I-95/I-395 HOV RESTRICTION STUDY

VOLUME I: SUMMARY REPORT

PREPARED FOR:

VIRGINIA DEPARTMENT OF TRANSPORTATION
Transportation Planning Division

PREPARED BY:

BMI
with
TYLIN International
Travesky & Associates, Ltd.
SG Associates, Inc.
Gallop Corporation
MCV Associates, Inc.

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Table of Contents

I. INTRODUCTION 1

Importance of HOV Facilities 1

History of HOV in Corridor 1

Current HOV Facility 2

Purpose and Objectives of Study 2

Methodology 4

II. CURRENT CONDITIONS 12

HOV Traffic Conditions 12

HOV Speeds and Travel Times 12

HOV Level of Service 12

HOV Safety, Violations and Enforcement 14

Transit in the Corridor 15

Dynamic Ridesharing (Slugs and Bodysnatchers) 15

III. PUBLIC INFORMATION PROGRAM 19

IV. FINDINGS 21

What are the impacts on HOV and transit usage if the HOV 3+ restriction was changed to HOV 2+ for the entire corridor ? 21

What are the impacts on HOV and transit usage if the HOV 3+ restriction was changed to HOV 2+ outside of the Beltway only? 30

Is it feasible to provide a third HOV lane inside the Beltway? 39

What are the impacts of changing the hours of HOV restrictions during the AM and/or PM periods? 43

How will construction of the new Springfield Interchange affect HOV operations? 46

Is a new ramp to Seminary Road justified and feasible? 46

Is a new ramp to Route 123 justified and feasible? 49

Is a new ramp to the Fairfax County Parkway justified and feasible? 49

What would be the impact of allowing southbound non-HOV traffic on the HOV lanes to exit at the Franconia-Springfield Parkway? 52

V. CONCLUSIONS 53

APPENDIX A TECHNICAL COMMITTEE MEMBERS 56

APPENDIX B ILLUSTRATIVE EXAMPLES OF SIX LEVELS OF SERVICE (LOS) CATEGORIES 58

APPENDIX C SUMMARY OF PUBLIC COMMENTS 59

APPENDIX D PROJECT STUDY CORRIDOR MAP 61

LIST OF TABLES

1. Comparison of HOV and Non-HOV Lanes for AM and PM Restricted Periods 3

2. Number of Accidents on HOV Lanes for 1996 and 1997 Transit Operations in the Corridor 14

3. Transit Operations in the Corridor 16

4. Major Slug Pick-Up Locations 17

5. Distribution of Slug Matching Activities 18

6. Change in Restricted Period Demand on the HOV Lanes under HOV 2+ for the Entire Corridor 26

7. Transit Impacts under HOV 2+ Restriction for Entire Corridor 29

8. Change in Restricted Period Demand on the HOV Lanes under HOV 2+ Outside the Beltway and HOV 3+ Inside the Beltway 35

9. Transit Impacts under the HOV 2+ Outside the Beltway and HOV 3+ Inside the Beltway 38

LIST OF FIGURES

1. General Work Program. 5

2. Mode Split Model (Pivot Point Model). 9

3. Mode Split Process. 9

4. Current Person and Vehicle Volumes on HOV Lanes. 13

5. Corridor Peak Hour Mode Shares under HOV 2+ Restriction for EntireCorridor. 22

6. 1998 Person and Vehicle Volumes Under HOV 2+ Restriction for Entire Corridor. 23

7. 2010 Person and Vehicle Volumes under HOV 2+ Restriction for Entire Corridor. 24

8. Comparison of 1998 HOV Facility Traffic Operations under HOV 3+ vs. HOV 2+ Restriction for Entire Corridor. 27

9. Comparison of 2010 HOV Facility Traffic Operations under HOV 3+ vs. HOV 2+ Restriction for Entire Corridor. 28

10. Corridor Peak Hour Mode Shares Under HOV 2+ Restriction Outside Beltway and HOV 3+ Restriction Inside Beltway. 31

11. 1998 Person and Vehicle Volumes Under HOV 2+ Restriction outside Beltway and HOV 3+ Restriction Inside Beltway. 32

12. 2010 Person and Vehicle Volumes Under HOV 2+ Restriction. 33

13. Comparison of 1998 HOV Facility Traffic Operations under HOV 3+ vs. HOV 2+ Restriction Outside Beltway and HOV 3+ Restriction Inside Beltway. 36

14. Comparison of 2010 HOV Facility Traffic Operations under HOV 3+ vs. HOV 2+ Restriction Outside Beltway and HOV 3+ Restriction Inside Beltway. 37

15. Typical Existing Cross Section on I-395 HOV. 40

16. Possible Option for Adding Third HOV Lane. 42

17. Potential Changes in HOV Demand due to Springfield Interchange Construction. 47

18. Conceptual Plan for HOV Ramp at Seminary Road. 48

19. Conceptual Plan for HOV Ramp at Route 123. 50

20. Conceptual Plan for HOV Ramp at Fairfax County Parkway. 51

EXECUTIVE SUMMARY

The I-95/I-395 **H**igh **O**ccupancy **V**ehicle (HOV) facility is a reversible two-lane freeway, about 27 miles long, between the southern terminus at Dumfries near Route 234 and the northern terminus between Route 27 and Eads Street in Arlington. Beyond this northern terminus, there are separate lanes for northbound and southbound traffic that extend across the Potomac River on the Rocheambeau Bridge. During the HOV-restricted periods, the HOV facility carries more people at higher speeds than the parallel general purpose lanes. The advantages of reliable higher speeds and lower travel times make the HOV lanes attractive to a large number of commuters in carpools, vanpools and buses.

The Virginia Department of Transportation (VDOT) frequently receives comments from citizens, specifically those using the general purpose lanes, that the HOV facility is underutilized. The HOV facility is viewed by some to be inefficient and propose that its restrictions on usage be modified. These concerns led VDOT to have this study undertaken. A technical committee was formed, comprised of representatives from numerous agencies, organizations and private transportation providers, to guide and monitor the study. Alternatives were identified for evaluation that included:

1) Changing the HOV lane occupancy requirements from HOV 3+ to HOV 2+ for either the entire corridor or for a portion of the corridor (e.g., HOV 2+ outside the Capital Beltway and HOV 3+ inside the Beltway),

2) Changing the HOV-restricted times during the morning (AM) and/or afternoon/evening (PM) periods,

3) Providing additional access ramps to/from the HOV facility at appropriate locations, and

4) Providing three (3) HOV lanes inside the Beltway.

In addition, the study team was directed to investigate the potential impacts on HOV lane demand that could result from upcoming construction activities associated with the Springfield I-95/I-395/I-495 interchange improvement project.

The findings of this study are summarized below in terms of the questions that were posed by VDOT and the Technical Committee.

What are the impacts on HOV and transit usage if the HOV 3+ restriction was changed to HOV 2+ for the entire corridor ?

This change is projected to result in significantly higher traffic volumes on the HOV lanes, with AM peak hour volume increases of 30 to 50 percent inside of the Beltway. These higher volumes will cause travel speeds to drop by 50 percent, to an average speed of 32 mph from Arlington south to the Beltway. A corresponding degradation in level of service to LOS E or F for this section is also projected. Provision of a third HOV lane inside the Beltway may relieve this congestion; however, the estimated cost to provide a third lane inside the Beltway is approximately $22 million and, in the end, will result in a facility with substandard shoulder and lane widths. By 2010, traffic volumes outside the Beltway will necessitate addition of a third HOV lane at least down to the Fairfax County Parkway. Although traffic volumes are projected to increase dramatically, person movement on the HOV lanes will remain relatively constant due to the fact that the increased traffic volumes on the HOV lanes will come primarily from a breakup of 3 or more person carpools already in the HOV lanes into 2-person carpools. To the extent that persons now traveling in the general purpose lanes divert to the HOV lanes, those trips are likely to be replaced on the general purpose lanes by trips diverting from other roadways.

Increased congestion, decreased speeds, and the need to only have 2 persons in a car on the HOV lanes will also have negative effects on bus and vanpool operators. Private and public bus ridership could decrease by as much as 50 to 80 percent and vanpool riders could be reduced by 60 percent. This will result in lower fare revenues and increased operating costs. A change to HOV 2+ will also significantly diminish the effectiveness of current informal carpool matching, or slugging, activities. This change is projected to result in only modest regional vehicle emission increases, estimated by MWCOG to be on the order of 0.01 to 0.06 percent.

What are the impacts on HOV and transit usage if the HOV 3+ restriction was changed to HOV 2+ outside of the Beltway only?

This change is projected to result in a 30 to 60 percent increase in traffic outside of the Beltway on the HOV lanes, although travel speeds will remain high enough to provide an incentive for HOV use. Traffic volumes inside of the Beltway will decrease by approximately 15 percent as persons currently in 3 or more person carpools split into 2-person carpools to take advantage of the travel time savings outside of the Beltway while not having to continue forming 3 or more person carpools. In the short term, projected increases in traffic volumes will not reduce existing speeds or result in LOS E or F conditions; however, there will be a critical issue related to the transition of 2-person vehicles from the HOV lanes to the general purpose lanes that will need to occur south of the Beltway, at the Newington flyover ramp, which will result in increased congestion at the merge onto the general purpose lanes. In 2010, this problem will be alleviated by the new ramps planned from the HOV lanes to the Beltway, which is now scheduled as the final phase of the improvement program. By 2010, increased vehicle volumes outside of the Beltway will result in LOS E or F conditions on projected between Edsall Road and the Horner Park & Ride Lot exit ramp. Although speeds and travel time are not expected to deteriorate significantly, traffic volumes on this section will be approaching capacity with an increased likelihood of slowdowns and diminished reliability.

Effects of this change on transit and vanpool usage is much less significant than it is with a change to HOV 2+ for the entire corridor, with ridership decreases projected in the 10 to 20 percent range. This change will also be much less damaging to slugging activities, since most slug trips are made to points in the northern portion of the corridor, which would remain at HOV 3+. The estimated effects on air quality are slight, with only a nominal increase in nitrogen oxides projected.

What are the impacts of changing the hours of HOV restrictions during the AM and/or PM periods?

Extending the restricted periods of HOV operations by a half hour, either by starting earlier in the morning at 5:30 AM instead of 6:00 AM, or extending operations later in the evening from 6:00 PM to 6:30 PM, could in the long term serve to increase person movement on the HOV lanes during these half hour periods as demand and congestion increase on the general purpose lanes. However, in the short term, total person trips on the HOV and general purpose lanes combined could decrease during the extended half hour periods by approximately 10 percent. Increases in transit and vanpool ridership are expected on the order of 1 to 3 percent for the peak period. Shortening the restricted period in the morning by ending HOV restrictions at 8:30 AM would probably not have negative impacts in the southern portion of the corridor, but may lead to congested conditions in the HOV lanes in the northern portion of the corridor during this 8:30 to 9:00 half hour period. The upcoming Springfield interchange construction project, which is scheduled to continue for up to eight years, could accelerate the rate of projected demand growth for the HOV lanes, which would argue for extending the HOV-restricted periods rather than shortening them. Were it not for the interchange construction project, ending the restricted period earlier in the AM could have been warranted, at least in the southern portion of the corridor.

Are new ramps to/from the HOV lanes justified and feasible?

More access points to and from the HOV lanes should enhance utilization of the HOV facility. New access ramps for morning northbound/evening southbound HOV traffic at Seminary Road, Route 123 and the Fairfax County Parkway are all feasible from an engineering perspective but will be costly, $5.2 million, $26.9 million, and $12.2 million, respectively. In lieu of adding a ramp at Seminary Road, one possibility would be to construct a new slip ramp from the northbound HOV lanes to the general purpose lanes at a point between Edsall Road and

Route 236 (Duke Street). This new ramp would serve to enhance HOV and bus access to Alexandria and Arlington. In addition, if it could be constructed quickly in conjunction with implementation of the HOV 2+ outside Beltway/HOV 3+ inside Beltway alternative, this ramp would divert traffic from the Newington flyover ramp and remove traffic from the Beltway interchange construction area. Projected volumes for a new Rt. 123 ramp are relatively low, but a new ramp at the Fairfax County Parkway could attract as many as 500 HOV vehicles per hour. Demand estimates for a new ramp at Seminary Road are approximately 200 to 300 HOV vehicles per hour.

How will construction of the new Springfield Interchange affect HOV operations ?

Considerable delays to vehicles on the general purpose lanes through the Springfield area are expected once the interchange construction project begins. These delays could range from 20 to 60 minutes. An analysis was performed to estimate how many new carpools might be formed given these high levels of delay on the general purpose lanes. It was estimated that traffic volumes on the HOV lanes during the AM and PM peak hours may increase by 50 to 75 percent in Prince William County and by 20 to 30 percent in Fairfax County. These increases represent 150 to 225 vehicles, and 400 to 600 vehicles, respectively. Volume increases inside of the Beltway would be expected to be much lower since over 80 percent of the person trips traveling from outside the Beltway to the Pentagon and downtown areas are already using HOV or transit modes. Vanpool ridership would not be expected to experience similar increases because most vanpool destinations are to the Pentagon and downtown areas. Only a nominal switch to transit would be expected.

I. INTRODUCTION

Importance of HOV Facilities

The metropolitan Washington, DC area has the dubious distinction of having the second worst congested road system in the United States, and the highest per capita congestion cost[1]. Traffic congestion is an unfortunate byproduct of growth in population and employment, coupled with a dependency on the use of the single occupant automobile for associated work and non-work trips and the lack of roadway capacity to meet the peak traffic demands. Traffic congestion results in reductions in mobility and safety, added costs to the movement of goods and services, stress to persons traveling on the system, and increasing air quality and environmental problems. Transportation providers have long realized that the solution to traffic congestion in dense urban areas cannot rely solely on the provision of unbounded highway capacity, but must also incorporate alternative modes (e.g., transit), demand management strategies and optimization of the person-carrying capacity of the existing highway network. The latter objective can be achieved through the use of **H**igh **O**ccupancy **V**ehicle (HOV) facilities.

The objective of an HOV facility, whether it be a reserved lane on an arterial street or freeway, or HOV lanes in separate rights-of-way, is to provide persons traveling in HOVs a cost-effective travel alternative with predictable travel times that are significantly less than they would experience as a non-HOV user. It is cost effective for the commuter because the total costs per work trip is less than driving alone. The time savings are realized because the HOV users can travel at free-flow speeds for most of the trip length, and with uncongested lanes there is a lower probability that there will be an incident that would cause a delay along the HOV facility.

History of HOV in Corridor

The Shirley Highway (I-395) component of the I-95/I-395 HOV facility was the first freeway HOV lane in the United States. Opened in 1969, it was originally a bus-only lane. The initial 4.8 mile reversible bus-only lane was extended and expanded into a 9 mile two-lane reversible facility in 1975 when it was opened to carpools and vanpools with four or more occupants (HOV 4+). In January 1989, the HOV requirement was reduced to HOV 3+. Since that time, the HOV facility has been extended further south on I-95 reaching its current limit just south of Route 234 in Dumfries in 1997. This facility, which carries 14 percent more persons during the morning HOV-restricted period (6:00 to 9:00) than the general purpose lanes and nearly 10 percent more persons during the evening HOV-restricted period (3:30 to 6:00), is recognized by the transportation community as the most successful HOV facility in the United States today.

[1] Texas Transportation Institute, *Urban Roadway Congestion* - 1982-1994

Current HOV Facility

The current HOV facility, shown in an oversize drawing provided at the end of this report, is a reversible two-lane freeway, about 27 miles long between the southern terminus at Dumfries near Route 234 and the northern terminus between Route 27 and Eads Street in Arlington. Beyond this northern terminus of the reversible lane facility, there are separate lanes for the northbound and southbound traffic which extend across the Potomac River on the Rocheambeau Bridge. These lanes terminate in Washington, D.C. at 14th Street and on I-395 just prior to the Case Bridge.

The HOV-restricted hours of operation are from 6:00 to 9:00 in the morning for northbound traffic and 3:30 to 6:00 in the afternoon/evening for southbound traffic. Trucks are permitted in the reversible lanes but must comply with HOV requirements during HOV-restricted periods. Motorcycles are permitted at all times. Access to the HOV facility is limited to the specific entry and exit ramps shown in the aforementioned drawing. In the northbound (AM) direction, there are significantly more entrances to the HOV lanes than exits from the HOV lanes. During non-restricted hours, the HOV lanes are open to either northbound or southbound general purpose (e.g., non-HOV) traffic, depending on the time of day.

Table 1 provides some key statistics that compare the performance of the HOV lanes to the general purpose lanes during the AM and PM HOV-restricted periods. By design, the HOV facility carries more people at higher speeds than the general purpose lanes, producing a trip with significantly less travel time compared to that experienced on the general purpose lanes. The advantage of reliable higher speeds and lower travel times makes the HOV lanes attractive to a large number of commuters.

Purpose and Objectives of Study

The Virginia Department of Transportation (VDOT) frequently receives comments from citizens, specifically those using the general purpose lanes, that the HOV facility is not used to its capacity. At times it is perceived that there are “hardly any vehicles on the HOV lanes” while vehicles in the general purpose lanes are at a crawl. The HOV facility is viewed by some to be inefficient; and therefore, recommend that its restrictions on usage be changed. These concerns have led VDOT to have this study undertaken.

A Technical Committee, comprised of representatives from numerous agencies (see Appendix A for list of organizations and representatives), was formed and established the following goals for the study:

1) Optimize use of the transportation system through increased person movement in the I-95/I-395 corridor.

Table 1. Comparison of HOV and Non-HOV Lanes for AM and PM Restricted Periods.

PERFORMANCE MEASURE	TIME PERIOD	
	6:00 - 9:00 AM	***3:30 - 6:00 PM***
HOV Lane Average Auto Occupancy	2.70	3.12
Non-HOV Lane Average Auto Occupancy	1.13	1.17
HOV Lane Person Movements	28,400	22,400
Non-HOV Lane Person Movements	24,900	20,500
HOV Lane Persons Per Lane Per Hour	4,700	4,500
Non-HOV Lane Persons Per Lane Per Hour	2,000	2,000
HOV Lane Mean Restricted Period Speeds (mph)	66	64
Non-HOV Lane Mean Restricted Period Speeds (mph)	25	27
HOV Route Travel Time (min)	26	26
Non-HOV Route Travel Time (min)	66	60

Source: "1997 Performance of Regional High-Occupancy Vehicle Facilities on Interstate Highways in the Washington Region, An Analysis of Person and Vehicle Volumes and Vehicle Travel Times." MWCOG. February 24, 1998.

2) Alleviate traffic congestion in the corridor.

3) Optimize HOV use in the corridor.

These goals led to the development of specific alternative changes to the HOV system that were to be evaluated, namely:

1) Change the requirements from HOV3+ to HOV2+ for either the entire corridor or for a portion of the corridor (e.g., inside/outside the Capital Beltway).

2) Change the HOV-restricted times during the morning (AM) and/or afternoon/ evening (PM) periods.

3) Provide additional access ramps to/from the HOV facility at appropriate locations.

4) Provide three HOV lanes inside the Beltway.

In evaluating these potential changes, several factors, or measures of effectiveness, were to be considered, namely:

- Vehicle volumes on HOV facility.
- Person volumes on HOV facility.
- Level of Service on HOV facility.
- Travel speeds and times for HOV trips.
- Violations and enforcement.
- Safety.
- Engineering feasibility and costs.
- Transit ridership, revenues, and costs.
- Air quality impacts.

While the evaluation focused on the HOV lanes, effects of the alternatives and potential changes on general purpose lane operations were also examined.

Methodology

The technical approach, or methodology, applied to meet the study objectives was designed to meet the general questions posed by VDOT and the Technical Committee. The general approach, which is presented schematically in Figure 1, is concisely summarized below.

Public Information Program

One of the initial efforts was to develop a public information program. Working with VDOT's Public Affairs department, a public information program was developed that consisted of the following:

- Three public informational meetings in different localities along the corridor (Fairfax County, Prince William County, and Stafford County) for invited stakeholders and the general public.

- An interactive web site that provided information about the project and allowed viewers to return comments through the Internet. In addition, for one night, a chat room was used to respond interactively to questions raised by public participants.

- A 24-hour telephone hotline.

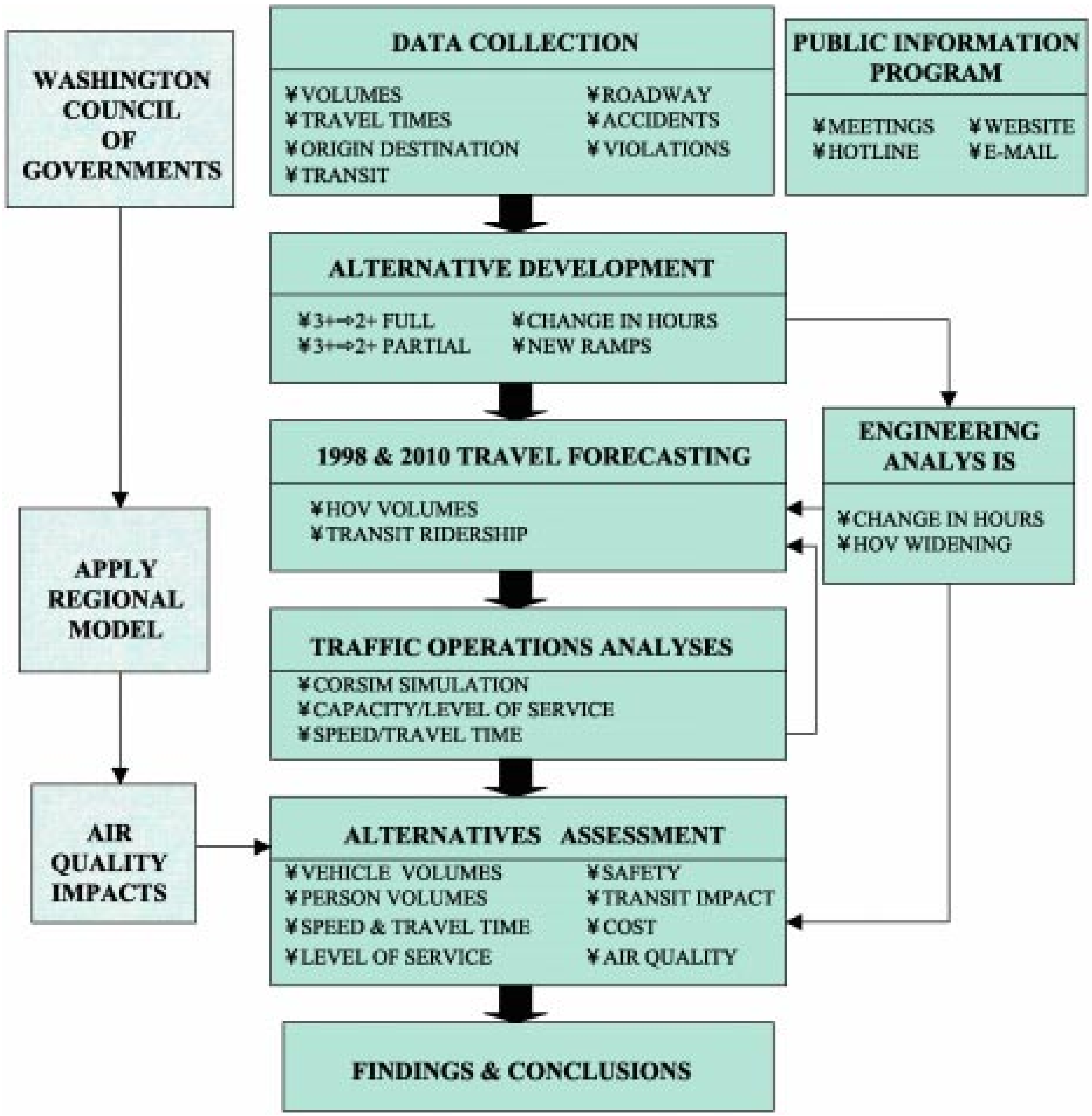


Figure 1. General Work Program.

Data Collection

To assess current HOV facility operational characteristics and gather inputs to the projection of future traffic volumes, a data collection program was developed, which consisted of the following:

- Traffic volume data collection:
    1. 72-hour portable machine counts on HOV lanes and ramps.
    2. Peak period turning movement counts at several interchanges.
    3. Peak period traffic volumes on general purpose lanes at selected locations.

- Travel time data for restricted and non-restricted periods between various points along the corridor for both the HOV and general purpose lanes.

- Transit ridership data gathered from the corridor's various transit providers.

- Data on vehicle crashes occurring on the HOV facility for the last two years were obtained from VDOT.

- Data on violations on the HOV facility for the last full year were provided by the Virginia State Police.

- Data on highway features including cross-sections and ramps were extracted from aerial photographs of the entire corridor.

The most extensive data collection activity was a video license plate matching survey undertaken to determine the travel patterns and number of vehicles on both the HOV and general purpose lanes for the entire I-95/I-395 corridor between Dumfries and Arlington. Over 45 video cameras were placed at six separate stations between Route 234 near Dumfries and the Pentagon to record the license plate, vehicle classification and time for every vehicle that passed each station during the AM and PM peak periods. The survey locations corresponded to the screenlines shown in the map at the end of this report. This data was then transcribed from the videotapes and entered into a database, which was then used with a special matching program to determine the travel patterns of trips along the corridor. For example, if a specific vehicle license plate was seen at all six recording stations, then that vehicle was known to have traveled from south of Route 234 in Dumfries to north of Arlington Ridge Road in Arlington. Over 110,000 license plate entries were made for the AM peak period alone as part of this effort. The data obtained provided critical inputs to subsequent travel demand forecasting activities. In addition to data on travel patterns, the survey also provided detailed data on travel times, vehicle classification and the proportion of out-of-state versus in-state vehicles.

Alternative Development

The next effort entailed development of specific alternatives to be analyzed. For the most part, these alternatives had already been established by the Technical Committee and only minor changes were made during the course of the project. The final alternatives that were analyzed included the following:

1. Changing the HOV restriction from HOV 3+ to HOV 2+ for the entire corridor under 1998 traffic conditions (assuming 2 HOV lanes inside Capital Beltway).

2. Changing the HOV restriction from HOV 3+ to HOV 2+ for the entire corridor under 2010 traffic conditions (assuming 3 HOV lanes inside the Capital Beltway).

3. Changing the HOV restriction from HOV 3+ to HOV 2+ outside the Capital Beltway *only* under 1998 and 2010 traffic conditions (assuming 2 HOV lanes everywhere).

4. Constructing new connecting ramps to/from the HOV lanes at Seminary Road, Route 123, and the Fairfax County Parkway interchange under 2010 traffic conditions assuming continuation of the current HOV 3+ restriction.

5. Changing the HOV-restricted time periods in the AM and PM, including both extensions and reductions of the operating hours under 1998 traffic conditions assuming HOV 3+.

Evaluation of the second and fourth alternatives above included an engineering assessment of the feasibility of providing three HOV lanes inside the Beltway and addition of the new HOV access ramps. In addition to the formal alternatives listed above, two supplemental analyses were performed: 1) an assessment of the potential impacts on HOV operations of the soon-to-be-initiated I-95/I-395/I-495 interchange reconstruction project, and 2) an investigation of the operational impacts of allowing PM southbound non-HOV traffic on the HOV lanes (that legally enters the HOV lanes at Turkeycock Run north of Edsall Road) to exit at the Franconia-Springfield Parkway off-ramp. Currently, this non-HOV traffic is required to exit at Old Keene Mill Road or move to the general purpose lanes in Springfield.

1998 & 2010 Travel Forecasting

A critical element of the work program involved forecasting HOV person and vehicle volumes and transit ridership changes that might occur under the various alternatives. A unique travel forecasting procedure was developed specifically for this study that used a mode split model, as shown in Figure 2, that was calibrated for the I-395 corridor in the mid-1980's. This model, known as the Shirley Highway Model, generates estimates of the number of people who would use single occupant vehicle (SOV), HOV and transit modes based on changes to their respective travel times and costs.

The Shirley Highway model was augmented by a sub-mode model developed for Virginia Railway Express (VRE), which was used to estimate how many transit passengers would use Metrorail, bus, or VRE. Since the object of this study was to determine how many travelers would change mode from a baseline condition during particular hours of the day, this model was applied by estimating the change in the use of each mode based on the change in relative travel times during the AM HOV-restricted period. This type of model is known as a pivot point mode split model because it produces forecasts by "pivoting" from existing conditions. The model was applied to trips between seven super-districts that comprise the corridor. These districts are defined by the area south of Route 234, Route 234 to Route 123, Route 123 to the Fairfax County Parkway, the Fairfax County Parkway to Commerce Street, Commerce Street to Edsall Road (e.g., entrances and exits to I-495), the area between Edsall Road and Arlington Ridge Road, and the area north of Arlington Ridge Road. The boundaries of the super-districts correspond to the screenlines shown in the map at the end of this report.

The role of the pivot point mode split model in the overall travel demand process for this project is depicted in Figure 3. The first step in this process was to assemble the appropriate 1998 data for input into the model. This involved combining data related to auto and van travel patterns derived from the license plate origin-destination (O/D) survey, with auto occupancy data observed by the Metropolitan Washington Council of Governments (MWCOG), and transit ridership data collected from the transit operators. This data was synthesized to develop existing person trips by mode between the seven super-districts**.** Existing travel times and estimated travel times for each scenario were then input into the pivot point mode split model along with these existing trips. The model provided estimates of the new number of trips by mode for each O/D interchange, and HOV trips were then assigned to the HOV network.

The resulting vehicle trips entering and exiting at each of the HOV lane ramps were then input into CORSIM, a computer simulation program that simulates vehicle flow, to determine the operational effects of the projected demand. CORSIM provided estimated travel times for the vehicles projected to use the HOV lanes for each HOV alternative. These CORSIM travel times were compared with the estimated travel times that were used to generate the demand. If the travel times were not comparable, then new travel times were entered into the pivot point mode split model to determine a revised HOV demand. The entire process was iterated in this fashion until the travel times simulated by CORSIM were comparable to the times input into the demand model. Once the travel times were found to be comparable, the final projected demand and operating conditions for the given alternative were accepted.

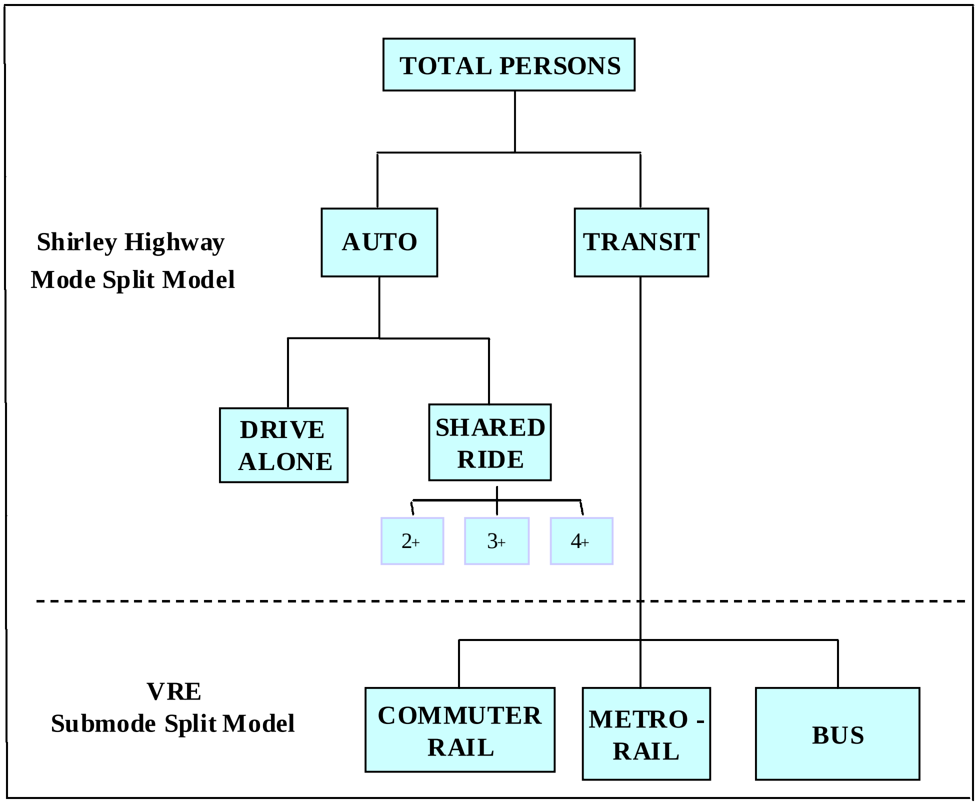


Figure 2. Mode Split Model (Pivot Point Model)

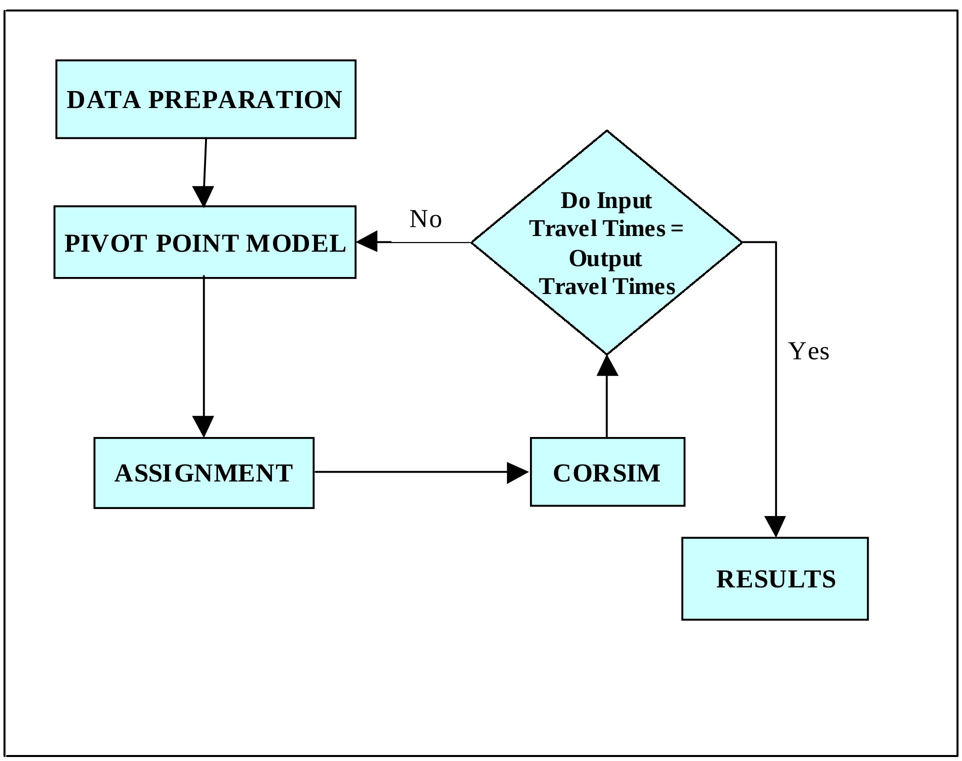


Figure 3. Mode Split Process

The same process was used to evaluate 2010 conditions for the alternatives tested for that year. The major difference was that the highway network was updated to reflect the opening of HOV ramps from the I-95/I-395 HOV lanes directly to the Capital Beltway, and that the existing trips between super-districts were factored up based on projected growth in travel by mode forecasted by MWCOG regional travel demand model. This model, which was validated in the I-95/I-395 corridor for 1998, used adopted Round 5.4 Cooperative Land Use Activity Forecasts and the Constrained Long Range Transportation Plan elements for 2010 to forecast travel growth by mode between 1998 and 2010. Outputs of the MWCOG 2010 model runs were then used to develop growth factors that were applied to the 1998 travel patterns from the O/D survey to produce 2010 travel demand forecasts for base conditions, which assume HOV 3+ for the corridor. The pivot point mode split model used for the 1998 analyses was then applied in the same way for the 2010 HOV alternative analyses.

Air Quality Impacts

MWCOG applied their standard air quality modeling process to analyze the air quality effects of the alternatives in 1998 and 2010. MWCOG staff applied a series of emissions calculation procedures to compute mobile source emissions for each of the alternatives. These procedures involve the separate estimation of mobile source components and enable the preparation of a comprehensive mobile source emissions inventory. The emissions factors (which indicate the rates at which emissions are produced by cars, trucks and buses) used in this analysis were developed from EPA’s MOBILE model and are the same factors applied in this year’s conformity assessment. Through the application of the emission factors to the MWCOG travel demand data, total mobile source emissions for each of the HOV alternatives were developed.

Engineering Analysis

While the travel forecasting and traffic operations analyses were being conducted, the engineering feasibility and cost of constructing new ramps was determined for the following interchanges:

- Seminary Road -- allowing for northbound HOV vehicles to exit at Seminary Road in the AM and return to the HOV facility southbound in the PM.

- Route 123 -- allowing for northbound HOV vehicles to exit at Route 123 in the AM and return to the HOV facility southbound in the PM.

- Fairfax County Parkway -- allowing for northbound HOV vehicles to exit at the Fairfax County Parkway in the AM and return to the HOV facility southbound in the PM.

The engineering feasibility of providing a third HOV lane inside the Capital Beltway was also examined. Alternative designs were evaluated considering VDOT design standards, with a preferred alternative presented in a conceptual scale drawing. Cost estimates were also developed.

Traffic Operations Analysis

Traffic operations analyses were performed for 1998 and 2010 conditions to determine the effects on HOV facility operations under the various alternatives. Limited analyses of operations on the general purpose lanes were also performed at ramp junctions to and from the HOV lanes. Traffic operations were evaluated in terms of level of service (LOS), travel times and speed. LOS was determined using accepted 1994 *Highway Capacity Manual* (HCM) procedures for freeway sections, merges, diverges and weaves. In addition, HCM procedures for signalized intersections were used to analyze at-grade HOV ramp termini, such as those located at the Franconia-Springfield Parkway and at Route 123.

Travel time and speed effects were evaluated using the CORSIM traffic simulation model, which simulated the flow of vehicles on the HOV facility during the AM and PM peak hours within the HOV-restricted periods. The CORSIM model also was used to analyze specific bottleneck areas, such as the one found in the AM at the Eads Street exit to the Pentagon.

Alternatives Assessment

The final steps in the work program were to compile the various impact analysis results and make an assessment of the effects of the various alternatives based on the selected measures of effectiveness. This assessment led to findings and conclusions, which are documented in the remainder of this Volume I, Summary Report. Volume II, Technical Supplement, contains background data and more inforamtion on the various analyses.

II. CURRENT CONDITIONS

HOV Traffic Conditions

Figure 4 shows current 1998 vehicle and person volumes on the HOV lanes during weekday morning and afternoon/evening periods at two locations in the corridor. These graphs show the number of persons and vehicles using the HOV lanes during both the HOV-restricted periods (shaded areas) and during the "shoulder" periods (before and after the restricted periods). Note that these volumes are shown in 15-minute increments; peak hour volumes can be derived by summing four 15-minute volumes. As shown in Figure 4, vehicle volumes in the HOV lanes are at their highest just before and just after the HOV-restricted periods, when they are open to all vehicles. However, person volumes, which include people in autos, vanpools and buses, are highest during the HOV-restricted periods.

HOV Speeds and Travel Times

During the HOV-restricted periods, travel speeds on the HOV lanes maintain free-flow levels with speeds averaging 60 to 67 miles per hour between Dumfries and Arlington. These speeds result in an average travel time of approximately 25 minutes to traverse the entire HOV facility. By way of comparison, average speeds on the general purpose lanes are half those found on the HOV lanes, resulting in non-HOV travel times that are twice as long as those found on the HOV lanes. These beneficial operating conditions on the HOV lanes provide the main incentive for formation of carpools and use of buses and vanpools in the corridor. During the non-HOV shoulder periods described above, vehicle speeds drop significantly on the HOV lanes, with a corresponding increase in travel times.

HOV Level of Service

Highway level of service (LOS) is dependent on traffic volumes, vehicle types, roadwaysection grade and traffic peaking characteristics. LOS is calculated for both mainline sections of the highway and ramp merge/diverge/weave locations. LOS ranges from LOS A to LOS F with LOS A representing free-flow uncongested conditions and LOS F representing above-capacity congested conditions. Appendix B shows examples of freeway traffic flow under the various LOS ratings.

During the AM HOV-restricted period, all mainline sections of the HOV lanes currently operate at LOS D or better, with a majority of the sections operating at LOS C or better. In addition, all of the merge and diverge locations to and from the HOV lanes operate at LOS C or better, with the exception of the merges from the Seminary Road and Shirlington interchanges, which are at LOS D.

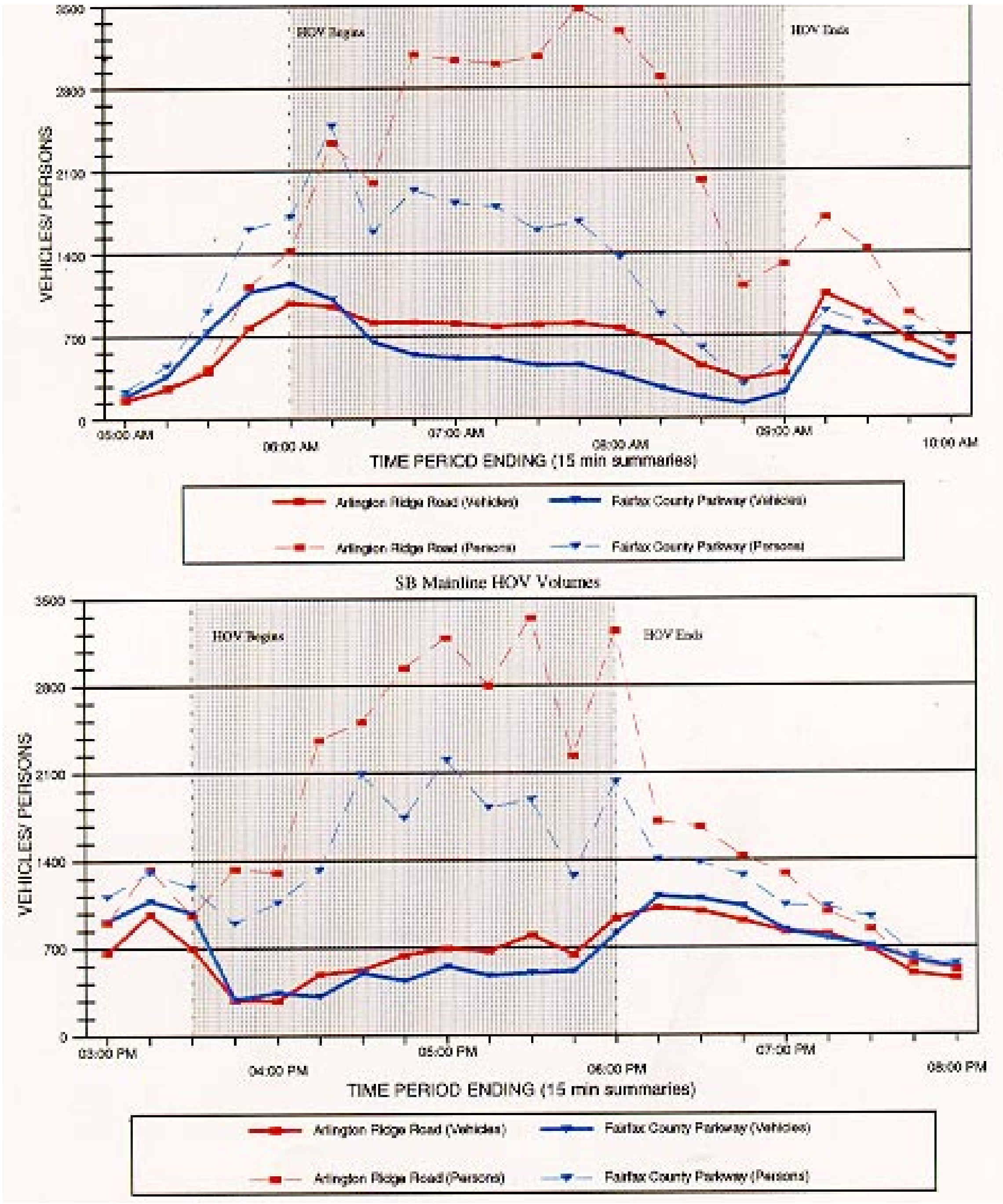


Figure 4. Current Person and Vehicle Volumes on HOV Lanes.

During the PM HOV-restricted period, all HOV mainline sections operate at LOS C or better, with the exception of the section south of the Turkeycock slip ramp north of Edsall Road, which operates at LOS E. This low level of service is caused by the influx of non-HOV traffic that is allowed to use this section of the HOV facility. All of the merge and diverge locations operate at LOS C or better, except the merge at Turkeycock Run and the diverge at Old Keene Mill Road, which is a direct result of the non-HOV traffic allowed at these locations.

HOV Safety, Violations and Enforcement

Current safety levels on the HOV lanes were determined from vehicle accident data for 1996 and 1997 obtained from VDOT's Highway Traffic Record Information System. Table 2 provides a summary of the number of reported accidents for the various operating periods in the northbound and southbound directions.

These accidents occurred throughout the 27-mile HOV facility with no one particular area more prone to accidents than others. While similar data for the general purpose lanes was not available for comparison, the HOV lane accident frequency is considered to be fairly low for a freeway facility. The reason that nearly twice as many accidents occurred in the southbound direction during PM HOV operations compared to northbound AM operations is not readily apparent and may be due to the randomness of accident occurrence.

Table 2. Number of Accidents in HOV Lanes for 1996 and 1997.*

Period	Northbound	Southbound
HOV Only		
6:00 AM to 9:00 AM	11	N/A
3:30 PM to 6:00 PM	N/A	21
Open to All Traffic		
9:00 AM to 11:00 AM	9	N/A
12:00 Noon to 3:30 PM	N/A	13
6:00 PM to 8:00 PM	N/A	15
8:30 PM to 6:00 AM	20	N/A

* Monday through Friday
N/A = not applicable

Estimates on the number HOV violators (e.g., vehicles with less than three persons) were derived from MWCOG auto occupancy count data from 1997. During the AM HOV-restricted period from 6:00 AM to 9:00 AM, data indicates that 35 percent to 45 percent of the vehicles on the HOV lanes have less than three persons. However, approximately 50 percent of these violators are on the HOV facility during the first half hour of HOV operations, which would indicate that the violation rate during the middle of the HOV-restricted period is closer to 15 percent to 20 percent. Violation rates in the PM HOV-restricted period are generally lower than the AM, with the largest numbers of violations occurring in the last half hour of HOV operations. It is important to note that, particularly during the AM HOV-restricted period, it is possible for a non-HOV vehicle to enter the HOV lanes before the restricted period begins and not reach an exit from the HOV lanes until after the restricted period has begun. This would still be a legal trip on the HOV lanes and could account for a portion of the relatively high AM violation rate during the first half hour of the HOV-restricted period.

Information on enforcement of the HOV restrictions was provided through interviews with the Virginia State Police and data they provided. With regard to HOV violations, during a 13-month period spanning 1997 and 1998, the State police issued over 15,000 tickets. HOV enforcement activities focus on ramps to and from the HOV facility, which is viewed by State Police as the most easy, safe and effective method. Also, State Police policy precludes enforcement from police cruisers stopped on freeway shoulders. In addition to enforcing HOV occupancy restrictions, the State Police have identified speeding as a particular problem on the HOV lanes.

Transit in the Corridor

Transit services in the HOV corridor include four public bus services, three private bus operations and two rail services. The public bus services are Metrobus, DASH (City of Alexandria), Fairfax Connector (County of Fairfax) and OmniRide (Potomac and Rappahannock Transportation Commission). The private bus operators are Quicks, National Coach and Lee Coaches. The rail services are Metrorail and the Virginia Railway Express Fredericksburg Line. These providers are listed in Table 3 with their general service areas as they relate to the I-95/I-395 corridor. Also shown in the table are the 1998 morning peak period transit operations (number of trips and ridership) in the I-95/I-395 corridor. Afternoon peak period services are comparable, although afternoon outbound ridership tends to be slightly greater than the morning inbound ridership.

Dynamic Ridesharing (Slugs and Bodysnatchers)

The time savings and travel reliability that are afforded by use of the HOV lanes make it attractive for drivers to seek passengers so that they can use the HOV lanes. While some travelers have formed formal carpools (groups that travel together on a daily basis), others assemble

Table 3. Transit Operations in the Corridor.

OPERATIONS	GENERAL SERVICE AREA	NUMBER OF INBOUND SCHEDULED TRIPS	ESTIMATED RIDERSHIP
Bus Services			
Private			
Lee Coaches	Spotsylania and Stafford Counties and the City of Fredricksburg	3	64
National Coach Works		12	377
Quicks		14	490
Public			
DASH	City of Alexandria	21	644
Fairfax Connector	Lorton/Newington	6	86
Metrobus	Northern Virginia/ Washington DC	179	3,905
OmniRide	Prince William County	37	691
Rail Services			
Metrorail	Franconia/Springfield Alexandria/Arlington	18	8,600
VRE	Fredericksburg/Stafford County Prince William County/ Fairfax County/ Alexandria	8	1,767
Note: Service included if any portion of the service is in operation at any point in the corridor at any time between 6:00 AM and 9:00 AM			

different groups each day. Originally, when the HOV lanes were first implemented, drivers would cruise past bus stops near I-95/I-395 seeking riders destined to the Pentagon or downtown Washington. Over time, this practice has evolved into a structured, but informal, system with well-known passenger pick-up locations and a generally-accepted culture. Persons seeking rides as passengers are known as "slugs"; drivers seeking riders are known as "bodysnatchers." The availability of transit service in close proximity to the slug pick-up points is important as a "back-up" should slugs not find rides. Slugging activities also seem to be concentrated in the early stages of the HOV-restricted periods.

Table 4 below identifies the primary locations at which slug activity is known to occur. Dynamic carpools are no doubt also formed at many individual bus stops along the corridor.

There are no formal sources of data on the number of slugs or bodysnatchers. Two methods were used in order to develop estimates of persons engaged in these activities. Since the number of afternoon pick-up locations is limited, counts of slug activity were made at each of these four locations. These persons represent those who likely slug both to and from work. In addition, there are known to be persons who slug to work in the morning, but use transit for their ride home in the afternoon. An estimate of the amount of this "morning only" slug activity was made by taking the difference between reported afternoon and morning transit ridership.

Table 4. Major Slug Pick-up Locations.

Morning Peak	
Tackett's Mill Park-Ride Lot	Prince William County
Potomac Mills Park-Ride Lot	Prince William County
Horner Road Park-Ride Lot	Prince William County
Hechingers Park-Ride Lot	Prince William County
Long John Silver's	Fairfax County
Rolling Road and Old Keene Mill Road	Fairfax County
Afternoon Peak	
14th Street at Connerce Department	Washington, DC
14th Street between Jefferson Drive and Madison Drive	Washington, DC
Fern Street	Pentagon
Bus Island	Pentagon

A total of 2,187 slugs were counted during a weekday afternoon peak period at the four locations noted in Table 4. In addition, the difference between average afternoon and morning transit ridership was calculated to be 898. The sum of these two values yields a resulting estimate of 3,085 morning peak period slugs using the I-95/I-395 corridor. The vast majority of these slugs have destinations to the Pentagon or downtown Washington, DC. This data demonstrates the significance of the "slugging" phenomenon. For example, it is estimated that approximately 25 percent of the vehicles on the HOV lanes south of the Pentagon during the AM HOV-restricted period have at least one slug in the vehicle.

To obtain additional data on the nature of dynamic carpool formation for use in evaluating the effects of the HOV alternatives on slugging, slug/bodysnatcher matching activities at the six primary suburban pick-up locations were observed. The number of persons in the arriving car (bodysnatchers) and the number of persons picked-up (slugs) was recorded. While there are variations among the locations, the overall patterns are as shown in Table 5. These data show that three-quarters of the matches involve one person picking up two or three slugs, with the majority of these matches resulting in two slugs being picked up to make a three-person vehicle. Only seven percent of the matches that occur result in vehicles with more than three persons. This indicates that bodysnatchers tend to pick up only as many slugs as they need to meet the minimum occupancy required to use the HOV lanes.

Table 5. Distribution of Slug Matching Activities.*

Persons in Arriving Car (Bodysnatchers)	*Persons Picked-up (Slugs)*			
	1	**2**	**3**	**Total**
1	——	**71%**	**4%**	**75%**
2	**22%**	**3%**	——	**25%**
Total	**22%**	**74%**	**4%**	**100%**

* Based on 659 observed matches

III. PUBLIC INFORMATION PROGRAM

The Program

The objectives of the public involvement program were twofold:

1. To make the public aware of the existence, purpose, and scope of the project.

2. To receive input from the public on issues, facts, and developments that should be considered.

At the outset of the project, it was realized that because the study corridor was so long (stretching from the Potomac River to Prince William County, VA), and the affected users so many (essentially all those who travel the corridor either in the general purpose lanes, the HOV lanes or in the various transit systems), that it would be difficult to reach out to all involved parties through the traditional methods of public meetings, newsletters, etc. Another limiting factor was that the project had a relatively short duration, which was not conducive to holding public meetings at various stages of the project. Given these limitations, it was decided that the following public information activities would be pursued:

- An announcement of the project in the newspapers identifying the sources of information.

- An interactive web site coordinated with an Internet service provider and operated for three months. In addition to the study description, the E-mail address was provided to allow for electronic correspondence. Also, there was a question of the week related to the study and a one-night chat session on the Internet was conducted.

- A web site on the VDOT home page was developed and maintained that included relevant information about the project.

- Three meetings in different localities along the study corridor (Fairfax County, Prince William County, and Stafford County) were conducted to impart information about the study objectives, scope and methodology. While formal invitations to each meeting were given to key stakeholder groups, the meetings were opened to the public and well-attended.

Results

The study team received comments from 1,641 people from project initiation through September 30, 1998, via several venues: telephone hotline (38 percent), E-mail (55 percent), and comment sheets from the meetings (7 percent). Appendix C contains a summary tabulation of the comments received. With a majority responding by E-mail, it appears that the Internet was the most effective way to reach the public and receive comment for this study. Also, the chat room over the Internet was useful for receiving public comment and responding to their questions and concerns in a real-time interactive setting.

The public information program was not designed to obtain a statistically reliable polling of the public about the various options being considered. With that caveat, key results of the feedback from the public were as follows:

<u>Responses by E-mail, telephone hotline and comment forms:</u>

- 929 comments to keep HOV-3 and 335 comments to change to HOV-2.
- 296 comments indicating HOV-2 will increase congestion.
- 178 comments that HOV-2 will destroy the ‘slug’ system.

<u>Responses through Interactive Web Site</u>

- 120 (67 percent of total) respondents support lowering carpool requirements to HOV-2.
- 64 (55 percent of total) respondents would not support starting the HOV-restricted time period earlier in morning.
- 58 (63 percent of total) respondents would not support extending the HOV-restricted time period later in the afternoon/evening.

IV. FINDINGS

The analysis findings are presented in this section in terms of the major questions that prompted this study.

What are the impacts on HOV and transit usage if the HOV 3+ restriction was changed to HOV 2+ for the entire corridor ?

The potential impacts of reducing the vehicle occupancy restriction from three or more persons to two or more persons for the entire HOV corridor were evaluated in terms of the measures of effectiveness selected for use in this study, including effects on person mode shares, person and vehicle volumes, level of service, travel times and speeds, transit ridership, safety and enforcement, and air quality. The 2010 analysis assumed that there will be three HOV lanes inside the Beltway due to the fact that the 1998 results showed that two HOV lanes would not be adequate to handle projected 2010 HOV demand under this alternative. Also, the adopted Constrained Long Range Transportation Plan for the Washington metropolitan area includes three HOV lanes for the I-95/I-395 corridor.

The effect of this alternative on corridorwide peak hour *person movement* mode shares is shown in Figure 5 for 1998 and 2010. These charts include peak hour person movement on the HOV and general purpose lanes and show a large increase in 2-occupant vehicles and a significant decrease in vanpool persons. The charts also show that the majority of persons converting to 2-occupant vehicles are from existing 3+ occupant vehicles, with little change occurring in single occupant vehicle (SOV) and transit use. These trends are consistent from 1998 to 2010.

Figures 6 and 7 show the effects of this alternative on *person and vehicle volumes* on the HOV lanes at two key corridor locations, inside the Beltway at Arlington Ridge Road and outside the Beltway at the Fairfax County Parkway, for the 1998 and 2010 AM and PM peak hours. Results from the MWCOG model runs indicate that volumes on the general purpose lanes remain constant under this alternative as compared to 1998 and 2010 base conditions. This is because trips that may be diverted to the HOV lanes under HOV 2+ operations will be replaced by trips that will divert from adjacent roadways to fill any surplus capacity on the general purpose lanes.

The peak hour person throughput volumes at Arlington Ridge Road effectively remain constant as compared to base conditions under HOV 3+, which is due to the fact that over 80 percent of persons traveling to the Pentagon and points beyond are already in high occupant modes and all that is occurring under this alternative is that persons currently in three or more occupant vehicles are splitting into two-occupant vehicles. In addition, the HOV lanes are approaching capacity inside the Beltway under this alternative, resulting in lower speeds and congested driving conditions.

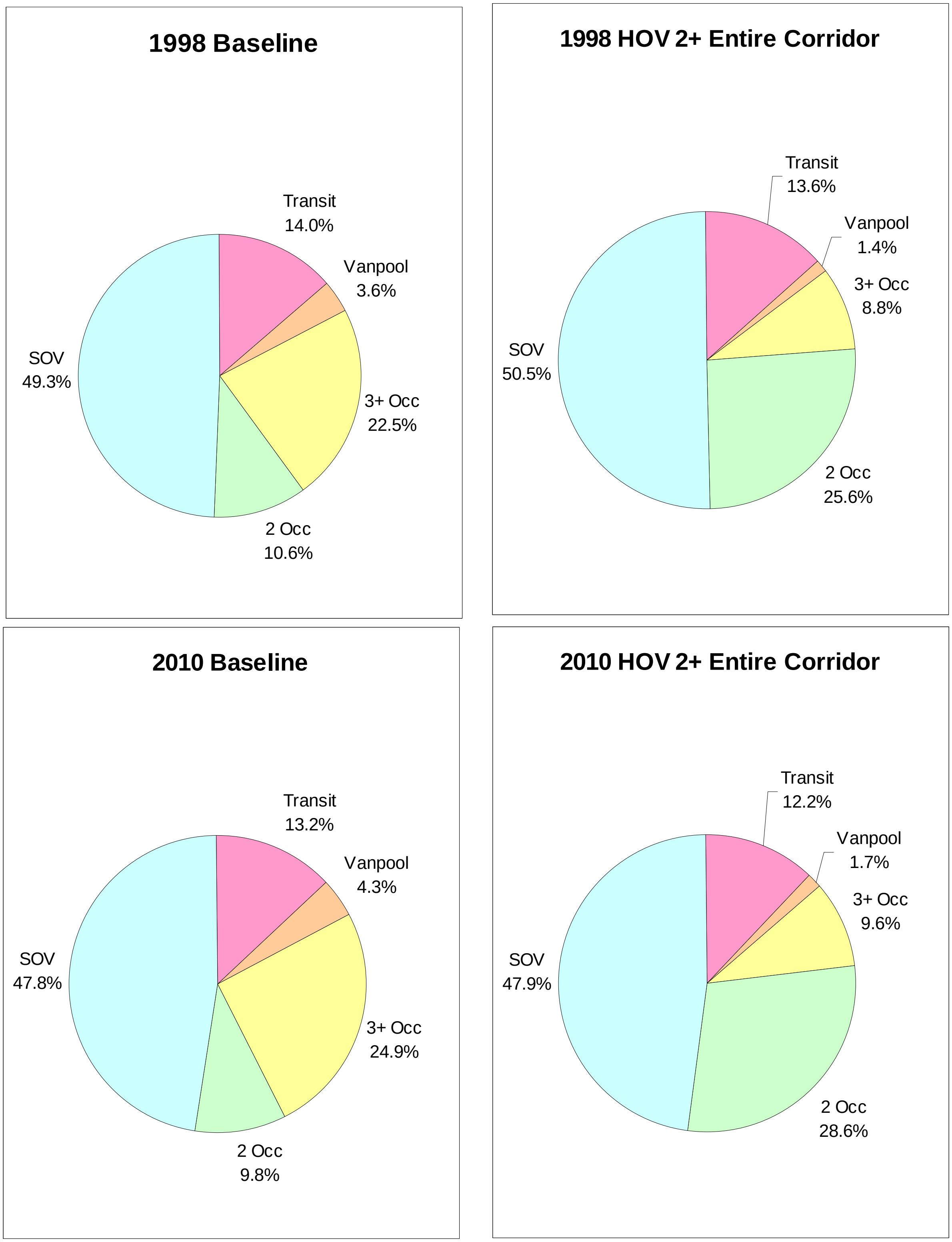


Figure 5. Corridor Peak Hour Mode Shares under HOV 2+ Restriction for Entire Corridor.

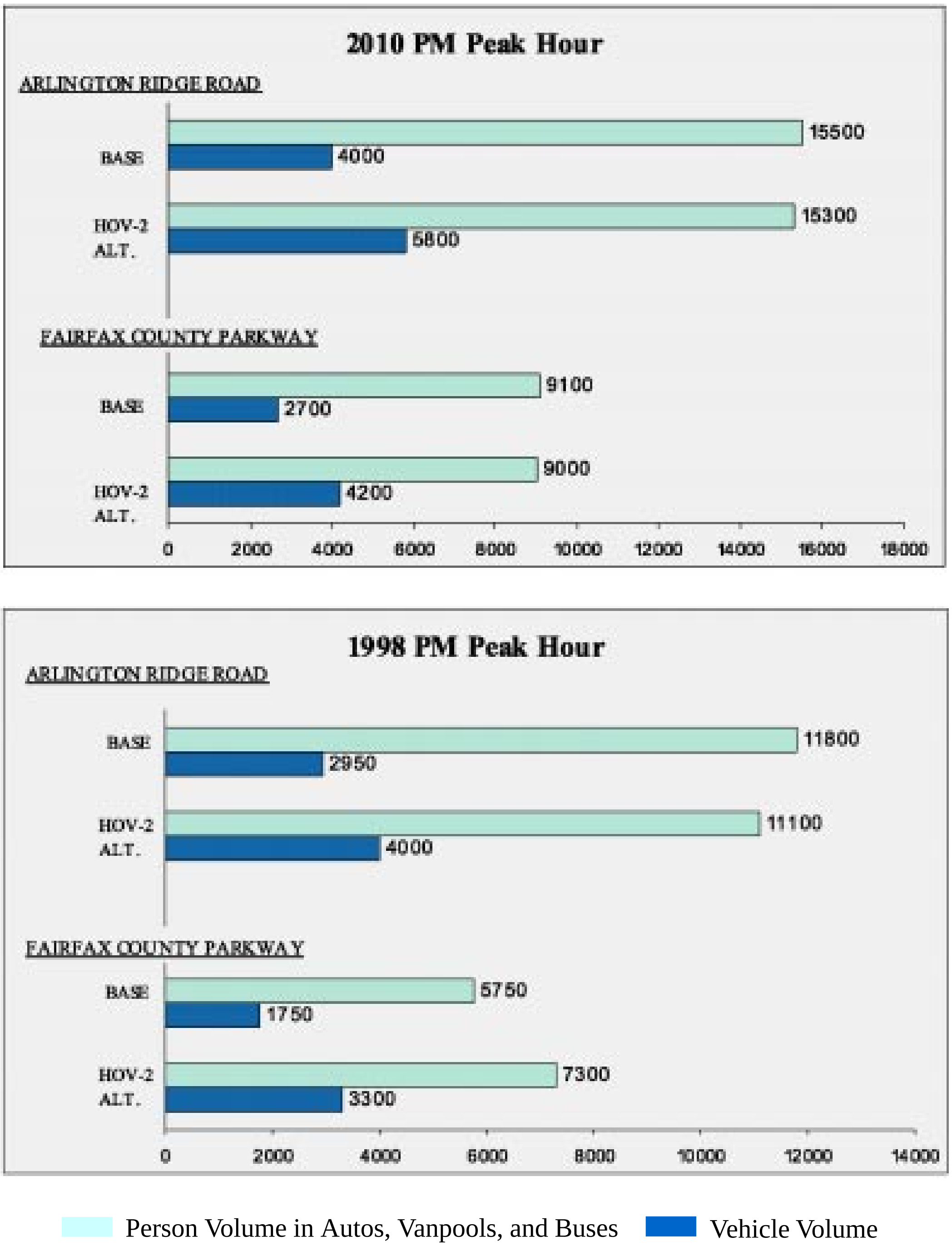


Figure 6. 1998 Person and Vehicle Volumes under HOV 2+ Restrictions for Entire Corridor.

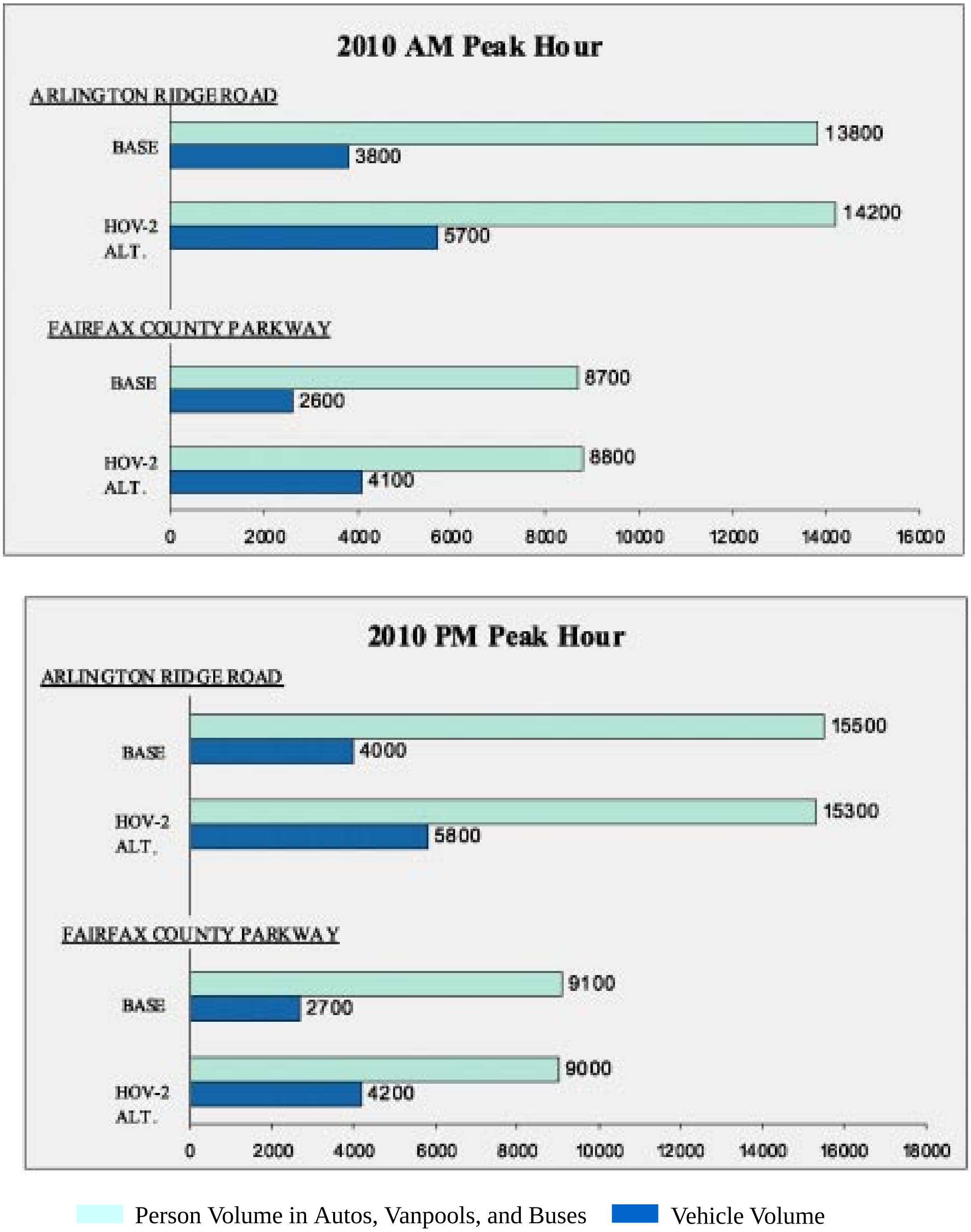


Figure 7. 2010 Person and Vehicle Volumes under HOV 2+ Restrictions for Entire Corridor.

Outside the Beltway, on the other hand, person volumes on the HOV lanes increase in 1998 under this alternative because there is demand for trips to the Beltway and northern Fairfax County that benefits from the higher speeds to be found on the HOV lanes. These speeds will remain high because, unlike conditions inside the Beltway, the HOV lanes will still be operating under capacity. However, as shown in Figure 7, person volumes outside the Beltway in 2010 remain constant because the HOV lanes are approaching capacity, resulting in lower speeds and less travel time savings.

In all cases, peak hour vehicle throughput volumes increase dramatically, as compared to base conditions, due to lower vehicle occupancies under the HOV 2+ restriction. For example, at Arlington Ridge Road in the AM peak hour, the average vehicle occupancy (including buses) on the HOV lanes in 1998 drops from approximately 3.6 persons per vehicle to 2.5 persons per vehicle. Similar reductions are seen in 2010.

Table 6 provides a summary of HOV lane person and vehicle <u>demand</u> for the AM and PM restricted periods. (The peak hour volumes shown in Figures 6 and 7 represented actual projected throughput, which is less than demand under congested conditions.) This table shows that over the course of the entire restricted period, person volumes on the HOV lanes are expected to increase under this alternative in 1998 by 2 percent at Arlington Ridge Road and by 15 percent at the Fairfax County Parkway. In 2010, person volumes are be expected to increase by 10 percent at both locations.

The effects of this alternative on HOV corridor *level of service*, *travel times and speed* are shown in Figures 8 and 9. In 1998, the increased traffic volumes discussed above result in LOS E or F conditions inside the Beltway, with a corresponding drop in speed during the AM and PM peak hours. This drop in speed results in a doubling of the time required to traverse this section of the HOV facility in the AM. In 2010, LOS E or F conditions are found throughout most of the HOV facility north of the Occoquan River. This congestion results in significant increases in travel time in the AM northbound and PM southbound directions. The HOV lanes are congested inside the Beltway despite assuming three lanes in this section. Overall, allowing 2-occupant vehicles to utilize the HOV lanes would be expected to degrade performance of the facility, particularly inside the Beltway, with significant increases in travel times for HOV users, thus making the facility less attractive to potential HOV, vanpool and bus users.

The effects of this alternative on *transit ridership and costs* are shown in Table 7. As shown in the table, the longer travel times that would be experienced by passengers on buses using the HOV lanes would result in significant losses in bus ridership. These losses would be proportionally greatest for the bus routes that travel greater distances on the HOV lanes (e.g. the private carriers from Spotsylvania and Stafford Counties and OmniRide), but Metrobus would see the greatest absolute loss in ridership. Loses in farebox revenues to each carrier would

Table 6. Change in Restricted Period Demand on the HOV Lanes under HOV2+ for Entire Corridor.

DEMAND[1]		Inside the Beltway @ Arlington Ridge Road[2]		Outside the Beltway @ Fairfax County Parkway	
		BASELINE[3]	HOV-2	BASELINE[3]	HOV-2
1998 AM	PERSONS	26,300	26,950 (+2%)	15,150	17,450 (+15%)
	VEHICLES	7,200	10,800 (+50%)	4,600	7,900 (+72%)
1998 PM	PERSONS	28,300	28,450 (+1%)	15,450	17,900 (+16%)
	VEHICLES	7,000	10,500 (+50%)	4,500	8,000 (+78%)
2010 AM	PERSONS	32,600	36,000 (+10%)	22,100	24,200 (+10%)
	VEHICLES	9,000	15,200 (+69%)	6,600	11,400 (+73%)
2010 PM	PERSONS	34,800	36,800 (+6%)	21,600	24,100 (+12%)
	VEHICLES	8,800	14,700 (+67%)	6,200	11,300 (+82%)

[1]Demand includes both buses and autos on the HOV lanes.
[2]Includes widening to three lanes inside the Beltway in 2010 for the HOV-2 Alternative.
[3]Derived from BMI license plate survey.

parallel the loss in ridership. Ridership losses are projected to be especially large for the private operators. The combined budget impacts (loss of farebox revenue and increased operating costs) are likely to threaten the viability of private carrier operations. The rail services, VRE and Metrorail, would experience increases in ridership. For 1998 conditions, there would be a small loss in total transit ridership. For 2010, the bus services would also lose ridership while rail would gain. In both years, since the average fare for rail service is greater than the bus fare for a comparable trip, there would be a net gain in transit farebox revenues.

Operating costs for bus services, per trip operated, would increase due to the increase in driver pay-hours. The operating cost impacts of service reductions by bus operators to compensate for lost ridership have not been considered in these analyses. WMATA and VRE rail services would be able to carry the projected additional riders without adding service, so no increased operating costs are identified. With respect to the projected increases in Metrorail ridership, the new riders will be using the Franconia-Springfield, Van Dorn, and to a lesser

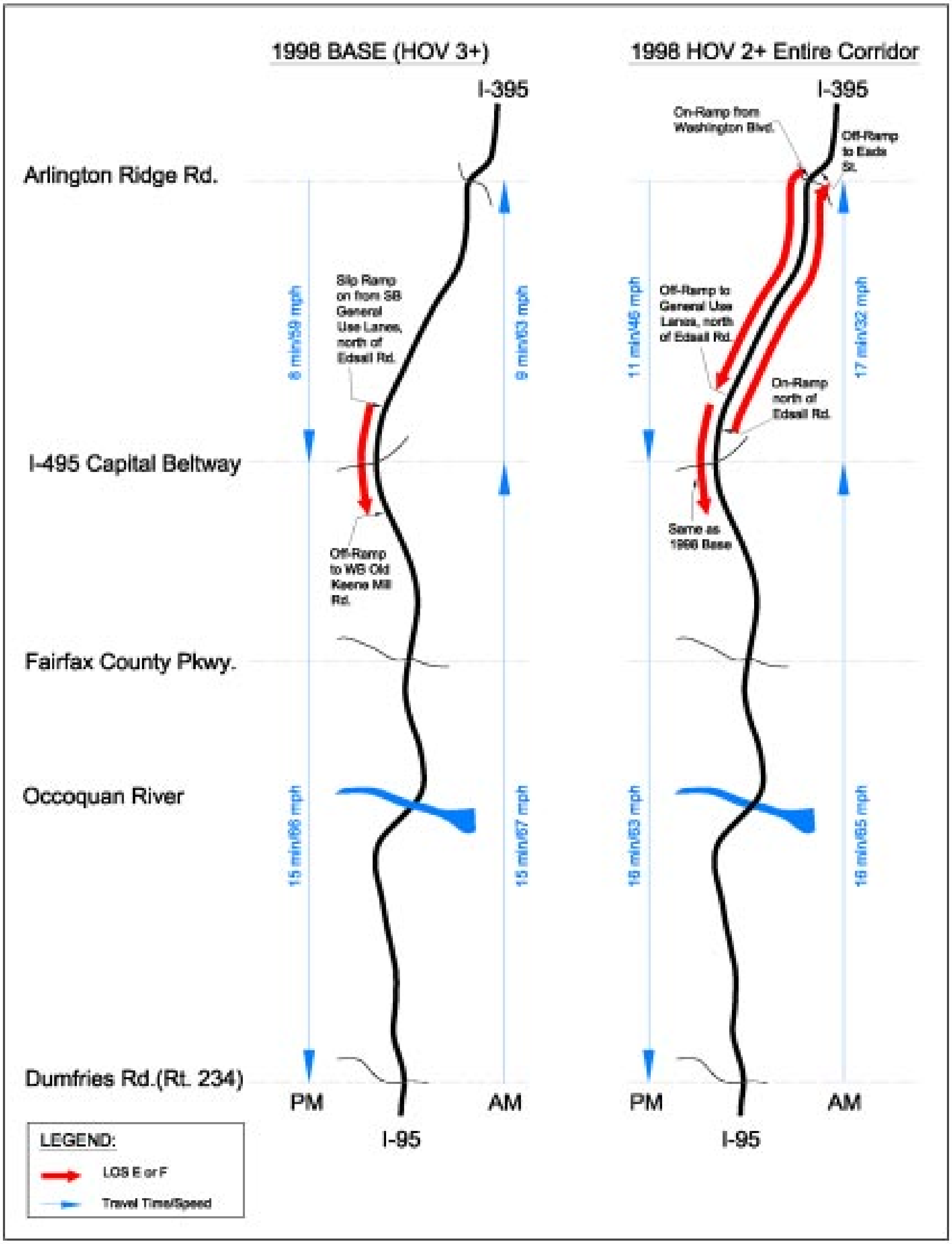


Figure 8. Comparison of 1998 HOV Facility Traffic Operations Under HOV 3+ vs. 2+ Restrictions for Entire Corridor.

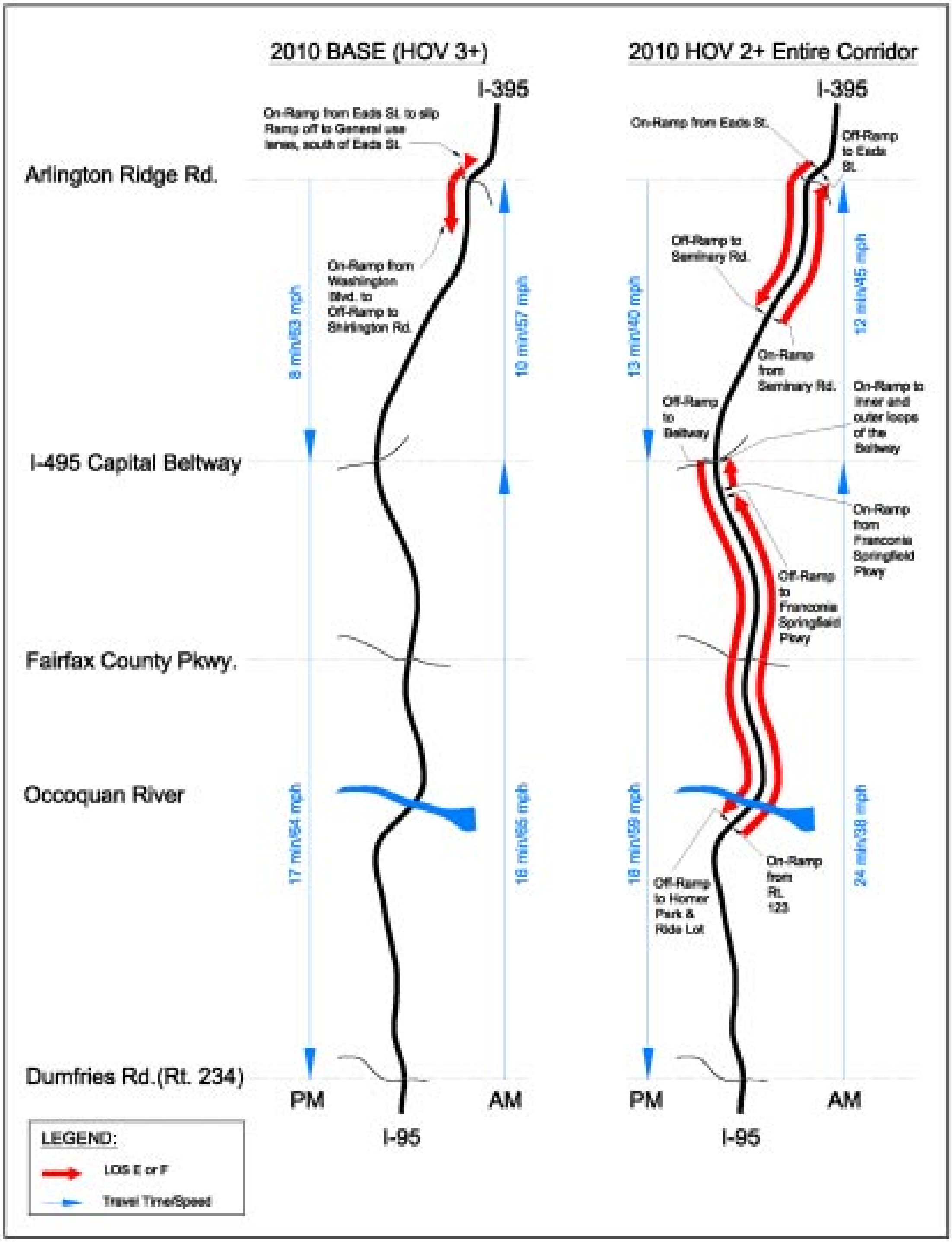


Figure 9. Comparison of 2010 HOV Facility Traffic Operations Under HOV 3+ vs. 2+ Restrictions for Entire Corridor.

Table 7. Transit Impacts under HOV 2+ Restriction for Entire Corridor.

AM RESTRICTED PERIOD PERSON TRIPS BY TRANSIT	CHANGE FROM BASE CONDITION 1998	CHANGE FROM BASE CONDITION 2010
Private Commuter Buses	-474 (-51%)	-883 (-82%)
Public Buses	-736 (-14%)	-944 (-16%)
VRE	+33 (2%)	+27 (1%)
Metrorail	+926 (11%)	+515 (5%)
Net Total Transit	**-251 (-2%)**	**-1,235 (-6%)**
ANNUAL CHANGE IN TOTAL BUDGET		
Private Commuter Buses	$1,106,818	$1,814,112
Public Buses	$5,872,188	$4,853,436
VRE	-$73,547	-$60,175
Metrorail	-$1,298,715	-$722,288
Net Total Transit	**$5,606,744**	**$5,885,085**

extent, the other stations along the Blue Line. A detailed mode-of-access analysis was not conducted to determine if parking at these stations would be adequate; however, those patrons unable to find parking would likely choose another rail access mode or continue to use bus service.

The anticipated effects of this alternative on *safety* are that, with increased volume, vehicle crashes and other incidents (e.g., disabled vehicles) will likely become more frequent, with a percentage growth rate greater than the volume increase. In addition to the economic loss associated with increased crashes, there will be more days when delays will be experienced by HOV users, thereby diminishing speed and travel time reliability.

According to the State Police representative on the Technical Committee, e*nforcement* of HOV 2+ restrictions should not be any more difficult than under the current HOV 3+ restriction, especially considering that the bulk of enforcement occurs at ramps. However, the higher HOV volumes under this alternative will likely increase the hazards of shoulder operations.

The effect of this alternative on the region's *air quality* was analyzed by MWCOG using their air quality model. Modest increases in volatile organic compound (VOC) and nitrogen oxide (NOx) emissions are expected. VOC emissions are projected to increase .04 tons/day in 1998 and .02 tons/day in 2010. NOx emissions are projected to increase .09 tons day in 1998 and .13 tons/day in 2010. However, MWCOG states that mitigation measures would not be necessary to meet regional air quality conformity requirements given these relatively small emission increases, which are on the order of .01 percent to .06 percent.

Changing the HOV restriction from 3+ to 2+ for the entire corridor will likely affect *slugging* in several ways:

1. Persons (bodysnatchers) already traveling in two-person carpools will no longer stop to pick up slugs.

2. The reduced occupancy requirement will induce some slugs to shift to formal two-person carpools.

3. The reduced travel time savings resulting from congested conditions on the HOV lanes will cause some bodysnatchers and slugs to shift to driving alone.

Analysis of current patterns of slug and bodysnatcher activity reveal that reducing the HOV occupancy restriction to 2+ could result in approximately a 14 percent reduction in the number of bodysnatchers. As a result, for current conditions, it is estimated that approximately 20 percent of current slugs (600 persons in the AM restricted period) would no longer be able to find rides. This pattern would be expected to continue in 2010.

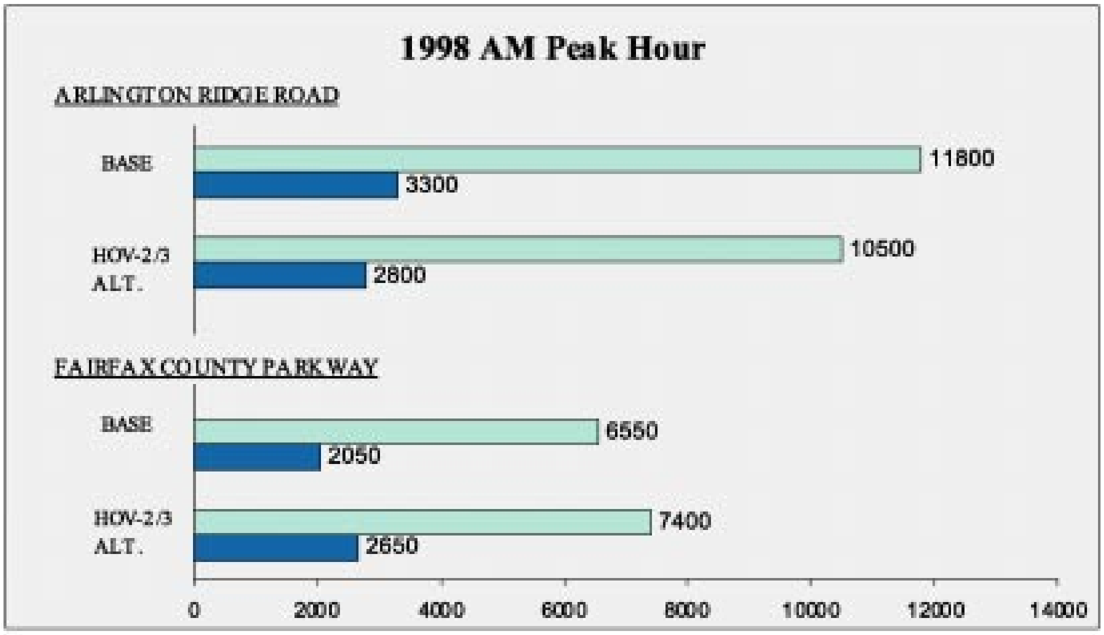
What are the impacts on HOV and transit usage if the HOV 3+ restriction was changed to HOV 2+ outside of the Beltway only?

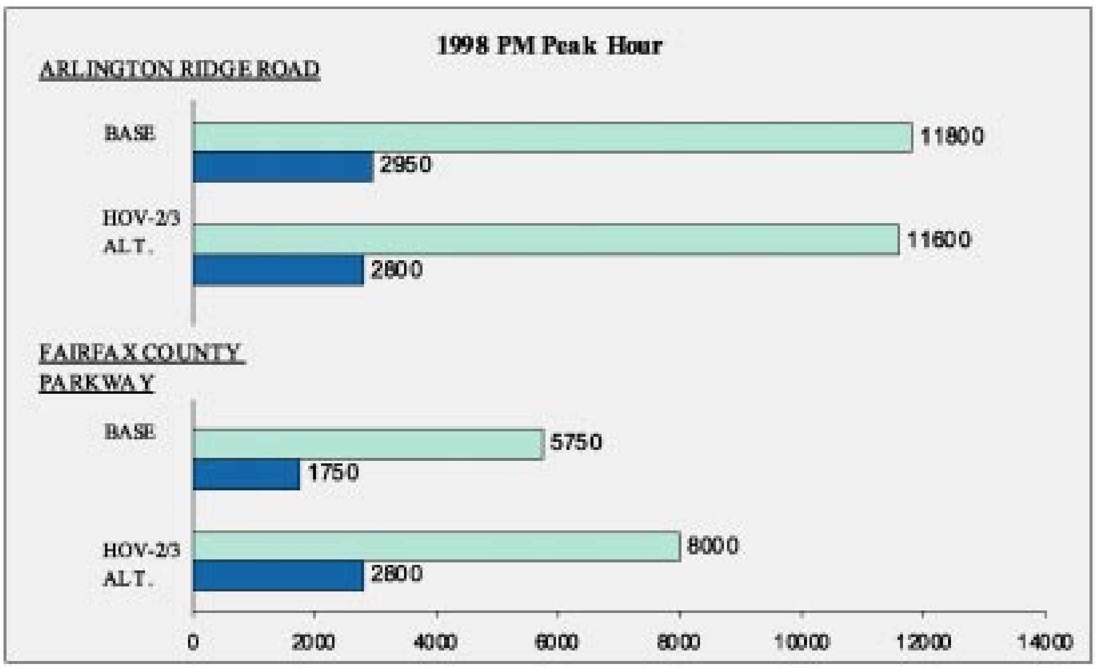
As discussed above, the majority of operational problems in 1998 under the HOV 2+ alternative are found inside the Beltway. For this reason, the impacts of permitting 2-person carpools *outside of the Beltway*, while maintaining the three or more person requirement inside the Beltway were examined. The 2010 analysis assumed a 2-lane HOV facility for its entire length. Under this alternative, all one or two person vehicles would be required to exit the HOV lanes south of the Beltway at the Newington flyover ramp from the HOV lanes to the general purpose lanes.

The effect of this alternative on corridorwide peak hour *person movement* mode shares is shown in Figure 10 for 1998 and 2010. These charts include peak hour person movement on the HOV and general purpose lanes and show an increase in 2-occupant vehicles and a slight decrease in vanpool persons. The chart also shows that the majority of persons converting to 2-occupant vehicles are coming from existing SOV and 3+ occupant vehicles, with little change occurring in transit usage. These trends are consistent from 1998 to 2010.

Figures 11 and 12 show the effects of this alternative on *person and vehicle volumes* on the HOV lanes at the two key corridor locations inside the Beltway and outside the Beltway for

Figure 10. Corridor Peak Hour Mode Shares under HOV 2+ Restriction Outside Beltway and HOV 3+ Restriction Inside Beltway





Person Volume in Autos, Vanpools, and Buses   Vehicle Volume

Figure 11. 1998 Person and Vehicle Volumes Under HOV 2+ Restrictions Outside Beltway and HOV 3+ Restrictions Inside Beltway.

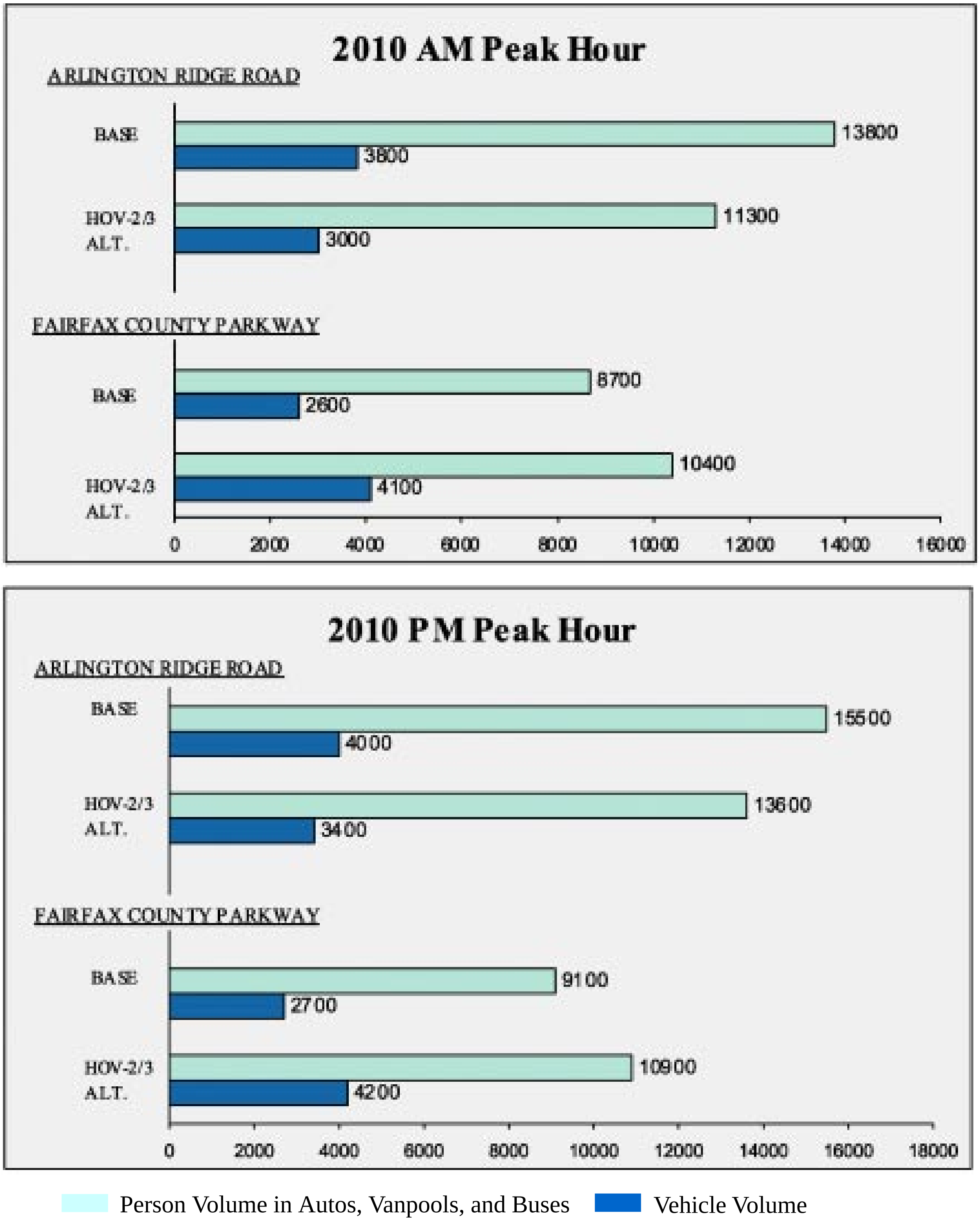


Figure 12. 2010 Person and Vehicle Volumes Under HOV 2+ Restrictions Outside Beltway and HOV 3+ Restrictions Inside Beltway.

the 1998 and 2010 AM and PM peak hours. Results from the MWCOG model runs indicate that volumes on the general purpose lanes will remain constant under this alternative as compared to 1998 and 2010 base conditions.

1998 peak hour person throughput volumes at Arlington Ridge Rd. decrease by approximately 10 percent during the AM peak hour, but remain constant during the PM peak hour. In 2010, peak hour person throughput decreases at this location by 18 percent in the AM and 12 percent in the PM. The reason for these decreases is that some of the commuters currently in three or more person vehicles that used to occupy the HOV lanes inside the Beltway, would now convert to 2-person vehicles because of the reduced travel time outside the Beltway and the increased convenience of a smaller carpool. Under this alternative, these northbound vehicles would now be required to exit the HOV lanes south of the Beltway, thereby traveling on the general purpose lanes inside the Beltway.

Outside the Beltway at the Fairfax County Parkway, person volumes on the HOV lanes are projected to increase by 13 percent to as much as 40 percent in 1998 and 2010 because there is a high level of demand for trips to the Beltway and northern Fairfax County that will benefit from the higher speeds to be found on the HOV lanes. Average vehicle occupancies generally remain constant compared to base conditions inside the Beltway, but decrease from approximately 3.25 persons per vehicle to 2.80 persons per vehicle outside of the Beltway. This drop in vehicle occupancies results in increases in total vehicles of 30 percent to 60 percent.

Table 8 provides a summary of HOV lane person and vehicle demand for the AM and PM restricted periods, which mirror the effects found during the peak hours with 10 percent to 16 percent person volume decreases inside the Beltway and 15 percent to 31 percent person volume increases outside the Beltway.

The effects of this alternative on HOV corridor *level of service, travel times and speed* are summarized in Figures 13 and 14. In 1998, LOS, speed and travel time conditions remain the same as under baseline conditions, with only one short section of LOS E or F in the PM southbound direction between Edsall Road and Springfield. There is one area of concern from a LOS standpoint in 1998, which is not reflected in Figure 13. The AM northbound flyover ramp at Newington from the HOV to general purpose lanes will experience a dramatic volume increase due to the fact that all non-HOV 3+ vehicles must exit the HOV lanes at this point under this alternative. The AM peak hour volume on the ramp is projected to be 1,425, which represents an increase of approximately 1,100 vehicles over current volumes. This volume increase will cause the general purpose lanes immediately north of the ramp junction to operate at LOS E. This will not be an issue in 2010, since there will be new HOV connector ramps constructed at the Beltway.

Table 8. Change in Restricted Period Demand on the HOV Lanes under HOV 2+ Outside the Beltway and HOV 3+ Inside the Beltway.

DEMAND		Inside the Beltway @ Arlington Ridge Road		Outside the Beltway @ Fairfax County Parkway	
		BASELINE	**HOV-2/3**	**BASELINE**	**HOV-2/3**
1998 AM	**PERSONS**	26,300	23,550 (+10%)	15,150	17,450 (+15%)
	VEHICLES	7,200	6,200 (-14%)	4,600	6,150 (+34%)
1998 PM	**PERSONS**	28,300	25,800 (-9%)	15,450	18,000 (+17%)
	VEHICLES	7,000	6,100 (-13%)	4,500	6,150 (+37%)
2010 AM	**PERSONS**	32,600	27,300 (-16%)	22,100	26,400 (+19%)
	VEHICLES	9,000	7,500 (-17%)	6,600	10,200 (+55%)
2010 PM	**PERSONS**	34,800	29,400 (-16%)	21,600	28,300 (+31%)
	VEHICLES	8,800	7,300 (-17%)	6,200	10,800 (+74%)

In 2010, the increased vehicle volumes outside of the Beltway result in LOS E or F conditions on AM northbound and PM southbound sections. In the PM, for example, LOS E or F conditions are projected between Edsall Road and the Horner Park & Ride Lot exit ramp. Although speeds and travel time are not expected to deteriorate significantly, traffic volumes on this section will be approaching capacity with an increased likelihood of slowdowns and diminished reliability.

The effects of this alternative on *transit ridership and costs* are shown in Table 9. In 1998, all transit modes are projected to lose riders, with the private operators losing 9 percent of their riders. The rail modes, VRE and Metrorail, will experience smaller ridership decreases, resulting in a net total transit ridership loss of 2 percent. The resulting revenue declines are estimated to result in an overall budget increase of approximately $505,000. In 2010, the private bus operators will lose up to 20 percent of their riders, and VRE is projected to lose approximately 10 percent of their riders. Metrorail ridership, on the other hand, will remain constant as compared to 2010 baseline conditions. As in 1998, the net total transit ridership loss will be 2 ercent; however, the total transit budget will increase by $920,429.

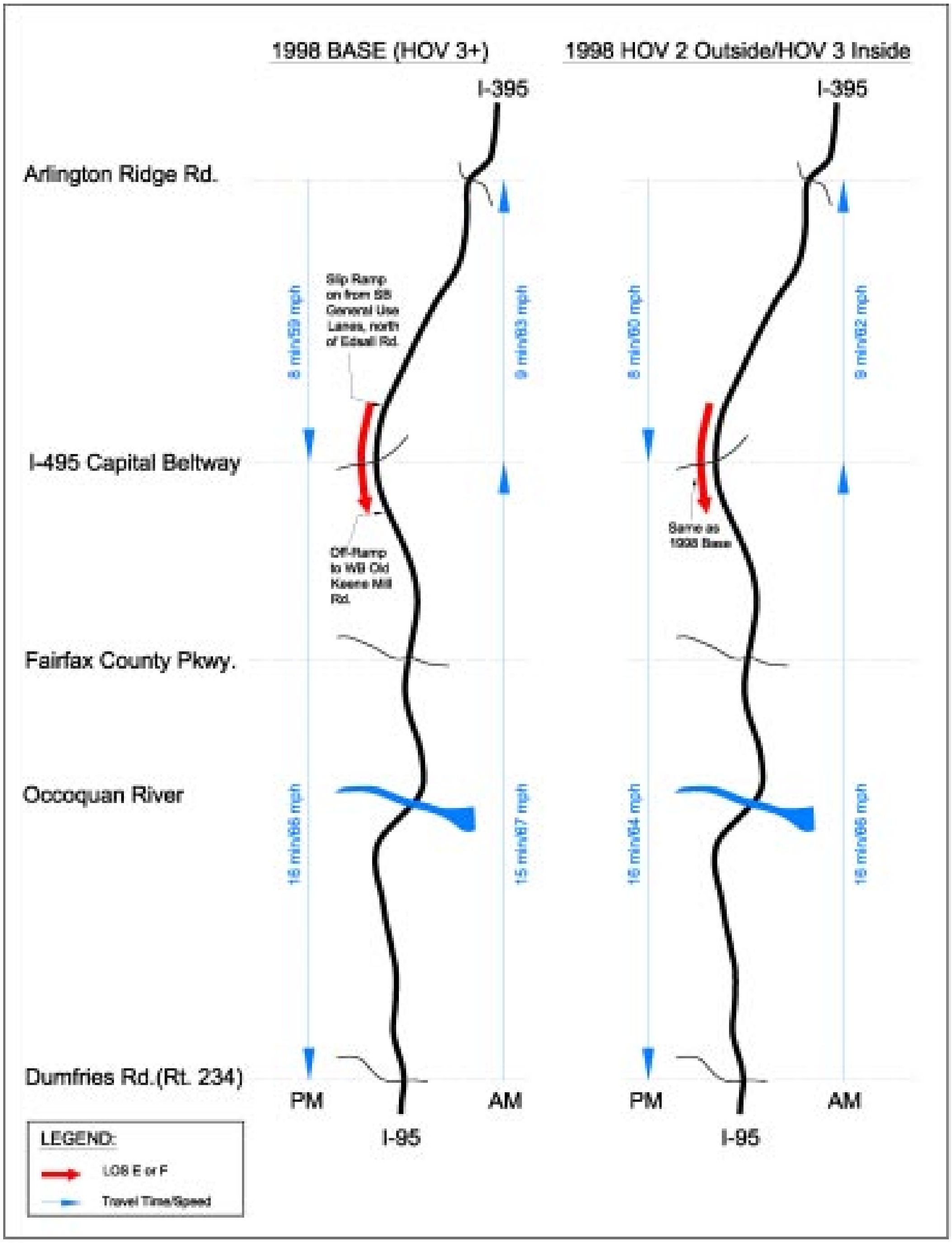


Figure 13. Comparison of 1998 HOV Facility Traffic Operations under HOV 3+ vs. HOV 2+ Restriction Outside Beltway and HOV 3+ Restriction Inside Beltway.

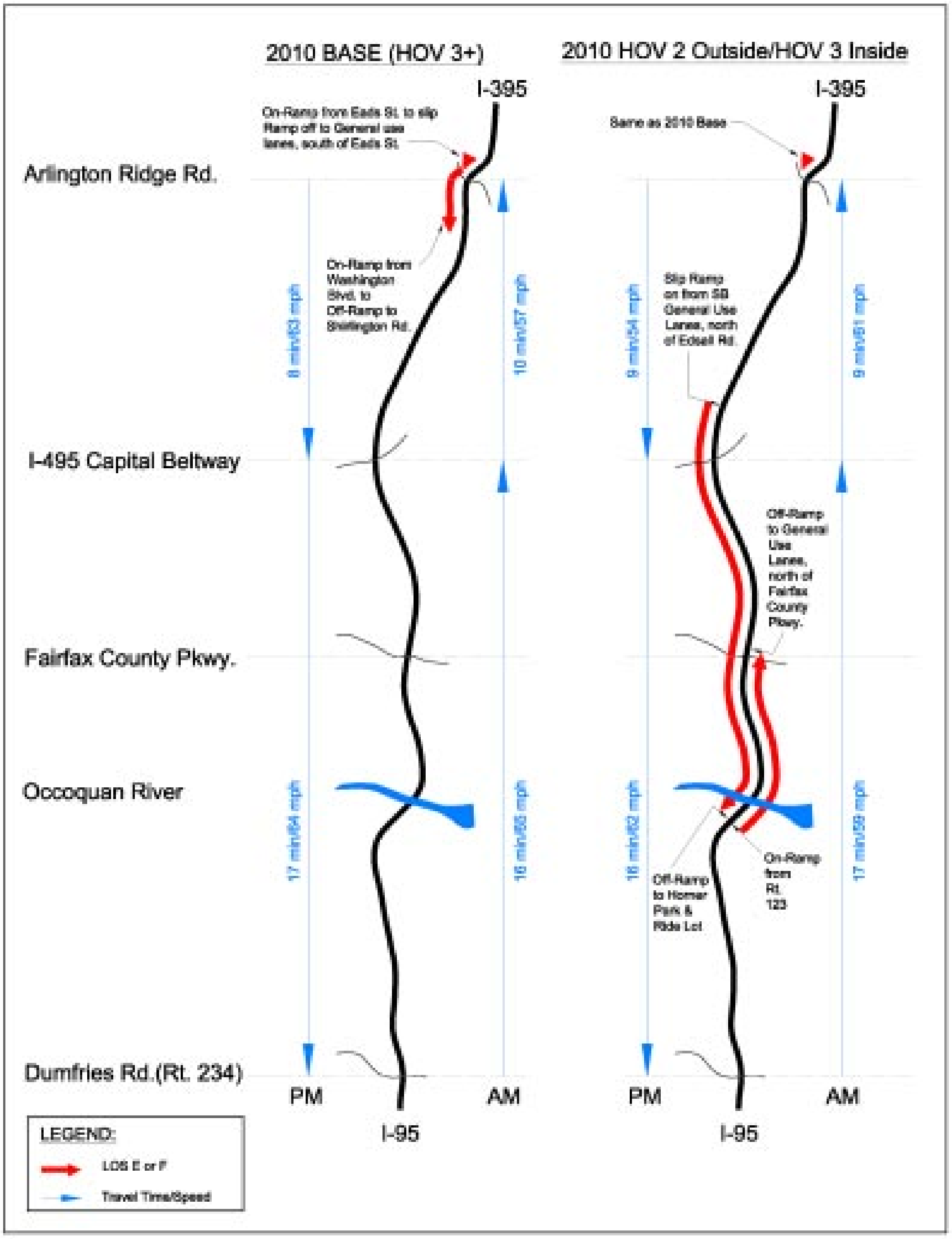


Figure 14. Comparison of 2010 HOV Facility Traffic Operations under HOV 3+ vs. HOV 2+ Restriction Outside Beltway and HOV 3+ Restriction Inside Beltway.

Table 9. Transit Impacts under HOV 2+ Outside the Beltway and HOV 3+ Inside the Beltway.

	CHANGE FROM BASE CONDITION	
AM RESTRICTED PERIOD PERSON TRIPS BY TRANSIT	**1998**	**2010**
Private Commuter Buses	- 82 (-9%)	- 207 (-20%)
Public Buses	- 84 (-2%)	- 63 (-1%)
VRE	- 69 (-4%)	- 211 (-10%)
Metrorail	- 82 (-1%)	+ 6 (0%)
Net Total Transit	**- 317 (-2%)**	**- 475 (-2%)**
ANNUAL CHANGE IN TOTAL BUDGET		
Private Commuter Buses	$140,270	$354,409
Public Buses	$95,441	$104,179
VRE	$153,780	$470,256
Metrorail	$115,005	-$8,415
Net Total Transit	**$504,496**	**$920,429**

The anticipated effects of this alternative on *safety* are that, with increased volumes on the HOV lanes outside the Beltway, vehicle crashes and other incidents (e.g., disabled vehicles) will likely become more frequent, at a percentage growth rate greater than the volume increase. In addition to the economic loss associated with increased crashes, there will be more days when delays will be experienced by HOV users, thereby diminishing speed and travel time reliability. The negative safety impacts will be less under this alternative than the first alternative with HOV 2+ for the entire corridor.

Enforcement of HOV 2+ restrictions should not be any more difficult than under the current HOV 3+ restriction, especially considering that the bulk of enforcement occurs at ramps.

The effects of this alternative on the region's *air quality* are that slight decreases in volatile organic compound (VOC) are expected, along with small increases in nitrogen oxide (NOx) emissions. VOC emissions are projected to decrease .01 tons/day in 1998 and 2010. NOx emissions are projected to increase .04 tons day in 1998 and .06 tons/day in 2010. MWCOG states that mitigation measures would not be necessary to meet regional air quality conformity requirements given these relatively small NOx emission increases.

Slugging activities in the corridor involve a limited number of matching locations and availability of bus service as a fall-back mode. As a result, almost all slugs have the Pentagon or downtown Washington, DC as a morning destination. The retention of HOV 3+ inside the Beltway means that the factors that induce slugging will remain. There should be essentially no change in slugging activities under this alternative.

Is it feasible to provide a third HOV lane inside the Beltway?

One of the alternatives examined was providing a third HOV land inside the Capital Beltway, under the assumption that more capacity would be needed certainly for HOV 2+ and possibly even HOV 3+ in the future. This investigation was limited to inside the Beltway because this section is constrained by the available width between the general purpose lanes; outside the Beltway there is ample room for widening. It is estimated that the cost to provide a third lane on the HOV facility inside the Beltway, without impacting the general purpose lanes, would be $21,700,000.

Inside the Beltway there are three typical cross sections, which are depicted in Figure 15. The first typical cross section is located from the Beltway to approximately 0.5 miles north of the Arlington County line; this section has a 54-foot cross section from the inside edge of the medians for the general purpose lanes. The second section extends north from the first section to the northern limit of the HOV reversible lane facility; this section has a variable width of 46 to 49 feet from the inside edge of the general purpose lane medians. The third section, which provides separate facilities for northbound and southbound HOV lanes, extends north from the second section to the Eads Street exit; its cross section width is variable with a minimum width of 95 feet from the inside edge of the general purpose lane medians.

To meet VDOT and American Association of State Highway Transportation Officials (AASHTO) desirable guidelines for an additional third lane, the facility would need to consist of a median barrier, 10-foot shoulder, three 12-foot HOV lanes, 10-foot shoulder, and a median barrier. The application of this configuration to all of the existing typical cross sections mentioned above would require moving the general purpose lanes out from the HOV lanes between 7 to 17 feet. This would also require additional right-of-way and bridge structure widening or modifications in the study area. A cost estimate was not prepared for this design, but it is likely to be cost prohibitive.

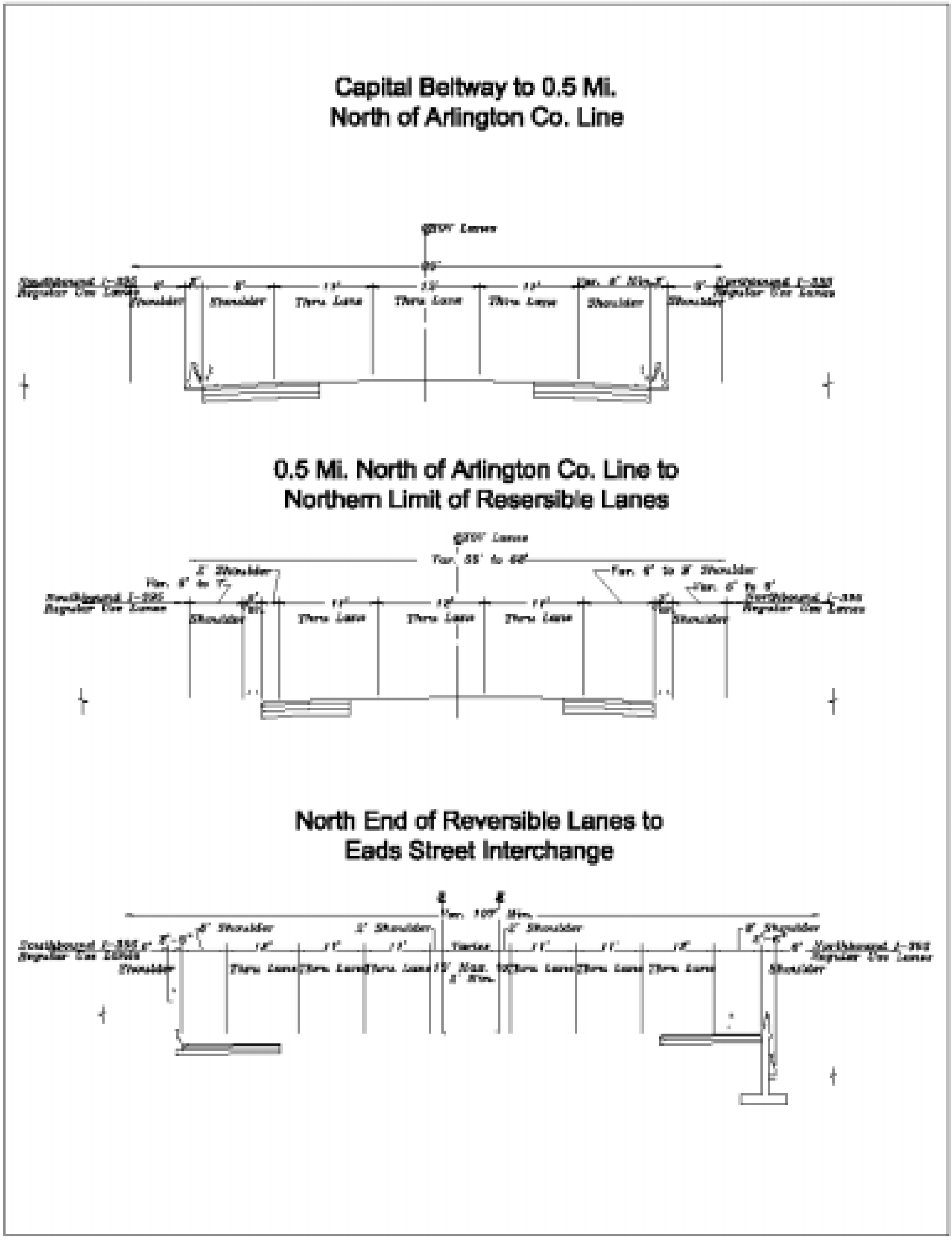


Figure 15. Typical Existing Cross Sections of I-395 HOV Lanes

Alternatives were then developed to minimize impacts to the general purpose lane right of way requirements and bridge structure modifications. Figure 16 shows an alternative for each of the three sections. For the first section, a third lane could be accomplished easily if 11-ft travel lanes and 8-ft shoulders were acceptable. For the second section, the shoulders would have to be reduced to a narrow 2-ft shoulder on one side and variable 6 to 9-ft shoulder on the other, again with 11-ft lanes. For the third section, 12 feet of additional width would be needed and could be provided by reconstructing about 1000 feet of the retaining barrier wall between the northbound express facility and the southbound express facility with a median barrier. The second and third cross section provide a minimal 2-ft shoulder on one side and the remaining shoulder width on the other. This was done because the use of shoulders between 4-ft to 8-ft wide are not recommended, as they give the appearance of safe pull-off. The single 12-ft lane mentioned in these cross sections could be in any of three lane positions. It was shown in the middle for the purposes of this study but could be moved to one side or the other to better accommodate buses.

The northern and southern terminus of the third HOV lane could be accomplished with little or no impacts or additional construction costs. The southern terminus could be achieved at the proposed HOV ramp to the Capital Beltway included in the proposed Springfield Interchange Project. The northern terminus could be achieved at the existing on and off ramps from the HOV express facility to Eads Street near the Pentagon. This northern terminus point would also serve the large percentage of HOV vehicles that exit at Eads Street during the AM peak hour.

The advantages associated with the third lane configurations that do not interfere with the general purpose use lanes are elimination of impacts to right-of-way and to virtually all bridge structures in the study area, much lower construction costs and reduced traffic congestion. The proposed configurations also have some disadvantages. Among these are shoulder widths that are less than the desirable width of 10 ft. and lane widths less than the desirable width of 12 ft. However, many expressways in the area, such as I-66 from Manassas to the Beltway during HOV restricted hours and the general purpose lanes on I-395, have minimal shoulder widths. Similar HOV reversible lane facilities in Houston, Texas including I-10, I-45, US 290 and US 59 have right and left shoulder widths of 3.75 to 4 ft.

The existing shoulders on the HOV facility would narrow with the provision of the third lane if the general purpose lanes are not impacted. This narrowing could hinder HOV enforcement efficiency and safety. There are no specific geometric requirements for HOV enforcement; however, there are some guidelines presented in the National Cooperative Highway Research Program (NCHRP) *HOV Systems Manual*.[2] The manual recommends a minimum shoulder

[2] Texas Transportation Institute, Parsons, Brinckerhoff, Quade and Douglass, Inc., Pacific Rim Resources, Inc., *HOV Systems Manual*, NCHRP Report 414, Transportation Research Board, 1998

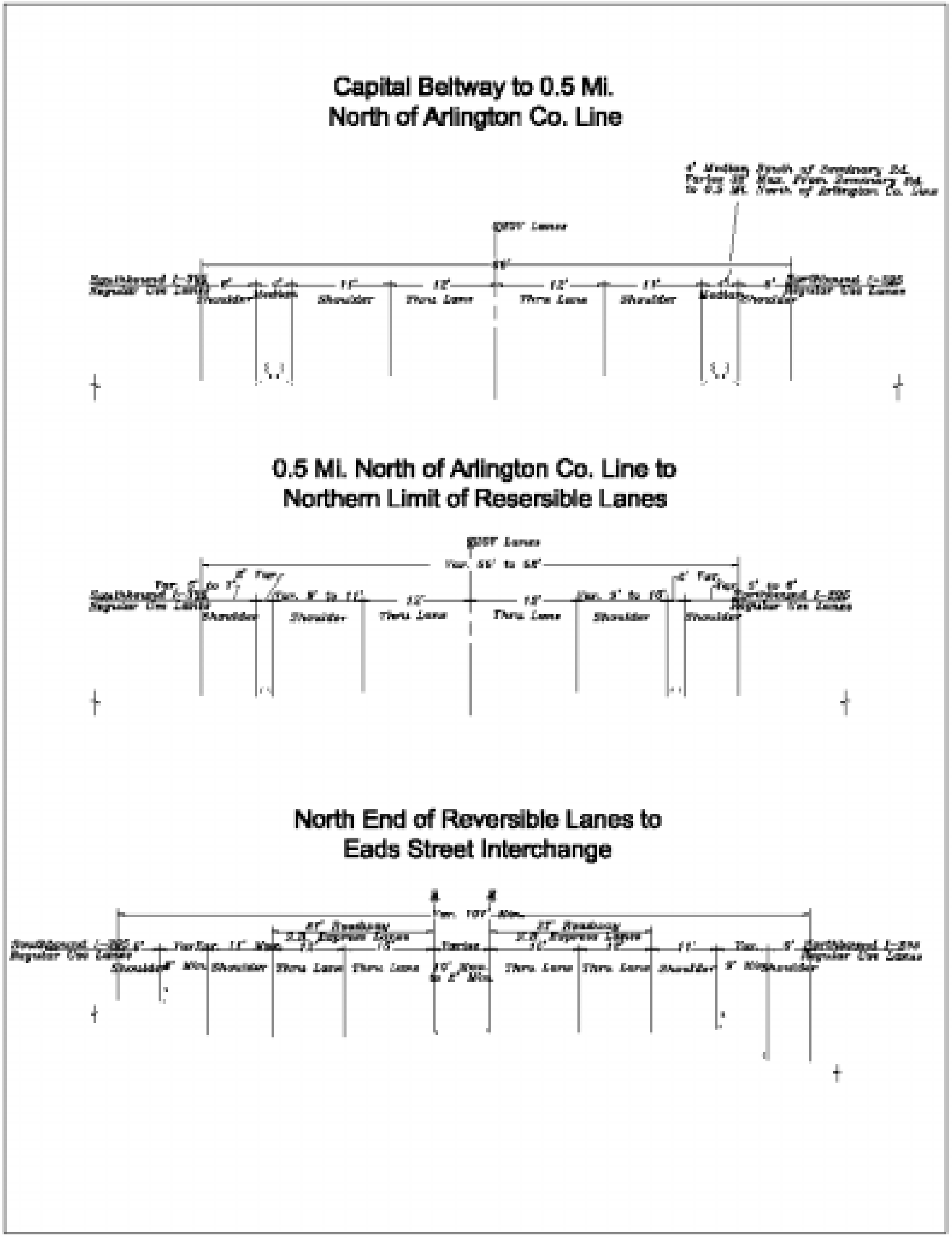


Figure 16. Possible Option for Adding Third HOV Lane.

width of 12 feet for a distance of at least 1300 feet. The manual also recommends a having this type of pull-off provided at intervals of about three miles. As a part of this feasibility study, several locations within the corridor were identified where these recommended guidelines were met. These locations are as follows:

- Turkeycock Run Area (East side of HOV lanes)
- Turkeycock Run Area (West side of HOV lanes)
- North of Seminary Road (East side of HOV lanes)
- South of Route 27 (East side of HOV lanes)

There are seven access points to the existing HOV facility within the limits of the third lane alternative and they were studied to determine what changes would be necessary to these connections. All of the ramps can be adjusted to provide the third HOV lane and meet VDOT design standards with the exception of :

Ramp	Reason for Standard non-compliance
Seminary	Ramp - escape width of 7 feet
Shirlington	Ramp - no escape provided; 3-ft ramp shoulder width
Route 27	Ramp - no escape provided.

Design exceptions would be required for these three ramps.

What are the impacts of changing the hours of HOV restrictions during the AM and/or PM periods?

The potential impacts of changes to the HOV restricted time periods were investigated in terms of three possible changes under existing 1998 conditions assuming a continuation of the HOV 3+ restriction.

1. Starting the AM restricted time period at 5:30 AM instead of the current 6:00 AM.

It has been hypothesized that starting the AM restricted period at an earlier time, such as 5:30 AM, would cause some non-HOV person trips currently using the HOV lanes between 5:30 and 6:00 to divert to transit or some other high occupancy mode. Several potential effects were considered in analyzing this scenario: 1) non-HOV persons would leave earlier than 5:30 and continue to use the HOV lanes prior to the restricted period, 2) non-HOV persons currently using the HOV lanes between 5:30 and 6:00 would switch back to the general purpose lanes, and 3) non-HOV persons would either form carpools or switch to transit modes. Since the pivot point methodology used for this study could not be used to estimate the first potential effect, two scenarios were tested to establish a range of possible impacts. One scenario assumed that 25% of the non-HOV person trips between 5:30 and 6:00 would leave earlier and the second scenario assumed that 50% would leave earlier. The second and third potential effects were tested under each of the two scenarios using mode share outputs of the pivot point model.

The potential impacts of this change to the restricted period were examined in terms of resultant person and vehicle volumes and changes in transit ridership. It is anticipated that total corridor person trips (HOV and general purpose lanes), under the 25% scenario discussed above, would decrease by approximately 10% from current levels during this half hour period. Traffic volumes on the HOV lanes would likely decrease significantly, on the order of 80-85%, throughout the corridor. For example, at the Fairfax County Parkway, the expected traffic volume would drop from the current 1,700 vehicles to approximately 350 vehicles. The combined effect of these drops in person and vehicle trips is a large increase in average vehicle occupancy (AVO) on the HOV lanes. Transit ridership (bus and rail), on the other hand, would increase in the corridor during this half hour period. In the southern portion of the corridor, transit ridership would be projected to increase 10% to 15%, which represents approximately 70 to 85 new users. In the northern portion of the corridor, ridership would be projected to increase 25% to 35%, which represents 200 to 300 new riders. Vanpool usage would also be expected to increase, with approximately 70 new vanpool users projected in the southern portion of the corridor.

Although this change will reduce person travel in the corridor between 5:30 and 6:00 AM by approximately 10% in the short term; in the long term, as volumes and congestion increase on the general purpose lanes, it is possible that person movement could increase over current levels with HOV-restricted operations during this half hour as people move from a SOV to HOV mode to save time on their commute. Anticipated delays on the general purpose lanes due to the Springfield Interchange construction project could also provide an incentive for switching to high occupancy modes during this half hour period.

2. Ending the AM restricted period at 8:30 AM instead of the current 9:00 AM.

The thought behind this potential change was that the HOV lanes are underutilized during the last half hour of the AM restricted period, particularly in the southern portion of the corridor. For example, at Route 234 in Dumfries, there are 170 persons in 90 vehicles on the HOV lanes during this half hour period. In the northern portion of the corridor, just south of the Pentagon, there are approximately 1,500 persons in 700 vehicles during this half hour. Traffic volumes on the general purpose lanes during this half hour period range from approximately 1,300 near Dumfries to 2,800 at the Fairfax County Parkway.

Ending the restricted period at 8:30 AM is projected to increase traffic volumes on the HOV lanes by 260% in the southern portion of the corridor and 100% in the northern portion. This would represent an increase of approximately 230 vehicles near Dumfries and 770 more vehicles near the Pentagon during this last half hour. The net result of making this change, in terms of person trips, is that the HOV lanes would be expected to carry 30% to 130% more persons between 8:30 and 9:00 AM if the HOV restriction is lifted.

The impacts of making this change would likely be different depending on the specific location within the corridor. In the southern portion of the corridor, traffic flows would be under capacity on both the general purpose and HOV lanes. However, in the northern portion of the corridor near the Pentagon where non-HOV traffic is currently permitted to switch over to the HOV lanes (the HOV lanes effectively end at this location), additional volumes on the HOV lanes if this change is made would add to the backup at this ramp merge. One alternative, which was not specifically analyzed, would be to stop the restricted period at 8:30 AM in the southern portion of the corridor but maintain the current restricted period in the northern portion of the corridor. Another factor to consider is the upcoming Springfield Interchange construction project. Delays on the general purpose lanes associated with this project could increase traffic volumes during this half hour period to the extent that the general purpose lanes become congested, which would encourage commuters to switch to high occupancy modes to avoid congestion on the general purpose lanes.

3. Ending the PM restricted period at 6:30 PM instead of the current 6:00 PM.

Under current conditions, both the HOV and general use lanes in the northern portion of the corridor are congested between 6:00 and 6:30 PM. This is because non-HOV traffic diverts from the general purpose lanes to the HOV lanes once the restrictions end at 6:00 PM. It has been proposed that extending the HOV restricted period to 6:30 PM would allow HOV users who leave work later in the day to continue to enjoy travel time savings. Analysis of the potential effects of this change was performed in the same way that the potential earlier start in the morning was analyzed. That is, by testing two scenarios for how many non-HOV people would decide to leave a half hour later under this change, and how many would change modes from non-HOV to HOV or transit.

In terms of anticipated traffic volumes on the HOV lanes between 6:00 and 6:30, they would be expected to drop significantly, on the order of 85 to 90%. For example, on the HOV lanes just south of the Pentagon, the volume for this half hour period is projected to drop from 2,100 vehicles to 300 vehicles under the 25% scenario. As was the case with the AM analysis of starting HOV earlier, transit ridership is projected to increase during this half hour period on the order of 10 to 15%, which represents, for example, 300 to 450 new riders in the northern portion of the corridor. Another factor to consider is that there are currently over 1,200 people in 48 buses during the 6:00 to 6:30 half hour period on the HOV lanes at Arlington Ridge Road that are being delayed by congestion on the HOV lanes, which would be alleviated by this change.

The findings of this analysis indicate that, while transit ridership would increase in the corridor and operations on the HOV lanes would improve dramatically, non-HOV person trips would be forced to divert to the heavily-congested general purpose lanes or leave later in the evening to achieve reasonable speeds and travel times.

How will construction of the new Springfield Interchange affect HOV operations?

Considerable additional delays are expected on the general purpose lanes in the corridor due to the planned reconstruction of the I-95/I-395/I-495 interchange in Springfield. There are three groups of commuters who pass northbound through the interchange in the morning: 1) people traveling from outside the Beltway to the Beltway, 2) people traveling from outside the Beltway to the Downtown, and 3) people traveling from outside the Beltway to destinations inside the Beltway along I-395. Eighty-one percent (81%) of the nearly 11,000 commuters traveling from outside the Beltway to downtown, which includes the DC core, Crystal City and the Pentagon, are currently either traveling in a carpool or transit. Therefore, there is very little opportunity to shift commuters heading downtown on the general purpose lanes to into the HOV lanes. The major shift to carpools that could result from the interchange construction will be by commuters who are traveling within Fairfax County and those heading to the Beltway. An analysis was performed to estimate how many new carpools would form with different levels of delay at the interchange.

The low and high estimate of carpools that would pass Route 234, the Fairfax County Parkway, and Arlington Ridge Road due to delays at the interchange are shown in Figure 17. As shown, at Route 234, traffic on the HOV lanes during the peak hour may increase by between 50% and 75%, or 150 to 225 vehicles. At the Fairfax County Parkway, the delay may encourage between 400 and 600 new peak hour carpools, an increase of 20% to 30%. Due to the lower number of single occupant vehicles that are passing the interchange and going downtown, an increase at Arlington Ridge Road of less than 200 new carpools (6%) could be expected. Only a nominal switch to transit would occur at all locations. Unfortunately, unless someone in the HOV lanes is going to the Downtown area, they must exit the HOV lanes at Newington, and suffer the congestion caused by the interchange construction. If these people could get off the HOV lanes further north, particularly at I-495, there would be more incentive for commuters to form carpools so that they can use the HOV lanes.

Is a new ramp to Seminary Road justified and feasible?

The feasibility of adding a new ramp from the existing two-lane HOV facility just south of Seminary Road to the eastbound portion of the radial roadway at the Seminary Road and I-395 interchange was examined. Various alternative alignments were considered prior to selecting a preferred alternative which is conceptually depicted in Figure 18. The construction cost

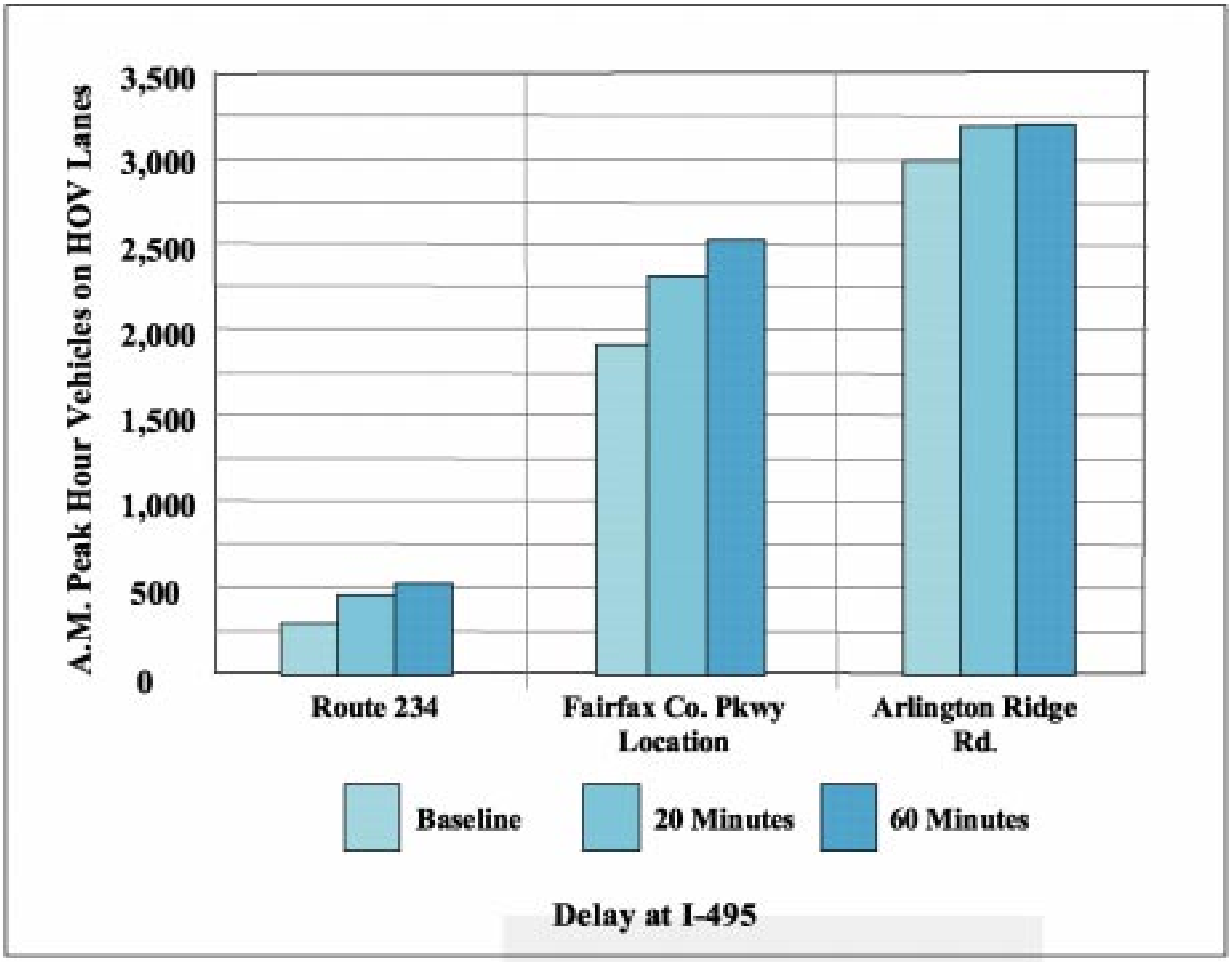


Figure 17. Potential Changes in HOV Demand Due To Springfield Interchange Construction.

estimate, which includes complete reconstruction of the existing eastbound roadway bridge, is $5,200,000.

Currently, there are less than fifty (50) vehicles with 3 or more occupants that are destined to Seminary Road in the AM peak hour. If a new HOV ramp were added here, it could be expected to divert new HOV persons to this interchange from the other nearby interchanges. For example, people that are currently using adjacent interchanges at Route 7 or Route 236 could conceivably realize significant travel time savings by forming carpools and exiting at a new HOV ramp at Seminary Road. Although the pivot point traffic forecasting methodology used for

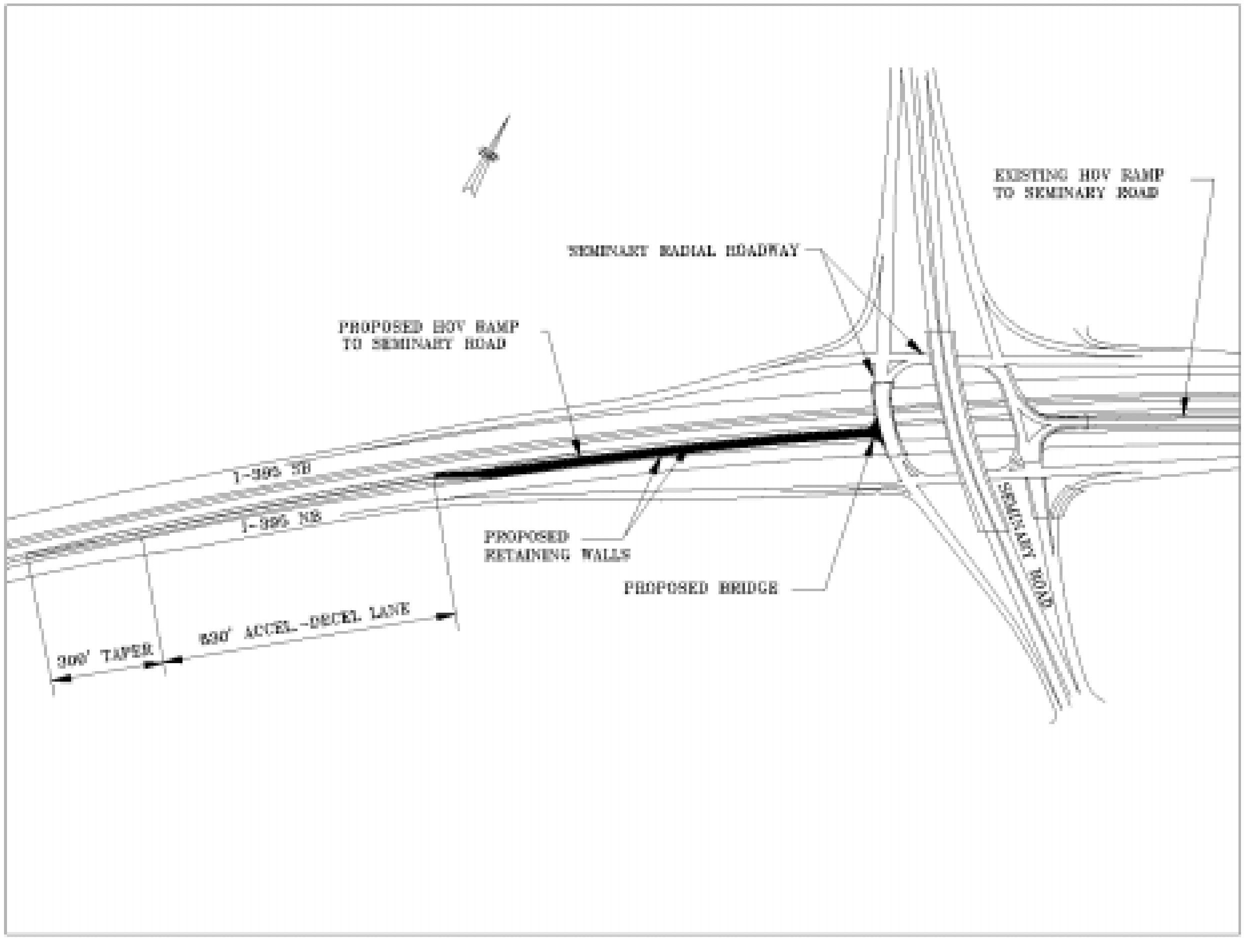


Figure 18. Proposed HOV Ramp at Seminary Road.

this study is not formulated to forecast demand for new facilities, such as a ramp, an analysis of the license plate survey data and outputs of the MWCOG regional model indicate that peak hour HOV demand for this ramp could be in the range of 150 to 300 vehicles, which would represent approximately 450 to 900 person trips.

An alternative to this new ramp would be construction of a new flyover ramp from the HOV facility that would merge with the general purpose lanes somewhere between Edsall Road and Route 236. This alternative would improve HOV access to Route 236 (Duke Street), Route 7 (King Street) and Seminary Road, all of which feed employment areas. A further benefit of this alternative is that it would reduce the demand at the existing HOV to general purpose lane flyover ramp at Newington, especially under the HOV 2+ outside Beltway and HOV 3+ inside Beltway alternative.

Is a new ramp to Route 123 justified and feasible?

The feasibility of adding a new ramp from the existing two-lane HOV facility just south of Route 123 was examined. The proposed ramp would serve the movement from the north-bound HOV facility to both eastbound and westbound Route 123 during AM hours and from eastbound and westbound Route 123 to the southbound HOV facility in the PM hours. The preferred alternative, shown conceptually in Figure 19, would diverge from the HOV facility on its east side about 4300 feet south of Route 123. The ramp would go upgrade towards Route 123 and follow between the HOV facility and the northbound general purpose lanes until it was high enough to span northbound I-95. At this point it would bear to the east and then connect to Route 123 between the existing loop and the directional ramp in that quadrant of the I-95/Route 123 interchange. The ramp would connect to Route 123 at a “T” intersection. This alternative was selected because it could be constructed with fewer impacts to adjacent roadways, bridge structures and right-of-way than the other alternatives considered.

The construction cost is estimated at $26,900,000, which includes $6.5 million for bridge modifications. It is estimated that this ramp would have a AM peak hour HOV volume of 50 to 100 vehicles, or 150 to 300 persons.

Is a new ramp to the Fairfax County Parkway justified and feasible?

The third location examined for a new access point was a ramp from the existing HOV facility to the Fairfax County Parkway interchange. The proposed ramp would serve the move-ment from the northbound HOV facility to both eastbound and westbound Fairfax County Parkway during AM hours and from eastbound and westbound Fairfax County Parkway to the southbound HOV facility in the PM hours. The preferred alternative is presented conceptually in Figure 20. The ramp would begin on the HOV facility on its east side about 3700 feet south of the Fairfax County Parkway and would go upgrade towards the Parkway and stay between the

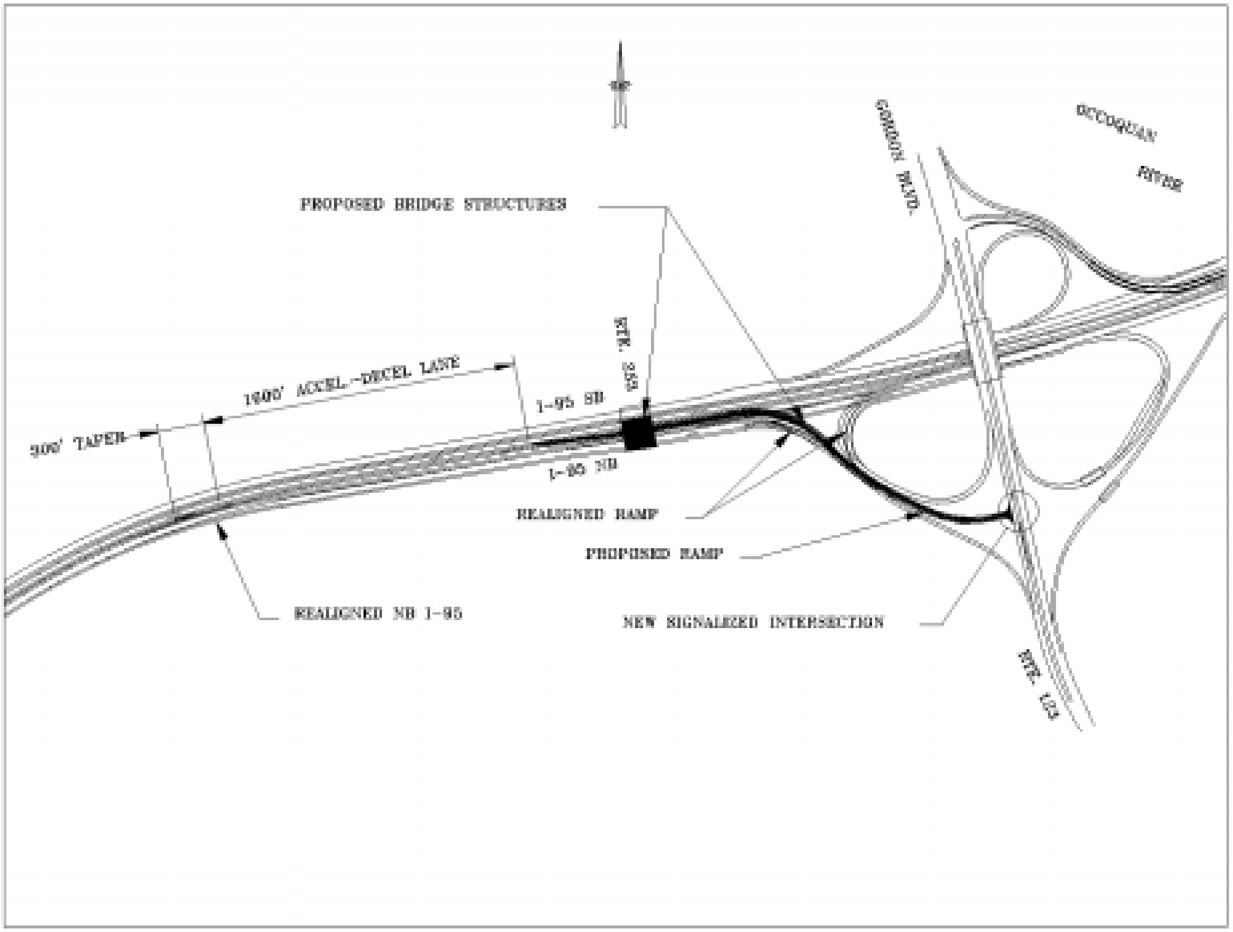


Figure 19. Conceptual Plan for HOV Ramp at Route 123.

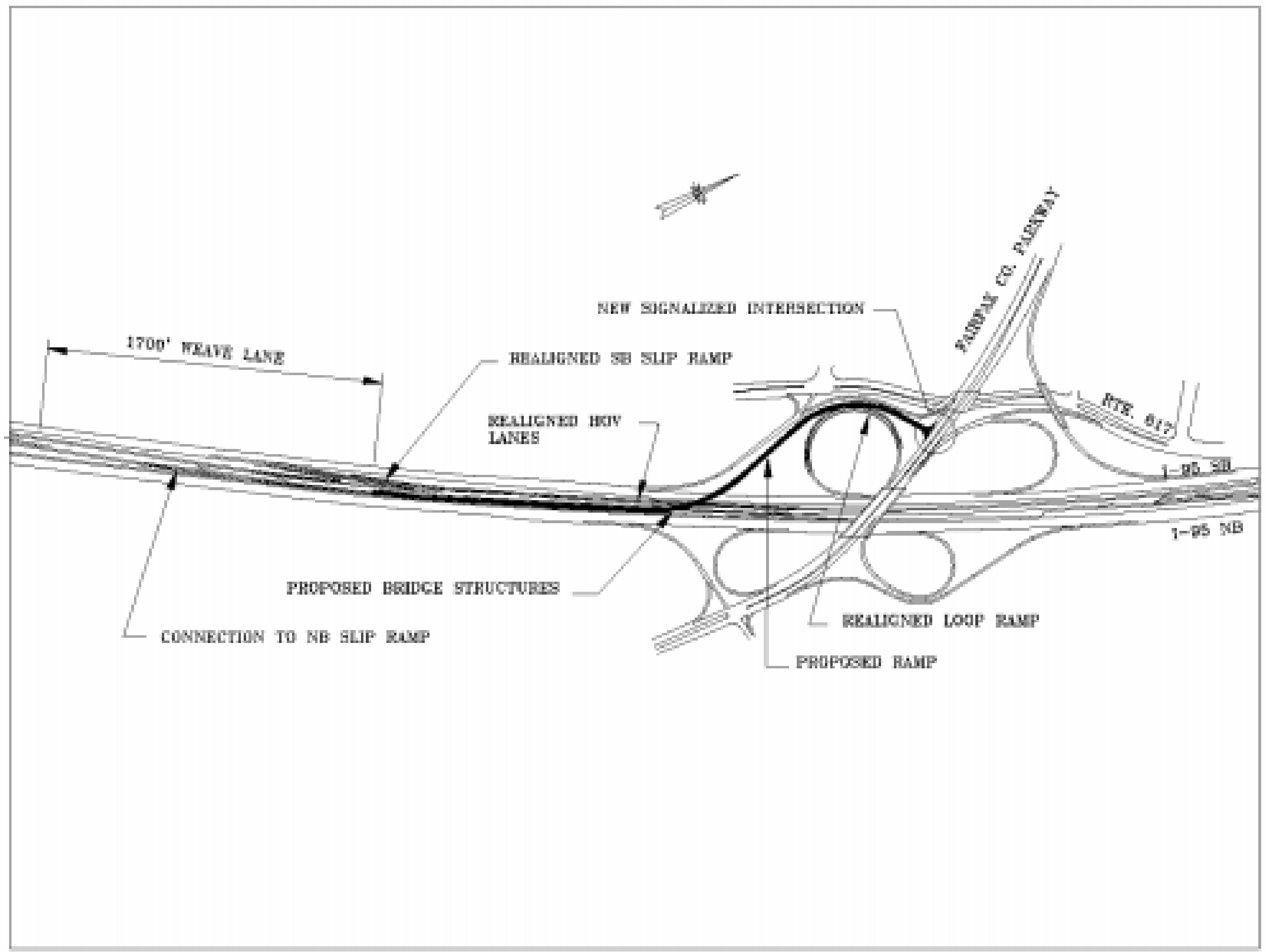


Figure 20. Conceptual Plan for HOV Ramp at the Fairfax County Parkway.

HOV facility and the northbound general purpose lanes until it was high enough to span the HOV facility and southbound I-95. At this point it would bear to the west and then connect to the Parkway between the existing loop and directional ramp in that quadrant of the I-95/Fairfax County Parkway interchange. The ramp would connect to the Parkway at a “T” intersection.

The construction cost is estimated to be $12.2 million, which includes $2.8 million for the ramp bridge construction. It is estimated that this ramp would have a peak hour HOV volume of 400 to 500 vehicles, or 1,200 to 1,500 persons.

What would be the impact of allowing southbound non-HOV traffic on the HOV lanes to exit at the Franconia-Springfield Parkway?

Currently, southbound non-HOV traffic in the PM is allowed to enter the HOV lanes at the Turkeycock Run slip ramp north of Edsall Road. This traffic must then exit the HOV lanes at Old Keene Mill Road or move back to the general purpose lanes on the slip ramp just south of Old Keene Mill Road. A question had been raised as to the effect of allowing this traffic to stay on the HOV lanes and exit at the Franconia-Springfield Parkway. Based on the license plate survey, it is estimated that approximately 225 PM peak hour vehicles would be added to the exit ramp to the Franconia-Springfield Parkway under this scenario. The effect of this additional volume would be that the signalized intersection at the end of the exit ramp would operate at LOS F, as opposed to LOS D under current conditions. In addition, traffic simulation analysis showed that traffic on the ramp could potentially queue down the ramp on to the HOV mainline lanes under this scenario, which would create a hazardous situation.

V. CONCLUSIONS

Based on a comprehensive evaluation of the I-95/I-395 corridor and the range of alternatives to current HOV restrictions, it is clear that any change to HOV operations brings both a positive and negative set of impacts.

A change to HOV 2+ for the entire corridor will certainly address perceived underutilization of the HOV facility as vehicle volumes will increase significantly, but it will come with several negative impacts including:

- Significantly increased travel times for HOV users.
- Disincentives to the highly effective slugging system.
- Decrease in public and private bus with a corresponding decrease in revenues.
- Increases in vehicle crashes and other incidents.
- 60% decrease in vanpool ridership.

Increased traffic volumes in the HOV lanes will come primarily from a breakup of 3 or more person carpools already in the HOV lanes to form 2-person vehicles and from 2-person vehicles in the general purpose lanes moving onto the HOV facility, with any extra capacity on the general purpose lanes being filled by trips diverting from other roadways. This increased vehicle volume is projected to result in congested conditions in the HOV lanes during the AM and PM peak hours between the Eads Street in Arlington and the Beltway. The change to HOV 2+ would require provision of a third HOV lane, at least inside the Beltway and probably as far south as the Fairfax County Parkway, in order to maintain reasonable time savings for HOV users. A third lane could be provided but it would cost $21.7 million and in the end would have a facility with substandard shoulder widths.

Also, a switch to an HOV 2+ restriction in the short term would be counterproductive to the goal of getting more users of the general purpose lanes to use carpool or vanpool to minimize the severe congestion that is expected to result from the upcoming Springfield interchange construction project. The effects of this project alone are expected to induce a 20 to 30 percent increase in person movement on the HOV lanes under the current HOV 3+ restriction. This level of diversion from the general purpose to HOV lanes would not be possible under a switch to HOV 2+, since the HOV lanes would become congested and existing HOV lane travel times savings would disappear.

The alternative of allowing HOV 2+ outside of the Beltway only, while maintaining HOV 3+ inside of the Beltway, has some merit but it also has significant negative impacts. To make this alternative effective, ramp connections to the Beltway are needed; otherwise, northbound AM HOV 2 traffic will need to merge onto the general purpose lanes before the Beltway at the Newington slip ramp. This will result in Level of Service E conditions on the general purpose lanes, even without the added negative traffic effects of the upcoming interchange construction. This will not be a problem by 2010 when the needed HOV to Beltway ramp connections will be constructed as the final phase of the Springfield Interchange improvement project. Unfortunately, by 2010, traffic volumes outside the Beltway on the HOV lanes are projected to be so high that widening of the HOV lanes may be necessary as far south as the Occoquan River.

Extending the restricted periods of HOV operations by a half hour, either by starting earlier in the morning or extending operations later in the evening, could in the long term serve to increase person movement on the HOV lanes. However, in the short term, total person trips on the HOV and general purpose lanes could decrease during the extended half hour periods by 10 percent. Shortening the restricted period in the morning by ending HOV restrictions at 8:30 AM would probably not have negative impacts in the southern portion of the corridor, but may lead to congested conditions in the HOV lanes in the northern portion of the corridor during this 8:30 to 9:00 half hour period. The upcoming Springfield interchange construction project, which is scheduled to continue for up to eight years, could accelerate the rate of projected demand growth for the HOV lanes. This would argue for extending the HOV-restricted periods rather than shortening them. Were it not for the interchange construction project, ending the restricted period earlier in the AM could have been warranted.

More access points to and from the HOV lanes may also enhance utilization of the HOV facility. New access ramps for morning northbound/evening southbound HOV traffic at Seminary Road, Route 123 and the Fairfax County Parkway are all feasible from an engineering perspective but will be costly, $5.2 million, $26.9 million, and $12.2 million, respectively. An alternative to constructing a new ramp at Seminary Road would be a flyover ramp from the HOV facility to the general purpose lanes somewhere between Edsall Rd. and Rt. 236. This would provide an additional exit for morning HOV traffic north of the existing Newington flyover ramp and improve HOV access to Duke St., Seminary Rd. and King St. Projected volumes for a new Rt. 123 ramp are relatively low, but a new ramp at the Fairfax County Parkway could attract as many as 500 HOV vehicles per hour.

There are several relatively minor changes that could be made to improve the efficiency of the HOV system, which include:

1. Improve the capacity of the northbound HOV off-ramp terminal at Eads Street and especially at the intersection at the Pentagon circulation road intersection. The queue that forms on the ramp and backs up into the HOV lanes for up to ½-mile or more is primarily due to the fact that traffic headed to the Pentagon parking areas must stop at the intersection of Eads Street and the Pentagon circulation road. A signal could be installed at this location, which would be interconnected with the signal at the intersection of Eads Street and Army-Navy Drive. Also, the ramp could be widened by just 2 to 3 feet to provide a full two-lane ramp.

2. Improve the capacity of the SB HOV ramp terminal at the Franconia-Springfield Parkway. Currently, during the PM peak period, the queue on the HOV off-ramp extends to the end of the ramp and beyond. The signal timing could be changed by providing more green time to this movement. This could be accomplished by reducing the maximum green time for the left turn traffic from the Parkway onto the SB HOV ramp. During the last 15 to 20 minutes of the HOV restriction period, this left turn lane is filled by many non-HOV violators. Enforcing the HOV restriction at the ramp will reduce the traffic volume and allow the reduction in green time.

3. Expand the capacity of the Park'n'Ride lot at Horner Road by filling and paving the north end of the lot.

4. Improve the access to the Park'n'Ride lot at Rt. 123.

5. Provide accommodations for the slugging system to include designated marshaling areas and pulloffs.

Based on the findings of the various analyses, several potential areas for future study were identified, including:

1. Changing the HOV requirement within the peak periods. For example, in Houston, some of the HOV facilities have a HOV 3+ requirement during the peak hour of the HOV-restricted period and a HOV 2+ requirement during the remainder of the restricted period.

2. Investigate "rolling" HOV time restrictions, such as ending the restricted period earlier in the southern portion of the corridor only.

3. Monitor and evaluate the performance of **H**igh **O**ccupancy **T**oll (HOT) lanes that are being tested in California for potential use in the I-95/I-395 corridor.

4. Evaluate the potential for adding slip ramps to the general purpose lanes in lieu of adding new HOV ramps at interchanges.

5. Evaluate restoration of HOV restrictions on the 14th Street Bridge river crossing.

APPENDIX A
TECHNICAL COMMITTEE MEMBERS

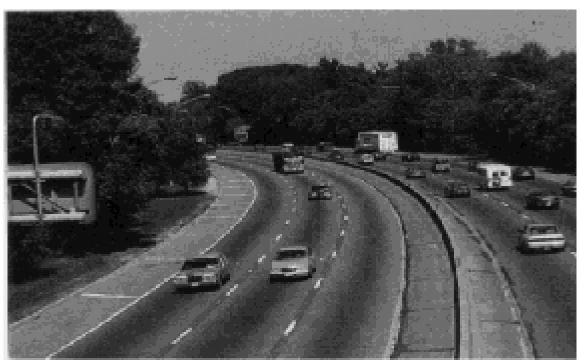
AGENCY	REPRESENTATIVES
Virginia Department of Transportation	Larry Trachy, Project Manager Valerie Pardo Stephen Read JoAnne Sorenson Brian King Kathy Graham Chris Detmer Jerry Morrison Grady Ketron
Virginia Department of Rail & Public Transportation	Gus Robey Gary Kuykendall
Fairfax County	Angela Fogle
City of Alexandria	Mary Anderson Betsy Massie
Town of Dumfries	Marvin Wilkins
DC Department of Public Works	Michelle Pourciau
County of Stafford	Bill Shelly Russell Seymour
County of Arlington	James Hamre Cheryl Mooty
County of Prince William	Peter Steele Tom Blaser
Metropolitan Washington Council of Governments	Ron Kirby Mike Clifford Larry Marcus Mark Radovic
Virginia State Police	Sergeant Rick Keevil

TECHNICAL COMMITTEE MEMBERS (CONT.)

AGENCY	REPRESENTATIVE
Fredericksburg Metropolitan Planning Organization	Michael Tardiff
Potomac Rappahannock Transportation Commission	Todd Seidman Eric Marx
Northern Virginia Transportation Commission	Jennifer Straub
Rappahannock Area Development Commission	Stephen Manster
Washington Metropolitan Area Transit Authority	Kathleen Benton Carol Kachadoorian
Virginia Railway Express	Steve Roberts
VPSI	Shane Boyle
National Coach Works	Bernie Pitchke John Oakman
Lee Coaches	JoAnne Scott
Quicks	Bob Quick Gary Everett
Federal Highway Administration	Thomas Jennings Robert McCarty
Federal Transit Administration	Sheila Byrne

APPENDIX B
ILLUSTRATIVE EXAMPLES OF SIX LEVELS OF SERVICE (LOS) CATEGORIES


LOS A


LOS B


LOS C


LOS D


LOS E


LOS F

APPENDIX C
SUMMARY OF PUBLIC COMMENTS

E-mail messages as of 9/30/98 = **903**
Phone messages as of 9/30/98 = **627**
Comment Sheets as of 9/30/98 = **111**
Total # of people commenting =**1641**

		Total	Phone Calls	E-mails	Comment Sheets
	Keep HOV-3	**929**	369	482	51
	Permit 100% occupied 2-seaters in HOV-3	**24**	7	15	2
	Change to HOV-2	**335**	161	164	10
	Test HOV-2 for limited time	**39**	10	27	2
	Change to HOV-2 after peak hours	**16**	5	9	2
	HOV-2 will worsen pollution	**95**	22	67	6
	HOV-2 will increase congestion	**296**	79	187	30
	HOV-2 will decrease congestion	**6**	0	6	0
	HOV-2 will increase commuting time	**21**	7	11	3
	HOV-2 will decrease mass transit	**9**	2	7	0
	HOV-2 will decrease carpooling	**16**	2	12	2
	HOV-2 will destroy the 'slug' system	**178**	45	116	17
	HOV-2 will be easier for 'slugging'	**4**	0	3	1
	If HOV-2, drivers would only pick up one slug/only what is needed	**45**	1	15	29
	If HOV-2, would not slug as only passenger	**43**	3	9	31
	Safety concerns for 'slugs' with HOV-2	**84**	13	41	30
	If HOV-2, would slug as only passenger	26	1	0	25
	Stop 'slug' harassment	**8**	1	6	1
	Change to HOV-4	57	24	24	9
	No HOV restrictions	**58**	14	44	0
	HOV lanes are underused	**21**	4	16	1
	Return HOV lanes to express lanes (their original intent)	**10**	1	9	0
	Revise restriction hours (begin earlier in a.m./end later in p.m.)	**312**	72	224	16
	Shorten restriction hours	**69**	24	42	3
	Uniform HOV hours on all major highways	**9**	3	6	0
	Do not start HOV hours earlier	**15**	0	15	0
	Add 3rd lane	**56**	14	39	3
	Extend HOV lanes further south	**10**	4	6	0
	Increase speed limit for HOV users	**9**	0	6	3
	New exit/entrance ramps	**118**	9	44	65
	No new exit/entrance ramps	**13**	2	8	3
	Open up Franconia-Springfield Pkwy ramps	**32**	4	28	0
	Improve exit ramps	**16**	0	13	3
	Entrance ramps onto HOV should merge into slow lane	**2**	0	2	0

		Total	Phone Calls	E-mails	Comment Sheets
	Stricter enforcement	121	41	77	3
	Police shift change at 6am – not monitoring the HOV	3	0	3	0
	Enforce the 'keep to the right/pass to the left' rule, ticket violators	2	0	2	0
	Prohibit large trucks in HOV lanes	13	2	11	0
	Route large trucks to HOV lanes	5	2	3	0
	Hot lanes	23	7	16	0
	No hot lanes	37	13	23	1
	Facilities: more & larger commuter lots, 'slug' shelters	67	9	31	27
	Decrease parking fees & metro fares	23	2	16	5
	Transit fares are cost prohibitive	22	3	18	1
	Subsidize bus & van pools	12	0	11	1
	Increase bus frequency	19	5	14	0
	Advertise Commuter options, i.e.: pick up places for 'slugs'	32	4	24	4
	Employees/ers need to be more flexible with hours	3	0	3	0
	Improve 395 into Pentagon and the tunnel	2	0	2	0
	Build a bypass	5	0	5	0
	Need more rail service south of Springfield/in VA	13	2	9	2
	Need extended Metro connections in VA	14	0	14	0
	Do not carpool because there are not exit ramps near work	3	0	3	0
	Do not carpool because I need my car	17	0	17	0
	Do not carpool because seldom have trip in corridor/hours do not encourage carpooling	34	0	31	3
	Information presented at citizen meeting was helpful	54	0	0	54
	Information presented at citizen meeting not helpful	28	0	3	25
	Purpose of Study needs to be defined	6	0	0	6
	This study was conducted during the wrong time of year (summer)	1	0	1	0

STUDY TEAM

BMI -- PRIME CONSULTANT

Hugh McGee, Principal-in-charge
Chris Gay, Project Manager
Warren Hughes
Phillip Shapiro
Sunil Taori
Michelle Smith
Dan Nabors
Rodney Strickland
Thang Nguyen
Steve Varner
Seifu Kerse
Marcy Katzman

T.Y. LIN INTERNATIONAL -- ENGINEERING

Thomas Fleming
Eric Mongelli
Richard Lawrie
Y.D. Li
Otis Deal
Russ Aylor
Denise Baumunk
Todd Oliver
Dave Dajc
Patrick LaFlamme

SG ASSOCIATES, INC -- TRANSIT ANALYSIS

Frank Spielberg
Randall Farwell
Kim Lieberman

TRAVESKY & ASSOCIATES, Ltd. -- PUBLIC INFORMATION

Marie Travesky
Denise Nugent
F. Tracey Pilkerton

GALLOP CORPORATION -- TRAVEL DEMAND FORECASTING

C. Y. Jeng
Eric Ho

MCV ASSOCIATES -- DATA COLLECTION

Joe Mehra
Ed Herlihy

CONSULTANT

Don Samdahl