastic pylons, the fear is the complete destruction of the warning device.

The majority of the states interviewed use extra wide white lines and reflectors to separate HOV lanes from general purpose lanes. Mass Highway indicates the use of a five-foot wide berm that can be plowed against. Concrete barriers are also used to separate lanes. Massachusetts and the New York Thruway use a "zipper barrier," which is a concrete barrier that is moved with a slow-moving zipper machine. Zipper lanes are used in peak periods to create a temporary HOV lane, then the barrier can be moved to either increase the number of HOV lanes or it can be moved to the median to convert the lane into a general purpose lane. Several authorities have indicated that it uses plastic pylons to separate lanes. Plastic pylons are used on Route 3, the limited-access highway through Cape Cod, in the portion that has one lane in each direction. The pylons prevent cars from passing or overtaking. The Port Authority of New York and New Jersey uses plastic pylons for a contra-flow express bus lane during the peak hours on the approach to the Lincoln Tunnel.

Interviewees indicated that snow removal with such warning devices is a manageable challenge. However, this challenge is evident regardless of the type of object present. In the instance of plastic pylons, VDOT's maintenance department stated that there would be difficulty in locating the pylons in snow, leading to their destruction by snowplow blades. Plastic pylons are meant to give freely since the intention is to divide lanes without damaging a vehicle should one pylon be hit. They stand no chance with a blade of a snowplow. Mass Highway has damaged plastic pylons from time to time; however, they attempt to make them more visible to plow drivers. Experienced plow drivers generally know where the pylons are.

In some cases, the snow is plowed to the left, assuming there is space in the median. This was mentioned by the Connecticut Department of Transportation. Snow from the HOV lane is pushed into either the median or to the area between the HOV lane and general traffic (near Hartford, the HOV lane is separated via very wide striping and reflectors. In this case, snow in the HOV lane can be plowed to the left or right.

Generally, snow would be pushed to the shoulder of the HOT lanes. The typical 6-foot shoulder could adequately be used to store snow for most snow storms in Northern Virginia. Consequently, it would be rare that snow would need to be pushed across the buffer and between the plastic pylons.

5.4 EVALUATION

A maintenance worker with VDOT expressed his concern with plastic pylons because of the likelihood of their destruction by snowplows. Based on the interviews conducted, his concerns are justified. From the sources interviewed, snow removal along barrier-separated lanes can be problematic but manageable. Therefore, the implementation of HOT lanes along the Capital Beltway would not present a great maintenance challenge.

Obviously, there would be a trail-and-error phase to determine the correct snow removal procedure.

Figure 5-2: Plastic Pylons Used on Duke Street in Alexandria, Virginia.

Figure 5-3: Plastic Pylons Used on Duke Street in Alexandria, Virginia.

Each authority interviewed has its own method of clearing roads. One similarity does remain: the simple acceptance of the damage or destruction of barriers during plowing. These authorities, located in states that receive more snow than Northern Virginia, make strides to avoid the barriers and are quick to replace the ones they do damage.

Although the Fluor proposal contemplates using plastic pylons, research shows that *any* barrier or warning device used to separate lanes is susceptible to snowplow damage.

The following two conclusions can be drawn:

1. The concrete barrier separating the opposing HOT lanes appears to be the most difficult to maintain. This condition is no more challenging than current VDOT plowing along HOT barriers along I-95/I-395. Considering the HOT lanes along the Capital Beltway are proposed to be nearest the median, there may be some difficulty plowing the snow. Snow would be pushed to the left of the HOT lanes and into the shoulder. In most instances, there would be no need to push snow across the buffer and between the plastic pylons. In sections where there is a grassy or spacious median, plows could move the snow into that median.

2. Plastic pylons would be easier to maintain because they can be removed before plowing. If they are not removed, the pylons are high enough to be seen by a snowplow given the anticipated accumulations in this region. In this case, snowplows will have to plow left. If the pylons are knocked down or damaged, they can easily be replaced without complication.

In all cases, a chemical solution such as salt or liquid magnesium would be used on the surface to keep the snow from accumulating as rapidly.

APPENDIX A
SUBJECTS INTERVIEWED REGARDING SNOW REMOVAL PRACTICES

McNamara, Daniel (Director of Maintenance, New Jersey Turnpike Commission). Personal Interview, 21 March 2003.

Durango, Robert (General Manager, George Washington Bridge, Port Authority of New York and New Jersey). Personal Interview, 21 March 2003.

Schaff, Mark (Operations Manager, Lincoln Tunnel, Port Authority of New York and New Jersey). Personal Interview, 24 March 2003

Turano, Mike (Director, Staff Maintenance, Connecticut Department of Transportation). Personal Interview, 12-14 March 2003.

Jodoin, Paul (ITS Operations Manager, Massachusetts Department of Highways). Personal Interview, 12-14 March 2003.

Derrico, James (Massachusetts Department of Highways). Personal Interview, 12-14 March 2003.

Falehi, Mr. (Virginia Department of Transportation). Personal Interview, 13 March 2003.

Rollins, Albert (Maintenance, Virginia Department of Transportation). Personal Interview, 13 March 2003.

Doherty, Joe (Director of Maintenance?, New York State Department of Transportation). Personal Interview, 12 March 2003.

Ross, Scott (New York State Thruway Authority). Personal Interview, 12 March 2003.

Appendix C

Financial Pro Forma

FLUOR®

Fluor Corporation
100 Fluor Daniel Drive
Greenville, South Carolina 29607-2770
USA

864.281.6450 tel
864.281.6447 fax
george.biediger@fluor.com

George E. Biediger
Senior Director
Project Finance

September 29, 2003

Mr. Duane Callender
TIFIA Joint Program Office
U.S. Department of Transportation
Room 4301, HABF-50
400 Seventh Street, S.W.
Washington, DC 20590

Re: Letter of Interest for TIFIA Credit Assistance
Fluor Daniel's Proposed I-495 Capital Beltway HOT Lane Project

Dear Mr. Callender:

Pursuant to the Notice of Funding Availability published in the Federal Register (66 FR 58549), Fluor Daniel hereby submits this Letter of Interest for TIFIA Credit Assistance. We have included the components suggested in the TIFIA Program Guide (May 2003) to provide the Department of Transportation with the information needed to determine if we are eligible to submit an application for a TIFIA secured loan.

The Beltway HOT Lane Project has been submitted as a proposal by Fluor Daniel to the Virginia Department of Transportation (the "VDOT") under the terms of the Public-Private Transportation Act of 1995. The proposal was submitted in June of 2002; and at the July Commonwealth Transportation Board meeting, the proposal was formally recommended to be advanced for final evaluation. A Phase Three Detailed Proposal will be submitted to VDOT on October 1.

PROJECT DESCRIPTION

The proposed Capital Beltway HOT Lanes will be constructed in the median of I-495 and will extend from west of the Springfield interchange near the Hemming Ave. bridge to just south of the Georgetown Pike (Route 193). (Figure 1 illustrates the HOT lane system plan.) This mainline roadway type consists of a continuous 12-lane system configured in the 4-2-2-4 typical section shown in Figure 2. The four-lane (two in either direction) inner directional roadways are dedicated for use by qualifying HOT lane traffic and are separated from the adjacent general-purpose roadways by a four-foot striped buffer and yellow plastic pylons. Eight general-purpose lanes (four in each direction) will be provided. In addition to the beginning and ending points of the HOT lanes, five intermediate access/egress points to the HOT lanes

will be provided, two of which connect directly to the interchanges at I-66 and the Dulles Access/Toll Road. The other three access/egress points will connect through entry/exit points in the buffer. The mainline general-purpose lanes will connect to all of the interchanges from and to the right. Collector-distributor (C-D) roadways will be relocated to accommodate the proposed widening.

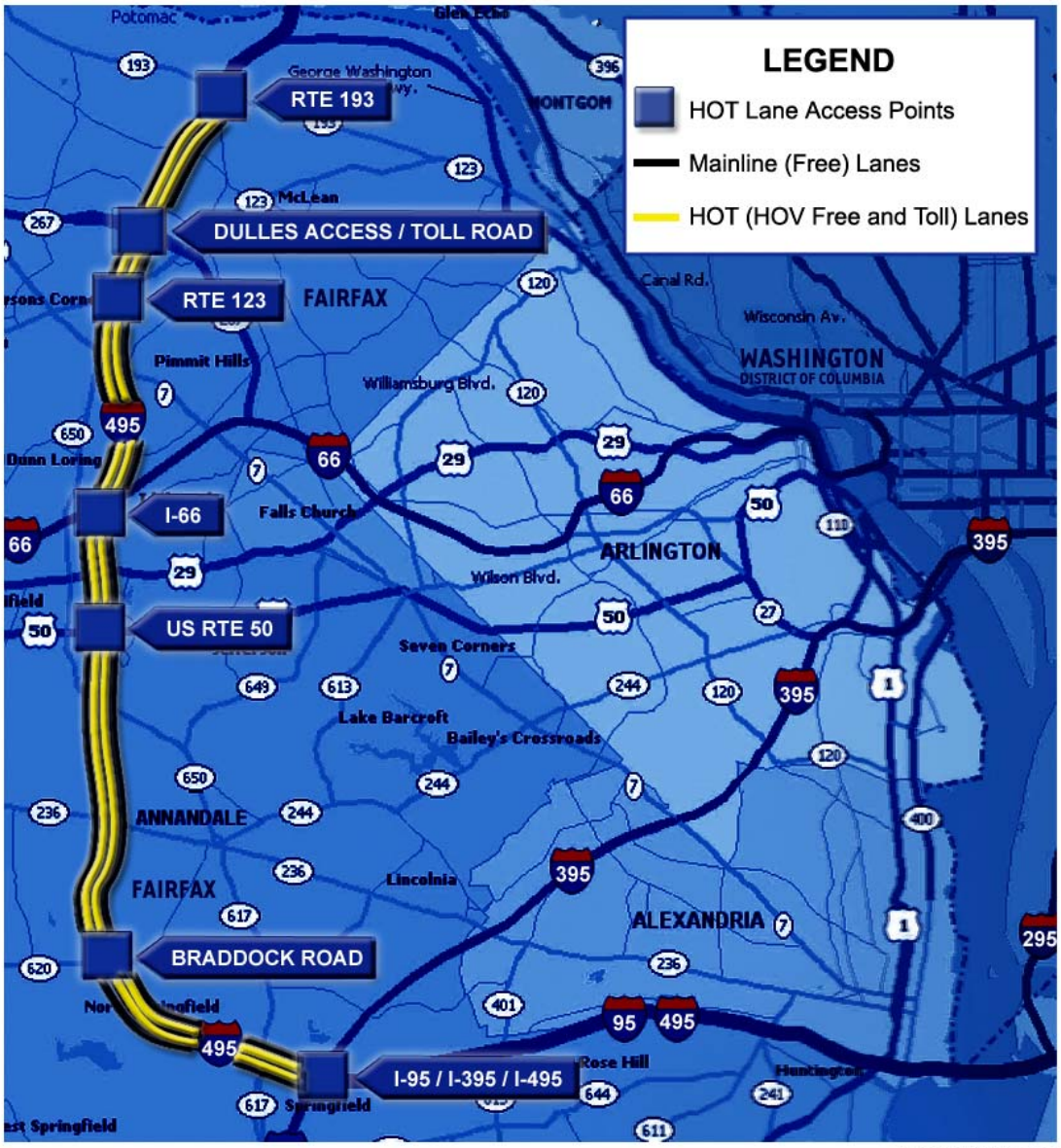

Figure 1. Capital Beltway HOT Lane System Plan

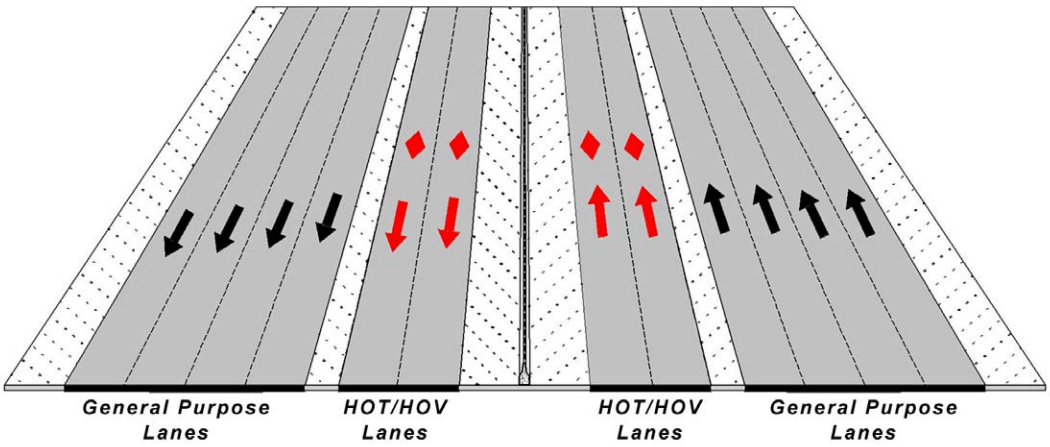

Figure 2. Proposed Capital Beltway HOT-Lane 4-2-2-4 Section

Roadway Operation

The addition of four HOT lanes on the Beltway will provide needed new capacity, encourage greater car pooling than would result from traditional HOV lanes, and facilitate greater bus ridership by allowing reliable express bus use of the HOT lanes/HOV network. The HOT lanes will operate at 65 mph while the general-purpose (outside 8) lanes will operate at the current 55 mph. A Smart Tag or E-Z- Pass transponder will be required to use the HOT lanes. Projections are the Capital Beltway HOT Lanes could divert up to 15 percent of the 2015 traffic from the eight conventional lanes. At intermediate access points where direct HOT ramps are not provided, traffic will use existing Beltway interchanges and access HOT lanes from the general-purpose lanes. These intermediate exit and egress points with supporting merging lanes will be strategically located to make maximum use of the HOT lanes and ensure safe Beltway operation.

Left exits and entrances from the mainline and the C-D roadways, for non-HOT traffic, will be eliminated. Such connections, however, could be provided from the HOT lanes only for HOT-lane traffic at the above mentioned three interchanges.

Collector-distributor roadways will be barrier-separated from the mainline roadways at interchanges and also between closely spaced interchanges to minimize movement conflicts and improve safety and traffic operations. Existing interchanges with C-D roadway configuration will not change. Generally, connection to interchanges will be made via the collector-distributor roadways; however, at selected locations, direct access/egress will be provided from the general-purpose lanes.

At the northern end of the project, the 12-lane roadway configuration will transition to match the roadway cross section south of the Georgetown Pike (Route193) interchange which is located south of the American Legion Memorial Bridge. Approaching that interchange, the required transition in the I-495 mainline cross section will begin just north of the Dulles Airport Access and Toll Road. Similarly, at the southern end of the Project, the I-495 mainline cross-section will tie into the Springfield interchange Project immediately east of the Hemming Ave. Bridge. At this location the Beltway cross-section will consist of 12 lanes.

PROJECT FINANCING

Fluor Daniel has developed a conceptual plan of finance that is based on the use of tax-exempt non-recourse toll revenue bonds for the Beltway HOT Lane Project. Fluor Daniel has engaged the services of Vollmer Associates to provide a preliminary analysis of traffic and revenue for the Project scope as outlined above, and has developed a plan of finance that relies on the ability to successful place toll revenue bonds backed solely by the prospective HOT Lane toll revenue generated after the completion of the Project.

The conceptual plan of finance projects the following sources and uses of funds:

Sources of Funds

41%	Senior Current Interest Bonds	$351,315,000
12%	Senior CABs	99,609,989
11%	Subordinated TIFIA Loan	246,437,053
29%	Public-Sector Investment	91,055,000
7%	Investment Earnings	58,299,469
	Total Sources	$846,716,511

Uses of Funds

Project Costs	$693,400,000
Pre-Development Costs	10,000,000
Issuance Costs	11,273,125
Capitalized Interest	86,950,463
Debt Service Reserve Fund	45,092,499
Contingency / (Shortfall)	425
Total Uses	$846,716,511

A detailed analysis of potential traffic and revenue will be conducted following the release of the Locally Preferred Alternative by the Virginia Department of Transportation, anticipated in the Spring of next year. With the scope of the Project defined through the Environmental Review Process, Fluor Daniel will engage Vollmer Associates to provide the level of detailed revenue analysis that will be necessary to secure investment-grade ratings for the Project Senior Debt. As evidence of the reasonableness of the plan of finance for this stage of Project development, the current plan of finance does not rely upon a time of day/level of congestion pricing strategy, rather, only a flat $.20/mile toll rate assumption.

As submitted to the Department, Fluor Daniel has proposed that all toll revenue be pledged to the repayment of senior project debt and the subordinated TIFIA loan, with provision made for the funding of toll operations and Project maintenance from the Department's operating budget. The non-recourse toll revenue debt is proposed to be issued either through an existing eligible conduit issuer or through a special purpose corporation established specifically for the Project and eligible to issue tax-exempt debt consistent with IRS requirements, such as we did on the Pocahontas Parkway project.

PROJECT PARTICIPANTS

Virginia Department of Transportation. The Project is and will continue to be owned by VDOT, which will be the critical decision-maker in both the selection of the preferred alternative, the decision to proceed with the Project, and approval of the method of finance. Based upon Fluor Daniel's experience in the successful development of the Pocahontas Parkway in Richmond, VDOT will play an active role in all aspects of Project development and will make the critical decisions regarding the scope of the Project and tolling policies.

Fluor Daniel, an international firm with strong Virginia development and construction experience specializing in innovative project financing, project development, and fast-track delivery methods

HNTB, Inc., the largest pure design firm in the United States with a long tradition of assisting VDOT in designing some of its most complex projects from the original Beltway to the I-95/I-395/I-495 Interchange

The Lane Construction Corporation, a major heavy construction contractor that has developed a reputation for dependability, integrity, and quality workmanship with its clients and is currently involved in construction of the I-95/I-395/I-495 Interchange

Vollmer Associates, a transportation forecasting, revenue analysis, and traffic engineering specialist

Bear Stearns serving as Fluor Daniel's financial adviser in the development of the HOT Lanes Project. In this capacity, Bear Stearns will analyze alternative debt structures, provide financial pro formas and facilitate the development of the traffic and revenue analysis necessary to securing investment grade ratings for the Project's senior debt.

Reed Smith, a major Virginia law firm experienced in general and environmental law and government relations

RSM, Inc., a recognized expert in public opinion polling and analysis in the area of Virginia transportation issues

Wetland Studies and Solutions, Inc., a leader in development of wetland mitigation banks and the development and processing of permits

The Project team organization for the development phase is illustrated in Figure 3.

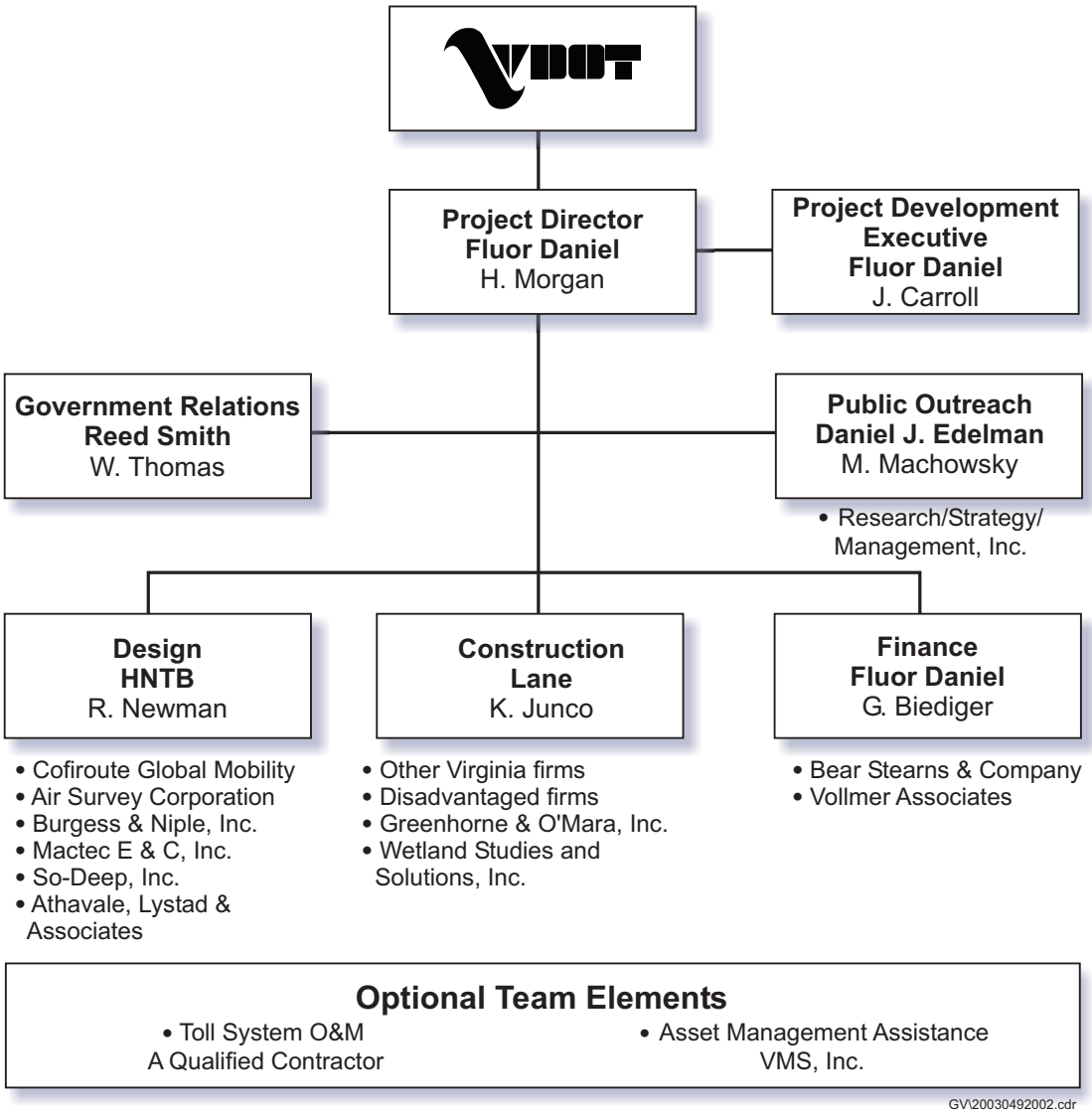

Figure 3. Project Team Development Phase Organization

BENEFITS

The primary benefits to the Project resulting from TIFIA participation is the ability it provides to increase leverage of private-sector funds during this period of scarcity of both Federal and State funds for new project construction. In addition to allowing more private sector funding from the proposed revenue stream, using TIFIA financing benefits the program in that it:

- **Provides Financial Support during Critical Ramp-Up Phase.** While the experience with the HOT Lane concept in this country has been uniformly positive, the relatively limited applications to date will raise concerns by both the rating agencies and municipal bond investors as to the time-frame required for motorists to recognize the inherent value in the HOT Lane concept. The inclusion of a TIFIA loan within the capital structure as "patient" capital to the Project will alleviate to a large degree these concerns.

- **Introduces the HOT Lane concept as an Alternative to HOV Lanes.** The Fluor Daniel HOT Lane proposal provides an additional four lanes to the existing eight-lane beltway, and will allow HOV vehicles to use the new HOT Lanes without charge. The successful introduction of the HOT Lane concept to the DC metro area may permit an expansion of the proposed Project to additional sections of the District beltway as well as other congested freeways in the nation.

- **Facilitates a Public Discussion of "Value Pricing."** Charging for the use of roadways based upon the real time demand for this capacity has been proven as an effective method to get greater asset value from existing infrastructure. Encouraging leisure travel to divert from peak to non-peak travel hours can raise the level of service on existing road networks while providing an incremental source of transportation funding. The high visibility of the proposed Project will certainly lead to greater dialogue on the potential for HOT Lanes to provide a larger share of the solutions to the nations road funding shortfall.

- **Provides Significant Increase in Beltway Capacity within Existing Right of Way.** While all identified alternatives to an increase in Beltway capacity are still under consideration, the proposal offered by Fluor Daniel is unique in its ability increase roadway capacity by 50 percent while largely maintaining the existing footprint of the Beltway.

TIFIA SELECTION CRITERIA

Our preliminary analysis of how this Project would respond to TIFIA selection criteria follows:

- **Project Significance.** The Beltway Express Lane Project would represent the largest application of the Express Lane concept anywhere. The addition of four lanes to the Beltway will facilitate improved mobility in the region, and the application of congesting pricing in a corridor as heavily traveled as the beltway will provide the industry insight into the efficacy of the altering user fees based upon demand.

- **Private Participation.** Fluor Daniel is proposing to partner with the Commonwealth of Virginia to develop the Beltway Express Lane Project under the auspices of the Public –Private Transportation Act. Fluor anticipates that more than 90 percent of project costs will be funded by the private sector.

- **Environment.** The innovative approach of altering tolls to the level of demand during each day will foster a greater awareness of the need to eliminate unnecessary vehicle use and encourage more drivers to adjust their travel to off-peak hours. In addition, the Beltway Express Lane Project will require the minimum amount of additional right of way, thereby providing the greatest additional capacity with the smallest impact on the environment. Air pollution will be reduced both from the induced use of public transportation and the reduction of fuel consumed in stop-and-go congestion driving.

- **Project Acceleration.** Under the Fluor Daniel proposal, additional capacity will be available by 2008, years ahead of what would be possible without private sector participation.

- **Creditworthiness.** While detailed traffic and revenue forecasts will not be undertaken until after the State has selected a Locally Preferred Alternative, the revenue potential for the Project is apparent based upon the level of congestion that currently exists on the Beltway for much of the day. We intend to structure the project financing to achieve investment grade ratings on the publicly traded senior debt and exceed the coverage required for TIFIA debt.

- **Use of Technology.** The Beltway Express Lane Project will make use of state of the art, "open-road" toll technology, allowing for user fees to be assessed on most traffic while permitting HOV, buses and public safety vehicles to use the facility free of charge.

ENVIRONMENTAL REVIEW

The Draft Environmental Impact Statement (EIS) was approved by the Federal Highway Administration on March 15, 2002. The Draft EIS was distributed to local, state, and federal government agencies on March 22, 2002. Public hearings were held in May 2002, and Fluor Daniel submitted the Beltway HOT-Lane proposal during the public comment period in June 2002. The Virginia Department of Transportation is expected to identify the Locally Preferred Alternative in the Spring of 2004. We expect a Record of Decision later next year.

We look forward to your favorable review of this letter and offer to meet with you and your team at your convenience to discuss this opportunity in more detail. Prior to that, please call me for with any questions or clarification issues that may arise.

Sincerely,

George E. Biediger

cc: Mrs. Barbara Reese, CFO VDOT
Ms. Suzanne Sale, Senior Financial Advisor, USDOT
Mr. David Klinges, Managing Director Bear Stearns

VOLLMER ASSOCIATES LLP
Engineers
Architects
Landscape Architects
Surveyors
Planners

50 West 23rd Street
New York, NY 10010-5205
Tel: 212.366.5600
Fax: 212.366.5629

September 25, 2003

Mr. George Biediger
Fluor Daniel
100 Fluor Daniel Drive
Greenville, SC 29607-2762

Re: I-495 HOT Lanes
Traffic and Revenue Assumptions

Dear Mr. Biediger:

We are pleased to submit our assumptions for this preliminary feasibility effort for the proposed Capital Beltway High-Occupancy Toll ("HOT") Lanes Project in Fairfax County, Virginia. Vollmer Associates conducted this study for Fluor Daniel to evaluate the revenue potential of the HOT lanes for several different alternatives. This letter report describes our assumptions and analyses for the Project.

Project Description

The proposed HOT lanes will run for 14 miles along the Capital Beltway (I-495) between the Springfield Interchange (I-95/I-395/I-495) and the American Legion Bridge to the north. The HOT lanes will be separated by a buffer zone from the general-purpose lanes, and run all day long in both directions, concurrent with the traffic.

One configuration studied for the HOT lane project is the "4-2-2-4" configuration, defined as four general-purpose and two HOT lanes per direction, with the HOT lanes on the inside (left side) of the road. Two other configurations were tested: "3-3-3-3" and "3-2-2-3".

At the northern and southern termini, the HOT lanes will be accessible from the general-purpose lanes via slip ramps. At two intermediate access points – the Dulles Toll Road and I-66 – the HOT lanes will be accessible through direct ramp

connections to other freeways. At the remaining access locations – Route 123, Route 50, and Braddock Road – both slip ramps and direct connectors are currently being investigated, however, for this study, revenue estimates were based on a system with direct connectors at all intermediate access points.

The project will have variable tolling based on the time of day, with higher tolls during peak traffic periods. Vehicles with three or more people will be able to ride on the HOT lanes at any time of day, free of charge.

The Traffic Model

Traffic and revenue were estimated with the use of MINUTP traffic models, obtained from MWCOG in 1997. Vollmer improved the models with the addition of tolling capabilities and refined them for various projects over the past six years, including the Dulles Greenway Traffic and Revenue Study, the Dulles Toll Road Revenue Feasibility Study, and the Route 28 Express Lane Study.

MWCOG's Round 5.3 land use forecasts were obtained in 1997 for use in these models. These were amended in the Dulles Greenway area in 1997. Updates to the MWCOG forecasts could not be used in our models because the entire zone structure has changed in their recent models. The level of work required to update the land use was not feasible or appropriate for a preliminary study.

The models have several notable constraints. They produce traffic results for an average weekday, but not by time of day, therefore, they could not model a variable tolling scenario. Though the models have both HOV and tolling capabilities, it is currently not possible to identify a road as being open to both toll customers and free HOV customers. Also, slip ramps cannot be modeled to accurately represent the impedence created by access to the HOT lanes across general-purpose lanes to reach the HOT lanes, therefore, in this study, configurations with slip ramps at intermediate access points were not analyzed. To account for these limitations, various post-processing calculations were performed to estimate revenue.

For the purposes of this analysis, only the models for the years 2005 and 2015 were utilized and updated. The Beltway was changed in the model networks so that there were toll lanes next to the general-purpose lanes.

A toll of 12 cents per mile (in 1997 dollars) was used in each model. This is roughly the average toll paid on newer toll roads in the U.S. Assuming a 3% annual inflation rate, the toll is equivalent to 15 cents per mile in 2005 and 20 cents per mile in 2015. Each piece or "link" of the HOT lanes was assigned a toll based on its length.

Post Processing of Results

The model output consisted of unadjusted average weekday traffic on general-purpose and toll lanes. In post-processing, it was assumed that 5% of the total Beltway traffic was "HOV 3+" (three or more passengers); these passengers would travel on the HOT lanes for free. The model traffic on the toll lanes was assumed to stay the same even if HOV 3+ users were added; it would just shift some of the toll-payers back to the general-purpose lanes and remove a small amount of revenue.

Vollmer used its experience on the SR 91 Express Lanes in California to factor up the revenue for congestion pricing. This is an existing HOT lane system similar in operation to the proposed Beltway HOT lanes. From the model Vollmer developed for SR 91, a variable toll versus flat toll scenario was tested, resulting in 22% more revenue for the variable toll scenario, where the peak toll was 90% higher than the flat toll. These estimates were used to adjust the Beltway HOT lane revenues.

The average weekday revenue was then expanded to a full year using an annualization factor of 312. This is based on the annual divided by the average weekday revenues obtained from VDOT for the Dulles Toll Road. The Dulles Greenway has a similar factor of 315.

A ramp-up period was assumed for the first few years after the opening of the HOT lanes. Ramp-up is often defined as the time it takes for drivers to become aware of a new facility and its potential benefits. We had assumed that the HOT lanes would open in 2005 with only 56% of their potential traffic and revenues. In the second, third, and fourth years the HOT lanes would carry 70%, 85%, and 95% of their potential traffic, respectively, and the ramp-up period would end by the fifth year. These ramp-up assumptions are based on data collected from existing toll roads. However, they produce conservative revenue estimates for this HOT lane project considering the toll lanes are directly adjacent to the general-purpose lanes; therefore, Beltway users would quickly be aware of them and notice their lower congestion.

Very truly yours,

Gerald V. Nielsten LC

Gerald V. Nielsten

Appendix D

Qualitative Analysis of the Potential Regional Air Quality Impact of HOT Lanes on the Capital Beltway

Qualitative Analysis of the Potential Regional Air Quality Impacts of HOT Lanes on the Capital Beltway in Virginia

Prepared by the

Metropolitan Washington Council of Governments

for Fluor Daniel

March 20, 2003

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1 Executive summary

Fluor Enterprises, Inc. (Fluor Daniel) is studying the feasibility of high-occupancy toll (HOT) lanes in the Washington, D.C. area. A HOT lane is a limited-access, buffer- or barrier-separated highway lane that provides free or reduced cost access to qualifying high-occupancy vehicles (HOVs) and provides tolled access to other vehicles that do not meet the passenger occupancy requirements. A HOT lane facility consists of one or more HOT lanes and is usually in the median of or adjacent to one or more lanes of general purpose (GP) traffic. Fluor is looking at the possibility of HOT lanes on the Capital Beltway (I-495) in Virginia, between Georgetown Pike and the Springfield interchange (I-395). The facility, which would open in 2009, would have 2 HOT lanes in each direction in the median of the Beltway, adjacent to 4 lanes in each direction of GP traffic.

This study is divided into two parts. The first part of this study is an investigation of experience elsewhere with HOT lane facilities. Currently there are only four operational HOT lane facilities in the United States:

- State Route 91 (SR-91) Express Lanes – Orange County, California
- I-15 FasTrak – San Diego, California
- Katy Freeway (I-10) QuickRide – Harris County, Texas
- Northwest Freeway (US-290) QuickRide – Harris County, Texas

The second part of the study involves using a sketch planning technique to estimate the average peak-hour volumes on the new facility and the likely resulting air quality mobile emissions impacts. Given the limited resources of this project, it was decided that there would be no new runs of the COG/TPB travel forecasting model (the "4-step model"). Instead, we would use the output from existing runs of the 4-step model as the input to our sketch planning analysis. The model outputs (daily link volumes for various segments of the Beltway) came from the latest air quality conformity analysis of record, that is the Air Quality Conformity Determination of the 2002 Constrained Long-Range Plan and the FY 2003-2008 Transportation Improvement Program. In this analysis, the following model runs were conducted: 2002, 2005, 2015, 2020, and 2025. Since 2015 was the first model year following the proposed 2009 opening date, we used model outputs from the 2015 highway network. The 2015 baseline configuration of the Beltway in Northern Virginia is 4 lanes of GP traffic in each direction and 1 lane of HOV3+ traffic in each direction. So the Fluor proposal would convert 1 lane of HOV3+ to HOV3+/HOT and add 1 lane of HOV3+/HOT traffic in each direction.

The emissions analysis described in this report assumes that there would be two distinct effects on emissions:

- Effect of lane management on speeds (Could increase or decrease emissions)
- Effect of adding highway capacity (Would likely increase emissions).

The basic methodology was as follows:

Demand forecast

- Three segments of the facility were chosen as representative of the whole facility. The proposed facility would traverse a section of the Beltway with 9 highway segments and 8 interchanges. The three representative segments were chosen to be:
    - Georgetown Pike to the Dulles Access/Toll Road (northern end of the facility)
    - VA Route 7 to I-66 (one of the heaviest volume segments)
    - Braddock Road to I-395 (southern end of the facility)
- Obtain estimated 2015 daily traffic volumes for the baseline configuration (HOV only) from the latest COG travel model runs.
- Convert the daily traffic to peak-hour traffic volumes.
- Assume that the HOT lanes could operate at a service flow rate of 1,600 passenger cars per hour per lane and still maintain the proposed 65 mph speed on the HOT lanes.
- Three forecasts of traffic under the HOT lane scenario were developed: a low, medium, and high forecast. In all three forecasts, we assume that traffic would be diverted from the GP lanes to the HOT lanes, and that the HOT lanes would fill up to their maximum service flow rate of 1,600 v/hr/ln. Since there are two HOT lanes in each direction, the capacity and flow rate of the HOT lanes becomes 3,200 v/hr in each direction. Thus, the difference between the three forecasts is not the level of traffic on the HOT lanes, which is always 3,200 v/hr, but rather the level of traffic on the adjacent GP lanes:
    - Low forecast: Assumes that, after traffic diverts from the congested GP lanes onto the free-flowing HOT lanes, the GP lanes do not fill up with any new traffic. The increase in traffic on the HOT lanes is equal to the decrease in traffic from the GP lanes. Consequently, there is no net increase in traffic on the Beltway.
    - Medium forecast: Assumes that, after traffic diverts from the congested GP lanes onto the free-flowing HOT lanes, the amount of traffic in the GP lanes increases by an amount equal to the capacity of the added lane of traffic in each direction (i.e., increases by 1,600 pc/h in each direction). This increase in traffic on the GP lanes would be due to traffic diverted from nearby arterials and/or induced traffic. Consequently, there is a net increase in traffic on the Beltway, compared to the base case.
    - High forecast: Assumes that, after traffic diverts from the congested GP lanes onto the free-flowing HOT lanes, the amount of traffic in the GP lanes increases, and returns to the same level of congestion as was found in the baseline case. This increase in traffic is equal to 3,200 v/hr minus the baseline HOV traffic, in each direction. Once again, this increase in traffic on the GP lanes would be due to traffic diverted from nearby arterials and/or induced traffic. Consequently, there is a net increase in traffic on the Beltway, compared to the base case.

Emissions forecast

- Calculate the volume-to-capacity ratio, speed, and LOS for each segment.
- Using average values for volume-to-capacity ratio, speed, and LOS , calculate the total running emissions for a peak hour for two pollutants: volatile organic compounds (VOC) and oxides of nitrogen (NOx).

Findings

A sketch planning technique was used to estimate both travel demand and mobile emissions for the 14-mile segment of the Beltway that would comprise the HOT lane facility. There were four demand forecasts and four emissions forecasts: base, action low, action medium, and action high. The medium and high demand forecasts were deemed to be the most likely of the three action or "build" scenarios.

- The proposed HOT lane facility would likely result in a slight increase in volatile organic compounds (VOC) – about 6% during the peak hour for the facility itself and about 0.05% on a daily basis at the regional level.

- The proposed HOT lane facility would likely result in a moderate increase in oxides of nitrogen (NOx) – about 15% during the peak hour for the facility itself and about 0.57% on a daily basis at the regional level.

- The foregoing emissions estimates are conservative, i.e., likely to overestimate emissions, because the increase in VMT in the medium and high travel forecasts is treated as 100% induced demand, meaning that it is all new VMT, not simply VMT moved from other facilities.

- The proposed HOT lane facility would likely result in three main benefits to users of the facility and its adjacent general purpose lanes on the Beltway:

    - More travel choices: In the base scenario, a user of this section of the Beltway had two travel options: SOV or HOV3+ (which includes 3+ person carpools, vanpools, and buses). In the action scenario, a user now has two new travel options: "SOV pay toll," and "HOV2 pay toll."

    - Travel time savings: In the base case, using the managed (HOV) lanes would save about 2.6 minutes over using the GP lanes, assuming one travels the full 14-mile segment. In the three action scenarios, using the managed lanes would save from 2.6 minutes to 4.8 minutes. However, simply stating the average time savings during the peak period for the base and action scenarios *understates* the total travel time benefit to users. For example, in the base case, only *one* class of users (HOV3+) could benefit from the 2.6-minute time savings, resulting in about 11,000 person-minutes of time savings, assuming an average vehicle occupancy of 3.6 persons per vehicle in the HOV3+ lanes. By contrast, in the action case, *three* classes of users (HOV3+, SOV pay toll, and HOV2 pay toll) could benefit from the 4.8-minute time savings (high forecast), resulting in about 43,000 person-minutes of time savings, assuming an average vehicle occupancy of 1.4 persons per vehicle in the HOT lanes. So the time savings in terms of person-minutes increases by a factor of about 4. Additionally, the aforementioned travel time savings represent the peak hour of an *average weekday* with no traffic

incidents. On a day where there is a major incident, the travel time savings in the managed lanes will likely be much more than 4.8 minutes.

- Consistency and dependability in travel times: The proposed HOT lane facility would maintain good levels of service on the managed lanes (anywhere from A to C) and would likely improve the level of service on the adjacent GP lanes, as compared to the base case. Users of existing HOT lane facilities in other states often report that one of the main perceived benefits of traveling on the HOT lanes is, in fact, the travel time dependability, which is ensured thanks to the variable pricing of the lanes.

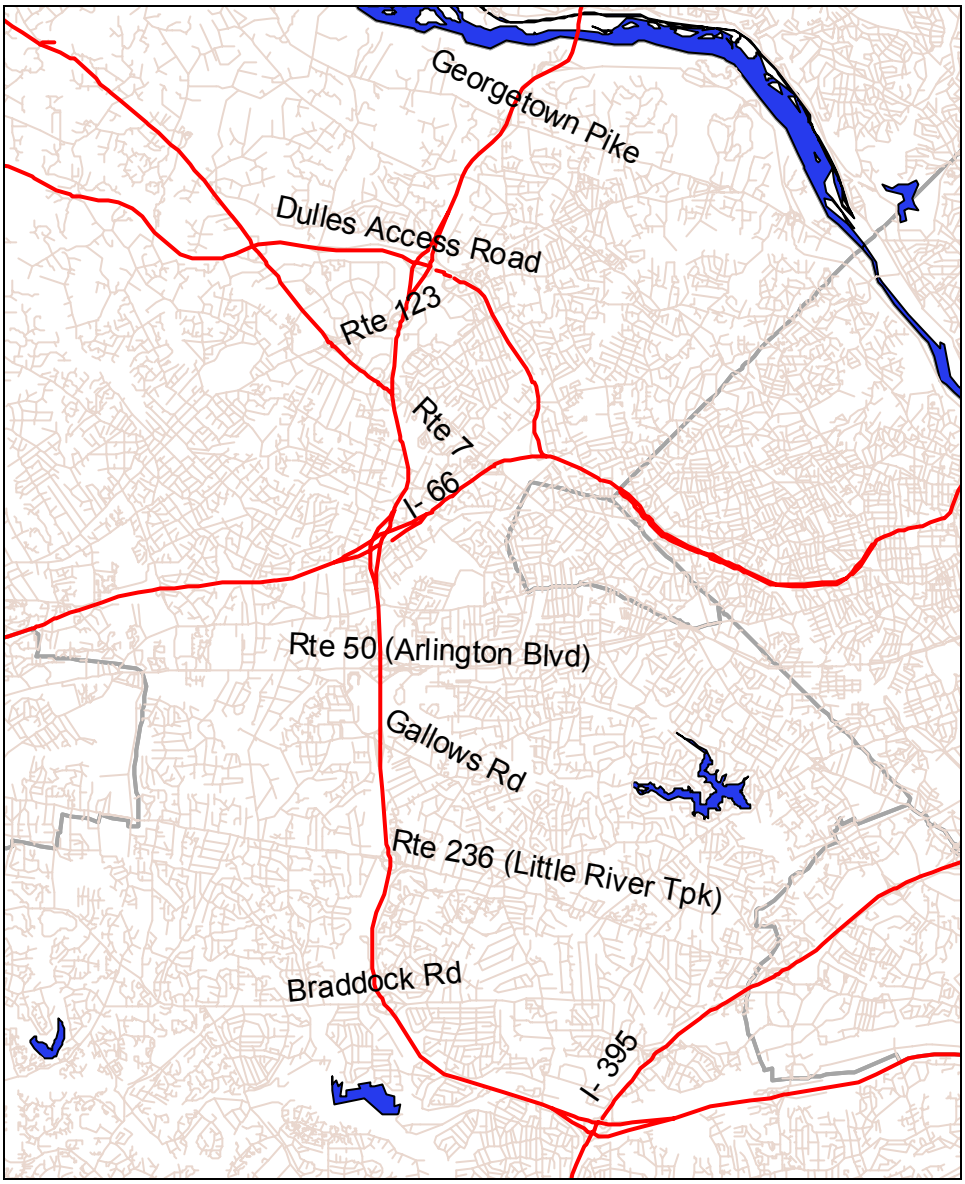
- Although the proposed HOT lane facility would result in both travel time savings and more consistent travel times, there would be even more user benefits if a *network* of HOT lanes were built in the region. Such a system is currently being proposed as a scenario for testing in the Regional Mobility and Accessibility Study, being conducted at Metropolitan Washington Council of Governments.

2 Scope of this study

2.1 Background

Fluor Enterprises, Inc. is studying the feasibility of high-occupancy toll (HOT) lanes in the Washington, D.C. area. Specifically, the firm is looking at the possibility of HOT lanes on the Capital Beltway (I-495) in Virginia, between Georgetown Pike and the Springfield interchange (I-395), shown in Figure 1. This conceptual proposal, which was submitted under Virginia's Public-Private Transportation Act, is being reviewed by VDOT.

Figure 1 Proposed HOT lane facility on I-495 from Georgetown Pike to I-395



Fluor is seeking a qualitative analysis of the air quality aspects of the Capital Beltway HOT lane concept as it relates to the TIP and projected regional air quality. The proposed HOT lanes would consist of two new lanes in each direction, located in the center of the Beltway, separated from the conventional lanes by a two to four-foot wide paved buffer area. On either side would be the existing four general-purpose traffic lanes. The final Beltway configuration would be 4-2-2-4 for a total of twelve lanes, four new and eight existing.

Access would be available at each end of the HOT lanes and at five intermediate locations. High-occupancy vehicles with three or more passengers (HOV-3), public buses, and emergency vehicles could use the HOT lanes without charge, while other vehicles would pay a toll that varies with the time of day. Direct access for HOV/HOT traffic would be constructed at the Dulles Airport Access and Toll Road and at the I-66 interchange. Three additional concurrent accesses, created by a break in the buffer area and upgradable to direct access connections, would be provided at Route 123, Braddock Road, and U.S. Route 50.

Operation of the HOT lanes would be 24 hours a day, seven days a week. Through use of a toll tag system comparable to that in use on the Dulles Toll Road, non HOV-3 motorists could use the road by paying a variable toll. Trucks would be prohibited from using these lanes, and speeds would be posted at least 10 mph higher than those posted in the adjacent conventional lanes. The toll rate would be set to ensure that users would be able to operate at the posted speed limit at all times. Fluor has assumed the initial maximum tolls would be $5.00 for 2009 and $6.00 for 2015. Initial off-peak tolls would be $1.00 for 2009 and $1.25 for 2015. Bus routes are anticipated to use the HOT lanes, generating 20 buses per hour during the peak and 7 buses per hour during the off-peak, based on existing bus service. Adding routes is anticipated to increase these figures by 24 buses per hour and 16 buses per hour, respectively.

2.2 Task 1— Investigation of Experience Elsewhere with HOT Lanes

Since HOT lanes are not currently being operated in the Washington region, TPB Staff will conduct a search of experience elsewhere. This will focus on the operating HOT lanes in San Diego, Los Angeles, and Houston, but will extend to other areas that investigation suggests should be pursued. Information that will be sought will include the performance of these HOT lane facilities, any data gathering (e.g. before and after surveys) that had been performed, and reviews in the literature regarding HOT lanes, including any emerging technical analysis methods. Information obtained from this investigation will be documented as a chapter in the final report to Fluor.

2.3 Task 2— Qualitative Analysis of HOT Lane Proposal for the Capital Beltway

Given the configuration described in the background section above, TPB Staff will conduct an analysis of likely impact of implementation of the HOT lane proposal for the Capital Beltway in Virginia. No detailed modeling of these lanes will be undertaken. Rather, it will be assumed that the facility will operate as specified by Fluor. Consequently, the performance of the adjacent conventional lanes will be estimated. This assessment will include likely level of service on both HOT lanes and conventional lanes and the likely resulting direction for regional

NOx and VOC emissions. The analysis will be for the year 2015 since this is the first analysis year beyond 2009 for which baseline emissions in the TIP and CLRP are available. The configuration of the Capital Beltway in the CLRP for that year is 4 lanes in each direction for mixed traffic, with one lane in each direction for HOV traffic between the Springfield Interchange and the American Legion Bridge.

2.4 Task 3— Findings Report

This report documents all of the information developed in Tasks 1 and 2.

3 Investigation of experience with HOT lanes around the U.S.

3.1 Introduction

A high-occupancy toll (HOT) lane is a limited-access, buffer- or barrier-separated highway lane that provides free or reduced cost access to qualifying high-occupancy vehicles (HOVs) and provides tolled access to other vehicles that do not meet the passenger occupancy requirements. A HOT lane facility consists of one or more HOT lanes and is usually in the median of or adjacent to one or more lanes of general purpose (GP) traffic. An HOV is defined as a carpool, a vanpool, or a bus. Traffic flow on a HOT lane is managed via the passenger occupancy requirement and the toll value, which typically varies throughout the day. The time-of-day toll variability can be either fixed or dynamic. A dynamic time-of-day toll is varied actively throughout the day, based on actual traffic congestion levels. A fixed time-of-day toll has pre-set values that can be published beforehand and are set based on historical patterns of congestion. Other terms used in relation to HOT lanes are "managed lanes," "value pricing," and "congestion pricing."

There are only four HOT lane facilities that are currently operating in the United States:

- State Route 91 (SR-91) Express Lanes – Orange County, California
- I-15 FasTrak – San Diego, California
- Katy Freeway (I-10) QuickRide – Harris County, Texas
- Northwest Freeway (US-290) QuickRide – Harris County, Texas

The last two facilities are both in the Houston, Texas area.

These four facilities share a number of similarities with each other (Perez and Sciara 2003). First, they are physically separated from the parallel general purpose (GP) lanes by continuous concrete barriers or a fence of collapsible pylons. Second, they each use fully automated electronic toll collection, with access restricted to HOVs and non-qualified, paying vehicles equipped with transponder tags. Thus, there are no tollbooths or queues associated with manual toll collection. Last, all systems have an information system of fixed or variable signs to provide users with information about access, occupancy requirements, hours, prices, and enforcement.

There are also a number of differences between these four facilities. The HOT lanes vary in width from one to four lanes (two in each direction). On the I-15 FasTrak in San Diego, HOV vehicles ride for *free*, while SOVs pay a toll. On the SR-91 Express Lanes in Orange County, HOV3+ carpools pay *reduced* tolls. In the Houston QuickRide program, which operates on both the Katy Freeway and US-290, HOV3+ vehicles ride for *free*, but HOV2 vehicles *pay* for use. I-15 FasTrak uses tolls whose value is dynamically adjusted every 6 minutes, whereas the rest of the facilities use fixed tolls whose value is a set amount given the time-of-day of the trip. Ownership and operating structures vary widely, from for-profit private developers to local planning organizations, transit agencies, or stated departments of transportation. Below is a brief description of each of the four facilities.

3.1.1 State Route 91 (SR-91) Express Lanes - Orange County, California

Opened in 1995, the SR-91 Express Lanes facility was the first HOT lane facility to open in the U.S. The facility is 10 miles long, has 2 lanes in each direction, and is located in the median of SR-91. Since SR-91 has 4 general purpose (GP) lanes in each direction, the total width of SR-91 is 12 lanes. On a typical day, roughly 250,000 vehicles use SR-91. Before the 91 Express Lanes opened, peak period delays of 20 to 40 minutes were common. The HOT lanes are separated from the GP lanes by a 2-foot buffer area highlighted by yellow, flexible pylons. Toll rates on the Express Lanes vary from $1.00 to $4.75 by time of day and day of week. Tolls for HOV3+ vehicles are reduced by 50%. Customers must have a transponder to use the facility. Two different views of the SR-91 Express Lanes are shown in Figure 2 and Figure 3. The SR-91 Express Lanes project was awarded on a concession basis to a private consortium, California Private Transportation Company (CPTC), which financed, built, and operated the new lanes, using project revenues to repay its debt and derive profit (Perez and Sciara 2003). Note that there is a system of public toll roads (about 67 miles) in Orange County, which are managed by the Transportation Corridor Agencies (TCA) (http://www.tcagencies.com/). This system of toll roads connects with, but does not include, SR-91. Both the toll road system and SR-91 are shown in Figure 4. In January 2003, CPTC sold the HOT lane facility to the Orange County Transportation Authority (OCTA).

Figure 2 SR-91 Express Lanes.

Overhead devices for electronic toll collection. Left lane is for HOV3+, which receives a 50% discount.

Source: Federal Highway Administration, Excellence in Highway Design, http://www.fhwa.dot.gov/eihd/91exp.htm

Figure 3 SR-91 HOT lanes

(Express Lanes to the left; General purpose lanes to the right)

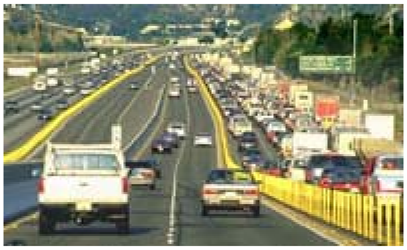


Photo courtesy of California Private Transportation Co.

Figure 4 Toll roads in Orange County, California.

SR-91 is at the top of figure. Public toll road network is south of SR-91.

Source: Federal Highway Administration, Excellence in Highway Design, http://www.fhwa.dot.gov/eihd/91exp.htm

3.1.2 I-15 FasTrak - San Diego, California

The I-15 FasTrak HOT lane facility was developed by converting an underutilized pre-existing 8-mile, 2-lane (reversible) HOV facility to peak-period reversible HOT. The HOT lane facility opened in 1996. The HOV facility had been operating since 1988. The I-15 FasTrak program allows SOVs to use the facility by paying a toll of $0.50 to $4.00 ($8.00 in extreme congestion); HOV2 and HOV3+ carpools travel for free. Customers must have a transponder to use the facility. The project is sponsored by the San Diego Association of Governments (SANDAG), the local metropolitan planning organization (MPO), which has earmarked a significant portion of the revenues derived from the HOT lane to fund transit improvements in the I-15 corridor. The lanes operate only during peak hours in the direction of the commute. From 5:30 AM to 11 AM, all vehicles in the HOT lanes travel southbound; from 11:30 AM to 7:30 PM, all vehicles travel northbound. SANDAG has committed to expanding the HOT lanes to four lanes (2 in each direction) and lengthening the system to 20 miles.

3.1.3 Katy Freeway (I-10) QuickRide - Harris County, Texas

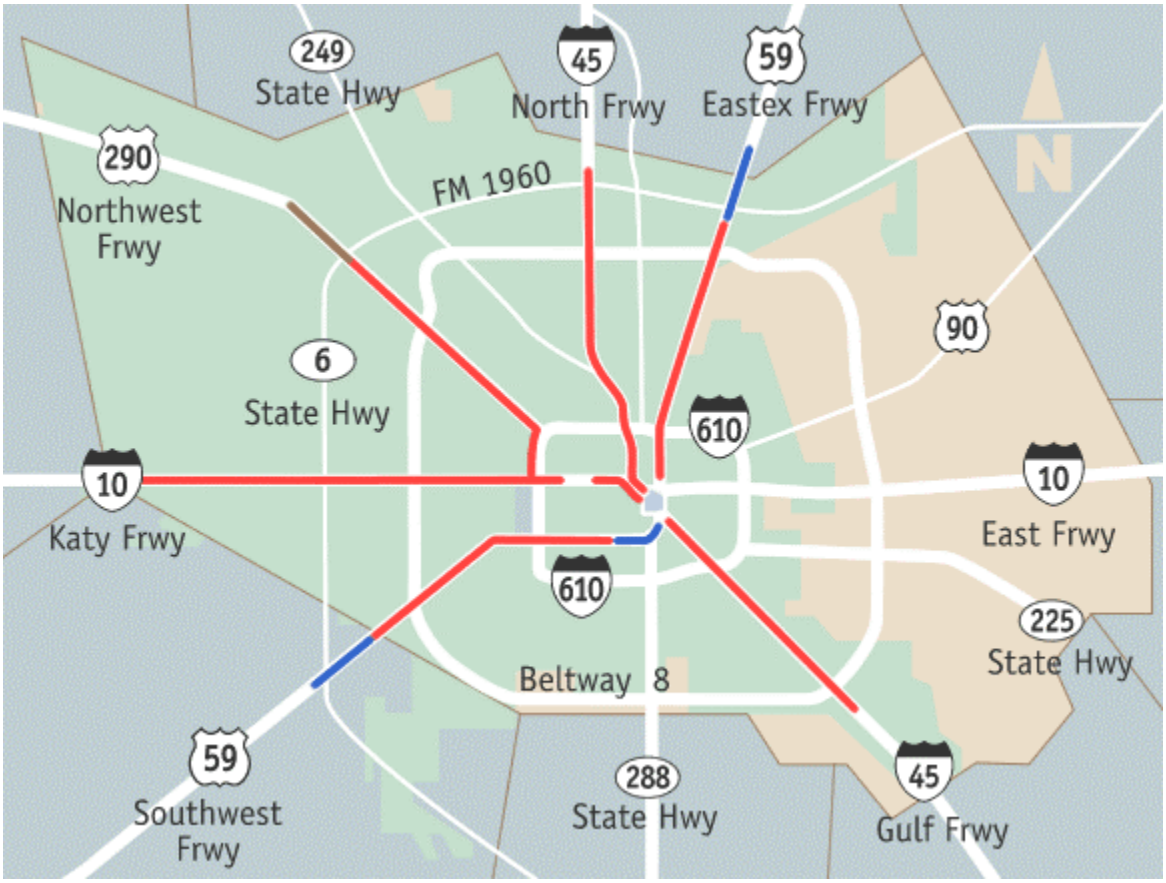
The Katy Freeway is an existing highway with a 13-mile, 6-lane freeway (3 each direction), with a 1-lane reversible HOV lane in the median, making a total of 7 lanes across. The HOV lane, which began in 1984, originally operated at HOV2, but the facility was too congested, so the occupancy constraint was raised to HOV3 to reduce congestion. However, this change resulted in excess capacity on the facility during the peak periods. As a result, the QuickRide program was introduced in 1998, allowing HOV2 vehicles to pay $2.00 per trip to use the facility during peak periods, while HOV 3+ vehicles continued to use the facility at no cost. Note that SOV traffic is never allowed on the QuickRide lane. Customers must have a QuickRide account, transponder, and windshield tag to use the facility. Figure 5 shows the extent of the HOV system in the Houston area, including the two HOT lane facilities, I-10 and US-290.

3.1.4 Northwest Freeway (US-290) QuickRide - Harris County, Texas

The US-290 QuickRide facility is a 15.5-mile long, 1-lane, reversible, barrier-separated facility that opened as HOV2+ in 1988. In 2000, the facility was converted to a HOT lane facility and is operated in a manner similar to the Katy Freeway. The US-290 QuickRide facility allows HOV2+ carpools to use the facility only in the morning peak period, when HOV3+ requirements are in effect. From 6:45 AM to 8:00 AM, the facility operates inbound, during which HOV3+ may use the lane for free, but HOV2 must pay a flat $2.00. Note that SOV traffic is never allowed on the QuickRide lane. Figure 5 shows the extent of the HOV system in the Houston area, including the two HOT lane facilities, I-10 and US-290.

Table 1 presents a comparison of the Fluor proposal and the four operating HOT lane facilities in the U.S.

Figure 5 HOV system in Houston, Texas



Source: Metropolitan Transit Authority of Harris County, Texas, http://www.hou-metro.harris.tx.us/services/areahovmap.asp

Table 1 Comparison of Fluor proposal to existing HOT lane facilities in the U.S.

	Proposed	Existing HOT lane facilities			
	I-495 Capital Beltway in Northern Virginia	**SR-91 Express Lanes - Orange County, California**	**I-15 FasTrak - San Diego, California**	**Katy Freeway (I-10) QuickRide - Harris Co., TX**	**Northwest Freeway (US-290) QuickRide - Harris Co., TX**
Type of facility	HOT, proposed	HOT	HOT	HOT	HOT
No. of lanes, HOT	2 each direction	2 each direction	2, reversible *	1, reversible	1, reversible
No. of lanes, general purpose (GP)	4 each direction	4 each direction	4 each direction	3 each direction	3 each direction
Length (miles)	14	10	8	13	15.5
Date opened	2009 proposed	1995	1996 (HOV since 1988)	1998 (HOV since 1984)	2000 (HOV since 1988)
Hours of operation, HOT lanes	24 hours	24 hours	Peak periods	Peak periods	Peak periods
Location of HOT lanes	In median	In median	In median	In median	In median
Facility type	In freeway ROW, buffer separated	In freeway ROW, buffer separated	In freeway ROW, barrier separated	In freeway ROW, barrier separated	In freeway ROW, barrier separated
Separation from GP lanes	2 to 4-ft wide paved buffer with yellow pylons	2-ft wide paved buffer with yellow pylons	Concrete barriers	Concrete barriers	Concrete barriers
Free use of HOT lanes	HOV 3+, buses, vanpools, emergency vehicles	Buses, vanpools, motorcycles; zero-emission vehicles; and vehicles with disabled persons license plates	HOV2, HOV3+, buses, vanpools	HOV 3+, buses, vanpools, motorcycles. HOV 2 is free during off peak hours.	HOV 3+, buses, vanpools, motorcycles
Toll required to use HOT lanes	SOV and HOV 2	SOV, HOV2, and HOV3+ (HOV3+ toll is 50% of SOV)	SOV	HOV 2 ($2 per trip) during AM & PM peak periods (6:45-8 AM and 5-6 PM)	HOV 2 ($2 per trip) during AM & PM peak periods
Not permitted on HOT lanes	Trucks	Trucks	Trucks	SOV, Trucks	SOV, Trucks
Pricing	Variable w/ congestion. Toll set so that users could operate at posted speed limit.	Varies from $1.00 to $4.75 by time of day and day of week. Not dynamic. 50% discount for HOV on posted toll amount.	Dynamic (real time); varies w/ congestion; adjusted every 6 minutes. Can go as high as $8.00.	$2 for HOV2 during AM and PM peak periods	$2 for HOV2 during AM and PM peak periods

* SANDAG is planning to widen facility to 4 lanes (2 in each direction).

3.2 Performance of HOT lanes

3.2.1 General findings

The traveler response to a HOT lane facility is likely to be similar to the traveler response to either a toll road and/or an HOV facility, since the HOT lane combines the lane management characteristics of these two types of facilities. Possible responses, in descending order of likeliness, include:

- Change in the route or path of a trip, i.e., diversion;
- Change in the departure time;
- Change in the travel mode;
- Change in the origin or destination of a trip; and
- Change in the propensity to make a trip.

Studies of the SR-91 corridor show that a diversion of some traffic from the general purpose lanes to the Express Lanes substantially improved peak period travel conditions in the general lanes. Additionally, the addition of the SR-91 HOT lanes also had the effect of shifting some traffic back to the state highway from parallel city streets (Perez and Sciara 2003). Several studies related to the SR-91 Express Lanes conducted by Cal Poly State University in San Luis Obispo are available on the Web (http://ceenve.calpoly.edu/sullivan/sr91/sr91.htm). For example, the report *Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Express Lanes* discusses a number of issues, including before and after observations, modeling of travel choices, and analysis of emissions. The report documents more than five years of field observations, including a year and a half of baseline conditions before the HOT lane facility opened.

The I-15 FasTrak Web site (http://argo.sandag.org/fastrak/library.html) provides access to a number of studies and reports conducted during the development of the I-15 HOT lanes, such as:

- **Worldwide Experience with Congestion Pricing**
  Reviews eleven worldwide examples of road pricing covering a wide range of sites, objectives, and implementation strategies.
- **Up-to-Date Results of the SR-91 Congestion Pricing Experiment**
  Discusses the results of the first project of its kind in the U.S., the State Route 91 (SR-91) Congestion Pricing experiment.
- **Phase I Air Quality Study**
  Estimates total emissions of volatile organic compounds, nitrogen oxides, particulate matter, and carbon monoxide for both the I-15 and I-8 corridors during 1996 and 1997.
- **Phase II Year Two Air Quality Study**
  Assesses the impact of the project on emissions in the I-15 corridor during 1998. Estimates total emissions of volatile organic compounds, nitrous oxides, particulate matter, and carbon monoxide for both the I-15 and I-8 corridors.
- **Phase II Year Three Air Quality Study**
  Assesses the impact of the project on emissions in the I-15 corridor during 1999. Estimates total emissions of volatile organic compounds, nitrous oxides, particulate matter, and carbon monoxide for both the I-15 and I-8 corridors.

Before and after studies of the Katy Freeway HOT lanes showed the following results:

- It increased the number of HOV3+ carpools during the peak period;
- It redistributed HOV2+ carpools to before and after the peak hour;
- It increased average traffic speed and improved the LOS on the HOV lanes; and
- It moved the same number of passengers, but moved them more efficiently (Perez and Sciara 2003).

3.2.2 Air Quality

The Washington area is currently designated as a "severe non-attainment" area for ground-level ozone (O_3). Since the precursors of ozone are volatile organic compounds (VOC) and oxides of nitrogen (NOx), these two pollutants will be the focus of discussions in this report. The latest air quality conformity determination was for the 2002 Constrained Long-Range Plan and the FY 2003-2008 Transportation Improvement Program (MWCOG 2002, available on the Web at http://www.mwcog.org/transportation/activities/quality/). The assessment years included 2002, 2005, 2015, 2020, and 2025.

A Guide for HOT Lane Development describes the air quality impact of HOT lanes as follows (p. 78):

> *One of the expected benefits of HOT lanes involves having more vehicles in the corridor moving at higher and more stable speeds. Generally speaking, this should result in a benefit (albeit small) in air quality, as faster moving vehicles generate less pollution. Slower, stop-and-go traffic – which would be expected with over-utilized general-purpose or HOV lanes – would produce more pollution. While air quality review may show an advantage for HOT lanes over general-purpose lanes (at least), that advantage is likely to be fairly small and may not provide a compelling argument on its own to justify the investment. However, in conjunction with other potential benefits, air quality improvements could be a factor in garnering support for HOT lane applications.*

The above statement, "this should result in a benefit (albeit small) in air quality," pertains to a case where there is no net increase in highway capacity when the HOT lane is created, e.g., converting an HOV lane to a HOT lane, or converting a general purpose lane to a HOT lane. In the Fluor proposal, however, there would be a net increase in highway capacity. Specifically, the base case in 2015 assumes a 10-lane Beltway with 8 general purpose lanes and 2 HOV3+ lanes; and the Fluor proposal assumes a 12-lane Beltway with 8 general purpose lanes and 4 HOT/HOV3+ lanes. Thus, there would be a net increase of 28 lane-miles (2 lanes times 14 miles). Therefore, any analysis of the air quality impacts of a major HOT lane facility should take into account these two phenomena:

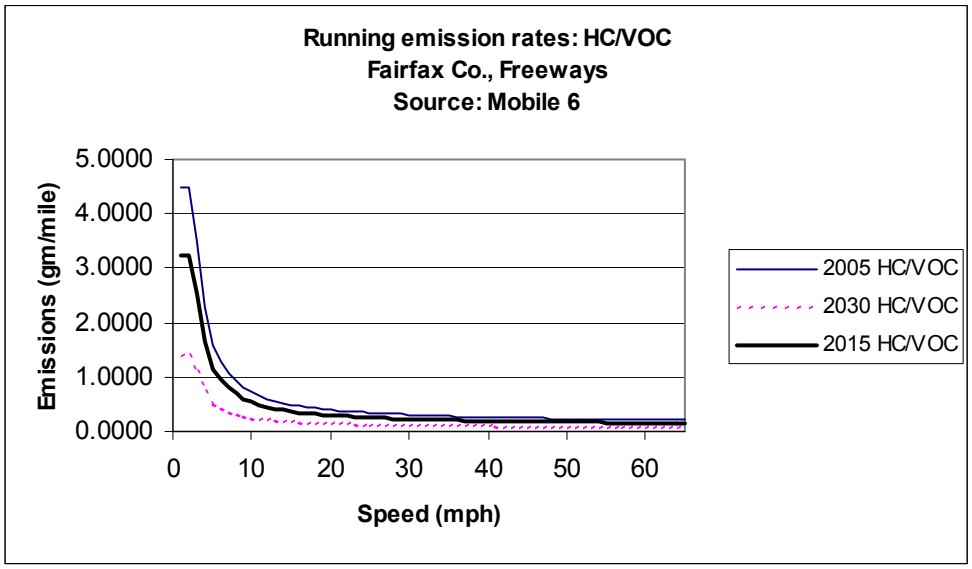
- Effect of lane management on speeds
- Effect of adding highway capacity

<u>Effect of lane management on speeds</u>: The dynamic lane management that occurs with HOT lanes should result in better operational levels of service (LOS), higher speeds, and more consistent travel times on the HOT lane facility, and, to some extent, through the corridor. The change in travel speeds has a direct impact on vehicle emissions, since running emissions, such as VOC and NOx, are a function of the vehicle speed. VOC running emissions generally drop as

speeds increase. The curve for NOx running emissions is "U" shaped. Consequently, changes in vehicles speeds could increase or decrease emissions, depending on the starting and ending point on the emissions/speed curve.
Effect of adding highway capacity: As the newly added highway capacity fills up with diverted traffic, or, potentially, induced travel, the added highway capacity should result in an increase in vehicle emissions (i.e., a degradation of air quality).

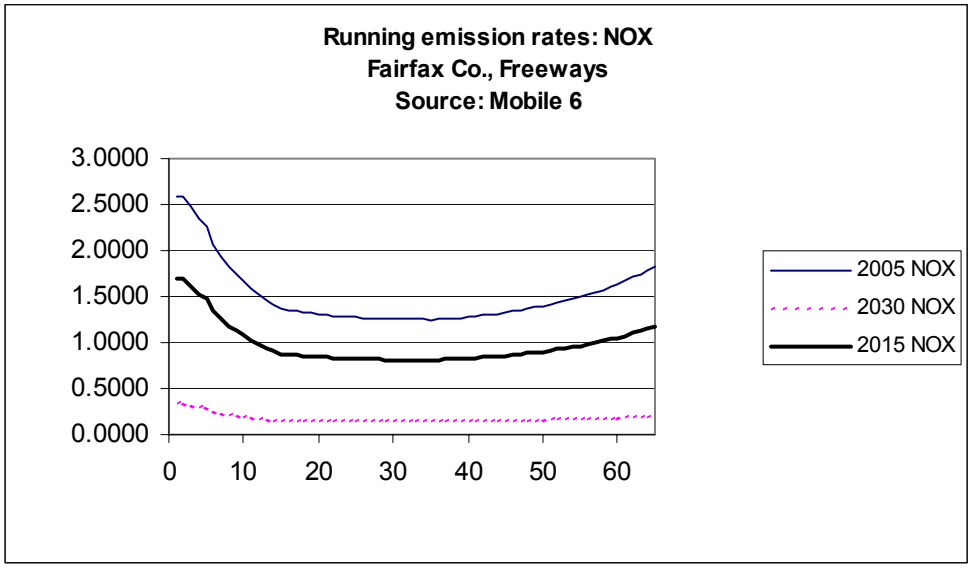
The sketch planning air quality assessment that will be used in this report will take into account these two phenomena. The EPA mobile emissions model, known as Mobile6, is used to develop a family of emissions factors that can be used to compute total mobile emissions. There is a separate set of emissions factors by pollutant (e.g., VOC or NOx), jurisdiction (e.g., D.C., Fairfax County), and facility type (e.g., freeway, arterial). Two examples of emission factors are shown in Figure 6 and Figure 7. Note that the 2015 curves are interpolated from emissions factors for 2005 and 2030.

Figure 6 Example emissions factors from Mobile6: Running VOC emissions for freeways in Fairfax Co., Va.



Note: 2015 values were interpolated from 2005 and 2030 values.
Ref: x215rnet_vol_ daily.xls

Figure 7 Example emissions factors from Mobile6: Running NOx emissions for freeways in Fairfax Co., Va.



Note: 2015 values were interpolated from 2005 and 2030 values.
Ref: x215rnet_vol_ daily.xls

According to the report *Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Express Lanes* (Sullivan, Edward 2000, p. 203):

1. *If dual HOV lanes had been constructed instead of the 91X toll lanes, and assuming no change in vehicle-miles of travel (VMT), the overall modeled emissions for March 1998 conditions would be approximately the same as with the existing 91X facility. (Section 7.4, Table 7-V.)*

2. *If general use lanes had been constructed instead of the 91X toll lanes, the modeled emissions for March 1998 would be approximately the same, assuming that induced traffic produced a 7% traffic (VMT) increase. For other assumptions on induced VMT, ranging from 0% to 10%, overall modeled emissions would vary from 6% less to 3.7% more than the values estimated for the existing 91X facility. (Section 7.5, Table 7-X through Table 7-XIII.)*

3. *If no additional capacity had been built, our best estimate is that VMT would be about 8% less and overall modeled emissions in March 1998 would be 18% less than the values for the existing 91X facility. This analysis is based on very limited data. (Section 7.6, Table 7-XV.)*

Point number 2 by Sullivan implies that whether there will be a degradation or improvement in air quality is a function of the amount of induced demand assumed: 0% induced demand results in a 6% drop in emissions, but 10% induced demand results in a 3.7% increase in emissions. The term "induced demand" means different things to different people, and often depends on one's window of analysis. If one is looking at only a corridor, there could be substantial "induced demand" due to added highway capacity. But if one's focus is the entire region, much of what seemed like new, induced demand could actually be diversion (path changes) and the actual net increase in demand at the regional level could be quite small or negligible.

4 Qualitative analysis of the Fluor HOT lane proposal for the Capital Beltway

Task 2 of the Fluor study is to conduct a *qualitative* analysis of the Fluor HOT lane proposal for the Virginia portion of the Capital Beltway. No detailed 4-step modeling of these lanes will be undertaken. Rather, it will be assumed that the facility will operate as specified by Fluor. Consequently, the performance of the adjacent conventional (general purpose) lanes will be estimated. This assessment will include likely level of service on both the HOT lanes and GP lanes, and the likely resulting direction for regional NOx and VOC emissions. The analysis year will be 2015, since this is the first analysis year beyond 2009 for which baseline emissions in the TIP and CLRP are available.

4.1 Review of technical methods to analyze HOT lanes

Technical methods to analyze HOT lanes can be divided into two groups: four-step modeling techniques and sketch planning techniques.

4.1.1 Four-step modeling

The "four-step" process for modeling travel demand is a trip-based process that includes four main steps: 1) trip generation, 2) trip distribution, 3) mode choice, and 4) traffic assignment. Some four-step models perform traffic assignment on a 24-hour, daily basis. Newer four-step models perform traffic assignment for two or more time-of-day periods, whose results can then be summed to obtain total daily (i.e., weekday) traffic. The time-of-day model usually occurs after mode choice and before traffic assignment, turning the process into a 5-step model: 1) trip generation, 2) trip distribution, 3) mode choice, 4) time-of-day choice, and 5) traffic assignment.

As stated earlier in this report, the traveler response to a HOT lane facility is likely to be similar to the traveler response to either a toll road and/or an HOV facility, since the HOT lane combines the lane management characteristics of these two types of facilities. Possible responses, in descending order of likeliness, are shown in Table 2.

Table 2 Likely traveler responses to a new HOT lane facility and the corresponding step in the 4-step model

Traveler responses to a new HOT lane facility	Relevant modeling step
Change in the route or path of a trip, i.e., diversion	Traffic assignment (step 5)
Change in the departure time	Time-of-day model (step 4)
Change in the travel mode	Mode choice (step 3)
Change in the origin or destination of a trip	Trip distribution (step 2)
Change in the propensity to make a trip	Trip generation (step 1)

The last item, change in the propensity to make a trip, is very unlikely to occur, since HOT lanes generally run in parallel with general purpose lanes and other parallel arterial roads. The second to last item, change in the origin or destination of a trip, is also rather unlikely, again, because the

HOT lane corridor generally has other alternative routes that do not have the occupancy restrictions or tolling. Consequently, the first three items in the list are the most likely traveler responses to a new HOT lane.

The National Capital Region Transportation Planning Board (COG/TPB) is currently in the process of moving to a new travel demand forecasting model. The current model, known as Version 1, is four-step model with a 24-hour traffic assignment. The newer model, known as Version 2 (Version 2.1, Release C), is also a four-step model, but includes a time-of-day model and traffic assignment using three time periods (AM peak period, PM peak period, and the off-peak period). The Version 2 model accounts for tolls in only the mode choice step and accounts for HOV travel in both the mode choice and traffic assignment steps. Consequently, the COG/TPB travel demand model is not set up to analyze HOT lanes. Although we eventually plan to modify the model to more fully incorporate tolls and HOT lanes, such a model revision was beyond the scope of this project. Consequently, we will use sketch planning techniques to analyze the likely air quality impacts of HOT lanes on the Beltway in Virginia.

4.1.2 Sketch planning techniques

4.1.2.1 A Guide for HOT Lane Development

In *A Guide For HOT Lane Development*, under a section entitled, "A Sketch Planning Methodology for Estimating HOT Lane Revenue,"the following sketch planning technique is proposed (Perez and Sciara 2003, p. 70):

> *First, peak traffic on the general-purpose lane is measured, and LOS determined. Utilizing this information, peak period congestion delays can be estimated, and the cost of those delays quantified based on hourly values of travel time. Then, based on the available capacity in the HOV lane (after "free" HOV vehicles are accounted for), SOV users are "shifted" to the HOT lane, just up to the point where free flow conditions can be maintained in the HOT lane. The HOT lane toll is modeled based on the degree of congestion in the general-purpose lane, and the cost of that congestion to SOV users. HOT lane revenues are then estimated after accounting for market penetration of electronic toll collection accounts.*

4.1.2.2 San Diego Association of Governments (SANDAG)

The San Diego Association of Governments (SANDAG) has used a similar approach. HOT lanes are not currently modeled in the four-step model. Instead, there is a post-traffic-assignment procedure, which is carried out in their geographic information system (GIS). The procedure is to:

1. Shift traffic from over-capacity main freeway lanes to adjacent "HOV/managed lanes" (HOT lanes) that have excess capacity; and
2. Shift traffic from over-capacity HOV/managed lanes to adjacent freeway main lanes.

In other words, on the general purpose freeway lanes, take the difference between the assigned volume and the capacity. In cases where the assigned volume is above the capacity, this volume

surplus is shifted to the managed lanes, such that the managed lanes never drop below LOS C, which they define as 1,600 vehicles per hour per lane (v/h/ln).[1]

4.1.2.3 Spreadsheet Model for Induced Travel Estimation (SMITE)

SMITE is a sketch-planning tool that applies the principles of economic analysis to evaluate highway capacity expansion in an urban setting, taking into account new travel that may be induced by highway expansion over and above that which is simply diverted from other regional highways. The model is useful in cases where four-step travel models are either unavailable or are unable to forecast the full induced demand effects. The model is applied via an electronic spreadsheet (originally Lotus 123, then also in Microsoft Excel). For a case study of toll options on the Capital Beltway, a new version of SMITE was developed, called SMITE-Managed Lanes or SMITE-ML (DeCorla-Souza 2002). SMITE estimates induced traffic that might result from faster highway travel speeds, including new trips generated or attracted, existing trips diverted from other destinations, and existing trips diverted from other modes. SMITE uses demand elasticity with respect to travel time to estimate induced travel. SMITE-ML incorporates a pivot-point mode choice model. According to the study paper, "Impedance coefficients used in the model were those calibrated for the Washington, DC metropolitan area" Source: Sierra Research, Inc. and J. Richard Kuzmyak. COMMUTER Model User Manual for Analysis of Voluntary Mobile Source Emission Reduction and Commuter Choice Incentive Programs. U.S. EPA. Draft Final report. September 1999.

In the study entitled, "Evaluation of Toll Options Using Quick-Response Analysis Tools: A Case Study of the Capital Beltway," the author investigated six network alternatives to the base-case "no-build" alternative of an 8-lane Capital Beltway in Virginia. The first three alternatives involved adding HOV lanes, but no tolls, to the Beltway in Virginia. The last three alternatives involved making the HOV lanes into HOT lanes. The forecast year was 2020. Alternative 6 was the most similar to the Fluor proposal. Under Alternative 6, one would add two barrier-separated priced express lanes in each direction. Carpools and buses would travel on the express lanes for free.[2] We will summarize some of the study findings relating to Alternative 6. For the study, which was based on Virginia's Capital Beltway Study,[3] the Virginia portion of the Beltway was divided into three segments:

Table 3 Segments used in the VDOT draft EIS for the Virginia portion of the Beltway

Segment of Virginia portion of Beltway	Approximate length (miles)	Estimated traffic, 2020 (vehicles per day)
Southern	3	280,000
Middle	6	310,000
Northern	5	250,000

[1] Telephone conversation with Bill McFarlane, Senior Transportation Planner, San Diego Association of Governments, on January 31, 2003.
[2] In the Fluor proposal, HOV3+ and buses would travel for free; SOV and HOV2 would pay a toll. In the DeCorla-Souza study, it was not clear whether HOV2 would pay the toll, or only SOV.
[3] Virginia Department of Transportation and Federal Highway Administration. *Capital Beltway Study*. Draft Environmental Impact Statement. Volume 1. March 2002.

Note that these findings apply to only the "southern segment" of the Virginia portion of the Beltway. It was estimated that Alternative 6 (two HOT lanes each direction) would result in an additional 21,151 transit person trips in 2020 (30,051 daily trips vs. 8,900 daily trips in the no-build base case). Other results can be seen in Table 4.

Table 4 SMITE-ML model: Est. travel, 2020, for the southern segment of the Virginia portion of the Beltway

	No build	Alt 6	Diff
Total daily person trips	445,000	445,000	0
Total initial daily vehicle trips	333,689	309,371	-24,318
Peak period person trips (prior to induced travel effect)			
- Solo	178,000	149,104	-28,896
- Carpool	35,600	43,345	7,745
- Transit	8,900	30,051	21,151
- Total	222,500	222,500	0
Peak period mode shares: (prior to induced travel effect)			
- Solo	80.00%	67.01%	-12.99%
- Carpool	16.00%	19.48%	3.48%
- Transit	4.00%	13.51%	9.51%
- Total	100.00%	100.00%	0.00%
Induced vehicle trips	0	36,251	36,251
Total daily vehicle trips	333,689	345,622	11,933
Freeway daily vehicle trips	280,299	309,107	28,808
Arterial daily vehicle trips	53,390	36,515	-16,875
Total	333,689	345,622	11,933

Source: DeCorla-Souza, P. (2002) "Evaluation of Toll Options Using Quick-Response Analysis Tools: A Case Study of the Capital Beltway." Prepared for presentation at the TRB Annual Meeting in January 2003.
Ref: deCorla-Souza smiteml.xls

4.1.3 Recommended technique for demand analysis

Given the limited time available to conduct Task 2, we recommend the travel demand analysis be done using a sketch planning method similar to that used by SANDAG or discussed in *A Guide For HOT Lane Development*. This method involves analysis of the facility during peak-period congestion and relies on shifting excess traffic volume from the general purpose lanes to the HOT lanes, such that free flow conditions can be maintained in the HOT lanes.

4.1.3.1 Managed and maximum capacities

The HOT lane facility proposed by Fluor would operate at 65 mph. Tolls would be varied to keep the flow rate of traffic such that this 65 mph speed is maintained. The Beltway is

composed of a series of "basic freeway segments," as defined in the Highway Capacity Manual. The level of service (LOS) for a basic freeway segment is a function of density and is shown in Table 5.

Table 5 LOS thresholds for a basic freeway segment

LOS	Density range (pc/mi/ln)
A	0 – 11
B	> 11 – 18
C	> 18 – 26
D	> 26 – 35
E	> 35 – 45
F	> 45

Source: 2000 Highway Capacity Manual, p. 23-3.

As the service flow rate (measured in passenger cars per hour per lane or pc/h/ln) on a basic freeway segment increases, the speed will decrease. At the lower LOSs, such as A or B, the speed drops very slightly. At LOS E, where the maximum flow rate occurs, the speed will have dropped 5 to 22 mph, depending on the free-flow speed of the facility. Exhibit 23-2 in the Highway Capacity Manual illustrates LOS criteria for basic freeway segments (reproduced here as Table 6). According to this table, for a facility with a free-flow speed (FFS) of 65 mph, you can achieve a maximum service flow rate of between 1170 pc/h/ln (speed = 65.0 mph) and 1680 pc/h/ln (speed = 64.6 mph).

According to *A Guide for HOT Lane Development* (p. 79):

> *. . . managed capacity levels may vary from one HOT facility to another depending on the number of access points, vehicle mix, roadway slope and configuration, separation treatments, and number of travel lanes. A single HOT lane will have a lower managed capacity than multiple HOT lanes. For example, flows on the Houston I-10 Katy Freeway QuickRide – a one lane, reversible-flow facility are kept to 1500 vehicles/hour. However, the SR 91 Express Lanes – which provide two travel lanes in each direction – have been able to operate at acceptable conditions with flow rates of 1800 vehicles/hour/lane.*
>
> *A safe range for establishing managed capacity for most project settings would be approximately 1700 hourly automobile equivalents per lane, with the understanding that road configuration, slopes and speed limits can drive this number up or down. This threshold is reflected in a number of HOV references and locally adopted policies, and is also appropriate for HOT lanes.*

Although the Guide for HOT Lane Development recommends using a maximum service flow rate of 1,700 vehicles per hour per lane, we recommend using a slightly lower figure, 1,600 v/h/ln, given the fact that the proposed facility will have five intermediate access points, which could reduce its capacity somewhat due to weaving.

Table 6 LOS criteria for basic freeway segments

EXHIBIT 23-2. LOS CRITERIA FOR BASIC FREEWAY SEGMENTS

Criteria	LOS A	LOS B	LOS C	LOS D	LOS E
FFS = 75 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	75.0	74.8	70.6	62.2	53.3
Maximum v/c	0.34	0.56	0.76	0.90	1.00
Maximum service flow rate (pc/h/ln)	820	1350	1830	2170	2400
FFS = 70 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	70.0	70.0	68.2	61.5	53.3
Maximum v/c	0.32	0.53	0.74	0.90	1.00
Maximum service flow rate (pc/h/ln)	770	1260	1770	2150	2400
FFS = 65 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	65.0	65.0	64.6	59.7	52.2
Maximum v/c	0.30	0.50	0.71	0.89	1.00
Maximum service flow rate (pc/h/ln)	710	1170	1680	2090	2350
FFS = 60 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	60.0	60.0	60.0	57.6	51.1
Maximum v/c	0.29	0.47	0.68	0.88	1.00
Maximum service flow rate (pc/h/ln)	660	1080	1560	2020	2300
FFS = 55 mi/h					
Maximum density (pc/mi/ln)	11	18	26	35	45
Minimum speed (mi/h)	55.0	55.0	55.0	54.7	50.0
Maximum v/c	0.27	0.44	0.64	0.85	1.00
Maximum service flow rate (pc/h/ln)	600	990	1430	1910	2250

Note:
The exact mathematical relationship between density and v/c has not always been maintained at LOS boundaries because of the use of rounded values. Density is the primary determinant of LOS. The speed criterion is the speed at maximum density for a given LOS.

Source: 2000 Highway Capacity Manual, Exhibit 23-2, p. 23-4.

4.2 Travel demand and emissions estimate

4.2.1 Methodology overview

In this section of the report, we prepared a qualitative estimate of the mobile emissions impact of the Fluor Daniels HOT lane proposal for the Capital Beltway in Northern Virginia. The analysis, which makes use of sketch planning techniques, is for a typical peak hour. As stated earlier in the report, the emissions part of the analysis takes into account two, possibly competing, effects:

- Effect of lane management on speeds (Could increase or decrease emissions)
- Effect of adding highway capacity (Would likely increase emissions).

The general approach for the analysis was as follows:

Demand forecast

- Obtain estimated daily traffic volumes for the baseline configuration of the proposed facility. Estimated daily traffic volumes came from the COG/TPB 4-step model from model runs that were conducted for the latest air quality conformity analysis of record, i.e., the air quality conformity determination of the 2002 Constrained Long-Range Plan and the FY 2003-2008 Transportation Improvement Program. Note that no new 4-step model runs were performed for this analysis, but the results of existing runs were used as input to the sketch planning methods of this analysis. The proposed HOT lane facility is to open in 2009, but existing model run data was available only for analysis years of the regional air quality conformity determination: 2002, 2005, 2015, 2020, and 2025. We chose to use the 2015 model run output as the input to our analysis, since this is the first available analysis year following the proposed 2009 opening date.
- Convert daily traffic volumes to peak-hour traffic volumes.
- Assume that the HOT lanes could operate at a maximum service flow rate of 1,600 passenger cars per hour per lane – the point at which speeds would begin to drop below 65 mph. This service flow rate (1,600 pc/h/ln) corresponds to a level of service of C. Since the proposed facility would have 2 lanes in each direction, this implies a maximum service flow rate of 3,200 pc/h by direction.
- Estimated vehicle trips from the GP lanes were diverted to the HOT lanes until the HOT lanes were at their LOS C capacity of 1,600 pc/h/ln.
- Three forecasts of traffic under the HOT lane scenario were developed: a low, medium, and high forecast. In all three forecasts, we assume that traffic would be diverted from the GP lanes to the HOT lanes, and that the HOT lanes would fill up to their maximum service flow rate of 1,600 v/hr/ln. Since there are two HOT lanes in each direction, the capacity and flow rate of the HOT lanes becomes 3,200 v/hr in each direction. The amount of traffic *diverted* from the GP lanes to the HOT lanes is assumed to be the same in all three cases and is equal to

  (traffic diverted from GP lanes to HOT lanes) = 3,200 – (baseline HOV volume)

  Thus, the difference between the three forecasts is not the level of traffic on the HOT lanes, which is always 3,200 v/hr, but rather the level of traffic on the adjacent GP lanes:
  - Low forecast: Assumes that, after traffic diverts from the congested GP lanes onto the free-flowing HOT lanes, the GP lanes do not fill up with any new traffic. The increase in traffic on the HOT lanes is equal to the decrease in traffic from the GP lanes. Consequently, there is no net increase in traffic on the Beltway.
  - Medium forecast: Assumes that, after traffic diverts from the congested GP lanes onto the free-flowing HOT lanes, the amount of traffic in the GP lanes increases by an amount equal to the capacity of the added lane of traffic in each direction (i.e., increases by 1,600 pc/h in each direction). This increase in traffic on the GP lanes would be due to both the "diverted traffic" from nearby arterials and from "induced traffic." Induced traffic is defined as *new* trips that would not have occurred if capacity had not been added to the Beltway. Consequently, there is a net increase in traffic on the Beltway, compared to the base case.

  - High forecast: Assumes that, after traffic diverts from the congested GP lanes onto the free-flowing HOT lanes, the amount of traffic in the GP lanes increases, and returns to the same level of congestion as was found in the baseline case. This increase in traffic is equal to 3,200 minus the baseline HOV traffic, in each direction. Once again, this increase in traffic on the GP lanes would be due to both "diverted traffic" from nearby arterials and "induced traffic." Consequently, there is a net increase in traffic on the Beltway, compared to the base case.
- Based on the estimated peak-hour traffic on each link, the following quantities were calculated, using lookup tables, for each link in the three freeway segments: volume-to-capacity ratio, speed, and LOS.

Emissions forecast

- Using the six GP links and six HOT links in the three freeway segments, average values were estimated for: volume-to-capacity ratio, speed, and LOS.
- Using the average values calculated in the previous step, we calculated total running emissions, for a peak hour, for two pollutants: VOC and NOx.

Effect of diverted and induced travel on emissions

There are four different traffic forecasts (baseline, action low, action medium, and action high) and four corresponding emissions forecasts. The low travel forecast assumes no new travel on the Beltway. By contrast, both the medium and high travel forecasts assume that there will be a net increase in traffic on the Beltway. The assumed increase in Beltway traffic under the medium and high travel forecasts would be made up of either "diverted traffic," or "induced traffic," or a combination of the two. Diverted traffic is traffic that was on other roads in the baseline case and moved over to the Beltway in the "action" case, due to the added capacity on the Beltway. Induced traffic is *new* traffic that did not exist in the base case, and was "created" due to the new highway capacity. If one were to assume that 100% of the new travel on the Beltway was "diverted travel," then, in the emissions analysis, one should both *add* the emissions due to the new travel on the Beltway and *subtract* (or "net out") the emissions due to the traffic that had been on other roads, but is now on the Beltway. If one were to assume that 100% of the new travel on the Beltway was "induced travel," then, in the emissions analysis, one should simply add the emissions due to the new travel on the Beltway. The reality is probably somewhere in between these two extremes. For our analysis, we have chosen to take the most conservative approach, i.e., the one that likely overestimates the running emissions. This approach corresponds to assuming that all of the new traffic on the Beltway is induced travel, meaning that one simply adds the new emissions without subtracting any emissions. So our analysis is likely to overstate the emissions impact of the proposed HOT lane facility.

4.2.2 Methodology details

The proposed project consists of a 14-mile segment of the Capital Beltway in Northern Virginia, starting from Georgetown Pike to the north, and ending at I-395 to the south of the corridor. This stretch of the Beltway includes 9 highway segments, delineated by 8 interchanges:

- Georgetown Pike
- Dulles Toll Road

- VA Route 123
- VA Route 7
- I-66
- US-50
- Gallows Road
- VA Route 236
- Braddock Road
- I-395

For our analysis, we have selected three representative segments that will represent the operations of the nine segments of the proposed HOT lane facility:

- Georgetown Pike to the Dulles Access/Toll Road
- VA Route 7 to I-66 (one of the heaviest volume segments)
- Braddock Road to I-395

The first representative segment is at the northern end of the facility. The second segment is in the middle of the facility and one of the highest volume segments on this section of the Beltway. The third segment is at the southern end of the facility.

We obtained a loaded-link 2015 highway network from the latest air quality conformity determination of record: the air quality conformity determination of the 2002 Constrained Long-Range Plan and the FY 2003-2008 Transportation Improvement Program.[4] Model runs were conducted for the current year (2002), the attainment year (2005), and the future years of 2015, 2020, and 2025. The year 2015 was selected because this was the first analysis year beyond the proposed 2009 opening date for the HOT lane facility.

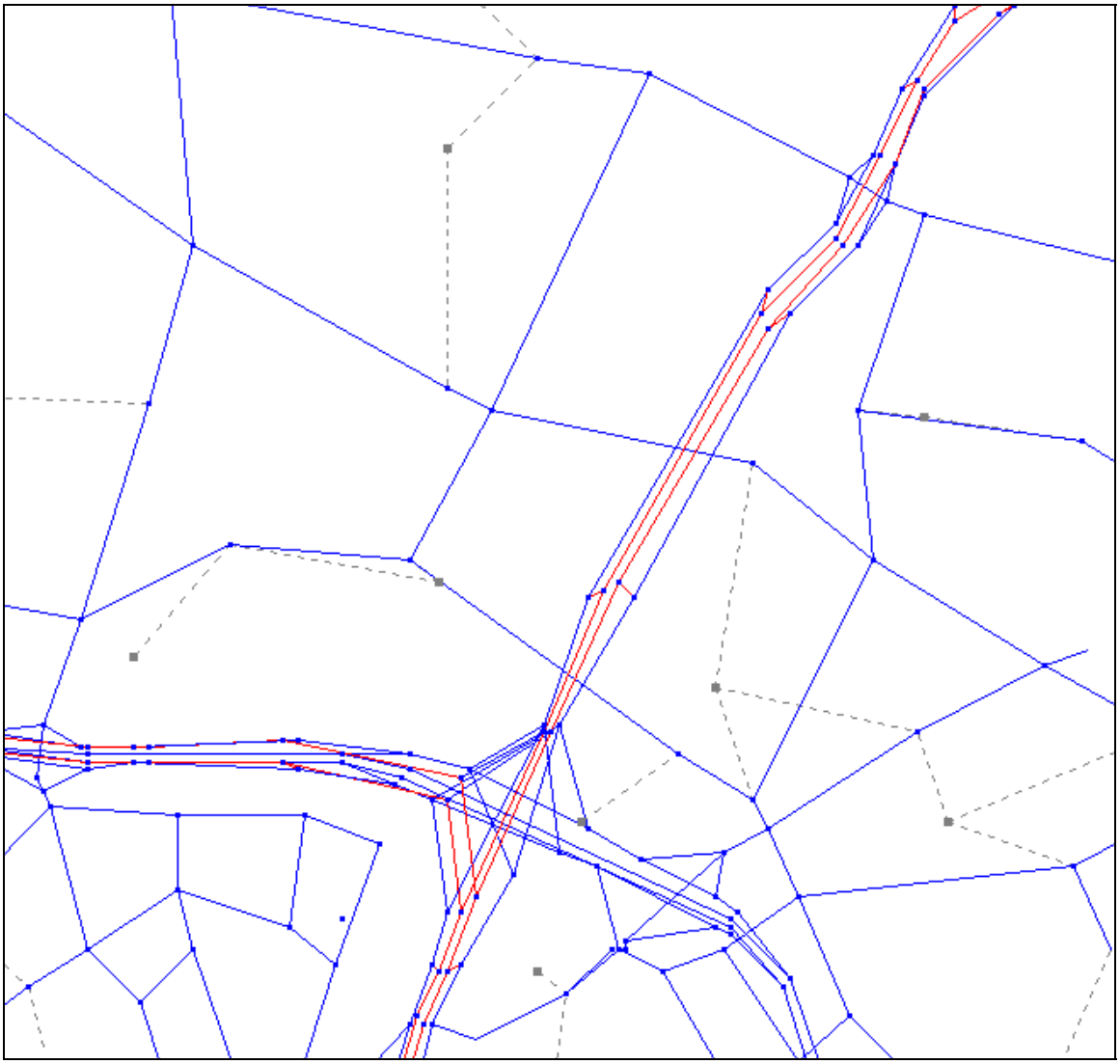
In the highway network, each segment of the Beltway is represented by four links, representing four distinct traffic flows:

- Outer loop, general purpose traffic (4 lanes)
- Outer loop, HOV3+ (1 lane in baseline, 2 lanes in proposal)
- Inner loop, HOV3+ (1 lane in baseline, 2 lanes in proposal)
- Inner loop, general purpose traffic (4 lanes)

On freeways without HOV traffic, each segment of freeway is represented by only two links, one for each direction. Arterial road segments are represented by one two-way link (actually two one-way links which lie on top of one another), which appear as a single line, instead of the parallel lines for freeways (See Figure 8).

[4] File name of loaded-link 2015 highway network: X215rnet.dat. Note that this network came from the air quality conformity determination of the 2001 Constrained Long-Range Plan and the FY 2002-2007 Transportation Improvement Program, since the model runs for the FY 2003-2008 conformity and the FY 2002-2007 conformity were identical.

Figure 8 2015 highway network: I-495 from Georgetown Pike to the Dulles Toll/Access Road



Source: MWCOG highway network for 2015 (X215rnet.dat) from air quality conformity determination of the 2002 Constrained Long-Range Plan and the FY 2003-2008 Transportation Improvement Program.

Next, the estimated 2015 daily traffic volumes for the four links in each of the three freeway segments were extracted from the loaded-link highway network (See Table 7). The average estimated daily volume for the three segments was about 128,000 for the general purpose lanes and 3,500 for the HOV lanes. The complete set of spreadsheets used in this analysis can be seen in Appendix A.

Table 7 Base case: Estimated 2015 *daily* traffic volumes for 3 representative segments of the Beltway

From	To	Loop	Link Type	HOV Req	Highway Network Nodes A Node	B Node	Lanes	Est daily volumes (4-step model) Vol	Vol / ln
G-town Pk	Dulles Toll Rd	Outer	GP		12797	12793	4	121,540	30,385
		Outer	HOV	3	12798	12794	1	4,282	4,282
							Total by direction	**125,822**	
		Inner	GP		12796	12800	4	128,277	32,069
		Inner	HOV	3	12795	12799	1	3,974	3,974
							Total by direction	**132,251**	
VA Route 7	I-66	Outer	GP		12717	12721	4	134,790	33,698
		Outer	HOV	3	12718	12722	1	3,020	3,020
							Total by direction	**137,810**	
		Inner	GP		12724	12720	4	132,967	33,242
		Inner	HOV	3	12723	12719	1	3,469	3,469
							Total by direction	**136,436**	
Braddock Rd	I-395	Outer	GP		12777	12781	4	130,140	32,535
		Outer	HOV	3	12778	12782	1	3,534	3,534
							Total by direction	**133,674**	
		Inner	GP		12784	12780	4	123,040	30,760
		Inner	HOV	3	12783	12779	1	2,680	2,680
							Total by direction	**125,720**	
Average, GP								128,459	32,115
Average, HOV/HOT								3,493	3,493
Average combined volume							**Total by direction**	**131,952**	

Daily volumes were converted to peak-hour volumes using two peak-hour factors, one for GP lanes and one for HOV lanes. The peak-hour factor for the GP lanes, 7.9%, is equal to 15.7% (the share of daily Beltway traffic occurring from 4 to 6 PM, based on observed ground counts) divided by 2 (the number of hours in the period). The peak-hour factor for the HOV lanes, 16%, was derived as follows:

$$pk\_hr\_fac\_hov = a * b * c$$

where

a = share of daily HOV traffic occurring in the period 6-9 AM and 4-7 PM (assumed to by 80%)

b = share of peak period HOV traffic in the period 4-7 PM (assumed to be 50%)

c = share of PM peak period HOV traffic in the peak hour (assumed to be 40%)

The estimated peak hour volumes are shown in Table 8. Volume to capacity ratios (v/c) were calculated using the LOS E capacities in Table 9. Since both the GP and HOV lanes in the baseline would operate at 55 mph, the 2,250 v/hr/ln figure was used. For the 2015 HOT lane forecasts, the 2,350 v/hr/ln figure was used for the HOT lanes only, since they are to operate at 65 mph.

Table 8 Base case: Estimated 2015 *peak-hour* volumes on 3 representative segments of the Beltway

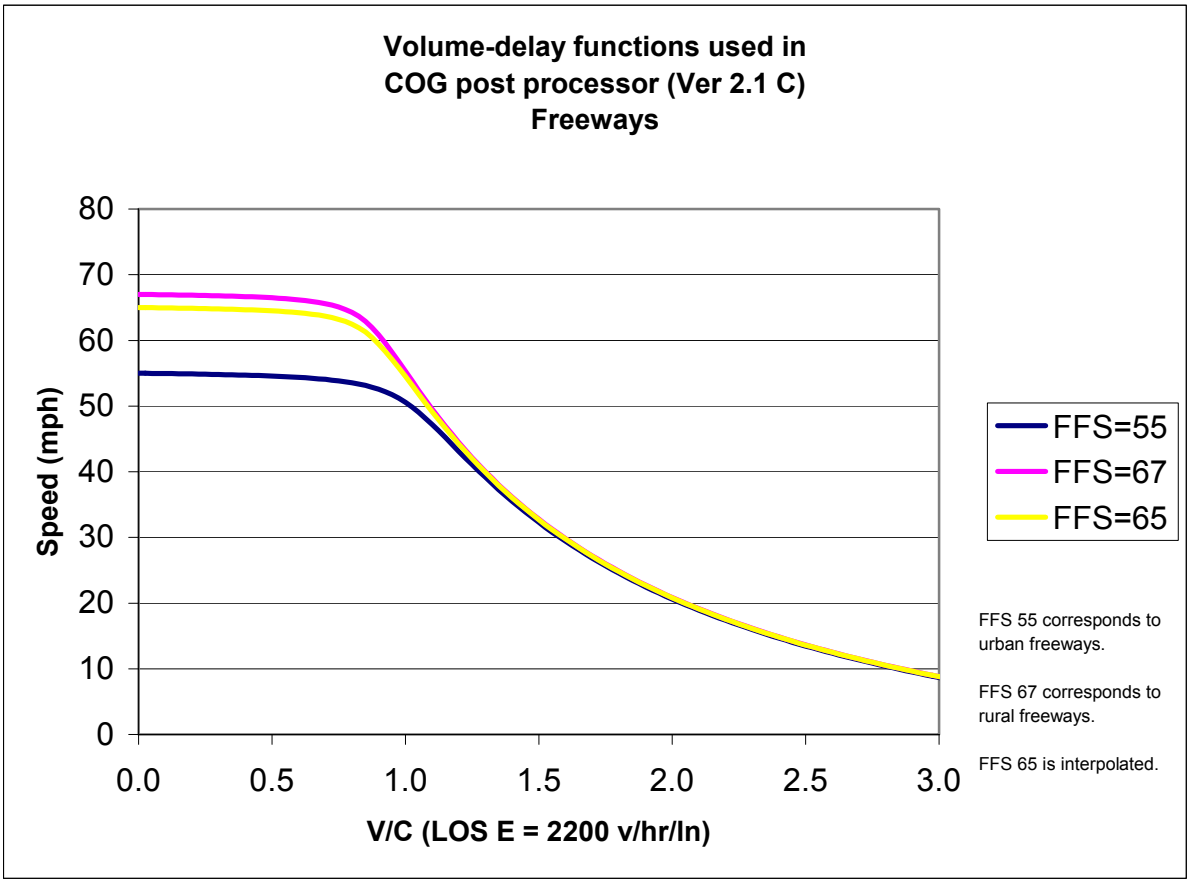
From	To	Loop	Link Type	HOV Req	Highway Network Nodes A Node	B Node	Lanes	Est daily volumes (4-step model) Vol	Vol / In	Est peak-hour volumes (pk-hr factor) Vol	Vol / In	V/C	Free flow Speed (mph)	Restrain. Speed (mph)	LOS
G-town Pk	Dulles Toll Rd	Outer	GP		12797	12793	4	121,540	30,385	9,541	2,385	1.06	55	49	F
		Outer	HOV	3	12798	12794	1	4,282	4,282	685	685	0.30	55	55	B
							Total by direction	**125,822**		**10,226**					
		Inner	GP		12796	12800	4	128,277	32,069	10,070	2,517	1.12	55	47	F
		Inner	HOV	3	12795	12799	1	3,974	3,974	636	636	0.28	55	55	B
							Total by direction	**132,251**		**10,706**					
VA Route 7	I-66	Outer	GP		12717	12721	4	134,790	33,698	10,581	2,645	1.18	55	44	F
		Outer	HOV	3	12718	12722	1	3,020	3,020	483	483	0.21	55	55	A
							Total by direction	**137,810**		**11,064**					
		Inner	GP		12724	12720	4	132,967	33,242	10,438	2,609	1.16	55	45	F
		Inner	HOV	3	12723	12719	1	3,469	3,469	555	555	0.25	55	55	A
							Total by direction	**136,436**		**10,993**					
Braddock Rd	I-395	Outer	GP		12777	12781	4	130,140	32,535	10,216	2,554	1.14	55	46	F
		Outer	HOV	3	12778	12782	1	3,534	3,534	565	565	0.25	55	55	A
							Total by direction	**133,674**		**10,781**					
		Inner	GP		12784	12780	4	123,040	30,760	9,659	2,415	1.07	55	49	F
		Inner	HOV	3	12783	12779	1	2,680	2,680	429	429	0.19	55	55	A
							Total by direction	**125,720**		**10,087**					
Average, GP								128,459	32,115	10,084	2,521	1.12	55	47	F
Average, HOV/HOT								3,493	3,493	559	559	0.25	55	55	A
Average combined volume							**Total by direction**	**131,952**		**10,643**					

Table 9 LOS E capacities as a function of free-flow speed

FFS (mph)	Capacity
55	2,250
65	2,350

Peak-hour speeds were estimated using a lookup table, shown in graphical form Figure 9, that comes from the COG post processor model, which is the model COG uses to convert output from the 4-step travel model to input suitable for EPA's mobile emissions model, Mobile 6.

Figure 9 Volume delay function used in COG post processor model (for Ver. 2.1 travel model)



Note that the curve for FFS = 65 mph was interpolated from the curves for 55 and 67 mph.
Source: Memo from Ronald Milone, MWCOG, to Files. Subject: Description of the Version 2.1/TP+/MOBILE6 Emissions Post–Processor. March 12, 2003, Table 6, Speed Delay Functions Used in the MWCOG Mobile Emissions Post Processor.

Level of service estimates shown in Table 8 and subsequent tables comes from a lookup table from the 2000 Highway Capacity Manual, shown in Table 10.

Table 10 LOS as a function of V/C ratio and flow rate

FFS = 55					FFS = 65				
min flow	max flow	min v/c	max v/c	LOS	min flow	max flow	min v/c	max v/c	LOS
0	600	0.00	0.27	A	0	710	0.00	0.30	A
600	990	0.27	0.44	B	710	1170	0.30	0.50	B
990	1430	0.44	0.64	C	1170	1680	0.50	0.71	C
1430	1910	0.64	0.85	D	1680	2090	0.71	0.89	D
1910	2250	0.85	1.00	E	2090	2350	0.89	1.00	E
2250	2600	1.00	1.16	F	2350	2600	1.00	1.11	F

Source: 2000 Highway Capacity Manual, Exhibit 23-2, p. 23-4. Note that since the data stops at LOS E in the HCM, the LOS F information in this table was added.

Three forecasts of traffic under the HOT lane scenario were developed: a low, medium, and high forecast. In all three forecasts, we assume that traffic would be diverted from the GP lanes to the HOT lanes, and that the HOT lanes would fill up to their maximum service flow rate of 1,600 v/hr/ln. Since there are two HOT lanes in each direction, the capacity and flow rate of the HOT lanes becomes 3,200 v/hr in each direction. The amount of traffic *diverted* from the GP lanes to the HOT lanes is the same in all three cases and is equal to

(traffic diverted from GP lanes to HOT lanes) = 3,200 – (baseline HOV volume)

Thus, the difference between the three forecasts is not the level of traffic on the HOT lanes, which is always 3,200 v/hr, but rather the level of traffic on the adjacent GP lanes:

- Low forecast: Assumes that, after traffic diverts from the congested GP lanes onto the free-flowing HOT lanes, the GP lanes do not fill up with any new traffic. The increase in traffic on the HOT lanes is equal to the decrease in traffic from the GP lanes. Consequently, there is no net increase in traffic on the Beltway.
- Medium forecast: Assumes that, after traffic diverts from the congested GP lanes onto the free-flowing HOT lanes, the amount of traffic in the GP lanes increases by an amount equal to the capacity of the added lane of traffic in each direction (i.e., increases by 1,600 pc/h in each direction). This increase in traffic on the GP lanes would be due to traffic diverted from nearby arterials and/or induced traffic. Consequently, there is a net increase in traffic on the Beltway, compared to the base case.
- High forecast: Assumes that, after traffic diverts from the congested GP lanes onto the free-flowing HOT lanes, the amount of traffic in the GP lanes increases, and returns to the same level of congestion as was found in the baseline case. This increase in traffic is equal to 3,200 minus the baseline HOV traffic, in each direction. Once again, this increase in traffic on the GP lanes would be due to traffic diverted from nearby arterials and/or induced traffic. Consequently, there is a net increase in traffic on the Beltway, compared to the base case.

The medium and the high travel demand forecasts are probably the most realistic. The three forecasts are presented in Table 11, Table 12, and Table 13.

Table 11 Action, low forecast: Est. 2015 *peak-hour* volumes on 3 representative segments of the Beltway

Assumes traffic is diverted from GP lanes to HOT lanes, but no new traffic is added to GP lanes.

From	To	Loop	Link Type	HOV Req	FFS (mph)	Base Lanes	Prop Lanes	Baseline Vol	Baseline Vol / In	HOT lane Low est Vol	HOT lane Low est Vol / In	Diff. in volume comp to baseline	V/C	Restrain. Speed (mph)	LOS
G-town Pk	Dulles Toll Rd	Outer	GP		55	4	4	9,541	2,385	7,026	1,757	-2,515	0.78	54	D
		Outer	HOT	3	65	1	2	685	685	3,200	1,600	2,515	0.68	64	C
							Total by direction	**10,226**		**10,226**		**0**			
		Inner	GP		55	4	4	10,070	2,517	7,506	1,876	-2,564	0.83	53	D
		Inner	HOT	3	65	1	2	636	636	3,200	1,600	2,564	0.68	64	C
							Total by direction	**10,706**		**10,706**		**0**			
VA Route 7	I-66	Outer	GP		55	4	4	10,581	2,645	7,864	1,966	-2,717	0.87	53	E
		Outer	HOT	3	65	1	2	483	483	3,200	1,600	2,717	0.68	64	C
							Total by direction	**11,064**		**11,064**		**0**			
		Inner	GP		55	4	4	10,438	2,609	7,793	1,948	-2,645	0.87	53	E
		Inner	HOT	3	65	1	2	555	555	3,200	1,600	2,645	0.68	64	C
							Total by direction	**10,993**		**10,993**		**0**			
Braddock Rd	I-395	Outer	GP		55	4	4	10,216	2,554	7,581	1,895	-2,635	0.84	53	D
		Outer	HOT	3	65	1	2	565	565	3,200	1,600	2,635	0.68	64	C
							Total by direction	**10,781**		**10,781**		**0**			
		Inner	GP		55	4	4	9,659	2,415	6,887	1,722	-2,771	0.77	54	D
		Inner	HOT	3	65	1	2	429	429	3,200	1,600	2,771	0.68	64	C
							Total by direction	**10,087**		**10,087**		**0**			
Average, GP					55			10,084	2,521	7,443	1,861	-2,641	0.83	53	D
Average, HOV/HOT					65			559	559	3,200	1,600	2,641	0.68	64	C
Average combined volume							**Total by direction**	**10,643**		**10,643**		**0**			

Table 12 Action, medium forecast: Est. 2015 *peak-hour* volumes on 3 representative segments of the Beltway

Assumes traffic is diverted from GP lanes to HOT lanes, and traffic on GP lanes increases by 1,600 v/hr in each direction.

From	To	Loop	Link Type	HOV Req	FFS (mph)	Base Lanes	Prop Lanes	Baseline Vol	Baseline Vol / In	HOT lane Medium est Vol	HOT lane Medium est Vol / In	Diff. in volume comp to baseline	V/C	Restrain. Speed (mph)	LOS
G-town Pk	Dulles Toll Rd	Outer	GP		55	4	4	9,541	2,385	8,626	2,157	-915	0.96	52	E
		Outer	HOT	3	65	1	2	685	685	3,200	1,600	2,515	0.68	64	C
							Total by direction	**10,226**		**11,826**		**1,600**			
		Inner	GP		55	4	4	10,070	2,517	9,106	2,276	-964	1.01	51	F
		Inner	HOT	3	65	1	2	636	636	3,200	1,600	2,564	0.68	64	C
							Total by direction	**10,706**		**12,306**		**1,600**			
VA Route 7	I-66	Outer	GP		55	4	4	10,581	2,645	9,464	2,366	-1,117	1.05	49	F
		Outer	HOT	3	65	1	2	483	483	3,200	1,600	2,717	0.68	64	C
							Total by direction	**11,064**		**12,664**		**1,600**			
		Inner	GP		55	4	4	10,438	2,609	9,393	2,348	-1,045	1.04	50	F
		Inner	HOT	3	65	1	2	555	555	3,200	1,600	2,645	0.68	64	C
							Total by direction	**10,993**		**12,593**		**1,600**			
Braddock Rd	I-395	Outer	GP		55	4	4	10,216	2,554	9,181	2,295	-1,035	1.02	51	F
		Outer	HOT	3	65	1	2	565	565	3,200	1,600	2,635	0.68	64	C
							Total by direction	**10,781**		**12,381**		**1,600**			
		Inner	GP		55	4	4	9,659	2,415	8,487	2,122	-1,171	0.94	52	E
		Inner	HOT	3	65	1	2	429	429	3,200	1,600	2,771	0.68	64	C
							Total by direction	**10,087**		**11,687**		**1,600**			
Average, GP					55			10,084	2,521	9,043	2,261	-1,041	1.00	51	F
Average, HOV/HOT					65			559	559	3,200	1,600	2,641	0.68	64	C
Average combined volume							**Total by direction**	**10,643**		**12,243**		**1,600**			

Table 13 Action, high forecast: Est. 2015 *peak-hour* volumes on 3 representative segments of the Beltway

Assumes traffic is diverted from GP lanes to HOT lanes, and traffic on GP lanes increases by 3,200 v/hr in each direction minus the baseline HOV traffic.

								Baseline		HOT lane High est		Diff. in volume comp to			
From	To	Loop	Link Type	HOV Req	FFS (mph)	Base Lanes	Prop Lanes	Vol	Vol / ln	Vol	Vol / ln	baseline	V/C	Restrain. Speed (mph)	LOS
G-town Pk	Dulles Toll Rd	Outer	GP		55	4	4	9,541	2,385	9,541	2,385	0	1.06	49	F
		Outer	HOT	3	65	1	2	685	685	3,200	1,600	2,515	0.68	64	C
							Total by direction	**10,226**		**12,741**		**2,515**			
		Inner	GP		55	4	4	10,070	2,517	10,070	2,517	0	1.12	47	F
		Inner	HOT	3	65	1	2	636	636	3,200	1,600	2,564	0.68	64	C
							Total by direction	**10,706**		**13,270**		**2,564**			
VA Route 7	I-66	Outer	GP		55	4	4	10,581	2,645	10,581	2,645	0	1.18	44	F
		Outer	HOT	3	65	1	2	483	483	3,200	1,600	2,717	0.68	64	C
							Total by direction	**11,064**		**13,781**		**2,717**			
		Inner	GP		55	4	4	10,438	2,609	10,438	2,609	0	1.16	45	F
		Inner	HOT	3	65	1	2	555	555	3,200	1,600	2,645	0.68	64	C
							Total by direction	**10,993**		**13,638**		**2,645**			
Braddock Rd	I-395	Outer	GP		55	4	4	10,216	2,554	10,216	2,554	0	1.14	46	F
		Outer	HOT	3	65	1	2	565	565	3,200	1,600	2,635	0.68	64	C
							Total by direction	**10,781**		**13,416**		**2,635**			
		Inner	GP		55	4	4	9,659	2,415	9,659	2,415	0	1.07	49	F
		Inner	HOT	3	65	1	2	429	429	3,200	1,600	2,771	0.68	64	C
							Total by direction	**10,087**		**12,859**		**2,771**			
Average, GP					55			10,084	2,521	10,084	2,521	0	1.12	47	F
Average, HOV/HOT					65			559	559	3,200	1,600	2,641	0.68	64	C
Average combined volume							Total by direction	**10,643**		**13,284**		**2,641**			

Based on the forecasted volumes, v/c ratios, speeds, and LOSs for these three segments of the Beltway, *average values* were calculated and appear at the bottom of Table 11, Table 12, and Table 13. These average values were then used to represent the entire 14-mile-long HOT lane facility.

The number of GP lane miles stays the same for all four scenarios (112 lane miles), but the total (GP plus managed) lane miles increase 20% (from 140 to 168), as shown in Table 14.

Table 14 Lane mile calculations

Analysis year: 2015	Baseline	Action Low	Action Medium	Action High
Length (miles)	14	14	14	14
Lanes, GP	8	8	8	8
Lanes, HOV/HOT	2	4	4	4
Lanes, total	10	12	12	12
Lane miles, GP	112	112	112	112
Lane miles, HOV/HOT	28	56	56	56
Lane miles, total	140	168	168	168

The estimated 2015 peak-hour volumes and vehicle miles of travel (VMT) used in this analysis are shown in Table 15. Comparing the "action high" forecast to the baseline, the estimated peak-hour volume is 25% higher, but the estimated peak-hour VMT is only 14% higher.

Table 15 Est. peak-hour 2015 volume and VMT

Analysis year: 2015		Baseline	Action Low	Action Medium	Action High
Est ave. peak-hour volume, GP		10,084	7,443	9,043	10,084
Est ave. peak-hour volume, HOV/HOT		559	3,200	3,200	3,200
	Total	10,643	10,643	12,243	13,284
	Pct diff	0%	0%	15%	25%
Est peak-hour VMT, GP		1,129,412	833,609	1,012,809	1,129,412
Est peak-hour VMT, HOV/HOT		15,649	179,200	179,200	179,200
	Total	1,145,061	1,012,809	1,192,009	1,308,612
	Pct diff	0%	-12%	4%	14%

Table 16 shows the assumed peak-hour values for speed, travel time over the 14-mile segment, volume-to-capacity ratio, and level of service.

Table 16 Est. peak-hour 2015 speeds, travel times, V/C, and LOS

Analysis year: 2015	Baseline	Action Low	Action Medium	Action High
Ave. peak-hour speed, GP	47	53	51	47
Ave. peak-hour speed, HOV/HOT	55	64	64	64
Travel time, GP (minutes)	17.9	15.7	16.6	17.9
Travel time, HOV/HOT	15.3	13.2	13.2	13.2
Travel time savings, GP minus HOV/HOT	2.6	2.6	3.4	4.8
Peak hour V/C, GP	1.12	0.83	1.00	1.12
Peak hour V/C, HOV/HOT	0.25	0.68	0.68	0.68
Peak hour LOS, GP (FFS = 55 mph)	F	D	F	F
Peak hour LOS, HOV/HOT (FFS = 55/65 mph)	A	C	C	C

In the base case, the free flow speed on both the GP lanes and the HOT/HOV3+ lanes is 55 mph, but the restrained speeds (shown in the table below) are estimated to be 47 mph on the GP lanes and 55 mph on the HOV3+ lanes. In the three action or "build" scenarios, the free flow speed on the HOT/HOV3+ lanes is raised 10 mph to 65 mph. The restrained speed on the HOT/HOV3+ lanes drops to approximately 64 mph, because of the LOS C (1,600 v/hr/ln) traffic. In the base case, using the managed (HOV) lanes would save about 2.6 minutes over using the GP lanes, assuming one travels the full 14-mile segment. In the three action scenarios, using the managed lanes would save from 2.6 minutes to 4.8 minutes.

However, simply stating the average time savings during the peak period for the base and action scenarios *understates* the total travel time benefit to users. For example, in the base case, only *one* class of users (HOV3+), traveling in about 1,000 vehicles (per hour), could benefit from the 2.6-minute time savings, resulting in about 3,000 vehicle-minutes of time savings or 11,000 person-minutes of time savings (assuming an average vehicle occupancy of 3.6 persons per vehicle in the HOV3+ lanes). See Table 17. By contrast, in the action case (high forecast), *three* classes of users (HOV3+, SOV pay toll, and HOV2 pay toll), traveling in about 6,400 vehicles (per hour), could benefit from the 4.8-minute time savings, resulting in about 31,000 vehicle-minutes of time savings or 43,000 person-minutes of time savings (assuming an average vehicle occupancy of 1.4 persons per vehicle in the HOT lanes). So the time savings in terms of vehicle-minutes increases by a factor of about 10 and the person-minutes of time savings increases by a factor of about 4 (See Table 17). Of course these travel times and time savings represent the

peak hour of an *average weekday* with no traffic incidents. On a day where there is a major incident, the travel time savings in the managed lanes will likely be much more than the 4.8 minutes shown in the table.

Table 17 Average time savings during the peak hour, action vs. baseline (assuming the "action medium forecast")

Scenario	Lane type	Total lanes	Ave. speed (mph)	Veh per hr (each way)	Veh per hr (both ways)	User classes (auto mode)	Ave. travel time (min.)	Assumed ave. occu-pancy	Average Time Savings Min	Veh*min	Pers*min
Base	Gen. purp.	8	47	10,084	20,168	All auto modes	17.9				
	Managed	2	55	559	1,118	HOV3+	15.3	3.6	2.6	2,942	10,591
Action	Gen. purp.	8	47	10,084	20,168	All auto modes	17.9				
(High forecast)	Managed	4	64	3,200	6,400	HOV3+ SOV pay HOV2 pay	13.2	1.4	4.8	30,643	42,901
Difference	Gen. purp.	0	0	0	0	Same	0				
(Action - Base)	Managed	2	9	2,641	5,282	Two new user classes	-2.2	-2.2	2.2	27,701	32,310

Total length of facility (miles)	14

Percent difference (action vs. base)	82%	942%	305%
Ratio (action/base)	1.8	10.4	4.1

Ref: x215rnet_vol_ daily.xls

Table 18 shows the assumed values used for the emissions calculation. A column has been added to the right-hand side of this table, which represents the average of the emissions estimates from the medium and high demand forecasts, since these two demand forecasts are considered the most likely. Note that Table 18 contains two types of emissions estimates:

- Peak-hour estimates for the HOT lane facility (both GP and managed lanes), and
- Daily estimates for the region.

Peak-hour estimates for the HOT lane facility appear in the first 10 rows of the table and daily estimates for the region appear in the last 4 rows of the table.

The peak-hour running emissions by pollutant and by lane type (shown in the first four rows in the table) are the product of the relevant VMT (shown in Table 15) and the corresponding emissions factor (not shown in this table, but included in the appendix). Peak-hour running emissions by pollutant (summed across GP and HOV/HOT lanes) are shown the next two rows of the table and are shown graphically in Figure 10 and Figure 11.

To calculate the *daily* emissions impact of the proposed facility at the *regional* level we have added two numbers:

- The total daily mobile emissions from the Air Quality Conformity Analysis of the 2002 CLRP and the FY 2003-2008 TIP (also shown in Table 19), and
- The increment in peak-hour emissions (compared to the base case) times a factor of four. It was reasoned that the total daily emissions from the proposed facility would be equal to about four times the peak-hour emissions.

Table 18 Est. peak-hour 2015 running emissions, both specific to facility and region wide

Analysis year: 2015	Baseline	Action Low	Action Medium	Action High	Action (ave. of med+high)
Pk-hr emissions, VOC, GP (grams/hr)	202,616	139,880	174,001	202,616	188,309
Pk-hr emissions, VOC, HOV/HOT	2,607	28,780	28,780	28,780	28,780
Pk-hr emissions, NOX, GP	978,296	783,759	912,744	978,296	945,520
Pk-hr emissions, NOX, HOV/HOT	14,904	201,313	201,313	201,313	201,313
Pk-hr emissions, VOC, total (grams/hour)	205,224	168,659	202,780	231,396	217,088
Pk-hr emissions, NOX, total	993,201	985,073	1,114,057	1,179,610	1,146,833
Pk-hr emissions, VOC, total, difference from base	0	-36,564	-2,443	26,172	11,864
Pk-hr emissions, NOX, total, difference from base	0	-8,128	120,856	186,409	153,632
Pk-hr emissions, VOC, total, pct diff from base	0%	-18%	-1%	13%	6%
Pk-hr emissions, NOX, total, pct diff from base	0%	-1%	12%	19%	15%
Regional total, daily VOC + (pk-hr emiss.) * factor	86,545,424	86,399,166	86,535,650	86,650,114	86,592,882
Regional total, daily NOx + (pk-hr emiss.) * factor	107,864,266	107,831,753	108,347,690	108,609,901	108,478,795
Regional total, VOC, percent difference	0.00%	-0.17%	-0.01%	0.12%	0.05%
Regional total, NOx, percent difference	0.00%	-0.03%	0.45%	0.69%	0.57%

Factor used to multiply peak-hour emissions before adding to daily	4

Based on the average of the emissions estimates for the medium and high travel demand forecasts, we estimate that peak-hour running VOC emissions would increase slightly – about 6% during the peak hour for the facility itself and about 0.05% on a daily basis at the regional level. Similarly, we estimate that peak-hour running NOx emissions would increase moderately – about 15% during the peak hour for the facility itself and about 0.57% on a daily basis at the regional level. One should remember that, as stated earlier, the emissions estimates are conservative, i.e., likely to overestimate emissions, because the increase in VMT in the medium and high travel forecasts is treated as 100% induced demand, meaning that it is all new VMT, not simply VMT moved from other facilities.

Figure 10 Estimated 2015 peak-hour running emissions from the 14-mile segment of the Beltway: VOC

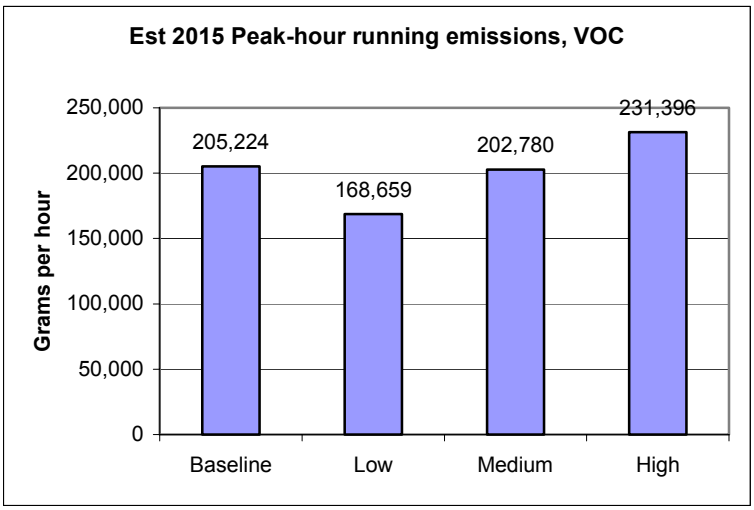


Figure 11 Estimated 2015 peak-hour running emissions from the 14-mile segment of the Beltway: NOx

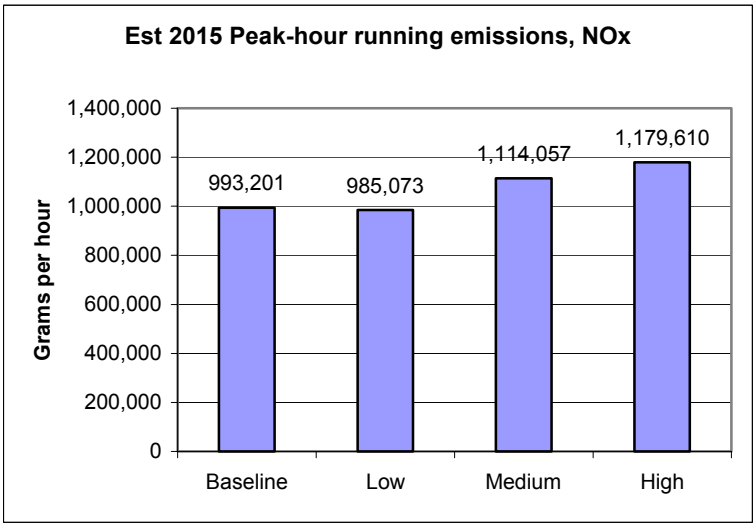


Table 19 Total daily mobile emissions from the Air Quality Conformity Analysis of the 2002 CLRP and the FY 2003-2008 TIP

Air Quality Conformity of 2002 CLRP & FY03-08 TIP		
	tons/day	grams/day
Mobile source VOC emissions, 2015	95.4	86,545,424
Mobile source NOx emissions, 2015	118.9	107,864,266
Conversion factor: grams per imperial ton	907,184.74	

Bus routes are anticipated to use the HOT lanes, generating 20 buses per hour during the peak and 7 buses per hour during the off-peak, based on existing bus service. Adding routes is anticipated to increase these figures by 24 buses per hour and 16 buses per hour, respectively. As can be seen in Table 20, this would add 40 passenger car equivalents (PCEs) to the baseline scenario and 88 PCEs to the HOT lane scenarios, assuming that each bus equals 2 passenger car equivalents. The effect of this bus service has not been explicitly accounted for in our analysis, since the number of PCEs is so small, and their inclusion would not have changed the emissions forecasts. Nonetheless, we think that the transit element is an important part of the project and should not be omitted when selling the project to potential sponsors.

Table 20 Conversion of buses to passenger car equivalents (PCEs)

	Buses			PCEs	
	Base (buses per hour)	Added Service (buses per hour)	Total Proposed (buses per hour)	Base (PCEs per hour)	Proposed (PCEs per hour)
Peak period	20	24	44	40	88
Off peak	7	16	23	14	46

Assumption:
Passenger car equivalents 1 bus = 2 PCEs

Ref: x215rnet_vol_ daily.xls

4.3 Findings

A sketch planning technique was used to estimate both travel demand and mobile emissions for the 14-mile segment of the Beltway that would comprise the HOT lane facility. There were four demand forecasts and four emissions forecasts: base, action low, action medium, and action high. The medium and high demand forecasts were deemed to be the most likely of the three action or "build" scenarios.

- The proposed HOT lane facility would likely result in a slight increase in volatile organic compounds (VOC) – about 6% during the peak hour for the facility itself and about 0.05% on a daily basis at the regional level.

- The proposed HOT lane facility would likely result in a moderate increase in oxides of nitrogen (NOx) – about 15% during the peak hour for the facility itself and about 0.57% on a daily basis at the regional level.

- The foregoing emissions estimates are conservative, i.e., likely to overestimate emissions, because the increase in VMT in the medium and high travel forecasts is treated as 100% induced demand, meaning that it is all new VMT, not simply VMT moved from other facilities.

- The proposed HOT lane facility would likely result in three main benefits to users of the facility and its adjacent general purpose lanes on the Beltway:

    - <u>More travel choices</u>: In the base scenario, a user of this section of the Beltway had two travel options: SOV or HOV3+ (which includes 3+ person carpools, vanpools, and buses). In the action scenario, a user now has two new travel options: "SOV pay toll," and "HOV2 pay toll."

- Travel time savings: In the base case, using the managed (HOV) lanes would save about 2.6 minutes over using the GP lanes, assuming one travels the full 14-mile segment. In the three action scenarios, using the managed lanes would save from 2.6 minutes to 4.8 minutes. However, simply stating the average time savings during the peak period for the base and action scenarios *understates* the total travel time benefit to users. For example, in the base case, only *one* class of users (HOV3+) could benefit from the 2.6-minute time savings, resulting in about 11,000 person-minutes of time savings, assuming an average vehicle occupancy of 3.6 persons per vehicle in the HOV3+ lanes. By contrast, in the action case, *three* classes of users (HOV3+, SOV pay toll, and HOV2 pay toll) could benefit from the 4.8-minute time savings (high forecast), resulting in about 43,000 person-minutes of time savings, assuming an average vehicle occupancy of 1.4 persons per vehicle in the HOT lanes. So the time savings in terms of person-minutes increases by a factor of about 4. Additionally, the aforementioned travel time savings represent the peak hour of an *average weekday* with no traffic incidents. On a day where there is a major incident, the travel time savings in the managed lanes will likely be much more than 4.8 minutes.

- Consistency and dependability in travel times: The proposed HOT lane facility would maintain good levels of service on the managed lanes (anywhere from A to C) and would likely improve the level of service on the adjacent GP lanes, as compared to the base case. Users of existing HOT lane facilities in other states often report that one of the main perceived benefits of traveling on the HOT lanes is, in fact, the travel time dependability, which is ensured thanks to the variable pricing of the lanes.

- Although the proposed HOT lane facility would result in both travel time savings and more consistent travel times, there would be even more user benefits if a *network* of HOT lanes were built in the region. Such a system is currently being proposed as a scenario for testing in the Regional Mobility and Accessibility Study, being conducted at Metropolitan Washington Council of Governments.

5 References and resources

Works cited

DeCorla-Souza, P. (2002) "Evaluation of Toll Options Using Quick-Response Analysis Tools: A Case Study of the Capital Beltway." Prepared for presentation at the TRB Annual Meeting in January 2003. Paper no. 03-2946. November 16, 2002. See also Web site: http://www.fhwa.dot.gov/steam/smiteml.htm

Metropolitan Washington Council of Governments (MWCOG). (2002) *Air Quality Conformity Determination of the 2002 Constrained Long Range Plan and the FY 2003-2008 Transportation Improvement Program for the Washington Metropolitan Region*. Washington, D.C. July 31, 2002.

Perez, B.G. and Sciara, G.C. (2003) *A Guide For HOT Lane Development* (Web document). URL: http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13668.html Prepared by Parsons Brinckerhoff, Inc., Texas Transportation Institute, and Federal Highway Administration. Likely to be released in printed form in April 2003.

Transportation Research Board (TRB) (2000) *Highway Capacity Manual*. Washington, DC.

Bibliography

Christiansen, Dennis L. (1990) *High-Occupancy Vehicle System Development In The United States: A White Paper*. Prepared by the Texas Transportation Institute for the U.S. DOT. December 1990.

Federal Highway Administration (FHWA). (1996) *Predicting High Occupancy Vehicle Lane Demand*, Final Report. Report No. FHWA-SA-96-073. Washington, DC. August 1996.

Kim, Eugene J. (2000) HOT Lanes: A Comparative Analysis of Costs, Benefits, and Performance. Ph.D. dissertation. University of California, Los Angeles.

Parsons Transportation Group, Inc. (2002) High Occupancy Vehicle Facilities Policy Guidelines And Plan For The MAG Freeway System. Prepared for the Arizona Department of Transportation, the Maricopa Association of Governments, and the Regional Public Transportation Authority.

Small, Kenneth A. (1997) "I-15 Congestion Pricing Project Monitoring And Evaluation Services, Task 1.1 Worldwide Experience with Congestion Pricing." Prepared for San Diego Association of Governments by San Diego State University. June 10, 1997.

Small, Kenneth A., Janusz Supernak, Tom Collins, and Eric Schreffler. (1997) "I-15 Congestion Pricing Project Monitoring And Evaluation Services, Task 1.2 Up-To-Date Results Of The SR-91 Congestion Pricing Experiment." Prepared for San Diego Association of Governments by San Diego State University. June 10, 1997.

Sullivan, Edward (1998) *Evaluating the Impacts of the SR 91 Variable-Toll Express Lane Facility*, Final Report. Prepared for the California Department of Transportation (Caltrans) by Cal Poly State University, San Luis Obispo, California. May 1998.

Sullivan, Edward (2000) *Continuation Study to Evaluate the Impacts of the SR 91 Value-Priced Express Lanes*, Final Report. Prepared for the California Department of Transportation (Caltrans) by Cal Poly State University, San Luis Obispo, California. December 2000.

Transportation Research Board (TRB). (1998) *HOV Systems Manual*. National Cooperative Highway Research Program (NCHRP) Report 414, Washington, D.C. February 1998. [Work not yet obtained]

Turnbull, Katherine F. (1992) *An Assessment of High Occupancy Vehicle (HOV) Facilities in North America: Executive Report*. Final Report. DOT-T-94-17. Prepared by the Texas Transportation Institute for the Federal Transit Administration and Texas DOT. Washington, DC. August 1992.

Turner, Shawn M., Gary A. Carlin, and Russell H. Henk. (1995) *Quantifying the Benefits of High-Occupancy Vehicle Facilities Using Automatic Vehicle Identification Technology*. Report No. SWUTC/95/465020-1. November 1995

Worldwide Web Links

HOT lanes, HOV lanes, Value pricing: General links

A Guide for HOT Lane Development: http://www.itsdocs.fhwa.dot.gov/JPODOCS/REPTS_TE/13668.html#_Toc17693436
California Department of Transportation (Caltrans): http://www.dot.ca.gov/
FHWA, Office of Transportation Management: http://ops.fhwa.dot.gov/Travel/
FHWA, Office of Transportation Management, HOV facilities: http://ops.fhwa.dot.gov/Travel/traffic/hov/index.htm
FHWA Value Pricing Pilot Project Web site: http://www.fhwa.dot.gov/policy/vppp.htm
FHWA value pricing stuff: http://www.tfhrc.gov/pubrds/marapr99/pricing.htm
FHWA analysis tools to estimate the effects of pricing (e.g., STEAM, SMITE): http://www.fhwa.dot.gov/steam/links.htm
Hubert Humphrey Institute's value pricing homepage: http://www.hhh.umn.edu/centers/slp/projects/conpric/index.htm
Texas Transportation Institute, Managed lanes Web site: http://managed-lanes.tamu.edu/
Urban Transport Pricing in Europe: http://www.transport-pricing.net/

HOT lanes, facility-specific

SR-91 Express Lanes in Orange County, California

Official Web page: http://www.91expresslanes.com/
State Route 91 Study Products: http://ceenve.calpoly.edu/sullivan/sr91/sr91.htm
Southern California Association of Governments (SCAG): http://www.scag.ca.gov/index.htm
Transportation Corridor Agencies (TCA). Formed in 1986 to plan, finance, construct and operate Orange County's 67-mile public toll road system: http://www.tcagencies.com/

I-15 Express Lanes in San Diego, California

Official Web page: http://argo.sandag.org/fastrak/index.html
I-15 project-related reports: http://argo.sandag.org/fastrak/library.html
San Diego Association of Governments (SANDAG): http://www.sandag.org

Houston's QuickRide System

QuickRide: http://www.hou-metro.harris.tx.us/services/quickride.asp
Metropolitan Transit Authority of Harris Co., Texas (Houston Metro): http://www.hou-metro.harris.tx.us/homepage.asp
Houston-Galveston Area Council (HGAC): http://www.hgac.cog.tx.us/
Texas Transportation Institute: http://tti.tamu.edu/

MPOs not already listed above

Maricopa Association of Governments (MAG): http://www.mag.maricopa.gov/display.cms

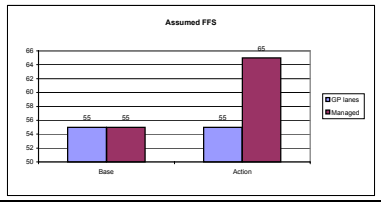
Appendix A
Spreadsheets used in demand and emissions estimates

Estimated traffic volumes on three representative segments of the Capital Beltway:
Converting daily volumes to hourly volumes

Baseline conditions assumed for 2015

Assumed Free Flow Speeds (mph)

	Base	Action
GP lanes	55	55
Managed	55	65



From	To	Loop	Link Type	HOV Req	Highway Network Nodes A Node	B Node	Lanes	Est daily volumes (4-step model) Vol	Vol / ln	Est peak-hour volumes (pk-hr factor) Vol	Vol / ln	V/C	Free flow Speed (mph)	Restrain. Speed (mph)	LOS
G-town Pk	Dulles Toll Rd	Outer	GP		12797	12793	4	121,540	30,385	9,541	2,385	1.06	55	49	F
		Outer	HOV	3	12798	12794	1	4,282	4,282	685	685	0.30	55	55	B
							Total by direction	**125,822**		**10,226**					
		Inner	GP		12796	12800	4	128,277	32,069	10,070	2,517	1.12	55	47	F
		Inner	HOV	3	12795	12799	1	3,974	3,974	636	636	0.28	55	55	B
							Total by direction	**132,251**		**10,706**					
VA Route 7	I-66	Outer	GP		12717	12721	4	134,790	33,698	10,581	2,645	1.18	55	44	F
		Outer	HOV	3	12718	12722	1	3,020	3,020	483	483	0.21	55	55	A
							Total by direction	**137,810**		**11,064**					
		Inner	GP		12724	12720	4	132,967	33,242	10,438	2,609	1.16	55	45	F
		Inner	HOV	3	12723	12719	1	3,469	3,469	555	555	0.25	55	55	A
							Total by direction	**136,436**		**10,993**					
Braddock Rd	I-395	Outer	GP		12777	12781	4	130,140	32,535	10,216	2,554	1.14	55	46	F
		Outer	HOV	3	12778	12782	1	3,534	3,534	565	565	0.25	55	55	A
							Total by direction	**133,674**		**10,781**					
		Inner	GP		12784	12780	4	123,040	30,760	9,659	2,415	1.07	55	49	F
		Inner	HOV	3	12783	12779	1	2,680	2,680	429	429	0.19	55	55	A
							Total by direction	**125,720**		**10,087**					
Average, GP								128,459	32,115	10,084	2,521	1.12	55	47	F
Average, HOV/HOT								3,493	3,493	559	559	0.25	55	55	A
Average combined volume							**Total by direction**	**131,952**		**10,643**					

Assumptions about peaking on Beltway

		Value	Var.	Notes
GP lanes	Share of daily Beltway traffic from 4 to 6 PM	15.7%	A	Source: Observed ground counts
	Hours in period	2	B	
	Factor to convert daily vol to hourly, GP lanes	**7.9%**	= A / B	
HOV lanes	Share of daily HOV traffic occurring 6-9 AM, 4-7 PM	80.0%	C	
	Share of peak-per HOV traffic in 4-7 PM	50.0%	D	
	Share of PM peak-per HOV traffic in peak hour	40.0%	E	
	Factor to convert daily vol to hourly, HOV lanes	**16.0%**	= C*D*E	

LOS E capacity (veh/hour/lane)

FFS (mph)	Capacity
55	2,250
65	2,350

Estimated traffic volumes under Fluor HOT lane proposal (peak hour)
Low, Medium, and High forecast

Maximum allowable volume for HOT lanes	1,600	v/hr/ln

Low forecast

From	To	Loop	Link Type	HOV Req	FFS (mph)	Base Lanes	Prop Lanes	Baseline Vol	Baseline Vol / ln	HOT lane Low est Vol	HOT lane Low est Vol / ln	Diff. in volume comp to baseline	V/C	Restrain. Speed (mph)	LOS
G-town Pk	Dulles Toll Rd	Outer	GP		55	4	4	9,541	2,385	7,026	1,757	-2,515	0.78	54	D
		Outer	HOT	3	65	1	2	685	685	3,200	1,600	2,515	0.68	64	C
							Total by direction	**10,226**		**10,226**		**0**			
		Inner	GP		55	4	4	10,070	2,517	7,506	1,876	-2,564	0.83	53	D
		Inner	HOT	3	65	1	2	636	636	3,200	1,600	2,564	0.68	64	C
							Total by direction	**10,706**		**10,706**		**0**			
VA Route 7	I-66	Outer	GP		55	4	4	10,581	2,645	7,864	1,966	-2,717	0.87	53	E
		Outer	HOT	3	65	1	2	483	483	3,200	1,600	2,717	0.68	64	C
							Total by direction	**11,064**		**11,064**		**0**			
		Inner	GP		55	4	4	10,438	2,609	7,793	1,948	-2,645	0.87	53	E
		Inner	HOT	3	65	1	2	555	555	3,200	1,600	2,645	0.68	64	C
							Total by direction	**10,993**		**10,993**		**0**			
Braddock Rd	I-395	Outer	GP		55	4	4	10,216	2,554	7,581	1,895	-2,635	0.84	53	D
		Outer	HOT	3	65	1	2	565	565	3,200	1,600	2,635	0.68	64	C
							Total by direction	**10,781**		**10,781**		**0**			
		Inner	GP		55	4	4	9,659	2,415	6,887	1,722	-2,771	0.77	54	D
		Inner	HOT	3	65	1	2	429	429	3,200	1,600	2,771	0.68	64	C
							Total by direction	**10,087**		**10,087**		**0**			
Average, GP					55			10,084	2,521	7,443	1,861	-2,641	0.83	53	D
Average, HOV/HOT					65			559	559	3,200	1,600	2,641	0.68	64	C
Average combined volume							**Total by direction**	**10,643**		**10,643**		**0**			

Medium forecast

From	To	Loop	Link Type	HOV Req	FFS (mph)	Base Lanes	Prop Lanes	Baseline Vol	Baseline Vol / ln	HOT lane Medium est Vol	HOT lane Medium est Vol / ln	Diff. in volume comp to baseline	V/C	Restrain. Speed (mph)	LOS
G-town Pk	Dulles Toll Rd	Outer	GP		55	4	4	9,541	2,385	8,626	2,157	-915	0.96	52	E
		Outer	HOT	3	65	1	2	685	685	3,200	1,600	2,515	0.68	64	C
							Total by direction	**10,226**		**11,826**		**1,600**			
		Inner	GP		55	4	4	10,070	2,517	9,106	2,276	-964	1.01	51	F
		Inner	HOT	3	65	1	2	636	636	3,200	1,600	2,564	0.68	64	C
							Total by direction	**10,706**		**12,306**		**1,600**			
VA Route 7	I-66	Outer	GP		55	4	4	10,581	2,645	9,464	2,366	-1,117	1.05	49	F
		Outer	HOT	3	65	1	2	483	483	3,200	1,600	2,717	0.68	64	C
							Total by direction	**11,064**		**12,664**		**1,600**			
		Inner	GP		55	4	4	10,438	2,609	9,393	2,348	-1,045	1.04	50	F
		Inner	HOT	3	65	1	2	555	555	3,200	1,600	2,645	0.68	64	C
							Total by direction	**10,993**		**12,593**		**1,600**			
Braddock Rd	I-395	Outer	GP		55	4	4	10,216	2,554	9,181	2,295	-1,035	1.02	51	F
		Outer	HOT	3	65	1	2	565	565	3,200	1,600	2,635	0.68	64	C
							Total by direction	**10,781**		**12,381**		**1,600**			
		Inner	GP		55	4	4	9,659	2,415	8,487	2,122	-1,171	0.94	52	E
		Inner	HOT	3	65	1	2	429	429	3,200	1,600	2,771	0.68	64	C
							Total by direction	**10,087**		**11,687**		**1,600**			
Average, GP					55			10,084	2,521	9,043	2,261	-1,041	1.00	51	F
Average, HOV/HOT					65			559	559	3,200	1,600	2,641	0.68	64	C
Average combined volume							**Total by direction**	**10,643**		**12,243**		**1,600**			

High forecast

From	To	Loop	Link Type	HOV Req	FFS (mph)	Base Lanes	Prop Lanes	Baseline Vol	Baseline Vol / ln	HOT lane High est Vol	HOT lane High est Vol / ln	Diff. in volume comp to baseline	V/C	Restrain. Speed (mph)	LOS
G-town Pk	Dulles Toll Rd	Outer	GP		55	4	4	9,541	2,385	9,541	2,385	0	1.06	49	F
		Outer	HOT	3	65	1	2	685	685	3,200	1,600	2,515	0.68	64	C
							Total by direction	**10,226**		**12,741**		**2,515**			
		Inner	GP		55	4	4	10,070	2,517	10,070	2,517	0	1.12	47	F
		Inner	HOT	3	65	1	2	636	636	3,200	1,600	2,564	0.68	64	C
							Total by direction	**10,706**		**13,270**		**2,564**			
VA Route 7	I-66	Outer	GP		55	4	4	10,581	2,645	10,581	2,645	0	1.18	44	F
		Outer	HOT	3	65	1	2	483	483	3,200	1,600	2,717	0.68	64	C
							Total by direction	**11,064**		**13,781**		**2,717**			
		Inner	GP		55	4	4	10,438	2,609	10,438	2,609	0	1.16	45	F
		Inner	HOT	3	65	1	2	555	555	3,200	1,600	2,645	0.68	64	C
							Total by direction	**10,993**		**13,638**		**2,645**			
Braddock Rd	I-395	Outer	GP		55	4	4	10,216	2,554	10,216	2,554	0	1.14	46	F
		Outer	HOT	3	65	1	2	565	565	3,200	1,600	2,635	0.68	64	C
							Total by direction	**10,781**		**13,416**		**2,635**			
		Inner	GP		55	4	4	9,659	2,415	9,659	2,415	0	1.07	49	F
		Inner	HOT	3	65	1	2	429	429	3,200	1,600	2,771	0.68	64	C
							Total by direction	**10,087**		**12,859**		**2,771**			
Average, GP					55			10,084	2,521	10,084	2,521	0	1.12	47	F
Average, HOV/HOT					65			559	559	3,200	1,600	2,641	0.68	64	C
Average combined volume							**Total by direction**	**10,643**		**13,284**		**2,641**			

Calculation of peak-hour running emissions

Analysis year: 2015	Baseline	Action Low	Action Medium	Action High			
Length (miles)	14	14	14	14		A	
Lanes, GP	8	8	8	8		B	
Lanes, HOV/HOT	2	4	4	4		C	
Lanes, total	10	12	12	12	calc	D = B+C	
Lane miles, GP	112	112	112	112	calc	E = A*B	
Lane miles, HOV/HOT	28	56	56	56	calc	F = A*C	
Lane miles, total	140	168	168	168	calc	G = E+F	
Est ave. peak-hour volume, GP	10,084	7,443	9,043	10,084		H	
Est ave. peak-hour volume, HOV/HOT	559	3,200	3,200	3,200		I	
Est ave. daily vol, GP (not used in emis. calc.)	128,459	(Not used in analysis)				J	Not used
Est ave. daily vol, HOV/HOT (not used in emis. calc.)	3,493	(Not used in analysis)				K	Not used
Est peak-hour VMT, GP	1,129,412	833,609	1,012,809	1,129,412	calc	L = E*H	
Est peak-hour VMT, HOV/HOT	15,649	179,200	179,200	179,200	calc	M = F*I	
Est daily VMT, GP (not used in emis. calc.)	14,387,408	(Not used in analysis)			calc	N = E*J	Not used
Est daily VMT, HOV/HOT (not used in emis. calc.)	97,809	(Not used in analysis)			calc	O = F*K	Not used
Ave. peak-hour speed, GP	47	53	51	47		P	
Ave. peak-hour speed, HOV/HOT	55	64	64	64		Q	
Emissions factor, VOC, GP	0.1794	0.1678	0.1718	0.1794	calc	R = lookup	
Emissions factor, VOC, HOV/HOT	0.1666	0.1606	0.1606	0.1606	calc	S = lookup	
Emissions factor, CO, GP	5.6164	6.2030	5.9382	5.6164	calc	T = lookup	
Emissions factor, CO, HOV/HOT	6.2848	7.1380	7.1380	7.1380	calc	U = lookup	
Emissions factor, NOX, GP	0.8662	0.9402	0.9012	0.8662	calc	V = lookup	
Emissions factor, NOX, HOV/HOT	0.9524	1.1234	1.1234	1.1234	calc	W = lookup	
Pk-hr emissions, VOC, GP (grams/hr)	202,616	139,880	174,001	202,616	calc	X = L*R	
Pk-hr emissions, VOC, HOV/HOT	2,607	28,780	28,780	28,780	calc	Y = L*S	
Pk-hr emissions, CO, GP	6,343,227	5,170,877	6,014,263	6,343,227	calc	Z = L*T	
Pk-hr emissions, CO, HOV/HOT	98,353	1,279,130	1,279,130	1,279,130	calc	AA = L*U	
Pk-hr emissions, NOX, GP	978,296	783,759	912,744	978,296	calc	BB = L*V	
Pk-hr emissions, NOX, HOV/HOT	14,904	201,313	201,313	201,313	calc	CC = L*W	
Pk-hr emissions, VOC, total (grams/hour)	205,224	168,659	202,780	231,396	calc	DD = X+Y	
Pk-hr emissions, CO, total	6,441,580	6,450,007	7,293,392	7,622,357	calc	EE = Z+AA	
Pk-hr emissions, NOX, total	993,201	985,073	1,114,057	1,179,610	calc	FF = BB+CC	
Pk-hr emissions, VOC, total, difference from base	0	-36,564	-2,443	26,172	calc		
Pk-hr emissions, CO, total, difference from base	0	8,427	851,812	1,180,776	calc		
Pk-hr emissions, NOX, total, difference from base	0	-8,128	120,856	186,409	calc		
Pk-hr emissions, VOC, total, pct diff from base	0%	-18%	-1%	13%	calc		
Pk-hr emissions, CO, total, pct diff from base	0%	0%	13%	18%	calc		
Pk-hr emissions, NOX, total, pct diff from base	0%	-1%	12%	19%	calc		
Regional total, daily VOC + (pk-hr emiss.) * factor	86,545,424	86,399,166	86,535,650	86,650,114			Factor = 4
Regional total, daily NOx + (pk-hr emiss.) * factor	107,864,266	107,831,753	108,347,690	108,609,901			
Regional total, VOC, percent difference	0.00%	-0.17%	-0.01%	0.12%			
Regional total, NOx, percent difference	0.00%	-0.03%	0.45%	0.69%			
Travel time, GP (minutes)	17.9	15.7	16.6	17.9	calc		
Travel time, HOV/HOT	15.3	13.2	13.2	13.2	calc		
Travel time savings, GP minus HOV/HOT	2.6	2.6	3.4	4.8	calc		
Peak hour V/C, GP	1.12	0.83	1.00	1.12			
Peak hour V/C, HOV/HOT	0.25	0.68	0.68	0.68			
Peak hour LOS, GP (FFS = 55 mph)	F	D	F	F			
Peak hour LOS, HOV/HOT (FFS = 55/65 mph)	A	C	C	C			

Air Quality Conformity of 2002 CLRP & FY03-08 TIP

	tons/day	grams/day
Mobile source VOC emissions, 2015	95.4	86,545,424
Mobile source NOx emissions, 2015	118.9	107,864,266
Conversion factor: grams per imperial ton	907,184.74	

Summary tables (values are read from main table above)

Analysis year: 2015	Baseline	Action Low	Action Medium	Action High
Length (miles)	14	14	14	14
Lanes, GP	8	8	8	8
Lanes, HOV/HOT	2	4	4	4
Lanes, total	10	12	12	12
Lane miles, GP	112	112	112	112
Lane miles, HOV/HOT	28	56	56	56
Lane miles, total	140	168	168	168

Analysis year: 2015		Baseline	Action Low	Action Medium	Action High
Est ave. peak-hour volume, GP		10,084	7,443	9,043	10,084
Est ave. peak-hour volume, HOV/HOT		559	3,200	3,200	3,200
	Total	10,643	10,643	12,243	13,284
	Pct diff	0%	0%	15%	25%
Est peak-hour VMT, GP		1,129,412	833,609	1,012,809	1,129,412
Est peak-hour VMT, HOV/HOT		15,649	179,200	179,200	179,200
	Total	1,145,061	1,012,809	1,192,009	1,308,612
	Pct diff	0%	-12%	4%	14%

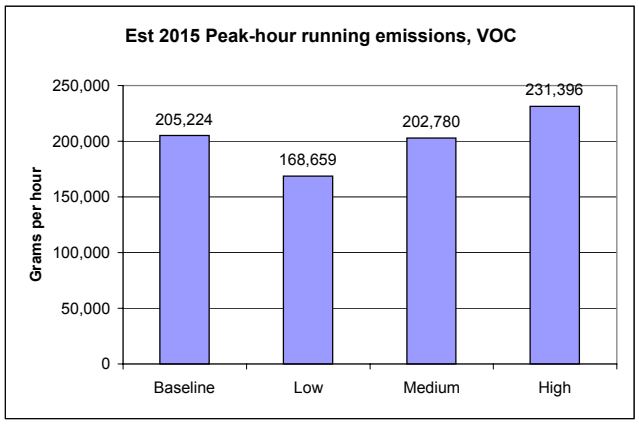
Analysis year: 2015	Baseline	Action Low	Action Medium	Action High
Ave. peak-hour speed, GP	47	53	51	47
Ave. peak-hour speed, HOV/HOT	55	64	64	64
Travel time, GP (minutes)	17.9	15.7	16.6	17.9
Travel time, HOV/HOT	15.3	13.2	13.2	13.2
Travel time savings, GP minus HOV/HOT	2.6	2.6	3.4	4.8
Peak hour V/C, GP	1.12	0.83	1.00	1.12
Peak hour V/C, HOV/HOT	0.25	0.68	0.68	0.68
Peak hour LOS, GP (FFS = 55 mph)	F	D	F	F
Peak hour LOS, HOV/HOT (FFS = 55/65 mph)	A	C	C	C

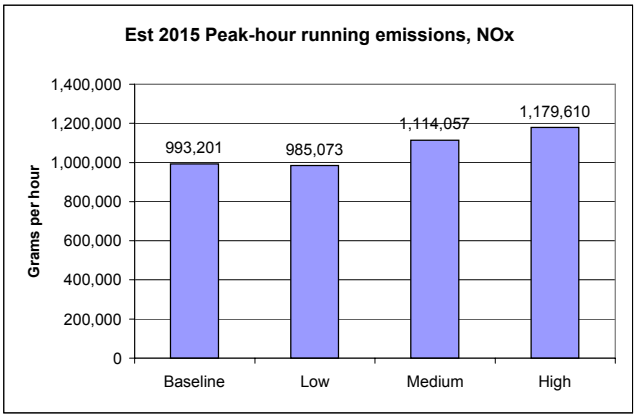
Analysis year: 2015	Baseline	Action Low	Action Medium	Action High	Action (ave. of med+high)
Pk-hr emissions, VOC, GP (grams/hr)	202,616	139,880	174,001	202,616	188,309
Pk-hr emissions, VOC, HOV/HOT	2,607	28,780	28,780	28,780	28,780
Pk-hr emissions, NOX, GP	978,296	783,759	912,744	978,296	945,520
Pk-hr emissions, NOX, HOV/HOT	14,904	201,313	201,313	201,313	201,313
Pk-hr emissions, VOC, total (grams/hour)	205,224	168,659	202,780	231,396	217,088
Pk-hr emissions, NOX, total	993,201	985,073	1,114,057	1,179,610	1,146,833
Pk-hr emissions, VOC, total, difference from base	0	-36,564	-2,443	26,172	11,864
Pk-hr emissions, NOX, total, difference from base	0	-8,128	120,856	186,409	153,632
Pk-hr emissions, VOC, total, pct diff from base	0%	-18%	-1%	13%	6%
Pk-hr emissions, NOX, total, pct diff from base	0%	-1%	12%	19%	15%
Regional total, daily VOC + (pk-hr emiss.) * factor	86,545,424	86,399,166	86,535,650	86,650,114	86,592,882
Regional total, daily NOx + (pk-hr emiss.) * factor	107,864,266	107,831,753	108,347,690	108,609,901	108,478,795
Regional total, VOC, percent difference	0.00%	-0.17%	-0.01%	0.12%	0.05%
Regional total, NOx, percent difference	0.00%	-0.03%	0.45%	0.69%	0.57%

Factor used to multiply peak-hour emissions before adding to daily	4

Air Quality Conformity of 2002 CLRP & FY03-08 TIP

	tons/day	grams/day
Mobile source VOC emissions, 2015	95.4	86,545,424
Mobile source NOx emissions, 2015	118.9	107,864,266
Conversion factor: grams per imperial ton	907,184.74	





Assumed Free Flow Speeds (mph)

	Base	Action
GP lanes	55	55
Managed	55	65

Average time savings: Action vs. Base

Scenario	Lane type	Total lanes	Ave. speed (mph)	Veh per hr (each way)	Veh per hr (both ways)	User classes (auto mode)	Ave. travel time (min.)	Assumed ave. occu-pancy	Average Time Savings Min	Veh*min	Pers*min
Base	Gen. purp.	8	47	10,084	20,168	All auto modes	17.9				
	Managed	2	55	559	1,118	HOV3+	15.3	3.6	2.6	2,942	10,591
Action	Gen. purp.	8	51	9,043	18,086	All auto modes	16.6				
(Medium forecast)	Managed	4	64	3,200	6,400	HOV3+ SOV pay HOV2 pay	13.2	1.4	3.4	21,905	30,667
Difference	Gen. purp.	0	4	-1,041	-2,082	Same	-1.4				
(Action - Base)	Managed	2	9	2,641	5,282	Two new user classes	-2.2	-2.2	0.8	18,963	20,076

Total length of facility (miles)	14

Percent difference (action vs. base)	30%	645%	190%
Ratio (action/base)	1.3	7.4	2.9

Assumed Free Flow Speeds (mph)

	Base	Action
GP lanes	55	55
Managed	55	65

Average time savings: Action vs. Base (High forecast)

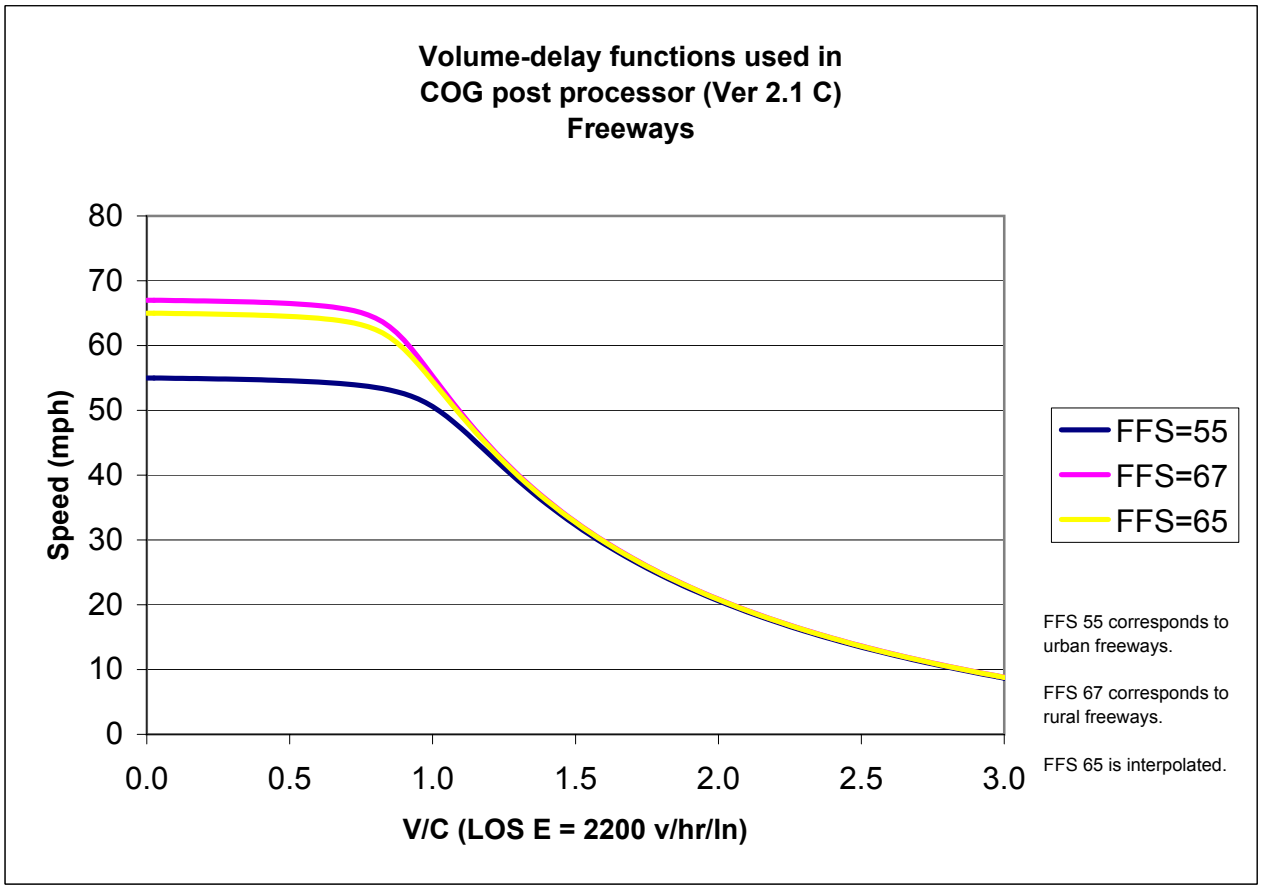
Scenario	Lane type	Total lanes	Ave. speed (mph)	Veh per hr (each way)	Veh per hr (both ways)	User classes (auto mode)	Ave. travel time (min.)	Assumed ave. occu-pancy	Average Time Savings Min	Veh*min	Pers*min
Base	Gen. purp.	8	47	10,084	20,168	All auto modes	17.9				
	Managed	2	55	559	1,118	HOV3+	15.3	3.6	2.6	2,942	10,591
Action	Gen. purp.	8	47	10,084	20,168	All auto modes	17.9				
(High forecast)	Managed	4	64	3,200	6,400	HOV3+ SOV pay HOV2 pay	13.2	1.4	4.8	30,643	42,901
Difference	Gen. purp.	0	0	0	0	Same	0				
(Action - Base)	Managed	2	9	2,641	5,282	Two new user classes	-2.2	-2.2	2.2	27,701	32,310

Total length of facility (miles)	14

Percent difference (action vs. base)	82%	942%	305%
Ratio (action/base)	1.8	10.4	4.1

Assumed Free Flow Speeds (mph)

	Base	Action
GP lanes	55	55
Managed	55	65



Density (pc/mile)	V/C	FFS=55 55	FFS=67 67	FFS=65 65
0	0.00	55.00	67.00	65.00
1	0.03	54.99	66.99	64.99
2	0.05	54.98	66.98	64.98
3	0.08	54.96	66.96	64.96
4	0.10	54.95	66.95	64.95
5	0.13	54.94	66.93	64.93
6	0.15	54.92	66.92	64.92
7	0.18	54.90	66.90	64.90
8	0.20	54.89	66.88	64.88
9	0.23	54.87	66.86	64.86
10	0.25	54.85	66.84	64.84
11	0.28	54.83	66.82	64.82
12	0.30	54.81	66.79	64.80
13	0.33	54.79	66.77	64.77
14	0.35	54.76	66.74	64.74
15	0.38	54.73	66.71	64.71
16	0.40	54.71	66.67	64.68
17	0.43	54.67	66.63	64.64

18	0.45	54.64	66.59	64.60
19	0.48	54.60	66.54	64.55
20	0.50	54.57	66.49	64.50
21	0.53	54.52	66.42	64.44
22	0.55	54.47	66.35	64.37
23	0.58	54.42	66.27	64.30
24	0.60	54.37	66.18	64.21
25	0.63	54.30	66.07	64.11
26	0.65	54.23	65.94	63.99
27	0.68	54.15	65.79	63.85
28	0.70	54.06	65.60	63.68
29	0.73	53.96	65.37	63.47
30	0.75	53.84	65.09	63.21
31	0.78	53.70	64.72	62.88
32	0.80	53.54	64.26	62.47
33	0.83	53.36	63.66	61.94
34	0.85	53.14	62.90	61.27
35	0.88	52.88	61.96	60.45
36	0.90	52.56	60.84	59.46
37	0.93	52.19	59.57	58.34
38	0.95	51.74	58.19	57.12
39	0.98	51.21	56.75	55.83
40	1.00	50.58	55.28	54.50
41	1.03	49.86	53.82	53.16
42	1.05	49.05	52.37	51.82
43	1.08	48.16	50.95	50.49
44	1.10	47.21	49.57	49.18
45	1.13	46.21	48.23	47.89
46	1.15	45.19	46.93	46.64
47	1.18	44.17	45.68	45.43
48	1.20	43.14	44.47	44.24
49	1.23	42.12	43.30	43.10
50	1.25	41.11	42.17	41.99
51	1.28	40.12	41.08	40.92
52	1.30	39.16	40.02	39.88
53	1.33	38.21	39.01	38.88
54	1.35	37.29	38.03	37.90
55	1.38	36.40	37.08	36.97
56	1.40	35.53	36.16	36.06
57	1.43	34.69	35.28	35.18
58	1.45	33.87	34.42	34.33
59	1.48	33.07	33.59	33.50
60	1.50	32.29	32.79	32.71
61	1.53	31.54	32.01	31.93
62	1.55	30.81	31.26	31.18
63	1.58	30.10	30.53	30.46
64	1.60	29.41	29.82	29.75
65	1.63	28.74	29.13	29.07
66	1.65	28.09	28.47	28.40
67	1.68	27.46	27.82	27.76
68	1.70	26.84	27.19	27.13
69	1.73	26.25	26.58	26.53
70	1.75	25.66	25.99	25.93

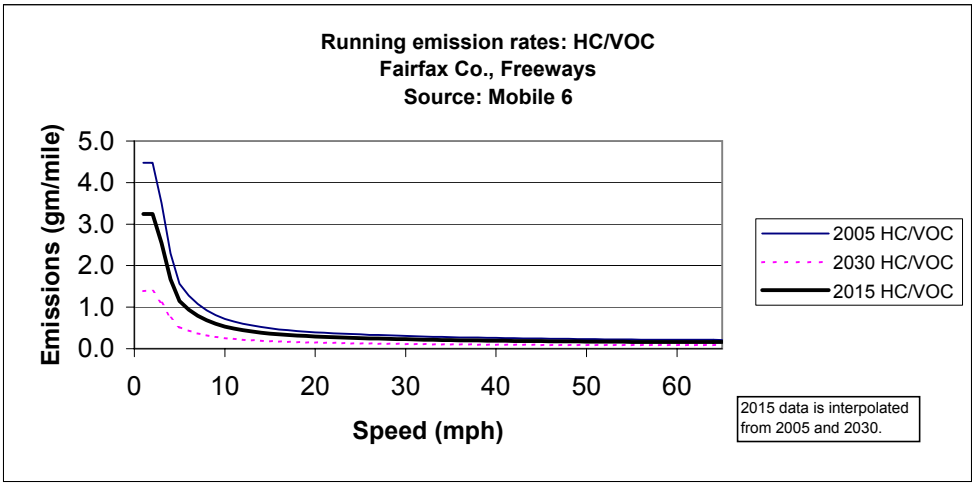
71	1.78	25.10	25.41	25.36
72	1.80	24.55	24.85	24.80
73	1.83	24.01	24.30	24.25
74	1.85	23.48	23.77	23.72
75	1.88	22.97	23.25	23.21
76	1.90	22.48	22.75	22.70
77	1.93	21.99	22.26	22.21
78	1.95	21.52	21.78	21.74
79	1.98	21.06	21.31	21.27
80	2.00	20.61	20.86	20.82
81	2.03	20.17	20.41	20.37
82	2.05	19.74	19.98	19.94
83	2.08	19.32	19.56	19.52
84	2.10	18.91	19.14	19.10
85	2.13	18.52	18.74	18.70
86	2.15	18.13	18.34	18.31
87	2.18	17.74	17.96	17.92
88	2.20	17.37	17.58	17.55
89	2.23	17.01	17.21	17.18
90	2.25	16.65	16.85	16.82
91	2.28	16.30	16.50	16.47
92	2.30	15.96	16.16	16.12
93	2.33	15.62	15.82	15.79
94	2.35	15.30	15.49	15.46
95	2.38	14.98	15.16	15.13
96	2.40	14.66	14.85	14.82
97	2.43	14.35	14.54	14.51
98	2.45	14.05	14.23	14.20
99	2.48	13.76	13.94	13.91
100	2.50	13.47	13.64	13.61
101	2.53	13.18	13.36	13.33
102	2.55	12.90	13.08	13.05
103	2.58	12.63	12.80	12.77
104	2.60	12.36	12.53	12.50
105	2.63	12.10	12.27	12.24
106	2.65	11.84	12.01	11.98
107	2.68	11.59	11.75	11.73
108	2.70	11.34	11.50	11.48
109	2.73	11.10	11.26	11.23
110	2.75	10.86	11.02	10.99
111	2.78	10.62	10.78	10.75
112	2.80	10.39	10.55	10.52
113	2.83	10.16	10.32	10.29
114	2.85	9.94	10.09	10.07
115	2.88	9.72	9.87	9.85
116	2.90	9.50	9.65	9.63
117	2.93	9.29	9.44	9.42
118	2.95	9.08	9.23	9.21
119	2.98	8.88	9.03	9.00
120	3.00	8.68	8.82	8.80
121	3.03	8.48	8.62	8.60
122	3.05	8.28	8.43	8.40
123	3.08	8.09	8.23	8.21

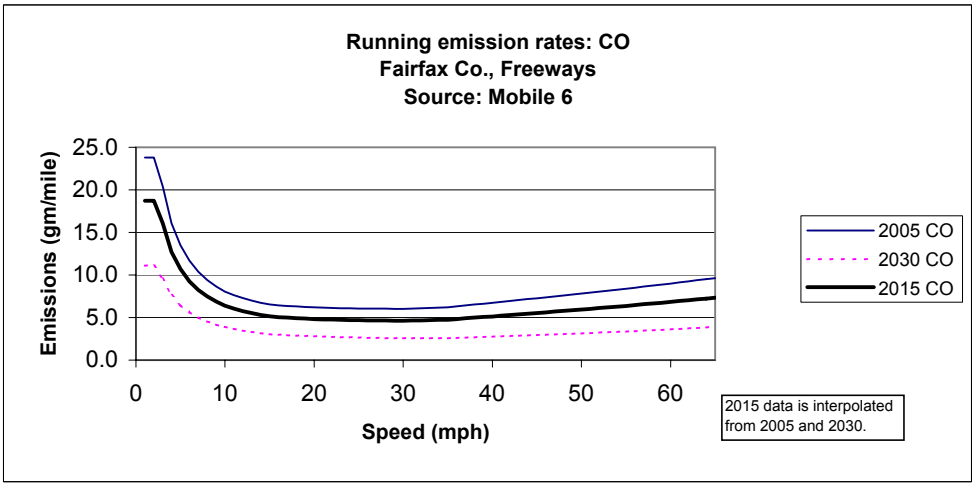
124	3.10	7.90	8.04	8.02
125	3.13	7.72	7.86	7.83
126	3.15	7.53	7.67	7.65
127	3.18	7.35	7.49	7.47
128	3.20	7.18	7.31	7.29
129	3.23	7.00	7.14	7.12
130	3.25	6.83	6.97	6.94
131	3.28	6.66	6.80	6.77
132	3.30	6.49	6.63	6.61
133	3.33	6.33	6.46	6.44
134	3.35	6.17	6.30	6.28
135	3.38	6.01	6.14	6.12
136	3.40	5.85	5.98	5.96
137	3.43	5.70	5.83	5.81
138	3.45	5.54	5.67	5.65
139	3.48	5.39	5.52	5.50
140	3.50	5.24	5.37	5.35

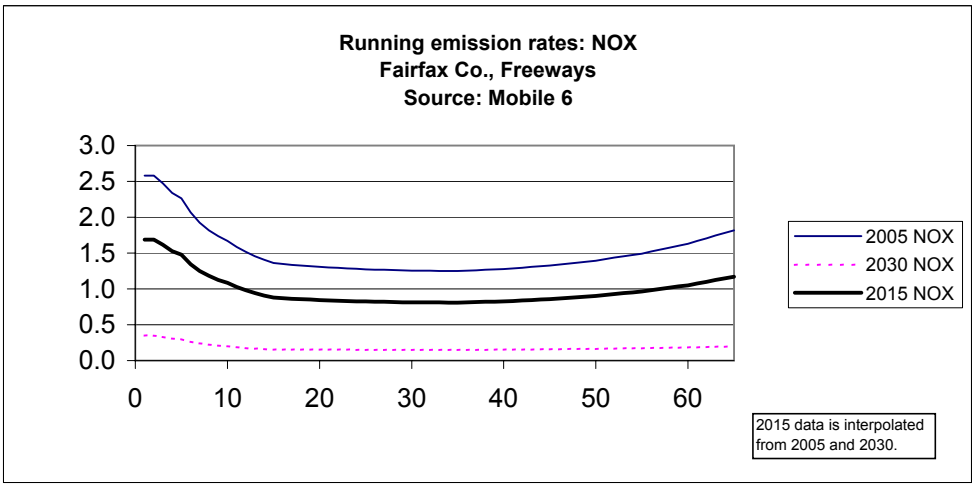
Mobile 6 running emission rates
Freeways in Fairfax

	Mobile 6 running emissions			Mobile 6 running emissions			Interpolated running emiss.		
Speed (mph)	2005 HC/VOC	2005 CO	2005 NOX	2030 HC/VOC	2030 CO	2030 NOX	2015 HC/VOC	2015 CO	2015 NOX
1	4.4770	23.7930	2.5790	1.3840	11.0970	0.3470	3.2398	18.7146	1.6862
2	4.4770	23.7930	2.5790	1.3840	11.0970	0.3470	3.2398	18.7146	1.6862
3	3.5060	20.3640	2.4740	1.0980	9.5630	0.3310	2.5428	16.0436	1.6168
4	2.2920	16.0770	2.3410	0.7400	7.6470	0.3100	1.6712	12.7050	1.5286
5	1.5630	13.5050	2.2620	0.5250	6.4970	0.2980	1.1478	10.7018	1.4764
6	1.2810	11.6880	2.0650	0.4370	5.6320	0.2650	0.9434	9.2656	1.3450
7	1.0800	10.3900	1.9240	0.3730	5.0150	0.2420	0.7972	8.2400	1.2512
8	0.9280	9.4170	1.8190	0.3250	4.5510	0.2250	0.6868	7.4706	1.1814
9	0.8110	8.6600	1.7360	0.2880	4.1910	0.2110	0.6018	6.8724	1.1260
10	0.7170	8.0540	1.6710	0.2580	3.9030	0.2000	0.5334	6.3936	1.0826
11	0.6540	7.6370	1.5870	0.2370	3.6700	0.1870	0.4872	6.0502	1.0270
12	0.6030	7.2900	1.5170	0.2180	3.4760	0.1760	0.4490	5.7644	0.9806
13	0.5600	6.9960	1.4570	0.2040	3.3110	0.1670	0.4176	5.5220	0.9410
14	0.5210	6.7440	1.4070	0.1900	3.1700	0.1590	0.3886	5.3144	0.9078
15	0.4900	6.5250	1.3630	0.1790	3.0480	0.1520	0.3656	5.1342	0.8786
16	0.4660	6.4410	1.3490	0.1700	2.9790	0.1520	0.3476	5.0562	0.8702
17	0.4440	6.3670	1.3370	0.1620	2.9180	0.1520	0.3312	4.9874	0.8630
18	0.4260	6.3020	1.3270	0.1550	2.8630	0.1510	0.3176	4.9264	0.8566
19	0.4090	6.2430	1.3170	0.1490	2.8150	0.1510	0.3050	4.8718	0.8506
20	0.3950	6.1900	1.3090	0.1430	2.7710	0.1510	0.2942	4.8224	0.8458
21	0.3820	6.1610	1.3010	0.1380	2.7380	0.1500	0.2844	4.7918	0.8406
22	0.3710	6.1340	1.2930	0.1350	2.7080	0.1500	0.2766	4.7636	0.8358
23	0.3610	6.1090	1.2860	0.1300	2.6810	0.1500	0.2686	4.7378	0.8316
24	0.3520	6.0870	1.2800	0.1270	2.6560	0.1490	0.2620	4.7146	0.8276
25	0.3430	6.0660	1.2740	0.1250	2.6330	0.1490	0.2558	4.6928	0.8240
26	0.3350	6.0570	1.2700	0.1210	2.6120	0.1490	0.2494	4.6790	0.8216
27	0.3280	6.0480	1.2660	0.1180	2.5920	0.1490	0.2440	4.6656	0.8192
28	0.3200	6.0390	1.2630	0.1150	2.5740	0.1480	0.2380	4.6530	0.8170
29	0.3140	6.0310	1.2590	0.1130	2.5560	0.1480	0.2336	4.6410	0.8146
30	0.3070	6.0240	1.2560	0.1100	2.5400	0.1480	0.2282	4.6304	0.8128
31	0.3010	6.0650	1.2550	0.1090	2.5420	0.1480	0.2242	4.6558	0.8122
32	0.2940	6.1030	1.2530	0.1060	2.5440	0.1480	0.2188	4.6794	0.8110
33	0.2880	6.1380	1.2520	0.1040	2.5460	0.1480	0.2144	4.7012	0.8104
34	0.2830	6.1720	1.2510	0.1020	2.5470	0.1470	0.2106	4.7220	0.8094
35	0.2780	6.2040	1.2500	0.1010	2.5490	0.1470	0.2072	4.7420	0.8088
36	0.2730	6.3200	1.2550	0.0980	2.5900	0.1480	0.2030	4.8280	0.8122
37	0.2700	6.4290	1.2610	0.0970	2.6280	0.1490	0.2008	4.9086	0.8162
38	0.2670	6.5330	1.2660	0.0960	2.6640	0.1490	0.1986	4.9854	0.8192
39	0.2620	6.6320	1.2710	0.0950	2.6990	0.1500	0.1952	5.0588	0.8226
40	0.2600	6.7260	1.2760	0.0940	2.7310	0.1500	0.1936	5.1280	0.8256
41	0.2560	6.8440	1.2860	0.0930	2.7740	0.1520	0.1908	5.2160	0.8324
42	0.2530	6.9560	1.2960	0.0910	2.8140	0.1530	0.1882	5.2992	0.8388
43	0.2500	7.0630	1.3060	0.0900	2.8520	0.1540	0.1860	5.3786	0.8452
44	0.2470	7.1650	1.3150	0.0890	2.8890	0.1550	0.1838	5.4546	0.8510
45	0.2450	7.2630	1.3240	0.0880	2.9240	0.1560	0.1822	5.5274	0.8568
46	0.2410	7.3820	1.3390	0.0870	2.9680	0.1570	0.1794	5.6164	0.8662
47	0.2390	7.4970	1.3540	0.0860	3.0100	0.1590	0.1778	5.7022	0.8760
48	0.2360	7.6070	1.3680	0.0850	3.0500	0.1600	0.1756	5.7842	0.8848
49	0.2340	7.7120	1.3810	0.0840	3.0890	0.1610	0.1740	5.8628	0.8930

50	0.2310	7.8130	1.3940	0.0830	3.1260	0.1620	0.1718	5.9382	0.9012
51	0.2290	7.9350	1.4150	0.0830	3.1730	0.1640	0.1706	6.0302	0.9146
52	0.2270	8.0520	1.4360	0.0830	3.2170	0.1660	0.1694	6.1180	0.9280
53	0.2250	8.1650	1.4550	0.0820	3.2600	0.1680	0.1678	6.2030	0.9402
54	0.2230	8.2740	1.4740	0.0820	3.3010	0.1700	0.1666	6.2848	0.9524
55	0.2210	8.3780	1.4920	0.0810	3.3400	0.1710	0.1650	6.3628	0.9636
56	0.2190	8.5100	1.5210	0.0810	3.3950	0.1740	0.1638	6.4640	0.9822
57	0.2190	8.6370	1.5490	0.0810	3.4480	0.1760	0.1638	6.5614	0.9998
58	0.2170	8.7590	1.5760	0.0810	3.5000	0.1780	0.1626	6.6554	1.0168
59	0.2170	8.8780	1.6030	0.0810	3.5490	0.1800	0.1626	6.7464	1.0338
60	0.2150	8.9920	1.6280	0.0810	3.5970	0.1820	0.1614	6.8340	1.0496
61	0.2140	9.1280	1.6680	0.0820	3.6550	0.1850	0.1612	6.9388	1.0748
62	0.2140	9.2590	1.7070	0.0810	3.7110	0.1880	0.1608	7.0398	1.0994
63	0.2130	9.3860	1.7450	0.0820	3.7660	0.1910	0.1606	7.1380	1.1234
64	0.2130	9.5080	1.7820	0.0820	3.8190	0.1940	0.1606	7.2324	1.1468
65	0.2110	9.6280	1.8170	0.0820	3.8700	0.1970	0.1594	7.3248	1.1690


Running emission rates: HC/VOC
Fairfax Co., Freeways
Source: Mobile 6
Emissions (gm/mile)
5.0
4.0
3.0
2.0
1.0
0.0
0
10
20
30
40
50
60
Speed (mph)
2005 HC/VOC
2030 HC/VOC
2015 HC/VOC
2015 data is interpolated from 2005 and 2030.


Running emission rates: CO
Fairfax Co., Freeways
Source: Mobile 6
Emissions (gm/mile)
25.0
20.0
15.0
10.0
5.0
0.0
0
10
20
30
40
50
60
Speed (mph)
2005 CO
2030 CO
2015 CO
2015 data is interpolated from 2005 and 2030.


Running emission rates: NOX
Fairfax Co., Freeways
Source: Mobile 6
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
2005 NOX
2030 NOX
2015 NOX
2015 data is interpolated from 2005 and 2030.