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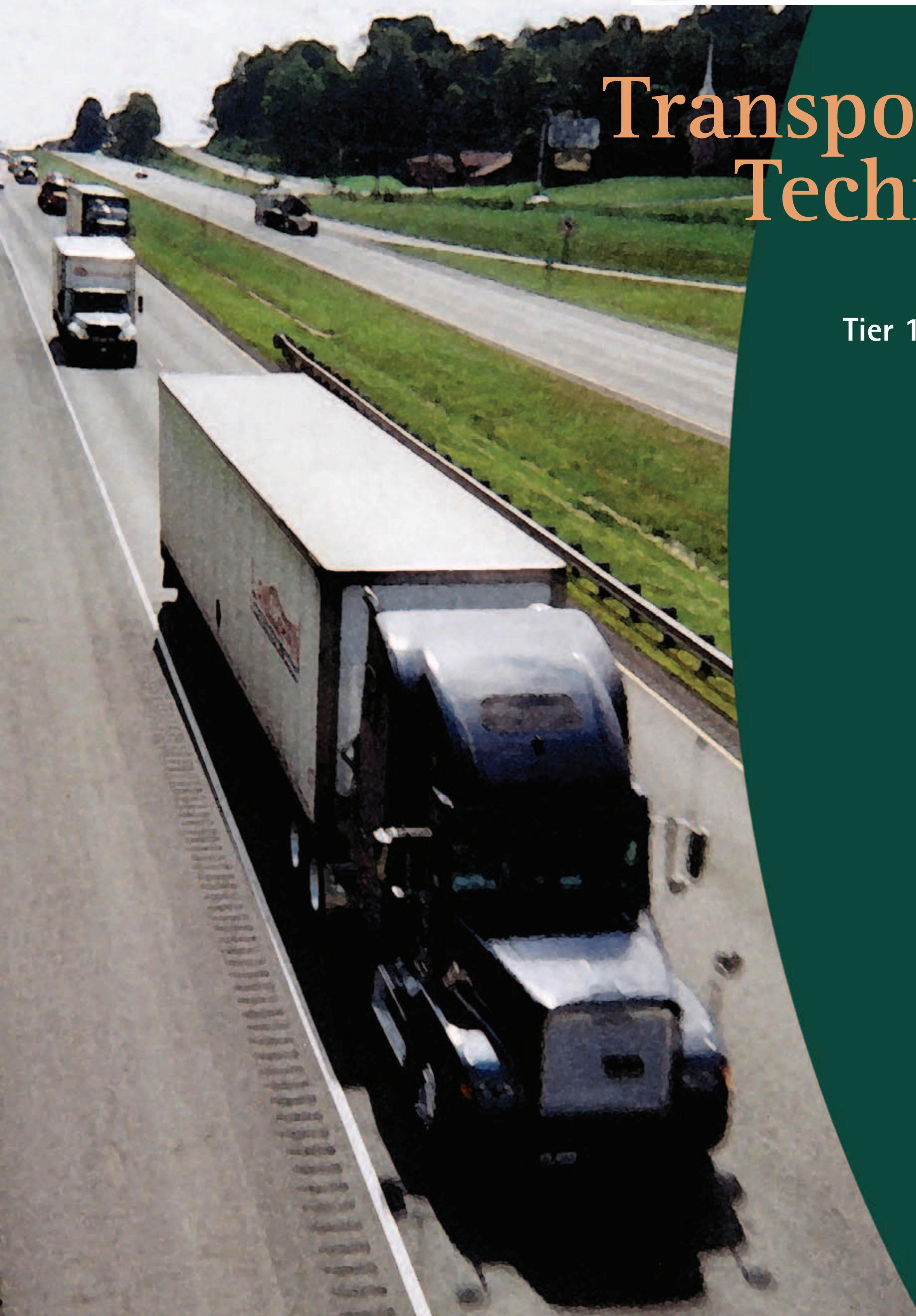

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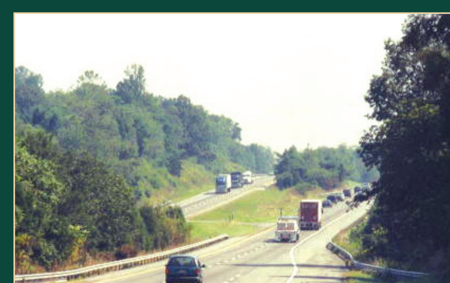
I-81 CORRIDOR IMPROVEMENT STUDY

Transportation Technical Report

Tier 1 Environmental Impact Statement



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Acronyms and Glossary of Terms

Government and Public Agencies

AASHTO	American Association of State Highway and Transportation Officials
BEA	Bureau of Economic Analysis
BTS	Bureau of Transportation Statistics
DOT	Department of Transportation
DRPT	Virginia Department of Rail and Public Transportation
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FHWA	Federal Highway Administration
FRA	Federal Railroad Administration
PENNDOT	Pennsylvania Department of Transportation
PPTA	Public-Private Transportation Act
SHA	State Highway Administration
STB	Surface Transportation Board
USACE	United States Army Corps of Engineers
VDOT	Virginia Department of Transportation

Data Sources

DRI	Data Resources, Inc.
GIS	Geographic Information Systems
GSP	Gross State Product
HCM	Highway Capacity Manual
HCS	Highway Capacity Software Version 4.1
HTRIS	Highway and Traffic Records Information System
REMI	Regional Economic Models, Inc.
RFP	Request for Proposal
TEA-21	Transportation Equity Act for the 21st Century
TIP	Transportation Improvement Program
VIUS	Vehicle Inventory and Use Survey

Organizations

AAA	American Automobile Association
AAR	Association of American Railroads
ATA	American Trucking Association

Organizations (Continued)

BB	Buckingham Branch Railroad Company
CARR	Chesapeake & Albemarle Railroad
CSXT	CSX Transportation (Railroad)
CW	Chesapeake Western Railway
CWRY	Commonwealth Railway, Inc.
ESHR	Eastern Shore Railroad, Inc.
HDR	HDR Engineering, Inc.
HJR-704	House Joint Resolution 704
JFA	Jack Faucett Associates, Inc.
NCVA	North Carolina & Virginia Railroad
NPB	Norfolk & Portsmouth Belt Line Railroad
NS	Norfolk Southern
SBIR	Small Business Innovative Research
SIC	Standard Industry Classification
SJR-55	Senate Joint Resolution 55
SV	Shenandoah Valley Railroad
SVIL	Virginia and Tennessee Railroad
VHB	Vanasse Hangen Brustlin, Inc.
VRE	Virginia Railway Express
VSRR	Virginia Southern Railroad
WEFA	Wharton Economic Forecasting Associates
WW	Winchester & Western Railroad Co.

Technical Terms

AADT	Average Annual Daily Traffic
AADTT	Average Annual Daily Truck Traffic
AAWDT	Average Annual Weekday Traffic
ADT	Average Daily Traffic
C-D	Collector-Distributor
COFC	Container on Flat Car
EB	Eastbound
EIS	Environmental Impact Study
FAF	Freight Analysis Framework
I-40	Interstate 40
I-581	Interstate 581
I-64	Interstate 64
I-66	Interstate 66
I-70	Interstate 70
I-76	Interstate 76
I-77	Interstate 77
I-78	Interstate 78

Technical Terms	(Continued)
I-80	Interstate 80
I-81	Interstate 81
I-83	Interstate 83
I-84	Interstate 84
I-88	Interstate 88
I-90	Interstate 90
I-95	Interstate 95
ISTEA	Intermodal Surface Transportation Efficiency Act
ITS	Intelligent Transportation Systems
L	Left
LOS	Level of Service
LR	Left-Right
LT	Left-Through
LTR	Left-Through-Right
MP	Milepost
mph	Miles Per Hour
N/A	Not Available
NAFTA	North American Free Trade Agreement
NB	Northbound
NEPA	National Environmental Policy Act of 1970
OD	Origin-destination
ORNL	Oak Ridge National Laboratory
R	Right
RR	Railroad
Rt.	Route
RV	Recreational Vehicle
SB	Southbound
STCC	Standard Transportation Commodity Classification
TMC	Turning Movement Count
TOFC	Trailer on Flat Car
TTA	Truck Trip Analyzer
vpd	Vehicles Per Day
vph	Vehicles Per Hour
WB	Westbound

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1

Introduction

The Federal Highway Administration (FHWA) and the Virginia Department of Transportation (VDOT) have prepared a Tier 1 Draft Environmental Impact Statement (EIS) for the *I-81 Corridor Improvement Study* in Virginia. The Tier 1 Draft EIS, prepared in accordance with the National Environmental Policy Act of 1969 (NEPA), evaluates and addresses the potential effects associated with conceptual-level improvements along the entire 325-mile length of Interstate 81 (I-81) in Virginia. The potential effects of specific improvements along I-81 would be analyzed in greater detail during subsequent Tier 2 studies if one or more "Build" concepts are advanced.

An Appendix to the *I-81 Corridor Study Tier 1 Draft EIS*, this *Transportation Technical Report* presents the transportation analysis conducted as part of the *I-81 Corridor Improvement Study*. This report presents baseline daily and peak period traffic conditions along the corridor, existing safety and geometric conditions, forecasts of future 2035 traffic and freight activity, and projections of future corridor operations. Information in this report is summarized in the Tier 1 Draft EIS.

1.1 Corridor Description

Interstate 81 (I-81) in Virginia is a 325-mile highway that runs in a southwest to northeast direction from western Virginia at the Tennessee border north to the West Virginia border. This portion of I-81 is critical to overall national system linkage.

I-81 is predominantly a four-lane limited access highway that was one of the earliest interstate highways constructed in the Commonwealth of Virginia. Within Virginia, I-81 connects to three major interstate highways including I-77 in Wytheville; I-64 near Lexington and Staunton; and I-66 near Middletown. A six-lane cross-section is provided in the areas of Bristol (from Tennessee to Exit 7) and Wytheville, where I-81 and I-77 overlap. There are 91 interchanges on I-81 in Virginia.

I-81 is used for both local travel and interstate travel in the eastern United States. For interstate travel, I-81 is a major trucking corridor as it connects Canada and the more densely populated northeastern United States to the mid-southern states and to other routes that connect to the Texas-Mexico border.

Beginning in July 2004, in response to safety concerns along the corridor, two truck restrictions were placed on I-81. Trucks are now prohibited from the leftmost travel lane on the six-lane sections of I-81 and all commercial vehicles must now stay in the rightmost lane if they are driving 15 mph or more below the posted speed limit (when there are no more than two lanes in each direction).

The I-81 corridor, rich in scenic and cultural resources, is also a major tourism corridor. An estimated $1.7 billion is expended annually in the corridor by visitors. These visitors are attracted by recreational opportunities in the Shenandoah and Blue Ridge Mountains, the rich Civil War history, and the numerous attractions in the 13 counties and numerous cities and towns located along the corridor.

1.1.1 National and Regional Context: System Linkage

I-81 is a corridor of national significance within the eastern United States. Following the spine of the Appalachian Mountains, I-81 is approximately 855 miles long extending from Tennessee to New York at the Canadian border.. Figure 1-1 provides a map of I-81 within the overall interstate system.

I-81 provides important system linkage to 12 major interstate highways, including:

- I-40 near Dandridge, Tennessee
- I-77 in Wytheville, Virginia
- I-64 near Lexington and Staunton, Virginia
- I-66 near Middletown, Virginia
- I-70 in Hagerstown, Maryland
- I-71 in Carlisle, Pennsylvania
- I-83 in Harrisburg, Pennsylvania
- I-80 in St. Johns, Pennsylvania
- I-84 in Scranton, Pennsylvania
- I-78 in Bordersville, Pennsylvania
- I-88 in Binghamton, New York
- I-90 in Syracuse, New York

Economies are dependent not only upon tourism and hospitality dollars generated by travelers but also on the truck freight systems that move manufacturing products to their destinations. I-81 is a major trucking corridor since it connects Canada and the more densely populated northeastern United States to the mid-southern states and provides connection to other routes to the Texas-Mexico border. The passage of the North American Free Trade Agreement (NAFTA) over a decade ago has increased cross-border trade and subsequent truck-hauled freight moving to and from the northeastern metropolitan regions. No other interstate corridors offer such a southwest-to-northeast alignment on the east coast that avoids the congestion around the major cities along the east coast, which adds to its attractiveness as a truck route.

Virginia's portion of I-81 is also critical to regional mobility due to its connection of other major corridors and important local access to rural communities and smaller cities/towns such as Bristol, Marion, Wytheville, Christiansburg, Roanoke, Lexington, Staunton, Harrisonburg, and Winchester. Figure 1-2 presents the I-81 corridor in the Commonwealth of Virginia.

1.1.2 I-81 History

Construction of I-81 in Virginia started in December 1957 with the first section of I-81 opened to traffic in 1959. By November 1963, 85 miles of I-81 were completed. Continued progress was made on the highway, with the final section from Dixie Caverns to Christiansburg opened on December 21, 1971, thus completing the entire 325-mile Virginia section of the interstate.

I-81 was fast recognized as an important and dependable corridor for north-south travel along the east coast. Traffic demands in 1978 ranged from 14,900 to 24,700 vehicles per day (vpd). Over the 25 years following 1978, travel demands have more than doubled and nearly tripled in some locations with average annual daily traffic in 2003 ranging from 34,000 to 57,000 vehicles per day, with a considerable portion of this traffic being heavy vehicles (about 9,200 to 13,500 trucks per day).

It became apparent during the 1990s that the aging I-81 infrastructure could not sustain itself under current and projected traffic demands. The highway, which in some locations was approaching 40 years old, was not designed for the volume of traffic using the facility daily. VDOT recognized the growing needs along I-81 and commissioned a full engineering review of the corridor in late 1995 (see later discussion in Section 1.2).

I-81 was constructed to directly parallel U.S. Route 11 from its southern end point east of Knoxville, Tennessee to its northern endpoint at the Canadian border near Watertown, New York. As the primary alternative route to I-81, and as a primary feeder at many locations throughout the corridor, a detailed evaluation of U.S. Route 11 is essential to understand how potential improvements to I-81 could affect U.S. Route 11 in Virginia.

1.1.3 U.S. Route 11 History and Functionality

Historically, U.S. Route 11 has been and will continue to be an important travel route in the western valleys of the Commonwealth of Virginia. U.S. Route 11 was built generally along the old Valley Pike or Valley Road, which itself was built along a Native American trail route. All of the major cities and many of the region's towns are located along U.S. Route 11.

Originally intended to provide access as a primary arterial roadway throughout the state, U.S. Route 11 no longer serves this purpose on all sections of the roadway. There are now sections where U.S. Route 11 travels coincide with I-81 (between Exit 72 and Exit 89 and between Exit 167 and Exit 175). In other locations, U.S. Route 11 parallels I-81 crossing the interstate 18 times. Since U.S. Route 11 is "Main Street" for many existing cities and towns, many of the I-81 interchanges connect directly or indirectly to U.S. Route 11.

The ability of U.S. Route 11 to provide for regional and local travel is, in part, a function of the roadway's design and its connections to other regional roads, including I-81. Connectivity between I-81 and U.S. Route 11 is available at many locations throughout the state, either with direct and indirect connections, or accessible within one-half mile.

U.S. Route 11 connects directly with I-81 at 20 exits, and indirectly (connection with a short roadway providing access only between U.S. Route 11 and I-81) with an additional three exits, as shown in Table 1-1. In addition, there are 19 additional exits where U.S. Route 11 is located within one-half mile of I-81.

Table 1-2 provides a summary of the breakdown of functional classifications on U.S. Route 11 by total miles. The functional classification of U.S. Route 11 varies considerably along its length. This reflects the varying role that U.S. Route 11 plays often as a parallel principal arterial to I-81, and in other areas as a minor arterial or a collector roadway. In many rural areas, U.S. Route 11 serves as a collector road to provide access to I-81. The majority of U.S. Route 11 (60 percent) is classified as a rural major collector.

Table 1-1 U.S. Route 11 Access to I-81

Exit Number	Cross Street	Jurisdiction	Direct Access	Indirect Access	Within ½ Mile
5	U.S. Route 11 & U.S. Route 19	City of Bristol	✓		
10	U.S. Route 11	Washington County	✓		
19	U.S. Route 11 & Route 56	Washington County	✓		
29	Route 91	Washington County			✓
32	U.S. Route 11 & Route 751	Washington County	✓		
35	Route 107 and Route 762	Smyth County			✓
39	U.S. Route 11 & Route 645	Smyth County	✓		
44	U.S. Route 11	Smyth County	✓		
47	U.S. Route 11 and Route F-010	Smyth County	✓		
54	Route 683	Smyth County			✓
60	Route 90 & Route 680	Smyth County			✓
67	U.S. Route 11	Smyth County	✓		
73	U.S. Route 11 and U.S. Route 52	Town of Wytheville	✓		
89	U.S. Route 11 and Route 100	Pulaski County	✓		
118	U.S. Route 11 and U.S. Route 460	Town of Christiansburg	✓		
132	Route 647	Roanoke County			✓
137	Route 112	Roanoke County			✓
150	U.S. Route 220	Botetourt County		✓	
156	Route 640	Botetourt County			✓
162	U.S. Route 11	Botetourt County	✓		
167	U.S. Route 11	Botetourt County	✓		
175	U.S. Route 11 & Route 609	Rockbridge County	✓		
180	U.S. Route 11 & Route 684	Rockbridge County	✓		
195	U.S. Route 11	Rockbridge County	✓		
200	Route 710	Rockbridge County			✓
213	U.S. Route 11	Augusta County	✓		
235	Route 256	Augusta County			✓
243	Connection to U.S. Route 11	Rockingham County		✓	
245	Route 659	Rockingham County			✓
251	Connection to U.S. Route 11	Rockingham County		✓	
257	U.S. Route 11 & Route 259	Rockingham County	✓		
264	U.S. Route 211 & Route 211	Shenandoah County			✓
269	Route 730	Shenandoah County			✓
273	Route 703 & Route 292	Shenandoah County			✓
277	Route 614	Shenandoah County			✓
298	U.S. Route 11	Shenandoah County	✓		
302	Route 627	Frederick County			✓
307	Route 277	Frederick County			✓
310	Route 37	Frederick County			✓
317	U.S. Route 11	Frederick County	✓		
321	Route 672	Frederick County			✓
323	Route 669	Frederick County			✓
	Total		20	3	19

Table 1-2 U.S. Route 11 Functional Classification Summary

Functional Classification	Total Miles on U.S. Route 11	Percent of Total
Urban Other Principal Arterial	41.3	13
Urban Minor Arterial	44.2	14
Rural Minor Arterial	27.8	9
Rural Major Collector	188.9	60
Urban Collector	12.7	4
Total	314.9	100

Roadway Geometry

U.S. Route 11 has a varying cross-section, often dependent on the through and local traffic needs being served. Table 1-3 provides a summary of roadway miles by cross-section. The majority of U.S. Route 11 (54 percent) has a two-lane cross-section. A four-lane cross-section is provided on 33 percent of U.S. Route 11, and a three-lane cross-section is provided on the remaining 13 percent. Often, the three-lane cross-section is used as a transition between two and four lanes or to provide turning lanes at key locations, so this cross-section is rarely in place for extended lengths and most of these are located within urban areas.

Table 1-3 U.S. Route 11 Roadway Cross-section Summary

Number of Travel Lanes	Median Treatment	Total Miles on U.S. Route 11	Percent of Total
Two	Undivided	170.5	54
Three	Undivided	40.8	13
Four	Divided	58.6	19
Four	Undivided	45.0	14
Total		314.9	100

1.2 Study Status

1.2.1 Previous I-81 Concept Studies

To gain a complete understanding of current and projected deficiencies and needs along I-81, VDOT conducted a review of the entire 325-mile corridor by dividing it into 10 concept study areas. The concept studies began in the spring of 1996 and concluded in the fall of 1998. The studies evaluated existing safety, traffic operations, and geometric conditions, forecasted future traffic demands to design year 2020, and identified preliminary improvements. The studies also examined specific issues, such as concepts to widen the existing highway, interchange improvements, goals to preserve the region's natural beauty, and traffic and land use matters unique to the various communities located along I-81.

The I-81 concept study findings presented in 1998 included the following:

- The pavement structure was not designed for the increased car and truck traffic that it now carries;
- The highway needs to be widened to maintain an acceptable level of service under increasing traffic demands (to a minimum of six lanes exclusive of truck climbing lanes over much of the corridor and eight lanes in the Roanoke/Salem, Harrisonburg, Staunton, Winchester, and I-77/I-81 overlap areas);
- Additional capacity should be constructed in the median area wherever feasible (more than 100 miles of widening was envisioned to be exclusively in the median area);
- Any widening projects should examine techniques to minimize the need for additional right-of-way;
- Many interchanges will have to be reconstructed;
- Separate truck lanes were evaluated and were found to be cost-prohibitive without substantially improving the level of service over general-use lane options; and
- The initial estimate was that $3.4 billion of improvements were needed to maintain a Level of Service C by the year 2020. (These costs were expected to be refined as future design plans were developed).

The I-81 concept studies were presented to the Commonwealth Transportation Board at its December 1998 workshop. The information from these concept studies assisted the Board in forming its priorities for I-81 improvements, which are set forward in the Virginia Transportation Six-Year Improvement Program.[1] As appropriate, the data collected as part of these studies has been used to supplement new data collected as part of this technical report.

1 For fiscal years 2004, 2005, and 2006.

1.2.2 I-81 Corridor Improvement Study

The Federal Highway Administration (FHWA) and VDOT began the *I-81 Corridor Improvement Study* in the Fall of 2003. The study identifies corridor deficiencies, analyzes the transportation effects of tolls, develops potential solutions to address corridor needs, and is being conducted in accordance with the provisions of the National Environmental Policy Act (NEPA).

2
Data Collection

This chapter summarizes the data that was collected as part of the Tier 1 Draft EIS process and the analysis completed to account for daily and seasonal variations of traffic flow. The raw data collected for each section of this chapter can be found in Appendix A to this technical report.

2.1 Traffic Data Collection

Mainline, ramp, and intersection traffic volumes are necessary to assess the existing traffic operations along the I-81 study corridor. Traffic flows along I-81 (northbound and southbound) are monitored continually by VDOT at eight permanent count stations strategically located throughout the study area. In addition, VDOT has been conducting and reporting supplemental traffic counts along the corridor for more than three decades.

2.1.1 VDOT Traffic Data

Average annual daily traffic volumes (AADT) were reviewed from the *VDOT Average Daily Traffic Volume, Classification Data for Interstate, Primary, and Arterial Routes*[2] publications back to the year 1978. Additionally, ADDT volumes at the eight permanent count stations on I-81 from 1997 to 2003 were reviewed from VDOT's electronic database, as were hourly traffic volume data and daily traffic volumes to develop conversion factors to AADT. All data were compiled and reviewed for validity before being applied to network production. These data were used to normalize all new data collected, as described in the subsequent sections.

2 *Average Traffic Volume and Classification Data for Interstate, Primary, and Arterial Routes*, Virginia Department of Transportation, 1978 – 2003.

Average Annual Daily Traffic

Traffic data from the eight permanent count stations located along I-81 were summarized to determine the variations in AADT conditions along the corridor. A summary of the count station data is presented in Table 2-1.

Table 2-1 I-81 Average Annual Daily Traffic

VDOT Permanent Count Station Location	Northbound Milepost	Southbound Milepost	2003 AADT
Route 140 to South Corporate Limit of Abingdon	16.4	17.0	41,900
U.S. Route 11 to North Corporate Limit of Wytheville	75.4	75.4	51,900
Route 177 to Route 8 (near Radford)	113.0	110.8	41,000
Route 581 to Route 115 (Roanoke)	145.3	146.1	57,100
U.S. Route 11 to U.S. Route 11-614 (Buchanan)	164.5	167.8	34,300
Route 606 to Augusta County Line	207.5	207.3	41,700
U.S. Route 11 to Route 659 (Harrisonburg)	245.4	245.3	48,000
Route 50 to South Corporate Limit of Winchester	315.8	316.0	56,200
Overall Corridor Average			46,400

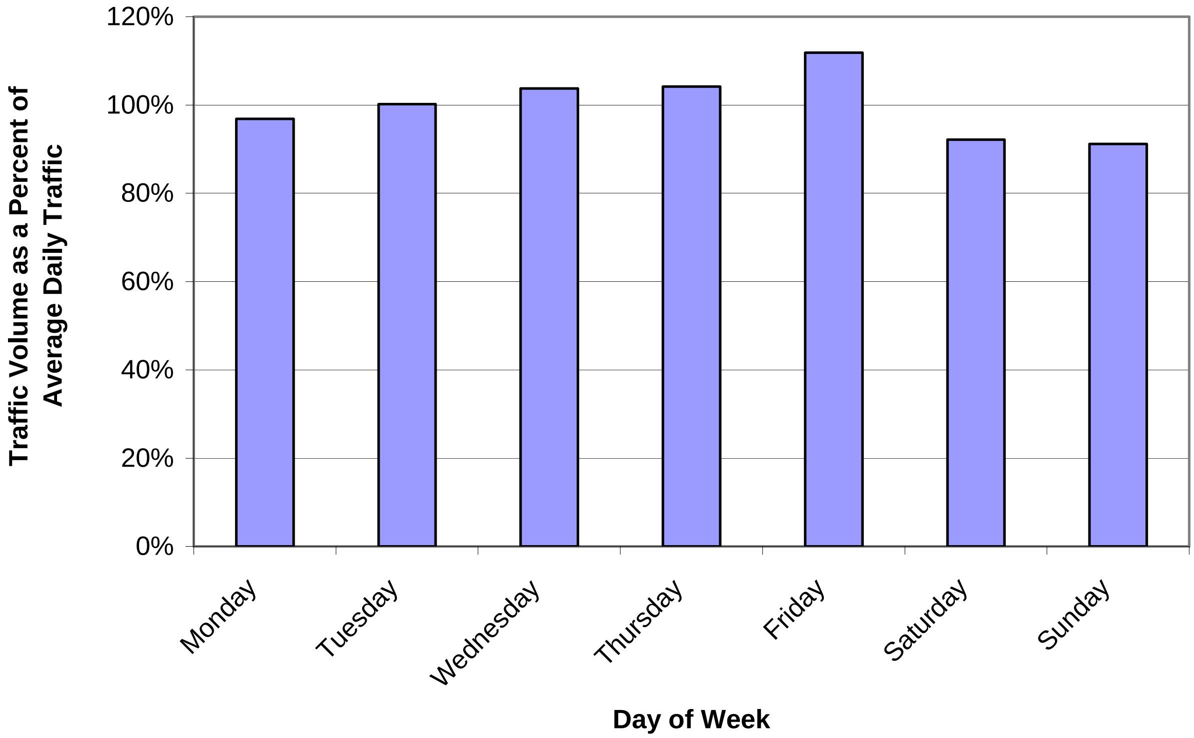
Source: VDOT 2003 Permanent Count Station Data

In 2003, AADT volumes along I-81 ranged from 34,300 vpd in Buchanan to 57,100 vehicles per day in Roanoke. In the south, approximately 41,900 vpd traveled on I-81 in the Abingdon area, with traffic volumes increasing to 51,900 vpd in Wytheville due to the influence of I-77. In the north, the traffic volume in the fast-growing Winchester area was approximately 56,200 vpd, almost as high as the Roanoke area.

Day of Week Patterns

The variation of I-81 traffic volumes from the eight permanent count stations were analyzed by day of the week. These data are summarized in Figure 2-1. Based on daily variation data, Thursday and Friday were shown to be the heaviest travel days on I-81 during a typical week (averaging four to 12 percent heavier than average daily flows, respectively). Conversely, Saturday and Sunday were found to be the lightest traveled days in the I-81 corridor (approximately nine percent lower than average daily flows).

Figure 2-1 I-81 Average Daily Variations in Traffic



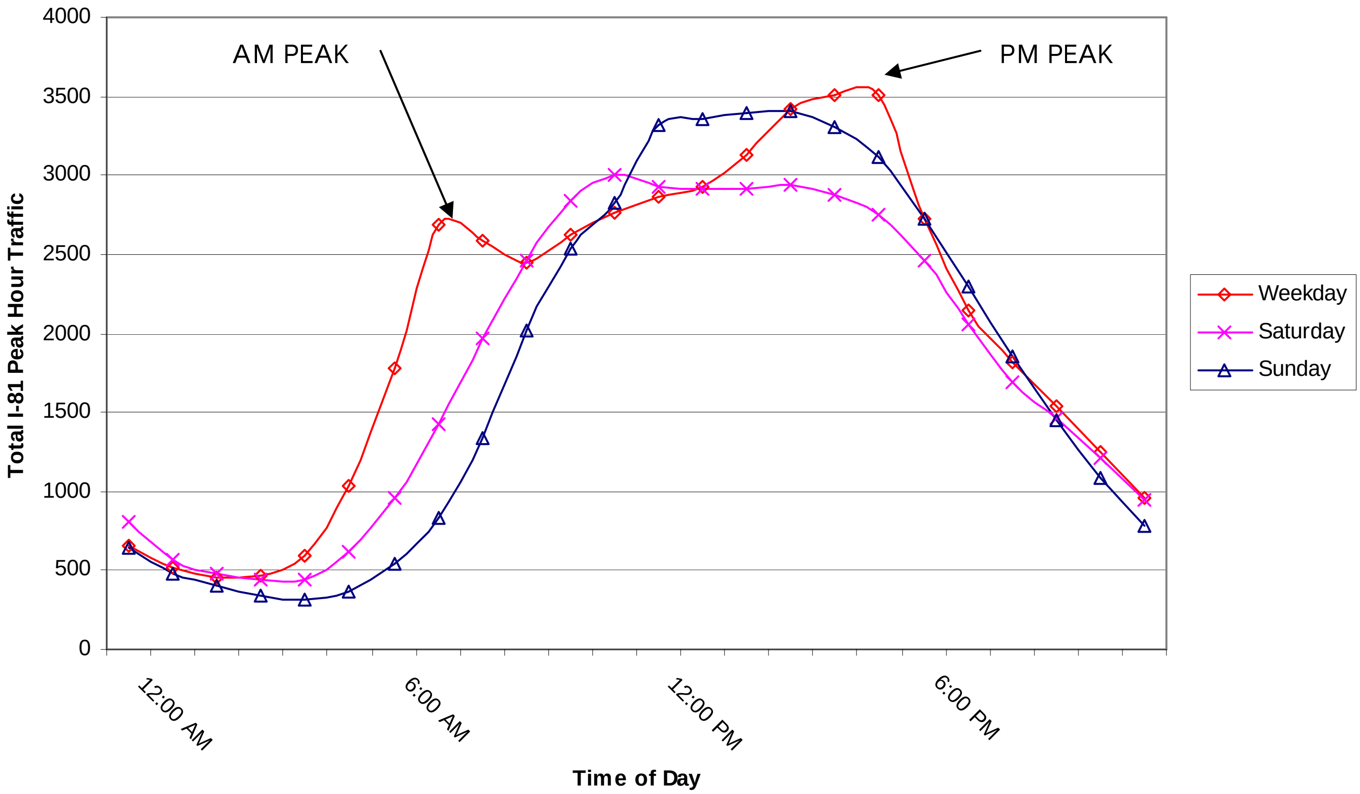
Source: VDOT 2003 Daily Count Data at representative locations along I-81 corridor

Daily Variations

Extensive VDOT daily traffic volume data were also reviewed and analyzed to determine the daily peaking characteristics of traffic volumes along the I-81 corridor. Traffic flows along I-81 exhibit two distinct peaks during the morning and evening peak periods (see Figure 2-2). The weekday evening peak hour is consistently 20 to 33 percent higher than the weekday morning peak hour traffic volumes on I-81. On the weekends, traffic flows on I-81 have a more gradual peaking characteristic during the afternoon period. In comparing volumes over the entire week, typically the weekday evening peak hour represents the overall peak traffic condition along the corridor.

Due to the nature of regional and national traffic that places demands on the corridor throughout the day and week, and the times of day they travel, the weekday evening peak hour typically represents only five to ten percent (generally referred to as the "k factor") of the average annual daily traffic along the mainline. This k factor range is considered low, particularly in comparison to corridors experiencing heavy commuter traffic; although some individual ramp locations experience considerably higher k factors (up to 25 percent). The average northbound k factor is 7.1 percent, while the southbound is 7.4 percent.

Figure 2-2 Average Hourly Peaking Characteristics of I-81 Corridor Traffic



Source: VDOT 2003 Daily Count Data at representative locations along I-81 corridor

Vehicle Classification

Vehicle classification counts from the VDOT permanent count stations on I-81 were also reviewed. As shown in Table 2-2 below, heavy vehicles account for almost 26 percent of the AADT volume on I-81 in Virginia. Daily truck percentages were observed to be as high as 35 percent in some locations.

Table 2-2 I-81 Vehicle Classification Summary

VDOT Permanent Count Station Location	Northbound Milepost	Southbound Milepost	Total AADT	Heavy Vehicle AADT	Heavy Vehicle Percentage
Southern Section					
Route 140 to South Corporate Limit of Abingdon	16.4	17.0	41,900	9,180	22.4%
U.S. Route 11 to North Corporate Limit of Wytheville	75.4	75.4	51,900	13,450	25.9%
Central Section					
Route 177 to Route 8 (near Radford)	113.0	110.8	41,000	11,240	27.4%
Route 581 to Route 115 (Roanoke)	145.3	146.1	57,100	11,990	21.0%
U.S. Route 11 to U.S. Route 11-614 (Buchanan)	164.5	167.8	34,300	11,970	34.9%
Northern Section					
Route 606 to Augusta County Line	207.5	207.3	41,700	13,480	32.4%
U.S. Route 11 to Route 659 (Harrisonburg)	245.4	245.3	48,000	12,870	26.8%
Route 50 to South Corporate Limit of Winchester	315.8	316.0	56,200	11,850	21.1%
Overall Corridor Average			46,400	12,010	25.9%

Source: VDOT 2003 Permanent Count Station Data

Selected hourly traffic volume data along the I-81 corridor from the count stations were also reviewed for vehicle classification. The peak hour data suggests that the morning and evening peak hour heavy vehicle percentages along the length of I-81 are approximately 20.4 and 18.4 percent of the overall traffic stream, respectively. An expanded discussion of freight movement through the corridor and truck traffic is presented in the *Freight Forecast and Diversion Technical Report*.

2.1.2 New Data Collection

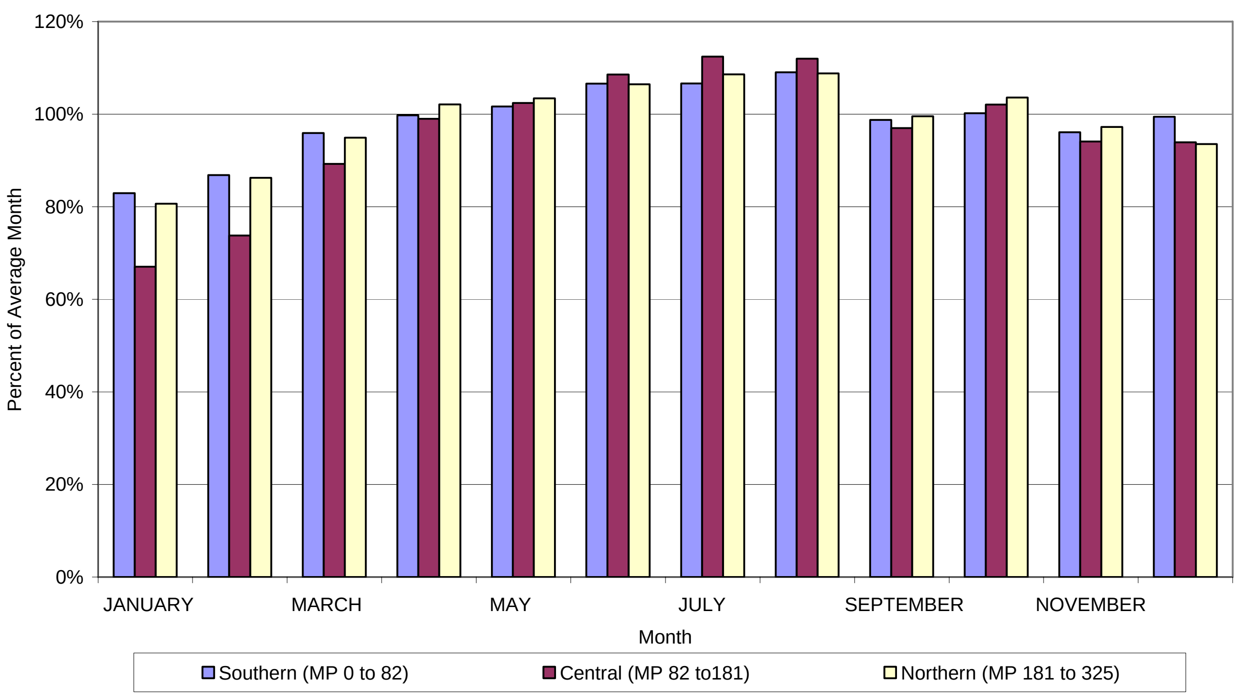
To supplement existing traffic data, an extensive traffic count program was also completed as part of this study effort. These data were collected over a four-month period from late January to early May of 2004. Specifically, the following new traffic data were collected:

- Daily volume counts on all 382 ramp sections of the 91 exits in the study area;
- Daily volume counts on local roads at 117 locations along the corridor; and
- Turning movement counts at intersections of the 172 ramp locations with local cross streets.

Seasonal Adjustment

The seasonal variation of traffic volumes was reviewed along the I-81 corridor using the 2003 daily traffic volumes received from the eight permanent count stations. Due to variations in travel patterns along the corridor, these counts were further analyzed for the southern (Milepost 0 to 82), central (Milepost 82 to 181), and northern (Milepost 181 to 325) sections of the corridor. As shown in Figure 2-3, the corridor shows its highest traffic volumes during the months of June, July, and August (five to 12 percent higher than the average month). January and February show the lowest utilization (15 to 19 percent lower than the average month), especially along the central portion of the corridor. This pattern likely reflects the influence that recreation and vacation travel has along the corridor.

Figure 2-3 I-81 Monthly Variations in Traffic (Southern, Central, and Northern sections of I-81)



Source: VDOT 2003 Seasonal Adjustment Data from seven regions along I-81 corridor

Based on the trends presented above, the traffic counts collected in early 2004 were adjusted higher to account for seasonality, and represent average annual conditions. This adjustment ensures that the transportation assessment of I-81 traffic growth and the analysis of each of the potential concepts are consistent and reflective of the average annual daily traffic along the corridor.

Annual Adjustment

All traffic data collected at ramps and local intersections along the corridor represent 2004 existing conditions and were seasonally adjusted as described above. To determine an appropriate annual adjustment of the 2003 mainline volumes to 2004, AADT volumes were reviewed from 1997 to 2003. Due to improvements in data collection and reporting, this six year period has shown to have the most accurate information available. These data established an average corridor-wide growth rate of 3.3 percent per year. Accordingly, the 2003 mainline daily and peak hour volumes were grown by 3.3 percent to reflect 2004 conditions for use in this study.

2.1.3 Park and Ride Facilities

The latest inventory of Park and Ride facilities in Virginia was conducted in 2003. All Park and Ride facilities that serve I-81 were extracted from the VDOT Transportation and Mobility Management Division inventory and summarized in tabular form. A summary of this information is presented in Table 2-3. Specific details are provided in Appendix A. Based on the location data and proximity to I-81, it has been determined that 23 Park and Ride facilities served I-81 in 2003.

Of the 23 Park and Ride facilities, 13 are VDOT-owned and maintained, five are informal but operational, four are privately-owned and operated, and one is currently listed as closed. None of the facilities currently have bicycle accommodations or impose a fee on commuters.

In addition to the provisions of each Park and Ride lot (such as bathroom facilities, vending machines, etc.), the inventory summarizes parking utilization counts. Although the exact time of day that the data were collected is not available, the utilization likely represents the midday period between typical working hours, which would represent approximately how many commuters use these facilities during an average workday. The existing total parking supply is approximately 677 parking spaces among all 23 facilities that serve I-81. Twenty-eight of these spaces are designated handicapped parking. A total of 339 spaces (50 percent) were occupied during the time of each site visit. A lot in Botetourt County was observed to be operating over capacity, where there were more vehicles parked than the number of marked spaces available.

Table 2-3 I-81 Park and Ride Facility Inventory

Jurisdiction	District	Location	Owner	Number of Spaces	Transit Connections	Percent Utilization
Abingdon	Bristol	Hall Street NW	VDOT	40	Yes	45 %
Chilhowie	Bristol	Shop Road	VDOT	12	No	67 %
Wythe County	Bristol	Route 52 at F-042	VDOT	65	No	37 %
Chilhowie	Bristol	Route 107	Private	10	No	80 %
Chilhowie	Bristol	Route T-762 at T-608	Private	10	No	70 %
Washington County	Bristol	U.S. Route 11 at I-81	Private	12	No	67 %
Wythe County	Bristol	Route 618 at I-81	Private	10	No	80 %
Wythe County	Bristol	Route 52/121 at I-81	VDOT	65	No	29 %
Botetourt County	Salem	Route 220 at Route 816	VDOT	13	No	170 %
Montgomery County	Salem	Route 635 at Route 603	VDOT	40	No	13 %
Pulaski County	Salem	Route 99 at Route F-047	VDOT	13	No	50 %
Roanoke County	Salem	Route 311 at Route 1150	VDOT	59	No	90 %
Christiansburg	Salem	Route 8 at I-81	Informal	25	No	44 %
Roanoke County	Salem	Route 419 at Route 780	Closed	--	--	--
Roanoke County	Salem	Route 419/ 311/ 630	Informal	32	No	82 %
Roanoke County	Salem	Route 419/ 311/ 863	Informal	35	No	35 %
Montgomery County	Salem	Route 640 at Route 1416	VDOT	55	No	15 %
Augusta County	Staunton	U.S. Route 11/ 612/ 1906	VDOT	35	No	29 %
Rockingham County	Staunton	Route 259 at U.S. Route 11	VDOT	32	No	94 %
Rockingham County	Staunton	Route 257	VDOT	20	No	55 %
Augusta County	Staunton	Route 256 at U.S. Route 11	Informal	25	No	60 %
Shenandoah	Staunton	U.S. Route 11 at Route 651	Informal	30	No	40 %
Augusta County	Staunton	U.S. Route 11 at Route 659	VDOT	10	No	20 %

Source: 2003 VDOT Transportation and Mobility Management Division Inventory

2.1.4 Rest Area Inventory

An inventory of rest areas that serve I-81 in Virginia was conducted in order to summarize services available to motorists and to determine existing parking conditions. In addition to conducting an inventory of parking spaces for both passenger cars and trucks at each rest area, a spot count was also performed of parked cars and trucks to assess utilization. Each rest area was visited twice – once between 11:00 AM and 2:00 PM, and then again between 11:00 PM and 2:00 AM. Including the Virginia Welcome Center for traffic entering Virginia from Tennessee, there are 15 rest areas along I-81 (in both directions within Virginia).

Truck parking at rest areas is kept separate from passenger car parking, often in an adjacent lot behind the rest area provisions and further away from the interstate. In some instances, recreational vehicle (RV) and bus parking is available within the passenger car parking areas. Restricted parking is available for state police vehicles and handicapped travelers. In addition to parking supply, each rest area provides restrooms, pay phones, and demarcated open space that often includes picnic tables. Many rest areas also provide vending machines and information kiosks with maps and brochures for local attractions. Other provisions include pet rest areas, water fountains, trash cans, and dumpsters. Each rest area has a two-hour parking restriction, with signs visibly posted. Overall, field observations indicate several instances of trucks parking in RV/bus spaces, specifically at the Virginia Welcome Center (which is restricted to cars only).

A summary of parking space supply and demand is provided in Appendix A. With the exception of two rest areas restricted to passenger cars only and one rest area restricted to truck use only, available parking supply ranges from 18 to 95 passenger car spaces and eight to 75 truck spaces. An average of 43 passenger car and 19 truck spaces were unoccupied at each rest area. On average, 11 passenger cars and 12 trucks were parked at each rest area during the 11:00 AM to 2:00 PM spot count and eight passenger cars and 30 trucks were parked at each rest area during the 11:00 PM to 2:00 AM count.

By comparing the number of passenger car and truck spaces available in each of the rest areas with the number occupied, a percent capacity was determined to assess utilization. Between 11:00 AM and 2:00 PM, the utilization in passenger car areas ranged from 13 to 50 percent of capacity, with an average utilization of 28 percent. Truck lot utilization ranged from 27 to 178 percent, with an average utilization of 74 percent. Three of the truck lot areas were operating at over 100 percent capacity. These areas are Troutville and Mount Sidney North in the northbound direction and Winchester Welcome Center in the southbound direction.

Between 11:00 PM and 2:00 AM, the utilization in passenger car areas ranged from seven to 33 percent of capacity, with an average utilization of 20 percent. Truck lot utilization ranged from 105 to 267 percent, with an average utilization of 168 percent. Many trucks were observed parking on the shoulders of the ramps into and out of the rest areas, and the queues often extended well beyond the parking areas of the rest stops. In the northbound direction, notable locations of truck parking overflow occur at the Bristol Welcome Center, Abingdon, Radford Area North, Ironto, Troutville, Mount Sydney North, and New Market North. In the southbound direction, notable locations of truck parking overflow occur at the Winchester Welcome Center, New Market South, Mount Sydney South, Fairfield, Radford South, and Smyth.

Based on the limited data collection, these existing conditions indicate that passenger car parking supply is sufficiently meeting the existing demand. However, no rest area along the corridor currently offers enough truck parking to serve the demand during the overnight hours.

2.1.5 Travel Speeds

Generally, the posted speed limit on I-81 in Virginia is 65 miles per hour (mph). There are three urban locations where the speed limit is reduced to 60 mph. These locations are:

- Roanoke (from milepost 136.4 to milepost 151.7 northbound and from milepost 151.9 to 136.7 southbound);
- Harrisonburg (from milepost 242.3 to milepost 249.0 northbound, and from milepost 248.2 to milepost 243.3 southbound); and
- Winchester (from milepost 312.9 to milepost 316.6 in both directions)

To assess existing operating speed conditions and to identify areas of recurring traffic congestion, travel time data were collected along the I-81 corridor during the month of June 2004. Time measurements were recorded at each exit in both directions over a multi-day period. Several observations were taken over each period on a typical day with no crashes, breakdowns, adverse weather conditions, or other special events that would result in atypical traffic conditions. Overall, the average travel speed on I-81 in both directions was 69 miles per hour (mph), while the 85th percentile speed (the speed equal to or higher than 85 percent of the speeds vehicles are traveling) was found to be 71 to 72 mph. Both the average speed and the 85th percentile speed exceed the posted speed limit.

Observed average travel speeds ranged from 56 to 75 miles per hour. In the northbound direction, 78 percent of the vehicles were observed to have speeds within one standard deviation of the average travel speed, with the southbound direction averaging 64 percent. Individual speed data can be found in Appendix A.

Areas experiencing lower overall average travel speeds include:

- Milepost 22-24 northbound
- Milepost 26-29 northbound
- Milepost 35-39 northbound
- Milepost 140-141 northbound
- Milepost 315-317 northbound
- Milepost 283-279 southbound
- Milepost 217-213 southbound
- Milepost 149-143 southbound
- Milepost 140-137 southbound
- Milepost 98-94 southbound
- Milepost 84-81 southbound

3

Analysis of Existing Conditions

An effective evaluation of existing conditions along I-81 requires an understanding of current traffic volumes, operations, and geometric conditions. The existing conditions evaluation focused on daily and evening peak hour traffic volumes, recent crash history along the corridor, and an inventory of highway and interchange geometry.

3.1 Traffic Volumes

Daily and peak hour traffic volumes for the I-81 mainline (325 miles) and all ramps at the 91 study area exits were analyzed, as well as peak period turning movement volumes at selected study intersections.

3.1.1 Existing Traffic Network

The creation of an existing peak hour traffic volume network was based on both existing mainline count data and newly collected ramp counts. Averaged mainline data from the VDOT historical hourly data and average annual daily traffic volumes from the eight permanent count stations were used to provide a baseline volume network in their respective regions.

Based on the peak hour volume data for the 2003 calendar year, the evening peak hour was chosen as the “design” peak hour because it generally represents the highest (or worst case) condition along the corridor (exhibiting higher k factors). Therefore, all volume data used for this study are based on the annualized weekday evening peak hour traffic volume data and the adjusted ramp counts (as described in Section 2.1.2). Further consideration on peaking characteristics was given to the I-77 overlap section of I-81, as this section shows somewhat higher weekend and seasonal peaking than other sections along the highway. A sensitivity analysis was conducted to ensure allocation of the proper number of lanes based on the higher weekend volumes. This assessment can be found in Chapter 4.

These data were first disaggregated by passenger cars and trucks to generate individual networks for each vehicle type. The traffic volumes between permanent count stations were balanced based on the entering and exiting ramp volumes to ensure that traffic volumes between each exit are equal. The data collection process can sometimes result in volume imbalances due to minor variations in traffic flow and unavoidable time lags between exits; this phenomenon is normal and expected. These imbalances are smoothed (manually adjusted to provide more natural agreement with other exit volumes and/or historical data) at individual exits to provide a consistently balanced network for the entire I-81 corridor. The resultant 2004 existing daily and peak hour traffic volume networks for passenger cars and trucks are contained in Figures 3-1 through 3-4.

While the I-81 Tier 1 study collected considerable traffic data on U.S. Route 11 where this road met I-81 at an exit, more extensive traffic data was needed in order to evaluate potential traffic impacts on U.S. Route 11 in general. For consistency, the most recent year (2002) comprehensive traffic data summary for U.S. Route 11 was used. Traffic data were summarized at the state lines, at County boundaries, and at selected locations throughout the corridor. This information is provided later in this document in Table 4-16 for both existing and future conditions.

3.1.2 Mainline and Ramp Volumes

The adjusted and smoothed existing daily traffic volumes along the I-81 mainline are shown on Figure 3-1. These volumes are also presented in Table 3-1 for key locations along the corridor. Approximately 28,000 to 73,000 vpd travel between the Tennessee and West Virginia State Lines (13,800 to 37,300 vpd in each direction). Peak hour mainline volumes are listed in Table 3-1 and shown in Figure 3-2. Ramp volumes are also presented on Figures 3-1 and 3-2.

I-81 is a heavy freight corridor with up to 35 percent of the daily traffic comprised of through trucks (based on the traffic counts conducted in 2004). Average daily truck traffic accounts for approximately 26 percent of traffic along the corridor, while peak hour truck percentages range from 18.4 to 20.4 percent. Traffic networks depicting the daily and peak hour heavy vehicles are presented in Figures 3-3 and 3-4, respectively.

During the "design" peak hour, northbound traffic ranges from 1,050 to 3,050 vph, with the heaviest flow occurring between Exits 137 and 150 in the Roanoke area. Southbound traffic volumes range from 900 to 3,150, with the heaviest flow occurring between Exits 118 and 146 in the areas of Roanoke, Christiansburg and Blacksburg. Other locations with higher traffic flows include the I-77 overlap (Exit 72 and 81) and the I-64 overlap (Exits 191-221). The exit ramps at the junction of these interstates experience heavy daily and design peak hour flows, as do the major junctions of I-81 at I-381 (Exit 3), I-581 (Exit 143), and I-66 (Exit 300).

Table 3-1 Existing (2004) I-81 Traffic Volumes

	Northbound		Southbound	
Location	Design Peak Hour (vph[1])	Daily (vpd[2])	Design Peak Hour (vph)	Daily (vpd)
Tennessee State Line	1,600	15,500	1,100	15,800
Wytheville	2,050	28,000	1,750	27,500
Roanoke	3,050	37,300	3,150	35,800
Lexington	1,500	20,500	1,500	19,700
Staunton	2,000	28,900	2,250	30,100
Middletown	1,300	22,200	1,650	21,600
Winchester	2,300	29,700	2,000	29,000
West Virginia State Line	1,800	23,100	1,200	21,000

1 Vehicles per hour
2 Vehicles per day

3.1.3 Peak Period Turning Movements

Peak period turning movement counts (TMCs) were conducted at 172 locations (where I-81 ramps meet with local streets). Coincident with the ramp data, TMC data were collected from January to May 2004 during the weekday evening (4:00 PM to 6:00 PM) peak periods. The peak hour volumes were used to calculate levels of service and evaluate existing operations at areas immediately adjacent to the interstate.

The VDOT historical traffic volume information reviewed to determine the seasonal traffic variations at the ramps were also applied to the local street ramp termini. Local street turning movement counts were all factored to average annual conditions. These turning movements have been further adjusted to conform with ramp volumes at the exits. The peak hour traffic volume networks at each of the 91 exits are presented in Appendix B of this report.

3.2 Traffic Operations Analysis

Understanding the relationship between demand and supply is a fundamental consideration in evaluating how well a transportation facility or service fulfills its objective to accommodate the traveling public. From the standpoint of a freeway facility, this assessment is usually accomplished by conducting a level of service (LOS) analysis. The level of service analysis compares "peak" traffic demands with the available freeway capacity. The peak demand utilized for this analysis is generally based on hourly traffic flows. For multi-lane, divided highways such as I-81, these flows are analyzed by direction.

To assess existing traffic operating conditions in the I-81 corridor, level of service analyses were conducted for mainline segments between exits, ramp diverges and merges, and weaving sections during the evening peak "design" hour. The following sections discuss the capacity analysis assumptions and results.

3.2.1 Mainline and Ramp Operations

The ideal capacity of a freeway segment can be affected by a number of factors, including the number of travel lanes, amount of heavy vehicles (large trucks or recreational vehicles) within the traffic stream, the terrain (grade), lane widths, the presence of obstructions adjacent to the highway, the drivers (regular or infrequent users, which is an indication of a driver's familiarity with the highway), and the prevailing speed of the traffic flow. Other non-recurring factors such as inclement weather and traffic accidents or incidents can also have a substantial effect on congestion, particularly on highways operating at or near capacity. Although these latter factors are not formally taken into consideration in the calculation of the freeway's capacity, they are important to the operations of the freeway, as both have the potential to substantially affect vehicle speed.

The other major factor affecting the capacity of a freeway is the interaction of vehicles at interchanges, where traffic on the mainline can be substantially affected by the "friction" between vehicles merging into the traffic stream and vehicles slowing to exit from the traffic stream. According to the *Highway Capacity Manual (HCM),*[3] this interaction can reduce the capacity of a freeway segment by the amount of merging vehicles, especially if there is inadequate distance provided by the acceleration/deceleration lanes on the freeway. Where acceleration/deceleration lanes do not meet current design standards, capacity along the freeway segment will be further impacted as vehicles will need to use part of the freeway to accelerate and decelerate. Section 3.4 of this report summarizes locations along I-81 that have geometric deficiencies.

The existing cross-section for I-81 includes a two to four-foot inside shoulder, two 12-foot travel lanes, and one 10-foot shoulder. In the southern section of the study area, where I-77 and I-81 overlap and in the vicinity of the Tennessee State Line, three 12-foot travel lanes are provided. Through Christiansburg, between I-64 near Staunton and I-66 near Middletown, 12-foot shoulders are provided in the northbound direction.

Mainline Level of Service Criteria

The study methods outlined in Chapter 23 (Basic Freeway Segments) of the *Highway Capacity Manual*[4] were used for the level of service analysis of the various I-81 segments within Virginia.

The term level of service is used to define the operational characteristics of traffic flow along a given highway. A letter grade from LOS A (representing free-flow traffic conditions) to LOS F

3 Transportation Research Board, *Highway Capacity Manual*, Special Report 209, Washington, D.C., 2000.
4 Ibid.

(representing a forced breakdown in traffic flow) is assigned to a specific segment of the highway, as can be seen Table 3-2 and Figure 3-5. Level of service represents reasonable ranges in the three critical flow variables: speed, density of vehicles in the traffic stream, and the flow rate of the vehicles. Basically, as the density of vehicles per mile of highway increases, the speed of the vehicles on the highway tends to decrease and the flow rate of the vehicles correspondingly decreases. A four-lane freeway can process approximately 2,400 passenger vehicles per lane per hour (4,800 vehicles per direction) under optimal conditions (12-foot travel lanes, 2-foot median lateral clearance and 6-foot right lane lateral clearance, level terrain, no heavy vehicles, and a driver population consisting of mostly regular users) in rural areas. The freeway capacity drops to about 2,300 passenger vehicles per lane per hour (4,600 vehicles per direction) in urban areas. These volumes would result in LOS E operations, the point at which a highway is considered to be operating at capacity.

Table 3-2 Level of Service (LOS) Summary of Conditions

Level of Service	Traffic Conditions	Description of Operations
LOS A (best LOS)	Free Flow	Vehicles almost completely unimpeded in their ability to maneuver within the traffic stream.
LOS B	Reasonable Free Flow	The ability to maneuver within the traffic stream is only slightly restricted.
LOS C	Stable Flow	Freedom to maneuver within the traffic stream is noticeably restricted.
LOS D	Approaching Unstable Flow	Freedom to maneuver within the traffic stream is more noticeably limited.
LOS E	Unstable Flow	Operations at capacity. No usable gaps in traffic stream.
LOS F (worst LOS)	Forced or Breakdown Flow	Queues form behind breakdown point and volume to capacity ratio exceeds 1.0.

Note: Description based on AASHTO and HCM standards.

A Policy on Geometric Design of Highways and Streets[5], published by the American Association of State Highway and Transportation Officials (AASHTO), is referenced in the Code of Federal Regulations and is used to provide the LOS standard for highways on the National Highway System, which includes I-81. The level of service standard for mainline operations of I-81 is LOS B in rural areas and LOS C in urban areas. Based on ideal conditions, plus a free-flow speed of 75 mph (70 mph in urban areas), the design capacity of a two-lane section of I-81 necessary to maintain LOS C is approximately 3,000 vehicles per hour per direction in urban areas and 3,300 vehicles per hour per direction in rural areas. For a three-lane segment, this capacity increases to 4,500 and 5,000 respectively as illustrated in Table 3-3. Taking into account the various factors that influence a highway's capacity, including peak hour factors,

5 *A Policy on Geometric Design of Highways and Streets*, 4th Edition, American Association of State Highway and Transportation Officials (AASHTO), Washington, D.C., 2001 as per direction of FHWA letter dated 3/19/2001

the presence of heavy vehicles, geometry, grade, and lateral clearance from obstructions along the highway, the effective capacity of I-81 is further reduced from these thresholds. (This adjustment does not take into account any reduction in freeway capacity which occurs at the exits along I-81, as subsequent sections of this report present information on operations at exit ramps.)

Table 3-3 Level of Service Comparison by Number of Lanes[1]

	Vehicles (per hour per direction)			
	2 lanes		3 lanes	
Level of Service	Rural	Urban	Rural	Urban
LOS C	3,300	3,000	5,000	4,500
LOS E (freeway at capacity)	4,800	4,600	7,200	6,900

Optimal Conditions as defined above.

Once the capacity of a highway is determined, the density can be calculated and the level of service can be determined. The *Highway Capacity Manual* (HCM) does not recommend a specific level of service for design purposes but does present a description of the conditions associated with each level of service. The manual describes LOS C as providing for flow with speeds at or near free flow speed; freedom to maneuver within the traffic stream is noticeably restricted; lane changes require additional care and vigilance; and queues may begin to form behind any substantial blockage.

As conditions deteriorate to LOS D, the HCM describes conditions as unstable flow; freedom to maneuver within the traffic stream is more noticeably limited; and a driver experience of reduced physical and psychological comfort levels. The HCM does indicate that the higher the design level of service, the more the highway facility can absorb additional atypical amounts of traffic and still function at a satisfactory level.

For the purposes of this Tier 1 document, the mainline location with the steepest grade and the fewest number of lanes between interchanges was selected as the point of analysis for each I-81 segment. Analyzing concepts under these conditions produced the worst case level of service on a highway segment-by-segment basis. While a two-mile segment between interchanges is summarized as two miles of deficient mainline, it may be that only a portion of that segment is deficient. If a “Build” concept (or portion of a “Build” concept) is advanced, the Tier 2 analysis would subdivide the segments to pinpoint and address localized deficiencies in greater detail, as necessary.

Heavy Vehicles

The effect of heavy vehicles on traffic flow depends on grade conditions as well as traffic composition. Traffic flow on freeways with a mix of vehicle types must be adjusted to an equivalent flow rate (expressed as passenger cars per hour per lane). This adjustment is made by calculating a passenger car equivalent for each heavy vehicle based on the procedure outlined in the *Highway Capacity Manual*. Passenger car equivalents are based on the grade and length of grade along a freeway segment and represent the number of passenger cars that would use the same amount of freeway as one heavy vehicle under prevailing highway and traffic conditions. Using the calculated passenger car equivalents and the percentage of heavy vehicles, an overall adjustment factor is used to determine flow and level of service.

Operational Results

The results of the level of service analysis conducted for the I-81 mainline are presented in Table 3-4 and shown on Figure 3-5.

The results of existing conditions along I-81 indicate that:

- In the northbound direction, 24 miles (7 percent) of I-81 operates worse than the level of service standard.
- In the southbound direction, 32 miles (10 percent) of I-81 operates worse than the level of service standard.
- The most constrained segment of I-81 appears to be in the Roanoke area between Exits 141 and 143 in the northbound direction and between Exits 140 and 143 in the southbound direction.

Table 3-4 Existing I-81 Freeway Operations Summary

Segment		Number of	2004 Northbound		2004 Southbound	
From Exit	To Exit	Lanes	Volume[1]	LOS[2]	Volume	LOS
Tennessee	1	3	1600	A	1100	A
1	3	3	1650	B	1200	A
3	5	3	2300	B	1700	A
5	7	3	2150	B	1550	A
7	10	2	2000	C	1650	B
10	13	2	1950	B	1600	B
13	14	2	2000	B	1600	B
14	17	2	1750	B	1450	B
17	19	2	1800	B	1450	B
19	22	2	1500	B	1250	B
22	24	2	1450	B	1150	A
24	26	2	1400	B	1100	A
26	29	2	1300	B	1050	A
29	32	2	1150	A	1000	A
32	35	2	1150	B	1000	A
35	39	2	1200	A	1150	A
39	44	2	1200	A	1300	B
44	45	2	1150	A	1250	B
45	47	2	1100	A	1100	A
47	50	2	1150	A	1000	A
50	54	2	1100	A	900	A
54	60	2	1050	A	900	A
60	67	2	1150	A	1000	A
67	70	2	1100	A	950	A
70	72	2	1250	B	1000	A
72	73	3	1750	B	1600	A
73	77	3	2050	B	1750	B
77	80	3	1950	B	1750	B
80	81	3	1900	B	1800	B
81	84	2	1450	B	1400	B
84	86	2	1400	B	1450	B
86	89	2	1400	B	1500	B
89	92	2	1450	B	1600	B
92	94	2	1450	B	1600	B
94	98	2	1450	B	1450	B
98	101	2	1600	B	1500	B
101	105	2	1600	B	1550	B

Note: Shaded sections are locations where substandard LOS is indicated.
1 Vehicles per hour
2 Level of Service

Table 3-4 Existing I-81 Freeway Operations Summary (Continued)

Segment		Number of	2004 Northbound		2004 Southbound	
From Exit	To Exit	Lanes	Volume[1]	LOS[2]	Volume	LOS
105	109	2	1550	B	1450	B
109	114	2	1700	B	1650	B
114	118	2	1650	C	1850	B
118	128	2	2050	C	2050	C
128	132	2	1950	C	2150	C
132	137	2	1900	C	2300	C
137	140	2	2450	C	2750	C
140	141	2	2700	C	2900	D
141	143	2	3050	D	3150	D
143	146	2	2700	C	2550	C
146	150	2	2450	C	2200	C
150	156	2	1450	B	1150	B
156	162	2	1300	B	1100	A
162	167	2	1200	A	1050	A
167	168	2	1250	B	1100	B
168	175	2	1250	B	1100	B
175	180	2	1250	B	1100	B
180	188	2	1250	B	1150	B
188	191	2	1400	B	1350	B
191	195	2	1500	B	1500	B
195	200	2	1500	B	1550	B
200	205	2	1450	B	1600	B
205	213	2	1450	B	1700	B
213	217	2	1450	B	1800	B
217	220	2	1600	B	2050	C
220	221	2	1750	B	2350	C
221	222	2	2000	C	2250	C
222	225	2	1950	C	2000	C
225	227	2	1800	B	1900	B
227	235	2	1650	B	1800	B
235	240	2	1650	B	1900	C
240	243	2	1650	B	1850	B
243	245	2	1800	B	1850	B
245	247	2	1800	C	1600	B
247	251	2	1700	B	1350	B
251	257	2	1650	B	1350	B
257	264	2	1350	B	1200	B
264	269	2	1300	B	1200	A

Note: Shaded sections are locations where substandard LOS is indicated.
1 Vehicles per hour
2 Level of Service

Table 3-4 Existing I-81 Freeway Operations Summary (Continued)

Segment		Number of	2004 Northbound		2004 Southbound	
From Exit	To Exit	Lanes	Volume[1]	LOS[2]	Volume	LOS
269	273	2	1250	B	1150	A
273	277	2	1350	B	1250	A
277	279	2	1300	B	1200	B
279	283	2	1300	B	1250	B
283	291	2	1300	B	1350	B
291	296	2	1300	B	1500	B
296	298	2	1300	B	1650	B
298	300	2	1550	B	1950	C
300	302	2	1450	B	1600	B
302	307	2	1550	B	1750	B
307	310	2	1700	B	1950	C
310	313	2	1600	B	1700	B
313	315	2	2300	C	2000	C
315	317	2	2350	C	1700	B
317	321	2	1950	C	1300	B
321	323	2	1900	B	1250	A
323	West Virginia	2	1800	B	1200	A

Note: Shaded sections are locations where substandard LOS is indicated.
1 Vehicles per hour
2 Level of Service

3.2.2 Ramp Operations

The analysis of merge and diverge operations at exit ramps is based on procedures presented in Chapter 25, Ramps and Ramp Junctions, of the *Highway Capacity Manual*.[6] The procedure focuses on the interaction between freeway mainline through traffic and traffic merging from or diverging to ramps. The analysis takes into account the length and taper of the acceleration/deceleration lanes, free-flow vehicle speed along the freeway, and the number of vehicles in the right-most (or left-most for left exits) two lanes of the freeway. The focus of the analysis is at the ramp junction with the mainline where entering vehicles attempt to find gaps in the adjacent traffic stream. The action of this merging traffic creates vehicle turbulence along the mainline which can affect freeway operations. The converse of this action is the diverge movement which forces exiting vehicles to shift in advance and occupy the right travel lane in order to exit the freeway causing some turbulence as the vehicles shift lanes and decelerate. According to the HCM, the influence area for both of these movements is approximately 1,500 feet before the diverge areas and beyond the merge areas (including acceleration and deceleration lanes). The ramp analysis does not include the operation of weaving areas found at cloverleaf interchanges where exiting traffic crosses entering traffic. This condition, known as a weave condition, is analyzed in the next section.

6 Ibid.

Ramp Level of Service

The results of the ramp analyses are summarized in Table 3-5 and shown on Figure 3-5. The operational standard for all ramps is LOS C. The analysis of existing conditions indicates that:

- In the northbound direction, two of the 189 ramps (one percent) serving I-81 operate worse than the level of service standard.
- In the southbound direction, two of the 192 ramps (one percent) operate worse than the level of service standard.

Table 3-5 I-81 Ramp Level of Service Analysis Summary

	2004 Northbound Ramps			2004 Southbound Ramps		
	Volume[1]	Density[2]	LOS[3]	Volume	Density	LOS
Exit 1A On-Ramp	NO NORTHBOUND RAMP			150	9.3	A
Exit 1A Off-Ramp	200	1.4	A	150	8.4	A
Exit 1B On-Ramp	250	11.1	B	NO SOUTHBOUND RAMP		
Exit 1B Off-Ramp	NO NORTHBOUND RAMP			100	8.8	A
Exit 3 On-Ramp	700	17.8	B	100	10.8	B
Exit 3 Off-Ramp	50	18.7	B	600	13.0	B
Exit 5 On-Ramp	250	19.0	B	400	15.4	B
Exit 5 Off-Ramp	400	23.3	C	250	10.7	B
Exit 7 On-Ramp	400	18.6	B	350	14.0	B
Exit 7 Off-Ramp	550	19.3	B	450	12.6	B
Exit 10 On-Ramp	100	16.0	B	150	14.5	B
Exit 10 Off-Ramp	150	18.0	B	100	14.1	B
Exit 13 On-Ramp	150	17.0	B	150	14.4	B
Exit 13 Off-Ramp	100	14.7	B	150	10.0	A
Exit 14 On-Ramp	250	20.5	C	400	12.7	B
Exit 14 Off-Ramp	500	21.1	C	250	10.4	B
Exit 17 On-Ramp	400	13.3	B	350	12.8	B
Exit 17 Off-Ramp	350	12.4	B	350	8.7	A
Exit 19A On-Ramp	210	12.9	B	170	10.7	B
Exit 19A Off-Ramp	550	13.9	B	NO SOUTHBOUND RAMP		
Exit 19B On-Ramp	40	14.9	B	230	13.1	B
Exit 19B Off-Ramp	NO NORTHBOUND RAMP			200	7.5	A
Exit 22 On-Ramp	50	13.6	B	150	7.9	A
Exit 22 Off-Ramp	100	12.3	B	50	9.4	A
Exit 24 On-Ramp	50	11.0	B	100	10.5	B
Exit 24 Off-Ramp	100	13.1	B	50	7.4	A
Exit 26 On-ramp	50	10.1	B	100	9.3	A

Note: Shaded sections are locations where substandard LOS is indicated.
1 Ramp volume expressed in vehicles per hour (vph)
2 Density expressed in passenger cars per mile per hour
3 LOS - Level of Service

Table 3-5 I-81 Ramp Level of Service Analysis Summary (Continued)

	2004 Northbound Ramps			2004 Southbound Ramps		
	Volume[1]	Density[2]	LOS[3]	Volume	Density	LOS
Exit 26 Off-Ramp	150	10.2	B	50	6.2	A
Exit 29 On-Ramp	150	7.4	A	200	9.3	A
Exit 29 Off-Ramp	300	7.8	A	150	5.4	A
Exit 32 On-Ramp	50	7.1	A	50	9.4	A
Exit 32 Off-Ramp	50	5.8	A	50	7.5	A
Exit 35 On-Ramp	250	8.7	A	150	7.7	A
Exit 35 Off-Ramp	200	9.1	A	300	9.1	A
Exit 39 On-Ramp	100	5.3	A	50	10.3	B
Exit 39 Off-Ramp	100	7.6	A	200	10.2	B
Exit 44 On-Ramp	50	11.1	B	150	10.8	B
Exit 44 Off-Ramp	100	9.8	A	100	9.3	A
Exit 45 On-Ramp	100	9.3	A	250	9.9	A
Exit 45 Off-Ramp	150	12.3	B	100	7.2	A
Exit 47 On-Ramp	150	11.5	B	200	10.1	B
Exit 47 Off-Ramp	100	7.5	A	100	7.6	A
Exit 50 On-Ramp	50	10.5	B	150	8.5	A
Exit 50 Off-Ramp	100	10.6	B	50	6.5	A
Exit 54 On-Ramp	50	9.2	A	50	7.2	A
Exit 54 Off-Ramp	100	8.2	A	50	4.0	A
Exit 60 On-Ramp	150	6.9	A	50	6.3	A
Exit 60 Off-Ramp	50	6.3	A	150	5.3	A
Exit 67 On-Ramp	NO NORTHBOUND RAMP			50	6.9	A
Exit 67 Off-Ramp	50	6.8	A	NO SOUTHBOUND RAMP		
Exit 70 On-Ramp	300	9.8	A	150	10.6	B
Exit 70 Off-Ramp	150	6.3	A	200	5.6	A
Exit 72 On-Ramp	900	9.2	A	400	3.6	A
Exit 72 Off-Ramp	400	9.6	A	1000	4.9	A
Exit 73 On-Ramp	400	18.7	B	200	9.7	A
Exit 73 Off-Ramp	100	17.5	B	350	22.0	C
Exit 77 On-Ramp	200	16.7	B	300	20.9	C
Exit 77 Off-Ramp	300	13.2	B	350	12.8	B
Exit 80 On-Ramp	200	15.5	B	300	18.3	B
Exit 80 Off-Ramp	250	11.4	B	350	10.9	B
Exit 81 On-Ramp	650	13.6	B	1150	12.2	B
Exit 81 Off-Ramp	1100	5.9	A	750	10.2	B
Exit 84 On-Ramp	100	13.6	B	100	11.1	B
Exit 84 Off-Ramp	150	12.5	B	150	12.5	B

Note: Shaded sections are locations where substandard LOS is indicated.
1 Ramp volume expressed in vehicles per hour (vph)
2 Density expressed in passenger cars per mile per hour
3 LOS - Level of Service

Table 3-5 I-81 Ramp Level of Service Analysis Summary (Continued)

	2004 Northbound Ramps			2004 Southbound Ramps		
	Volume[1]	Density[2]	LOS[3]	Volume	Density	LOS
Exit 86 On-Ramp	50	14.5	B	50	11.7	B
Exit 86 Off-Ramp	50	12.2	B	100	12.0	B
Exit 89A On-Ramp	15	18.5	B	70	14.3	B
Exit 89A Off-Ramp	20	13.2	B	175	15.3	B
Exit 89B On-Ramp	85	14.3	B	30	17.0	B
Exit 89B Off-Ramp	30	15.4	B	25	12.6	B
Exit 92 On-Ramp	50	15.7	B	50	13.4	B
Exit 92 Off-Ramp	50	11.9	B	50	13.4	B
Exit 94A On-Ramp	10	17.5	B	300	15.4	B
Exit 94A Off-Ramp	35	17.9	B	NO SOUTHBOUND RAMP		
Exit 94B On-Ramp	90	17.6	B	NO SOUTHBOUND RAMP		
Exit 94B Off-Ramp	65	17.5	B	150	18.8	B
Exit 98 On-Ramp	400	14.1	B	400	15.6	B
Exit 98 Off-Ramp	250	16.7	B	450	12.3	B
Exit 101 On-Ramp	100	14.4	B	100	12.9	B
Exit 101 Off-Ramp	100	13.5	B	150	15.5	B
Exit 105 On-Ramp	100	19.0	B	200	19.7	B
Exit 105 Off-Ramp	150	19.0	B	100	15.6	B
Exit 109 On-Ramp	350	16.8	B	200	11.3	B
Exit 109 Off-Ramp	200	13.9	B	400	15.4	B
Exit 114 On-ramp	200	15.5	B	200	13.5	B
Exit 114 Off-Ramp	250	14.1	B	400	12.3	B
Exit 118 Off (to CD Road)	500	1.9	A	850	15.5	B
Exit 118A On-Ramp	445	7.6	A	435	6.0	A
Exit 118A Off-Ramp	45	0.0	A	10	0.4	A
Exit 188B On-Ramp	285	10.4	B	30	2.9	A
Exit 118B Off-Ramp	290	9.0	A	560	0.0	A
Exit 118C On-Ramp #1	130	9.3	A	95	0.0	A
Exit 118C On-Ramp #2	40	11.1	B	90	5.2	A
Exit 118C Off-Ramp	165	0.0	A	280	6.0	A
Exit 118 On (to I-81)	900	16.1	B	650	8.3	A
Exit 128 On-Ramp	100	20.6	C	50	18.9	B
Exit 128 Off-Ramp	200	27.7	C	150	27.3	C
Exit 132 On-Ramp	300	20.7	C	100	21.5	C
Exit 132 Off-Ramp	350	22.4	C	250	23.3	C
Exit 137 On-Ramp	700	25.1	C	200	24.2	C

Note: Shaded sections are locations where substandard LOS is indicated.
1 Ramp volume expressed in vehicles per hour (vph)
2 Density expressed in passenger cars per mile per hour
3 LOS - Level of Service

Table 3-5 I-81 Ramp Level of Service Analysis Summary (Continued)

	2004 Northbound Ramps			2004 Southbound Ramps		
	Volume[1]	Density[2]	LOS[3]	Volume	Density	LOS
Exit 137 Off-ramp	150	24.4	C	650	28.4	D
Exit 140 On-Ramp	500	22.6	C	300	22.4	C
Exit 140 Off-Ramp	250	22.7	C	450	27.0	C
Exit 141 On-Ramp	600	30.0	D	350	23.9	C
Exit 141 Off-Ramp	250	27.9	C	600	32.1	D
Exit 143 On-Ramp	1250	12.7	B	1850	24.7	C
Exit 143 Off-Ramp	1600	23.8	C	1250	13.9	B
Exit 146 On-Ramp	300	24.8	C	550	24.4	C
Exit 146 Off-Ramp	550	27.5	C	200	26.3	C
Exit 146 Off-Ramp	NO NORTHBOUND RAMP			705	20.1	C
Exit 150A On-Ramp	425	29.0	D	155	15.2	B
Exit 150A Off-Ramp	200	15.4	B	545	14.1	B
Exit 150B On-Ramp	775	20.7	C	45	5.6	A
Exit 150B Off-Ramp	50	18.0	B	100	13.5	B
Exit 156 On-Ramp	200	20.1	C	50	13.2	B
Exit 162 On-Ramp	50	13.8	B	100	9.1	A
Exit 162 Off-Ramp	150	21.8	C	50	12.8	B
Exit 167 On-Ramp	50	12.9	B	NO SOUTHBOUND RAMP		
Exit 167 Off-Ramp	NO NORTHBOUND RAMP			50	14.0	B
Exit 168 On-Ramp	50	18.4	B	50	13.7	B
Exit 168 Off-Ramp	50	16.1	B	50	14.3	B
Exit 175 On-Ramp	50	9.9	A	50	8.1	A
Exit 175 Off-Ramp	50	13.7	B	50	6.5	A
Exit 180A On-Ramp	10	18.8	B	25	8.8	A
Exit 180A Off-Ramp	50	8.9	A	65	6.6	A
Exit 180B On-Ramp	40	11.0	B	25	9.2	A
Exit 180B Off-Ramp	NO NORTHBOUND RAMP			35	5.3	A
Exit 188A On-ramp	NO NORTHBOUND RAMP			100	11.0	B
Exit 188A Off-Ramp	50	13.2	B	235	6.1	A
Exit 188B On-Ramp	250	8.5	A	NO SOUTHBOUND RAMP		
Exit 188B Off-Ramp	50	15.9	B	65	6.3	A
Exit 191 On-ramp	350	8.2	A	250	7.2	A
Exit 191 Off-Ramp	250	3.3	A	400	7.7	A
Exit 195 On-Ramp	100	15.9	B	50	12.2	B
Exit 195 Off-Ramp	100	10.5	B	100	10.0	A
Exit 200 On-Ramp	50	25.2	C	50	13.9	B
Exit 200 Off Ramp	100	11.6	B	100	10.0	B

Note: Shaded sections are locations where substandard LOS is indicated.
1 Ramp volume expressed in vehicles per hour (vph)
2 Density expressed in passenger cars per mile per hour
3 LOS - Level of Service

Table 3-5 I-81 Ramp Level of Service Analysis Summary (Continued)

	2004 Northbound Ramps			2004 Southbound Ramps		
	Volume[1]	Density[2]	LOS[3]	Volume	Density	LOS
Exit 205 On-Ramp	150	12.8	B	150	11.8	B
Exit 205 Off-Ramp	150	13.8	B	250	13.7	B
Exit 213A On-Ramp	NO NORTHBOUND RAMP			100	16.1	B
Exit 213A Off-Ramp	100	13.7	B	175	17.4	B
Exit 213B On-Ramp	100	12.6	B	NO SOUTHBOUND RAMP		
Exit 213B Off-Ramp	NO NORTHBOUND RAMP			25	17.4	B
Exit 217 On-Ramp	200	15.8	B	50	17.0	B
Exit 217 Off-Ramp	50	12.5	B	300	21.4	C
Exit 220 On-Ramp	350	12.5	B	200	19.4	B
Exit 220 Off-Ramp	200	15.4	B	500	21.3	C
Exit 221 On-Ramp	1050	17.0	B	1100	19.5	B
Exit 221 Off-Ramp	800	15.7	B	1000	18.3	B
Exit 222 On-Ramp	350	18.0	B	550	19.5	B
Exit 222 Off-Ramp	400	11.2	B	300	20.3	C
Exit 225 On-Ramp	200	14.5	B	350	16.8	B
Exit 225 Off-Ramp	350	20.7	C	250	17.3	B
Exit 227 On-Ramp	150	13.5	B	300	14.1	B
Exit 227 Off-Ramp	300	16.0	B	200	16.2	B
Exit 235 On-Ramp	200	14.8	B	200	13.4	B
Exit 235 Off-Ramp	200	14.7	B	300	19.9	B
Exit 240 On-Ramp	200	9.4	A	250	14.5	B
Exit 240 Off-Ramp	200	10.1	B	200	10.8	B
Exit 243 On-Ramp	350	11.4	B	250	11.9	B
Exit 243 Off-Ramp	200	10.5	B	250	11.4	B
Exit 245 On-Ramp	350	15.2	B	500	9.1	A
Exit 245 Off-Ramp	350	7.3	A	250	6.3	A
Exit 247A On-Ramp	115	16.2	B	340	9.6	A
Exit 247A Off-Ramp	420	15.8	B	30	12.1	B
Exit 247B On-Ramp	435	11.5	B	260	13.4	B
Exit 247B Off-Ramp	230	18.0	B	320	6.7	A
Exit 251 On-Ramp	100	9.2	A	100	8.8	A
Exit 251Off-Ramp	150	11.7	B	100	9.5	A
Exit 257 On-Ramp	50	12.1	B	200	10.2	B
Exit 257 Off-Ramp	350	10.9	B	50	6.2	A
Exit 264 On-Ramp	150	7.6	A	150	2.2	A
Exit 264 Off-Ramp	200	7.1	A	150	5.8	A
Exit 269 On-Ramp	50	9.1	A	100	12.5	B
Exit 269 Off-Ramp	100	11.9	B	50	4.3	A
Exit 273 On-Ramp	250	8.8	A	100	4.0	A
Exit 273 Off-Ramp	150	8.5	A	200	4.6	A

Note: Shaded sections are locations where substandard LOS is indicated.
1 Ramp volume expressed in vehicles per hour (vph)
2 Density expressed in passenger cars per mile per hour
3 LOS - Level of Service

Table 3-5 I-81 Ramp Level of Service Analysis Summary (Continued)

	2004 Northbound Ramps			2004 Southbound Ramps		
	Volume[1]	Density[2]	LOS[3]	Volume	Density	LOS
Exit 277 On-Ramp	NO NORTHBOUND RAMP			50	6.3	A
Exit 277 Off-Ramp	50	9.4	A	NO SOUTHBOUND RAMP		
Exit 279 On-Ramp	100	11.1	A	50	3.7	A
Exit 279 Off-ramp	100	5.1	A	100	7.7	A
Exit 283 On-Ramp	250	7.7	A	250	5.6	A
Exit 283 Off-Ramp	250	9.8	A	350	9.1	A
Exit 291 On-Ramp	200	10.7	B	150	7.6	A
Exit 291 Off-Ramp	200	8.1	A	300	10.9	B
Exit 296 On-Ramp	100	8.9	A	50	14.3	B
Exit 296 Off-Ramp	100	14.9	B	200	14.8	B
Exit 298 On-Ramp	300	13.6	B	100	9.3	A
Exit 298 Off-Ramp	50	4.9	A	400	14.7	B
Exit 300 On-Ramp	550	16.3	B	800	21.2	C
Exit 300 Off-Ramp	650	11.4	B	450	1.8	A
Exit 302 On-Ramp	200	12.4	B	100	13.4	B
Exit 302 Off-Ramp	100	15.2	B	250	15.7	B
Exit 307 On-Ramp	400	18.0	B	250	16.6	B
Exit 307 Off-Ramp	250	12.8	B	450	18.7	B
Exit 310 On-Ramp	400	17.0	B	700	19.8	B
Exit 310 Off-Ramp	500	17.6	B	450	15.2	B
Exit 313A On-Ramp	NO NORTHBOUND RAMP			435	6.1	A
Exit 313A Off-Ramp	NO NORTHBOUND RAMP			485	17.4	B
Exit 313B On-Ramp	1250	22.6	C	165	18.1	B
Exit 313B Off-Ramp	550	16.8	B	415	18.6	B
Exit 315 On-Ramp	800	24.5	C	800	19.6	B
Exit 315 Off-Ramp	750	22.1	C	500	15.4	B
Exit 317 On-Ramp	450	19.2	B	700	15.9	B
Exit 317 Off-Ramp	850	24.5	C	300	13.3	B
Exit 321 On-Ramp	50	18.4	B	100	14.1	B
Exit 321 Off-Ramp	100	19.3	B	50	10.5	B
Exit 323 On-Ramp	150	16.6	B	200	11.8	B
Exit 323 Off-Ramp	250	17.1	B	150	10.6	B

Note: Shaded sections are locations where substandard LOS is indicated.

1 Ramp volume expressed in vehicles per hour (vph)

2 Density expressed in passenger cars per mile per hour

3 LOS - Level of Service

Weaving Operations

The analysis of weaving operations at exit ramps is based on procedures presented in Chapter 24, Freeway Weaving, of the *Highway Capacity Manual*[7]. A weaving movement is defined as the interaction between the crossing of two or more traffic streams traveling in the same direction without the aid of traffic control devices. The measure of effectiveness to determine the level of service is based on many parameters, including density and the speed of both the weaving and non-weaving vehicles. The higher the speeds and lower the density, the better the operations of the weaving segment. The operational standard for all weave areas is LOS C.

The analysis results, which are summarized in Table 3-6 and shown on Figure 3-5, account for the interaction between the weaving vehicles and how the interaction affects general traffic operations along the mainline and the ramps. There are 10 weaving sections along I-81; five on the northbound side and five on the southbound side. At Exit 118, these weaving maneuvers occur on a collector-distributor (C-D) roadway off of the interstate. The C-D roadway provides a safer area for vehicles to merge and diverge. All of the weaving segments currently operate above the level of service standard.

Table 3-6 Existing I-81 Weaving Operations Summary

		2004 Peak Hour	
Segment		Density[1]	LOS[2]
Exit 14	Northbound	18.1	B
Exit 89	Northbound	10.2	B
Exit 94	Northbound	10.3	B
Exit 118	Northbound	13.9	B
Exit 247	Northbound	10.6	B
Exit 89	Southbound	8.9	A
Exit 118	Southbound	1.2	A
Exit 150	Southbound	13.2	B
Exit 247	Southbound	8.5	A
Exit 313	Southbound	14.0	B

1 Density -- Expressed in passenger cars per vehicle per lane
2 LOS -- Level of Service

3.2.3 Intersection Level of Service

Intersection capacity analyses were conducted to assess the existing quality of flow at intersections near I-81 interchanges. Capacity analysis provides an indication of how well an intersection serves the traffic demand. Operating conditions are classified by calculated levels of service as described below.

7 Ibid.

Intersection Level of Service Criteria

Intersection level of service is the term used to denote the different operating conditions which occur at a given intersection under various traffic volume loads. It is a qualitative measure of the effect of a number of factors, including roadway geometrics, speed, travel delay, freedom to maneuver, and safety. Level of service provides an index to the operational qualities of an intersection. The operational standard at intersections is generally LOS C.

Level of service designation is reported differently for signalized and unsignalized intersections. For signalized intersections, the analysis considers the operation of each lane or lane group entering the intersection and the level of service designation is for overall conditions at the intersection. For unsignalized intersections, the analysis assumes that traffic on the mainline is not affected by traffic on the side streets. The level of service is only determined for left-turns from the main street into the minor or side street and all movements from the minor street. The overall level of service designation is for the most critical movement, which is most often the left-turn out of the side street.

The evaluation criteria used to analyze area intersections are based on Chapter 16, Signalized Intersections, and Chapter 17, Unsignalized Intersections, of the *2000 Highway Capacity Manual*[8]. It should be noted that interchanges having directional ramps (where only right-turns can be made to/from local streets) are not included as part of this analysis. These locations often operate under yield locations and have lower delay.

Unsignalized Intersections

Unsignalized intersection capacity analyses were conducted for 143 study area intersections. Unsignalized analyses were conducted using Highway Capacity Software (HCS) [9] intersection analysis software. The results of the unsignalized intersection capacity analyses are presented in Table 3-7. Unsignalized intersection level of service results are based on the average delay experienced by vehicles exiting the minor or side street. As the table shows, 31 of the 143 unsignalized intersections currently operate worse than the level of service standards. In all but four cases, the deficient movement is the turn from the interstate off-ramp onto the adjacent local street. These deficient ramps are located at:

- Exit 14 (southbound off-ramp at Route 140)
- Exit 19 (northbound off-ramp at U.S. Route 11)
- Exit 35 (northbound and southbound off-ramps at Routes 763/107)
- Exit 70 (southbound off-ramp at Routes 52/21)
- Exit 77 (southbound off-ramp at Routes 11/52/336)
- Exit 98 (northbound and southbound off-ramps at Route 100)

8 Ibid.
9 Highway Capacity Software Version 4.1e, University of Florida, Gainesville, 2003.

- Exit 109 (northbound and southbound off-ramps at Route 177)
- Exit 114 (northbound and southbound off-ramps at Route 5)
- Exit 118C (northbound and southbound off-ramps at Route 460)
- Exit 140 (northbound off-ramp at Route 311)
- Exit 141 (northbound and southbound off-ramps at Route 419)
- Exit 146 (southbound off-ramp at Routes 115/185)
- Exit 150 (northbound off-ramp at U.S. Routes 11/220)
- Exit 222 (northbound off-ramp at Route 250)
- Exit 225 (northbound off-ramp at Route 275)
- Exit 227 (northbound off-ramp at Route 612)
- Exit 235 (southbound off-ramp at Route 256)
- Exit 240 (northbound off-ramp at Routes 257/682)
- Exit 257 (northbound off-ramp at U.S. Route 11)
- Exit 291 (northbound off-ramp at Route 651)
- Exit 298 (southbound off-ramp at U.S. Route 11)

In addition to these locations, the westbound left-turn from Route F-010 (Exit 47) onto U.S. Route 11, the southbound movements from Holston Street (at Exit 77), the eastbound left-turn from Route 220 (Exit 150), and the northbound movements from Route 661 (Exit 317) also operate worse than the level of service standard.

Signalized Intersections

Signalized intersection capacity analyses of existing conditions were performed at 29 study area intersections. The analyses were also conducted using HCS intersection analysis software. The results of the signalized intersection capacity analyses are shown in Table 3-7.

Ten of the 29 signalized intersections reviewed are currently operating at a deficient level of service. They include:

- Exit 7 northbound and southbound ramps at Old Airport Road
- Exit 17 southbound ramps at Routes 75/58
- U.S. Route 11 at Route 220 (Exit 150)
- Exit 307 northbound ramps at Route 227
- Exit 310 northbound ramps at Route 37
- Exit 313 northbound ramps at Routes 17/50/522
- Exit 315 northbound and southbound ramps at Route 7
- Exit 317 northbound off-ramp at U.S. Route 11

Table 3-7 Existing Intersection Operations Summary

Intersection[1]	Critical Movement[2]	Existing Conditions Delay[3]	Existing Conditions LOS[4]
Exit 1 NB Ramps @ U.S. Routes 58/421	NB Off-Ramp LT	20.0	C
Exit 1 SB Ramps @ U.S. Routes 58/421	Rte 611 WB L	8.2	A
Exit 5 NB Off-Ramp @ U.S. Rtes 11/19	Intersection	11.6	B
Exit 5 NB On-Ramp @ U.S. Rtes 11/19	Rtes 11/19 EB L	11.6	B
Exit 5 SB Ramps @ U.S. Routes 11/19	Intersection	10.9	B
Exit 7 NB Ramps @ Old Airport Rd.	Intersection	57.0	E
Exit 7 SB Ramps @ Old Airport Rd.	Intersection	90.5	F
Exit 10 NB Ramps @ U.S. Route 11	NB Off-Ramp LTR	11.9	B
Exit 10 SB Ramps @ U.S. Route 11	SB Off-Ramp LTR	10.1	B
Exit 13 NB Ramps @ Route 611	NB Off-Ramp LTR	12.7	B
Exit 13 SB Ramps @ Route 611	SB Off-Ramp LTR	11.1	B
Exit 14 NB Ramps @ Route 647	NB Off-Ramp L	13.0	B
Exit 14 SB Ramps @ Route 140	SB Off-Ramp LTR	27.7	D
Exit 14 NB Ramps @ U.S. Route 11	Rte 647 WB LT	9.1	A
Exit 17 NB Ramps @ Routes 75/58	Intersection	15.4	B
Exit 17 SB Ramps @ Route 75/U.S. Route 58	Intersection	38.1	D
Exit 19 NB Ramps @ U.S. Route 11	NB Off-Ramp L	36.8	E
Exit 19 SB Ramps @ U.S. Routes 11/58	SB Off-Ramp LR	14.3	B
Exit 22 SB Ramps @ Route 704	SB Off-Ramp L	10.4	B
Exit 22 NB Ramps @ Route 704	NB Off-Ramp LT	10.8	B
Exit 24 NB Ramps @ Route 80	NB Off-Ramp LTR	10.3	B
Exit 24 SB Ramps @ Route 80	SB Off-Ramp LTR	10.8	B
Exit 26 NB Ramps @ Route 737	NB Off-Ramp LTR	10.7	B
Exit 26 SB Ramps @ Route 737	SB Off-Ramp LTR	9.9	A
Exit 29 NB Ramps @ Route 91	NB Off-Ramp L	13.2	B
Exit 29 SB Ramps @ Route 91	SB Off-Ramp LTR	13.6	B
Exit 32 NB Ramps @ U.S. Route 11/Route 751	NB Off-Ramp LTR	10.0	A
Exit 32 SB On-Ramp @ Rtes 11/751	Rte 751SB LTR	8.5	A
Exit 32 SB Off-Ramp @ U.S. Route 11/Route 751	SB Off-Ramp LR	10.0	B
Exit 35 NB Ramps @ Routes 763/107	NB Off-Ramp LTR	99.8	F
Exit 35 SB Ramps @ Routes 763/107	SB Off-Ramp LTR	39.0	E
Exit 39 NB Ramps @ Routes 11/645	NB Off-Ramp LT	14.1	B
Exit 39 SB Ramps @ Routes 11/645	SB Off-Ramp LT	13.1	B
Exit 44 NB Ramps @ U.S. Route 11	NB Off-Ramp L	16.4	C
Exit 44 SB Ramps @ U.S. Route 11	Rte 11 SB L	8.2	A
Exit 44 SB Ramps @ U.S. Route 11	SB Off-Ramp LR	8.8	A
Exit 44 SB Ramps @ U.S. Route 11	Rte 730 EB LTR	7.3	A

Note: Shaded sections are locations where substandard LOS is indicated.
1 Signalized Intersections are displayed in bold print, and Delay and LOS data listed applies to the overall intersection.
2 Delay and LOS data listed for unsignalized intersections are for either the critical movement on the cross street or the minor (off-ramp) approach.
3 Delay - Average delay, expressed in seconds per vehicle.
4 LOS – Level of Service.

Table 3-7 Existing Intersection Operations Summary (Continued)

Intersection[1]	Critical Movement[2]	Existing Conditions Delay[3]	LOS[4]
Exit 45 NB Ramps @ Route 16	NB Off-Ramp LT	17.0	C
Exit 45 SB Ramps @ Route 16	SB Off-Ramp LT	15.5	C
Exit 47 NB Ramps @ Route F-010	Rte F-010 EB L	8.7	A
Exit 47 NB Ramps @ Route F-010	NB Off-Ramp L	8.4	A
U.S. Route 11 @ Route F-010	Rte F-010 WB L	26.9	D
Exit 47 SB Ramps @ U.S. Route 11	SB Off-Ramp LR	15.7	C
Exit 47 SB Ramps @ Route F-010	Rte F-010 WB L	8.1	A
Exit 50 NB Ramps @ Route 622	NB Off-Ramp LTR	10.1	B
Exit 50 SB Ramps @ Route 622	SB Off-Ramp LTR	9.7	A
Exit 54 NB Ramps @ Route 683	NB Off-Ramp LTR	9.1	A
Exit 54 SB Ramps @ Route 683	SB Off-Ramp LTR	9.8	A
Exit 60 NB Ramps @ Routes 90/680	NB Off-Ramp LTR	10.4	B
Exit 60 SB Ramps @ Routes 90/680	SB Off-Ramp LTR	12.1	B
Exit 67 NB Ramps @ U.S. Route 11	NB Off-Ramp LR	12.1	B
Exit 67 SB Ramps @ U.S. Route 11	NB Rte 11 LT	8.0	A
Exit 70 NB Ramps @ U.S. Routes 52/21	NB Off-Ramp LTR	15.1	C
Exit 70 SB Ramps @ U.S. Routes 52/21	SB Holston LTR	38.4	E
Exit 70 SB Ramps @ U.S. Routes 52/21	SB Off-Ramp LR	25.1	D
Exit 77 NB Ramps @ U.S. Routes 11/52/Route 336	NB Off-Ramp LTR	15.5	C
Exit 77 SB Ramps @ U.S. Routes 11/52/Route 336	SB Off-Ramp LTR	35.2	E
Exit 80 NB Ramps @ U.S. Routes 52/121	**Intersection**	**7.9**	**A**
Exit 80 SB Ramps @ U.S. Routes 52/121	**Intersection**	**30.3**	**C**
Exit 84 NB Ramps @ Route 619	NB Off-Ramp LTR	12.4	B
Exit 84 SB Ramps @ Route 619	SB Off-Ramp LTR	10.9	B
Exit 86 NB Ramps @ Route 618	NB Off-Ramp LTR	9.9	A
Exit 86 SB Ramps @ Route 618	SB Off-Ramp LTR	9.5	A
Exit 92 NB Ramps @ Old Route 100	NB Off-Ramp LTR	9.0	A
Exit 92 SB Ramps @ Old Route 100	SB Off-Ramp LTR	9.7	A
Exit 94 SB Off Ramp @ Route 99	SB Off-Ramp LT	14.8	B
Exit 94 SB On Ramp @ Route 99	WB Route 99 L	7.7	A
Exit 98 NB Off Ramp @ Route 100	NB Off-Ramp LR	35.9	E
Exit 98 NB On Ramp @ Route 100	EB Route 100 L	11.4	B
Exit 98 SB Ramps @ Route 100	SB Off-Ramp L	66.2	F
Exit 101 NB Ramps @ Route 660	NB Off-Ramp LT	11.9	B
Exit 101 SB Ramps @ Route 660	SB Off-Ramp LT	12.9	B
Exit 105 SB Ramps @ Rts 232 & 605	SB Off-Ramp R	9.7	A

Note: Shaded sections are locations where substandard LOS is indicated.

1 Signalized Intersections are displayed in bold print, and Delay and LOS data listed applies to the overall intersection.

2 Delay and LOS data listed for unsignalized intersections are for either the critical movement on the cross street or the minor (off-ramp) approach.

3 Delay - Average delay, expressed in seconds per vehicle.

4 LOS – Level of Service.

Table 3-7 Existing Intersection Operations Summary (Continued)

Intersection[1]	Critical Movement[2]	Existing Conditions Delay[3]	Existing Conditions LOS[4]
Exit 109 NB Ramps @ Route 177	NB Off Ramp LT	120+	F
Exit 109 SB Ramps @ Route 177	SB Off Ramp LT	59.5	F
Exit 114 NB Ramps @ Route 8	NB Off Ramp LT	120+	F
Exit 114 SB Ramps @ Route 8	SB Off Ramp LT	119.4	F
U.S. Rt. 460 WB Off Ramp @ U.S. Rt. 460 Bus	**Intersection**	**10.6**	**B**
U.S. Rt. 460 EB Off Ramp @ U.S. Rt. 460 Bus	**Intersection**	**12.0**	**B**
Exit 118C NB Ramps @ U.S. Route 460	NB Off Ramp L	29.1	D
Exit 118C SB Ramps @ U.S. Route 460	SB Off Ramp L	120+	F
Exit 128 NB Ramps @ Route 603	NB Off Ramp LT	13.1	B
Exit 128 SB Ramps @ Route 603	SB Off Ramp LT	11.6	B
Exit 132 NB Ramps @ Route 647	NB Off Ramp LT	12.2	B
Exit 132 SB Ramps @ Route 647	SB Off Ramp LT	14.9	B
Exit 137 NB Ramps @ Route 112	NB Off Ramp LT	23.4	C
Exit 137 SB Ramps @ Route 112	SB Off Ramp R	15.1	C
Exit 140 NB Ramps @ Route 311	NB Off Ramp LT	61.8	F
Exit 140 SB Ramps @ Route 311	SB Off Ramp L	18.5	C
Exit 141 NB Ramps @ Route 419	NB Off Ramp LR	50.6	F
Exit 141 NB Ramps @ Route 419	**Intersection**	**N/A**	**N/A**
Exit 141 SB Off Ramp @ Route 419	SB Off Ramp L	120+	F
Exit 141 SB Off Ramp @ Route 419	**Intersection**	**N/A**	**N/A**
Exit 141 SB On Ramp @ Route 419	WB Route 419 L	10.2	B
Exit 146 NB Ramps @ Rts 115/185	NB Off Ramp R	20.5	C
Exit 146 SB Ramps @ Rts 115/185	SB Off Ramp LT	120+	F
Exit 150 NB Off Ramp @ U.S. Route 11	NB Off Ramp L	32.6	D
Exit 150 NB On Ramp @ U.S. Route 220	EB Route 220 L	25.1	D
Exit 150 SB Ramps @ U.S. Route 220	SB Off Ramp R	15.1	C
U.S. Route 11 & U.S. Route 220	**Intersection**	**47.3**	**D**
Exit 156 NB Ramps @ Route 640	NB Off Ramp LTR	10.6	B
Exit 156 SB Ramps @ Route 640	SB Off Ramp LTR	11.0	B
Exit 162 NB Ramps @ U.S. Route 11	NB Off Ramp LT	13.6	B
Exit 162 SB Ramps @ U.S. Route 11	SB Off Ramp LR	11.5	B
Exit 167 SB Ramp @ U.S. Route 11	SB Off Ramp LR	10.4	B
Exit 168 NB Ramps @ Route 614	NB Off Ramp LTR	9.2	A
Exit 175 NB Ramps @ U.S. Route 11	NB Off Ramp LTR	8.8	A
Exit 175 SB Ramps @ U.S. Route 11	SB Off Ramp LT	9.5	A

Note: Shaded sections are locations where substandard LOS is indicated.
1 Signalized Intersections are displayed in bold print, and Delay and LOS data listed applies to the overall intersection.
2 Delay and LOS data listed for unsignalized intersections are for either the critical movement on the cross street or the minor (off-ramp) approach.
3 Delay - Average delay, expressed in seconds per vehicle.
4 LOS – Level of Service.

Table 3-7 Existing Intersection Operations Summary (Continued)

Intersection[1]	Critical Movement[2]	Existing Conditions Delay[3]	Existing Conditions LOS[4]
Exit 180 NB Ramps @ U.S. Route 11	NB Off Ramp LR	10.6	B
Exit 180 SB Ramps @ U.S. Route 11	Service Road LR	9.7	A
Exit 188 NB On Ramp @ U.S. Route 60	EB Route 60 L	8.6	A
Exit 188 SB Off Ramp @ U.S. Route 60	SB Off Ramp R	10.6	B
Exit 195 NB Ramps @ U.S. Route 11	NB Off Ramp LTR	13.9	B
Exit 195 SB Ramps @ U.S. Route 11	SB Off Ramp LT	13.1	B
Exit 200 NB Ramps @ Route 710	NB Off Ramp LTR	11.3	B
Exit 200 SB Ramps @ Route 710	SB Off Ramp LTR	11.3	B
Exit 205 NB Ramps @ Route 606	NB Off Ramp LTR	13.7	B
Exit 205 SB Ramps @ Route 606	SB Off Ramp LTR	16.2	C
Exit 213 NB Ramps @ U.S. Route 11	NB Off Ramp LT	14.3	C
Exit 213 SB Ramps @ U.S. Route 11	WB L U.S. Route 11	7.9	A
Exit 217 NB Ramps @ Route 654	NB Off Ramp LTR	15.4	C
Exit 217 SB Ramps @ Route 654	SB Off Ramp LTR	16.5	C
Exit 222 NB Off Ramp @ U.S. Route 250	NB Off Ramp L	59.1	F
Exit 222 NB On Ramp @ U.S. Route 250	EB Route 250 L	11.1	B
Exit 222 SB Ramps @ U.S. Route 250	**Intersection**	**6.3**	**A**
Exit 225 NB Ramps @ Route 275	NB Off Ramp LT	120+	F
Exit 225 SB Ramps @ Route 275	SB Off Ramp LT	23.5	C
Exit 227 NB Ramps @ Route 612	NB Off Ramp LT	120+	F
Exit 227 SB Off Ramp @ Route 612	SB Off Ramp L	14.4	B
Exit 227 SB On Ramp @ Route 612	WB Route 612 L	8.9	A
Exit 235 NB Ramps @ Route 256	NB Off Ramp LTR	21.2	C
Exit 235 SB Ramps @ Route 256	SB Off Ramp LTR	98.3	F
Exit 240 NB Ramps @ Rts 257 & 682	NB Off Ramp LTR	29.4	D
Exit 240 SB Ramps @ Rts 257 & 682	SB Off Ramp LTR	11.8	B
Exit 245 NB Ramps @ Rte. 659	**Intersection**	**21.7**	**C**
Exit 245 SB Ramps @ Rte. 659	**Intersection**	**18.4**	**B**
Exit 257 NB Ramps @ U.S. Route 11	NB Off-Ramp LTR	28.1	D
Exit 257 SB On-Ramp @ U.S. Route 11	**Intersection**	**10.9**	**B**
Exit 257 SB Off-Ramp @ Route 259	WB Off-Ramp LR	12.3	B
Exit 264 NB Ramps @ U.S. Route 211	NB Off-Ramp L	23.3	C
Exit 264 SB Ramps @ Route 211	SB Off-Ramp LTR	23.2	C
Exit 269 NB Ramps @ Route 730	NB Off-Ramp LTR	10.2	B
Exit 269 SB Ramps @ Route 730	SB Off-Ramp LTR	10.4	B

Note: Shaded sections are locations where substandard LOS is indicated.

1 Signalized Intersections are displayed in bold print, and Delay and LOS data listed applies to the overall intersection.

2 Delay and LOS data listed for unsignalized intersections are for either the critical movement on the cross street or the minor (off-ramp) approach.

3 Delay - Average delay, expressed in seconds per vehicle.

4 LOS – Level of Service.

Table 3-7 Existing Intersection Operations Summary (Continued)

Intersection[1]	Critical Movement[2]	Existing Conditions Delay[3]	Existing Conditions LOS[4]
Exit 273 NB Ramps @ Route 292	NB Off-Ramp LT	13.0	B
Exit 273 SB Ramps @ Route 292	SB Off-Ramp L	16.2	C
Exit 277 NB Ramps @ Route 614	NB Off-Ramp LR	9.5	A
Exit 277 SB Ramps @ Route 614	Rte. 614 WB LT	7.5	A
Exit 279 NB Ramps @ Route 185	NB Off-Ramp LR	12.1	B
Exit 279 SB Ramps @ Route 185	SB Off-Ramp LTR	11.9	B
Exit 283 NB Ramps @ Route 42	**Intersection**	**15.0**	**B**
Exit 283 SB Ramps @ Route 42	**Intersection**	**13.3**	**B**
Exit 291 NB Ramps @ Route 651	NB Off-Ramp L	30.0	D
Exit 291 SB Ramps @ Route 651	SB Off-Ramp L	19.4	C
Exit 296 NB Ramps @ Route 55	NB Off-Ramp L	14.0	B
Exit 296 SB Ramps @ Route 55	SB Off-Ramp LT	13.6	B
Exit 298 NB Ramps @ U.S. Route 11	NB Off-Ramp LT	21.3	C
Exit 298 SB Ramps @ U.S. Route 11	SB Off-Ramp LTR	50.3	F
Exit 302 NB Ramps @ Route 627	NB Off-Ramp LTR	15.0	B
Exit 302 SB Ramps @ Route 627	SB Off-Ramp L	12.3	B
Exit 307 NB Ramps @ Route 277	**Intersection**	**42.5**	**D**
Exit 307 SB Ramps @ Route 277	**Intersection**	**21.8**	**C**
Exit 310 NB Ramps @ Route 37	**Intersection**	**78.3**	**E**
Exit 310 SB Ramps @ Route 37	**Intersection**	**9.7**	**A**
Exit 313 NB Ramps @ U.S. Rts 17/50/522	**Intersection**	**56.9**	**E**
Exit 315 NB Ramps @ U.S. Route 7	**Intersection**	**120+**	**F**
Exit 315 SB Ramps @ Route 7	**Intersection**	**58.3**	**E**
Exit 317 NB Off-Ramp @ U.S. Route 11	**Intersection**	**43.6**	**D**
Exit 317 NB On-Ramp @ U.S. Route 11	Route 661 NB LTR	120+	F
Exit 317 SB Ramps @ U.S. Route 11	U.S. Route 11 WB L	11.9	B
Exit 321 NB Ramps @ Route 672	NB Off-Ramp LTR	9.9	A
Exit 321 SB Ramps @ Route 672	SB Off-Ramp L	11.2	B
Exit 323 NB Ramps @ Route 669	**Intersection**	**11.3**	**B**
Exit 323 SB Ramps @ Route 669	**Intersection**	**13.4**	**B**

Note: Shaded sections are locations where substandard LOS is indicated.
1 Signalized Intersections are displayed in bold print, and Delay and LOS data listed applies to the overall intersection.
2 Delay and LOS data listed for unsignalized intersections are for either the critical movement on the cross street or the minor (off-ramp) approach.
3 Delay - Average delay, expressed in seconds per vehicle.
4 LOS – Level of Service.

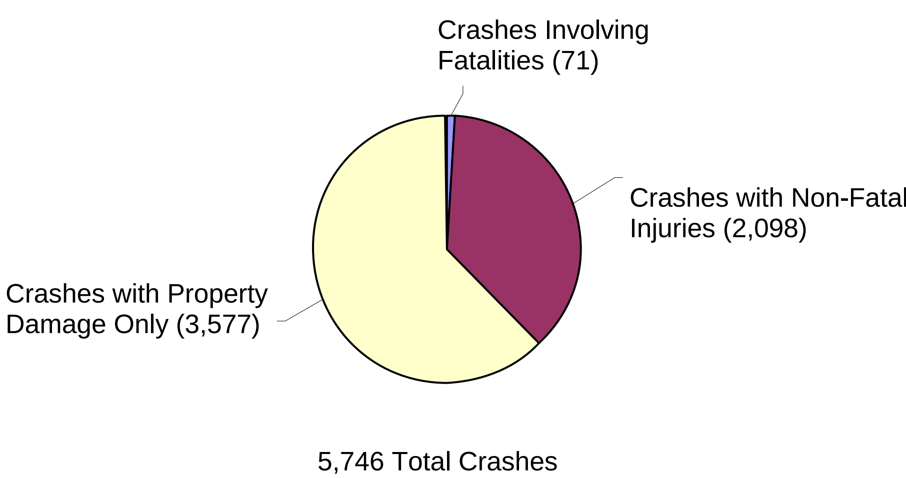
3.3 Safety

A safety analysis was conducted for I-81 to determine if the traffic demands combined with the geometric conditions of the highway (see Section 3.4) or its ramps have resulted in unsafe operating conditions. VDOT safety data for the three-year period from January 2000 to December 2002 (the most recent period available at the onset of this study) were analyzed as part of this study. Typically, a three year period is sufficient to have enough data to both establish trends in crash history and substantiate the benefits of any improvements. The following section summarizes this safety data. The detailed analysis can be found in Appendix B of this report.

Crash statistics for the three-year period revealed 5,746 reported crashes on I-81. Seventy-one (1.2 percent) of these crashes involved fatalities, as can be seen in Figure 3-6 below. Another 2,098 crashes (36.5 percent) involved personal injury to 3,095 persons. Major crash types observed from the data included:

- Forty-one (41) percent of crashes involved collisions with a fixed object;
- Nineteen (19) percent involved rear-end-type collisions;
- Eighteen (18) percent were sideswipe crashes between two vehicles traveling in the same direction; and
- Eight (8) percent of crashes involved deer or other animals.

Figure 3-6 I-81 Crashes 2000 to 2002



Fixed object-type collisions are typical for interstates like I-81 where driver speed and/or fatigue causes the motorist to leave the traveled way and strike fixed objects adjacent to the highway. This condition may be exacerbated by the lack of an inside shoulder along most of the corridor and the presence of guardrail along many segments. Rear-end collisions typify speed differentials along the highway and can result from a motorist overtaking another motorist (which can often be the case on highways like I-81 with rolling terrain). Rear-end-type crashes can also be indicative of congestion with vehicles having to slow (sometimes unexpectedly) in response to other drivers. Sideswipe collisions are indicative of both traffic demands and geometry. The cross-section of I-81, including many segments that are on fill sections with guardrail on both sides, the high percentage of large vehicles, and the numerous locations of merging and diverging traffic all contribute to the volume of sideswipe-type collisions that are occurring along the highway.

Statewide weighted crash scores are determined so that crash statistics can be compared among similar functionally classified roadways within a state that have different traffic volume levels (such as I-81 and I-95). From these crash scores, an overall statewide average for a functional class is published. Crashes are scored as one point for property damage, eight points for crashes involving injuries, and 20 points for crashes involving a fatality. The I-81 weighted crash score is less than the 2002 statewide weighted crash score for interstate highways in Virginia (a weighted crash score of 160 per 100 million vehicle miles of travel for I-81 versus a weighted crash score of 277 per 100 million vehicle miles of travel for the average interstate in Virginia).

Although the overall weighted crash score is less, a number of segments were found to have crash scores in excess of the statewide weighted average. These segments are listed below, and can also be seen in Figure 3-7:

- Twenty-four northbound miles (7 percent) have crash scores more than 25 percent higher than the statewide weighted average, with seven
- miles having crash scores more than twice the statewide weighted average.
- Twenty-one southbound miles (6 percent) have crash scores more than 25 percent higher than the statewide weighted average, with one mile having a crash score more than twice the statewide weighted average.
- The above high crash segments accounted for approximately 21 percent of all crashes along the I-81 corridor and more than one-third of all fatalities.

Specific segments that were identified with crash scores more than double the statewide weighted average include:

- Milepost 73-74 northbound
- Milepost 94-95 northbound
- Milepost 180-181 northbound
- Milepost 292-293 northbound

- Milepost 162-163 northbound
- Milepost 168-169 northbound
- Milepost 314-315 northbound
- Milepost 48-49 southbound

Specific segments that were identified with crash scores more than 25 percent higher than the statewide weighted average include:

- Mileposts 7-8; 16-17; 23-24; 45-46; 49-50; 80-81; 105-106; 109-110; 156-157; 181-182; 189-190; 195-196; 213-214; 223-224; 252-253; and 296-298 in the northbound direction.
- Mileposts 319-318; 315-314; 300-299; 285-284; 275-274; 249-246; 206-205; 203-202; 197-196; 171-169; 151-150; 122-121; 95-94; 68-67; 44-43; 35-34; and 8-7 in the southbound direction.

The review of I-81 crash history also included heavy vehicles along the corridor. It is typically expected that the percentage of crashes involving heavy vehicles should be somewhat proportionate with the percentage of vehicle miles traveled by heavy vehicles over the course of the three-year period studied. The data do not show a disproportionately high involvement of heavy vehicles in crashes along the corridor (*i.e.,* heavy vehicles are estimated to constitute approximately 29 percent of all vehicle miles traveled along the corridor and were involved in approximately 29 percent of all reported accidents).

Non-recurring Incidents on I-81

As part of the I-81 ITS Program Evaluation Framework project (known locally as the "Travel Shenandoah" program), the Center for Technology Deployment within Virginia Tech's Transportation Institute has been producing monthly reports of all incidents posted in the I-81 511 program for all VDOT construction districts. As of 2000, 511 is the nationwide abbreviated dialing number assigned by the Federal Communications Commission (FCC) to provide travelers in the area up to date information on roadway conditions. The annual report for the period December 1, 2002 through December 1, 2003 shows the following:

- The typical I-81 crash duration ranged from 63 minutes to 70 minutes with an overall average duration of a lane closure being 67 minutes. Seventy-six percent of the crash durations were under two hours.
- Based on 511 postings, overall accidents and construction information were the top two categories of information posted on variable message signs, with accidents being the top category in the Bristol District, weather (fog and wind) the top category in the Salem District, and construction and accidents the top two categories in the Staunton District.
- A special case study prepared in the Bristol District has shown that severe accidents, (accidents involving multiple vehicles or involving tractor trailers) tend to occur near truck stops, and are more probable in areas with steep terrain.

The preceding data (while difficult to tie directly to the crash data analysis) may help to explain some citizens' perception (see below) about level of service and safety along I-81, as the analyses of level of service do not consider incident duration, only traffic volume and roadway geometry.

Public Perception of Safety on I-81

During the March 2004 scoping meetings held as part of this study, citizens' throughout the study area were given the opportunity to discuss issues and concerns on many topics. A number of citizens noted that safety along I-81 is of great concern. Some of the specific concerns noted include:

- A lack of enforcement regulating speeds and left-lane truck prohibition;
- A lack of sufficient shoulder widths and acceleration/deceleration lanes;
- An increased number of trucks tailgating and excessively speeding on downgrades;
- An increased number of trucks blocking both lanes of traffic and backing up traffic on upgrades;
- A feeling of confinement when surrounded by trucks; and
- A feeling of loss of control as trucks "wiz" by.

While geometric deficiencies were found throughout the corridor (see Section 3.4), the crash statistics do not show a direct link between the safety concerns and an increased number of crashes along the corridor. Many of the perceived deficiencies may result from the narrow cross-section of the existing interstate and from the continually increasing percentage of heavy vehicles traveling the corridor. Further, with advances in technology (such as the 511 system) drivers are alerted to traffic congestion (whether caused by crash, breakdown, or heavy demand), which can sometimes lead to the feeling that crashes are occurring more frequently. Section 5.5 of this technical report discusses safety with respect to "Build" concepts.

3.4 Geometric Conditions Review

The geometric conditions of the highway, combined with speed and weather conditions, may be contributing factors to some crashes along I-81. Some sections of I-81 are more than 40 years old and do not meet current AASHTO geometric design criteria. Geometric conditions that do not meet AASHTO geometric design criteria involve vertical clearance, sight distance, the absence of truck climbing lanes, shoulder width, and acceleration and deceleration lanes. A detailed review of the existing geometric conditions was completed as part of VDOT's previous I-81 Concept Studies. These studies, combined with a field review performed as part of this study, found that:

- Approximately 70 percent of the existing exits have geometric deficiencies, as summarized in Table 3-8;
- More than two-thirds of I-81 in Virginia has inside shoulder widths that do not meet AASHTO geometric design criteria, based on the volume of heavy vehicles using the corridor;
- More than 100 locations have sight distances that do not meet AASHTO geometric design criteria because of the alignment of the highway;
- Ten locations have conditions that may slow truck traffic to speeds below the minimum for interstate travel; and
- Approximately 53 bridges (42 percent) have vertical clearances less than AASHTO geometric design criterion of 17 feet 6 inches.

These geometric conditions, when combined with the traffic demands placed on I-81, further exacerbate traffic operations along the corridor. A detailed list of features that do not meet AASHTO geometric design criteria can be found in Appendix B to this report. These features are graphically depicted in Figure 3-5.

Highway grades have also been considered as part of the overall perception of safety deficiencies along the corridor. Figure 3-8 provides the grade profile of I-81 within Virginia.

Table 3-8 Existing I-81 Geometric Deficiencies Summary[1]

Deficiency	Number of Locations	Exit(s)
Insufficient ramp geometry and/or length	10	35, 39, 47, 50, 67,70,80,126, 251, 291
Insufficient ramp termini spacing on side road	23	24, 26, 29, 32, 35, 39, 45, 47, 60, 80, 84, 86, 89, 92, 109, 205, 243, 245, 273, 302, 307, 310, 313
Insufficient weaving distance between northbound ramps	2	14, 94
Insufficient weaving distance between southbound ramps	4	247, 220, 221, 222
Insufficient stopping sight distance on ramp	3	67, 296, 302
Steep ramp grade	1	45
Low ramp design speed	3	41, 72, 81
Insufficient tapers, acceleration and/or deceleration lane lengths	12	132, 137, 140, 141, 143, 146, 156, 162, 167, 168, 180, 323
Significant ramp delay and backup	4	150, 205, 247, 313
Left-hand exit safety issues	2	191, 300
Insufficient ramp geometry at rest area	1	Northbound Milepost 129.3

1 Interchange improvements are included in the FY04-06 Virginia Transportation Six-Year Improvement Program for Exits 109, 144, 162, 180, 190, 191, 245, 307, 310, 313, 315, and 323.

Bridge Deficiencies

Bridge deficiencies were evaluated at all appropriate locations along I-81 from the Tennessee to the West Virginia State Line. Geometric deficiencies at bridge locations can be defined as inadequate vertical clearances (if I-81 is an underpass) or as inadequate shoulder widths (if I-81 is an overpass). As all locations where a roadway crosses over or under I-81 were analyzed, it is important to note that there could be more than one bridge at each location. Based on design guidelines presented in the VDOT Road Design Manual Standard GS-1, desired vertical clearance is 16.5 feet and required shoulder widths on bridges for two lane highways are 6 feet for the inside shoulder and 12 feet for the outside shoulder. Three lane highways require 12 feet shoulders on both the inside and outside.

Vertical clearances were evaluated using the August 2004 VDOT Restricted Structure Atlas[10]. Shoulder widths were determined by analyzing the number of lanes versus the width of the bridge using information summarized by VDOT's Structure and Bridge Division.

The following is a brief summary of bridge deficiencies. Detailed information is provided in Appendix B of this report.

10 Virginia Department of Transportation *Restricted Structure Atlas*, Office of Public Affairs Cartography Section August 2004.

- Fifty-nine of 131 overpass locations (45 percent) have below standard shoulder width.
- Fifty-three of 126 underpass locations (42 percent) have below standard vertical clearance.

3.5 Existing Railway Infrastructure

3.5.1 Railroads in Virginia

The existing rail infrastructure within the Commonwealth of Virginia is presented in Figure 3-9 and Tables 3-9 and 3-10. The two largest (or Class 1) railroads operating in Virginia are Norfolk Southern Corporation (NS) and CSX Transportation (CSXT) with 3,194 miles of railroad in the state. There are 11 "short-line" local railroads that operate in Virginia, but these facilities only account for 314 miles or 8.9 percent of Virginia's total miles.

Table 3-9 Railroads in Virginia - Class 1

Class One Railroads	Class	Miles of Rail in Virginia
CSX Transportation (CSXT)	Class 1	1,050.0
Norfolk Southern (NS)	Class 1	2,144.0
TOTAL		3,194.0

Source: Railroad Service in Virginia, 2002, Association of American Railroads (www.aar.org)

Table 3-10 Railroads in Virginia - Short Line

Short Line Railroads	Symbol	Location	Length (miles)	Class 1 Interchange	Service in Corridor
Buckingham Branch Railroad Company	BB	Dillwyn to Bremo, VA	17.3	CSXT	Yes
Chesapeake & Albemarle Railroad	CARR	Chesapeake, VA to Edenton, NC	14.1	NS, CSXT	No
Chesapeake Western Railway	CW	Harrisonburg, VA to Elkton, VA	16.4	NS	Yes
Commonwealth Railway, Inc.	CWRY	Suffolk, VA to West Norfolk, VA	17.3	NS	No
Eastern Shore Railroad, Inc.	ESHR	Pocomoke City, MD to Norfolk, VA	96 (70-rail, 26-float)	NS, CSXT	No
Norfolk & Portsmouth Belt Line Railroad	NPB	Norfolk, Chesapeake, and Portsmouth, VA	36	NS, CSXT	No
North Carolina & Virginia Railroad	NCVA	Boykins, VA to Kelford, NC	2.5	CSXT	No
Shenandoah Valley Railroad	SV	Pleasant Valley, VA to Staunton, VA	20	NS, CSXT	Yes
Virginia and Tennessee Railroad (non-operating)	SVIL	Glade Spring, VA to Saltville, VA	9.2	NS	Yes
Virginia Southern Railroad	VSRR	Burkeville, VA to Oxford, NC	58.8	NS	No
Winchester & Western Railroad Co.	WW	Hagerstown, MD to Winchester, VA	26.6	NS, CSXT	Yes
TOTAL SHORT LINE			314.2		

Source - Virginia Department of Rail and Public Transportation, December 2004
Note - Total short line mileage is not all within Commonwealth of Virginia

Class 1 Railroads in Study Area

Two Class 1 railroads operate in the study area: NS and CSXT. Two NS rail lines run parallel to I-81, while several CSXT lines cross the corridor east to west. Cross-connections between the two Norfolk Southern rail lines are provided in two locations within Virginia: between Roanoke and Lynchburg in the south and between Front Royal and Manassas in the north. A third connection is provided via a CSXT rail line between Waynesboro and Charlottesville in the middle of the state. Further connections to the east (towards Richmond and the ports of Norfolk and Virginia Beach) and west (to the coalfields of West Virginia and to the Midwest) are provided along both lines.

CSXT

The current (and former) CSXT lines that are within the I-81 and U.S. Route 29 corridors do not parallel but only cross the main NS lines (*e.g.*, at Charlottesville, VA). CSXT lines that do roughly parallel the corridor are farther east in the I-95 corridor.

Norfolk Southern (NS)

Two rail lines owned by Norfolk Southern railroad currently run parallel to the I-81 corridor. The NS “Shenandoah Line” runs immediately adjacent to I-81 and connects Knoxville, Tennessee with Harrisburg, Pennsylvania. A second NS route, the "Piedmont Line", runs roughly parallel to I-81, but farther east of the Appalachian Mountains. This line connects Atlanta, Georgia with Danville, Virginia, then north to Manassas, Virginia, west to Front Royal, Virginia, and then north to Harrisburg, Pennsylvania.

NS Shenandoah Line

The NS Shenandoah Line north of Bristol, Tennessee consists of former Conrail-owned lines purchased during the NS and CSXT purchase of Conrail in the mid-1990s. Much of this route is single-track on significant grades and curvature which limits both train speeds and their ability to haul higher tonnage. The NS "Operating Timetables" show the characteristics of this line:

- 832 miles long with about 336 miles in Virginia;
- Less than 38 miles of double-track;
- Almost one-third of the route does not have signals;
- Numerous grades approaching 4 percent (a severe restriction for train movements); and
- Numerous speed restrictions (<25 mph) south of Hagerstown, MD

NS Shenandoah Line Rail Section	Miles	Notes
Bristol to Roanoke	158.0	Mostly single tracked, moderate grades and horizontal curves
Roanoke to Front Royal	178.0	Significant grades and horizontal curves. Built 1880's.
Subtotal	336.0	

NS Piedmont Line

The NS Piedmont Line is a higher quality rail line than the NS Shenandoah Line. This difference can be explained by the nature of the terrain as well as the rail infrastructure. The aptly named Piedmont Line travels north through the more level "piedmont" terrain of central Virginia. Starting in Danville, this rail route runs north to Lynchburg and on to Manassas, Virginia. A connecting line runs west from Lynchburg to Roanoke, allowing connection to the Shenandoah line. This section of the railroad is the former Southern Railway "main line" to Atlanta, Georgia.

From Manassas, the route turns northwest and connects to Front Royal, Virginia using an older Southern Railway branch line called the "B Line". This section is single-tracked, and lacks adequate signals and sidings, and has other operational constraints. From Front Royal, the line turns north (at Riverton Junction) where it uses the former N&W rail line north to Hagerstown, Maryland. The NS "Operating Timetables" show the basic characteristics of this line:

- Total route is 798 miles long with about 335 miles in Virginia;
- North from Danville to Manassas, it uses both double-track and single-track with extensive sidings (about 77 percent of the total line), is on level grade and has many long straight (tangent) sections which favors rail operations;
- Northwest from Manassas to Front Royal (the older "B Line") is mostly single-track on more challenging grade with significant vertical and horizontal curves; and
- About 90 percent of the line is signalized (except for the older "B Line").

Overall, the Piedmont Line can be characterized as a more modern rail line and superior to the Shenandoah Line due to terrain and existing rail infrastructure such as double tracks, extensive sidings, and rail signals and communication systems. By removing key chokepoints, primarily on the older "B Line", Norfolk Southern could add substantial rail capacity and improve service, reliability, and operations on the Piedmont Line.

NS Piedmont Line Rail Section	Miles	Notes
Danville to Lynchburg	67.5	The Former Southern Railway "Main Line"
Lynchburg to Manassas	145.0	The Former Southern Railway "Main Line"
Manassas to Front Royal	50.0	The "B Line"
Front Royal to WV line	23.0	
Roanoke to Lynchburg	49.0	Connection to Shenandoah Line
Subtotal	334.5	

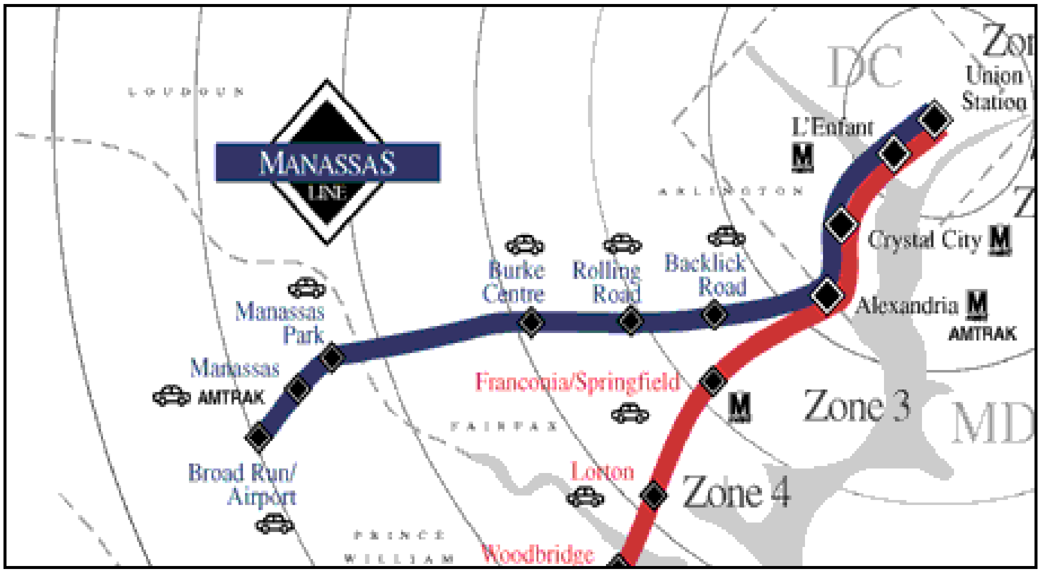
Short Line Railroads in Study Area

There are several short-line railroads in Virginia, some of which provide service in the I-81 and the U.S. Route 29 Corridors. They serve a number of purposes but all focus on providing rail access to customers on light density routes that could not be economically served by the major Class 1 railroads (CSXT and NS).

Passenger Rail Service

Railroads in Virginia within the study area are almost exclusively haulers of freight. Passenger service is offered only by third parties who "lease" access to NS or CSXT rail lines. In the north, the commuter rail line Virginia Railway Express (VRE) runs on a portion of the NS Piedmont Line from near Manassas, Virginia east towards Washington, D.C. (see Figure 3-10). VRE may seek to extend service farther west along the Piedmont route toward Haymarket and Bealton in the future. These future improvements are described in the VRE strategic plan, but are not currently funded.

Figure 3-10 VRE Commuter Rail Service



Source: www.vre.org

The Amtrak Cardinal service also runs on the Piedmont route south from Washington, D.C. to Charlottesville, Virginia then west to Chicago, Illinois (see Figure 3-11). This service currently runs three times per week.

Figure 3-11 Amtrak Passenger Rail Service - Cardinal Route

Source: Amtrak

3.5.2 Rail Intermodal Systems

Existing Rail Intermodal Freight Traffic

Goods and commodities moving through the I-81 corridor are carried primarily by trucks, with a very small portion moving by rail. Options for freight movement through the I-81 corridor include truck only, rail only, and rail intermodal service. Rail intermodal service is a shipping system where trucks pick up and deliver shipments of goods and commodities, but the truck trailer is carried between cities on a rail car. This method is termed TOFC (Trailer on Flat Car).

COFC (Container on Flat Car) is another intermodal service option using highway trailers and railroad cars. This system serves to efficiently move goods over longer distances and reduce truck congestion on long-haul routes. Trucks move to a designated intermodal facility on the railroad where gantries or rubber-tired cranes lift the 20-foot, 48-foot, and up to 53-foot long truck trailers or containers onto specially fitted rail flat or “well” cars.

The graphics below illustrate the rubber-tired lift crane (left) and gantry system (right) at the Burlington Northern – Santa Fe and Norfolk Southern intermodal facilities.


Containers (not trailers) are often stacked two units high (“Double Stacks”), which increases rail efficiencies for longer hauls. Tunnels on a rail line can restrict the height of a double stacked rail car, creating a barrier to efficient intermodal movements. Once the container arrives at the destination intermodal site, the railroad contacts the trucking company. The truck hauler then picks up and delivers the container to its final destination.

A survey of shippers in the “*The Northeast-Southeast-Midwest Corridor Market Analysis*” found that over two-thirds relied solely on trucking as their method of transporting their goods. The remaining one-third used a combination of rail, rail intermodal, and trucking to move their products to the market. Currently, rail accounts for about five percent of freight movement in the I-81 corridor, and lacking future capacity improvements to the rail network, this share could decline.[11]

Rail Freight Growth

Projections from other studies show an increase in freight movements through the study area as economic growth and NAFTA-induced trade between the U.S., Mexico, and Canada continues to grow. Long-haul freight accounts for a small, but rising portion of traffic along I-81. Estimates of freight movements through the I-81 corridor were based on forecasted growth in commodities by key industry sectors. The rail share of this future growth could be limited by several key constraints along the rail system, including the rail intermodal capacity and reliability.

Existing Intermodal Systems/Constraints

Shippers demand reliability. They expect freight carriers to get their goods to their destination on time, intact, and at a competitive price. The service reliability of truck-haul is about 95 to 98 percent "on time" for door-to-door delivery, while the reliability of rail intermodal service is well below that. Physical constraints (or chokepoints) along the rail lines restrict the movement of trains (especially double-stacked intermodal units) and impede the railroad's ability to improve their on-time service reliability. Shippers have indicated a fundamental dissatisfaction with rail's generally poor service reliability, thus they continue to rely on truck haul.

By making improvements to the rail intermodal system, rail owners can mitigate the effects of these chokepoints. By adopting a more open type of intermodal technology, one that is more aligned to the needs of truck shippers, railroads can capture a larger share of the intermodal shipping market. Finally, by marketing their services more aggressively as they make these improvements, railroads could account for a larger portion of the total freight movements in the corridor.

The NS systems have many existing intermodal facilities throughout their service area from Maine to Florida. Table 3-11 is a list of all existing NS intermodal facilities located in Virginia.

11 "*The Northeast-Southeast-Midwest Corridor Market Analysis*" by Reebie Associates, Virginia Department of Rail and Public Transportation, December 2003.

Table 3-11 Existing Norfolk Southern Intermodal Facilities in Virginia

City/State	Capacity & Parking	Terminal Capabilities
Alexandria, VA	40 - 89' Rail Cars 250 Wheeled Units	TOFC / COFC Bottom Lift Only
Front Royal, VA	75 - 89' Rail Cars 625 Wheeled Units 200 Stacked Containers Cross dock transfer	TOFC / COFC / Stack Cars Bottom and Top Lift
Norfolk, VA	49 - 89' Rail Cars 895 Wheeled Units 320 Stacked Containers	TOFC / COFC / Stack Cars Bottom and Top Lift

Source: NS Corporate web site at http://www.nscorp.com/intermodal/index.jsp
TOFC = trailer on flat car. COFC = container on flat car.

Norfolk Southern has stated that their rail intermodal capacity is limited by their ability to provide new terminal space for the truck-to-rail interface. Recent experience has shown that locating and constructing a facility on a suitable site can take many years. (NS required six to 10 years to negotiate and construct intermodal facilities in Pennsylvania and Georgia). The process of locating, negotiating and purchasing, designing, and constructing new intermodal capacity may continue to be a long-term challenge to the railroad.

3.6 Previous Rail Studies

Diverting freight from highways to railroads is not a new concept. Previously, the Virginia Department of Rail and Public Transportation (DRPT), in conjunction with VDOT, looked at the possibility of diverting some of the truck-carried freight onto rail. These studies include:

HJR-704 (1999) House Joint Resolution 704 funded a statewide study focusing on the need to establish additional intermodal facilities in order to divert truck freight to railroads. It was an initial look into the issue and called for additional research. In the next General Assembly session, the Senate funded SJR-55;

SJR-55 (2000) Senate Joint Resolution 55 resulted in a study that evaluated the potential to divert truck traffic from I-81 onto adjacent rail lines. The authors evaluated specific improvements to the NS (Norfolk Southern) rail line in the Shenandoah Valley because it was adjacent and parallel to I-81, and they suggested that a 10 percent diversion (average) of freight from trucks to rail could occur. It concluded that the NS Shenandoah Line was too restricted by topography and infrastructure to carry much additional freight, and that the costs were very high in relation to the improvements to speed and service.

The study also concluded that the NS Piedmont Line (parallel to U.S. Route 29) should be evaluated as the primary rail line for north-south freight movements because it had the capacity and was the primary Norfolk Southern rail line from Atlanta to the Northeast markets. These findings led to the most recent rail-diversion study by the DRPT;

The Northeast-Southeast-Midwest Corridor Marketing Study (2003), completed by Reebie Associates for DRPT, found that investments in rail improvements could divert up to 10 percent of freight carried by trucks in the I-81 corridor with a $500 million investment within Virginia only (with a primary focus on the NS Piedmont Line). A more aggressive multi-state scenario found potential diversions of up to 30 percent, but at a much higher cost ($7.6 billion over several decades).

3.7 Existing Rail System Constraints

In addition to the constraints imposed by inadequate rail intermodal facilities, rail owners are faced with other challenges when attempting to increase their share of the freight movements in the I-81 corridor. Rail improvements are costly and the railroads do not have easy access to investment capital at a competitive price. Constraints within the two Norfolk Southern rail lines in the corridor include operational issues, train capacity, and line capacity, as described below.

Rail Operations - current service in the two corridors is provided by several through-trains between Atlanta, GA, Knoxville, TN, and the Northeast and their southbound counterparts. These trains have seen an increase in demand and represent a significant growth target for NS. Norfolk Southern is facing a challenge to provide added capacity in this corridor due to operational constraints such as dispatch and tracking of available empty cars. Table 3-12 shows Norfolk Southern's current and proposed rail operations in both corridors.[12]

12 Ibid, page 53 Appendix 5

Table 3-12 Existing and Future Rail Operations

Rail Corridor	Trains	Units/Train	Cars	Speed (mph)
Existing Piedmont Line				MAXIMUM:
Danville to Lynchburg	25-30 trains	2-3 units/train	80-100 cars	50 freight/60 intermodal
Lynchburg to Manassas	20-25 trains	2-3 units/train	80-100 cars	50 freight/60 intermodal
Manassas to Front Royal	12-15 trains	2-3 units/train	80-100 cars	35 unspecified
Front Royal to Hagerstown WV	16 trains	2-3 units/train	80-100 cars	Unspecified
Existing Shenandoah Line				
Bristol to Roanoke	34-39	2-3 units/train	80-100 cars	Unspecified
Roanoke to Lynchburg	17-22	2-3 units/train	80-100 cars	Unspecified
Future Piedmont Line				AVERAGE (ESI):
Danville to Lynchburg	33-38	3 units/train	150 cars	33
Lynchburg to Manassas	32-37	3 units/train	150 cars	33
Manassas to Front Royal	24-27	3 units/train	150 cars	33
Front Royal to Hagerstown WV	28	3 units/train	150 cars	33
Future Shenandoah Line				
Bristol to Roanoke	38-43	3 units/train	150 cars	33
Roanoke to Lynchburg	21-26	3 units/train	150 cars	33

Source: Norfolk Southern

Train capacity - a new train start represents a significant undertaking for a railroad due to the costs of rolling stock, labor costs, and dispatch and operational issues. These fixed costs are not taken on until it can be shown that there is a backlog of available freight for the railroad to carry. Short-term increases in rail freight demand do not translate into additional rail capacity - the railroad must be convinced that the increased demand is long-term and sustainable before it will commit to the cost of adding train capacity.

Line Capacity - these two corridors contain many single-track segments as well as segments with speed and height restrictions (see above). A detailed listing of chokepoints has been developed by Norfolk Southern engineering staff and is incorporated in the *Northeast-Southeast-Midwest Marketing Study*[13]. The initial costs range up to $1 billion to reduce curvature and grades and add to line capacity for rail freight movements.[14]

13 Ibid
14 Ibid, Appendix 7

4

Analysis of Future No-Build Conditions (2035)

This chapter describes the future transportation conditions that can be expected within the study area if no improvements are made in the I-81 corridor. Subsequent chapters analyze transportation conditions that could be expected with various improvements. This chapter includes an overview of the methods used to develop no-build traffic projections, the projected traffic demands, and the expected impacts of these demands on the operations of the corridor. The year 2035 was selected because it is envisioned that the improvements that may emerge from this study may take at least 10 years to complete and should have a useful life of at least 20 years beyond completion.

4.1 Forecast Methods

The forecast of traffic growth for the I-81 corridor in the Commonwealth of Virginia is based on a variety of historical data as well as recent transportation and socioeconomic indicators. Several key activities were part of this forecast methods analysis:

- The historical average daily traffic and truck volume data on I-81 were evaluated and forecast trendlines determined (Section 4.1.1);
- Forecasts previously completed for the I-81 corridor (including the 2020 VDOT Trendline analyses for I-81; 2020 forecasts from the previous I-81 Concept Studies; 2025 interchange design studies; and 2020, 2028, and 2030 traffic and truck volume forecasts for the states of Maryland, West Virginia, and Pennsylvania) and various economic forecasts were reviewed and their relevance to this study considered (Section 4.1.2);
- Trends in growth within individual regions and sections of the I-81 corridor were analyzed and incorporated (Section 4.1.3);
- A detailed review and analysis of freight forecasts affecting traffic flows along the corridor was completed (Section 4.1.4); and

- All individual component analyses were compiled into an overall forecast for I-81 (Section 4.1.5).

4.1.1 Historical Traffic Data

Traffic growth along I-81 was reviewed over the 25-year period (1978-2003) for which average annual count data are available from VDOT Average Annual Daily Traffic Volume publications and permanent counts stations on I-81. Historical growth rates were calculated based on the average daily traffic volume data available on I-81. The following sections describe how these data were analyzed and compared. Details of the analysis are also provided in Appendix C of this report.

Historical Traffic Growth: 1978-2003

Historical traffic data along I-81 was evaluated as a whole, and by the eight VDOT permanent count stations on I-81 that represent a relatively broad range of locations along the corridor. Aggregate growth was determined based on the total growth from 1978 to 2003 for each permanent count station. Average annual growth for each station was calculated based on the period of time for which data was available (25 years). Average daily traffic volumes, average annual growth rates, and aggregate growth for each station from available traffic data for the years 1978 to 2003 are presented in Table 4-1.

Table 4-1 Historical Traffic Volume Growth along I-81: 1978-2003

Permanent Count Station Location (from south to north)	Northbound Milepost	Southbound Milepost	Average Daily Traffic Volume 1978	Average Daily Traffic Volume 2003	Average Annual Growth Rate	Aggregate Growth
Route 140 to South Corporate Limit of Abingdon	16.4	17.0	18,100	41,900	3.4%	131%
U.S. Route 11 to North Corporate Limit of Wytheville (I-77 overlap)	75.4	75.4	21,400	51,900	3.6%	143%
Route 177 to Route 8 (near Radford)	113.0	110.8	15,400	41,000	4.0%	166%
Route 581 to U.S. Route 115 (Roanoke)	145.3	146.1	24,700	57,100	3.4%	131%
U.S. Route 11 to U.S. Route 11-614 (Buchanan)	164.5	167.8	14,900	34,300	3.4%	130%
Route 606 to Augusta County Line (I-64 overlap)	207.5	207.3	15,300	41,700	4.1%	173%
U.S. Route 11 to Route 659 (Harrisonburg)	245.4	245.3	16,700	48,000	4.3%	187%
Route 50 to South Corporate Limit of Winchester	315.8	316.0	18,900	56,200	4.5%	197%
Average at Permanent Count Stations			18,000	46,500	3.9%	158%

Source: Virginia Department of Transportation Annual and Permanent Count Reports

As presented in Table 4-1, I-81 count data exhibits a range of growth rates over the eight locations and to some extent shows the regional variation in growth as well. Growth rates at the southernmost count stations are lower than many of the stations in the north; the exception to this trend is I-81 in the I-77 overlap area. Periodic traffic counts at the I-77 overlap section, in addition to the permanent count station data, suggest an historical annual growth rate of approximately 4.7 percent, while traffic at the southernmost permanent count station in Abingdon shows growth at 3.4 percent. The central stations in Roanoke and Buchanan exhibited the lowest average annual growth rate at approximately 3.4 percent. The northern stations have grown the fastest with average annual growth rates between 4.1 and 4.5 percent. Traffic demands over much of I-81 have essentially tripled since the late 1970s with an average annual growth rate at the permanent count stations for the entire I-81 corridor of approximately 3.9 percent.

Since approximately the mid-1980s, the annual growth of daily traffic has progressed along a relatively linear growth curve, with a lower annual growth rate with each subsequent year. This linear growth is displayed in traffic volume data for the entire I-81 corridor, as shown in Table 4-2 and Figure 4-1 on page 4-5. Further graphical depiction of this linear growth is provided in Appendix C. The annual increase in traffic in the corridor has ranged from approximately 1,475 to 1,750 vpd.

Table 4-2 Rolling Average Historical Growth Rates

	I-81 Corridor Average Daily Traffic Volume			Average Growth
I-81 Data Source	Start of Time Period	End of Time Period	Average Annual Increase	Entire Corridor
Historical Data (1985-1995)	19,400	35,400	1,600	6.2%
Historical Data (1990-2000)	25,200	42,700	1,750	5.4%
Historical Data (1995-2003)	35,400	47,200	1,475	3.7%

Source: Virginia Department of Transportation Annual and Permanent Count Reports

As shown in Table 4-2, the period from 1985 to 1995 shows an annual growth rate of 6.2 percent for the I-81 corridor as a whole. The next time period (1990-2000), which overlaps the first period, displays a slightly higher annual increase in traffic volume (1,750 vpd compared to 1,600 vpd); however, the period’s growth rate drops to 5.4 percent because the growth trend has remained relatively constant while the base corridor traffic volume has increased. By the 1995-2003 period, the historical count data exhibited only a 3.7 percent growth rate for the entire corridor, the lowest growth rate of any period analyzed. The effect of the linear growth trend exhibited by historical count data on I-81 is that the corridor growth rate diminishes over time. Table 4-2 is intended only to demonstrate the effect of a diminishing growth rate as a result of a linear historical trend, not to qualitatively compare data for forecasting.

Historical Traffic Growth: 1997-2003

More recent VDOT studies have relied on data from 1997 to the present, after which the traffic count system statistics were enhanced due to better technology and the installation of computerized permanent count stations. Therefore, the period from 1997 to 2003 was analyzed separately to determine if any substantial differences exist between the 1978-2003 growth trend and the more recent traffic growth trend data. Table 4-3 summarizes annual growth rates and aggregate growth based on available traffic data for the period from 1997 to 2003.

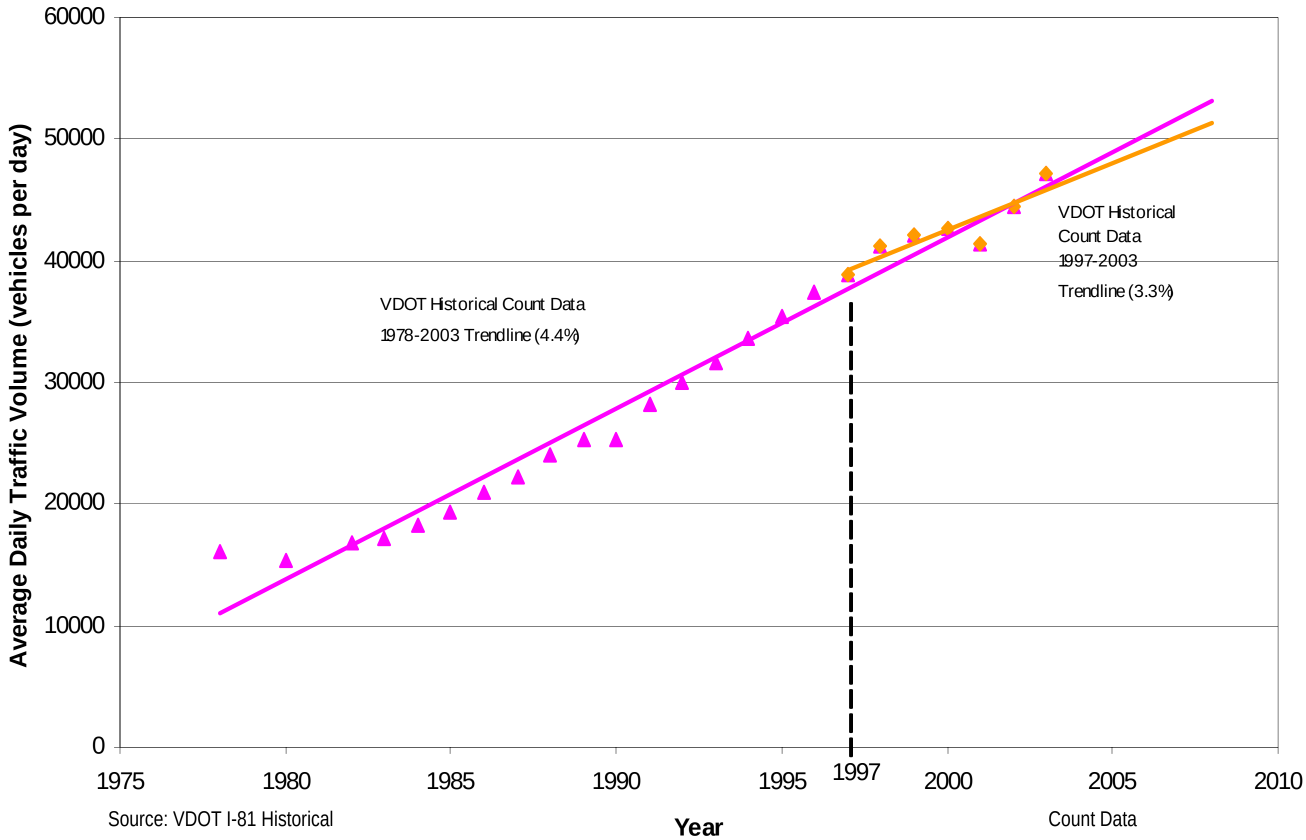
Table 4-3 Historical Traffic Volume Growth along I-81: 1997-2003

Location (from south to north)	Northbound Milepost	Southbound Milepost	Average Daily Traffic Volume 1997	Average Daily Traffic Volume 2003	Average Annual Growth Rate	Aggregate Growth
Route 140 to South Corporate Limit of Abingdon	16.4	17.0	37,000	41,900	2.1%	13%
U.S. Route 11 to North Corporate Limit of Wytheville (I-77 overlap)	75.4	75.4	46,800	51,900	1.7%	11%
Route 177 to Route 8 (near Radford)	113.0	110.8	32,000	41,000	4.2%	28%
Route 581 to Route 115 (Roanoke)	145.3	146.1	52,000	57,100	1.6%	10%
U.S. Route 11 to U.S. Route 11-614 (Buchanan)	164.5	167.8	30,000	34,300	2.3%	14%
Route 606 to Augusta County Line (I-64 overlap)	207.5	207.3	33,000	41,700	4.0%	26%
U.S. Route 11 to Route 659 (Harrisonburg)	245.4	245.3	39,000	48,000	3.5%	23%
Route 50 to South Corporate Limit of Winchester	315.8	316.0	48,000	56,200	2.7%	17%
Average at Permanent Count Stations			39,700	46,500	2.7%	17%

Source: Virginia Department of Transportation Annual and Permanent Count Reports

Comparing Table 4-1 to Table 4-3 shows that the 1978-2003 permanent count station data displays a higher overall average annual growth rate (3.9 percent) than the 1997-2003 data (2.7 percent). Similarly, Figure 4-1 below compares the 1978 to 2003 traffic volume data for all available points on I-81 with more recent 1997 to 2003 traffic trend lines (it should be noted that the percentages on Figure 4-1 are slightly higher because they consider all available data along the corridor while the above tables consider data only at permanent count station locations). The difference in growth rate between historical traffic count data from 1978 to 2003 versus the most recent data can be observed by comparing the trend lines. Much like the permanent count station data, Figure 4-1 shows that all available traffic volume data on the corridor suggests a higher growth rate for the 1978-2003 historical traffic count data than the 1997-2003 historical count data.

Figure 4-1 I-81 Historical Average Daily Traffic Volumes



Source: VDOT I-81 Historical Count Data

As shown in Figure 4-1, the overall VDOT historical count data average annual growth rate for the I-81 corridor from 1997 to 2003 (3.3 percent) is lower than the historical growth rate observed from 1978 to 2003 (4.4 percent). The lower growth rate observed for the more recent data also likely reflects the recessionary period in 2000 and 2001.

Both of these historical VDOT count data sets and trend lines help provide the basis for forecasting growth rates on the I-81 corridor in Virginia. Discussion of growth rate trends and how these data sets were utilized in the forecast analyses is contained in the following section.

4.1.2 Review of Forecast Data

Over the past three years, several forecasts of expected growth along I-81 have been completed. The forecasts reviewed as part of this study include:

- Virginia Department of Transportation previous I-81 Concept Studies (1997);
- Other Agency I-81 Study Forecasts, including West Virginia, Maryland, and Pennsylvania; and,

- Projected economic trends based on historical economic data and regional economic modeling.

Subsequent sections of this report provide data and analysis of the freight and truck forecasts along the corridor.

Prior VDOT Corridor Forecasts

VDOT I-81 Concept Studies

In 1996, VDOT retained a number of consultants to produce traffic volume forecasts and traffic capacity analyses to plan for I-81 corridor improvements. The concept studies divided the 325-mile I-81 corridor into 10 separate sections for greater manageability and detailed review. Each section was analyzed individually, with separate growth rates for the sections calculated for both 2010 and 2020. As a result of the individual analyses and varying conditions along the corridor, the growth rates for the full 2020 design horizon ranged from approximately 2.6 percent in the rural middle section of the state to about 3.1 percent in the more urban northern section between Harrisonburg and Winchester and as high as 3.5 percent in the I-77 overlap section in Wytheville.

Table 4-4 contains a summary of all ten VDOT I-81 Concept Study growth rates. Also included for comparison are two HDR Engineering, Inc. (HDR) final design reports[15] [16] for specific sections of I-81 and three Anderson & Associates, Inc. interchange design reports[17] [18] [19], all of which used the Concept Studies as a basis to extend design forecasts to 2025. The 2025 average annual growth rate observed from these final design reports is approximately 2.8 percent.

15 *Traffic Forecasting Report – FINAL, I-81 Traffic Development & Analysis, MP 240.6-253, Rockingham County*, HDR Engineering, Inc. January 19, 2001

16 *Traffic Forecasting Report – Revised Final, I-81 Traffic Development & Analysis, MP 312-320, Frederick County*, HDR Engineering, Inc. May 3, 2001

17 *Traffic Analysis Methodology, I-81 Traffic Development & Analysis, MP 135.9-152.4, Roanoke & Botetourt Counties, VA*, Anderson & Associates, Inc., January 8, 2003 (revised March 21, 2003)

18 Exit 140 (Route 311), VDOT Project 0081-080-110, PE-105, *I-81 Traffic Development & Analysis, MP 135.9-152.4, Roanoke & Botetourt Counties, VA*, Anderson & Associates, Inc., January 21, 2003

19 Exit 146 (Route 115), VDOT Project 0081-080-110, PE-105, *I-81 Traffic Development & Analysis, MP 135.9-152.4, Roanoke & Botetourt Counties, VA*, Anderson & Associates, Inc., April 3, 2003

Table 4-4 Summary of Prior I-81 Forecasts by the Virginia Department of Transportation

Source	Period: Base Year	Period: Forecast Year	Description and Location	Forecasted Annual Growth Rate	Aggregate Growth
VDOT I-81 Improvement Study Study Area #1	1996	2010 2020	Regression based forecasts from Milepost (MP) 7 to MP 22	2010: 3.5% 2020: 3.1%	Base year 1996 2020 Growth: 113.0%
VDOT I-81 Improvement Study Study Area #2	1997	2010 2020	Regression based forecasts from MP 22 - 72	2010: 3.4% 2020: 2.9%	Base year 1997 2020 Growth: 93.0%
VDOT I-81 Improvement Study Study Area #3	1997	2010 2020	Regression based forecasts from MP 72 - 83	2010: 4.0% 2020: 3.5%	Base year 1997 2020 Growth: 120.6%
VDOT I-81 Improvement Study Study Area #4	1997	2010 2020	Regression based forecasts from MP 83 - 116	2010: 2.8% 2020: 2.6%	Base year 1997 2020 Growth: 88.7%
VDOT I-81 Improvement Study Study Area #5	1997	2010 2020	Regression based forecasts from MP 118 - 163	2010: 2.7% 2020: 2.6%	Base year 1997 2020 Growth: 80.5%
VDOT I-81 Improvement Study Study Area #6	1997	2010 2020	Regression based forecasts from MP 163 - 180	2010: 3.4% 2020: 2.9%	Base year 1997 2020 Growth: 93.0%
VDOT I-81 Improvement Study Study Area #7	1997	2010 2020	Regression based forecasts from MP 180 - 229	2010: 3.3% 2020: 2.9%	Base year 1997 2020 Growth: 93.0%
VDOT I-81 Improvement Study Study Area #8	1997	2010 2020	Regression based forecasts from MP 229 - 264	2010: 3.7% 2020: 3.1%	Base year 1997 2020 Growth: 101.8%
VDOT I-81 Improvement Study Study Area #9	1997	2010 2020	Regression based forecasts from MP 264 - 305	2010: 3.8% 2020: 3.1%	Base year 1997 2020 Growth: 101.8%
VDOT I-81 Improvement Study Study Area #10	1996	2010 2020	Regression based forecasts from MP 305 to West Virginia	2010: 3.2% 2020: 2.6%	Base year 1996 2020 Growth: 85.2%
HDR Final Forecasting Report for I-81 near Harrisonburg	2000	2010 2025	Mileposts 240.6 - 254	2010: 3.5% 2025: 2.8%	Base year 2000 2020 Growth: 73.7%
HDR Final Forecasting Report for I-81 near Winchester	2000	2010 2025	Mileposts 312 - 320	2010: 3.2% 2025: 2.7%	Base year 2000 2020 Growth: 70.4%
Anderson & Associates I-81 Traffic Development & Analysis for Exits 137 to 150; in Roanoke and Botetourt Counties, Virginia	2000	2025	Traffic Forecasting Report for I-81 from Exit 137 to 150	2025 Range: 2.3% to 3.3%	Base year 2000 2025 Growth: 74.9% to 126.7%

VDOT Trendline Analysis

A trend line analysis was produced based on 1982-1987 average daily volume data (as well as selected 1996 data) for the I-81 Concept Studies. The annual growth rate for the full 2020 design horizon was calculated to be approximately 1.6 percent from the base year of 2003. This trend line analysis was considered to be only a guideline for the VDOT I-81 Concept Studies due to the age and limitation of the data used and it was not directly referenced in any of the ten segment studies.

Other Agency Forecasts

Forecast traffic volumes and information were also obtained from the State Departments of Transportation for West Virginia, Maryland, and Pennsylvania. Traffic growth information is listed below and summarized in Table 4-5.

West Virginia Department of Transportation

The West Virginia Department of Transportation (WVDOT) prepared traffic growth forecasts as part of design improvements programmed for the approximately 25 mile long section of I-81 in West Virginia. Growth forecasts were based on historical count trends and existing base year data for 2003. Projections of traffic demands to the year 2028 were made for these design improvements. The annual growth in traffic was calculated to be approximately 2.0 percent along the corridor in West Virginia.

Maryland State Highway Administration

The Maryland State Highway Administration (MDSHA) is analyzing projected traffic volumes as part of its own I-81 Improvement Project. The I-81 Traffic Study volume networks were reviewed for base year 2000 existing traffic conditions and projected 2025 traffic volumes. These networks suggest an average annual corridor growth rate of approximately 1.4 percent per year in Maryland.

Pennsylvania Department of Transportation

The Pennsylvania Department of Transportation (PENNDOT) prepared traffic growth forecasts as part of its *I-81 Widening Study*[20]. PENNDOT has published 2030 forecasts for growth on the approximately 90-mile-long corridor in southern Pennsylvania. Growth is forecast based on a TRANPLAN model of economic, population, and roadway capacity factors which influence travel behavior.

20 http://www.i-81study.com/trafficstudies.htm and http://www.i-81study.com/futureconditions.htm, Pennsylvania Department of Transportation, 2002

Average annual growth rates for the resulting overall corridor were 3.0 percent for the No-Build condition. Traffic forecasts for the "Build" condition were not considered because the Build condition design concepts have not been finalized.

Table 4-5 Summary of Other Agency Forecasts

	Period				
Source	Base Year	Forecast Year	Purpose	Methods	Annual Growth Rate
West Virginia DOT ADT Forecasts	2003	2028	Design volume forecasts for widening through West Virginia	Regression	Average Growth: 2.0%
Maryland SHA ADT Forecasts	2000	2025	Traffic forecasting volumes for the I-81 Improvement Study for Maryland	Regression	Average Growth: 1.4%
Pennsylvania DOT ADT Forecasts	2002	2030 No-Build	Traffic forecasting volumes from the PENNDOT I-81 Widening Study	TRANPLAN Model	No-Build Average Growth: 3.0%

Source: West Virginia and Pennsylvania Departments of Transportation; Maryland State Highway Administration

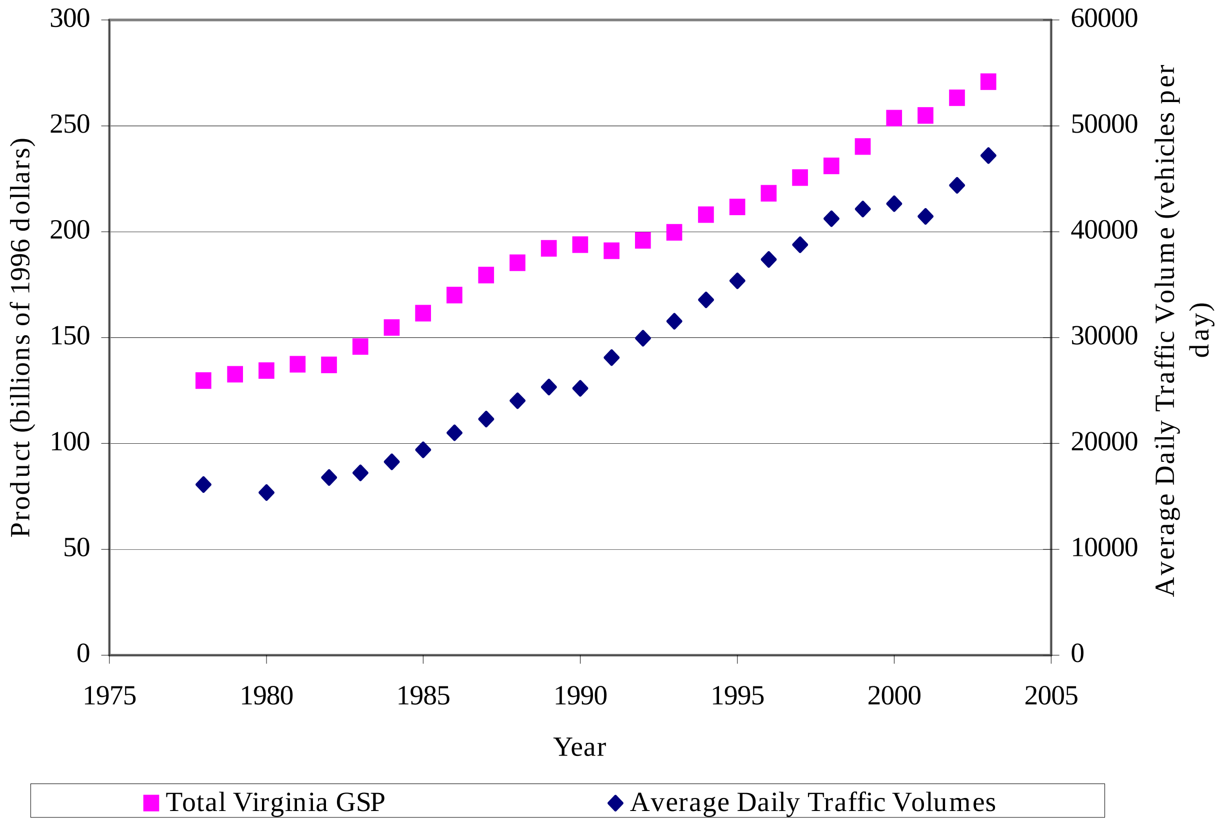
Tennessee Department of Transportation

The Tennessee Department of Transportation (TennDOT) has no traffic growth forecasts specific to I-81. However, historical traffic volumes on the I-81 corridor in Tennessee suggest growth at less than 2 percent per year.

Economic Forecasting

Regional and State economic data for the Commonwealth of Virginia are available through Regional Economic Modeling, Inc. (REMI) and the U.S. Department of Commerce, Bureau of Economic Data. Various economic indicators were examined to determine if any relationship between average annual daily traffic and historical economic data exists. The Virginia-based economic indicator that showed the best correlation to AADT is Gross State Product (GSP), based on the linear regression relationship. Both historical Gross State Product and AADT data show similar growth trends, as shown in Figure 4-2.

Figure 4-2 Virginia Gross State Product (GSP) vs. I-81 Average Daily Traffic Volumes



Source: Virginia Department of Transportation and Regional Economic Models, Inc.

The relationship between Virginia Gross State Product and I-81 average annual daily traffic allows another means for relating the forecasting of daily traffic to economic forecasts for the Commonwealth of Virginia. REMI produced forecasts for Real Gross State Product, among other indicators, for the planned project horizon in 2035. Based on this economic forecast and the relationship between GSP and AADT, average daily traffic volume forecasts were projected for the I-81 corridor. The I-81 forecast growth rate based on REMI economic forecast data is projected to be approximately 2.6 percent per year by the 2035 planning horizon.

Population and Employment

Population and employment forecasts for the Commonwealth of Virginia were also produced in the REMI model. These forecasts were reviewed and compared to I-81 average daily traffic volumes to determine if any reasonable relationship existed between the data sets. While population maintains a somewhat similar linear growth trend to the I-81 AADT, the forecasted employment trend does not demonstrate as strong of a relationship to the I-81

AADT. Table 4-6 shows current 2004 and projected 2035 employment and population data for the Commonwealth of Virginia and the I-81 Corridor Economic Study Region as generated by REMI model. The I-81 Corridor Economic Study Region includes the 13 counties and seven cities through which I-81 traverses, as well as 17 neighboring jurisdictions that play a major factor in car and truck trips along the interstate.

Table 4-6 Current and Forecast Virginia Employment and Population Data

Variable	2004	2035	Aggregate Growth	Annualized Growth
Commonwealth of Virginia				
Employment	4,488,564	5,215,802	16.2 %	0.5 %
Population	7,548,592	9,518,559	26.1 %	0.8 %
I-81 Corridor Economic Study Region				
Employment	647,667	705,361	8.9 %	0.3 %
Population	1,115,778	1,266,832	13.5 %	0.4 %

Source: Regional Economic Model Data

As shown in Table 4-6, the forecasted employment and population trends maintain a fairly slow growth rate over the next several decades. A comparison of the projected growth rates reveals that population and employment within the I-81 Corridor Economic Study Region is expected to grow at a slightly slower rate than the entire state.

4.1.3 Overview of Forecasts

Summary of Corridor Forecasts

As shown in Table 4-7 and Figure 4-3, the various forecast sources indicate that a range of annual growth rates in AADT from 1.4 to 3.0 percent over the next 30 years could be expected. The PennDOT forecast and the REMI Economic Model based forecasts for I-81 traffic volumes projected the highest growth rate, while the trend line analysis based on the most recently available data (1997 to 2003) predicts the lowest. The previous VDOT Concept Studies predict a slightly higher growth rate (2.4 to 2.6 percent) than the historical VDOT count trend line growth rates (1.7 to 2.1 percent); however, the Concept Studies only forecasted to a 2020 design horizon and dampen somewhat (from the values shown in Table 4-4 to approximately 2.0 to 2.3 percent) when extrapolated for 2035 forecasts, as shown in Table 4-7.

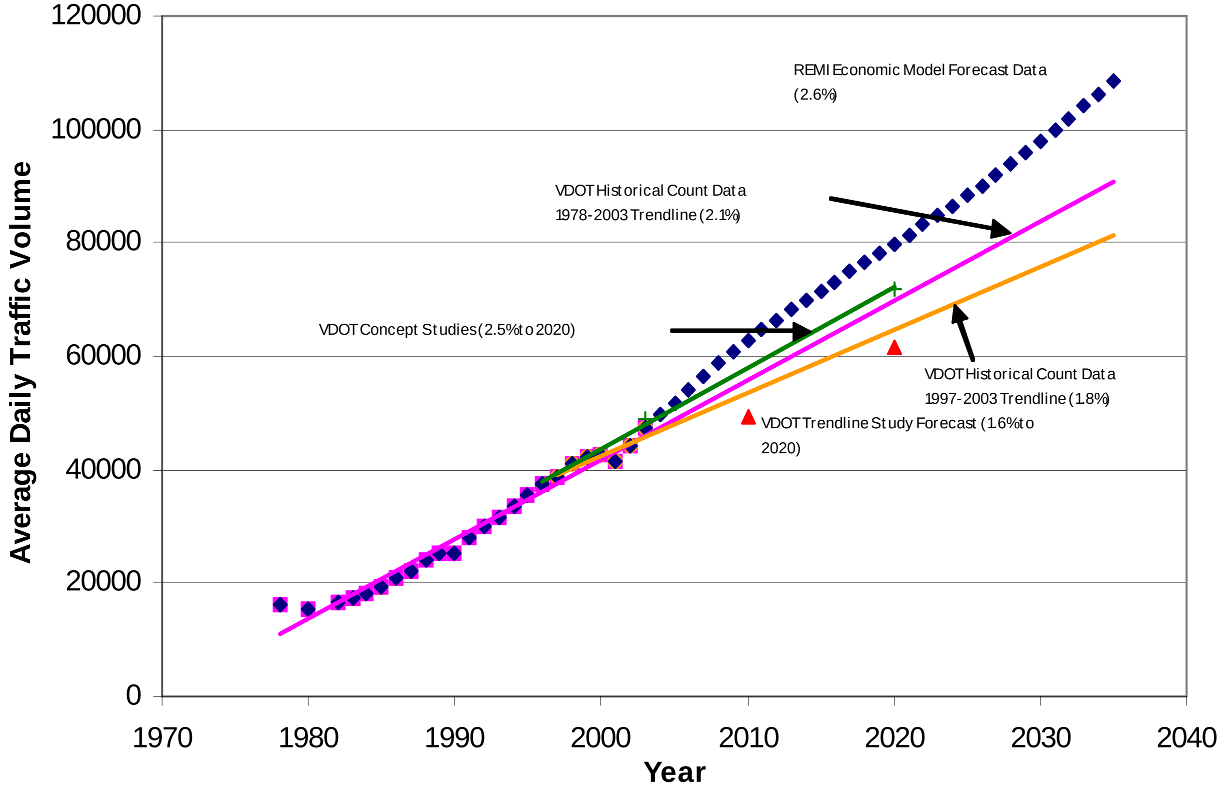
Table 4-7 Summary of I-81 Corridor AADT Forecast Growth Trends

I-81 Forecast Source	Forecasted Annual Growth Rate	Aggregate Growth
2003 - 2020 Growth		
VDOT Concept Studies	2.4 to 2.6%	50 to 55%
2003 - 2035 Growth		
VDOT Concept Studies[1]	2.0 to 2.3%	88 to 107%
Long-term - Trend line Analysis 1(1978-2003 Historical Counts)	1.8 to 2.1%	77 to 101%
Short-term - Trend line Analysis 2 (1997-2003 Historical Counts)	1.4 to 1.9%	56 to 83%
Regression Analysis based on REMI GSP Forecast	2.6%	127%
Other States		
West Virginia DOT Forecast (2028)	2.0%	74%
Maryland SHA Forecast (2025)	1.4%	42%
Pennsylvania DOT Forecast (2030)	3.0%	143%
Tennessee DOT	Not Available	Not Available
I-81 Corridor Improvement Study	1.7 to 2.1%	72 to 101%

Note: VDOT Concept Study growth rates were extrapolated to 2035 design horizon for these summaries.

As mentioned previously, the historical VDOT traffic count data were grown by method of historical trends, extended to result in the Trendline Analyses 1 (long-term historical counts) and 2 (short-term historical counts) forecasts listed in Table 4-7. Comparison of the existing 2003 and projected 2035 corridor volumes yielded projected growth rates of 2.1 and 1.8 percent per year for the Trendline Analysis 1 and 2 alternatives, respectively. As shown in Figure 4-3 the historical data forecasts are compared with the other forecast methodologies.

Figure 4-3 Comparison of 2035 Annual Average Daily Traffic Forecasts on I-81 in Virginia



The results of all historical volume analyses and projected future volume research indicate that average annual traffic volumes on I-81 are likely to continue growing along their current linear path. Based on the data available, the VDOT historical count data trend lines were determined to be the most reliable for use in forecasting future conditions. Based on these two trends, a range of growth rates for traffic (between 1.7 and 2.1 percent) is a reasonable forecast from 2003 to the 2035 design horizon. The actual growth rate used along sections of I-81 varies within this range to reflect local and regional influences, as well as heavy vehicles. This growth is a weighted average of two components – heavy vehicle growth and passenger car growth. Heavy vehicles are expected to grow at 2.8 percent per year throughout the corridor. The remaining percentage (which varies by location) accounts for passenger car growth. The subsequent sections of this report discuss these components in greater detail.

Regional Growth Trends

Table 4-8 examines growth trends along the corridor over the past 25 years (1978 to 2003) by location of each permanent count station.

Table 4-8 Interstate 81 Average Annual Daily Traffic: Regional Trendlines from Permanent Count Stations

VDOT Permanent Count Station Location (south to north)	Northbound Milepost	Southbound Milepost	1978 AADT	2003 AADT	Annual Growth	Projected Growth * (2003-2035)
Route 140 to South Corporate Limit of Abingdon	16.4	17.0	18,100	41,900	3.4%	1.7%
U.S. Route 11 to North Corporate Limit of Wytheville(I-77 overlap)	75.4	75.4	21,400	51,900	3.6%	2.1%
Route 177 to Route 8 (near Radford)	113.0	110.8	15,400	41,000	4.0%	2.1%
Route 581 to Route 115 (Roanoke)	145.3	146.1	24,700	57,100	3.4%	1.8%
U.S. Route 11 to U.S. Route 11-614 (Buchanan)	164.5	167.8	14,900	34,300	3.4%	2.0%
Route 606 to Augusta County Line (I-64 overlap)	207.5	207.3	15,300	41,700	4.1%	2.1%
U.S. Route 11 to Route 659 (Harrisonburg)	245.4	245.3	16,700	48,000	4.3%	2.1%
Route 50 to South Corporate Limit of Winchester	315.8	316.0	18,900	56,200	4.5%	2.2%
Average at Permanent Count Stations			18,000	46,500	3.9%	2.0%

Source: VDOT 1978 and 2003 Permanent Count Station Data
Note: * Based on historical trends extended at each permanent count station.

The projected growth, based on historical trends extended at each permanent count station, suggests a low growth range of 1.7 to 1.8 percent per year (near the Tennessee border and in the Roanoke area) to a high growth range at 2.1 to 2.2 percent per year (at the I-77 overlap, near Radford, and in the north). This range of growth rates reasonably brackets the travel demand increases that are expected well into the future along the I-81 corridor and gives indications of expected variations in growth by region. Further discussion of local growth variations and their inclusion in the forecast methods is provided in the next section of this report.

The Virginia Statewide Transportation Model

The Virginia Statewide Travel Demand Model (just recently completed) is a mathematical model that assesses the transportation system performance, identifies and analyzes the deficiencies, and supports the development of local and regional plans. The statewide model includes forecasts of population and employment changes and can determine the impacts of growth on Virginia's transportation system.

The Virginia Statewide Travel Demand Model draws upon a wide variety of data sources, including federal, state, and locally-produced data. One of the principal sources of data is U.S. Census population and household information. Forecast population, household, and employment data is derived from the Virginia State Data Center and from regional Metropolitan Planning Organizations.

The model also includes transportation information directly provided by VDOT. VDOT maintains an extensive set of highway map products and a statewide inventory system known as the HTRIS (Highway and Traffic Records Information System).

The statewide model, while still under development during this phase of the study, finalized its estimates of future land use changes between 2000 and 2025 expected throughout the Commonwealth. These forecasts, summarized by the western counties of Virginia in Table 4-9, provide further insight into expected differences in regional growth along the I-81 corridor.

As noted in Table 4-9, the I-81 corridor counties are expected to add approximately 253,000 people and 153,000 jobs by the year 2025. The distribution of this growth varies by location. Southern counties along the I-81 corridor are expected to realize low to moderate growth in population and employment. By contrast, some of the urbanized areas in the central portion of the study area (Pulaski, Blacksburg/Christiansburg) are expected to experience more substantial growth. Similar growth, largely concentrated in Harrisonburg, Front Royal, and Winchester, is expected to occur in the northern region.

Accounting for high and low growth areas along the I-81 corridor is important in the approach to forecasting future traffic flows. The land use data input to the statewide model was used as the basis of the determination of high and low growth areas along I-81 for this study, as discussed further in section 4.1.5.

Variations in growth along the 325-mile I-81 corridor were accounted for first at the county and city level and then at the exit level. The 2025 forecasts in population, households, and employment available from the Virginia statewide model were summarized at the county level, translated into new trips (productions and attractions or places people are coming from and want to go to), and compared to determine variations in growth expected along the I-81 corridor. This comparison is summarized in Table 4-10.

Table 4-9 Projected Land Use Changes Along the Virginia I-81 Corridor

	Population (Persons)				Employment (Jobs)		
County[1]	Total Change 2000 to 2025	Percent Change 2000 to 2025	Percent of Total Study Area	County[1]	Total Change 2000 to 2025	Percent Change 2000 to 2025	Percent of Total Study Area
South				South			
Bland	763	11%	0.30%	Bland	202	9%	0.13%
Russell	8,194	27%	3.24%	Russell	3,185	31%	2.08%
Smyth	2,441	7%	0.97%	Smyth	2,088	12.83%	1.36%
Tazewell	3,481	8%	1.38%	Tazewell	4,352	25.34%	2.84%
Washington	7,133	14%	2.82%	Washington	7,452	32.19%	4.87%
Wythe	4,906	18%	1.94%	Wythe	3,277	25.92%	2.14%
Subtotal Southern	26,918		10.65%	Subtotal Southern	20,556		13.44%
Central				Central			
Alleghany	(1,144)	-5%	-0.45%	Alleghany	663	6.51%	0.43%
Augusta	15,876	15%	6.28%	Augusta	9,206	17.85%	6.02%
Bath	233	5%	0.09%	Bath	224	8.67%	0.15%
Bedford	38,282	57%	15.15%	Bedford	11,339	57.42%	7.41%
Botetourt	12,007	39%	4.75%	Botetourt	3,626	42.56%	2.37%
Craig	768	15%	0.30%	Craig	141	16.63%	0.09%
Giles	211	1%	0.08%	Giles	733	12.27%	0.48%
Highland	127	5%	0.05%	Highland	94	9.24%	0.06%
Montgomery	27,563	28%	10.91%	Montgomery	14,693	32.45%	9.60%
Pulaski	3,330	9%	1.32%	Pulaski	4,874	27.84%	3.19%
Roanoke	23,222	11%	9.19%	Roanoke	34,599	25.51%	22.61%
Rockbridge	3,578	11%	1.42%	Rockbridge	3,791	24.74%	2.48%
Subtotal Central	124,053		49.09%	Subtotal Central	83,983		54.89%
North				North			
Clarke	2,313	18%	0.92%	Clarke	1,504	27.13%	0.98%
Frederick	32,193	39%	12.74%	Frederick	18,378	38.71%	12.01%
Page	3,858	17%	1.53%	Page	1,802	21.74%	1.18%
Rockingham	40,760	38%	16.13%	Rockingham	19,621	32.59%	12.82%
Shenandoah	6,714	19%	2.66%	Shenandoah	3,015	18.19%	1.97%
Warren	15,880	50%	6.28%	Warren	4,136	38.11%	2.70%
Subtotal Northern	101,718		40.25%	Subtotal Northern	48,456		31.67%
Total Study Area	252,689			Total Study Area	152,995		

Source: Virginia DOT Statewide Transportation Model 2000 and 2025 Land Use
Note: The corridor is divided into south, central, and north sections for informational purposes only.
1 Despite being reported separately, individual city data was grouped with the county data for the purposes of this study.

Table 4-10 Projected Growth in Virginia I-81 Corridor Counties

	2000			2025			Change			
County	Productions[1]	Attractions[2]	Total	Productions	Attractions	Total	Productions	Attractions	Overall	Growth[3]
Bland	23,380	11,370	34,750	25,902	13,085	38,987	2,522	1,715	12.2%	low
Russell	107,224	61,433	168,657	135,806	81,771	217,577	28,582	20,338	29.0%	high
Smyth	120,866	90,371	211,237	130,426	105,095	235,521	9,560	14,724	11.5%	low
Tazewell	165,180	137,789	302,969	178,084	178,452	356,536	12,904	40,663	17.7%	moderate
Washington	189,349	159,514	348,863	216,646	232,794	449,440	27,297	73,280	28.8%	high
Wythe	102,417	90,951	193,368	121,192	114,501	235,693	18,775	23,550	21.9%	moderate
Alleghany	87,399	66,983	154,382	83,305	69,064	152,369	-4,094	2,081	-1.3%	low
Augusta	393,594	350,175	743,769	452,752	435,268	888,020	59,158	85,093	19.4%	moderate
Bath	18,305	13,547	31,852	19,166	14,887	34,053	861	1,340	6.9%	low
Bedford	249,166	134,478	383,644	392,670	220,283	612,953	143,504	85,805	59.8%	high
Botetourt	113,680	62,184	175,864	158,303	86,400	244,703	44,623	24,216	39.1%	high
Craig	19,073	6,471	25,544	22,051	7,676	29,727	2,978	1,205	16.4%	low
Giles	62,798	40,141	102,939	64,055	44,559	108,614	1,257	4,418	5.5%	low
Highland	9,794	5,236	15,030	10,317	5,888	16,205	523	652	7.8%	low
Montgomery	334,012	303,267	637,279	436,082	408,791	844,873	102,070	105,524	32.6%	high
Pulaski	130,137	108,352	238,489	142,661	140,529	283,190	12,524	32,177	18.7%	moderate
Roanoke[4]	760,679	982,053	1,742,732	848,920	1,177,673	2,026,593	88,241	195,620	16.3%	low
Rockbridge	118,652	102,731	221,383	132,043	127,738	259,781	13,391	25,007	17.3%	moderate
Clarke	46,511	29,335	75,846	55,509	36,500	92,009	8,998	7,165	21.3%	moderate
Frederick[4]	305,547	332,734	638,281	432,266	470,489	902,755	126,719	137,755	41.4%	high
Page	85,716	50,697	136,413	100,770	61,520	162,290	15,054	10,823	19.0%	moderate
Rockingham[4]	368,720	389,519	758,239	516,976	518,022	1,034,998	148,256	128,503	36.5%	high
Shenandoah	131,315	104,511	235,826	158,699	130,531	289,230	27,384	26,020	22.6%	moderate
Warren	115,410	83,913	199,323	174,658	120,269	294,927	59,248	36,356	48.0%	high
Total	4,058,924	3,717,755	7,776,679	5,009,259	4,801,785	9,899,044	950,335	1,084,030	22.9%	moderate

Source: Virginia DOT Statewide Transportation Model 2000 and 2025 Land Use

Notes: 1 - Total productions include trips classified as home-based work, home-based other, and non home-based.
2 - Total attractions include trips classified as home-based work, home-based other, and non home-based.
3- Based on overall percent change, growth rates between 1.7 and 2.1 were assigned to existing traffic volumes, as above.
4 Despite being reported separately, individual city data for Winchester, Harrisonburg, and Roanoke was grouped with the appropriate county data for the purposes of this study.

Overall, the counties along the I-81 corridor are expected to see on average a 23 percent increase in trips. Using this average as a comparison, a low, moderate, or high growth expectation was assigned to each county based on the overall change in productions and attractions, such that:

- Low growth areas were assigned an average annual growth rate of 1.7 percent;
- Moderate growth areas an average annual growth rate of 1.9 percent; and
- High growth areas an average annual growth rate of 2.1 percent.

These local growth rates are based on the information provided in Table 4-8.

Using the existing highway infrastructure along the I-81 corridor, these growth rates were translated to an interchange, or series of interchanges, that provide access to each county. For interchanges that serve counties with different local growth rates, an average was assumed (1.8 for low/moderate; 1.9 for low/high, and 2.0 for moderate/high). This method was used to forecast growth at each of the I-81 interchanges. Through trips (originating either in Tennessee or West Virginia) were grown at 2.1 percent per year through 2035 to reflect the higher growth in adjacent states (particularly to the north).

A separate forecast of freight movements through the corridor was conducted to estimate growth in truck traffic along I-81. Section 4.1.4 of this report provides insight into how freight movements are expected to grow along the corridor.

4.1.4 Freight Forecast

As previously discussed, truck flows are a substantial component of current I-81 traffic flows in Virginia, accounting for between 21 and 35 percent of the average annual daily traffic (AADT) depending on the section and direction. Truck traffic is growing faster then personal vehicle traffic nationwide and a similar future is expected for the I-81 corridor, suggesting that truck volumes should be grown at a different rate than passenger vehicles in the forecasts of 2035 traffic. A detailed *Freight Forecast and Diversion Technical Report* has been prepared as a separate document to this study. The section below provides an overview of the freight forecast.

Truck Forecast Results

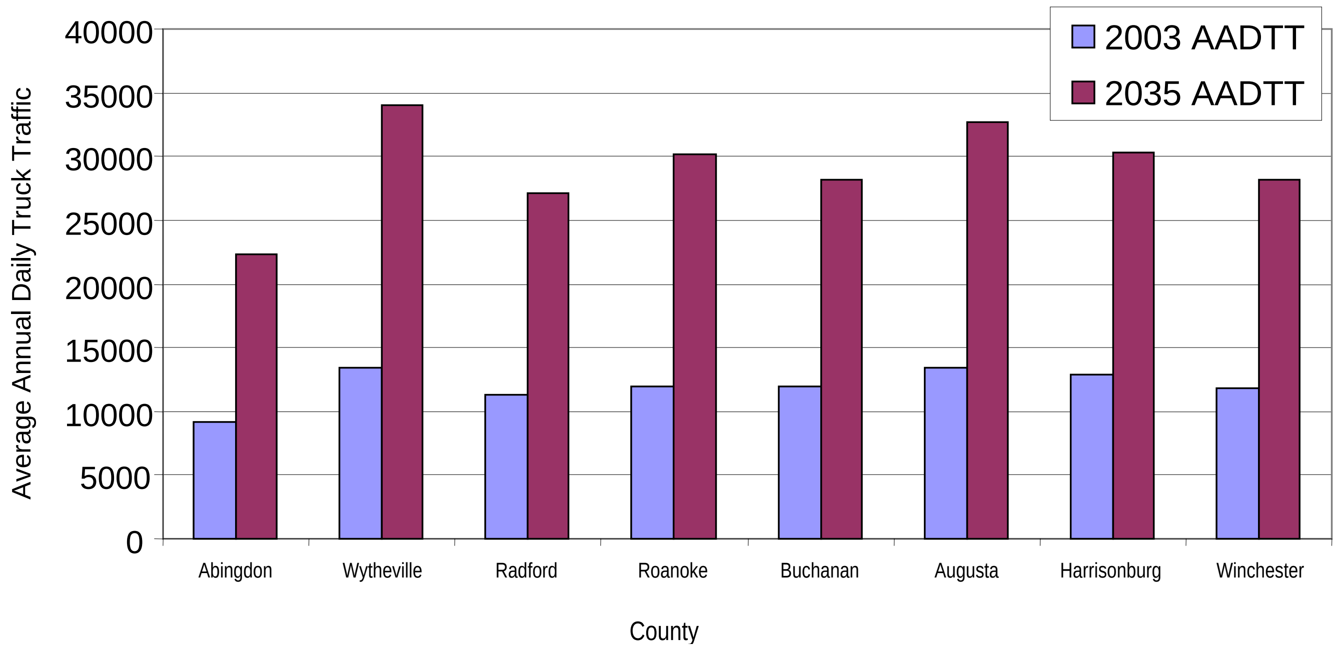
Table 4-11 provides traffic forecasts at the VDOT permanent count station locations for 2003 and the 2035 design horizon. Traffic volumes are provided for combination trucks or heavy trucks. The final columns provide the annual and aggregate percent growth from 2003 to 2035 for trucks for each of the eight count stations. Truck traffic levels for 2035 at each of the I-81 links are summarized in the future conditions network in Appendix E to the *Freight Forecast and Diversion Technical Report*.

The growth of total trucks at individual count stations varies from 135 to 152 percent. These translate to directional compounded average annual growth rates of approximately 2.8 percent per year through 2035. These growth rates compare favorably to a compounded average annual growth rate for I-81 truck traffic of 2.96 percent predicted for the 1998 to 2020 period by the Freight Analysis Framework (FAF) model and a compounded average annual growth rate for I-81 freight flows of 2.45 percent predicted for the 2005 to 2020 period by the Virginia Statewide Model. Furthermore, the 2035 commodity flow model prepared for this study indicates that approximately 68 percent of all truck traffic has neither an origin nor a destination in Virginia and utilizes some portion of I-81 during their trip. The model was developed from user surveys and national freight information and was calibrated via actual truck counts at various locations along I-81.

Table 4-11 Summary of I-81 Count Station Truck Volume and Growth Data

	Average Annual Heavy Truck Traffic		Aggregate	Annual
I-81 Permanent Count Station	Existing	No-Build	Growth	Growth
Route 140 to South Corporate Limit of Abingdon	9,180	22,310	2.8 %	143 %
U.S. Route 11 to North Corporate Limit of	13,450	33,970	2.9 %	153 %
Route 177 to Route 8 (near Radford)	11,240	27,120	2.8 %	141 %
Route 581 to Route 115 (Roanoke)	11,990	30,210	2.9 %	152 %
U.S. Route 11 to U.S. Route 11-614 (Buchanan)	11,970	28,130	2.7 %	135 %
Route 606 to Augusta County Line	13,480	32,750	2.8 %	143 %
U.S. Route 11 to Route 659 (Harrisonburg)	12,870	30,330	2.7 %	136 %
Route 50 to South Corporate Limit of Winchester	11,850	28,220	2.7 %	138 %

Figure 4-4 Summary of I-81 Count Stations Truck Volume Forecasts



4.1.5 Forecasting for Special Conditions

As described throughout this chapter, traffic projections for the 2035 No-Build are based on corridor-length traffic and economic information. A time period of one hour is typically used to evaluate operating conditions on highways and set future design requirements. To create 2035 traffic volume networks that could adequately represent expected growth along the entirety of I-81 within Virginia, a design hour volume (DHV) was used instead of a traditional peak hour volume. The DHV refers to the one hour period in the future design year that most appropriately assesses operating conditions and the functional requirements of a facility. The purpose for selecting a DHV below the maximum and above the average demand levels is to avoid over-designing or under-designing a transportation facility.

Typically, the traffic volumes occurring during the 30th, 50th, or 100th highest hour (over the course of a year) are considered for design purposes. A review of hourly traffic volumes along I-81 (at the eight permanent count stations) over the course of a year (2003) showed that the majority of the top 30 hours occur on holidays and heavily traveled summer weekends and that use of the 30th highest hour would in fact be designing for a special condition. The 50th and 100th highest hours appear to occur on more typical days of the year. Therefore, using the projected 2035 daily volumes (as described in Section 4.1), the 2035 design hour traffic volumes were based on approximately the 50th highest hour which translates into about nine percent of the 2035 daily projections.

The I-77 overlap section of I-81 (between Exit 72 and Exit 81) has been observed to experience heavier traffic volumes than other sections of the highway during weekends and peak summer travel times. As such, there is concern that using a DHV would not adequately reflect the potential future congestion along this stretch of highway and would not be sufficient to handle the overlap traffic volume during these times. While the purpose of this study is to develop interstate cross-sections that are capable of accommodating typical 2035 traffic volume, a sensitivity analysis was conducted to determine the impact a higher seasonal volume along I-77 would have on I-81.

The results of this analysis show that traffic volume at the two I-81/I-77 interchanges (Exit 72 and Exit 81) are higher during a weekend summer condition than during a typical weekday. However, heavy vehicle volumes are 50 to 60 percent lower on a Friday than during the mid-week and as much as 70 percent lower on Sunday. Because of the significantly reduced heavy vehicle percentages, traffic operations associated with a weekend condition are expected to be the same. These analyses can be found in Appendix D to this technical report.

4.1.6 Approach to Overall 2035 No-Build Forecasts

To forecast overall traffic growth for the 325-mile I-81 corridor to the year 2035, the study team used a combination of data to reflect growth in through traffic, freight movement, and local traffic. The methods employed in developing the forecasting procedure are described below. The forecast growth rates described in this section pertain only to the No-Build Concept. Adjustments in component growth rates due to I-81 "Build" concepts are addressed in Chapter 5.

Through Traffic

Traffic growth in through traffic should reflect growth trends along the I-77 and I-64 overlap areas of I-81 and at the state lines of West Virginia and Tennessee, which are in the range of 2.0 to 2.1 percent per year. West Virginia has forecast traffic along I-81 to grow at 2.0 percent per year through 2028. The Tennessee Department of Transportation has no traffic growth forecasts specific to I-81, but historical traffic volumes on the I-81 corridor in Tennessee suggest growth at less than 2 percent per year. As such, the more conservative (higher) overall growth rate of 2.1 percent per year was assumed and applied to traffic traveling through the corridor, including traffic at system interchanges on I-81 (consisting of exits at I-77, I-581, I-64, and I-66).

Truck Traffic

A substantial portion of the growth in through traffic is truck traffic that is expected to grow at a faster pace than that of passenger cars. Growth in various commodity flows expected between 2004 and 2035 result in a forecasted growth in heavy vehicles of approximately 2.8 percent per year throughout the corridor. This growth rate for heavy vehicles was accounted for in both through traffic and at interchanges as part of the development of the 2035 forecasts.

Local Traffic

Variations for growth along the 325-mile I-81 corridor were accounted for first at the county and city level and then at the interchange level. The 2025 forecasts in population, households, and employment available from the Virginia Statewide Transportation Model were summarized at the county level, translated into new trips (productions and attractions), and compared to determine variations in growth expected along the I-81 corridor (see Section 4.1.3.3).

Overall, the counties along the I-81 corridor are expected to see on average a 123 percent increase in trips. Using this average as a comparison, a low, moderate, or high growth expectation was assigned to each county based on the overall change in productions and attractions.

- Low growth areas were assigned an average annual growth rate of 1.7 percent;
- Moderate growth areas an average annual growth rate of 1.9 percent; and
- High growth areas an average annual growth rate of 2.1 percent.

Using the existing highway infrastructure along the I-81 corridor, these growth rates were translated to an interchange, or series of interchagnes, that provide access to each county. It should again be noted that these growth rates represent overall traffic volume growth and are a weighted average between heavy vehicle growth and passanger car growth. Heavy vehicles have been grown by 2.8 percent per year. Passanger cars are expected to grow by the remaining percentage, which varries throughout the corridor.

Development of 2035 Traffic Volume Network

Starting with the 2004 traffic volume networks, traffic volumes for through passenger vehicles, all heavy vehicles, and local ramp traffic were grown individually using a range of growth rates between 1.7 and 2.8 percent per year through 2035. These separate networks were then added together. After combining the separate mainline vehicle class volumes and ramp volumes, the network was then balanced throughout to ensure that traffic volumes at successive interchanges agree and that all corridor traffic is accounted for at the entry and exit points. The resultant 2035 daily and peak hour traffic volumes can be seen in Figures 4-5 and 4-6 respectively. The 2035 daily and peak hour heavy vehicle traffic volumes can be seen in Figures 4-7 and 4-8, respectively.

4.2 Future No-Build Traffic Operations

The following sections present the results of the various 2035 No-Build levels of service analyses.

4.2.1 Mainline Level of Service

The projected future No-Build levels of service for the mainline, ramps, and weaving sections were calculated according to the Highway Capacity Manual methodologies described in Chapter 3, Analysis of Existing Conditions. These analyses were based on the projected No-Build traffic volumes identified above and represent expected conditions if no improvements are made to the I-81 corridor.

Mainline Operations

Traffic volumes and the associated levels of service along the I-81 freeway segments are summarized in Table 4-12 and shown in Figure 4-9.

Compared to existing levels of service, traffic operating conditions decline along the mainline during the 2035 design peak hour. Based on projected 2035 No-Build volumes:

- In the northbound direction, 295 miles (91 percent) of I-81 are projected to operate worse than the level of service standard.
- In the southbound direction, 299 miles (92 percent) of I-81 are projected to operate worse than the level of service standard.

The shaded segments in Table 4-12 indicate those areas that do not meet the Level of Service standard.

Table 4-12 2035 I-81 Freeway Operations Summary

Segment		Number of	Northbound				Southbound			
			2004 Peak Hour		2035 Peak Hour		2004 Peak Hour		2035 Peak Hour	
From Exit	To Exit	Lanes	Volume[1]	LOS[2]	Volume	LOS	Volume	LOS	Volume	LOS
Tennessee	1	3	1600	A	2150	B	1100	A	2000	B
1	3	32	1650	B	2250	C	1200	A	2150	B
3	5	3	2300	B	3700	D	1700	A	3500	C
5	7	3	2150	B	3500	C	1550	A	3200	C
7	10	2	2000	C	3400	E	1650	B	3300	D
10	13	2	1950	B	3150	D	1600	B	3100	D
13	14	2	2000	B	3200	D	1600	B	3200	D
14	17	2	1750	B	2900	D	1450	B	2950	D
17	19	2	1800	B	2950	D	1450	B	2950	C
19	22	2	1500	B	2400	C	1250	B	2400	C
22	24	2	1450	B	2250	C	1150	A	2250	C
24	26	2	1400	B	2200	C	1100	A	2200	C
26	29	2	1300	B	2050	C	1050	A	2100	C
29	32	2	1150	A	1950	B	1000	A	2000	C
32	35	2	1150	B	1950	C	1000	A	2000	C
35	39	2	1200	A	2150	C	1150	A	2200	C
39	44	2	1200	A	2300	C	1300	B	2350	C
44	45	2	1150	A	2200	C	1250	B	2250	C
45	47	2	1100	A	2000	C	1100	A	2050	C
47	50	2	1150	A	1950	C	1000	A	1900	B
50	54	2	1100	A	1750	C	900	A	1750	B
54	60	2	1050	A	1650	B	900	A	1700	B
60	67	2	1150	A	1800	B	1000	A	1800	C
67	70	2	1100	A	1700	B	950	A	1750	B
70	72	2	1250	B	1900	B	1000	A	1900	C
72	73	2	1750	B	3750	D	1600	A	3700	C
73	77	3	2050	B	4150	D	1750	B	4150	D
77	80	3	1950	B	3950	C	1750	B	4100	D
80	81	3	1900	B	3950	C	1800	B	4050	D
81	84	2	1450	B	2700	D	1400	B	2650	C
84	86	2	1400	B	2600	D	1450	B	2650	D
86	89	2	1400	B	2600	D	1500	B	2700	C
89	92	2	1450	B	2800	D	1600	B	2850	D
92	94	2	1450	B	2850	E	1600	B	2900	D
94	98	2	1450	B	2800	D	1450	B	2800	D
98	101	2	1600	B	3100	D	1500	B	3000	C
101	105	2	1600	B	3100	D	1550	B	3000	D

Note: Shaded sections are locations where substandard LOS is indicated.
1 Vehicles per hour
2 Level of Service

Table 4-12 2035 I-81 Freeway Operations Summary (Continued)

Segment		Number of Lanes	Northbound				Southbound			
			2004 Peak Hour		2035 Peak Hour		2004 Peak Hour		2035 Peak Hour	
From Exit	To Exit		Volume[1]	LOS[2]	Volume	LOS	Volume	LOS	Volume	LOS
105	109	2	1550	B	2900	E	1450	B	2800	C
109	114	2	1700	B	3200	D	1650	B	3150	D
114	118	2	1650	C	3300	E	1850	B	3300	D
118	128	2	2050	C	3700	E	2050	C	3700	E
128	132	2	1950	C	3700	E	2150	C	3800	E
132	137	2	1900	C	3850	F	2300	C	4100	E
137	140	2	2450	C	4700	F	2750	C	4950	F
140	141	2	2700	C	5000	F	2900	D	5200	F
141	143	2	3050	D	5600	F	3150	D	5550	F
143	146	2	2700	C	4250	E	2550	C	4750	F
146	150	2	2450	C	3800	E	2200	C	4350	E
150	156	2	1450	B	2550	D	1150	B	2750	D
156	162	2	1300	B	2450	D	1100	A	2650	C
162	167	2	1200	A	2350	C	1050	A	2500	C
167	168	2	1250	B	2500	C	1100	B	2600	D
168	175	2	1250	B	2450	D	1100	B	2550	D
175	180	2	1250	B	2400	D	1100	B	2500	C
180	188	2	1250	B	2500	D	1150	B	2550	D
188	191	2	1400	B	2800	C	1350	B	2900	C
191	195	2	1500	B	3050	D	1500	B	3150	D
195	200	2	1500	B	3100	E	1550	B	3200	D
200	205	2	1450	B	3050	E	1600	B	3200	D
205	213	2	1450	B	3150	D	1700	B	3200	E
213	217	2	1450	B	3250	D	1800	B	3250	D
217	220	2	1600	B	3650	E	2050	C	3600	E
220	221	2	1750	B	4000	E	2350	C	4050	E
221	222	2	2000	C	4350	E	2250	C	4700	E
222	225	2	1950	C	4100	E	2000	C	4300	E
225	227	2	1800	B	3850	D	1900	B	4000	D
227	235	2	1650	B	3600	D	1800	B	3700	D
235	240	2	1650	B	3700	D	1900	C	3750	E
240	243	2	1650	B	3700	D	1850	B	3700	D
243	245	2	1800	B	3750	E	1850	B	3850	E
245	247	2	1800	C	3700	E	1600	B	3750	D
247	251	2	1700	B	3100	D	1350	B	3500	D
251	257	2	1650	B	3050	D	1350	B	3450	D

Note: Shaded sections are locations where substandard LOS is indicated.
1 Vehicles per hour
2 Level of Service

Table 4-12 2035 I-81 Freeway Operations Summary (Continued)

Segment		Number of	Northbound				Southbound			
			2004 Peak Hour		2035 Peak Hour		2004 Peak Hour		2035 Peak Hour	
From Exit	To Exit	Lanes	Volume[1]	LOS[2]	Volume	LOS	Volume	LOS	Volume	LOS
257	264	2	1350	B	2600	C	1200	B	3000	D
264	269	2	1300	B	2600	C	1200	A	2900	C
269	273	2	1250	B	2550	D	1150	A	2850	C
273	277	2	1350	B	2700	C	1250	A	3000	D
277	279	2	1300	B	2650	C	1200	B	2950	D
279	283	2	1300	B	2700	D	1250	B	3000	D
283	291	2	1300	B	2750	D	1350	B	3050	D
291	296	2	1300	B	2900	D	1500	B	3250	D
296	298	2	1300	B	3000	D	1650	B	3350	D
298	300	2	1550	B	3500	E	1950	C	3750	E
300	302	2	1450	B	3250	D	1600	B	3400	D
302	307	2	1550	B	3550	D	1750	B	3650	D
307	310	2	1700	B	4000	E	1950	C	4000	E
310	313	2	1600	B	3550	E	1700	B	3650	D
313	315	2	2300	C	4600	E	2000	C	4700	E
315	317	2	2350	C	4650	F	1700	B	4450	E
317	321	2	1950	C	3750	E	1300	B	3600	D
321	323	2	1900	B	3650	D	1250	A	3450	D
323	West Virginia	2	1800	B	3450	D	1200	A	3250	D

Note: Shaded sections are locations where substandard LOS is indicated.
1 Vehicles per hour
2 Level of Service

Merge and Diverge Operations

The results of the merge and diverge analyses are presented in Table 4-13, along with the existing conditions analysis results. The results are also shown on Figure 4-9.

The results indicate that during the 2035 design peak hour:

- In the northbound direction, 125 of the 189 ramps (66 percent) serving I-81 operate worse than the level of service standard.
- In the southbound direction, 112 of the 192 ramps (58 percent) operate worse than the level of service standard.

As in previous tables, the shaded segments in Table 4-12 indicate those areas that do not meet the Level of Service standard.

Table 4-13 2035 I-81 Ramp Level of Service Analysis Summary

	Northbound Ramps						Southbound Ramps					
	2004 Peak Hour			2035 Peak Hour			2004 Peak Hour			2035 Peak Hour		
	Volume[1]	Density[2]	LOS[3]	Volume	Density	LOS	Volume	Density	LOS	Volume	Density	LOS
Exit 1A On-Ramp	NO NORTHBOUND RAMP						150	9.3	A	250	17.9	B
Exit 1A Off-Ramp	200	1.4	A	300	8.5	A	150	8.4	A	240	17.8	B
Exit 1B On-Ramp	250	11.1	B	400	17.6	B	NO SOUTHBOUND RAMP					
Exit 1B Off-Ramp	NO NORTHBOUND RAMP						100	8.8	A	160	20.2	C
Exit 3 On-Ramp	700	17.8	B	1550	33.6	D	100	10.8	B	150	21.1	C
Exit 3 Off-Ramp	50	18.7	B	100	31.6	D	600	13.0	B	1500	33	D
Exit 5 On-Ramp	250	19.0	B	500	34.7	D	400	15.4	B	750	33.1	D
Exit 5 Off-Ramp	400	23.3	C	700	42.4	F	250	10.7	B	450	29.2	D
Exit 7 On-Ramp	400	18.6	B	900	33.5	D	350	14.0	B	700	30.1	D
Exit 7 Off-Ramp	550	19.3	B	1000	37.6	F	450	12.6	B	800	32.9	D
Exit 10 On-Ramp	100	16.0	B	150	30	D	150	14.5	B	350	32.6	D
Exit 10 Off-Ramp	150	18.0	B	400	36	E	100	14.1	B	150	32.7	D
Exit 13 On-Ramp	150	17.0	B	300	29.6	D	150	14.4	B	200	31.2	D
Exit 13 Off-Ramp	100	14.7	B	250	30.3	D	150	10.0	A	300	26.7	C
Exit 14 On-Ramp	250	20.5	C	500	35.7	E	400	12.7	B	800	27.5	C
Exit 14 Off-Ramp	500	21.1	C	800	31.4	D	250	10.4	B	550	29	D
Exit 17 On-Ramp	400	13.3	B	750	25.2	C	350	12.8	B	700	29	D
Exit 17 Off-Ramp	350	12.4	B	700	26.1	C	350	8.7	A	700	24.3	C
Exit 19A On-Ramp	210	12.9	B	380	22.5	C	170	10.7	B	425	24.6	C
Exit 19A Off-Ramp	550	13.9	B	1000	28.1	D	NO SOUTHBOUND RAMP					
Exit 19B On-Ramp	40	14.9	B	70	25.2	C	230	13.1	B	575	24.6	C
Exit 19B Off-Ramp	NO NORTHBOUND RAMP						200	7.5	A	450	20.9	C
Exit 22 On-Ramp	50	13.6	B	100	22.9	C	150	7.9	A	250	20	B
Exit 22 Off-Ramp	100	12.3	B	250	23.7	C	50	9.4	A	100	22.1	C
Exit 24 On-Ramp	50	11.0	B	100	18.7	B	100	10.5	B	150	21.9	C
Exit 24 Off-Ramp	100	13.1	B	150	23.4	C	50	7.4	A	100	19	B
Exit 26 On-ramp	50	10.1	B	100	18.2	B	100	9.3	A	200	19.7	B
Exit 26 Off-Ramp	150	10.2	B	250	18.8	B	50	6.2	A	100	18.4	B
Exit 29 On-Ramp	150	7.4	A	450	14.9	B	200	9.3	A	550	20.1	C
Exit 29 Off-Ramp	300	7.8	A	550	16.7	B	150	5.4	A	450	17.8	B
Exit 32 On-Ramp	50	7.1	A	100	16.9	B	50	9.4	A	100	20.5	C
Exit 32 Off-Ramp	50	5.8	A	100	14.3	B	50	7.5	A	100	20.8	C
Exit 35 On-Ramp	250	8.7	A	550	17.9	B	150	7.7	A	350	19.2	B
Exit 35 Off-Ramp	200	9.1	A	350	20.2	C	300	9.1	A	550	21.9	C
Exit 39 On-Ramp	100	5.3	A	300	16.5	B	50	10.3	B	150	21.7	C
Exit 39 Off-Ramp	100	7.6	A	150	18.2	B	200	10.2	B	300	23	C
Exit 44 On-Ramp	50	11.1	B	150	21.4	C	150	10.8	B	250	22.2	C

Note: Shaded sections are locations where substandard LOS is indicated.
1 Ramp volume expressed in vehicles per hour (vph)
2 Density expressed in passenger cars per mile per hour
3 LOS - Level of Service

Table 4-13 2035 I-81 Ramp Level of Service Analysis Summary (Continued)

	Northbound Ramps						Southbound Ramps					
	2004 Peak Hour			2035 Peak Hour			2004 Peak Hour			2035 Peak Hour		
	Volume[1]	Density[2]	LOS[3]	Volume	Density	LOS	Volume	Density	LOS	Volume	Density	LOS
Exit 44 Off-Ramp	100	9.8	A	250	22.7	C	100	9.3	A	150	20.7	C
Exit 45 On-Ramp	100	9.3	A	200	18.9	B	250	9.9	A	400	20	B
Exit 45 Off-Ramp	150	12.3	B	400	23.9	C	100	7.2	A	200	19	B
Exit 47 On-Ramp	150	11.5	B	250	20.2	C	200	10.1	B	350	20.5	C
Exit 47 Off-Ramp	100	7.5	A	300	18.3	B	100	7.6	A	200	18	B
Exit 50 On-Ramp	50	10.5	B	100	19.2	B	150	8.5	A	300	17.8	B
Exit 50 Off-Ramp	100	10.6	B	300	20.5	C	50	6.5	A	150	16.8	B
Exit 54 On-Ramp	50	9.2	A	50	17.3	B	50	7.2	A	100	16.8	B
Exit 54 Off-Ramp	100	8.2	A	150	17.7	B	50	4.0	A	50	12.3	B
Exit 60 On-Ramp	150	6.9	A	300	14.3	B	50	6.3	A	150	13.7	B
Exit 60 Off-Ramp	50	6.3	A	150	15	B	150	5.3	A	250	15.8	B
Exit 67 On-Ramp	NO NORTHBOUND RAMP						50	6.9	A	50	16.5	B
Exit 67 Off-Ramp	50	6.8	A	100	15.3	B	NO SOUTHBOUND RAMP					
Exit 70 On-Ramp	300	9.8	A	500	15.9	B	150	10.6	B	250	19.8	B
Exit 70 Off-Ramp	150	6.3	A	300	14.3	B	200	5.6	A	400	15.7	B
Exit 72 On-Ramp	900	9.2	A	2450	35.7	E	400	3.6	A	500	13.4	B
Exit 72 Off-Ramp	400	9.6	A	600	16.6	B	1000	4.9	A	2300	27.6	C
Exit 73 On-Ramp	400	18.7	B	650	41.1	E	200	9.7	A	250	30.2	D
Exit 73 Off-Ramp	100	17.5	B	250	46.6	E	350	22.0	C	700	55.8	F
Exit 77 On-Ramp	200	16.7	B	550	36.3	E	300	20.9	C	600	52.5	E
Exit 77 Off-Ramp	300	13.2	B	750	30.6	D	350	12.8	B	550	32.3	D
Exit 80 On-Ramp	200	15.5	B	550	35.4	E	300	18.3	B	650	44.4	E
Exit 80 Off-Ramp	250	11.4	B	550	26	C	350	10.9	B	600	26.9	C
Exit 81 On-Ramp	650	13.6	B	1600	30.1	D	1150	12.2	B	3100	34.1	D
Exit 81 Off-Ramp	1100	5.9	A	2850	26.3	C	750	10.2	B	1700	23.5	C
Exit 84 On-Ramp	100	13.6	B	250	30.3	D	100	11.1	B	300	23.2	C
Exit 84 Off-Ramp	150	12.5	B	350	30.9	D	150	12.5	B	300	28.3	D
Exit 86 On-Ramp	50	14.5	B	100	28.8	D	50	11.7	B	100	25.9	C
Exit 86 Off-Ramp	50	12.2	B	100	30.5	D	100	12.0	B	150	26.5	C
Exit 89A On-Ramp	15	18.5	B	45	34.7	D	70	14.3	B	70	27.4	C
Exit 89A Off-Ramp	20	13.2	B	40	29.1	D	175	15.3	B	220	30.5	D
Exit 89B On-Ramp	85	14.3	B	255	32	D	30	17.0	B	30	30.6	D
Exit 89B Off-Ramp	30	15.4	B	60	31.6	D	25	12.6	B	30	27.8	C
Exit 92 On-Ramp	50	15.7	B	100	36	F	50	13.4	B	50	27.2	C
Exit 92 Off-Ramp	50	11.9	B	50	31.9	D	50	13.4	B	100	30.7	D
Exit 94A On-Ramp	10	17.5	B	20	35.7	E	300	15.4	B	350	31	D
Exit 94A Off-Ramp	35	17.9	B	90	40.7	F	NO SOUTHBOUND RAMP					

Note: Shaded sections are locations where substandard LOS is indicated.
1 Ramp volume expressed in vehicles per hour (vph)
2 Density expressed in passenger cars per mile per hour
3 LOS - Level of Service

Table 4-13 2035 I-81 Ramp Level of Service Analysis Summary (Continued)

	Northbound Ramps						Southbound Ramps					
	2004 Peak Hour			2035 Peak Hour			2004 Peak Hour			2035 Peak Hour		
	Volume[1]	Density[2]	LOS[3]	Volume	Density	LOS	Volume	Density	LOS	Volume	Density	LOS
Exit 94B On-Ramp	90	17.6	B	180	35.4	E	NO SOUTHBOUND RAMP					
Exit 94B Off-Ramp	65	17.5	B	160	39.6	F	150	18.8	B	250	38.4	E
Exit 98 On-Ramp	400	14.1	B	850	28.6	D	400	15.6	B	600	33.5	D
Exit 98 Off-Ramp	250	16.7	B	550	36.7	E	450	12.3	B	800	28.1	D
Exit 101 On-Ramp	100	14.4	B	250	31.6	D	100	12.9	B	300	27.1	C
Exit 101 Off-Ramp	100	13.5	B	250	30.3	D	150	15.5	B	300	35.3	E
Exit 105 On-Ramp	100	19.0	B	150	38.9	F	200	19.7	B	350	37.4	E
Exit 105 Off-Ramp	150	19.0	B	350	38.1	E	100	15.6	B	150	29.9	D
Exit 109 On-Ramp	350	16.8	B	650	33.2	D	200	11.3	B	350	24.1	C
Exit 109 Off-Ramp	200	13.9	B	350	36.1	F	400	15.4	B	700	34.3	D
Exit 114 On-ramp	200	15.5	B	550	34.9	D	200	13.5	B	400	30.1	D
Exit 114 Off-Ramp	250	14.1	B	450	33.1	D	400	12.3	B	550	27.8	C
Exit 118 Off (to CD Road)	500	1.9	A	1100	24.7	F	850	15.5	B	1450	38.6	F
Exit 118A On-Ramp	445	7.6	A	740	18.1	B	435	6.0	A	705	9.6	A
Exit 118A Off-Ramp	45	0.0	A	100	0	A	10	0.4	A	15	2.3	A
Exit 188B On-Ramp	285	10.4	B	475	19.4	B	30	2.9	A	45	4.2	A
Exit 118B Off-Ramp	290	9.0	A	635	20.6	C	560	0.0	A	955	0	A
Exit 118C On-Ramp #1	130	9.3	A	215	17.1	B	95	0.0	A	155	0.2	A
Exit 118C On-Ramp #2	40	11.1	B	70	19.6	B	90	5.2	A	145	9.5	A
Exit 118C Off-Ramp	165	0.0	A	365	0	A	280	6.0	A	480	14.5	B
Exit 118 On (to I-81 NB)	900	16.1	B	1500	37	E	650	8.3	A	1050	21.8	C
Exit 128 On-Ramp	100	20.6	C	200	43	F	50	18.9	B	150	39.5	F
Exit 128 Off-Ramp	200	27.7	C	200	53.2	F	150	27.3	C	250	50.6	F
Exit 132 On-Ramp	300	20.7	C	400	45.6	F	100	21.5	C	100	42.6	F
Exit 132 Off-Ramp	350	22.4	C	250	47.5	F	250	23.3	C	400	46.3	F
Exit 137 On-Ramp	700	25.1	C	1150	49.5	F	200	24.2	C	300	44.7	F
Exit 137 Off-ramp	150	24.4	C	300	51.6	F	650	28.4	D	1150	51.5	F
Exit 140 On-Ramp	500	22.6	C	700	44.7	F	300	22.4	C	450	43.2	F
Exit 140 Off-Ramp	250	22.7	C	400	49.8	F	450	27.0	D	700	53	F
Exit 141 On-Ramp	600	30.0	D	1000	56.5	F	350	23.9	C	600	47.5	F
Exit 141 Off-Ramp	250	27.9	C	400	52.5	F	600	32.1	D	950	56.9	F
Exit 143 On-Ramp	1250	12.7	B	1600	28.4	D	1850	24.7	C	2850	46.6	E
Exit 143 Off-Ramp	1600	23.8	C	2950	53.8	F	1250	13.9	B	2050	38.5	F
Exit 146 On-Ramp	300	24.8	C	450	42.2	F	550	24.4	C	850	46.3	F
Exit 146 Off-Ramp	550	27.5	C	900	44.8	F	200	26.3	C	450	51.8	F

Note: Shaded sections are locations where substandard LOS is indicated.
1 Ramp volume expressed in vehicles per hour (vph)
2 Density expressed in passenger cars per mile per hour
3 LOS - Level of Service

Table 4-13 2035 I-81 Ramp Level of Service Analysis Summary (Continued)

	Northbound Ramps						Southbound Ramps					
	2004 Peak Hour			2035 Peak Hour			2004 Peak Hour			2035 Peak Hour		
	Volume[1]	Density[2]	LOS[3]	Volume	Density	LOS	Volume	Density	LOS	Volume	Density	LOS
Exit 150A On-Ramp	NO NORTHBOUND RAMP						705	20.1	C	1210	43	E
Exit 150A Off-Ramp	425	29.0	D	640	48.9	F	155	15.2	B	425	40.3	F
Exit 150B On-Ramp	200	15.4	B	550	31	D	545	14.1	B	940	34.4	D
Exit 150B Off-Ramp	775	20.7	C	1160	37.4	E	45	5.6	A	125	26.6	C
Exit 156 On-Ramp	50	18.0	B	100	36	E	100	13.5	B	200	32.2	D
Exit 156 Off-Ramp	200	20.1	C	200	37.6	E	50	13.2	B	100	29.4	D
Exit 162 On-Ramp	50	13.8	B	100	25.7	C	100	9.1	A	200	23.8	C
Exit 162 Off-Ramp	150	21.8	C	200	41.8	E	50	12.8	B	50	29.4	D
Exit 167 On-Ramp	50	12.9	B	150	25.6	C	NO SOUTHBOUND RAMP					
Exit 167 Off-Ramp	NO NORTHBOUND RAMP						50	14.0	B	100	33.9	D
Exit 168 On-Ramp	50	18.4	B	50	37.1	E	50	13.7	B	100	31.6	D
Exit 168 Off-Ramp	50	16.1	B	100	30.3	D	50	14.3	B	50	32.3	D
Exit 175 On-Ramp	50	9.9	A	50	26	C	50	8.1	A	100	24.4	C
Exit 175 Off-Ramp	50	13.7	B	100	34.2	D	50	6.5	A	50	24	C
Exit 180A On-Ramp	10	18.8	B	40	35.9	E	25	8.8	A	60	24.5	C
Exit 180A Off-Ramp	50	8.9	A	100	26.7	C	65	6.6	A	130	24.5	C
Exit 180B On-Ramp	40	11.0	B	160	29.3	D	25	9.2	A	90	25.3	C
Exit 180B Off-Ramp	NO NORTHBOUND RAMP						35	5.3	A	70	22.9	C
Exit 188A On-ramp	NO NORTHBOUND RAMP						100	11.0	B	200	26.7	C
Exit 188A Off-Ramp	50	13.2	B	125	34.2	D	235	6.1	A	430	21.8	C
Exit 188B On-Ramp	250	8.5	A	550	22.3	C	NO SOUTHBOUND200 RAMP					
Exit 188B Off-Ramp	50	15.9	B	125	35.7	E	65	6.3	A	120	22.6	C
Exit 191 On-ramp	350	8.2	A	600	26.4	C	250	7.2	A	400	21.9	C
Exit 191 Off-Ramp	250	3.3	A	350	19.1	B	400	7.7	A	650	25.8	C
Exit 195 On-Ramp	100	15.9	B	250	36.1	E	50	12.2	B	200	28.4	D
Exit 195 Off-Ramp	100	10.5	B	200	30.5	D	100	10.0	A	250	30.4	D
Exit 200 On-Ramp	50	25.2	C	200	39.4	F	50	13.9	B	150	32.4	D
Exit 200 Off-Ramp	100	11.6	B	250	34.4	F	100	10.0	B	150	30	D
Exit 205 On-Ramp	150	12.8	B	550	31.2	D	150	11.8	B	450	30	D
Exit 205 Off-Ramp	150	13.8	B	450	38.8	F	250	13.7	B	450	35.5	F
Exit 213A On-Ramp	NO NORTHBOUND RAMP						100	16.1	B	250	35.6	E
Exit 213A Off-Ramp	100	13.7	B	250	34.6	D	175	17.4	B	260	36.1	E
Exit 213B On-Ramp	100	12.6	B	350	30.1	D	NO SOUTHBOUND RAMP					
Exit 213B Off-Ramp	NO NORTHBOUND RAMP						25	17.4	B	40	36.3	E
Exit 217 On-Ramp	200	15.8	B	500	37.3	E	50	17.0	B	100	34	D
Exit 217 Off-Ramp	50	12.5	B	100	32	D	300	21.4	C	450	41.4	F
Exit 220 On-Ramp	350	12.5	B	700	33.7	D	200	19.4	B	300	37.2	F

Note: Shaded sections are locations where substandard LOS is indicated.
1 Ramp volume expressed in vehicles per hour (vph)
2 Density expressed in passenger cars per mile per hour
3 LOS - Level of Service